STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

Manual Change Transmittal No. 2-87

SUBJECT	**Highway Design Manual Change No. 11**
TO	Deputy Engineer-Director, Deputy Directors, District Engineers, Division Heads, General Counsel, Internal Review and Audit
REFERENCE	Highway Design Division Operations and Procedures Manual
RESPONSIBLE OFFICE	Highway Design Division (D-8) — **DATE** February 20, 1987

Background

Parts III and IV, and Appendix A, of the Highway Design Division Operations and Procedures Manual have been revised to clarify design guidelines. Part V has been changed to show a revised Form 1002 (Rev. 1-87).

Part III Changes

Pages 3-3 through 3-6 showing nonfreeway 3R guidelines have been revised. Where existing, a crown width of 28 feet (rather than previously used 30 feet) may be retained on all rural two lane highways with 750 or more ADT as shown on page 3-4. New footnote "i" on page 3-4 revises clear zone criteria for rural two lane collector highways where ADT is 1500 or less. Also structures 28 feet or more in width may now be retained for four lane divided highways and rural two lane arterials as shown on pages 3-3 and 3-4. Only minor editorial changes have been made to pages 3-5 and 3-6.

Part IV Changes

Pages 4-40 and 4-115 have been revised to provide guidance on the selection of horizontal clearances to new bridge columns as measured from the curb face of underpassing streets.

Revised information regarding the placement of metal beam guard fence atop culverts where there is insufficient post embedment depth is shown on pages 4-46 and 4-47. Minor editorial changes have been made to pages 4-63, 4-74, and 4-91.

-more-

Appendix A Changes	Standard sheet CST-75, page A-3, is obsolete and is deleted; current information on superelevation treatment is shown in Part IV, paragraph 4-202D. Updated standard sheet GF(TD)-87, page A-4, shows a new detail for connecting steel guard fence post to culvert ceiling. Updated standard sheet CBR(P&P)-87 on page A-59, shows bolted angle, rather than channel, steel connectors for the precast traffic barrier segments. Pages A-70 and A-71 have been revised to clarify anchorage requirements for metal beam guard fence.
Form 1002 (Rev. 1-87)	Replace Form 1002 (8-82) with revised Form 1002 (Rev. 1-87).
Posting Instructions	These revisions should be posted in the Manual binder immediately upon receipt.

Roger G. Welsch
Deputy Director, Design
and Construction

Attachments

cc: All Departmental Manual Holders
Texas Transportation Institute
Center for Transportation Research
All Subscribers Outside SDHPT

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

ADMINISTRATIVE CIRCULAR NO. 41-86

To: All District Engineers and Division Heads — Date: July 31,1986

Subject: Highway Design Division Operations and Procedures Manual — Expires: Upon Receipt

Reference: — File: D-8

HIGHWAY DESIGN MANUAL CHANGE LETTER

Manual Change Transmittal No. 10

Gentlemen:

Parts III, IV, V, and Appendix A of the Highway Design Division Operations and Procedures Manual have been revised. Additionally, pages iii, iv, and v of the Table of Contents have been updated.

Figures 3-1, 3-2, and 3-3, on pages 3-3, 3-4, and 3-5, respectively, of Part III, "Nonfreeway Resurfacing, Restoration, or Rehabilitation (RRR) Construction Projects," have been revised to show only "minimum" criteria for RRR projects. Each Figure and page 3-2 of the text now refer to Part IV, "Design," for conditions where existing highway features fail to meet RRR minimum values thereby resulting in the application of "full" (i.e., new location or reconstruction) design criteria.

Page 4-9 of Part IV has been revised to include previously omitted information on the bottom two lines of the page. Figure 4-16, page 4-29, has been revised to correct drafting errors in the bottom left portion of the drawing.

Figure 4-38, page 4-74, has been revised to add bridge widths for various highway functional classes and traffic volume conditions. The structure widths shown match approach roadway width, or they are slightly wider (2 feet as described in footnote 8) to maximize use of currently available bridge standards. For certain conditions, a structure width of 30 feet is tabulated and there are no bridge standards available at this time. While standards for this width are being developed, the FHWA has indicated that bridge layouts showing widths of 34 feet will be approved until November 1, 1986. Whenever structures are wider than the standard roadway crown, the crown should be widened on bridge approaches to accommodate guard fence placement at bridge ends.

Figure 4-68, page 4-115, has been revised to eliminate conflicts with the horizontal clearance criteria shown in Figure 4-21.

-Continued-

In Part V, "Plans, Specifications, and Estimate Submissions," a new paragraph has been added under item 6 on page 5-13 regarding accounting for salvaged and stockpiled base material. On page 5-25, paragraph 5-102K1b regarding title sheet requirements has been revised.

In Appendix A, plate dimensions for the terminal anchor post assembly shown on standard sheet GF(TD)-86, page A-4, have been revised and a new general note has been added regarding material requirements for backup plates. In Appendix A, standard sheet CBR (P&P)-86, page A-59, shows an increased recess in portable, precast concrete barrier to accommodate the steel channel sections that are used to connect barrier segments. Standard sheet TB(BMGF)-86, page A-60, includes new details for blocking out temporary guard rail element at its attachment to concrete traffic barrier. Pages A-68 and A-71 have been revised to permit the location of guard fence behind curbs where speeds are 40 mph or less.

Manual pages should be removed and replaced with the revised versions immediately upon receipt of this Circular.

Sincerely yours,

M. G. Goode

M. G. Goode
Engineer-Director

Attachments

DISTRIBUTION:
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CTR
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HIGHWAY DESIGN

DIVISION

OPERATIONS AND PROCEDURES

MANUAL

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

(SDHPT)

AUTHENTICATION

This *Highway Design Division Operations and Procedures Manual* with subsequent revisions shall apply to Interstate Highways, U.S. Highways, State Highways, and Farm and Ranch to Market Roads. It constitutes policy for designing and processing for contracting projects on these highway systems.

The pertinent provisions of all Administrative Orders, Administrative Circulars, Information Circulars and Newsletters pertaining to the Highway Design Division's operations have been included in this Manual. The Manual will be revised periodically to incorporate future operation and procedural instructions.

M. G. Goode
Engineer-Director

HIGHWAY DESIGN DIVISION

This Manual establishes policies for operations and procedures for preliminary project planning and development; geometric design; base and pavement design; and preparing plans, specifications and estimates. It is not designed as and does not establish legal standards for these operations. The Manual is provided solely for use of the Texas Department of Highways and Public Transportation.

This Manual is subject to revision as conditions, experience or research data may warrant. The loose-leaf form will facilitate accomplishment of revisions. Changes will be issued by Administrative Circular. The change may be in the form of new sheets to be added, revised sheets to replace superseded ones or sheets to be deleted.

The Manual is not intended as a textbook nor is it all-inclusive. It is not a substitute for engineering experience, knowledge or judgment. Special situations may arise which appear to call for variation from the policy requirements established herein. Such variation will be subject to approval of the Chief Engineer of Highway Design, or the Administration, as the case may be.

HIGHWAY DESIGN DIVISION OPERATIONS AND PROCEDURES MANUAL

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PART I

GENERAL INFORMATION

GENERAL INFORMATION
HIGHWAY DESIGN DIVISION FUNCTION AND ORGANIZATION (1-100)

1-101 FUNCTIONS

The Highway Design Division is responsible for guiding the development of all highway construction projects through the preliminary engineering stages on both the rural and urban highway systems. The Division's responsibilities begin with the initial stage of each project's conception and development, prior to actual location and design, and continue through the design stages to the completion of plans, specifications and estimates prior to release for bids for construction. More specifically, this Division develops design criteria; prepares highway design standards; issues authority to do preliminary planning; assists with programming Federal-aid projects; coordinates the development of the Project Development Plan, the one-year advance letting schedule and the monthly letting schedule; processes plans and specifications for letting; and, through Field contact representatives coordinates archeological and environmental studies, plan development, construction specifications, engineering estimates and agreements. Also available to the Field upon request are specialized consultant services in the area of automated project data, illumination, traffic, geometrics, pavement design and rehabilitation, social and environmental considerations, archeological and cultural resources, air, water and noise pollution studies, and highway economic and evaluation studies.

1-102 CHIEF ENGINEER, HIGHWAY DESIGN

The Chief Engineer, Highway Design is the head of the Highway Design Division which has a staff of approximately 116 employees. He is directly responsible to the Deputy Director for Design and Construction for the administration and operation of the Highway Design Division. The Chief Engineer, Highway Design is responsible for the development and recommendation of policies concerning all phases of highway design, except bridges and signing. He is responsible for coordinating design recommendations with other Divisions and the Districts to make certain that policies approved by the Engineer-Director are carried out.

1-103 ASSISTANT CHIEF ENGINEER, HIGHWAY DESIGN

The Chief Engineer, Highway Design is assisted by the Assistant Chief Engineer, Highway Design. This assistant is delegated the duties and responsibilities of the Chief Engineer during his absence and carries the direct line of authority from the Chief Engineer to the Division organization.

1-104 ORGANIZATION

The Highway Design Division is organized into nine sections covering seven general areas of operation as shown in Figure 1-1. The Sections and their responsibilities within the Division are as follows:

A. Design Administrative Section

The Design Administrative Section, under the direction of the Design Administrative Engineer, is responsible for all accounting and budgetary functions and for maintaining and processing all personnel records. The functions of the Automation Administrator reside in this section. This section also provides administrative support as designated by the Chief Engineer, Highway Design or the Assistant Chief Engineer, Highway Design. In the absence of the Chief Engineer, Highway Design or his assistant, the Design Administrative Engineer is delegated the duties and responsibilities of the Chief Engineer, Highway Design.

B. Programming and Scheduling Section

The Programming and Scheduling Section, under the direction of the Assistant Chief Engineer, Highway Design, is responsible for providing special studies and analysis based on project data for the various levels of Departmental management including the Project Development Plan, the One-Year Advance Letting Schedule and the Monthly Letting Schedule. This section is also responsible for the management of the Design Construction Information System (DCIS) and provides consultation services to the Districts and Divisions on matters related to DCIS.

C. Field Coordination

Field Coordination is divided into three Sections, each under the direction of an Engineer of Field Coordination. Engineers of Field Coordination are responsible for a geographic area of the State comprising certain Districts of the Department.

Each of these three Sections provides liaison between the Austin Headquarters of the Department and the field offices in the Districts. They are responsible for matters concerning project development, project plans, specifications, construction cost estimates, and general matters as may be required.

D. Project Services

The Project Services Section, under the direction of the Engineer of Design Services, is responsible for the processing of completed plans, specifications and estimates prior to the letting of contracts for construction; coordinating the review of proposed specifications; preparing the notification to Contractors of upcoming new projects and advertising the letting of contracts. The Section also provides drafting services to the Division.

E. Geometric Design

The Geometric Design Section, under the Engineer of Geometric Design, is responsible for development of design policies, procedures, standards, etc., relating to geometrics, illumination, and general roadway design features for all classes of highways. This Section is responsible for the preparation of most detail standard sheets used in final plan assemblies. This Section provides assistance to the Field Coordination Sections and is available to assist Districts in developing schematics and alternate geometric design, performing traffic analyses, preparing PS&E, and handling other special assignments. This Section is also responsible for monitoring research projects and for assisting in activities of the American Association of State Highway and Transportation Officials (AASHTO) as they relate to geometric design, traffic, safety and illumination.

F. Pavement Design

The Pavement Design Section, under the Engineer of Pavement Design, is responsible for pavement design criteria, procedures, and policies relating to the structural design of pavements. This Section provides assistance to the Field Coordination Sections and the Districts in the review and design of pavements, and coordinates the Highway Design Division's efforts in the Pavement Management System. The Pavement Design Section monitors research studies relating to pavements. The Engineer of Pavement Design Section serves as Research Area III Coordinator, and assists in activities of committees of the American Association of State Highway and Transportation Officials.

G. Environmental and Community Factors

The Environmental and Community Factors Section, under the direction of the Director of Environmental Studies, performs social, economic and environmental investigations including evaluation of historic and prehistoric resources that are affected by highway construction. This section also assists the District offices in these and other combined studies involving various disciplines. An important function of this section is to monitor the public involvement process. This section also serves as a clearing house for environmental statements prepared and circulated by other agencies.

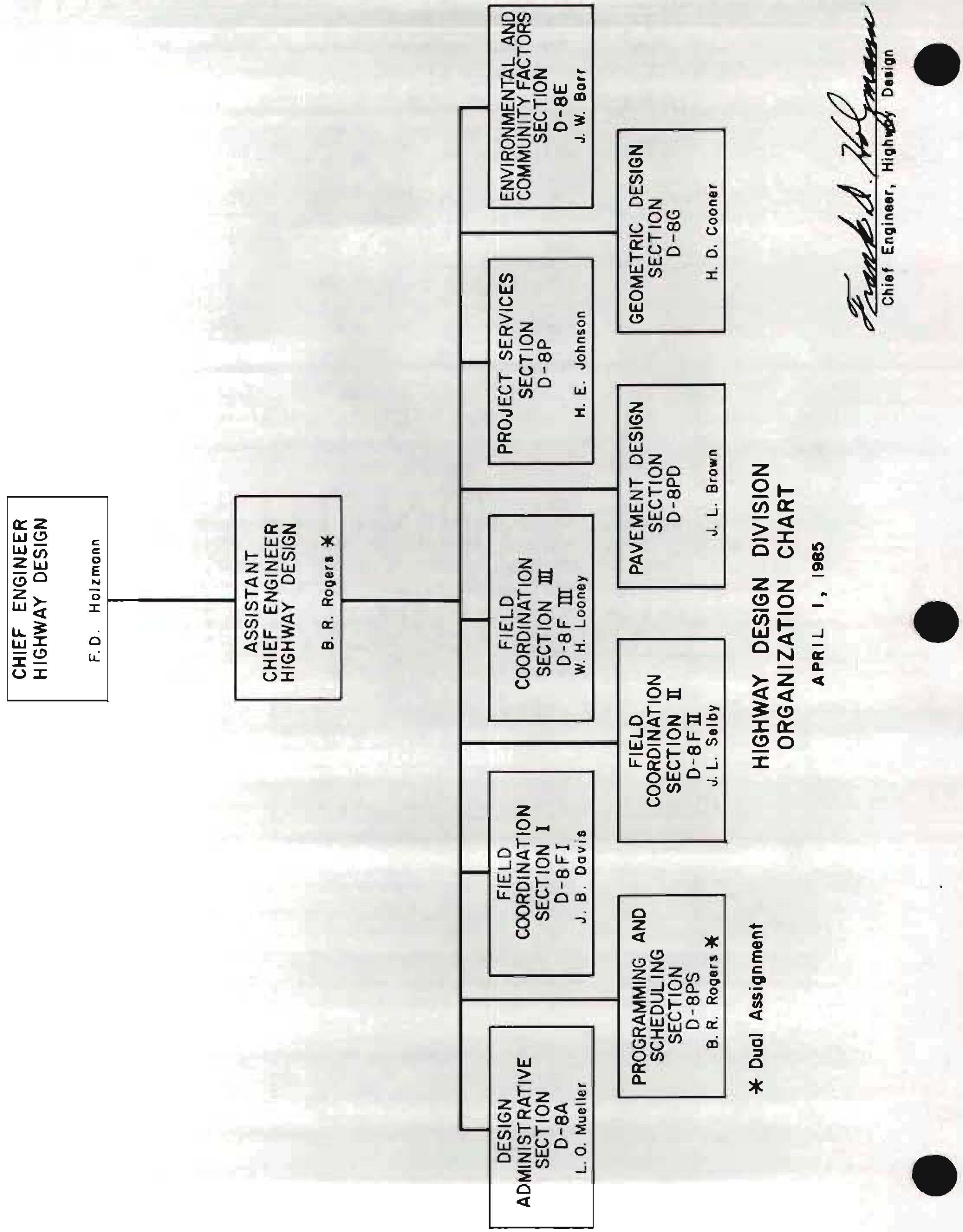


Figure 1-1 Refers to Paragraph 1-104

PART II-A

PRELIMINARY PROJECT PLANNING AND DEVELOPMENT

PART II-A

PRELIMINARY PROJECT PLANNING AND DEVELOPMENT (2A-100)

2A-101 INTRODUCTION

Before actual design work can be undertaken on a highway project, necessary preliminary planning must be accomplished. The project must be selected, authorized, identified and developed in accordance with the required procedures of local, state and Federal governments. The following sections relate to the development of a highway project from inception to geometric design.

AUTHORITY FOR PRELIMINARY WORK (2A-200)

2A-201 PROJECT AUTHORITY

When the District is ready to initiate preliminary work from projects authorized by the 20-Year Project Development and Control Plan or other programs of work approved by the Commission, proper authority shall be obtained by the submission of requests through the Highway Design Division.

2A-202 APPROVAL OF PRELIMINARY WORK

When the initiation of preliminary work is concurred in by the Highway Design Division, based on prior Commission or Administrative approval, an Investigation and Planning Expense Authorization (IPE), which is the governing authority for preliminary work, will be issued. Preliminary engineering work shall not be performed on any project until authority for the initiation of preliminary work has been obtained from the Highway Design Division (File D-8) with the receipt of an IPE Authorization (except for Safety and other related projects authorized by the Safety and Maintenance Operations Division (File D-18) as explained later).

PROJECT DEVELOPMENT (2A-300)

2A-301 GENERAL

After a project or a possible project has been selected, and proper authority has been obtained for the beginning of preliminary studies, the project should be developed in accordance with acceptable engineering practices. Socioeconomic and environmental studies should be initiated at the beginning of project development to determine the social, economic, and environmental impacts associated with the proposed project. These studies will involve early coordination with other agencies to take advantage of their expertise in the identification of certain environmental effects. This phase of development is outlined in detail in Part II-B.

2A-302 RECONNAISSANCE AND LOCATION STUDIES

A. Area-wide reconnaissance studies should be made between established control points to determine what routes are feasible for development. Sufficient location studies including social, economic and environmental studies should be performed on each of the selected routes in order to determine the one with the most positive social, economic and envionmental effects. This is covered in detail in Part II-B.

B. Basic and acceptable engineering criteria and judgment shall be used in the selection of the proposed route. In some instances it may be necessary to perform more detailed surveys, environmental studies and design work in order to determine the most feasible route for development. It is essential in the reconnaissance and location study phase of highway project development that a sufficient analysis be made of alternate routes to permit a thorough presentation of alternatives at the public hearing stage. Public hearing requirements are outlined in detail in Part II-B.

2A-303 HIGHWAY ROUTE LOCATION CRITERIA

A. Although basic engineering criteria should be utilized in determining highway routes, equal consideration should be given to social, economic and environmental criteria to insure that the highway project will have a positive effect on the quality of human environment.

B. Care should be exercised in the section of highway locations to preclude encroachment on parks, wildlife refuges, churches, cemeteries and historical, recreational or isolated scenic beauty sites. An effort should be made to blend the highway location into the local environment to enhance the aesthetic appearance of the highway and its surroundings.

INVESTIGATION AND PLANNING EXPENSE (IPE) (2A-400)

2A-401 GENERAL

Investigation and Planning Expense (IPE) is the expense involved in the proper execution of all preliminary work, such as reconnaissance, location surveys, drainage area and foundation studies for structures, preparation of right-of-way data, design appraisals,and Plans, Specifications and Estimates (PS&E) required in the development of any authorized project.

2A-402 BUDGETS FOR INVESTIGATION AND PLANNING EXPENSE

At the beginning of each fiscal year an IPE budget is prepared by the Highway Design Division for approval by the Administration to cover the estimated cost of investigation and planning work during the ensuing year. Minute Orders are then prepared by the Highway Design Division for Commission approval for the appropriation of funds to cover IPE requirements during the fiscal year. This fund is prorated to the Districts in amounts sufficient to cover the anticipated needs.

2A-403 INITIATION OF INVESTIGATION AND PLANNING WORK

A. The IPE Authorization issued by the Highway Design Division is the only authority to initiate preliminary work (except as indicated in Section 2-417, Paragraph C) and to incur preliminary expense for the development of a highway project. The request for the issuance of an IPE Authorization, Form 254 Rev. (see Figure 2A-1) should be submitted to File D-8.

B. If a highway project is covered by a Commission Minute Order requiring acceptance by local governmental agencies, a certified copy of a resolution from the pertinent agency must be furnished to the Program Engineer. After the Minute is declared operative by the Administration, an IPE Authorization can be issued.

2A-404 ISSUANCE OF IPE AUTHORIZATION

All requests for the issuance or revision of an IPE Authorization shall originate in the District Office. Each request for an IPE Authorization shall clearly outline the preliminary work proposed. The stage of preliminary work authorized under the IPE Authorization shall not exceed that specified in the authorization.

The 20-Year Project Development and Control Plan, as approved by the Commission, authorized certain stages for the development of a project dependent upon its tentative schedule for construction. These schedules and authorizations are as follows:

> The One-Year Advanced Letting Schedule and the Four-Year Letting Schedule, comprising the Five-Year Letting Plan, authorized the development of a project through to construction. This constitutes approval of Stages 1 through 4 of development as explained below.

State Department of Highways
and Public Transportation
Form 149-A - Rev. 12-77

AUTHORIZATION

☐ INITIAL ☐ INCREASE ☐ CANCELLATION ☐ INFORMATION

DATE OF AUTHORIZATION ____________ COUNTY ____________ Prepared by: D-______

GENERAL SET UP CARD NO. 2

* TRANS-ACTION	DATE MO.	DATE YR.	SUB.	PREFIX 1-3-7	DETAIL	EXPENDITURE UNIT

COUNTY NO.	HIGHWAY SYST. (17)	HIGHWAY NUMBER	MILEAGE	CONTROL	CONT. SECT.	JOB NO	MGR NO

DESCRIPTION (27 SPACES)

* TRANSACTION CODE: SEE CODE CHART 46 FOR ENTRIES

TRANSACTION CARD NO. 1

DATE/VOUCHER	MONTH	YEAR	VOUCHER
ACCOUNT NO.	SUB	PREFIX 2-4-8	DETAIL
INITIAL AUTH.	$		CR
INCREASE AUTH.	$		CR
CANCEL AUTH.	$		
TOTAL AUTH.	$		
FROM (DR)	TO (CR)		
ACCOUNT NO.	SUB	PREFIX	DETAIL
AMOUNT	$		

D-3 USE ONLY

DEBIT			CREDIT		
GEN. LEDG. NO.		$	GEN. LEDG. NO.		$

AUTHORITY:

CONTROL & SECTION	TYPE	MILES	FROM	TO

Approved ____________ Audited

Title ____________ ____________

DIRECTOR FINANCE

DIST/DIV/SUB NO. ______

PREFIX NO. ______

DETAIL (AUTH/IPE) ______

Figure 2A-1

The next 5 years in the Plan, called the Five-Year Development Schedule, authorized project planning to include route studies, environmental reports, public meetings and hearings, schematics, determination of right-of-way requirements and acquisition of right-of-way where previously approved. This constitutes approval of Stages 1 through 2 or 3 of development, dependent upon the right-of-way situation.

The following 10 years in the Plan, called the Ten-Year Advanced Planning Schedule, authorized advance planning to include engineering, social, economic and environmental studies necessary to determine the feasibility of the proposed route or scope of the project. This constitutes approval of Stage 1 of development.

Other programs of work, such as Farm to Market Road Programs, approved by the Commission, define the Stage of work authorized. Such programs are usually developed on a year-to-year basis and authorize the development of a project through to construction.

Stage 1, Route Studies

The first stage should normally consist of preliminary investigations, including the engineering and social, economic and environmental studies necessary to determine the proposed route and the preparation of such other data that may be required to support the proposed route and necessary public hearings on route location. (Function Code 110)

Stage 2, Location and Determination of Right-of-Way and Schematic Requirements

The second stage should consist of such engineering studies and survey work and continuing social, economic and environmental studies as may be required to prepare preliminary schematics if conditions warrant and determine right-of-way requirements. This stage should not be undertaken until the proposed route is agreed upon and approved except in unusual cases where more detailed information is required to establish the route location. (Function Codes 110 and 120)

Stage 3, Preparation of Right-of-Way Data

The third stage should normally consist of preparation of right-of-way map and deeds on approved location, staking right-of-way limits, furnishing such preliminary engineering assistance as may be required in the acquisition of right-of-way and the completion of any additional survey work or social, economic or environmental studies that may be required to proceed with the final design of proposed improvements and the preparation of PS&E. Right-of-way deeds should not be prepared and furnished to the local authorities until the proposed right-of-way widths are agreed upon with the Austin Office and submission of this data to the local authorities is authorized by letter, program approval, or by Minute Order.

On Interstate projects, the actual purchase of right-of-way must not be initiated until the letter of authorization is received from the Right-of-Way Division. The preliminary work required in the preparation of right-of-way data, such as right-of-way surveys, preparation of deeds and maps, staking right-of-way, etc., shall be classified as preliminary engineering. This includes design appraisals. (Function Codes 110, 120, 130 and 140)

Stage 4, PS&E

The fourth and final stage should consist of preparation and completion of PS&E. This work, without exception, should not be initiated until properly authorized by the IPE Authorization which is based on program approvals, Minute Orders or Administrative approvals. The IPE Authorization is the governing authority for the beginning of preliminary work and in no case should any stage of preliminary work be undertaken until and unless properly covered by an approved IPE Authorization. (Function Codes 110-180)

The function codes listed are those used by the Districts to assure the proper distribution of preliminary expense as it accrues to the various stages of preliminary work.

2A-405 PROPER SEQUENCE OF PRELIMINARY WORK

An approved IPE Authorization which authorizes PS&E covers all four stages of preliminary work. An approved IPE Authorization which authorizes preliminary work through Stage 3, "Preparation of Right-of-Way Data," does not cover the preparation of construction plans and in no case should the preparation of plans be undertaken until the IPE Authorization is revised to cover this additional stage of preliminary work.

2A-406 DORMANT IPE AUTHORIZATIONS

If the preliminary work authorized under an IPE Authorization is discontinued because project developments make further preliminary work impractical or inadvisable for various reasons such as completion of work authorized, location, right-of-way, financial complications or other difficulties, the IPE Authorization should be placed in the Dormant Stage. The Highway Design Division should be notified so that Form 149-A Rev. (see Figure 2A-2) can be prepared, placing the IPE Authorization in the Dormant Stage. No further preliminary work can be performed on the project or preliminary expense applied to the authorization until the IPE Authorization has been reopened by the Highway Design Division.

2A-407 REOPENED IPE AUTHORIZATION

A dormant IPE Authorization may become active again by being reopened. Another submission, similar to the original submission, should be submitted to the Highway Design Division.

2A-408 CLOSE-OUT OF IPE AUTHORIZATION

An IPE close-out should be initiated on Form 1153 (see Figure 2A-3). An IPE Authorization which has been closed out in error to a contracted project, may be returned to its previous active status. Request for reinstatement of an IPE Authorization should be submitted on Form 254 Rev. to the Highway Design Division.

2A-409 CHARGE-OFF OF INVESTIGATION & PLANNING EXPENSE - CANCELLATION OF IPE AUTHORIZATION

When preliminary work on a project is halted and the project is abandoned with no intention of continuing in the future, the IPE Authorization shall be cancelled and the preliminary engineering expense charged off as undistributable investigation and planning expense. Charge-off can be justified on projects where the highway designation is cancelled, there is a change of control points, or

FORM 254 REV.
10-66

REQUEST FOR {ISSUANCE / REVISION} OF I.P.E. AUTHORIZATION

MEMORANDUM TO FILE D-8: DATE ________________ 19____

AUTHORITY IS REQUESTED FOR THE INAUGURATION OF INVESTIGATION AND PLANNING WORK AS FOLLOWS:

COUNTY ____________________ HIGHWAY NO. ____________

CONTROL NO. __________ SECTION NO. _____ LENGTH _____ MILES

DIST. NO.	MGR. NO.	I.P.E. NO.

FROM ____

TO ____

SCOPE OF INVESTIGATION AND PLANNING WORK PROPOSED ____

____ THROUGH STAGE No. | 1 | 2 | 3 | 4 |*

DESCRIPTION OF IMPROVEMENTS PROPOSED ____

________________________ ESTIMATED CONST. COST $ ____________

________________________ EST. R.O.W. COST TO STATE$ ____________

Is project programmed? _______ If so, what program? ____________________

Is preliminary work covered by Commission Order? _____ Give Minute No. ____________

Does Minute require acceptance of provisions by city? _________ By county? ____________

If so, has satisfactory resolution been passed by city? _______ By county? ____________

Has copy of resolution by city and/or county been furnished Austin Office? ____________

Has Minute been declared operative? ______ By which Division? ____________________

If not programmed or authorized by Commission Minute, give justification for proposed preliminary work ____

____

Has there been any previous preliminary work on this project? _______ Give I.P.E. No. ________

What is average width of present right-of-way? ____________________

Is additional right-of-way required? _______ If so, give width of proposed R.O.W. ________

Is it proposed to follow present road with or without modification or establish new location?

____

Describe type and condition of existing improvements. ____________________

____

Is there an airport or airstrip within two miles of any portion of this project? ________

Name and location of airport ____

____

*Refer to Page Number 35
in the Accounting Manual.
Mark out Stages not applicable.

____
DISTRICT ENGINEER

Figure 2A-2

FORM 1153

MEMORANDUM TO DISTRICT ENGINEER

SUBJECT: I.P.E. AUTHORIZATION CLOSE OUT

The following memorandum, which represents a request for I.P.E. Close Out, should be submitted to File D-8 for each and every project on which work orders are issued or contracts are let indicating whether or not an I.P.E. Authorization has been issued to cover the project. If more than one authorization has been issued to cover an individual project, a separate close out notice should be submitted for each I.P.E. In the event an I.P.E. Authorization covers two or more projects which are to be closed out, your close out notice when submitted should clearly indicate the expense applicable to each project or your close out notice should be accompanied by a copy of Distribution Form 1150, properly prepared. If a partial close out is requested, your close out notice should, without exception, be accompanied by two copies of Distribution Form 1150 showing a breakdown of the Preliminary Engineering by Function Codes.

Unless otherwise agreed upon with File D-8, the application of preliminary expense to an I.P.E. Authorization should cease on the date work order is issued on day labor jobs and on the date contract is let on contract jobs, and an I.P.E. Close Out Notice should be submitted not later than the 20th day of the following calendar month. Example: If work order is issued or contract let in April, close out notice should be submitted by May 20.

FORM 1153

REQUEST FOR I.P.E. AUTHORIZATION CLOSE OUT

Date ____________________

MEMORANDUM TO FILE D-8 P 421

SUBJECT: I.P.E. AUTHORIZATION CLOSE OUT

Please close out the following I.P.E. Authorization as indicated:

Budget ____________________ Federal Project No. ____________________

Authorization No. ____________________ Letting Date ____________________

County ____________________ Work Order Date ____________________

Highway ____________________ Total Field Charges $ ____________________

Length ____________________ This project to be handled through the Maintenance / Construction Division

Control ________ Section ________ Job ________

Limits ____

____

Proposed Improvements ____

____
District Engineer

Figure 2A-3

the location is abandoned because of right-of-way difficulties. Also, all investigation and planning work of a general nature which is not applicable to a specific project, such as that applied to IPE Authorizations 200, 300, and 600 is to be charged off as well as the work charged to IPE Authorizations 400 and 500.

2A-410 FILE REFERENCE

The IPE Authorization Number shall be used as a reference on all correspondence and reports relating to that project. The plans shall have the IPE Authorization Number indicated on the title sheet.

2A-411 REVISION OF IPE AUTHORIZATION

The IPE Authorization, when initially issued, may or may not cover a section of highway as proposed for letting. However, as soon as it is determined that the IPE Authorization does not cover the project as proposed for contract letting, a request for the revision of the IPE Authorization on Form 254 Rev., along with distribution Form 1150 (Fig. 2A-4), should be submitted immediately to the Highway Design Division so that proper revision and modification in the limits of scope of work of the IPE Authorization can be made. Distribution by function code should be made on the back of Form 1150. Whenever a new program of work is approved by the Commission, the District Offices should review all existing IPE Authorizations to determine if the limits, stage, or type of work need to be modified to more accurately describe the project as it will be contracted.

2A-412 HIGHWAY DESIGNATION

A. The designation of a highway by the Commission is construed as defining a broad traffic corridor which in some cases may be several miles wide. Such latitude is necessary because usually insufficient social, economic, environmental and engineering studies are made prior to actual designation. System designation usually does not authorize development of PS&E or construction.

B. In some instances the Commission may authorize advance planning studies and withhold official designation until studies prove the proposed highway project to be both feasible and acceptable.

C. It should also be noted that numerous urban transportation plans and/or studies have been and are still being developed in various cities and areas of Texas. Although these plans often depict corridors of possible future highway routes, such displays represent suggested proposals for future consideration by a planning group. Such exhibits do not represent either an implied or an official commitment by the Department regarding future highway designations in such corridors.

2A-413 HIGHWAYS OFFICIALLY DESIGNATED AS CONTROLLED ACCESS HIGHWAYS

In order to develop highway projects under the provisions of H.B. 179, 55th Legislature, the section of highway involved must be officially designated by the Commission, with approval by Minute Order.

2A-414 FEDERAL HIGHWAY SYSTEM

The Federal Highway System is composed of four basic systems: (1) the National System of Interstate and Defense Highways; (2) the Federal Primary System; (3) the Federal Urban System; and (4) the Federal Secondary Highway System. These are described as follow:

A. The National System of Interstate and Defense Highways consists of routes of highest importance to the nation which connect the principal metropolitan areas, cities, and industrial centers, including important routes into, through and around urban areas, serve the national defense, and connect at suitable border points with routes of continental importance in the Dominion of Canada and the Republic of Mexico.

B. The Federal Primary System consists of routes of the National System of Interstate Highways and other important state routes, including important loops, belt highways and spurs. The latter are principal state highways which are usually through routes between population centers.

C. The Federal Urban Highway System is designated within urban areas of population over 5,000.

D. The Federal Secondary System consists of the principal secondary and feeder routes, including farm-to-market roads, rural mail and public school bus routes and local rural roads.

E. In addition, there is also a National Forest Highway System which is composed of both primary and secondary routes as well as some county roads. This system includes over 400 miles of such highways and roads in Texas.

F. At the time a highway project is officially designated, it should also be considered for inclusion in a pertinent Federal Highway System, if eligible. Although it is not necessary for a project to be added to the Federal Highway System when first designated, subsequent procedures for project development are dependent upon the type of Federal System involved.

2A-415 FEDERAL HIGHWAY SYSTEM RECORDS

The Transportation Planning Division (File D-10) is responsible for initiating action for the addition of highways, streets and county roads to all Federal and State Highway Systems.

2A-416 DEFENSE ACCESS ROADS

Although defense access roads are constructed generally with 100 percent Federal funds, such roads do not actually become a part of the State or Federal Highway Systems since they are maintained by local governmental agencies rather than by the State or the Federal governments. Preliminary work should be performed on defense access projects only at the request of the Federal Government and only after administrative authority for the initiation of such preliminary work has been obtained. In some instances, preliminary engineering may need to be performed prior to the certification of a defense access road project by the Federal Government. In such cases, only such preliminary work as might be needed to make a general investigation should be performed. A considerable expenditure of effort and funds, such as detailed plan preparation, should be deferred until there is definite assurance that the project has been certified and Federal funds have been committed.

2A-417 FEDERAL PROGRAM DATA SUBMISSION TO THE AUSTIN OFFICE FOR PRELIMINARY ENGINEERING

A. For all highway projects on any Federal highway system where it is intended to request Federal reimbursement for preliminary engineering expense, it will be necessary to receive a letter from the FHWA authorizing reimbursement. An IPE Authorization will not be issued until this letter is received. Projects where reimbursement for preliminary expense is requested would include, but not necessarily be limited to, Interstate and Urban System projects.

B. The request for IPE Authorization (Form 254 Rev.) for these two types of projects will provide all of the program data required for submission to the FHWA by the Austin office with one exception. When a project has not been included in the Annual Program of Proposed Federal-aid Projects (105 Program) the status of the Project Notification and Review process (A-95 review) should be included on the form. No other program forms, maps, etc. are required.

C. Safety projects developed under Title II of the 1973 and subsequent Highway Acts are usually programmed collectively for preliminary engineering, and the usual program procedures and submissions to the appropriate Division as outlined in their Manuals should continue as before on this type project.

2A-418 PROJECT IDENTIFICATION

It is necessary that every proposed highway project be properly and completely identified. In addition to being identified by highway number, descriptive limits, mileage and type of improvements, a highway project should be identified by control and section number and, at the proper time, by job number. Control, section, and job numbers covering every project are assigned by the Highway Design Division.

2A-419 STATE PROJECT NUMBERS

The control and section number will be utilized with the addition of a letter prefix and a job number to become the State project number. The assignment of the job number will not usually be made until the project is received in the Austin office for contracting. Pre-assignment may be made in special cases. A pre-assignment request should include complete project information.

2A-420 FEDERAL INTERSTATE PROJECT NUMBERS

If Interstate funds are to be utilized, in addition to a control, section and state job number, a Federal Interstate Project number must be assigned. The Federal Interstate project number is composed of a letter prefix, the Interstate Highway number, a section number indicating the Highway District, a parenthesis number and a post mileage number (example I 10-4(9) 506). The section number will begin with Number One at the most western or southern Highway District and be increased in ascending order for each Highway District from west to east or south to north. A different parenthesis number will be assigned to each project in ascending order in each District. However, the original parenthesis number assigned will be reserved to cover the last construction project when stage construction is employed. The post mileage number is the distance from the most western or southern terminal of the Interstate Highway to the west or south end of the proposed project. The entire project number with the exception of the parenthesis number is to be shown on all plans submitted for review. The parenthesis number will be added by the Highway Design Division after plans are received.

FORM 1150
REV. 3-72

RECOMMENDED REVISION OF I.P.E. AUTHORIZATION AND DISTRIBUTION OF PRELIMINARY EXPENSE

(SEE REVERSE SIDE FOR MAKING DISTRIBUTION OF EXPENSE BY FUNCTION CODE)

DATE ____________

IPE:	COUNTY:	LIMITS:	SCOPE OF WORK AUTHORIZED:
MILES:	HIGHWAY:		

LIMITS OF NEW SECTIONS	MILES	PROJECT AND CONTROL	SCOPE OF PRELIM. WORK RECOMMENDED	PROPOSED IMPROVEMENTS	① ESTIMATED CONST. COST ② AUTHORIZED CONST. FUNDS	① EST. R.O.W. COST TO ST. ② AUTHORIZED R.O.W. FUNDS	PRELIMINARY EXPENSE	R.O.W. ACQD.	LOC STDY. %	ALL SURV. %	SCHEM COMP. %	PLANS COMP. %
A.					①	①						
					②	②						
B.					①	①						
					②	②						
C.					①	①						
					②	②						
D.					①	①						
					②	②						
				TOTAL ESTIMATED COST	①	①	←TOTAL PRELIMINARY ENGINEERING EXPENSE					
				TOTAL AUTHORIZED FUNDS	②	②						

REMARKS:

NOTES:

1. DISTRIBUTION SHOULD BE MADE ON BASIS OF PROPOSED METHOD OF CONTRACT LETTING.
2. DISTRIBUTION BY FUNCTION CODE IS REQUIRED TO BE SHOWN ON THE REVERSE SIDE OF THIS FORM ONLY WHEN PARTIAL CLOSE OUT OF I.P.E. AUTHORIZATION IS INVOLVED.
3. THIS FORM SHOULD BE SUBMITTED IN DUPLICATE TO HIGHWAY DESIGN DIVISION-FILE D-8.

DISTRICT ENGINEER

Figure 2A-4

2A-421 COMPOSITION OF OTHER FEDERAL PROJECT NUMBERS

Federal Primary, Secondary, and Urban project numbers are composed of a letter prefix, indicating type of funds, a Federal Project Number and a Federal Project Parenthesis Number both of which are assigned by the Highway Design Division. These projects also require a control, section and State job number.

CORRELATION AND AGREEMENT WITH OTHER AGENCIES (2A-500)

2A-501 GENERAL

In the development of any highway project, consideration shall be given during the early stages of social, economic, environmental and engineering studies to the selection of a highway route or alternate route with complete cooperation and correlation with local, state and Federal agencies to provide the opportunity for others to identify any social, economic or environmental consequences, both beneficial and detrimental, of the proposed project and to contribute to the project's development.

2A-502 AGREEMENTS WITH OTHER STATES

During the early stages of project development, if a project is on or crosses the State line, at the direction of the Highway Commission by approved Minute Order, an agreement shall be executed between the States for the joint improvement of the highway project. Agreements covering bridge projects will be handled by the Bridge Division. Agreements covering highway projects will be handled by the Highway Design Division. These agreements should cover the preliminary engineering, design, construction, and maintenance of the proposed project. The Attorney General of Texas has ruled that the execution of such agreements with other States shall provide for the signature of approval by the Governor of Texas.

2A-503 OTHER AGREEMENTS

During the early stages of project development, any necessary agreements with local governmental agencies, water, or reservoir districts, Corps of Engineers, etc., should be negotiated at the direction of the State Highway Commission by approved Minute Order.

2A-504 AIRWAY-HIGHWAY CLEARANCE

During the early phases of project development, consideration must be given to the effect any proposed highway project might have on vicinity airports. Any airports within two miles of a project should be reported on Form 254 Rev. at the time authority is requested to initiate preliminary work. Airway-highway clearances shall be studied to avoid encroaching upon an airfield or establishing a highway location that would be an obstruction to air navigation. Minimum airway-highway clearance requirements must be considered to avoid the creation of a safety hazard for both highway and air traffic. Airway-highway clearances are different for Military Airports, Civil Use Airports, and Private Airfields. The criteria for these three types of airfields are outlined in Federal Aviation Regulations, Part 77, Objects Affecting Navigable Airspace. Figure 2A-5 outlines in chart form the criteria specified by the Federal Aviation Administration to establish and maintain airway-highway clearance for Civil Use Airfields. Private Airfields generally are not considered Civil Use Airfields; however, the Federal Aviation Administration considers Private Airfields which are open to the public as Civil Use Airfields. Highway locations in the vicinity of Private Airfields not open to the public shall comply with the airway-highway clearance requirements of Civil Use Airfields because the status of the airfield may change from private to civil use and affect the highway location at some future date. The Highway Design Division is responsible for handling all airway-highway clearance matters with the Federal Aviation Administration.

2A-505 AIRPORT CLEARANCE PROCEDURES

In order to clear a proposed highway project any point of which is within 2.0 miles of an airfield, a sketch shall be submitted to File D-8 showing the distances from the ends of the pertinent runways to the nearest edge of highway pavement. Should the highway project extend to within the runway approach area, the distance from the end of the runway to the nearest edge of pavement within the approach area should also be shown on the sketch. The critical distance usually is within the approach area. The sketch should also show the elevation at the highway centerline. Should there be a frontage road or connecting road between the main lanes and the runway, distances to such frontage or connecting roads shall also be shown on the sketch as well as the appropriate elevations. This sketch should be submitted to File D-8 as soon as this information is available.

2A-506 HIGHWAY ILLUMINATION NEAR AIRPORTS

In addition to highway projects within 2.0 miles of an airport, all high level or standard illumination projects that penetrate the Federal Aviation Administration's reporting slopes, specified in paragraph 77.13 of FAA Part 77 Regulations, must be reported prior to the beginning of construction. The necessary data, consisting of execution of FAA Form 7460-1, shall be submitted to File D-8. A layout sketch shall be submitted showing the sites of each illumination tower or pole in relation to the airport runways. A chart shall be included on the sketch showing the ground elevation at each site and the elevation at the top of each pole or tower. Also, the distance from the nearest point on the nearest runway to each pole or tower shall be included in the chart as well as the angular measurement from the appropriate nearest point on the runway to each pole or tower that penetrates the reporting slopes.

2A-507 PROCEDURES FOR SELECTION OF CONSULTING ENGINEERING SERVICES

Selection of consultants should be initiated through the Consultants Review Committee (File D-5) in accordance with current procedures.

AIRPORT — HIGHWAY
CLEARANCE REQUIREMENTS
for
CIVIL AIRPORTS

TYPE OF AIRPORT	NOMINAL RUNWAY LENGTH RANGE	VISUAL OR INSTRUMENT	a	b	SLOPE	c	d	m	v
BASIC UTILITY (Small Single Engine)	2700' to 3700'	VFR IFR	250' 500'	200' 200'	20:1 20:1	5000' 5000'	1250' 2000'	200' 200'	15' or 17' 15' or 17'
GENERAL UTILITY (Large Twins)	3700' to 4700'	VFR IFR	250' 500'	200' 200'	20:1 20:1	5000' 5000'	1250' 2000'	250' 250'	15' or 17' 15' or 17'
BASIC TRANSPORT (Small Business Jets)	4700' to 6500'	VFR IFR	500' 500'*	200' 200'	20:1 34:1	5000' 10000'	1500' 3500'	500' 500'	15' or 17' 15' or 17'
GENERAL TRANSPORT (Large Business Jets)	6000' up	VFR IFR	500' 500'*	200' 200'	20:1 34:1	5000' 10000'	1500' 3500'	500' 500'	15' or 17' 15' or 17'
AIR CARRIER AIRPORTS	5000' up	VFR IFR	500' 500'*	200' 200'	20:1 34:1	5000' 10000'	1500' 3500'	750' 750'	15' or 17' 15' or 17'
PRECISION INSTRUMENT (ILS)	5000' up	IFR	1000'	200'	**	50000'	16000'	750'	15' or 17'

* 1,000' if visibility minimums are 0.75 Mile or lower.

** 50:1 for inner 10,000' and 40:1 for additional 40,000'.

• 4,000' if visibility minimums are 0.75 mile or lower.

NOTES.

1. V.F.R. means Visual Flight Rules
2. I.F.R. means Instrument Flight Rules.
3. "a" - Refers to the width of the primary surface longitudinally centered on the runway.
4. "b" - Refers to the extension of the primary surface beyond the end of the runway or the distance between the end of the runway and beginning of the approach clearance surface. (This distance is 100' for turf or dirt runways)
5. "c" - Refers to the length of the approach area and the approach surface measured horizontally along the extension of the runway centerline beginning at the end of the primary surface.
6. "d" - Refers to the width of the approach area and the approach surface at the maximum length (Distance "c") of the approach area.
7. "m" - Refers to the minimum transverse clearance distance measured from the runway centerline to the building line.
8. "v" - Refers to the minimum vertical clearance between the profile at the highway pavement edge and the approach or transition surfaces.

   v - for non-interstate highways and frontage roads on interstate highways is 15 feet.

   v - for interstate highway main lanes is 17 feet.

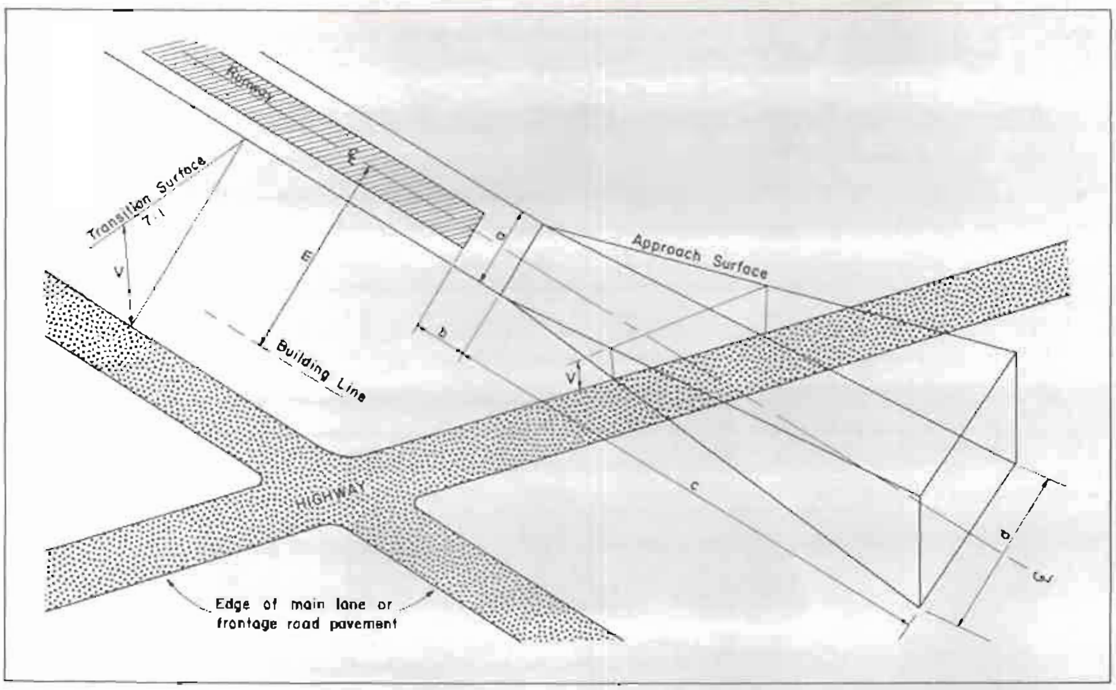


Figure 2A-5

PART II-B

PRELIMINARY PROJECT PLANNING AND DEVELOPMENT

PART II-B

PRELIMINARY PROJECT PLANNING AND DEVELOPMENT

INTERDISCIPLINARY PROJECT PLANNING (2-300)

As outlined in the Texas Action Plan, and in conjunction with legislation and policy directives from both the State and Federal governments (specifically, the Texas Policy for the Environment, 1973, and the National Environmental Policy Act of 1969), the State Department of Highways and Public Transportation uses a systematic, interdisciplinary approach in the development of major projects that may have a significant effect on the environment.

The Highway Design Division (File D-8) has primary staff responsibility for social, economic and environmental matters in the development of highway projects. Qualified professionals in a wide range of disciplines and specialties are available within File D-8 and other Divisions.

2-301 INTERDISCIPLINARY-ENVIRONMENTAL STUDIES

Interdisciplinary-environmental studies should be considered for each project and conducted when appropriate depending on the project's social, economic, environmental and transportation significance. Studies serve as the basis for any required environmental assessments, statements or declarations.

Appropriate environmental studies and documentation should be developed for all projects considered to be major actions. For the criteria to make a major-nonmajor determination, see Section 2-402. Projects which are obvious nonmajor actions need little or no environmental study or documentation.

2-302 HIGHWAY SECTION PROCESSING (LOGICAL TERMINI)

A. For discussion in Social, Economic and Environmental (SEE) Assessments, Negative Environmental Declarations and Environmental Impact Statements, a highway section should be as long as practicable to permit consideration of environmental matters on a broad scope and meaningful evaluation of alternatives. A highway section may include, when appropriate, completed as well as uncompleted portions of the highway and one or more future highway projects. Piece-mealing proposed highway improvements in separate SEE assessments, Negative Environmental Declarations (NED) or Environmental Impact Statements (EIS) should be avoided. The highway section identified in the SEE assessment, NED or EIS should include the total length of highway between logical termini even though only a short length of the total identified highway section is proposed for construction or reconstruction. The SEE assessment, EIS or NED should clearly identify the length or segment of the total highway section that is proposed for improvement and furnish any

FIGURE IIB-1

FLOW CHART SHOWING PROCESS GUIDELINES

FOR PROJECT DEVELOPMENT EMPHASIZING PUBLIC

INVOLVEMENT AND SOCIAL, ECONOMIC

& ENVIRONMENTAL CONSIDERATIONS

is included as the final page in PART II-B.

(Flow Chart is from 1976 Edition of Design Manual.)

available information concerning long-range possibilities for future improvements within the highway section. Environmental effects identified and discussed in the SEE assessment, NED, or EIS should ordinarily be those anticipated to be precipitated by the proposed construction, but should also, as pertinent, include effects associated with the total highway section. For instance, completing a gap in a highway may substantially increase traffic volumes, change traffic patterns or improve access to an area creating a need to include a discussion of effects related to the entire highway section.

B. The flow chart showing process guidelines for project development emphasizing public involvement and social, economic and environmental consideration is presented in Figure IIB-1.

2-303 PUBLICITY OF PROJECT PLANNING AND AVAILABILITY OF INFORMATION TO THE PUBLIC

A. Early and extensive publicity should be considered for all major action types of projects and all nonmajor action types of projects in urban areas. Media releases should be a normal course of action taken at the beginning of project planning.

This early publicity should:

1. Point out the need for the project.

2. Describe the project to the extent possible at such an early stage.

3. Emphasize the beneficial effects anticipated on the project's total area of influence.

4. Extend an invitation to all citizens (particularly those living in the area of influence) to contact the resident or District office where their input will be welcomed. Include the name and address of the District personnel to contact.

5. Emphasize that early input by all of the citizens of the area will make a valuable contribution to the selection of reasonable alternatives for study.

6. Correlate the project with previous systems planning.

At the same time that media press releases are made, it is advisable to also notify those individuals and groups that were involved during systems planning of initiation of project planning. Any individual or groups included on a maintained early notification list should be individually notified that project planning is beginning.

Methods of early publicity (and publicity throughout project development) will vary depending on the area, type of project, significance, etc. Suggested methods include press releases, notices, advertisements, letters to property owners, handbills, posters, bulletin board anouncements, contacts with community leaders, clubs, organizations, schools, churches, etc.

B. During all phases of planning, timely and accurate information must be made available to the public so that their participation will be on the most informed basis possible. Most planning studies result in reports of some kind which should upon completion be made available to the public when requested. As a guide, material should be considered completed if a correlative decision has been made by the appropriate individual at the orgainzational level authorized to make final approval for the Department.

Requests for information should be satisfied as expeditiously as possible and in a manner reassuring to the public that planning activities are open to the public and that the public's early and continuing input is welcomed during systems and project planning.

When environmental documents are approved by the Austin Office and submitted to the FHWA, that is the time under the Texas Open Records Act (House Bill 6) the documents must be considered as completed and made available to any citizen requesting a copy.

SOCIAL, ECONOMIC AND ENVIRONMENTAL (SEE) ASSESSMENTS (2-400)

2-401 PURPOSES AND PROCEDURES

A. Purposes of the SEE assessment are:

1. To provide early assessment of anticipated social, economic and environmental effects;

2. To indicate whether a project is a nonmajor action, or a major action and, if a major action, whether the anticipated social, economic and environmental effects are significant or insignificant; and the type of environmental report appropriate;

3. To serve as documentation for determining whether a Project Concept Conference should be held; and

4. To provide general information relative to the project that may be furnished the interested public and other agencies.

B. As soon as practical after an Investigation and Planning Expense (IPE) Authorization is issued for a project, the District should make an initial assessment of the anticipated social, economic and environmental effects of the project using the criteria set forth in Sections 2-402 and 2-403. The SEE assessment should be prepared using the format in Section 2-404 and submitted to the Austin Office for review and concurrence. The information included in the SEE assessment should be to the extent possible at the initial stage of project planning.

C. The letter transmitting the SEE assessment should indicate the District's recommendations regarding (1) whether a Project Concept Conference should be held; (2) any special coordination and/or permits needed or anticipated; (3) the project's need for a noise report; and (4) the extent of public involvement believed necessary. Submit the original and four copies of the SEE assessment.

2-402 DETERMINATION OF MAJOR AND NONMAJOR ACTIONS

A. A project determined to be a "major" action will require either an Environmental Impact Statement or Negative Environmental Declaration. (The criteria for selecting which will be appropriate is discussed in Section 2-403.) Major actions are those projects of superior, large and considerable importance. Any project that is likely to precipitate significant foreseeable alterations in land use, planned growth, development patterns, traffic volumes, travel patterns, transportation services including public transportation, and natural and man-made resources should be considered a major action. The following are examples of types of projects which are ordinarily considered to be major actions:

1. A new freeway or expressway,

2. A highway which provides new access to an area and is likely to precipitate significant changes in land use or development patterns,

3. A new or reconstructed arterial highway which provides substantially improved access to an area and is likely to precipitate significant changes in land use or development patterns,

   (Note: For those projects which will not provide substantially improved access to an area and will not precipitate significant changes in land use or development patterns, a nonmajor action determination may be appropriate. The SEE assessment should be submitted early enough in project development to assist in the determination of nonmajor action to avoid the possibility of delaying other phases of project development should the project be determined to be a major action.)

4. A new circumferential or belt highway which bypasses a community,

5. A highway which provides new access to areas containing significant amounts of exploitable natural resources,

6. Added interchanges to a completed freeway or expressway which provide new or substantially improved access to an area and are likely to precipitate significant changes in land use or development patterns, and

7. A highway project which requires the taking of land from any publicly-owned land from a public park, recreation area, wildlife and waterfowl refuge, or any land from a historic site.

B. Nonmajor actions do not require environmental impact statements, or negative environmental declarations. A SEE assessment should be prepared for projects which provide for additional through traffic lanes. A SEE assessment should also be prepared covering those types of projects indicated in (1) below. For those types of improvements categorized in (2) below, the majority of the projects will permit the determination of nonmajor action to be deferred until submission of PS&E; however, some modernization projects may involve features which may cause a delay in nonmajor action concurrence at the PS&E stage. Therefore, where there is doubt, nonmajor action concurrence should be obtained by submission of a SEE assessment early enough in project planning to avoid the possibility of delaying other phases of project development should the project be determined to be a major action. For all of the types of projects or actions identified below in (3) through (11), a statement that the proposed improvement is a nonmajor action should be included in the request for FHWA authorization for construction. It will not be necessary to obtain this concurrence of nonmajor action prior to the submission of PS&E unless there is some doubt the project is a nonmajor action.

The following are examples of types of actions which are ordinarily considered to be "nonmajor" actions:

1. Construction of a new rural two-lane highway which does not provide new access to an area and which would not be likely to precipitate significant changes in land use or development patterns;

2. Modernization of an existing highway by resurfacing, widening less than a single lane width, adding shoulders, adding auxiliary lanes for localized purposes (weaving, climbing speed change, etc.), and correcting substandard curves and intersections;

3. Lighting, signing, pavement marking, signalization, freeway surveillance and control systems, and railroad protective devices;

4. Safety projects such as grooving, glare screen, safety barriers, energy attenuators, etc.;

5. Reconstruction of existing crossroad or railroad separations and existing stream crossings;

6. Highway landscaping and rest area projects;

7. Construction of bus shelters and bays;

8. Alterations to existing buildings to provide for noise attenuation and installation of noise barriers;

9. Temporary replacement of a highway facility which is commenced immediately after the occurrence of a natural disaster or catastrophic failure to restore the highway for the health, welfare, and safety of the public;

10. Approval of utility installations along or across a highway or approval of grade separated crossings of highways by railroads or highways; and

11. Highway safety work programs.

2-403 DETERMINATION OF SIGNIFICANCE AND INSIGNIFICANCE

Determination of significance or insignificance of a major action should be made using the following guidelines. The determination of significance or insignificance will be the basis for selecting the type of environmental report required for the project. In evaluating the significance, the changes which may be caused by the action and the importance and scale of those changes are to be considered.

A. The following are examples of types of major actions which ordinarily have a "significant effect on the quality of the human environment," and therefore will require draft and final environmental impact statements:

1. An action that has more than minimal effect on and requires the taking of land from any publicly-owned land from a public park, recreation area, wildlife and waterfowl refuge, or any land from a historic site;

2. An action that is likely to be highly controversial on environmental grounds or with respect to the availibility of adequate relocation housing;

3. An action that is likely to have a significantly adverse impact on natural, ecological, cultural or scenic resources of national, State or local significance;

4. An action that (a) causes significant division or disruption of an established community or disrupts orderly, planned development, or is determined to be significantly inconsistent with plans or goals that have been adopted by the community in which the project is located, as determined by a responsible official(s), or (b) causes a significant increase in traffic congestion; or

5. An action which (a) is determined to be inconsistent with any law or regulation relating to the environment, or (b) has a signficant detrimental impact on air or water quality or on ambient noise levels for adjoining areas, or (c) may contaminate a public water supply system.

B. Draft and final negative environmental declarations should be prepared for those major actions which will not have a significant impact upon the quality of the human environment of a magnitude to require the processing of an EIS.

2-404 FORMAT OF SEE ASSESSMENT

A. Description of Proposed Action and Reasonable Alternatives (comparable to the extent suitable for comparison and to the extent known at the initiation stage of project planning).

1. Project limits, logical termini for study, and character of area (rural, urban, etc.)

2. Project length (new and existing alignment)

3. Right-of-way width and access control (existing and proposed)

4. Type of facility, including:

   a. Number of lanes

   b. General horizontal and vertical alignment

   c. Location of bridges, interchanges, grade separations, at-grade intersections, other structures and features

   d. Current and design ADT

   e. Nature of service which the highway is intended to provide

   f. Anticipated utility adjustments needed

5. Description of surrounding terrain and land use, including surrounding natural and cultural features such as:

   a. Towns, communities, neighborhoods, developed areas, landmarks, institutions, principal roads and highways, and similar features

   b. Lakes and streams

   c. Principle vegetation types, such as pine forest, grassland, etc.

   d. Historical and archeological sites

6. Description of the existing facility including, but not limited to, its condition and deficiencies in meeting present and future traffic demands, and the planning basis of the proposed project (the purpose and need for the proposed project). The relationship between the proposed project and the fulfillment of present and future traffic demands (as indicated by any urban, area-wide, or other transporation studies or plans, and/or by specific recent or planned developments or changes in land use) should be thoroughly discussed in order to show why the project is needed. Note should be made if there is no known plan for development in the area.

7. Items of special nature such as navigation or airway-highway clearances, special permits or agreements

8. Estimated cost of construction, right-of-way utility adjustments and relocation assistance

9. Local governmental and private views and support

10. Include a map showing the section of highway discussed in the SEE assessment. Also show all reasonable alternate routes considered. Other graphic materials should be included when necessary.

B. Discussion of Potential Social, Economic and Environmental Effects of the Proposed Action and Reasonable Alternatives (to the extent applicable at this initiation stage of project development). The effects of the following should be considered:

1. Regional and Community Growth

Discuss any trends for land use change that are present in the area and any general plans that exist for proposed land use. Any anticipated development that may affect total transportation requirements should be specifically addressed indicating the need for the proposed project. The status of how the proposed project fits into any overall development plan should be mentioned. Also, the discussion should include how the proposed project is expected to affect the trend for land use change in the area, as well as the specific use of adjacent properties. This discussion should include the anticipated effects of the proposed project on adjacent property values and the local tax base. The general beneficial economic effects -- both short-term and long-term -- which are expected to accrue to the area should also be discussed.

2. Conservation and Preservation

This includes soil erosion and sedimentation, the general ecology of the area as well as man-made and other natural resources, such as park and recreational facilities, wildlife and waterfowl areas, historic and archeological sites, and natural landmarks. If no Section 4(f) lands are involved, include a statement indicating that the use of land from a publicly owned park, recreation area or wildlife and waterfowl refuge of National, State or local significance is not anticipated.

a. Lakes and Streams

Discuss any anticipated impoundment, diversion, channel deepening, or other modification of a stream or body of water, or any affected navigable waters and associated wetlands. Other anticipated modifications which should be discussed include changes to a stream or lake as the result of bridging or culverting, borrow or fill material in the water or floodplain, or the encroachment into the floodplain. (Refer to Section 2-607.) The District's letter of transmittal should indicate if permits or coordination with other agencies is believed necessary. For example, agencies such as U.S. Coast Guard and U.S. Army Corps of Engineers issue permits which may require early coordination. Other agencies which, as appropriate, should be coordinated early in project planning are the U.S. Fish and Wildlife Service, Texas Parks and Wildlife Department, Texas Department of Water Resources, and others depending upon possible project effects.

b. Historical and Archaeological Sites

The National Register of Historic Places, the Texas Historical Commission's inventory of cultural properties, *Historic Preservation in Texas*, and the *Guide to Official Texas Historical Markers* should be examined to determine if there are any inventoried properties in the project area. The County Chairman of the Texas Historical Commission should also be consulted to determine whether properties in the project area are eligible for inclusion in or are under nomination to the National Register of Historic Places.

(1) If a known archaeological or historical site may be adversely affected by the project, the type and significance of property as well as the nature of effect should be discussed.

(2) If no adverse effect is anticipated, it should be noted in the assessment along with the resource materials examined and the persons and agencies contacted in support of this determination.

(a) If a project is believed to be a nonmajor action and if the project will require additional right-of-way, the District's letter of transmittal should indicate that an archaeological and historical survey will be requested before the PS&E will be prepared. On-site surveys should not be requested before the SEE assessment is submitted to File D-8. Based on the review of the assessment, File D-8 will determine whether a survey is required and will notify the District. Results of the survey will be reported to the State Historic Preservation Officer (SHPO) and his endorsement acquired before the FHWA will approve the PS&E (see Section 2-603).

(b) If a project is believed to be a nonmajor action and if the project will require an insignificant amount of or no additional right-of-way then, in most cases, an on-site survey will not be needed. The District's letter of transmittal should indicate whether an on-site survey is believed necessary. File D-8 will determine whether a survey is warranted after an examination of the SEE assessment and other resource materials. Generally, a survey will not be conducted on projects in an urban area unless there is a possibility that (1) archaeological material may be found, or (2) the project may have an effect on an historic site or on an architecturally prominent structure. Structures with a Texas Historical Commission medallion should be considered eligible for inclusion in the

National Register of Historic Places until positive determination is made to the contrary or until it is determined that they will not be affected by the proposed project. Architecturally prominent structures as well as other historical and archaeological sites within approximately 100 yards of a project should be evaluated for effect. If it is determined that an on-site survey is not required, File D-8 will obtain the concurrence of the SHPO that the project will not have an adverse effect upon historical or archaeological resources known to exist in the area. If a survey is not required, File D-8 will obtain the SHPO endorsement immediately following the review of the SEE assessment. Evidence of coordination with the SHPO will be furnished to the FHWA by File D-8.

(c) If a project is a major action, the archaeological and historical survey should be conducted before preparation of a draft EIS or a draft NED. (Also see Section 2-603.) The SEE assessment should indicate that a survey will be conducted. On-site surveys should not be requested before the SEE assessment is submitted to File D-8.

(d) On-site surveys will be conducted before the submission of the SEE assessment only in those cases where such surveys are necessary to determine whether the project is a major or nonmajor action or whether project effects are significant or insignificant. In cases of such questions, submit a written request to File D-8.

3. Public Facilities and Services including religious, health and educational facilities; and public utilities, fire protection and other emergency services.

4. Community Cohesion, including residential and neighborhood character and stability, highway impacts on minority and other specific groups and interests. Indicate whether the project is likely to divide or disrupt an established community or disrupt orderly planned development or be inconsistent with plans or goals adopted by the community.

5. Displacement of People, Businesses and Farms, including economic activity (employment gains and losses, etc.). Each assessment should indicate the approximate number and ethnic makeup of family units to be displaced, and the number and types of businesses to be relocated. Each assessment should also include (if appropriate) statements regarding the relocation assistance program and services available, and the likelihood of available decent, safe and sanitary replacement housing and business sites during the acquisition stage of project development.

   To insure a complete discussion of Items 4 and 5, refer to Section 2-702, item (D) 5 of this Manual.

6. Air, Noise and Water Pollution, including consistency with approved State Implementation Plan for air pollution control, FHWA noise level standards, and any relevant Federal or State water quality standards.

   a. Refer to the Department's Noise Guidelines. A noise report is required for all projects unless specifically exempted by Federal regulations. The SEE assessment should either contain the "short form" noise analysis, if appropriate, or indicate that a separate noise report will be submitted for approval at some time prior to PS&E submission. If the short form analysis is selected, the SEE assessment should also contain information regarding construction noise and coordination with local officials. Discuss in specific terms the coordination efforts made with the local officials and/or local planning agency. The SEE assessment should indicate that local officials will be furnished copies of the FHWA publication *The Audible Landscape: A Manual for Highway Noise and Land Use,* FHPM 7-7-3, and the noise report for the project.

b. A comparison of the expected CO concentration under worse meteorological conditions at design year with the National Ambient Air Quality Standard should be made and other information furnished as outlined in the Department's Air Quality Guidelines. In this way consistency of the highway project with the State Implementation Plan can be demonstrated.

7. Aesthetic and Other Values, including visual quality, such as "view of the road" and "view from the road," and the joint development and multiple use of space.

C. End the assessment with one of the three following statements as appropriate:

1. This assessment of social, economic, and environmental effects indicates that the proposed project is a nonmajor action; therefore, neither an environmental impact statement nor a negative declaration will be prepared.

2. This assessment of social, economic, and environmental effects indicates that the proposed project is a major action with significant effects; therefore, a draft environmental impact statement will be prepared.

3. This assessment of social, economic, and environmental effects indicates that the proposed project is a major action with insignificant effects; therefore, a draft negative environmental declaration will be prepared.

PROJECT CONCEPT CONFERENCE (2-500)

2-501 PROCEDURES

A. The Project Concept Conference (PCC) is intended to be an informal, working meeting, primarily involving those persons who will be directly involved in the development of the project. Local governmental officials should be invited to attend and participate. If they choose to attend, they should be made aware that the meeting is intended as a Departmental work session. The PCC should not be considered an open meeting for making final decisions and binding commitments about the project or a publicity-type meeting for press coverage.

B. The PCC should be held early in project development for those highway projects which are major actions significantly affecting the quality of the human environment. See Section 2-402 for guidelines for determining whether a project is a major or a nonmajor action; and if a major action, see Section 2-403 for guidelines for determining the significance or insignificance of the social, economic and environmental effects.

2-502 PURPOSES

A. Identify beneficial and detrimental social, economic and environmental effects. It is intended that these effects be considered in broad, general terms, and since studies have not been conducted at this point, the effects identified are only potential.

B. Determine the fields of specialization which may be needed to provide interdisciplinary input during project planning, including a determination of what assistance from other agencies may be necessary. The Project staff should be established during the PCC with the realization that the staff can subsequently be modified during development of the project.

C. Evaluate existing data bases to determine the types of study and analysis needed. The District, insofar as possible, should gather existing data and have it available before the PCC. Examples of data which might be gathered prior to the PCC include: (1) route maps; (2) photographs; (3) census data or transportation study information on population, land use, economics; (4) travel and traffic information and forecasts; (5) approved long-range plans; (6) materials related to historic or archaeological sites; (7) study techniques and methodologies; and (8) other related data.

D. Make preliminary investigations of the most likely alternatives, including the "no-build" alternative. Alternatives refer to modes of transportation as well as to location and general types of facilities.

E. Make preliminary determination of the extent of public involvement needed, including identification of special interest groups. The District Environmental Coordinator and the Resident Engineer should make some identification of the "publics" (groups, individuals [including minorities] and institutions within the community) affected by, or interested in, the project before the PCC. Some determination of the extent of public involvement required can then be determined.

F. Evaluate the relationship of the proposed project to the community, regional and State goals as set forth by adopted or proposed planning efforts. Local officials, if present, should be encouraged to discuss how a project will affect a community. Goals and objectives previously adopted from existing transportation plans, city plans, county plans or other studies should be examined to determine if the proposed project is consistent with these prior plans.

G. Prepare a PCC Report that reflects the decisions made and the expected course of project development. Following the PCC, the District Environmental Coordinator should prepare a report containing brief, annotated minutes basically outlining what occurred at the conference. The report should also contain (1) a general description of the project; (2) a sketch map; (3) a discussion of interdisciplinary studies to be performed; (4) the composition of the Project staff; (5) identification of the most likely alternatives; (6) the tentative plans for public involvement; (7) a review of the relationship of the project to existing systems plans; and (8) a preliminary determination of the significant social, economic and environmental effects. Expand the SEE assessment, or else attach SEE assessment if no new information is presented at project concept conference.

The PCC report is the basis for project publicity and solicitation of views from local, State and Federal governmental agencies, including A-95 Clearinghouse, and interested individuals and private groups. This procedure is initiated at both the District and Austin Office by the District Public Affairs Officer and the Division Environmental Coordinator. Those individuals and groups interested in the initiation of project development may request notification. If special coordination with other State or Federal agencies such as Fish and Wildlife Service, Corps of Engineers, Department of Water Resources, or State Historic Preservation Officer will be required or is believed necessary, the District should so indicate in the letter of transmittal.

H. Prepare the Project History and Status (PHAST) file to reflect the degree of planning required. File D-8 will create an entry on the PHAST system as soon as an IPE is issued for each proposed project.

COORDINATION WITH OTHER AGENCIES (2-600)

Other governmental agencies are involved in project development through the mutual exchange of information relative to concerns involving both agencies, appropriate cooperative solution of mutual problems, and establishment of a formal review process at optimum intervals. Relationships with some governmental agencies having jurisdictional interests or special expertise have been formalized by cooperative agreements or memoranda of understanding. Other interested governmental agencies are provided opportunities for information exchange and review through the Department's notification and solicitation of views process, and through the ciruculation of draft environmental impact statements for review and comments.

2-601 LOCAL GOVERNMENTAL AGENCIES

During early stages of project development, any necessary agreements with local governmental agencies, water or reservior districts, should be negotiated at the direction of the State Highway and Public Transportation Commission by approved Minute Order. Throughout project development, the local governmental agencies and local elected officials should continually be apprised of the status of project planning. Prior to a public hearing process, copies of maps and design drawings should be filed with the County and/or city.

2-602 COUNCILS OF GOVERNMENTS - Metroplitan and Regional Clearinghouses.

A. Section 204 of the Demonstration Cities and Metroplitan Development Act of 1966 and Title IV of the Intergovernmental Cooperation Act of 1968 as interpreted by Bureau of the Budget Circular A-95 require cooperation between State, Federal and local governments in the evaluation, review and coordination of Federal assistance programs and projects. The project notification and review system (PNRS) procedures should be followed for all projects except those exempted by agreement.

B. The District Engineer will be responsible for notification of the appropriate clearinghouse Council of Government (COG) for all projects within the District.

C. The project data submitted to the clearinghouse should generally include the following: a map showing the project location and a brief description of the proposed project by type, number of lanes, right-of-way width and estimated cost. It should include a statement of whether or not an environmental statement or negative declaration is required and, if so, an indication of the nature and extent of environmental impacts anticipated.

D. Notification of the Department's intent to develop a project should be made at the earliest possible date. The PNRS process should take place prior to the determination of environmental significance as soon as a project appears on an approved right-of-way or construction program, is authorized by a Commission Minute Order, or is approved for advanced planning by the State Engineer-Director. Copies of all correspondence should be made a part of the appropriate project file and should be submitted as documentation as needed. Draft environmental statements when circulated for review are to be accompanied by comments made by clearinghouses. Actual copies of any correspondence supplied by the clearinghouse should be a part of the draft environmental statement. For draft negative environmental declarations, a discussion of the clearinghouse's views obtained by the PNRS process should be included. After a draft EIS is adopted by the FHWA, copies should be furnished to the clearinghouse for review and comments.

2-603 STATE HISTORIC PRESERVATION OFFICER - Texas Historical Commission and the Advisory Council on Historic Preservation

A. The Department and the Texas Antiquities Committee are parties to a Memorandum of Understanding assuring cooperation and mutual exchange of information where projects affect sites of archaeological and/or historical significance. Historical and archaeological surveys and exploratory test excavations are conducted as needed.

B. The National Historic Preservation Act of 1966 created the Advisory Council on Historic Preservation. The State Historic Preservation Officer (SHPO) acts as liaison for the purpose of implementing the National Historic Preservation Act. Evidence of coordination with the SHPO is required on all projects (except the obvious nonmajor actions listed in Section 2-402B (3) through (11) of the Design Manual). According to the Advisory Council on Historic Preservation guidelines, only the SHPO can determine if a site, either already on the National Register of Historic Places or eligible for addition to the Register, will be affected by a proposed project.

C. A Departmental staff archaeologist should conduct an on-site survey for archaeological as well as historic sites. The survey results are reported to the SHPO. Surveys should be conducted for most types of highway improvements. Archaeological and historic site surveys and investigations will be conducted by staff archaeologists upon written request by the District. Types of nonmajor action projects listed in Section 2-402B (3) through (11) do not need evidence of coordination with the SHPO.

D. If the project is believed to be a nonmajor action, i.e., one of the types listed in Section 2-402B (1) and (2), and if the project is in an urban area where an insignificant amount or no additional right-of-way is needed then, in most cases, an on-site survey will not be required. The District's letter transmitting the SEE assessment should indicate whether an on-site survey is believed necessary. File D-8 will determine whether a survey is warranted after examination of the SEE assessment and other resource material. Generally, a survey will not be conducted on projects in an urban area unless there is a possibility that (1) archaeological material may be found; or (2) the project may have an effect on an historic site or on an architecturally prominent structure. Structures with a Texas Historical Commission medallion should be considered eligible for inclusion in the National Register of Historic Places until positive determination is made to the contrary or until it is determined that they will not be affected by the proposed project. Architecturally prominent structures as well as other historical and archaeological sites within approximately 100 yards of a project will be evaluated for effect.

If it is determined that an on-site survey is not required, File D-8 will obtain the concurrence of the SHPO that the project will not have an adverse effect upon historical or archaeological resources known to exist in the area. Evidence of coordination with the SHPO will be funished to the FHWA by File D-8.

E. An archaeological and historical site survey should be conducted on all projects except those exempted by paragraphs C and D above. After the SEE assessment is submitted to the Austin Office, it will be reviewed to determine whether a survey is required. As soon as right-of-way requirements are reasonably known, written request should be submitted by the District to File D-8 for an on-site survey by staff archaeologists. Following the survey, File D-8 will prepare a letter to the SHPO providing notification of the results of the survey and requesting endorsement that no sites on the National Register of Historic Places or sites eligible for addition to the Register are affected. An endorsed copy of that letter will be returned by the SHPO and will be transmitted to the District to be included in a draft NED or draft EIS. If the project is a nonmajor action, File D-8 will send a copy of the endorsed letter to the FHWA to obtain the removal of the qualified endorsement of the SEE assessment.

F. The Department's archaeological survey responsibility covers the area within the proposed right-of-way as well as all properties affected by easements, material sources, and waste sites under option to the Department. This includes additional right-of-way, and existing right-of-way not previously disturbed by highway construction but where construction is planned. The Department's historical survey interest extends outside the proposed right-of-way. Architecturally prominent structures as well as other historical and archaeological sites within approximately 100 yards of a project will be evaluated for effect. A survey must be conducted on all such property by a staff archaeologist before construction on State-funded projects and before environmental clearance by the FHWA on Federal projects. Under certain circumstances, particularly in urban areas, previous construction and/or land use may exempt a project from a survey. In all cases where there is doubt whether a survey should be conducted, the District should check with File D-8.

G. The Advisory Council on Historic Preservation has promulgated Procedures for the Protection of Historic and Cultural Properties pursuant to the National Historic Preservation Act of 1966. These procedures apply to all projects which could affect a property which is included or eligible for inclusion in the National Register of Historic Places.

H. The National Register is constantly being enlarged by the addition of new entries. File D-8 furnishes each District a complete cumulative listing of the National Register each year and interim additions, changes, or deletions. The Advisory Council procedures require the Department, the FHWA, and the SHPO to apply the National Register criteria to all possible historic sites within the project's area of effect at the earliest planning stage. Potential entries should be identified before preparation of the draft EIS.

I. If the Department, FHWA or SHPO determines that it is questionable whether a property meets the National Register criteria, the Department through the FHWA will request, in writing, an opinion from the Secretary of the Interior, Attention: The Keeper of the National Register, National Park Service, Washington, D.C. 20240, with respect to the property's eligibility for inclusion in the National Register. If the Secretary declares the property eligible, it will be assumed that it will be named to the Register.

J. File D-8 initiates coordination with the FHWA, SHPO, DOI, the Advisory Council on Historic Preservation, and others as needed whenever a project affects a property which is included or eligible for inclusion in the National Register. Therefore, Districts should advise File D-8 of possible effects on historic sites as early as possible in project planning. The coordination should be completed before environmental statements or negative declarations are prepared.

2-604 TEXAS AIR CONTROL BOARD

A. The Texas Air Control Board (TACB) is responsible for maintaining the quality of the State's air resources. The consistency of the Air Quality Report with the Texas Air Control Board's State Implementation Plan as currently approved is the determining factor for acceptances of the air quality study in regard to environmental clearance of a project considered to be a major action with significant effects.

B. Various levels of air quality analysis depend on the degree of project complexity. These various levels and required data are described in the Department's Air Quality Guidelines.

C. The studies and coordination activities related to construction or reconstruction projects shall include appropriate consideration of air quality. The level of this consideration and the air quality analysis is determined on the basis of project type and location, the anticipated traffic volume, existing air quality problems, sensitivity of nearby receptors to air pollution, and meteorological conditions. It is anticipated that lower volume facilities in areas without critical air quality problems can be satisfactorily analyzed using simplified analysis techniques and that on-site measurements will not be required. High volume facilities in areas with critical air quality problems will usually require on-site data gathering and a high level of analysis.

D. Air quality reports should be prepared early in project planning and coordinated through File D-8 with the Texas Air Control Board prior to the preparation and submission of a draft EIS, if required. TACB's comments regarding the air quality report should always be included in the draft EIS.

E. If the project will require a negative environmental declaration, an air quality report need not be submitted for coordination with TACB prior to the submission of the draft negative environmental declaration to File D-8. However, thorough and adequate consideration of air quality must be contained in all draft and final negative environmental declarations.

F. All negative declarations and environmental statements should reflect compliance with TACB's Regulation 1, Rule 101, when appropriate. Regulation 1, "Control of Air Pollution from Smoke, Visible Emissions and Particulate Matter," Rule 101 allows burning of debris under specified conditions.

2-605 TEXAS NATURAL RESOURCES COUNCIL

Draft environmental statements are circulated to members of the Natural Resources Council (NRC). A listing of Council members is shown in Figure IIB-2.

Agency Members

Texas Natural Resources Council

Governor

Texas Air Control Boards

Texas Industrial Commission

Texas Parks and Wildlife Department

Texas Railroad Commission

Texas State Soil and Water Conservation Board

State Department of Highways and Public Transportation

Texas Department of Water Resources

University of Texas System

General Land Office

Texas A & M University System

Texas Department of Agriculture

Texas Department of Health Resources

Texas Historical Commission

FIGURE IIB-2

2-606 TEXAS PARKS AND WILDLIFE DEPARTMENT

The Memorandum of Understanding with TP & WL provides for the submission of Departmental programs for early coordination. Coordination also is initiated under the provisions of the Fish and Wildlife Coordination Act for certain types of activities. See Section 2-607.

2-607 U.S. FISH AND WILDLIFE SERVICE OF THE DEPARTMENT OF THE INTERIOR

A. The Fish and Wildlife Coordination Act (FWCA) requires that the views of the Fish and Wildlife Service of the Department of the Interior and the State agency responsible for fish and wildlife (Texas Parks and Wildlife Department) be obtained whenever a highway project involves impoundment, diversion, channel deepening, or other modification of a stream or body of water. The FWCA is applicable to those highway projects affecting water resources and their dependent contiguous environment (bottomlands, marshes, swamps) and causing ecosystem changes to the detriment of fish and wildlife.

B. Navigable waters are a special case of the FWCA which require both a review by the Fish and Wildlife Service and a permit from the Corps of Engineers.

C. Other modifications such as changes to a stream or lake as a result of bridging or culverting, borrowing of material from the water or floodplain, and encroachment into the floodplain are initially evaluated by the staff ecologist to determine possible adverse ecosystem changes. Coordination on these types of modifications should be carried out when adverse ecosystem changes are anticipated, or when there is doubt as to project effects.

D. In the early planning stages of a highway project, prior to the preparation of the SEE assessment, the District should, if in doubt, consult with the Bridge Division (File D-5) to determine if navigable waters or associated coastal wetlands are involved. File D-5 will notify File D-8 and the District of its findings.

E. Generally, the type of data which should be included in a SEE assessment when fish and wildlife coordination is required includes: (1) location and type of structure involved; (2) a description of the proposed work to include changes that will be made to the water resource and an estimate of the volume of material that will be involved; (3) stream or lake stabilization measures at the bank or in the water itself; (4) any mitigation features that have been decided upon; and (5) a description of anticipated hydraulic changes.

F. File D-8 will be responsible for contact with the Fish and Wildlife Service and the Texas Parks and Wildlife Department. Coordination with the Fish and Wildlife Service, TP & W Department and/or the Corps of Engineers should be documented in the draft environmental statement or the draft negative environmental declaration.

2-608 TEXAS DEPARTMENT OF WATER RESOURCES

For projects requiring draft EIS, the Austin Office will coordinate with TDWR based on the effects described in the SEE assessment.

ENVIRONMENTAL STATEMENTS AND DECLARATIONS (2-700)

A. A project determined to be a "major" action (See Section 2-402) will require either an Environmental Impact Statement (EIS) or a Negative Environmental Declaration (NED). The criteria for selecting the type of environmental statement or declaration is discussed in Section 2-403.

B. Concurrence by the Austin Office in the project's SEE assessment should be obtained before proceeding with either a draft EIS or a draft NED.

C. The NED or EIS (and if required, Section 4(f) statement and historic preservation processing) should be completed during the location stage, prior to the selection of a particular location; except for those "instream" highway projects which have received location approval prior to the requirements for environmental reports.

D. When a public hearing process is required, the draft NED or draft EIS should be prepared and submitted to the Austin Office for concurrence (and circulation of draft EIS) prior to the publication of the initial public hearing process notice. After the public hearing process, the NED or EIS should be finalized and submitted to the Austin Office.

2-701 PROCESSING OF DRAFT AND FINAL NEGATIVE ENVIRONMENTAL DECLARATIONS

A. A draft NED should be prepared by the District for each major action when the studies and coordination demonstrate that implementing the proposed action will not have a significant impact upon the quality of the human environment of a magnitude to require the processing of an EIS. Concurrence by the Austin Office in the SEE assessment should always be received before proceeding with a draft NED.

B. A draft NED is a written document which records the determination that implementing the proposed action will not have a significant effect upon the quality of the human environment. See Section 2-702 for the format and content for negative environmental declarations.

C. The draft NED should be submitted to the Austin Office for review and concurrence and handling prior to scheduling a public hearing process if one is required. The original and four complete copies should be submitted. All pages, including exhibits, maps, etc., should be numbered consecutively.

D. For those projects which may utilize Federal funds, the draft NED will be submitted to the FHWA by the Austin Office for FHWA's review and adoption.

E. A draft NED does not need to be circulated for comment, but its public availability should be included in the notice of the public hearing or opportunity for public hearing.

F. When a public hearing notice is not required, the District Office should place a notice in local newspaper(s), similar to a public hearing notice, and at a similar stage of development, advising the public of the availability of the draft NED and where to obtain information concerning the undertaking, and that any written comments should be furnished to the Department within 30 days of the notice in the newspapers. See Figure IIB-3 for a suggested notice format. When the publication of the notice of availability is necessary, the final NED should not be submitted to the Austin Office until after the 30-day public comment period has expired. Also, the date of publication of the notice should be included in the letter transmitting the final NED to the Austin Office.

NOTICE OF AVAILABILITY OF ENVIRONMENTAL STATEMENT

The State Department of Highways and Public Transportation has prepared a (draft environmental impact statement) or (draft negative environmental declaration) covering the proposed (improvement) or (construction) of ______highway and limits______ in ______County.

The (draft environmental impact statement) or (draft negative environmental declaration) may be inspected and reviewed at the ______office______address______.

Copies may be obtained for the cost of actual reproduction. Comments should be sent to the above address within 30 days of the date of this notice.

FIGURE IIB-3

G. The final NED should include a summary and disposition of the public hearing comments and/or any other comments received on the social, economic, environmental, and other effects of the proposed action, including alternatives raised at the public hearing, or when the notice of availability was published.

H. The final NED should be submitted to the Austin Office for review, concurrence and handling. Submit the original and four complete copies. All pages should be numbered consecutively (including exhibits, maps, etc.).

I. For those projects which may utilize Federal funds, the final NED will be submitted to the FHWA by the Austin Office for FHWA's review and adoption.

J. A draft EIS should be prepared and processed in lieu of a NED if significant impacts are identified prior to finalizing the NED or at any subsequent time. It is not necessary in such instances to hold a public hearing for the sole purpose of presenting the draft EIS. Circulation of the draft EIS affords the public and governmental agencies an opportunity to express their views on the anticipated environmental impacts should the proposed action be implemented.

K. The NED should be reevaluated by the Department periodically for the purpose of determining whether there has been a substantial change in the social, economic and environmental effects of the proposed action prior to proceeding with major project activities. If there are substantial changes in the proposed action that will significantly affect the quality of the human environment, draft and final EIS's should be prepared and processed.

2-702 FORMAT AND CONTENT OF NEGATIVE ENVIRONMENTAL DECLARATION (DRAFT AND FINAL)

A. Title Page

Each NED (draft or final) should have a title page as shown in Figure IIB-4. The signature line should be included only on the final NED.

____

(Route, Termini, County, City, etc.)

DRAFT (FINAL)
NEGATIVE ENVIRONMENTAL DECLARATION

U.S. DEPARTMENT OF TRANSPORTATION

FEDERAL HIGHWAY ADMINISTRATION

AND

TEXAS DEPARTMENT OF HIGHWAYS

AND

PUBLIC TRANSPORTATION

______________________ ______________________

Date FEDERAL HIGHWAY ADMINISTRATION

FIGURE IIB-4

B. Description of Proposed Action and Reasonable Alternative, and the Social, Economic and Environmental Context of the Area

This section should describe in comparable detail the proposed and recommended location and design and any feasible alternatives considered. Briefly describe the social, economic and environmental setting for the area prior to any proposed action. The significant differences and the reasons supporting the proposed location and design should be discussed. If only one location and/or design is considered, specific reasons should be given why alternatives were not studied. Always discuss the "do-nothing" alternative.

1. Project limits, logical termini for study and character of area (rural, urban, etc.)

2. Project length (new and existing alignment)

3. Right-of-way width and access control (existing and proposed)

4. Type of facility, including:

   a. Number of lanes

b. General horizontal and vertical alignment

c. Location of bridges, interchanges, grade separations, at-grade intersections, other structures and features

d. Current and design ADT

e. Nature of service which the highway is intended to provide

f. Anticipated utility adjustments needed

5. Description of surrounding terrain and land use, including surrounding natural cultural features such as:

   a. Natural environment-topography, terrain, geology, soils, meteorology, climatology, hydrology, vegetation, fish, wildlife and visual

   b. Social environment-land tenure, population, growth characteristics, racial and ethnic composition, housing, transportation facilities including principal roads, streets and highways, recreation, cultural aspects, public institutions, aesthetics, community facilities and services

   c. Economic setting-land and improvements, tax base, income, labor force, business, industry and services

6. Description of existing facility, its condition and deficiencies, and the planning basis for the proposed project

7. Items of special nature such as navigation or airway-highway clearances, special permits or agreements

8. Estimated cost of construction, right-of-way, utility adjustments and relocation assistance

9. Local governmental support and citizen views. Include a discussion of views received as the result of PNRS (Council of Governments), and any other views received and/or known as the result of earlier coordination, public meeting, etc. The final NED should include a summary and disposition of comments and views expressed at the public hearing process, including alternatives raised at the public hearing, or as the result of the notice of availability. Feasible alternatives raised by agencies, persons or groups outside the Department should be discussed in comparable detail in the NED.

10. Maps, typical sections, and other attachments.

    a. The recommended location and any alternate locations considered should be clearly shown on an attached map. This map (and other attachments) may be attached at end of NED. The map must be of sufficient scale to show necessary details and pertinent features such as parks, hospitals, schools, etc., mentioned in the declaration. The map should also identify principal roads and highways in the area and any other pertinent features. Symbols should be used instead of colors on the map. Maps should be limited to 8½ x 11-inch size as much as possible. If necessary, a strip map no wider than 11 inches may be used if folded in accordion fashion to unfold from the right-hand margin. If cronaflexes are submitted, do not fold them.

b. A typical section should be attached for the recommended design showing all pertinent features within the right-of-way, omitting structural details.

c. Other drawings, sketches, etc., may be attached as necessary.

C. Purpose and Need for the Proposed Project

This section should explain why the proposed project is needed and the relationship of the proposed project to any urban, area-wide or other transportation studies or plans. Note should be made if there is no known plan of development for the area. Include reasons why a highway project is proposed rather than another mode. Discuss regional and community growth including general plans and proposed land use, total transportation requirements, and status of the planning process.

D. Discussion of Social, Economic and Environmental Impacts of the Proposed Action and Alternatives, and the Basis for Negative Environmental Declarations

This section of the NED should describe the beneficial and detrimental environmental impacts anticipated if the proposed project is implemented. (If there are significant detrimental impacts identified, a draft EIS should be prepared and circulated.) Topics to be investigated and the depth of investigation and discussion will vary with the nature, scale and geographic area. Summarize any studies used as sources and any studies undertaken. Include enough data or cross-referencing to determine validity of the study methodology.

Discuss reasons why the social, economic and environmental effects are not considered significant, and reasons why a negative environmental declaration is appropriate for the proposed action.

Discuss the anticipated effects of the proposal and the alternatives under consideration on the following:

1. Regional and Community Growth

Discuss any trends for land use change that are present in the area and any general plans that exist for proposed land use. Any anticipated development that may affect total transporation requirments should be specifically addressed indicating the need for the proposed project. The status of how the proposed project fits into any overall development plan should be mentioned. Also, the discussion should include how the proposed project is expected to affect the trend for land use change in the area, as well as the specific use of adjacent properties. This discussion should include the anticipated effects of the proposed project on adjacent property values and the local tax base. The general beneficial economic effects -- both short-term and long-term -- which are expected to accrue to the area should also be discussed.

2. Conservation and Preservation

This includes soil erosion and sedimentation, the general ecology of the area as well as man-made and other natural resources, such as park and recreational facilities, wildlife and waterfowl areas, historic and archaeological sites, and natural landmarks. If no Section 4(f) lands are involved, include a statement indicating that the use of land from a publicly-owned park, recreation area or wildlife and waterfowl refuge of National, State or local significance is not anticipated.

a. General Ecology

The general vegetation types and their associated wildlife species should be mentioned. The effects of the project upon these and any known endangered species should be noted.

b. Lakes and Streams

Discuss any anticipated impoundment, diversion, channel deepening, or other modification of a stream or body of water, or any affected navigable waters and associated wetlands. Other anticipated modifications which should be discussed include changes to a stream or lake as the result of bridging or culverting, borrowing of material from the water or floodplain, or the encroachment into the floodplain (refer to Section 2-607). Discuss any permits, agreements and/or coordination with other agencies which have been initiated, completed, or are needed. Other agencies which might be involved are U.S. Coast Guard, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, Texas Parks and Wildlife Department, Texas Department of Water Resources and others.

c. Historical and Archaeological Sites

The National Register of Historic Places, the Texas Historical Commission's inventory of cultural properties *Historic Preservation in Texas*, and the *Guide to Official Texas Historical Markers* should be examined to determine if there are any inventoried properties in the project area. The County Chairman of the Texas Historical Commission should also be consulted to determine whether properties in the project area are eligible for inclusion in or are under nomination to the National Register of Historic Places.

(1) If a known archaeological or historical site may be adversely affected by the project, the type and significance of property as well as the nature of effect should be discussed. In many cases, an adverse effect on an archaeological or historical site will require an EIS and possibly a Section 4(f) determination and/or a determination of significance (see Sections 2-603 and 2-705).

(2) If no adverse effect is anticipated, it should be noted in the NED along with the resource materials examined, and the persons and agencies contacted in support of the determination. Evidence of coordination with the State Historic Preservation Officer in the form of an endorsed letter should be attached to the Negative Environmental Declaration and discussed in this section of the negative declaration.

3. Public Facilities and Services including religious, health and educational facilities, and public utilities, fire protection and other emergency services. Also the provision of national defense.

4. Community Cohesion including residential and neighborhood character and stability, highway impacts on minority and other specific groups and interests.

5. Relocation of Individuals and Families Impacts

   Discuss the following information for each alternate studied. This information can be obtained by a visual inspection and supplemented by other readily available data such as U.S. census, housing surveys, city and regional planning agencies and local or State housing authorities. To insure compliance with Title VI of the Civil Rights Act, refer to the guidelines in Figure IIB-5.

   a. Estimate of households to be displaced, including the family characteristics (e.g., minorities, income levels, tenure, the elderly, large families, single or multi-dwelling).

   b. Divisive or disruptive effect on the community, such as separation of residences from community facilities or separation of neighborhoods.

   c. Impact on the neighborhood and housing where relocation is likely to take place (e.g., what effects will relocation have on community and public services such as schools, police, water, sewer, etc.). Secondary impacts.

   d. Estimate of the number of businesses, non-profit orgainzations and farms to be displaced.

   e. General effect of business, non-profit organizations and farm displacements on the economy of the community, including effect on minority ownership and minority employment. Secondary impacts.

   f. Description of replacement housing in the area.

   g. General location and quality of replacement housing.

   h. Ability to provide adequate replacement housing for the types of families to be displaced. Discuss Departmental policy that: (1) No person shall be displaced by the Department's construction projects unless and until adequate replacement housing has already been provided for or is in place and has been made available to all affected persons. (2) Replacement housing must be offered to all affected persons regardless of their race, color, religion, sex or national origin. (3) All replacement housing must be fair housing, open to all persons regardless of race, color, religion, sex or national origin.

   i. Description of special relocation advisory services that will be necessary for identifying unusual conditions.

   j. Description of the actions proposed to remedy insufficient relocation housing including, if necessary, housing of last resort.

GUIDELINES

for

FHWA TITLE VI COMPLIANCE REVIEW

B. ENVIRONMENT & DESIGN

I. Location Selection and Design

The Department, as normal practice, should compile and consider the following type of information when selecting a highway location. Maps and other display techniques can be utilized.

a. The major racial populations that will be affected by each alternate. This includes those contiguous to the location alternate(s).

b. The character of minority area(s) affected by each alternate, including levels of income, single or multi-dwelling, residential or commercial, etc.

c. Estimated number of minority businesses and individuals by race employed at these businesses to be affected by each alternate.

d. Effect of each alternate on and access to community services and facilities in minority area(s) including hospitals, libraries, shopping areas, fire and police protection, schools, churches, parks, recreation centers, etc.

e. Effect of each alternate on existing and/or planned residential and commercial areas.

f. Will alternates affect local minority community and/or neighborhood planning goals and needs?

g. Effect of each alternate on existing streets, roads, and traffic volumes in minority area(s).

h. Provide proper access to and exit from minority area(s) for each proposed alternate.

i. Has the general location and quantity of replacement housing been identified?

j. Effect of cross streets, pedestrian crossings with consideration of adequate safety and design features for minority area(s).

FIGURE IIB-5 (continued)

II. Public Involvement

a. Opportunities should be provided for minority groups and individuals to participate in an open exchange of views (meetings, forums, councils, task forces, citizen advisory groups and committees, etc.)

b. Local minority leaders, (elected officials, ministers, businessmen, spokesmen, etc.), groups and individuals who are affected or who have an interest should be identified, notified and encouraged to participate in project development.

c. Special efforts should be made to overcome language barriers.

III. Public Hearings

a. The hearing should be held at a convenient time and place for minority groups and individuals.

b. The hearing must be held before the Department is committed to any alternative.

c. Public notification of hearings to inform minority groups and individuals of hearing opportunities should be by means convenient to minority area(s), as radio stations, newspapers, posters, letters to affected property owners, etc.

d. Arrangements should be made for responsible highway officials to be present at hearings to respond to questions and problems that may arise.

e. Special effort should be made to overcome language barriers.

IV. Consultant Contracts

a. Does the Department have procedures for identifying, contracting and involving minority consultant firms in the normal contract selection process?

b. If the Department maintains a list of acceptable consultant firms, are minority consultant firms included in the list? How many minority consultant firms have active contracts?

c. When sub-contractors are utilized, does the consultant contractor have procedures to identify, contact, and involve minority firms in the sub-contract selection process?

V. General

Has the Department received any civil rights complaints in this program area? If so, what corrective action has the State taken?

FIGURE IIB-5

k. Results of consultation with local officials, social agencies and community groups regarding the impacts on the community affected.

6. Social Impacts

Discuss the significant social impacts anticipated to be caused by the proposed project and alternatives. Discuss changes (beneficial or adverse) in life style for the neighborhoods and/or various groups. These impacts may include splitting the neighborhood, isolating a portion of a distinct ethnic group, new development, etc. If the proposed action will change travel patterns, such as vehicular, commuter or pedestrian, identify the impact. Discuss temporary impacts due to construction activities. The following are examples of groups or individuals who may have special problems and may require special consideration with respect to access to jobs, schools, churches, parks, recreation areas, hospitals, shopping facilities, and community services:

a. Elderly
b. School-age children
c. Those dependent upon public transportation
d. Handicapped
e. Illiterate
f. Nondrivers
g. Pedestrians
h. Bicyclists
i. Low income
j. Racial, ethnic, or religious groups.

Refer to Figure IIB-5 for Guidelines for FHWA Title VI Compliance Review on Environment and Design.

7. Air, Noise and Water Quality including consistency with the approved State Implementation Plan for air pollution control, the FHWA noise level standards and any relevant Federal or State water quality standards.

a. Noise Impacts (Refer to the Department's Noise Guidelines for details of preparing the noise report.)

A noise report is required for each project unless specifically exempted by Federal regulations. The noise report should be summarized in the NED and attached to the NED as an appendix. The primary purpose for preparing a noise report is to determine the change in the noise atmosphere for the immediate area as a result of a highway-related improvement, to explain the nature and extent of this change in layman's terms, and to make every reasonable effort possible to keep the change from unduly disrupting the activities and habits of those who will be affected by an increase in the ambient noise level. The noise report should include a discussion of the following for each alternate location and/or design:

(1) Information on the numbers and types of activities which may be affected (identification of sound sensitive areas)

(2) Ambient (existing) noise levels

(3) Design year noise levels and a comparison of the ambient levels to the design levels

(4) An indication of whether the projected levels exceed FHWA standards

(5) Traffic data on which calculations are based (current and design year traffic volumes)

(6) Extent of the impact (in decibels) and an explanation of the nature and extent of the change in the noise for the immediate area in layman's terms

(7) Likelihood that noise abatement measures can reduce the noise impacts if the FHWA standards are exceeded and/or if there is a great difference between the ambient and the calculated design year levels

(8) Noise abatement measures which will likely be incorporated in the project. Abatement measures to be discussed should include barriers, elevated or depressed roadways, rerouting truck traffic, purchase of noise buffer zones, etc. Briefly discuss the feasibility, economic justification, driver safety, aesthetics, etc., for the abatement measures.

(a) In the draft NED, any viewpoint of property owners regarding abatement measures should be avoided.

(b) In the final NED, it would be proper to indicate property owners' views since the final NED will follow the public hearing process which presumably included a full discussion with affected property owners where abatement measures are considered feasible and effective.

(9) Coordination to control future noise-sensitive land development adjacent to the highway. Discuss in specific terms the coordination efforts made with the local officials and/or planning agency. Local officials should be furnished copies of the FHWA publication *The Audible Landscape: A Manual for Highway Noise and Land Use*, FHPM 7-7-3 and the noise report for the project.

(10) Construction noise and possible mitigation

(11) Noise problems for which no apparent solution is available, i.e., an exception may be required as indicated in the FHWA standards. If the FHWA DNL standards will be exceeded, this section of the NED should provide a summary of the factual information that the design noise levels will be exceeded. However, this section of the NED should not make any statement that an exception may be required. If an exception is required for a project or if FHWA standards are exceeded, the noise report must be a separate docu-

ment. If an exception will be required or if FHWA standards will be exceeded, the NED should include a summary of the conclusions reached in the noise report and should make reference to the complete noise report. If an exception will be required or if standards will be exceeded, four additional separate copies of the noise report should be submitted when the final NED is submitted. The four additional copies of the noise report supporting the request for an exception or explaining that standards will be exceeded will be used for separate handling and submission to the FHWA. Exceptions may be granted by the FHWA and standards being exceeded will be allowed to exist only after the noise report has demonstrated that noise abatement measures are either not possible or not feasible.

b. Air Quality

Air quality considerations involved in the development of the project should be discussed for the appropriate level as indicated in the Department's Air Quality Guidelines. Various levels of air quality analysis will be necessary depending on the location and degree of complexity of the project. A separate air quality report is not required for NED-type projects nor do NED-type projects normally need to be coordinated with the Texas Air Control Board (TACB). This section of the NED should include a discussion of the conclusions of the air quality analysis. In addition, items such as traffic projections, topography and land use (both existing and anticipated) should be included in the NED. Items which need special attention and are more fully described in the Air Quality Guidelines include:

(1) Ambient air quality data, including point sources.

(2) Computations for carbon monoxide concentration to be based on worst case meteorology. Include at least one sample of calculations. Also for urban projects, indicate CO concentrations for at least one typical residence and one typical business. Indicate concentration for ETC, design year and appropriate intermediate years (usually every five years).

(3) Carbon monoxide and hydrocarbons need to be shown as total pollutant load in tons per year for time of completion, design year and sufficent years in between to indicate a trend.

(4) Identify sensitive receptors (hospitals, rest homes and schools) within 500 feet of the right-of-way, or indicate that none exist.

(5) Present data for each alternate including as a minimum the no-build condition.

(6) Include a tentative finding of consistency with the TACB's State Implementation Plan.

c. Water Quality

Include in this section a discussion on significant water quality impacts, including summaries of analyses and consultations with the Texas Department of Water

Resources. Possible water quality impacts related to highways include: erosion and subsequent sedimentation problems; use of deicing, weed, rodent and insect control products; waste water disposal at safety roadside rest areas; spillage of poisons or chemicals by trucks into a water supply system; and contamination of surface and ground water supplies and of recharge areas by polluted fill material.

d. Aquatic Considerations

(1) All Waters. The aquatic environment which would be influenced by the project should be described. The following items should be included:

(a) Location and types of structures

(b) The approximate area affected; this should be given in surface-acres for impoundments. For streams, the channel description should include the approximate depth and width of the natural channel as well as the affected length.

(c) Bottom type. The nature of the natural bottom such as mud, limestone, pebbles, etc., should be given.

(d) Vegetation in the affected area. A listing of the prominent types of vegetation and some discussion of the local topography (whether the channel is in a wide bottomland area or steep woody banks, etc.) should be included.

(e) Effects of reshaping or rechanneling. Any proposed rechanneling or reshaping, including the use of fill materials below the natural water line, should be discussed. Any anticipated effects of these changes should also be discussed.

(2) Intermittent Streams

If intermittent waters are crossed, general comments describing erosion control specifications, other pertinent measures proposed to minimize erosion during and after construction, and the expected results should be presented.

(3) Perennial Streams

Constantly flowing streams usually require more extensive treatment than do intermittent waters. For affected perennial waters a general description of water quality, uses of the water, aquatic life, and the proposed temporary and permanent mitigating measures should be presented. If the stream is listed in the State's water quality standards, reference to those standards should be included.

(4) Valuable Waters

If valuable waters are crossed or encroached upon (i.e., municipal water supply, waters receiving contact recreation, rivers heavily utilized by commercial fishermen, or streams maintaining brackish coastal marshes), it may be necessary to make an in-depth evaluation of project effects on the water to determine the impacts and mitigating measures. Monitoring before, during, and after construction may be required. Consultation with outside agencies may be helpful in these endeavors. For instance, it is likely that one of the water-oriented agencies (Texas Department of Water Resources, State Health Department, U.S. Corps of Engineers) may have a monitoring station near project sites in waters of this description. Consultation with File D-8 personnel is encouraged in these studies.

This section of the statement should also include a summary of consultations with the appropriate public and governmental agencies. For example, when there is a need for a permit from the U.S. Coast Guard or the Army Corps of Engineers, such related Federal actions should be described. A discussion of the degree of coordination that has been or will be carried out to minimize conflicts should also be included. Section 2-600 of this Manual discusses coordination with various other agencies.

e. Wetlands and Coastal Zones Impact

This section should summarize the anticipated significant impacts on wetlands and coastal zones, including analyses, consultations and efforts to reduce the impact. Where applicable, the discussion should set forth any inconsistencies with wetlands or coastal zone management programs.

f. Stream Modification or Impoundment Impacts

This section should include a summary of information which is necessary to comply with the Fish and Wildlife Coordination Act. Briefly, the Fish and Wildlife Coordination Act requires consultation with the U.S. Fish and Wildlife Service and the Parks and Wildlife Department when a Federal action involves impoundment (surface area 10 acres or more), diversion, channel deepening or other modification of a stream or body of water. The draft NED should include a summary of the early consultation (see Section 2-607).

g. Flood Hazard Evaluation

When an alternative under consideration significantly encroaches on a flood plain, this section should include a summary of studies and consultation made for compliance with the FHWA directive implementing Executive Order 11296 and Flood Hazard Evaluation Guidelines for Federal Executive Agencies, or information evidencing that such requirements can be met during project development.

h. Construction Impacts

In general, adverse impacts during construction will be less important than long-term impacts. However, if appropriate, the NED should discuss significant impacts (particularly air, noise and water) associated with construction. Also, where applicable, the impact of the proposed disposal methods and the impact of borrow areas should be discussed.

8. Aesthetic and Other Values including visual quality, such as "view of the road" and "view from the road," and the joint development and multiple use of space.

2-703 PREPARATION AND PROCESSING OF DRAFT AND FINAL ENVIRONMENTAL IMPACT STATEMENTS

A. The purpose of the environmental impact statement (EIS) is to clarify issues, and to forecast and analyze significant impacts of a proposal and its reasonable alternatives. Therefore, efforts should be made early in the EIS preparation to weed out unnecessary information. Less important material should be summarized, consolidated or simply referenced. By focusing on meaningful analyses, the legal adequacy of an EIS will also be supported and enhanced.

B. Descriptive material in an EIS should be adequate to permit an assessment of potential environmental impacts by decision makers, commenting agencies and the public. Convey the required information concisely, giving attention to the substance of the information conveyed rather than to the particular form, or length, or detail of the EIS. Highly technical and specialized analyses and data should be avoided in the body of the EIS. Such material should be submitted with the EIS as technical appendices. The body of the EIS should summarize the analyses and data, and indicate that the complete data is available for those wishing to review it and where it may be viewed.

C. Specific baseline inventories and environmental research may be needed to determine if there are environmental problems which should be analyzed in an EIS. While these studies should be made available to the public, they should be referenced as technical appendices, rather than simply reproduced in the EIS. The need for manageable, concise EIS's does not imply a reduction in the quality or specificity of environmental studies or investigations which should be done before preparing the EIS.

D. A draft environmental impact statement should be prepared by the District for each major action which significantly affects the quality of the human environment. Concurrence by the Austin Office in the SEE assessment should always be received before proceeding with a draft EIS.

E. The draft EIS should be submitted to the Austin Office for review, concurrence and circulation prior to scheduling a public hearing process if one is required. Submit the original and four complete copies of the draft EIS. Also submit any tracings, cronaflexes, etc., needed for reproduction of multiple copies. Do not fold cronaflexes. Number all pages, including exhibits, maps, etc., consecutively. The District should indicate how many copies of the draft EIS will be needed for local circulation.

F. While the air quality report should not be attached to the EIS, two copies of it should be submitted to File D-8 along with the draft EIS so copies of the air quality report can be furnished to the FHWA and EPA. If the air quality report is revised at the final EIS stage, then four copies of that report should be submitted to File D-8 along with the final EIS.

G. For those projects which may utilize Federal funds, the draft EIS will be submitted to the FHWA by the Austin Office for FHWA's review and adoption. If in agreement with the scope and content, the FHWA will take responsibility for the draft EIS by signing and dating the title page before it is released for circulation and comments.

H. The draft EIS is circulated by the Department for comment and made available to the public at least 30 days before the public hearing and no later than the publication of first notice for the hearing or opportunity therefor. Agencies, groups, etc., which are furnished copies of the draft EIS should be given a minimum of 50 days to review the statement and return comments. A calendar date for return of comments should be included in the letter transmitting the draft EIS for review. The transmittal letter to commenting entities should also indicate where to send comments and that, if significant comments are furnished, a copy of the final EIS will be provided upon request.

I. The Department circulates the draft EIS for review and comment to: Federal, State and local agencies with jurisdiction by law and special expertise with respect to any environmental impacts involved; the area-wide clearinghouse; the affected city and/or county; public and private organizations and individuals with special expertise with respect to the environmental impacts involved; organizations and individuals who are known to have an interest in the project; and organizations and individuals who request an opportunity to comment. The draft EIS should also be furnished to the public library in the project area.

J. The Austin Office is responsible for circulating the draft EIS to the Federal and State agencies and groups. Comments received will be reviewed and transmitted to the Districts.

K. The District Office is responsible for circulating the draft EIS to appropriate local agencies, clearinghouse, city, county, public library, organizations, individuals, etc.

L. The draft EIS is available for review by the public at the Main Office of the Department and appropriate District offices and the public hearing. The availability of the draft EIS should be included in the public hearing notice.

M. Circulation of the draft EIS affords the public and governmental agencies opportunity to comment on the anticipated environmental effect if the proposed action is implemented. Therefore, a public hearing or public meeting is not ordinarily required for the sole purpose of presenting and receiving comments on a draft EIS. When a hearing is not held where the draft EIS may be discussed, a notice should be placed in the newspaper similar to the public hearing notice advising where the draft EIS is available for review, how copies may be obtained, and where comments should be sent. See Figure IIB-3 for a suggested notice format. When the publication of this notice of availability is necessary, the final environmental impact statement should not be submitted to the Austin Office until after the 30-day public comment period has expired. The date of publication of the notice should be furnished in the letter transmitting the final EIS to the Austin Office. Also see paragraphs (N) and (P) of this Section for other time periods which should expire before a final EIS is prepared and submitted.

N. The draft EIS should, if necessary, be revised, unless the final EIS is adopted within 3 years from the date the draft EIS was circulated. If the draft EIS is revised, it should also be recirculated for comment. Such recirculation should be in the same manner as an original draft EIS.

O. A draft EIS may be changed to a negative environmental declaration if the review process and public hearing comments indicate the anticipated environmental impacts are not considered significant. The Austin Office's concurrence in such a change should be obtained prior to the preparation of the NED. All agencies and individuals that received copies or commented on the draft EIS should be informed by the Department that a NED was substituted for the draft EIS and given a brief explanation of the reason thereof.

P. The final EIS should not be submitted to the Austin Office until after the expiration of 45 days from the date the availability of the draft EIS is published in the Federal Register. The Austin Office will notify the District of the date when the availability of the draft EIS is published in the Federal Register.

Q. A final EIS should be prepared by the District for major actions which significantly affect the quality of the human environment. It should contain the same information required in the draft EIS with appropriate revisions to reflect comments received from circulation of the draft EIS and the public hearing process (if required). See Section 2-704 for the format and content of the EIS.

R. The final EIS should be submitted to the Austin Office along with the public hearing process documentation (see Sections 2-807 and 2-808) if a public hearing process is required. If the public hearing process has been previously approved, then the final EIS may be submitted alone.

S. The District should submit the original and four complete copies of the final EIS. Also submit tracings, cronaflexes, etc., needed for reproduction of multiple copies. Number all pages, including exhibits, maps, etc., consecutively. Do not fold cronaflexes. The District should indicate how many copies of the final EIS will be needed for distribution.

T. For those projects which may utilize Federal funds, copies of the final EIS will be submitted to the FHWA by the Austin Office along with other required material (see Sections 2-807 and 2-808).

U. If an exception to the Federal design noise levels is required, the District should also submit four separate copies of the noise analysis information supporting the request for an exception. This should be done at the same time that the original and four copies of the complete final EIS are submitted to the Austin Office.

2-704 FORMAT AND CONTENT OF ENVIRONMENTAL IMPACT STATEMENTS (DRAFT AND FINAL)

(SEE FIGURES IIB-6 and IIB-7)

A. Title Page

Each environmental impact statement (draft or final) should have a title page as shown in Figure IIB-8. The report number at the top of the title page will be assigned by D-8.

B. Summary

Each EIS (draft and final) should have a summary containing the information indicated in Figure IIB-9. Immediately following the summary, insert an 8½ by 11-inch map showing the project area and alternate locations considered.

C. Need for the Proposed Project

This section should provide a complete and factual discussion of the need for the project. Identify the transportation problem, objectives and concept solutions to the problem. This section should be developed to such an extent that it will later serve as the nucleus of the "no-build" discussion under Alternatives. Include reasons why a highway project is proposed rather than another mode. Technical reports and studies may be summarized if the summarized factual data standson its own.It may be necessary to discuss a longer section of the highway than that actually covered by the environmental statement. This section should include comments on the following:

1. The relationship of the proposed project to functional classification studies or transportation plans (transporation requirements and demand).

2. Any legislation specifically directing the development of the project.

3. Any particular economic developments in the area or any identifiable social needs the project is intended to serve (new employment, schools, land use plans, recreation, etc.).

4. Coordinative planning and supportive and complimentary roles of other modes of transportation such as the inclusion of carpool or bus lanes, rail facilities, etc. Include a description of how the proposed project may interface with airports, rail terminals, and port facilities.

5. The relationship of the proposed project to the development of a usable and complete highway facility. A description of its relationship to the local, state and national system.

6. The accident rate and whether it is considered excessively high, and how the proposed improvement will reduce the accident rate and improve safety (anticipated safety benefits or lack thereof if project is not built).

7. The existing and anticipated traffic and what level of service the proposed improvement is expected to provide (capacity).

8. The structural condition of the existing facility and/or facilities, and the cost of maintaining the facility without significant improvements.

9. The social, economic and environmental effects if the proposed project is not constructed ("no-build" alternative).

10. The current status of the proposed project with a brief historical resume of project development, the point in the decision-making process the proposed is at now, and an estimate of when the facility may be constructed.

FORMAT OF A DRAFT EIS

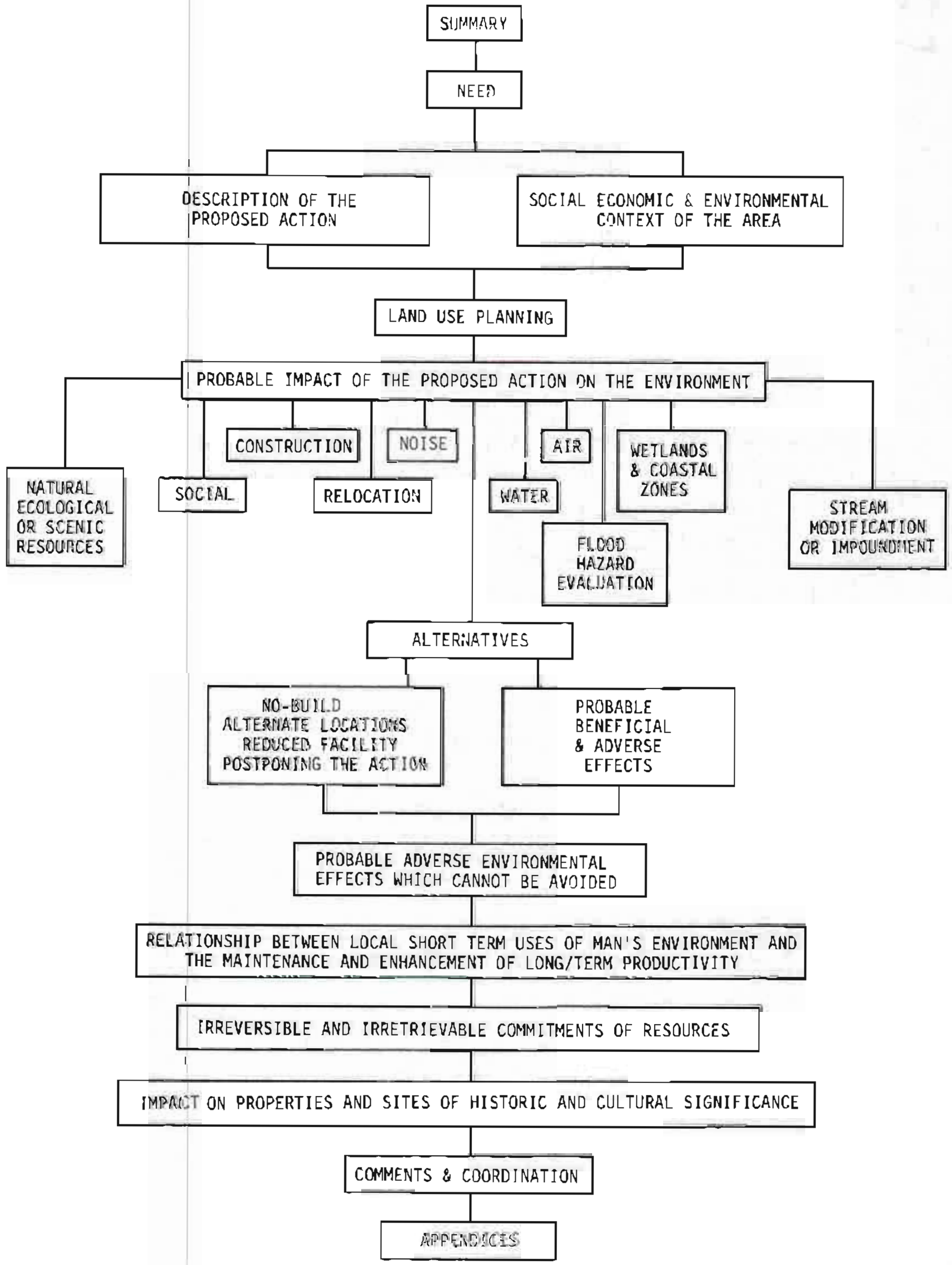


FIGURE 2B-6

FORMAT OF A FINAL EIS

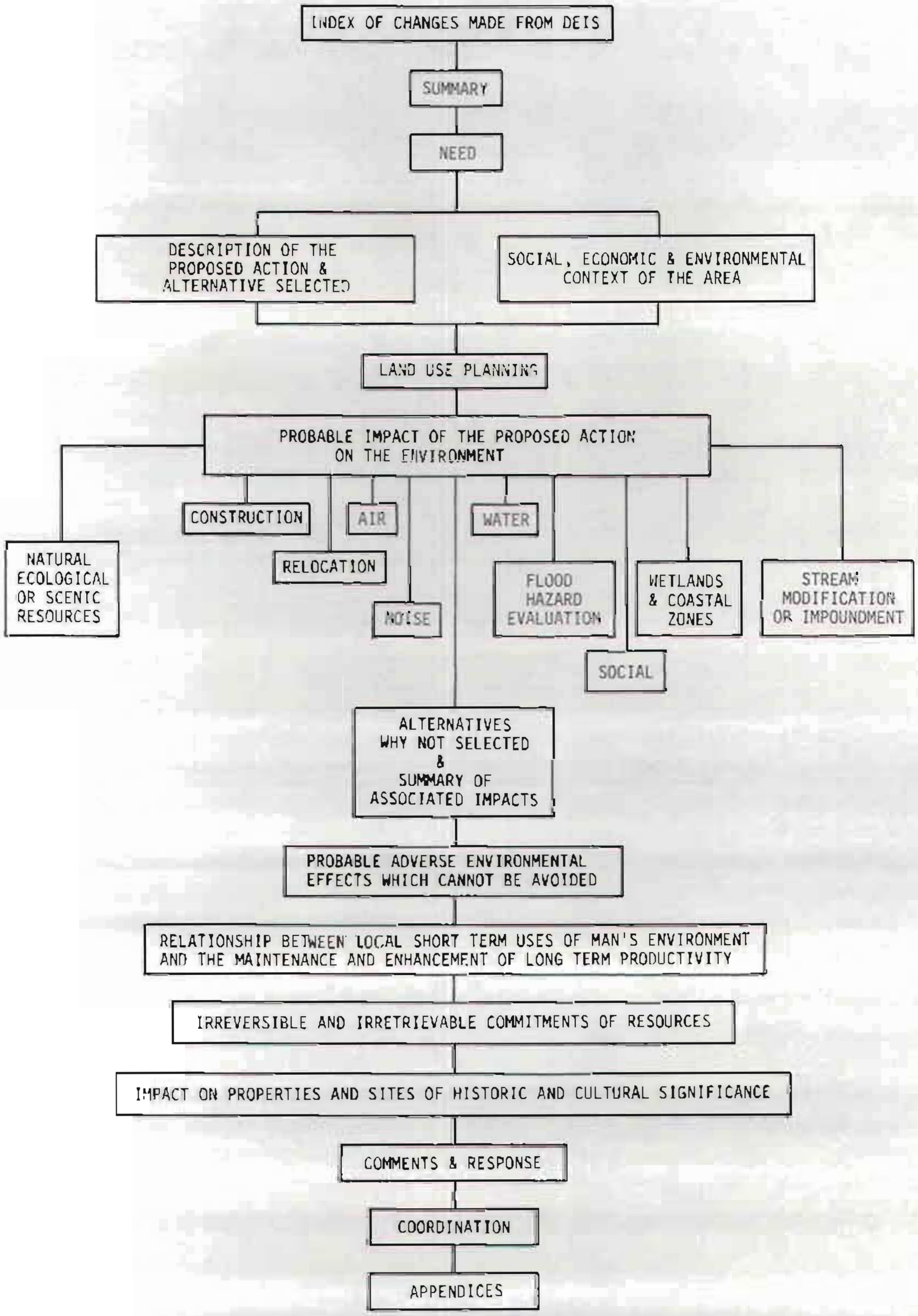


FIGURE 2B-7

Report Number: FHWA-TEX-EIS-________-________
Federal Highway Administration
Region 6
Fort Worth, Texas 76102

Highway and Limits
County and/or City

ADMINISTRATIVE ACTION

(DRAFT) or (FINAL)
ENVIRONMENTAL IMPACT STATEMENT

U.S. DEPARTMENT OF TRANSPORTATION

Federal Highway Administration

and

Texas Department of Highways and Public Transportation

Submitted pursuant to 42 U.S.C. 4332 (2) (C),
23 U.S.C. 128 (a) and (when applicable) 49 U.S.C. 1653 (f)
and 16 U.S.C. 470 (f)

(For draft EIS)

____
Date

____
Division Administrator
Federal Highway Administration

(For Final EIS)

____
Regional Director
Office of Environment and Design
Federal Highway Administration

Price per copy________

FIGURE IIB-8

Summary Sheet

Federal Highway Administration
and
Texas Department of Highways and Public Transportation

Administrative Action

1. (Draft) or (Final) Environmental Impact Statement (Section 4(f) Statement Attached) (if appropriate)

2. The names, addresses and telephone numbers of the individuals at the Department and FHWA who can be contacted for additional information concerning the action and statement. (Leave eight lines blank and this information will be filled in by D-8.)

3. Brief description of the proposed action indicating route, termini, type of highway, number of lanes, length, county, city, State, etc., as appropriate. Also list coordination which has been or will be carried out with local, State or Federal agencies. (For example,note if a permit is needed from U.S. Coast Guard, Corps of Engineers, Forest Service, etc.)

4. Summary of environmental impacts, both beneficial and adverse. Indicate the broad scope of impacts.

5. Summary of major alternatives considered. Also summary of advantages or disadvantages relative to the proposed action.

6. Draft EIS: List of all entities solicited for comments. The following should be listed:

   Department of Transportation
   Department of Health, Education and Welfare
   Department of Housing and Urban Development
   U.S. Army Corps of Engineers
   U.S. Department of Agriculture
   Department of the Interior
   Environmental Protection Agency
   Federal Energy Administration
   Texas Natural Resources Council
      Governor
      Texas Air Control Board
      Texas Industrial Commission
      Texas Parks and Wildlife Department
      Texas Railroad Commission
      Texas State Soil and Water Conservation Board
      Texas Department of Water Resources

FIGURE IIB-9 (continued)

General Land Office
Texas Department of Agriculture
Texas Historical Commission
University of Texas System
Texas A & M University System
Texas Health Department

Local entities:

Final EIS: List all entities solicited for comments and indicate those entities commenting on the draft EIS.

7. For final EIS, include the following statement:

The draft environmental statement was mailed to the Environmental Protection Agency on ____________________ .

FIGURE IIB-9

D. Description of the Proposed Action

(In the draft EIS, this section should briefly describe the broad proposed action. In the final EIS, this section should describe the alternative selected.)

This section of the EIS should include information such as the following:

1. Location, type of facility, and length (new and existing alignment).

2. Highway and traffic engineering factors including traffic data and number of lanes.

3. Predominant right-of-way width and access control (existing and proposed).

4. Other major design features such as the general horizontal and vertical alignment, and the location of interchanges, separation structures, at-grade intersections, stream crossings, etc.

5. Features to reduce or eliminate adverse environmental impacts.

E. Social, Economic and Environmental Context of Area

Briefly describe the social, economic and environmental setting for the area affected by all of the altenative proposals prior to any proposed action. The description should be a single description for the area rather than a separate one for each alternative.

1. Natural Environment

Topography, terrain, etc.
Geology
Soils
Meteorology and climatology
Hydrology
Vegetation
Fish and Wildlife
Visual

2. Social Environment

Land tenure
Population, growth characteristics, racial and ethnic composition
Housing
Transportation facilities including principal roads, streets and highways
Recreation
Cultural aspects
Public institutions
Aesthetics
Community facilities and services

3. Economic Setting

Land and improvements
Tax base
Income
Labor force
Business and industry and services

F. Land Use Planning

Review relevant plans, ordinances and established goals for the area and discuss. Indicate any meetings and consultations with those agencies involved in the area's planning process. Describe existing land uses and projected or anticipated land uses, and indicate those land uses on maps of the same base. Note in the discussion whether the land use plan for the area was developed with the proposed action as part of it. Assess the compatibility and consistency of the proposed action with goals, objectives and plans of the area. Where conflicts or inconsistencies exist, discuss reconciliation and reasons.

G. Probable Impact of the Proposed Action on the Environment

This section of the EIS should describe the significant beneficial and detrimental environmental consequences anticipated if the proposed project is implemented. Topics to be investigated and the depth of investigations and discussion will vary with the nature, scale and geographic area and the values placed on them by those concerned. Present complete but concise information to establish the range and reasonableness of the impacts anticipated. Summarize any studies used as sources and any studies undertaken. Include enough data or cross-referencing to determine validity of study methodology. Technical studies such as air quality and noise analysis reports should be referenced and included as "technical appendices." Technical appendices should be submitted along with the EIS and are considered as part of the legal EIS document. When technical appendices are referenced, indicate that while they are not attached to the EIS, they will be made available to those who request them.

The discussion of the probable impact of the proposed action on the environment should include both secondary and primary impacts. Seconday impacts are those stimulated or induced by highways such as more rapid land development or changed patterns of social economic activities. Give basis for predicting an impact, i.e., Comprehensive Plan for City for 1995. Indicate whether the plan was developed with an awareness of the proposed action. To the extent possible and predictable, discuss the changes that the action may bring to land use, development patterns, or community growth. If such changes are likely, estimate the public facilities needed to serve the new development and problems or issues which would arise in connection with these facilities, i.e., water, sewer, schools, police, etc. Discuss any community disruption and/or changes in community life styles created by the highway facilities.

This section of the EIS should also include discussion of practical and feasible measures to mitigate adverse impacts, and their relative cost and benefits. The discussion should cover the full range of reasonable measures to resolve or minimize anticipated problems and pros and cons of each.

The impacts upon the following elements, factors and features should be discussed in this section of the EIS. (For the final EIS, the content should essentially be the same with appropriate changes to address the comments received, and some additional detail of the impacts associated with the selected alternate.)

1. Natural, Ecological or Scenic Resources Impacts

   Discuss the significant effects on natural, ecological and scenic resources anticipated to be associated with the implementation of the proposed action. Include a summary of any consultations with appropriate public and governmental agencies. The effects on major types of vegetation and wildlife should be noted. Discuss food chains, habitat, types and area involved. The first time the name of any flora or fauna is used, the scientific name should appear in parenthesis following the common name, thereafter use the common name. Describe any potential effects (or lack of effects) of the project upon threatened and endangered species. If there are any threatened and endangered species, include a summary of coordination and documentation, and outline mitigation items for protection of these species. Identify alterations to land forms and its effect on the overall natural configuration.

2. Relocation of Individuals and Families Impacts

   Discuss the following information which can be obtained by a visual inspection and supplemented by other readily available data such as U.S. census, housing surveys, city and regional planning agencies and local or State housing authorities. To insure compliance with Title VI of the Civil Rights Act, refer to the guidelines in Figure IIB-5.

a. Estimate of households to be displaced, including the family characteristics (e.g., minorities, income levels, tenure, the elderly, large families, single or multi-dwelling).

b. Divisive or disruptive effect on the community, such as separation of residences from community facilities or separation of neighborhoods.

c. Impact on the neighborhood and housing where relocation is likely to take place (e.g., what effects will relocation have on community and public services such as schools, police, water, sewer, etc.). Secondary impacts.

d. Estimate of the number of businesses, non-profit organizations and farms to be displaced.

e. General effect of business, non-profit organizations and farm displacements on the economy of the community, including effect on minority ownership and minority employment. Secondary impacts.

f. Description of replacement housing in the area.

g. General location and quality of replacement housing.

h. Ability to provide adequate replacement housing for the types of families to be displaced. Discuss Departmental policy that: (1) No person shall be displaced by the Department's construction projects unless and until adequate replacement housing has already been provided for or is in place and has been made available to all affected persons. (2) Replacement housing must be offered to all affected persons regardless of their race, color, religion, sex or national origin. (3) All replacement housing must be fair housing, open to all persons regardless of race, color, religion, sex or national origin.

i. Description of special relocation advisory services that will be necessary for identifying unusual conditions.

j. Description of the actions proposed to remedy insufficient relocation housing, including if necessary, housing of last resort.

k. Results of consultation with local officials, social agencies and community groups regarding the impacts on the community affected.

3. Social Impacts

Discuss the significant social impacts anticipated to be caused by the proposed action. Discuss changes (beneficial or adverse) in life style for the neighborhoods and/or various groups. These impacts may include splitting the neighborhood, isolating a portion of a distinct ethnic group, new development, etc. If the proposed action will change travel patterns, such as vehicular, commuter or pedestrian, identify the impact.

Discuss temporary impacts due to construction activities. The following are examples of groups or individuals who may have special problems and may require special consideration with respect to access to jobs, schools, churches, parks, recreation areas, hospitals, shopping facilities, and community services:

a. Elderly
b. School-age children
c. Those dependent upon public transportation
d. Handicapped
e. Illiterate
f. Nondrivers
g. Pedestrians
h. Bicyclists
i. Low income
j. Racial, ethnic, or religious groups.

Refer to Figure IIB-5 for Guidelines for FHWA Title VI Compliance Review on Environment and Design.

4. Air Quality

An air quality report should be coordinated through File D-8 with the Texas Air Control Board (TACB) before the draft EIS preparation begins. Various levels of air quality analysis will be necessary depending on the location and degree of complexity of the project. These analyses and required data are described in the Department's *Air Quality Guidelines*. This section of the EIS should include a concise discussion of the conclusions of the air quality report together with graphs and/or tables showing CO concentrations and CO and hydrocarbons total pollutant loads. All aspects of the air quality report described in the Air Quality Guidelines should be concisely discussed in this section, with special attention to the air quality impact of the different alternatives.

The draft EIS must contain the following:

a. An identification of the air quality impact of the highway section. (Identification consists of pollution concentrations both predicted and existing for base condition at sensitive receptors.)

b. An identification of the analysis methodology utilized. (Identification should consist of microscale model or technique used, mesoscale model or technique used, whether model has been calibrated for section studied, and level of sophistication of the analysis, i.e., paper study vs. complete study.)

c. A brief summary of the early consultation with TACB and, where appplicable, a brief summary of any consultation with the indirect source review agency.

d. Any comments received from TACB and, where applicable, any comments received from the indirect source review agency. Attach copies of any letters received from TACB concerning the consistency of the proposal with the State implementation plan. Also attach any letters from indirect source review agency.

e. Determination on the consistency of each alternative under consideration with the approved State implementation plan.

f. This section of the EIS should also indicate that the complete air quality report is available for those wishing to review it and state where it may be viewed. The air quality report should not be attached to the EIS; however, two copies should be submitted to File D-8 with the draft EIS so that copies can be furnished to the FHWA and to the EPA. If at the final EIS stage the air quality report is revised, then four copies of the revised air quality report should be submitted to File D-8 along with the final EIS.

Where required by the Environmental Protection Agency Indirect Source Regulations, the preferred alternative should be submitted through File D-8 to the indirect source review agency for review. The proposed final EIS should not be submitted to FHWA for adoption if the indirect source review agency has found that the highway section will result in a violation of applicable portions of the control strategy or will interfere with the attainment or maintenance of the National Ambient Air Quality Standards.

The final EIS will be adopted by the FHWA only after FHWA has determined that the proposed highway section is consistent with the approved State implementation plan. The determination on consistency will be made by the Regional Federal Highway Administrator.

5. Noise Impacts (Refer to the Department's *Noise Guidelines* for details of preparing the Noise Report and Summary).

This section of the EIS should discuss noise impacts in layman's terms with enough technical information to alert the expert to any significant noise problem. Summarize the noise report and indicate that the complete noise report is available for those wishing to review it and where it may be viewed. While the noise report should not be attached to the EIS, it should be submitted with the EIS to File D-8 as a technical appendix. If an exception to the design noise level standards is required, four separate copies of the noise analysis information supporting the request for an exception should be submitted at the same time the final EIS is submitted to File D-8.

Summarized information from the noise report can be presented in tabular form or shown on maps. The EIS should contain information and discussion concerning the following items.

a. Existing (ambient) noise levels. Sufficient determinations should be made, shown and correlated with site numbers to quantify the existing noise environment. These determinations should represent the actual existing noise environment for all the alternates being considered.

b. Predicted future noise levels. Include traffic characteristics and data on which calculations are based (current and design year volumes, percentage trucks, and speed.) If the predicted future noise levels are presented in tabular form, the site numbers should correspond with the measured site numbers.

c. Identification of sound sensitive areas. Clearly indicate the numbers and types of noise sensitive land uses and activities which may be impacted by the proposed project.

d. Extent of the impact in decibels. Include an explanation of the nature and extent of the change in the noise for the immediate area.

e. Noise abatement measures which will likely be incorporated into the project. Discuss in summary form abatement measures such as barriers, elevated or depressed roadways, rerouting truck traffic, purchase of noise buffer zones, etc. Briefly discuss the feasibility, economic justification, driver safety, aesthetics, etc., for the abatement measures. In draft EIS, avoid any reference to the views of property owners regarding abatement measures. In final EIS, property owners' views can be presented since the final EIS will be prepared following the public hearing process which presumably included a full discussion with affected property owners where abatement measures are considered feasible and effective.

f. Numbers and types of land uses which will remain impacted even after abatement and mitigation measures are taken, or for which abatement measures are not feasible or prudent. If an exception to the FHWA Standards will be required, or if FHWA Standards are exceeded, submit four additional separate copies of the noise report to D-8 along with the final EIS. The EIS discussion of noise impacts should not indicate that an exception will be required or requested but should indicate in some manner that FHWA Standards will be exceeded.

g. Coordination to control future noise sensitive land development adjacent to the highway. Discuss in specific terms the coordination efforts made with the local officials and/or local planning agency. Local officials should be furnished copies of the FHWA publication, *The Audible Landscape: A Manual for Highway Noise and Land Use*, FHPM 7-7-3, and the noise report for the project.

h. Construction noise and possible mitigation.

i. A copy of a chart of typical noise levels and a copy of the FHWA Standards should be included.

6. Water Quality

Include in this section a discussion on significant water quality impacts, including summaries of analyses and consultations with the Texas Department of Water Resources. Possible water quality impacts related to highways include: erosion and subsequent sedimentation problems; use of deicing, weed, rodent and insect control products; waste water disposal at safety roadside rest areas; spillage of poisons or chemicals by trucks into a water supply system; and contamination of surface and ground water supplies and of recharge areas by polluted fill material.

a. Aquatic Considerations for All Waters

The aquatic environment which would be influenced by the project should be described.

The following items should be included:

(1) Location and types of structures.

(2) The approximate area affected. This should be given in surface-acres for impoundments. For streams, the channel description should include the approximate depth and width of the natural channel as well as the affected length.

(3) Bottom type. The nature of the natural bottom such as mud, limestone, pebbles, etc., should be given.

(4) Vegetation in the affected area. A listing of the prominent types of vegetation and some discussion of the local topography (whether the channel is in a wide bottomland area or steep woody banks, etc.) should be included.

(5) Effects of reshaping or rechanneling. Any proposed rechanneling or reshaping, including the use of fill materials below the natural water line, should be discussed. Any anticipated effects of these changes should also be discussed.

b. Aquatic Considerations for Intermittent Streams

If intermittent waters are crossed, general comments describing erosion control specifications, other pertinent measures proposed to minimize erosion during and after construction, and the expected results should be presented.

c. Aquatic Considerations for Perennial Streams

Constantly flowing streams usually require more extensive treatment than do intermittent waters. For affected perennial waters a general description of water quality, uses of the water, aquatic life, and the proposed temporary and permanent mitigating measures should be presented. If the stream is listed in the State's water quality standards, reference to those standards should be included.

d. Aquatic Considerations for Valuable Waters

If valuable waters (i.e., municipal water supply, waters receiving contact recreation, rivers heavily utilized by commercial fishermen, or streams maintaining brackish coastal marshes) are crossed or encroached upon, it may be necessary to make an in-depth evaluation of project effects on the water to determine the impacts and mitigating measures. Monitoring before, during, and after constuction may be required. Consultation with outside agencies may be helpful in these endeavors. For instance, it is likely that one of the water-oriented agencies (Texas Department of Water Resources, State Health Department, U.S. Corps of Engineers) may have a monitoring station near project sites in waters of this description. Consultation with File D-8 personnel is encouraged in these studies.

This section of the statement should also include a summary of consultations with the appropriate public and governmental agencies. For example, when there is a need for a permit from the U.S. Coast Guard or the Army Corps of Engineers, such related Federal actions should be described. A discussion of the degree of coordination that has been or will be carried out to minimize conflicts should also be included. Section 2-600 of this Manual discusses coordination with various other agencies.

7. Wetlands and Coastal Zones Impacts

This section should summarize the anticipated significant impacts on wetlands, marshes, coastal zones, estuaries, etc., including analyses, consultations and efforts to reduce the impact. Where applicable, the discussion should set forth any inconsistencies with wetlands or coastal zone management programs.

8. Stream Modification or Impoundment Impacts

This section should include a summary of information which is necessary to comply with the Fish and Wildlife Coordination Act. Briefly, the Fish and Wildlife Coordination Act requires consultation with the U.S. Fish and Wildlife Service and the Parks and Wildlife Department when a Federal action involves impoundment (surface area 10 acres or more), diversion, channel deepening or other modification of a stream or body of water. The draft EIS should include a summary of the early consultation (see Section 2-607).

9. Flood Hazard Evaluation

When an alternative under consideration significantly encroaches on a flood plain, this section should include a summary of studies and consultation made for compliance with the FHWA directive implementing Executive Order 11296 and Flood Hazard Evaluation Guidelines for Federal Executive Agencies, or information evidencing that such requirements can be met during project development.

10. Construction Impacts

In general, adverse impacts during construction will be less important than long-term impacts. However, if appropriate, the EIS should discuss significant impacts such as noise, dust, temporary drainage, and changing traffic patterns and access associated with construction and discuss mitigation measures. Also, where applicable, the impact of the proposed disposal methods and the impact of borrow areas should be discussed.

H. Alternatives

This section of the EIS should discuss reasonable location, design and scope alternatives including the "no-build" (status quo) and mode of transportation alternatives. In some instances, it may be necessary to discuss alternatives which are outside the responsibility of the Department or would require changes in statutory authority. Reasonable alternatives, developed as the result of the study and evaluation of the proposed action, should be described accurately and clearly. Discuss each alternative's termini, location, scope (number of lanes, right-of-way requirements, etc.) and other design elements.

The probable beneficial and adverse effects and costs of reasonable alternatives should be described in a manner consistent with the scale of the proposed highway improvement and significance of the impact. The discussion of environmental impacts in this section should include significant impacts associated with the alternatives themselves, as opposed to the discussion of regional environmental impacts associated with implementing the action.

In one of the previous sections of the EIS, Probable Impact of the Proposed Action on the Environment, those impacts which are regional in scope should have been discussed. Therefore, this section of the EIS, Alternatives, should include the probable impacts resulting from a specific alternative on its immediate surroundings.

In the draft EIS, this section should include a discussion of why the highway alternative or a combination highway/transit alternative was selected for the proposed action. This section should then present the reasonable alternatives which have been studied and which vary in location, design and/or scope. Each alternative should be discussed in comparable detail in the draft EIS. Discuss the dispostion of the existing facility if appropriate.

If an alternative is preferred at the time that the draft EIS is prepared, the proposed action should still be for a highway and/or transportation facility, not the preferred alternative. The draft should always state that all alternatives are under consideration and that a decision will be made only after the public hearing transcript and comments have been evaluated.

In the final EIS, the Alternatives section should discuss the alternatives not selected, why they were not selected, and the associated impacts of the alternatives. In the final EIS, the selected alternative should be described in detail in the section, Description of the Proposed Action. The final EIS should clearly state which alternative was selected and why.

I. Probable Adverse Environmental Effects Which Cannot be Avoided

Unavoidable impacts such as water, noise or air pollution, damage to life systems, threats to health, undesirable land use patterns, effects on minorities, etc., should be summarized in this section. These will be adverse environmental effects outlined in preceding sections, and should include only those which cannot be reduced in severity and those for which the use of reasonable corrective or abatement measures will not reduce the impact to acceptable levels.

J. The Relationship Between Local Short-Term Uses of Man's Environment and the Maintenance and Enhancement of Long-Term Productivity

This section of the EIS should contain a brief discussion of the extent to which the proposed action involves trade-offs between short-term environmental gains at the expense of long-term environmental losses, or vice-versa, and a discussion of the extent to which the proposed action forecloses future options. "Short-term" refers to the immediate effects of a project, while "long-term" is the period over which the direct or indirect effects of the project are apparent. For example, a highway project may induce change in land use patterns and changed land use patterns may result in homes being built on farmland. There is a gain, therefore, in available housing units, but the option to use the land for agricultural production has been foreclosed. The gains (short-term and long-term) may be the benefits associated with a proposed highway to the area or region such as improved transportation, reduction of traffic congestion, improvement in air quality, reduction in noise, improved economic base, accessibility, improved development potential, etc. The losses (short- and long-term) may be the disadvantages associated with the proposed highway, such as use of land by the highway, use of land for highway-associated developments (residential and industrial), loss of parks and recreation areas, and increased pollution (air, water and noise) and impacts on open space, wetlands, etc.

K. Irreversible and Irretrievable Commitments of Resources

This section of the EIS requires an identification of the extent to which the irreversible adverse effects curtail the range of potential uses of the environment. "Resources" means the full range of natural and cultural resources committed to loss or destruction by the action. A transportation facility may precipitate other related actions such as land development, exploitation of resources, travel, etc. that could induce a significant irreversible and irretrievable commitment curtailing other use of the area. An effect is irreversible or a resource commitment irretrievable, if once the project is undertaken, the effects cannot be eliminated by any countermeasures. The EIS should indicate the cost of land, construction materials, labor and other economically measurable costs which cannot be retrieved once a highway is constructed, and the resources which may be irretrievably lost and the nature of each such loss to which a dollar value cannot be readily assigned (for example, the loss of forested recreational land).

L. Impact on Historical and Archaeological Resources

This section of the EIS should discuss the effect (if any) of each alternative on districts, sites, buildings, structures, and objects of historical, architectural, archaeological, or cultural significance, and mitigation measures to be taken where appropriate.

1. The National Register of Historic Places, the Texas Historical Commission's inventory of cultural properties *Historic Preservation in Texas*, and the *Guide to Official Texas Historic Markers* should be examined to determine if there are any inventoried properties in the project area. The County Chairman of the Texas Historical Commission should also be consulted to determine if there are any inventoried properties in the project area. The County Chairman of the Texas Historical Commission should also be consulted to determine whether properties in the project area are eligible for inclusion in or are under nomination to the National Register of Historic Places.

2. If a known archaeological or historical site may be adversely affected, the type and significance of property as well as the nature of effect should be discussed. In many cases, an adverse effect on an archaeological or historical site of National, State, or local significance may require a Section 4(f) determination, a record of coordination with the Executive Director, Advisory Council on Historic Preservation (ACHP), or other information to be supplied on a project-by-project basis (see Sections 2-603 and 2-705).

3. If no adverse effect is anticipated, it should be noted in the EIS along with the resource material examined and the persons and agencies contacted in support of the determination. Evidence of coordination with the State Historic Preservation Officer in the form of an endorsed letter should be attached to the EIS and discussed in this section of the statement.

M. Comments and Coordination

1. The draft EIS should include a summary of coordination and public and minority involvement during the development of the project and pertinent comments received during the coordination. If public meeting(s) have been held, include a discussion of views received.

2. In areas which specifically call for early coordination, insert copies of letters showing that early consultation and discussion have taken place during the development of the draft EIS.

3. The draft EIS should be revised, as appropriate, to reflect the consideration given to substantive comments received, and to reflect consideration given to public hearing comments. The final EIS should include a copy of all substantive comments (letters, etc.) received (or summaries thereof where response has been exceptionally voluminous) as the result of circulation for comments, along with a discussion of each substantive comment and suggestion. When the draft EIS is revised as a result of comments received, the copy of the comment (letter, etc.) should contain marginal references indicating the page and paragraph where revisions were made or the discussion of comments should contain such references.

4. Any letters or material received from a commenting entity which is not legible when reproduced may be summarized. Every effort should be made to insure that the statement will be legible when reproduced.

5. Any unresolved environmental issues and efforts to resolve them should be discussed in this section.

6. The final EIS should contain a summary and disposition of substantive social, economic, environmental and other comments received in connection with the public hearing process, including the alternatives which were raised at the public hearing. Do not include a copy of the public hearing transcript or other public hearing data in the final EIS.

2-705 SECTION 4(f) STATEMENTS - Procedures and Contents

If a proposed action will require the use of any publicly-owned land from a public park, recreation area, wildlife and waterfowl refuge, or historic site of local, State or National significance as determined by the local, State or Federal officials having jurisdiction thereof, a preliminary Section 4(f) statement should be prepared and submitted to D-8, either as a separate document or in a special section of a draft EIS. The determination of significance should be accomplished by means of early consultation with the relevant official having jurisdiction over the publicly-owned land, and subsequently obtaining a written determination from the agency concerned.

A. The purpose of a Section 4(f) statement is to document the consideration, consultations and alternative studies for a determination that there are no feasible and prudent alternatives to the use of land from a publicly-owned park, recreation area, or wildlife and waterfowl refuge of national, State or local significance, or any land from a historic site of national, State or local significance. The purpose of the Section 4(f) statement is also to support a determination that the proposed project includes all possible planning to minimize harm.

B. If the project will use land from a historic property that is included, or eligible for inclusion, in the National Register of Historic Places, the Section 4(f) statement should provide evidence that the Advisory Council on Historic Preservation, Procedures for the Protection of Historic and Cultural Properties have been satisfied. If the project will use land from a historic site not included or eligible for inclusion in the National Register of Historic Places, the Section 4(f) statement should provide evidence that the official having jurisdiction thereof has determined it to be of national, State or local significance.

C. A Section 4(f) statement is not required when the Federal, State or local official having jurisdiction over a park, recreation area, refuge or historic site determines that it is not significant. The FHWA will review the non-significance determination to assure the reasonableness of such determination. In the absence of such a statement, the Section 4(f) land will be considered to be significant.

D. The provisions of this section and Section 4(f) do not apply to publicly-owned lands that are administered for multiple uses if the portion of the land to be taken is not in fact being used for park, recreation, wildlife, waterfowl, or historic purposes and there is no definite formulated plan for such use as determined by the official having jurisdiction over such lands. The FHWA will review the land-use determination to assure its reasonableness.

E. Park and recreation lands, wildlife and waterfowl refuges, and historic sites are sometimes designated or determined to be significant late in the development of a highway section. In such cases, a project may proceed without the preparation of a Section 4(f) statement if the right-of-way from such 4(f) type lands was acquired prior to the designation or change in significance.

F. The Section 4(f) information should be self-contained to the extent practicable and be consolidated in a special section of an EIS or in a separate statement. It may be necessary to repeat information contained in the EIS to eliminate unnecessary reference to the EIS.

G. The preliminary Section 4(f) statement should be prepared at the draft EIS stage of project development.

H. The preliminary Section 4(f) statement should be coordinated with the agency having jurisdiction over the Section 4(f) lands, and with the U.S. Departments of the Interior, Housing and Urban Development and, if appropriate, with the Department of Agriculture. The circulation will ordinarily be accomplished by including it in the draft EIS as a special section, or by attaching it to the draft EIS. Separate circulation may be made if there are unusual conditions which warrant separate circulation. Such conditions could include, for example, when a Section 4(f) area is identified, designated or involved after the final EIS processed, and when another agency is the lead agency for EIS processing. Separate circulation of the preliminary Section 4(f) statement should be in the form of a supplement to the EIS. The FHWA will review the preliminary Section 4(f) statement if separate from the EIS or negative declaration and indicate its acceptability by signing the title page before it is circulated for comment.

I. When circulating a preliminary Section 4(f) statement to the agencies noted above, the agencies should be given a minimum of 50 days to return their comments.

J. The following information, where pertinent and available, should be included in the preliminary Section 4(f) statement to initiate the necessary interagency review.

1. A description of the proposed action including alternatives contained in the EIS. At least one of the alternatives should miss the Section 4(f) lands. Alternatives should also include the "no-build" alternative and an alternative that causes least damage to the 4(f) land.

2. Describe the Section 4(f) land in sufficient detail to permit those not acquainted with the project to have an understanding of the relationship between the project and the Section 4(f) land and the extent of the impact, including detailed maps and/or drawings of sufficient scale to discern the essential elements of the highway/Section 4(f) land involvement.

   a. Size (acres or square feet) and location (maps or other exhibits such as photographs, slides, sketches, etc.).

   b. Type (recreation, historic, etc.).

   c. Available recreational activities (fishing, swimming, golf, etc.).

   d. Facilities existing and planned (description and location of ball diamonds, tennis courts, etc.).

   e. Usage (approximate number of users for each activity).

   f. Relationship to other similarly used lands in the vicinity.

   g. Access (both pedestrian and vehicular) and effect thereon.

   h. Ownership (city, county, State, etc.).

   i. Applicable clauses affecting title, such as covenants, restrictions or conditions, including forfeiture.

   j. Unusual characteristics of the Section 4(f) land (flooding problems, terrain conditions, or other features that either reduce or enhance the value of portions of the area).

   k. The location and amount of land (acres or square feet) to be used by the highway.

   l. The facilties affected.

   m. The probable increase or decrease in physical effects on the Section 4(f) land users (noise, fumes, etc.).

3. Provide a description of the transportation problem, objectives and concept solutions to the problem. This section may be repeated from the EIS section concerning Need.

4. Provide a text description supported by maps of sufficient scale to relate the project alternatives to 4(f) lands. Special design or environmental constraints to these alternatives should be shown. Provide reasons why the alternatives shown do not meet the need established earlier, and are not judged to be prudent or feasible.

5. List and show on the maps all facilities that are affected or taken. Describe how the proposed action will change the remaining portions of the 4(f) land with regard to access, noise, air, water, visual, aesthetic, etc.

6. Accurate and detailed information is needed to support the determination that there is no feasible or prudent alternative. Supporting information should demonstrate that there are unique problems, truly unusual factors present, and evidence that the cost or community disruption resulting from alternative routes reaches extraordinary magnitudes. Section 4(f) determinations will be reviewed for legal sufficiency by the FHWA Office of the Chief Counsel.

7. The Section 4(f) statement should include the best available information on possible measures to minimize harm to the Section 4(f) land by the highway involvement. The discussion should be as specific as possible, consistent with the state of the highway section planning and the need to demonstrate that all possible planning to minimize harm has been included in the highway proposal. Even though the transportation project may be at the location stage, detailed planning of design features to minimize harm is desirable. Include maps and/or sketches to show in some detail the design features being considered to alleviate damage caused by the take, i.e., landscaping, berms, relocated facilties, etc. Following are some measures which may be used to minimize harm.

   a. Provisions for compensating or replacing the Section 4(f) land and improvements thereon (include the status of any agreements, i.e., agreed-upon functional replacement and type of land, etc.).

   b. Design features to enhance the Section 4(f) land or to lessen adverse effects (improving or restoring existing pedestrian, bicycle or vehicular access, landscaping, aesthetic treatment, noise abatement measures, etc.).

   c. Coordination of construction to permit orderly transition and continual usage of Section 4(f) land facilities and least damage to wildlife and vegetation (new facilities constructed and available for use prior to demolishing existing facilities, moving of facilities during off-season, etc.).

   d. Description of the coordination with the public agency having jurisdiction over the Section 4(f) land relative to measures to minimize harm. Summarize discussions with agency having jurisdiction. Include relevant letters from agency having jurisdiction.

K. After receipt of the comments from the circulation of the preliminary Section 4(f) documentation, and after the required public hearing, the finalized Section 4(f) statement should be prepared and should ordinarily accompany the final EIS through the review process. This finalized version of the Section 4(f) statement should be a self-contained document. The final EIS should summarize the 4(f) involvement in the appropriate sections of the EIS.

L. The Section 4(f) statement should be prepared for selected 4(f) alternative with detailed descriptions and refined design details proposed to minimize harm. Discuss the other alternatives considered and the rationale for selection of the selected alternative as opposed to the other alternatives. Discuss prudency and feasibility. Summarize coordination, include copies of comments received, and discuss disposition of the points (comments) raised.

M. Special effort should be made to resolve any issues concerning Section 4(f) lands prior to preparing the Section 4(f) statement.

N. If land acquired or improved with Federal grant money (Department of Housing and Urban Development open space, or Bureau of Outdoor Recreation land and water conservation funds) is involved, the Section 4(f) statement should include a description of the coordination with the grantor agency.

PUBLIC INVOLVEMENT THROUGHOUT PROJECT DEVELOPMENT (2-800)

A. Public involvement as used herein refers to the processes whereby all interested persons, including minorities, are given adequate opportunities to become fully acquainted with transportation projects and to express views early enough in the project planning process when flexibility to respond still exists.

B. Public involvement is the process which facilitates interaction between the Department and the public. This process provides for the interchange of information concerning the direct and indirect consequences of a project. The results of this process are used in the Department's decision-making process during project planning.

C. Goals of the Department's public involvement process are: (1) public awareness, (2) public participation, (3) public confidence.

D. Public involvement strategies and techniques should be developed on a project-by-project basis to suit the community, people, and factors inherent in each project. Opportunities should be provided for groups and individuals (including minorities) to participate in an open exchange of views (especially at public meetings - see Section 2-803). In an area where the population is significantly Mexican-American, the following should be considered:

1. Have an interpreter present at public meetings and hearings if language difficulties are anticipated.

2. Have the public notices advertised in Spanish as well as English.

3. Always have the Departmental brochure on the relocation assistance program available in Spanish as well as English for distribution.

E. While flexibility in implementing public involvement is a primary and desired characteristic, the Department has recognized that certain minimum considerations must be satisfied. The following requirements have been established for projects which are determined to be major actions (see Section 2-402).

1. Hold at least one public meeting where Department representatives and community leaders, individuals, groups, organizations, or representatives thereof, can discuss and participate in an open exchange of views regarding the proposed project. A brief written summary of the meeting should be developed and made a part of the project records and submitted to File D-8 as soon after the meeting as practical (see Section 2-803).

2. Hold a public hearing or afford an opportunity for a public hearing to be requested for the project before the Department commits itself to a particular location and/or

design, and allow the public an opportunity to officially comment concerning the highway project's need, alternative locations and major design features, and their social economic and environmental effects. A verbatim transcript should be made of the public hearing (if one is held) to become a part of the project records. See Sections 2-807 and 2-808 for submissions to File D-8.

F. For projects determined to be nonmajor actions (see Section 2-402), a public hearing opportunity should be afforded if the project will:

1. Require the acquisition of significant or substantial amounts of additional right-of-way; or

2. Have a significant adverse impact upon abutting real property; or

3. Substantially change the layout or function of connecting roads or of the facility being improved; or

4. Otherwise have a significant social, economic or environmental effect.

G. Project publicity (both early and throughout project development) should encourage public involvement in project development. Methods of early publicity (and publicity throughout project development) will vary depending on the area, type of project, significance, etc. Suggested methods include press releases, notices, advertisements, letters to property owners, handbills, posters, bulletin board announcements, contacts with community leaders, clubs, organizations, schools, churches, etc.

2-801 APPLICATION OF PUBLIC INVOLVEMENT REQUIREMENTS

A. These instructions apply to all highway projects.

B. For Federal highway projects, if preliminary engineering or acquisition of right-of-way related to an undertaking to construct a portion of a Federal highway project is carried out without Federal funds, subsequent phases of the work can be eligible for Federal funding only if the non-participating work is done in accordance with these instructions.

C. These instructions do not apply to the construction of highway projects where a formal determination has been made that the construction of the project is urgently needed because of a national emergency, a natural disaster or a catastrophic failure.

D. The determination that a project is a nonmajor action (see Section 2-402) does not mean that the public involvement process is not required. A public hearing opportunity must be afforded on all Federal highway projects that provide for the construction of additional throughway lanes even though the proposed improvement is within existing right-of-way and no additional right-of-way is required. Since under Section 2-402 a project may qualify as a nonmajor action and still require significant amounts of right-of-way, it will be necessary that each nonmajor project be evaluated to determine if at least a public hearing opportunity should be afforded. As a general rule, this will be determined based solely on whether or not a significant or substantial amount of additional right-of-way is required; however, consideration should also be given to the possibility of the proposed project having a significant social, economic or environmental effect regardless of the amount of right-of-way required.

2-802 COORDINATION

A. When consideration is first given to the development or improvement of a highway project in a particular area, the views of the State's resources, recreation, and planning agencies, and of those Federal agencies and local public officials and agencies, and public advisory groups should be solicited. The Social, Economic and Environmental (SEE) assessment and/or the project concept conference report should be used as the basis for project publicity and solicitation of views from local, State and Federal governmental agencies, including A-95 Clearinghouse, and interested individuals and private groups (including minorities). This procedure should be initiated by both the District and File D-8. Mailing lists should be maintained in the District to provide the names and addresses of those interested in receiving early notification of project planning. District mailing lists will vary from project to project depending on variables such as location, local interest, scope of project, etc. If the project affects another State, views should also be solicited from the appropriate agencies within that State by File D-8 and the Administration. All written views received as a result of coordination should be made available to the public as a part of the public hearing procedures set forth in Section 2-808.

B. File D-8 is responsible for soliciting the views of the Federal and State agencies and groups. The District is responsible for such solicitation from local agencies, groups and individuals.

C. **Section 2-600, Coordination with Other Agencies, should be consulted throughout project development to ensure that coordination is accomplished at the appropriate times.**

2-803 PUBLIC MEETINGS

A. If a project is determined to be a major action, at least one public meeting should be scheduled and held prior to the public hearing process in the vicinity of the project. Public meetings may occur at any stage in project planning. However, the following instructions are specifically applicable to those types of public meetings held between project inception and the official public hearing process.

It is not necessary to hold a public meeting prior to affording a public hearing opportunity on projects which have been approved as nonmajor action projects. If a meeting is held on a nonmajor action project, the files should reflect that such meeting is not required by Action Plan.

B. A public meeting(s) should be scheduled and held as early as the District considers feasible to assure public input into project planning. Meetings should not be scheduled before sufficient studies have been conducted to permit the Department to discuss the potential effects of possible alternatives. In most cases, it is preferable that a SEE assessment be submitted to File D-8 for review and concurrence prior to scheduling a public meeting. Should Departmental studies and early coordination with local governments point to a preferred alternative, it is appropriate for such a tentative solution to be noted at the meeting(s) with the qualification that such alternative appears to be the solution based on the studies performed so far.

C. The alternatives discussed at the meeting(s), whether presented by the Department or other meeting participants, should be treated in discussions as alternatives that will be evaluated, as feasible, for continued study and consideration through necessary detailed social, economic, and environmental studies. At the meeting(s), the Department should emphasize that feasible alternatives will be studied in comparable detail and evaluated continually through the environmental study and review phase of project planning. It should be explained that the Department will probably recommend one of the alternatives at the time the official public hearing process is initiated although a decision will not be made until after the public hearing process is completed.

D. It is recommended that the public meeting(s) be presided over by a representative of the Department. Local community leaders, groups and individuals (including minorities) who are affected or who have an interest in the project should be identified, notified and encouraged to participate in project development. Representatives of local governments should be encouraged to participate especially in the discussions relating to the initiation of the project, and its relationship to the community's goals and objectives as outlined in regional, city or countywide transportation plans.

E. Public meetings should be scheduled and held at a time and place convenient to the public (including minorities) in the vicinity of the project. In an area where the population is significantly Mexican-American, an interpreter should be present at the public meetings if language difficulties are anticipated.

F. Meetings should be publicized in the same manner and to the same extent that public hearings are publicized. The public meeting should be announced by the publication of two newspaper notices or advertisements at times similar to the publication of public hearing notices. Notices or ads should contain the information shown in Figure IIB-10. The initial publication should be approximately 30 days before the date of the meeting and the second publication should be approximately 10 days before the date of the meeting. Advance notification of public meetings should be submitted to File D-8 approximately 30 days prior to the meeting. In an area where the population is significantly Mexican-American, the public notices should be advertised in Spanish as well as English. Other publicity of public meetings should be by means convenient to the citizens involved, such as radio and TV stations, newspaper articles, posters, letters to affected property owners, etc., as deemed appropriate by the District.

G. After the public meeting is held, a brief written summary of the proceedings should be developed and made a part of the records which should be forwarded to File D-8.

NOTICE OF PUBLIC MEETING

The State Department of Highways and Public Transporation will conduct a public meeting on ___date, time and place___ for the purpose of discussing the need for and suggested alternatives for the possible improvement to ___Highway and Limits___

All interested citizens are invited to attend this public meeting to express their views.

FIGURE IIB-10

2-804 PUBLIC HEARING REQUIREMENTS

A public hearing opportunity will be afforded on all projects except those projects that are solely for such improvements as resurfacing, widening existing lanes less than lane width, adding auxiliary lanes, replacing existing structures, installing traffic control devices or similar improvements. However, a public hearing opportunity will be afforded on these usually minor types of improvements if the proposed project will:

1. Require the acquisition of significant or substantial amounts of additional right-of-way; or

2. Have a significant adverse impact upon abutting real property; or

3. Substantially change the layout or function of connecting roads or streets or of the facility being improved; or

4. Otherwise have a significant social, economic or environmental effect.

A public hearing opportunity is required for adding travel lanes within existing right-of-way.

2-805 "LIMITED" MEETINGS WITH PROPERTY OWNERS IN LIEU OF PUBLIC HEARING OPPORTUNITIES

For the types of improvements listed in Section 2-804, if an opportunity for a public hearing is not required, but in evaluating (1.) it is determined that the project will require only an insignificant amount of additional right-of-way from an isolated property or properties, then in lieu of a public hearing opportunity a meeting shall be held with the owner or owners of such isolated properties to discuss the effects of the project on the property and residents and formally obtain the view of the owners and residents.

Before this type of "limited" meeting is scheduled with affected property owners, concurrence must be obtained from File D-8. After such "limited" meetings are held, a brief written summary of each meeting should be developed and made a part of the records which should be forwarded to File D-8 along with the District's recommendation for the further development of the project.

2-806 "LIMITED" MEETINGS WITH PROPERTY OWNERS FOLLOWING HEARING OPPORTUNITIES

When a location or design revision is found to be needed after an opportunity for a hearing has been afforded or a hearing has been held, another opportunity for a hearing will not be required if, upon application of conditions (1.) through (4.) of Section 2-804 to the proposed revision, it is determined that the revision is insignificant and provided that a meeting is held with the affected property owners and residents.

Before this type of "limited" meeting is scheduled with affected property owners, concurrence must be obtained from File D-8. After such "limited" meetings are held, a brief written summary of each meeting should be developed and made part of the records which should be forwarded to File D-8 along with the District's recommendation for the further development of the project.

When location or design revisions are considered to be significant, the environmental document should be revised and an additional public hearing opportunity should be considered based on the provisions of Section 2-810.

2-807 OPPORTUNITY FOR PUBLIC HEARING

A. The requirements for a public hearing process may be satisfied by either holding a public hearing, or publishing two notices of opportunity for public hearing and holding a public hearing in those instances where written requests for such a hearing are received which cannot be otherwise satisfied. The initial notice affording an opportunity should be published approximately 30 days in advance of the deadline for submission of a written request to hold a hearing. The second notice should be published approximately 10 days before the deadline. The procedure for requesting a public hearing should be explained in the notices.

The notices should be published in newspaper(s) having general circulation in the vicinity of the proposed undertaking. The notices should also be published in any newspaper having a substantial circulation in the area concerned, such as foreign language and local community newspapers. In an area where the population is significantly Mexican-American, the public notices should be advertised in Spanish as well as English. Notices should be similar to example shown in Figure IIB-11, and should describe the type of highway facility proposed for construction, number of lanes, general right-of-way width and relocations. A statement concerning relocation assistance should be included in all notices even though additional right-of-way may not be required for the project.

B. A copy of the notice as proposed for publication should be submitted to File D-8 at least two weeks prior to the first date of publication. The scheduled dates of publication and newspapers involved should be reported at the same time. File D-8 will submit copies of the notice to the FHWA no later than date of first publication. All notices submitted to File D-8 should be accompanied by a small scale map showing the proposed location. Maps should be prepared from half or full scale maps and be 8½ x 11 inches in size, if possible.

File D-8 is responsible for mailing copies of the notice and map to Federal and State agencies and groups. The District is responsible for notifying local agencies and groups. Local community leaders, groups and individuals (including minorities) who have an interest in the project should be identified and notified by the District.

C. If no requests are received in response to the notice within the time specified for submission, the District should submit a request for Departmental approval of the project and the following:

1. A separate certification page signed by the District Engineer certifying that:

   a. The opportunity has been afforded to request a public hearing covering the project's location and design and no request for a public hearing was received;

   b. The economic and social effects of the project's location and design and its impact on the environment have been considered;

   c. In determining economic, social and environmental effects, the statutory provisions of the Civil Rights Act of 1964 have been considered; and

NOTICE AFFORDING OPPORTUNITY FOR PUBLIC HEARING

The State Department of Highways and Public Transportation is planning the (improvement) or (construction) of ______(highway and limits)______ . The proposed project will pass through the cities and/or towns of ______________ .

(Paragraph containing general statement describing type of improvements or construction proposed, general right-of-way widths and relocations.)

Maps and other drawings showing the proposed location and design, (draft environmental impact statement) or (the draft negative environmental declaration) or (environmental studies), and any other information about the proposed project are on file and available for inspection and copying at the Resident Engineer's Office at ______address______ . Also the maps and drawings showing the proposed location and design have been placed on file with the ______county and/or city______ .

Information about the State's Relocation Assistance Program, the benefits and services for displacees and information concerning the relocation assistance office as well as information about the tentative schedules for acquisition of right of way and construction can be obtained at the Resident Engineer's Office.

Any interested citizen may request that a public hearing be held covering the social, economic and environmental effects of the proposed location and design for this highway project by delivering a written request to the Resident Engineer's Office on or before ______date______ . The address of the Resident Engineer's Office is ______________ .

In the event such a request is received, a public hearing will be scheduled and adequate notice will be publicized about the date and location of the hearing.

FIGURE IIB-11

d. The project's consistency with the goals and objectives of such urban planning as promulgated by the community has been considered. (If a community is involved that does not have a known plan of development, this should be noted in the submission and the certification modified as necessary.)

2. The appropriate final environmental report (either a final environmental impact statement or a final negative environmental declaration), if required. See Section 2-704 for content and format for a FEIS, and Section 2-702 for the content and format for a FNED.

3. A summary and analysis of the views received as a result of earlier coordination and in connection with the opportunity for a public hearing. This summary and analysis should be a part of the appropriate environmental statement or declaration if one is required.

D. The opportunity for another public hearing should be afforded, or a "limited" meeting with affected property owners should be held (see Section 2-806) in those cases where subsequent studies or comments result in location and/or design changes different from those previously presented in an opportunity notice or at a public hearing. (See the public hearing requirements in Section 2-804.)

E. The opportunity for a public hearing should be afforded in each case where there is any doubt if a public hearing is required.

F. If public land is involved as outlined in Senate Bill 324, 61st Legislature, State law requires that a public hearing be held.

2-808 PUBLIC HEARING PROCEDURES

A. Notices Published Prior to Public Hearing

1. When a public hearing is to be held, notices of public hearing should be published at least twice in newspaper(s) having general circulation in the vicinity of the proposed undertaking. The notice should also be published in any newspaper having a substantial circulation in the area concerned, such as foreign language newspapers and local community newspapers. In an area where the population is significantly Mexican-American, the public notices should be advertised in Spanish as well as in English. The initial notice should be published approximately 30 days in advance of the date of the hearing, and the second should be published approximately 10 days before the date of the hearing. The timing of additional publications is optional except in the case where the project requires the use of land designated as a park, recreation area, scientific area, wildlife refuge or historic site; State law requires that public hearing notices be published for three consecutive weeks. These notices should be in addition to the two required above.

2. In addition to publishing a notice of public hearing, the Department should furnish copies of the notice to the FHWA, appropriate news media, the State's resource, recreation, and planning agencies, and appropriate representatives of the Departments of the Interior, and Housing and Urban Development. The Department should also furnish copies to other Federal agencies, local public officials, public advisory groups, and public agencies or individuals (including minorities) who have requested notice of hearing, and other groups, or agencies who, by nature of their function, interest, responsibility or prehearing public involvement, the Department knows or believes might be interested in or affected by the proposal.

3. Notices should be similar to examples in Figure IIB-12. Each notice of public hearing should specify the date, time and place of the hearing and should contain a narrative description of the proposal, including the type of facility proposed, number of lanes, general right-of-way widths and relocations. Notices should indicate that verbal and written comments from the public regarding the project are requested and that comments may be presented either at the hearing or submitted within 10 days after the hearing. The address where written comments may be submitted should be included in each notice. To promote public understanding, the inclusion of a map or other drawing as part of the notice is desirable and encouraged. The notice of public hearing should specify the maps, drawings, environmental studies and other pertinent information

developed by the Department and written views received will be available for public inspection and copying and should specify where this information is available, namely, at the nearest Department office or at some other convenient location in the vicinity of the proposed project. Notices of public hearing should indicate that relocation assistance information will be available and tentative schedules of right-of-way acquisition and construction will be discussed.

4. All proposed notices concerning public hearings should be submitted by the District to File D-8 two weeks before the date of first publication and be accompanied by a small scale map showing the proposed location. Maps should be prepared from half or full scale maps and be 8½ x 11 inches in size, if possible. The scheduled dates of publication and newspapers involved should be reported at the same time.

5. File D-8 will submit copies of the notice to the FHWA no later than date of first publication.

6. File D-8 is responsible for mailing copies of the notice and map to Federal and State agencies and groups. The District is responsible for notifying local agencies and groups.

7. Local community leaders, groups and individuals (including minorities) who are affected or who have an interest in the project should be identified, notified and encouraged to participate in the public hearing phase of project development. Public notification of hearings may also be by means convenient to the citizens involved (including minorities), such as radio and TV stations, newspaper articles, posters, letters to affected property owners, etc., as deemed appropriate by the District.

B. Conduct of Public Hearings

1. It will be the responsibility of the District to arrange for a proper meeting place in which to hold the public hearing. The hearing should be held at a place convenient to the location of the proposed project and at a time considered most convenient to the citizens involved (including minorities) to encourage maximum attendance. A tape recorder should be provided to record the entire public hearing. In an area where the population is significantly Mexican-American, an interpreter should be present at public hearings if language difficulties are anticipated. Arrangements should be made for the registration of complete names and addresses of those in attendance. In arranging for the hearing, efforts should be made to encourage officials of local governmental agencies, regional clearinghouse (Council of Governments) and any private organizations and individuals (including minorities) to make statements at the hearing for the record or submit written statements in regard to the proposed project.

2. Provision should be made for submission of written statements and other exhibits in place of, or in addition to, oral statements at a public hearing. The procedure of the submission should be described in the notice of public hearing and at the public hearing. The final date for receipt of such statements or exhibits should be at least 10 days after the public hearing.

3. At each required public hearing, pertinent information concerning the social, economic and environmental effects of location and design alternatives studies by the Department should be made available. If the project requires an environmental report (either

NOTICE OF PUBLIC HEARING

The State Department of Highways and Public Transportation will conduct a public hearing on __________date, time and place__________ for the purpose of discussing the (improvements) or (construction) of _____highway and limits_____. The proposed project will pass through the cities and/or towns of ____________________.

(Paragraph containing general statement describing type of (improvements) or (construction) proposed, the general right-of-way widths and relocations.)

Maps and other drawings showing the proposed location and design will be displayed at the public hearing and together with (the draft environmental impact statement) or (the draft negative environmental declaration) or (environmental studies) and any other information about the proposed project are on file and available for inspection and copying at the Resident Engineer's Office at _____address_____.

Also, the maps and drawings showing the proposed location and design have been placed on file with the _____county and/or city_____.

The State's Relocation Assistance Program, the benefits and services for displacees and information conerning the relocation assistance office will be discussed. Tentative schedules for right-of-way acquisition and construction will also be discussed.

All interested citizens are invited to attend this public hearing. Verbal and written comments from the public regarding the project are requested. Comments may be presented either at the hearing or within 10 days after the hearing. Written statements and other exhibits may be submitted to the Resident Engineer's Office at _____address_____, but must be received not later than 10 days after the public hearing.

FIGURE IIB-12

a draft Negative Environmental Declaration, or a draft Environmental Impact Statement), it should be discussed and its availability announced.

4. Public hearing displays should be commensurate with the complexity, size and scope of the project. Public hearing displays should include, as appropriate, a map showing the proposed project and alternate locations studied, schematic drawings, aerial photographs, and/or if the project is in an urban area, scale models. Prominent landmarks such as major streets, rivers, parks, large buildings, etc., should be identified in large, bold letters. Any other helpful displays should be utilized whenever possible to aid in public understanding of the proposed project and its alternatives. Schematic diagrams prepared for office use should be modified to omit contour lines, curve data, etc., so that the lay person can more easily understand the display.

5. The District should make suitable arrangments for responsible highway officials to be present at public hearings as necessary to conduct the hearings and to be responsive to questions which arise.

6. The District should describe the State-Federal relationship in the Federal-aid highway program by an appropriate brochure, pamphlet, or statement, or by other means. See Figure IIB-13 for sample statements.

7. The District may arrange for local public officials or other qualified individuals to conduct a required public hearing.

8. The District should discuss the relocation assistance program and relocation assistance payments available as appropriate for the project being considered (see Figure IIB-14) and the proposed time schedule of project development, including tentative schedules of right-of-way acquisition and construction. The Departmental booklet on the relocation assistance program (which is available in both English and Spanish) should be provided at all public hearings free of charge.

9. At each public hearing the District should announce or otherwise explain that all information developed in regard to the proposed project location and design will be available upon request for public inspection and copying.

10. At each public hearing, after the required statements and descriptive review of the proposed project and alternatives, it is recommended that a recess be held to provide an opportunity to those in attendance to review the displays and ask questions. This will provide an effective means of answering some questions in advance of the period when recorded questions and statements are requested from those in attendance. Statements should be solicited rather than questions.

    The presiding officer should not engage in a debate or present arguments in rebuttal to statements unless it is considered essential to good public relations. Every effort should be made to answer questions relating to location and design and if proper information is not available to answer any question, arrangements should be made to furnish a reply as soon after the hearing as possible. During the receipt of statements from those in attendance at the public hearing, in order to insure correct interpretation of the verbatim transcript, the presiding officer should, as appropriate, restate all remarks or questions made by participants which are vague and uninformative and which refer to unidentifiable reference points on maps or schematic.

C. Transcript of Public Hearings

1. A verbatim written transcript should be made of the oral proceedings at each public hearing. A copy of the transcript should be submitted to File D-8 within a reasonable period after the public hearing, together with:

    a. Copies of, or reference to, or photographs of each statement, letter or exhibit used or filed in connection with a public hearing, including those submitted both before the hearing and within the time specified after the public hearing.

    b. Photographs of schematics as displayed at the public hearing if there are no changes since File D-8 and FHWA approval of the schematics prior to the public hearing. If there are any geometric changes to the schematic after File D-8 and FHWA approval and before the public hearing, five copies of the revised schematic, as displayed at the hearing, should be submitted either prior to or accompanying the public hearing data.

SUGGESTED STATEMENT CONCERNING
LOCAL-STATE-FEDERAL RELATIONSHIPS
IN HIGHWAY CONSTRUCTION*

Highway planning and construction requires close cooperation among all levels of government. The highway project covered by this public hearing will be developed cooperatively by the ______county or city or both______, the State Department of Highways and Public Transportation and the Federal Highway Administration.

LOCAL GOVERNMENT-STATE RELATIONSHIP

The right-of-way will be acquired under the provisions of House Bill 620, 55th Legislature and right-of-way costs will be shared on a 50-50 basis between the ______county and/or city______ and the State. The ______county and/or city______ will further participate in the cost of the proposed project by financing all improvements such as curb, gutter and storm sewers, etc.

STATE-FEDERAL RELATIONSHIP

The project, also, is being developed in cooperation with the United States Department of Transportation, FHWA. Although the Federal government does not participate in either the cost of preliminary engineering or right-of-way for projects of this type, the construction cost is shared with the State; therefore, FHWA concurrence will be obtained relative to the proposed project.

*(Modifications required for Interstate and Farm-to-Market Road projects)

FIGURE IIB-13

PUBLIC INFORMATION ON RELOCATION ASSISTANCE

A. General Requirements. In order to assure that the public has adequate knowledge of the relocation program, the Department should present information and provide opportunity for discussion of relocation services and payments at public hearings, distribute a relocation brochure, and give full and adequate public notice of the relocation assistance program. In order to give proper information and assistance to relocatees, every effort should be made to communicate with them in their language.

B. Public Hearings. The discussion should include but not necessarily be limited to the following:

1. Departmental policy that:

   (a) No person shall be displaced by the Department's construction projects unless and until adequate replacement housing has already been provided for or is in place and has been made available to all affected persons.

   (b) Replacement housing must be offered to all affected persons regardless of their race, color, religion, sex or national origin.

   (c) All replacement housing must be fair housing, open to all persons regardless of race, color, religion, sex or national origin.

2. The relocation assistance eligibility requirements and payment procedures including:

   (a) Eligibility requirements and payment limits for moving costs.

   (b) Replacement housing payment eligibility requirements and payment limits.

   (c) Mortgage interest rate differential eligibility requirements and payment.

   (d) Payment of closing costs incident to the purchase of a replacement dwelling.

   (e) Appeal procedures.

3. Discussion of the services available under the Department's relocation assistance advisory program. The address and telephone number of the local relocation office and the name of the relocation officer in charge.

4. The estimated number of individuals or families to be relocated.

5. The estimated number of dwelling units presently available that meet replacement housing requirements.

FIGURE IIB-14 (continued)

6. An estimate of the time necessary for relocation and the number of dwelling units meeting the replacement housing requirements that will become available during that period.

7. The depth of presentation should be influenced by the comprehensiveness of the brochure. If the brochure covers a particular item in sufficient detail, it will be satisfactory to highlight what the brochure contains without going into any great detail. If a particular item is not applicable to the project it will not be necessary to discuss the item beyond the mere mention that the law makes provision for such item.

C. Brochure. The Department has available a brochure describing its relocation program. The brochure, available in both English and Spanish, should be distributed without cost at all public hearings and to all other individuals and organizations as appropriate. The brochure also states where copies of any State regulations implementing the relocation assistance program can be obtained.

FIGURE IIB-14

c. A summary or index of all information made available to the public before the public hearing.

d. The appropriate final enviromental report (either a final environmental impact statement or a final negative environmental declaration) if required. See Section 2-704 for the content and format for a FEIS, and Section 2-702 for the content and format for a FNED. The final environmental report should contain a summary and analysis of the views received as a result of earlier coordination and in connection with public hearing(s).

e. A summary and analysis of views received as a result of earlier coordination and in connection with public hearing(s) if a final environmental report is not required.

f. A separate certification page, signed and dated by the District Engineer, certifying that:

(1) A public hearing has been held;

(2) The economic and social effects of the project's location and design and its impact on the environment have been considered;

(3) In determining economic, social and environmental effects, the statutory provisions of the Civil Rights Act of 1964 have been considered; and

(4) The project's consistency with the goals and objectives of such urban planning as promulgated by the community has been considered. (If a community is involved that does not have a known plan of development, this should be noted in the submission and the certification modified as necessary.)

2. Copies of these materials described above should be made available for public inspection and copying no later than the date the transcript is submitted.

D. Request For Project Approval

1. At the time the transcript and related materials described above are transmitted to File D-8, the District should include recommendations regarding Departmental action on the project.

2. At this point, any one of three actions is possible: (1) the Administration may disapprove or defer the project; (2) the Administration may approve the project, in which case the final negative environmental declaration or the final environmental impact statement, if required, is processed; or (3) the Administration may submit the project to the Project Review Board for further study and recommendation. The following are likely types of projects that could warrant the latter action: (1) projects containing significant, unresolved social, economic or environmental questions; (2) projects containing difficult trade-off's among alternatives; and (3) projects that have been developed amid significant controversy.

3. After action on a project by the Administration, its progession depends upon the prospective source of funding as follows:

   a. Federal Secondary Funds. The final negative environmental declaration or final environmental impact statement, if required, is submitted to the FHWA for approval. After notification that the final negative environmental declaration has been adopted, the District will be authorized by the Administration to initiate right-of-way acquisition procedures and preparation of construction plans. If a final environmental impact statement has been submitted, the District may not proceed until notified that the final environmental statement has been approved and adopted. For those nonmajor actions which require a public hearing process, but do not require either an environmental impact statement or a negative environmental declaration, the District should not proceed until notified that the appropriate reports, transcripts and certifications have been accepted by the Administration and that the District is authorized to initiate right-of-way acquisition procedures and preparation of construction plans.

   b. Other Federal Projects. If the project is to be developed with Federal participation other than Federal Secondary funds, the documentation submitted by the District is further submitted to the FHWA for review and acceptance. After notification that the final negative environmental declaration has been adopted, the District will be authorized by the Administration to initiate right-of-way acquisition procedures and preparation of construction plans. If a final environmental impact statement has been submitted the District should not proceed until notified that the final environmental statement has been approved and adopted.

   c. For those nonmajor actions which require a public hearing process, but do not require either an environmental impact statement or a negative environmental declaration, the District should not proceed until notified that the appropriate reports, transcripts and certifications have been accepted by the Administration and the FHWA, and that the District is authorized to initiate right-of-way acqusition procedures and preparation of construction plans.

E. Approvals

Approval of the final environmental document by the FHWA is deemed as acceptance of the required reports and certifications, and acceptance of the general location and design features.

2-809 POST-HEARING PUBLIC INVOLVEMENT

Following the Department's and, if required, the FHWA's adoption of the appropriate final environmental statement or declaration, and/or acceptance of the appropriate reports, transcripts and certifications, the District should provide for the effective publicizing of the actions. The emphasis on public involvement after the approval action shifts from an informational exchange to: (1) the routine provision of information to interested parties, and (2) responding to inquiries from and coordinating with property owners and displacees as to right-of-way and relocation assistance policies and procedures.

2-810 ADDITIONAL HEARING OPPORTUNITIES

Following the usual approval action of a project's location and design, an additional public hearing process (opportunity, hearing, or limited meeting) should be held when there has been a substantial change in the proposal, or substantial unanticipated development in the area affected by the proposal, or an unusually long lapse of time since the last hearing, or significant social, economic, or environmental effects are identified that were not previously considered at the earlier public hearing process. The determination of an "unusually long lapse of time" since the last hearing must be on a project-by-project basis, and not on a prescribed lapsed time applied unvaryingly to every project. The determination of an "unusually long lapse of time" should take into consideration (1) the time normally required to develop a project from inception to contract, (2) whether or not there has been substantial change in the project, (3) whether or not there has been a substantial unanticipated development in the area, or (4) the identification of significant effects not previously considered at earlier hearings.

Before scheduling an additional public hearing process, the District should consult File D-8.

FIGURE I

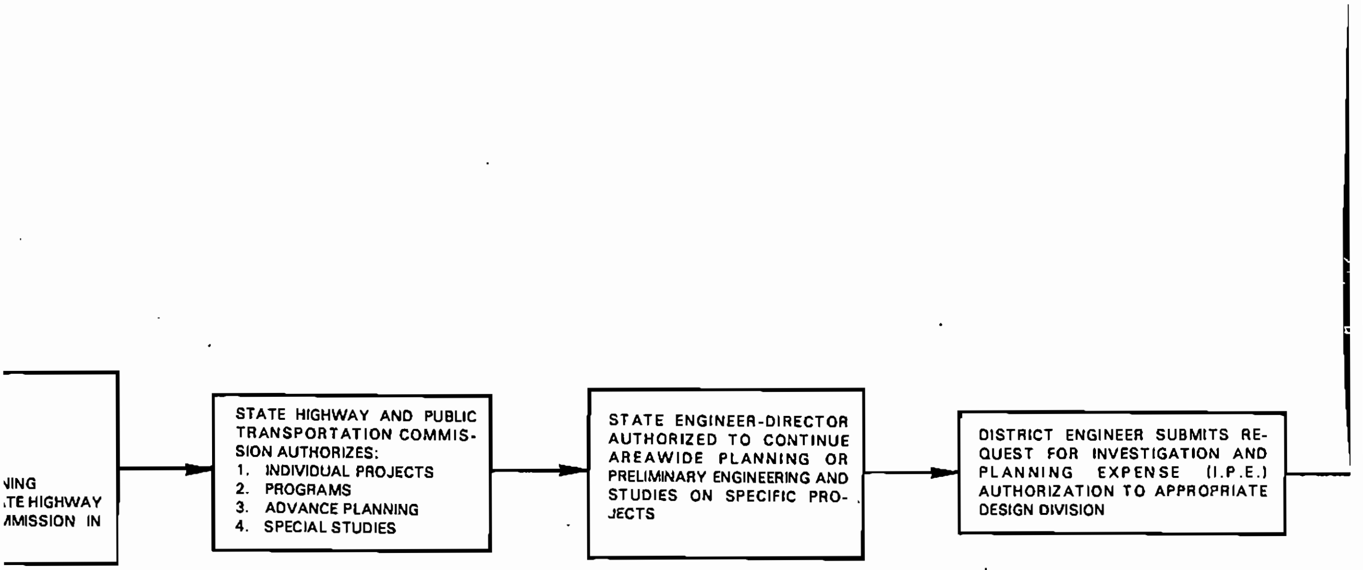
FLOW CHART SHOWING PROCESS GUIDELINES FOR PROJECT DEVELOPMENT EMPHASIZING PUBLIC INVOLVEMENT AND OCIAL, ECONOMIC & ENVIRONMENTAL CONSIDERATION

ABBREVIATIONS

DES. DIV.	DESIGN DIVISIONS
E.C.	ENVIRONMENTAL COORDINATOR
IPE	INVESTIGATION AND PLANNING EXPENSE
SEE	SOCIAL, ECONOMIC AND ENVIRONMENTAL
DNED	DRAFT NEGATIVE ENVIRONMENTAL DECLARATION*
FNED	FINAL NEGATIVE ENVIRONMENTAL DECLARATION*
DEIS	DRAFT ENVIRONMENTAL IMPACT STATEMENT*
FEIS	FINAL ENVIRONMENTAL IMPACT STATEMENT*
BPO	GOVERNOR'S BUDGET AND PLANNING OFFICE
COG	COUNCIL OF GOVERNMENTS
FHWA	FEDERAL HIGHWAY ADMINISTRATION
PS&E	PLANS, SPECIFICATIONS AND ESTIMATES

* TO BE ACCOMPANIED BY SECTION 4(f) DOCUMENTATION IF SECTION 4(f) LANDS ARE INVOLVED.

INDIVIDUAL PROJECTS
PROGRAM DEVELOPMENT
LONG RANGE (SYSTEMS) I
LOCAL AREA STUDIES
NEEDS AND COST STUDIE
URBAN TRANSPORTATION
DELEGATIONS APPEARING
AND PUBLIC TRANSPORT
PUBLIC HEARING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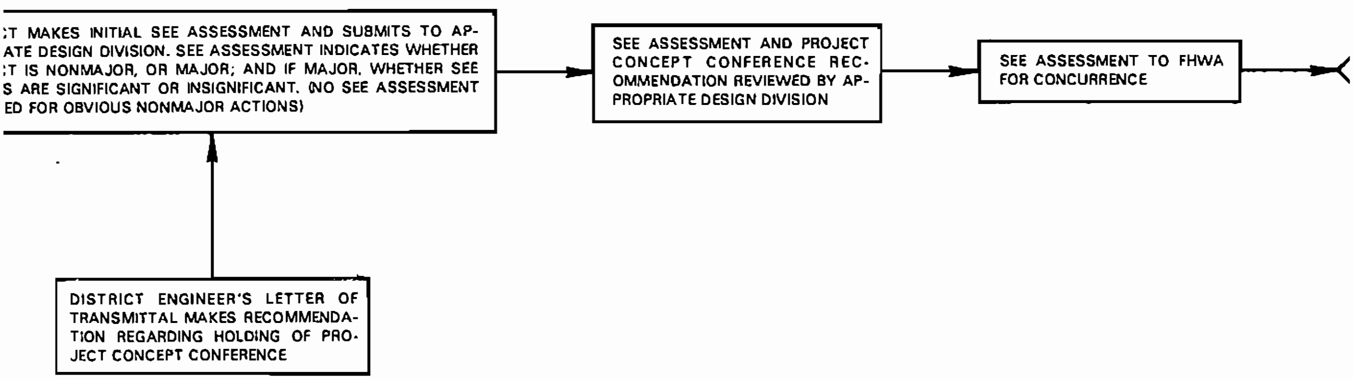
MMISSION IN
STATE HIGHWAY AND PUBLIC TRANSPORTATION COMMISSION AUTHORIZES:
1. INDIVIDUAL PROJECTS
2. PROGRAMS
3. ADVANCE PLANNING
4. SPECIAL STUDIES
STATE ENGINEER-DIRECTOR AUTHORIZED TO CONTINUE AREAWIDE PLANNING OR PRELIMINARY ENGINEERING AND STUDIES ON SPECIFIC PROJECTS
DISTRICT ENGINEER SUBMITS REQUEST FOR INVESTIGATION AND PLANNING EXPENSE (I.P.E.) AUTHORIZATION TO APPROPRIATE DESIGN DIVISION


:T MAKES INITIAL SEE ASSESSMENT AND SUBMITS TO AP-
ATE DESIGN DIVISION. SEE ASSESSMENT INDICATES WHETHER
:T IS NONMAJOR, OR MAJOR; AND IF MAJOR, WHETHER SEE
S ARE SIGNIFICANT OR INSIGNIFICANT. (NO SEE ASSESSMENT
ED FOR OBVIOUS NONMAJOR ACTIONS)
SEE ASSESSMENT AND PROJECT CONCEPT CONFERENCE REC-OMMENDATION REVIEWED BY AP-PROPRIATE DESIGN DIVISION
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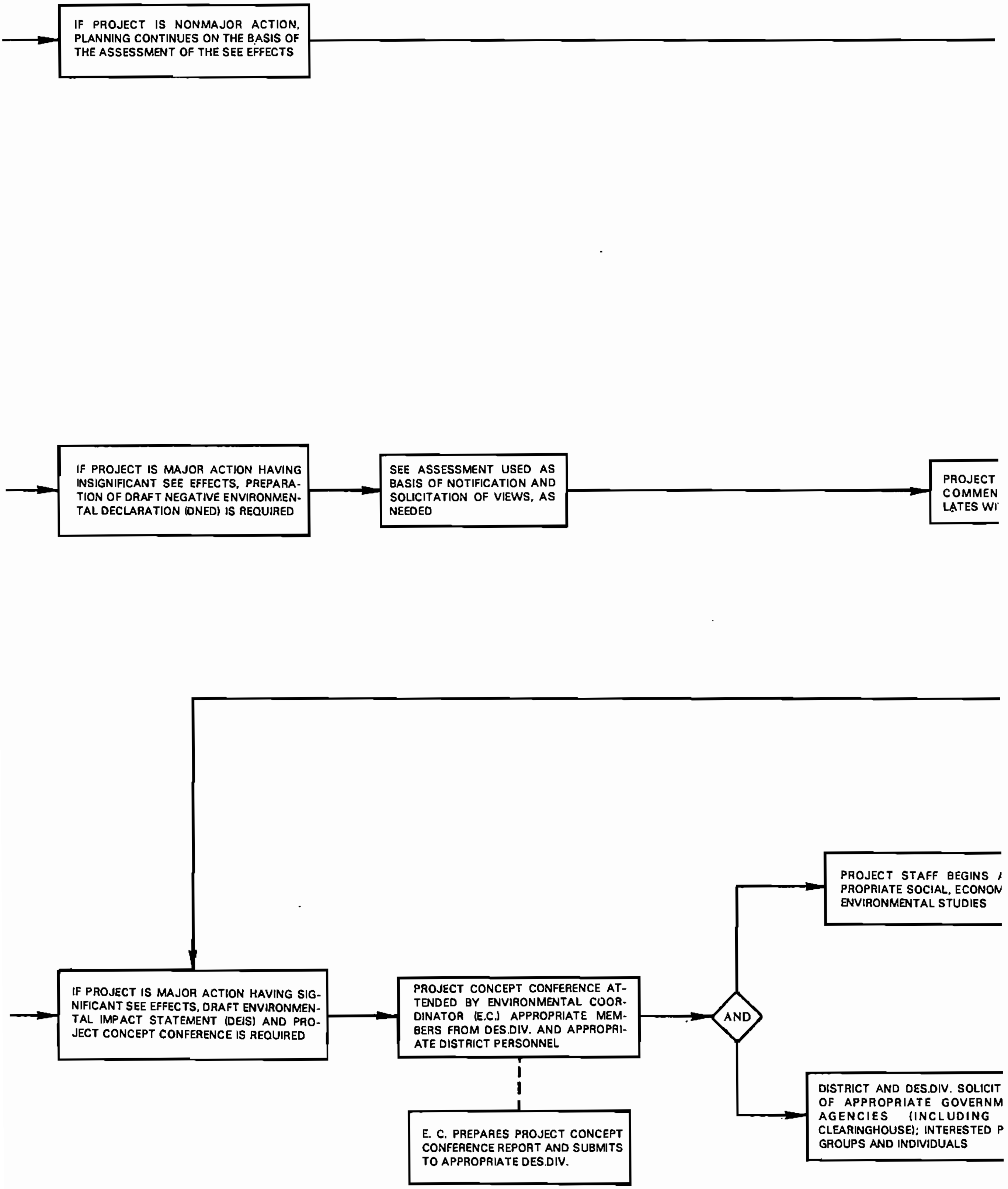
DISTRICT ENGINEER'S LETTER OF TRANSMITTAL MAKES RECOMMENDA-TION REGARDING HOLDING OF PRO-JECT CONCEPT CONFERENCE



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AND
PROJECT STAFF BEGINS
PROPRIATE SOCIAL, ECONOM
ENVIRONMENTAL STUDIES
E. C. PREPARES PROJECT CONCEPT CONFERENCE REPORT AND SUBMITS TO APPROPRIATE DES.DIV.
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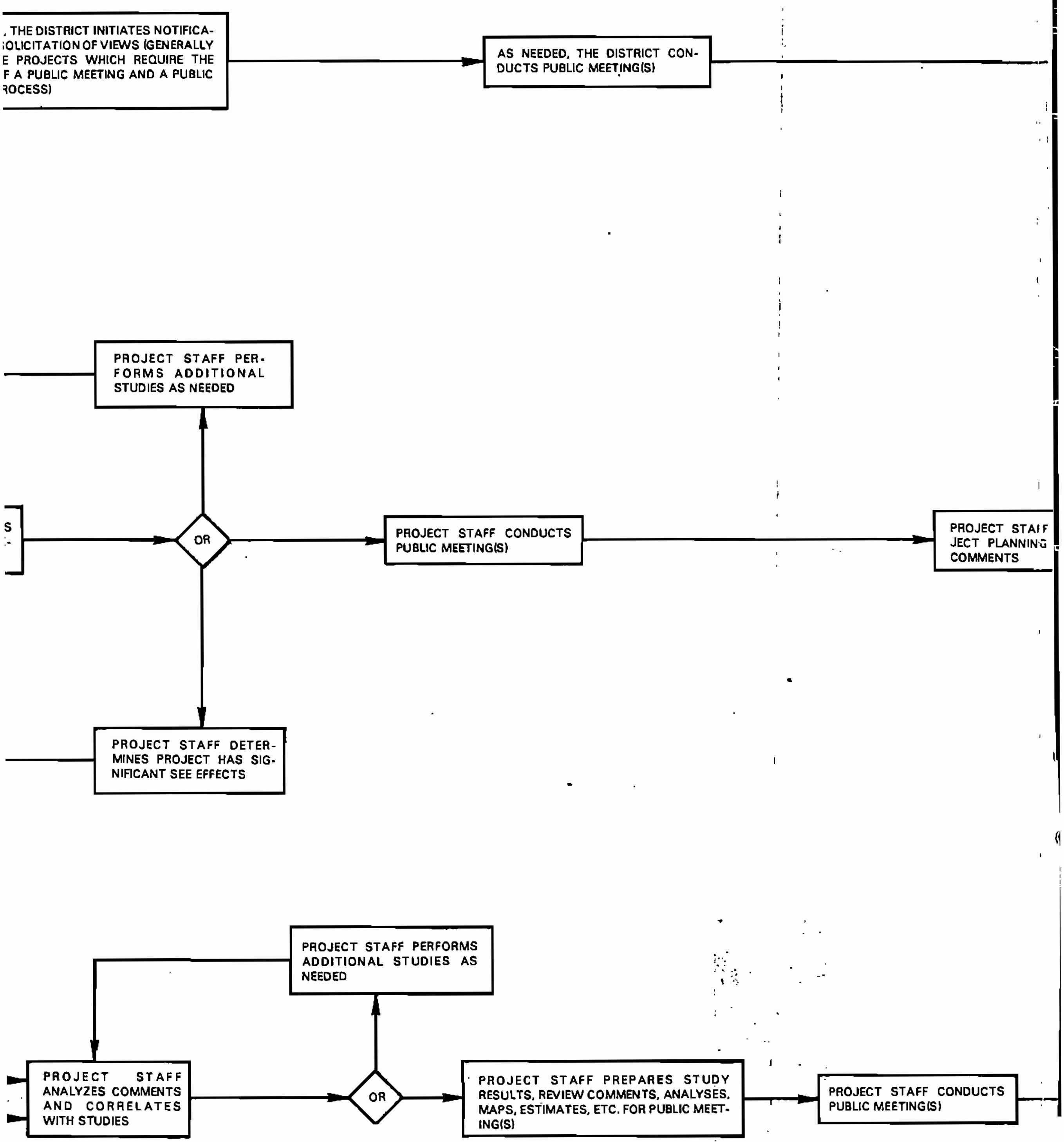

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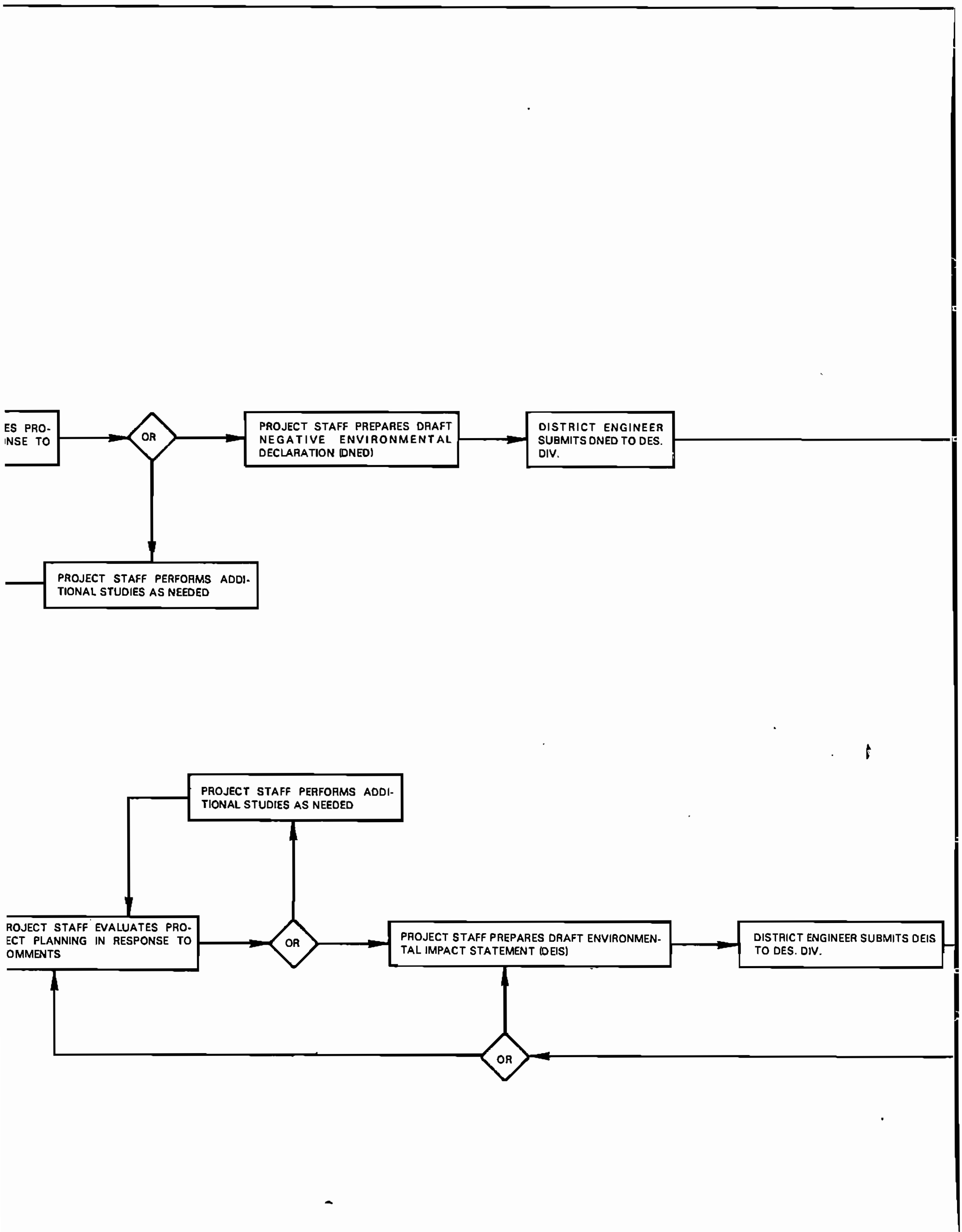
PROJECT STAFF DETERMINES PROJECT HAS SIGNIFICANT SEE EFFECTS
PROJECT STAFF PERFORMS ADDITIONAL STUDIES AS NEEDED
PROJECT STAFF ANALYZES COMMENTS AND CORRELATES WITH STUDIES
OR
PROJECT STAFF PREPARES STUDY RESULTS, REVIEW COMMENTS, ANALYSES, MAPS, ESTIMATES, ETC. FOR PUBLIC MEETING(S)
PROJECT STAFF CONDUCTS PUBLIC MEETING(S)



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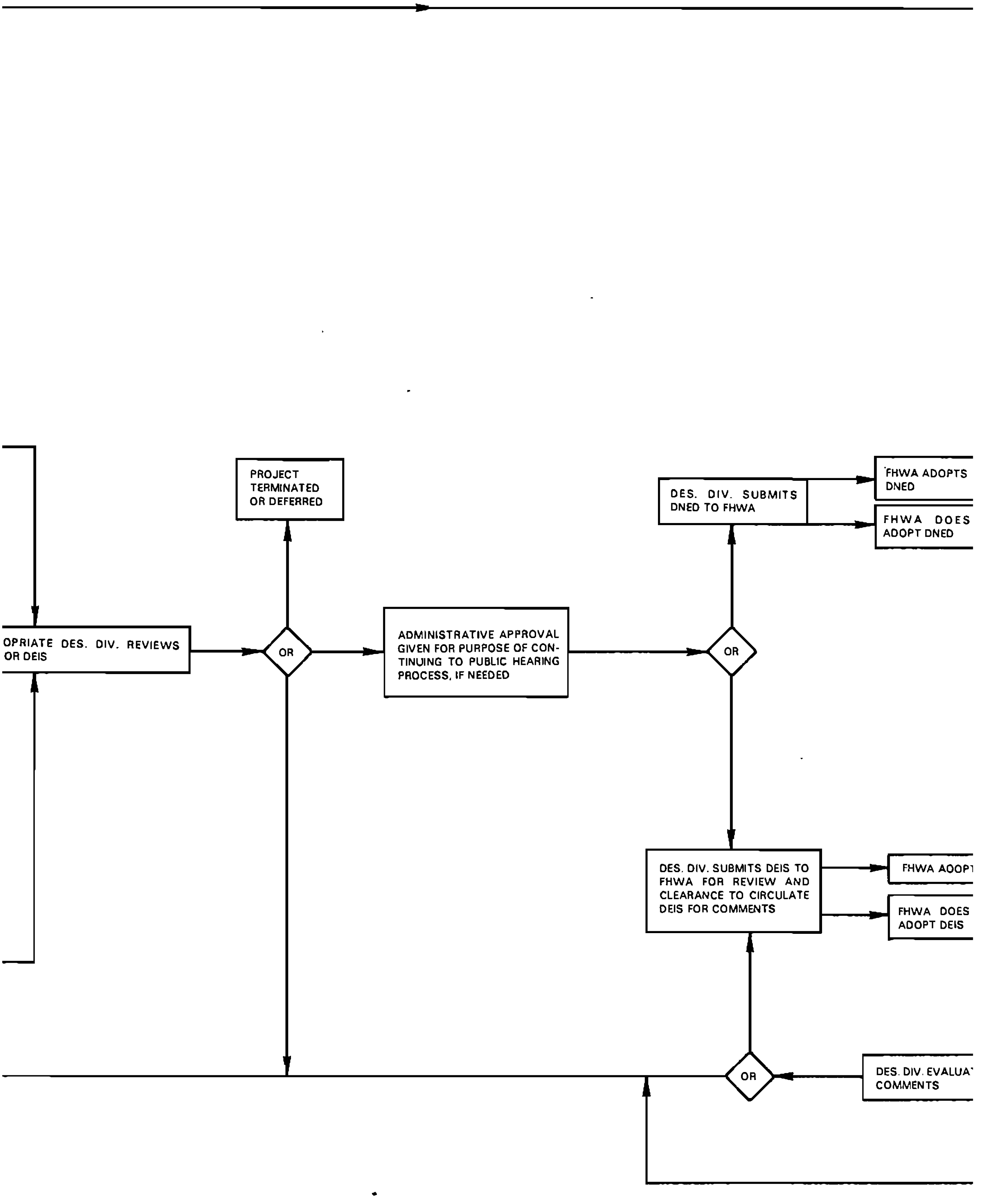

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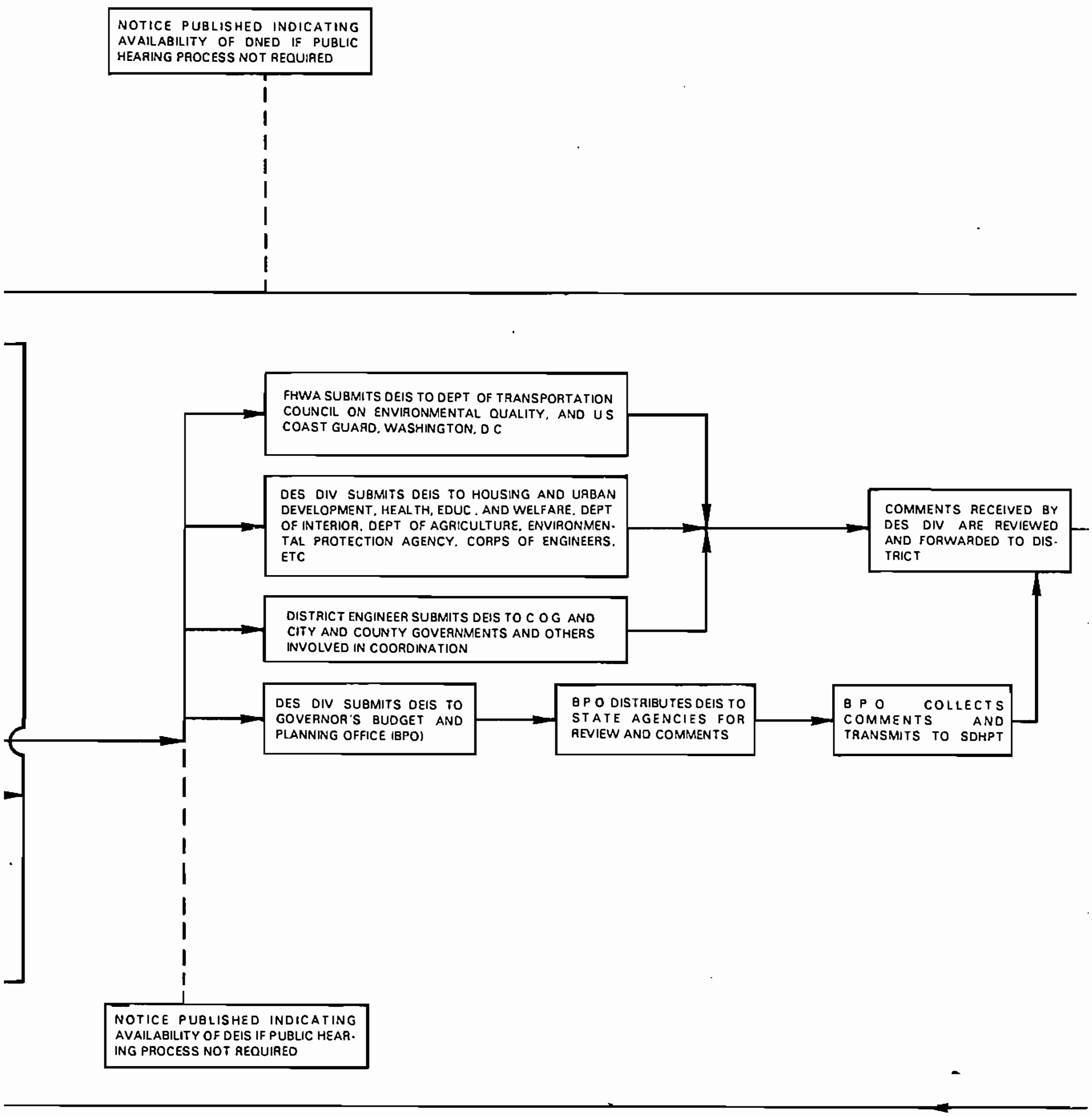
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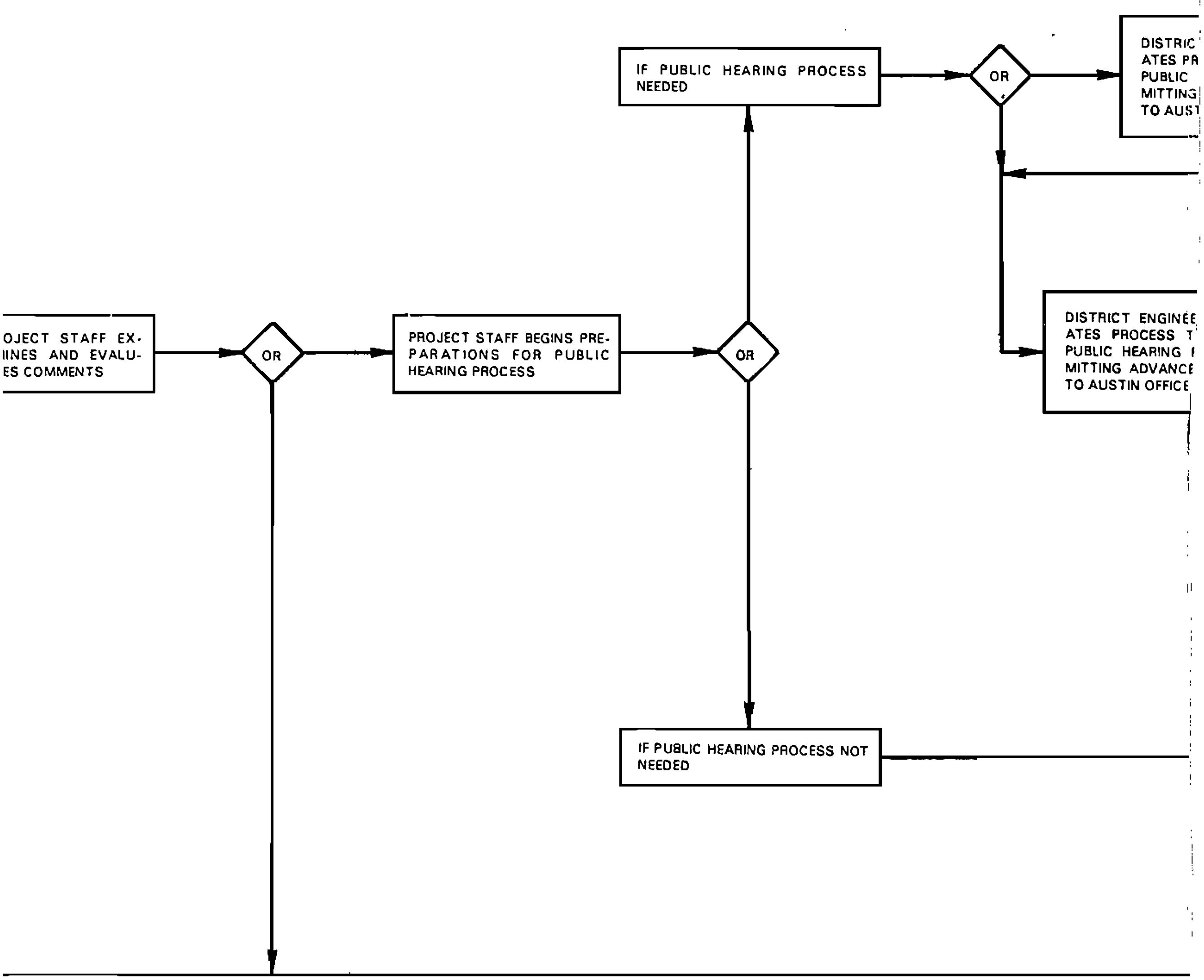
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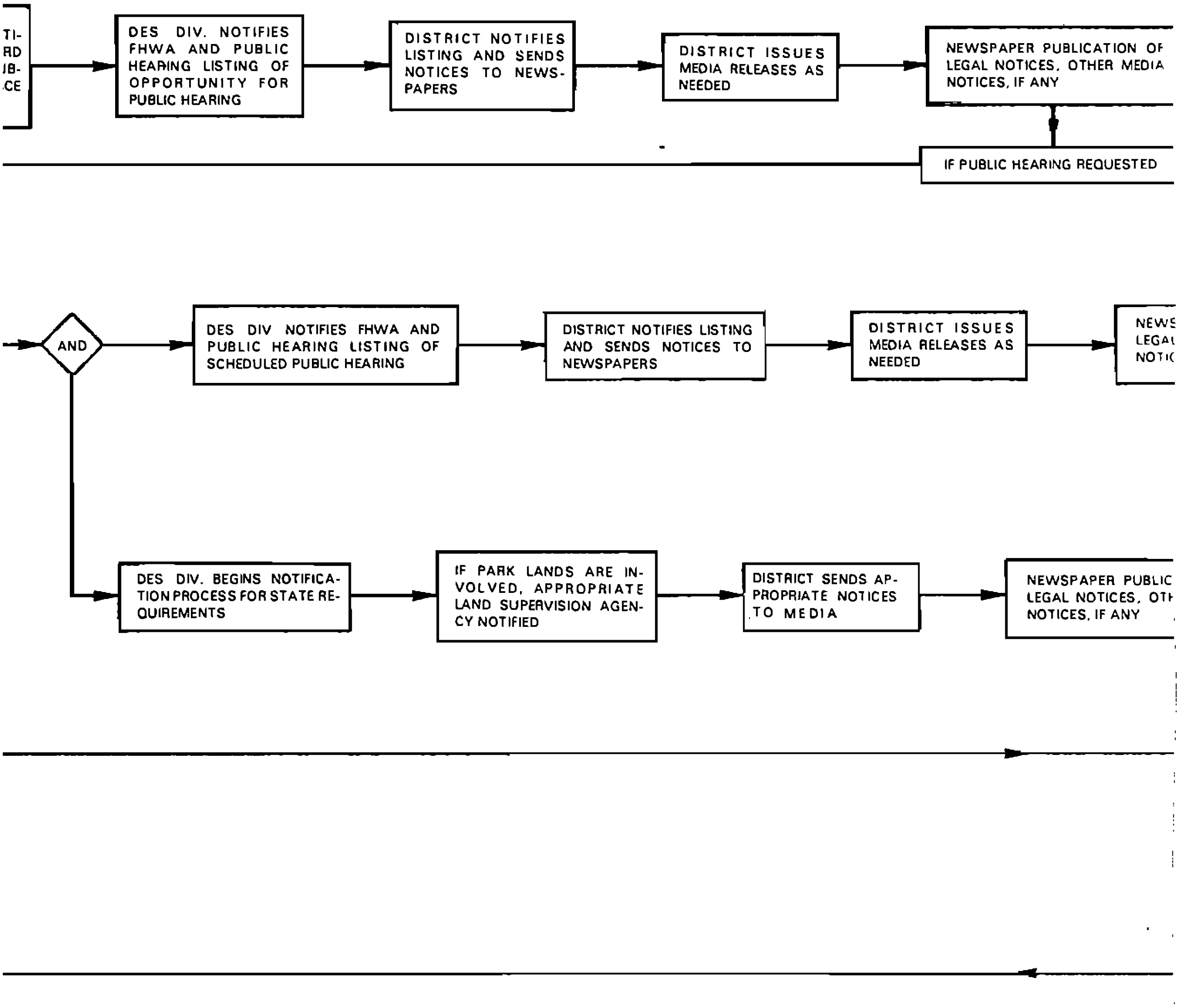
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IF PUBLIC HEARING REQUESTED
AND
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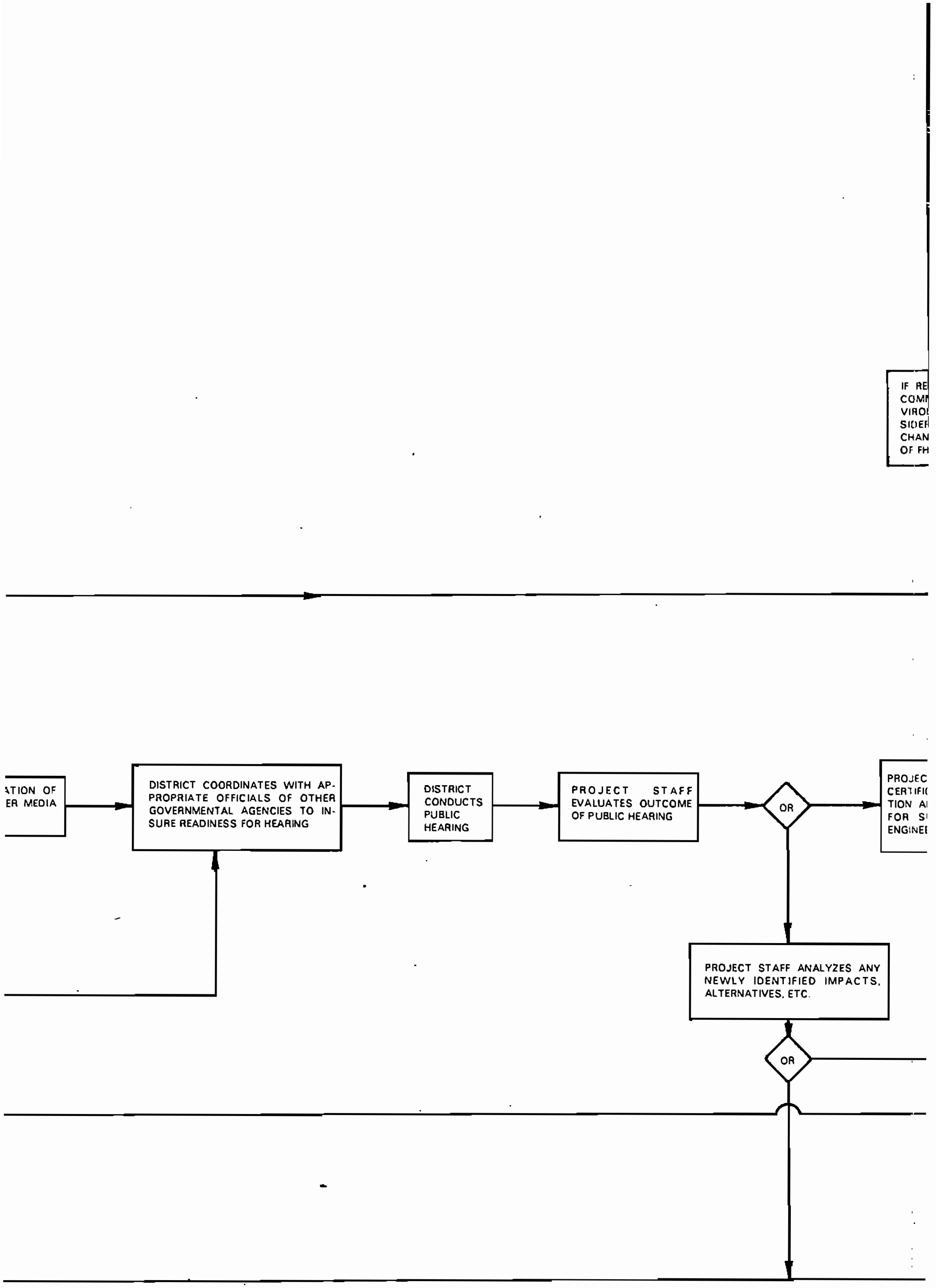
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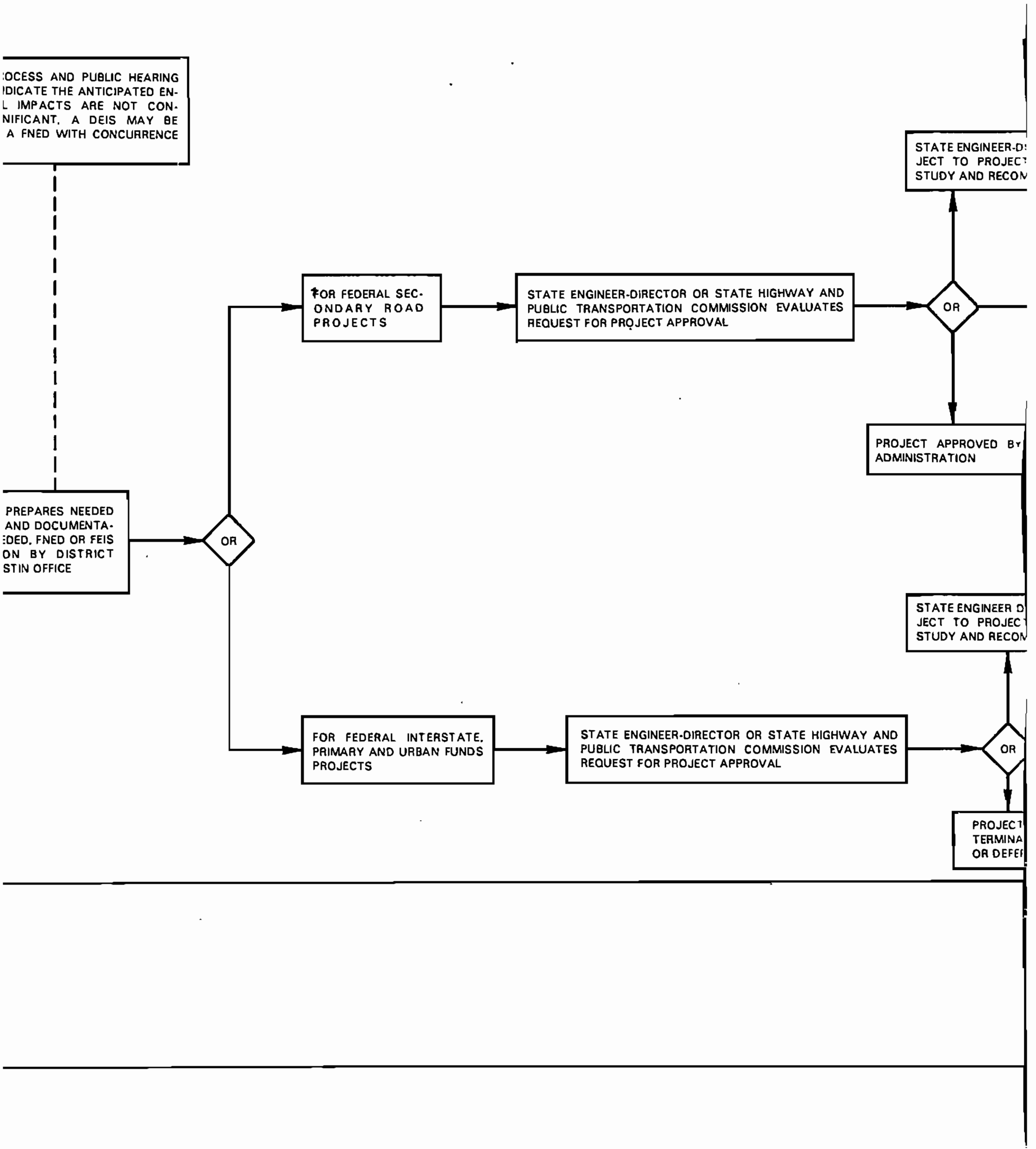
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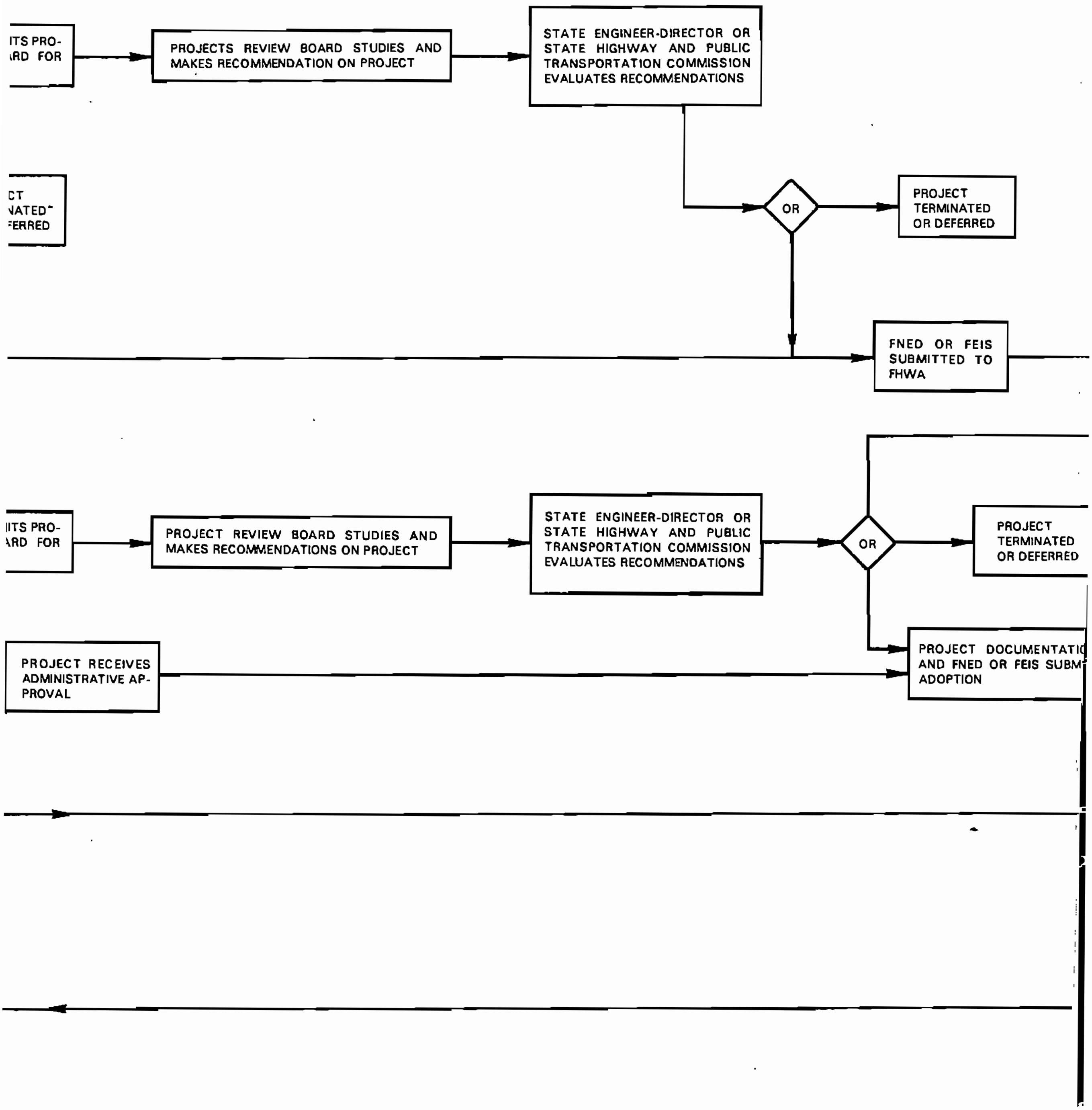

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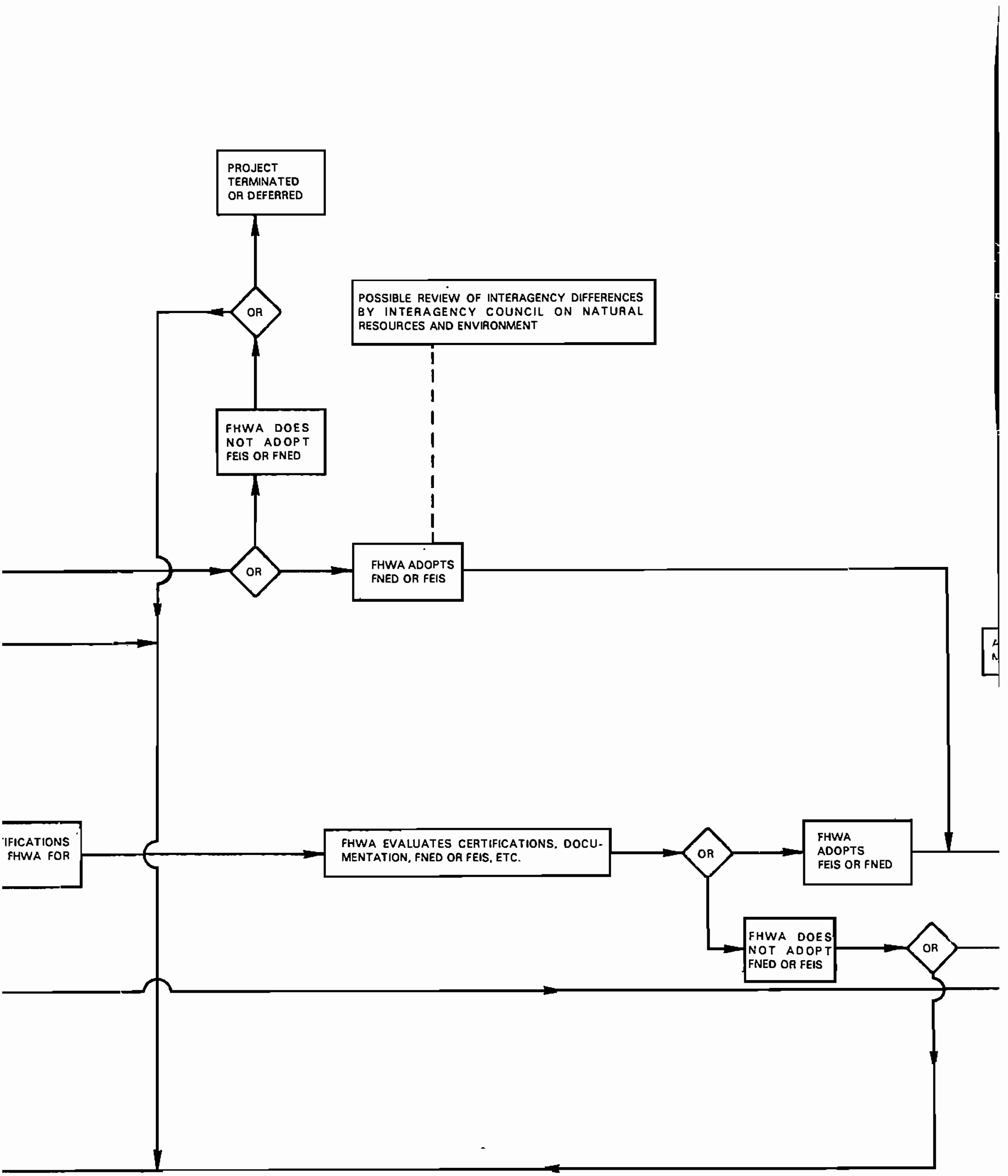
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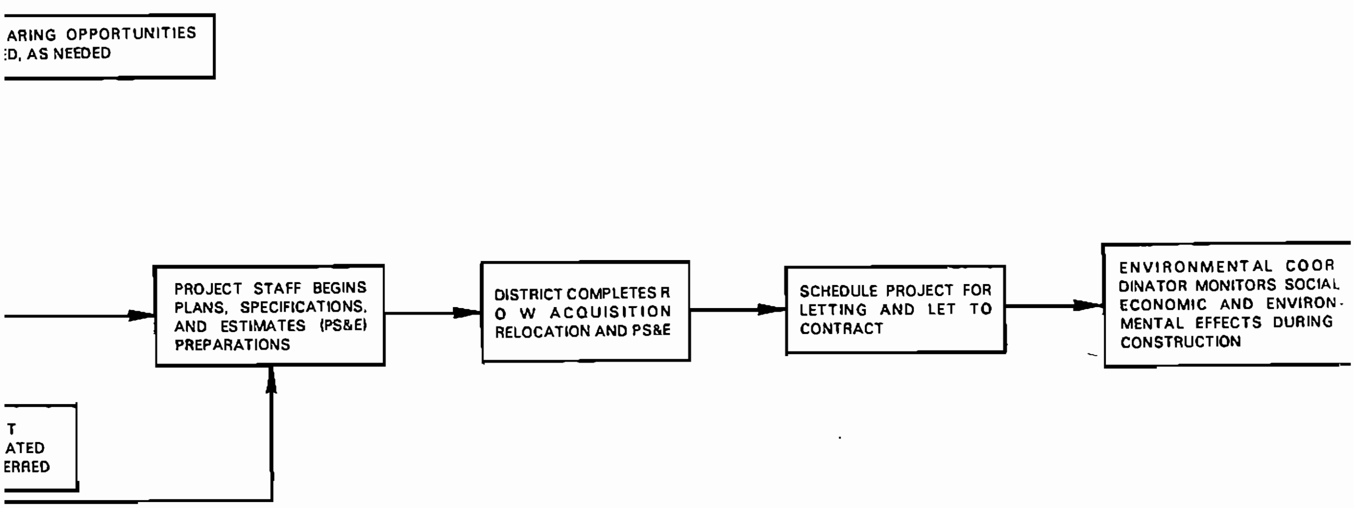

ARING OPPORTUNITIES
:D, AS NEEDED
PROJECT STAFF BEGINS PLANS, SPECIFICATIONS, AND ESTIMATES (PS&E) PREPARATIONS
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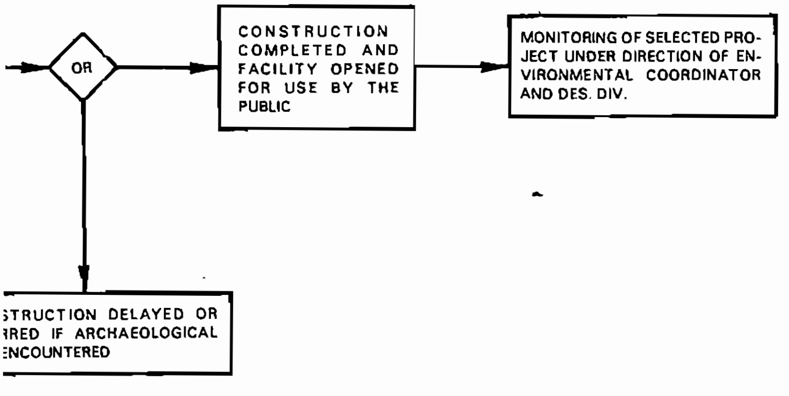
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CONSTRUCTION COMPLETED AND FACILITY OPENED FOR USE BY THE PUBLIC
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PART III

NONFREEWAY RESURFACING, RESTORATION OR REHABILITATION (RRR) CONSTRUCTION PROJECTS

PART III
FEDERAL-AID RRR CONSTRUCTION PROJECTS (3-100)

3-101 PURPOSE

The basic purposes of resurfacing, restoration, or rehabilitation (RRR) construction projects are to preserve and extend the service life of existing highways and streets and to enhance safety. The scope of RRR projects vary from thin overlays and minor safety upgrading to rehabilitation. Pavement rehabilitation includes all pavement related work undertaken to extend the service life of an existing facility. This includes placement of additional surfacing material and/or other work necessary to return an existing roadway, including shoulders, to a condition of structural and/or functional adequacy. The following are some examples of pavement rehabilitation work:

1. Resurfacing to provide improved structural capacity and/or serviceability.
2. Removing and replacing deteriorated materials.
3. Replacing or restoring malfunctioning joints.
4. Reworking or strengthening of bases and subbases.
5. Recycling existing materials.
6. Adding underdrains.

Special design guidelines have been developed for RRR projects which allow greater design flexibility than applying the full standards traditionally used for new construction and reconstruction projects. In unusual situations where it is not feasible to meet the conditions of these (RRR) guidelines, a request for an exception should be made. Approval for design exceptions should be obtained from the responsible Austin Division Office and the Federal Highway Administration (FHWA) at the earliest practical point in project development.

The RRR criteria contained herein establish pavement, geometric, roadside, and bridge design guidelines that will be used to determine eligibility for Federal-aid RRR funding. In those instances where specific RRR design values are not presented in Part III of this Manual, reference should be made to Part IV "Design" for guidance.

These guidelines offer sufficient flexibility to insure cost effective design and further assure compliance with the program goals of preserving and extending service life and enhancing safety.

Sections 3-101, 3-102, 3-103, and 3-104 apply to Federal-aid RRR projects, and Section 3-201 applies to RRR projects utilizing 100% State funds.

3-102 DESIGN CHARACTERISTICS

A. Pavement Design

Less than 3/4 overlays and coats not eligible for fed-aid

The existing pavement condition and deficiencies should be identified for RRR projects. Design strategies selected to correct deficiencies will vary from thin (minimum 3/4 inch) overlays to thick overlays or complete pavement structure reconstruction. Seal coat surfacing of the travelway and overlays of less than 3/4 inch are ineligible for Federal-aid RRR funding. Rehabilitation strategies such as coldplaning and recycling are eligible for Federal-aid RRR funding.

Service life must be extended a min of 5 years and be documented

Corrective measures for pavement deficiencies must extend the service life for a minimum of five years. To document that this minimum design life will be attained, pavement design may be based on analytical methods, such as typified by the Flexible Pavement Design System (FPS), or on historical information. Historical data, when used, should show that a similar pavement design has provided a five or more year life under similar traffic and other relevant conditions. Documentation of the basis for pavement design selection should be submitted to the Highway Design Division (D-8) with typical sections (see Section 3-104).

B. Geometric Design

Geometric design guidelines for rural two-lane highways, rural multilane highways, and urban streets are shown in Figures 3-1 through 3-3. Minimum values are shown for cross sectional design elements including roadway crown components and roadside obstruction clearances.

Where the existing highway features comply with minimum design values, the designer may choose to not modify these features. However, where existing values do not meet minimums, upgrading should generally be to the values shown in Part IV of this Manual. Where attaining the values shown in Part IV dictates the acquisition of additional right of way, or in other unusual conditions, consideration may be given to upgrading to the maximum extent feasible within existing right of way as long as these values meet or exceed minimum values. In these cases, prior approval will be required from the responsible Austin Division Office and the FHWA.

Typically, RRR projects will involve minor or no change in either vertical or horizontal alignment. However, flattening of curves or other corrective measures should be considered where suggested by accident history, or where existing curvature is inconsistent with prevailing traffic speeds or prevailing rate of curvature on the route. Superelevation deficiencies on high speed roadways should be corrected to the maximum extent feasible.

3R DESIGN GUIDELINES FOR RURAL MULTILANE

HIGHWAYS (NONFREEWAY)

Design Element	Highway Class		
	6-Lane Divided	4-Lane Divided	4-Lane Undivided
Alignment:	Min.[a,d]	Min.[a,d]	Min.[a,d]
Design Speed[b] (mph)	50	50	50[c]
Roadway Cross Section:			
Lane Width (Ft)	11	11	11
Outside Shoulder (Ft)	4	4	4
Inside Shoulder (Ft)	4	2	N/A
Obstruction Clearance (Ft)	16	16	16
Bridges:			
Widened or Reconstruct (Ft)	Use Standards for New Construction		
To Remain, Min. (Ft)	42	28	52

a Minimum values, if existing, may be retained without modification.
b Flat or rolling terrain
c For rolling terrain, 40 mph acceptable
d Where existing highway features fail to comply with minimum values, upgrading should meet the requirements shown in Part IV for new construction and reconstruction projects.

Figure 3-1. Refers to Paragraph 3-102(B)

3R DESIGN GUIDELINES FOR RURAL TWO-LANE HIGHWAYS

Design Element	Traffic Brackets for Design Control (ADT)[a]		
	0-400	400-750	750 or More
Alignment:			
Min. Design Speed[b] (mph)	30	40	40[c]
Roadway Cross Section:	Min.[d,h]	Min.[d,h]	Min.[d,h]
Shoulder Width (Ft)[e]	1	1[f]	3
Traveled Way Width (Ft)	22	22	22
Crown Width (Ft)	24	24	28
Obstruction Clearance (Ft)	7	7	16[i]
Bridges[g]:			
Width (Ft) for Collectors	22	24[f]	24[f,g]
Width (Ft) for Arterials	28	28	28

a ADT is current average daily traffic.
b Flat or rolling terrain
c 50 mph for flat terrain and 1500 or more ADT
d Minimum values, if existing, may be retained.
e Shoulders preferably surfaced full width; unsurfaced or partially surfaced shoulders permissible.
f Use additional 1 ft. width on shoulders and 2 ft. on bridges where design speed is 50 mph or more.
g For current ADT exceeding 3000, minimum width of bridge is 30 feet.
h Where existing highway features fail to comply with minimum values, upgrading should meet the requirements shown in Part IV for new construction and reconstruction projects.
i A 7' wide obstruction clearance may be retained on rural collectors with current ADT volume of 1500 or less.

Figure 3-2. Refers to Paragraph 3-102(B)

reached only if the guard fence is less a danger than the hazard it would protect, or if the cost of otherwise safety treating the hazard is prohibitive.

c. Use of higher than minimum design standards result in a driver environment which is fundamentally safer because it is more likely to compensate for driver errors. Frequently, a more liberal design, including sight distances greater than minimum, flattened slopes, etc., costs little more over the life of a project and increases its safety and usefulness substantially.

d. For improved safety performance, highway geometry and traffic control devices should merely confirm drivers' expectations. Unexpected situations, such as left side ramps on freeways, sharp horizontal curvature introduced within a series of flat curves, etc., have demonstrated adverse effects on traffic operations and safety.

These principles have been incorporated as appropriate into the design standards included herein. It is the responsibility of the designer that these principles be carefully examined for their applicability at each particular site based on its particular circumstances, including the aspects of social impact, environmental impact, economy, and safety.

8. Horizontal Clearances to Obstructions

A clear recovery area should be provided along high speed rural highways. Such a recovery area should be clear of unyielding objects where practical or shielded by crash cushions or guardrail.

Figure 4-21 shows criteria for horizontal clearances to obstructions on new location projects and "major" reconstruction projects on existing routes. "Major" reconstruction projects are those which involve extensive vertical or horizontal re-alignment, and/or extensive alteration of side slopes.

The clear zone values shown in Figure 4-21 are measured from the edge of travel lane. These are appropriate design values for all cut sections (see Paragraph 4-202(H)3 for cross sectional design of ditches within the clear zone) and for all fill sections with side slopes 6:1 or flatter. For steeper fill slopes, errant vehicles have reduced chance of recovery and the lateral extent of each roadside encroachment increases. It is therefore preferable to provide a hazard-free area beyond the toe of steep side slopes even when this area is outside the clear zone.

HORIZONTAL CLEARANCES ON NEW LOCATION
AND MAJOR RECONSTRUCTION PROJECTS

Location	Functional Classification	Design Speed (mph)	Avg. Daily Traffic[1]	Clear Zone Width (ft.)[2,3,4] Minimum	Desirable
Rural	Freeways	All	All	30 (16' for ramps)	
Rural	Arterial	All	0 - 750 750 - 1500 1500 or more	10 16 30	16 30 --
Rural	Collector	45 or more	All	Use above rural arterial criteria.	
		40 or less	All	10	--
Rural	Local	All	All	10	--
Urban	Freeways	All	All	30 (16' for ramps)	
Urban	All (curbed)	45 or less	All	1.5 from curb face[5]	3'
Urban	All (uncurbed)	45 or more	All	Use above rural arterial criteria.	
Urban	All (uncurbed)	40 or less	All	10[5]	--
Urban	All (curbed)	50 or more	All	Use above rural arterial criteria insofar as available border width permits.	

1 Average ADT over project life, i.e., 0.5 (present ADT and future ADT). Use total ADT on two-way roadways, directional ADT on one-way roadways.

2 W/O barrier or other safety treatment of appurtenances.

3 Measured from edge of travel lane for all cut sections and for all fill sections where side slopes are 6:1 or flatter. Where fill slopes are steeper than 6:1 it is desirable to provide a hazard-free area beyond the toe of slope.

4 Desirable, rather than minimum, values should be used where feasible.

5 See discussion in Section 4-302(J) regarding culvert end offset. For lateral clearance values to bridge piers for underpassing curbed streets, see Figure 4-68.

Figure 4-21. Refers to Paragraph 4-202(G)8

3R DESIGN GUIDELINES FOR URBAN STREETS

Design Element	Street Class All
Alignment:	Min.[a,b]
Design Speed[c] (mph)	30
Street Cross Section:	
Travel Lanes (Ft)	10
Turn Lanes (Ft)	10[d]
Parallel Parking Lanes (Ft)	7
Curb Offset (Ft)	0
Shoulders[e] (Ft)	2[f]
Obstruction Clearance (Ft)	To back of curb or outside edge of shoulder
Bridges:	
Widened or Reconstruct (Ft)	Approach roadway, including shoulders and sidewalk where applicable
To Remain, Min. (Ft)	Approach roadway not including shoulders

a Where existing highway features fail to comply with minimum values, upgrading should meet the requirements shown in Part IV for new construction and reconstruction projects.
b Minimum values, if existing, may be retained without modification.
c Flat or rolling terrain
d For two-way left turn lanes, 14' usual
e Applicable to uncurbed streets
f Minimally 1' of shoulder surfaced where lane width is 10' thereby providing a 22' surfacing width.

Figure 3-3. Refers to Paragraph 3-102(B)

Existing side and backslopes usually should be retained except where major crown widening or grade changes create conditions that dictate otherwise.

3-103 SAFETY ENHANCEMENTS

A. Basic Safety Improvements

Basic safety improvements will be required for all RRR projects. Basic safety improvements are defined as upgrading guard fence to present standards, providing signing and pavement markings in accordance with the Manual on Uniform Traffic Control Devices, providing a skid resistant surface meeting regular Federal-aid Highway requirements, and safety treating cross drainage pipe culverts 36 inches in diameter or smaller that are inside desirable (see Figure 4-21 in Part IV) obstruction clearance.

3" tolerance for MBGF

Metal beam guard fence (MBGF) shall be upgraded to current standards. Connections to structures, post spacing, and end treatment shall meet current design practices. Where rail height is 3 inches or more too high or too low, corrections in height are required.

Remove unwarranted MBGF

All MBGF that is unwarranted should be removed. MBGF also should be removed where obstacles being shielded may be cost effectively design treated (removed, made yielding, etc.).

Do not S.E.T. where other hazards require MBGF.

Headwalls on small (36 inch or less) cross drainage pipe culverts that are inside desirable (see Figure 4-21 in Part IV) obstruction clearance should be removed and sloping (3:1 or flatter) culvert ends that blend with existing side slopes should be installed. Where located behind MBGF, these culvert ends should be safety treated and MBGF removed where there are no other obstructions involved. Where MBGF is required for shielding other hazards, headwalls behind guard fence need not be safety treated. Also, where other non-removable, non-treatable hazards are present near these culvert ends, culverts need not be treated.

B. Other Safety Enhancements

Cross drainage box and pipe culverts greater than 36" may remain as they exist where minimum or greater obstruction clearance values are satisfied. Where minimum obstruction clearance values are not existing, safety treatment (grates, extension, or guard fence) will be required. Where the culvert end creates a severe safety hazard that is out of context with the remaining portion of the project, even though it meets minimum clearances, consideration must be given to safety treatment. On the other hand, where other non-removable and non-treatable hazards are located near culvert ends, treatment of culvert ends would be out of context with the immediate area, and guard fence or non-treatment may be the only choices.

repeated on page 3-7

for culverts 3'-5', pipe grated design is usually effective. check effects on hydraulics.

guard fence or non-treatment may be the only choices. For culvert spans from 3' to 5' and heights up to 5' that need to be safety treated, the pipe grated design is very effective from a safety standpoint and generally cost effective from an economic standpoint. Whenever sloping or grated inlet designs are utilized for these low height and width culverts, inlet restrictions (entrance loss coefficients) should be evaluated as to their effects on hydraulics. The entrance loss coefficients to be used should be 0.7 for a sloping pipe or straight wingwalls with a single pipe grate, 0.5 for flared wingwalls with pipe grates, and 0.4 for flared wingwalls no grates.

Treatment of driveway embankments and pipes will be required on RRR projects only where other design improvement necessitate the relocation or regrading of side ditches unless the embankments and pipes are located within the minimum obstruction clearance.

other work influences safety improvement

The extent of safety improvement selected for a particular project may be influenced by the extent of other work. Where pavement improvements extend pavement life substantially, more significant geometric and safety related improvements will generally be appropriate.

3-104 PRELIMINARY SUBMISSION

Required typical section

A typical section showing the existing and proposed pavement structure and proposed pavement cross slope, lane widths, shoulder widths, and typical side slope conditions should be submitted to the Highway Design Division (D-8) prior to P.S.&E. development for review and approval. For normal circumstances, the typical section and its documentation will be retained in Departmental files. For unusual conditions it will be submitted to the FHWA and become the approved basis for further project development.

Required accident data should accompany typical section.

The typical section should be accompanied by a submission of summarized accident data within project limits reflecting the last three available years of data. Normally summary information will be submitted for the following categories:

1. Fixed object, runoff road, and overturn accidents
2. Intersection and intersection related accidents
3. Wet surface condition accidents

This data should be analyzed by the designer and taken into account when scoping work in order that corrective measures may be taken where practical and feasible. Data may be printed in a format that can be easily understood and quickly analyzed using techniques developed by D18-TS.

In addition to the typical section and accident data, a brief report should be submitted that documents the extent of planned safety enhancements and the basis for performing (or not performing) this proposed work.

3-105 BRIDGES (INCLUDING BRIDGE CLASSIFICATION CULVERTS)

Figures 3-1 through 3-3 show minimum bridge widths that may remain without widening.

Existing minimum width bridges usually requiring no additional work

Where minimum bridge widths exist it is generally expected that no additional structure work will be necessary. The exception would be where severely deficient railing or deteriorated deck exists or where the structure has unsafe load carrying capability. In such cases the Bridge Division (D-5) should be consulted for design recommendations.

Existing structures not meeting minimum width shall be widened to desirable width and other structure elements such as railing should be constructed to present standards.

100% STATE FUNDED RRR CONSTRUCTION PROJECTS (3-200)

3-201 GUIDELINES

The following guidelines apply to RRR projects where 100% State funds are utilized for construction financing. These guidelines also should be used in determining design scope and estimating cost for individual candidate projects whenever a Rehabilitation Program is being developed.

A. Normally the scope and estimated cost of rehabilitation projects should be based on satisfying Federal-aid 3R guidelines. Accident data should be examined and, where there is an unusually high accident rate, high accident location, or high frequency of certain classes of accidents, emphasis should be placed on corrective design measures even if higher than 3R guidelines are necessary. Where cost effective and funds are sufficient to upgrade to full standards (Reference Part IV, Highway Design Division Operations and Procedures Manual) without jeopardizing District priorities for other rehabilitation work, development of P.S.&E. to full standards may be used at the District's discretion.

Development to full standards may be used at the District discretion.

B. Under certain abnormal conditions, development of P.S.&E. to meet Federal-aid 3R guidelines may not be practical nor cost effective. In these instances, individual projects should be identified and a request with supporting information should be submitted to the Highway Design Division before P.S.&E. development for funding with 100% State funds. The basic type of work for these projects typically involves measures to restore pavement structure and riding quality. In addition, skid resistance and new pavement markings enhance safety. Where pavement overlays effectively reduce guardrail height to more than three inches lower than standard height, adjustments should be made. Lastly, if there exists a high accident spot or location, corrective measures are encouraged in these highway subsections.

When projects are developed which do not meet 3-R guidelines, they should be submitted to D-8 before P.S.&E. development

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PART IV

DESIGN

PART IV
DESIGN — GENERAL (4-100)

4-101 APPLICATION OF DESIGN STANDARDS

A. Application of Part IV Guidelines

Part IV contains design guidelines that are applicable to new location and reconstruction projects. Reconstruction is:

1. Construction on the approximate alignment of an existing route where the entire existing pavement structure is removed and replaced, and/or

2. Construction that provides substantial changes in the general geometric character of a highway, such as widening to provide additional lanes, realignment vertically and/or horizontally, etc.

Part III Section 3-101 should be referenced for guidelines for nonfreeway resurfacing, restoration, and rehabilitation projects.

B. Minimum Standards

minimum standards and design flexibility

The Standards contained herein generally represent minimum values that should be considered by the Engineer as the lowest acceptable limits in design. It is expected that design will embody the highest values possible, commensurate with conditions. A few of the design values may be considered inviolable, while others are presented as guide values or ranges of values that are sufficiently flexible to permit designs to be tailored to unique situations (such as those where costs, including social, environmental, or construction, dictate).

C. Departures from Standards

Deviation from standards

These design policies and guidelines are intended to serve as a basic Departmental guide in design work; however, they are not to be considered as inflexible. They are not intended as a substitute for engineering knowledge, experience or judgment. When it is deemed necessary or desirable to deviate from these design policies and standards, approval will be secured from proper Departmental authorities.

D. Policy on Use of AASHTO Standards

This manual takes precedence over AASHTO standards

The American Association of State Highway and Transportation Officials (AASHTO) has established various standards, policies, guides, etc., relating to highway practice. These are approved references to be used in conjunction with this Manual; however, since AASHTO policies and guidelines represent nationwide guidelines which do not always satisfy Texas conditions, the instructions in this Manual shall take precedence over AASHTO standards.

4-102 PREPARATION AND SUBMISSION OF GEOMETRIC LAYOUTS

Submission of geometric layouts.

Prior to initiating detailed plan preparation for a proposed project, a preliminary plan should be prepared which indicates the general geometric features and location requirements peculiar to the project. Four copies of geometric layouts should be submitted to File D-8 for approval and subsequent coordination with the FHWA where applicable. Layouts should be submitted for two-lane arterial highway projects on new location and for all multilane highway projects.

The geometric layout should include basic information which is necessary for the proper review and evaluation of the proposed improvement such as the following:

1. The location of interchanges, mainlanes, grade separations, frontage roads and ramps.

2. Profiles and horizontal alignment of mainlanes, ramps, and crossroads at proposed interchanges or grade separations. Frontage road alignment data need not be shown on the schematic, however, it should be developed in sufficient detail to determine right of way needs.

3. For freeways, the location and text of the proposed mainlane guide signs should be shown. Lane lines and/or arrows indicating the number of lanes shall also be shown.

4. A complete explanation of the sequence and methods of stage construction, if proposed, which would include the initial and ultimate proposed treatment of crossovers and ramps.

5. The tentative right-of-way limits.

6. The geometrics (pavement cross slopes, lane and shoulder widths, slope rates for fills and cuts) of the typical sections of proposed highway mainlanes, ramps, frontage roads, and crossroads.

7. The projected traffic volumes.

8. The control of access lines if Interstate or designated under House Bill 179.

9. Direction of traffic flow on all roadways.

10. Location and width of median openings for highways without access control.

11. The geometrics of speed change (acceleration, deceleration, climbing) lanes.

Handling of traffic during construction should be a consideration in the development of preliminary designs.

Geometric layout is exhibited at public hearings

Upon approval of the geometric layout by File D-8 (FHWA on Federal-aid projects), it should be the basis for an exhibit at any required public hearing prior to final development of the project. If there are any changes to the schematic after File D-8 and FHWA approval and before the public hearing, four copies of the revised schematic, as displayed at the hearing, should be submitted either prior to or accompanying the public hearing data. If there are not changes in the schematic as displayed at the hearing, only photographs of the schematic and other displays should be submitted with the public hearing data.

For all freeway construction projects, these schematics should show the location and text of the proposed mainlane guide signs.

Encourage preliminary contact on complex projects

On complex projects, informal contact with Austin Office and FHWA personnel is encouraged with regard to development of preliminary design, prior to official schematic submission.

4-103 TYPICAL SECTIONS

Prior to initiating detailed plan preparation for a project a preliminary investigation should be made to determine the approximate section and pavement type to be used for the pavement structure. The Flexible Pavement Designer's Manual for flexible pavement and Appendix F for rigid pavement may be used for this purpose.

A typical section of the proposed design for all collector and arterial construction projects together with documentation of the pavement design should be furnished to the Highway Design Division prior to detailed preparation of the PS&E.

The Pavement Design Section is available for consultation and assistance for pavement design problems. The typical section should also reflect proposed geometrics including pavement cross slopes, lane and shoulder widths, and slope rates whenever this data has not been previously shown on a schematic submission.

BASIC DESIGN CRITERIA (4-200)

4-201 TRAFFIC CHARACTERISTICS

Traffic volume is important

The volume of traffic is an important basis for determining what improvements, if any, are required on a highway or street facility. Traffic volumes may be expressed in terms of average daily traffic or design hourly volumes. Vehicles of different sizes and weights have different operating characteristics which must be considered in highway design.

A. Average Daily Traffic

ADT

Average daily traffic (ADT) represents the total traffic for a year divided by 365, or the average traffic volume per day. Due to seasonal, weekly, daily, or hourly variations, ADT is generally undesirable as a basis for design, particularly for high volume facilities. ADT should only be used as a design basis for low and moderate volume facilities, where additional lanes unquestionably are not justified.

B. Design Hourly Volumes

DHV for level of service and geometric design

The design hourly volume (DHV) is the thirtieth highest hourly volume for the design year, commonly twenty years from the time of construction. DHV is the traffic parameter most commonly used in level of service evaluations and for geometric design. In particular situations involving high seasonal fluctuations in ADT, some adjustment of DHV may be appropriate. DHV is determined by the application of conversion factors to ADT as discussed in Paragraph 4-201(D).

C. Factors Affecting Design Hourly Volume Determination

Traffic composition, directional distribution, and the percent of ADT occurring in the design hour are factors considered in converting ADT to DHV.

"K" factor is percent of ADT in the thirtieth highest hourly volume (DHV)

1. The percent of ADT occurring in the design hour is commonly referred to as the "K" factor, or sometimes called the DHV factor. "K" factor is the percentage of ADT representing the thirtieth highest hourly volume in the design year. For typical main rural highways, "K" factors generally range from twelve to eighteen percent. For urban facilities, "K" factors are typically somewhat lower, ranging from eight to twelve percent.

"D" factor is percentage of DHV in the predominant direction of travel

2. The percentage of the design hourly volume that is in the predominant direction of travel is known as the directional distribution factor, or "D". As a general rule, traffic tends to be more equally divided by direction near the center of an

urban area or on loop facilities. For other facilities, "D" factors of sixty or seventy percent frequently occur.

"T" factor is percentage of trucks during the design hour.

3. Composition of traffic is normally expressed as the percentage of trucks during the design hour and is referred to by the letter "T". For geometric design and capacity studies, the truck traffic is usually converted to passenger cars through application of equivalency factors. Truck traffic volume is equivalent to a larger volume of passenger cars since trucks occupy a greater road space and exhibit restricted operating characteristics. For design purposes, light delivery trucks, such as panels and pickups, operate similarly to passenger cars and are included as such. Combination truck-trailers, buses, and single unit trucks with dual rear tires are included in "T".

D. Conversion of ADT to DHV

Projected traffic volumes provided by D-10

Projected traffic volumes are provided by the Transportation Planning Division, File D-10, upon request and serve as a basis for design of proposed improvements. For high volume facilities, a tabulation showing traffic converted to DHV will be provided by D-10 if specifically requested. Generally, however, projected traffic volume is expressed as ADT, with K, D, and T factors provided. The user then must convert ADT to DHV.

The first step in converting ADT to DHV is selection of an appropriate truck equivalency factor, E_t. For approximate analysis of operations on a given highway section it is usually sufficient to apply an overall approximate E_t as selected from Figure 4-1 to the entire section. In more refined spot analysis, however, truck operations on each of the more significant grades should receive individual attention. Appropriate truck equivalencies for spot analysis for freeways, expressways, and multilane highways are shown in Figure 4-2.

The value of E_t depends on the type of highway facility and its grades. In level terrain where trucks can maintain speeds that are equal to or approach the speed of passenger cars, trucks are equivalent, in a capacity sense, to two passenger cars on multilane highways and two to three passenger cars on two-lane highways. For rolling or mountainous terrain, however, E_t increases as shown in Figure 4-1. Particular care should be exercised in selecting an appropriate E_t for urban freeways on level terrain, since design mainlane profile may, in effect, induce rolling terrain characteristics.

Once an E_t has been selected, the ADT to DHV conversion may be accomplished through application of E_t and the factors furnished by File D-10 (K, D, T). ADT may be furnished as directional (one-way) or non-directional (two-way), and the conversion procedures for these two cases are as follows:

TWO-LANE HIGHWAYS
PASSENGER CAR EQUIVALENTS FOR TRUCKS
(INCLUDING UPGRADES, DOWNGRADES, AND LEVEL SUBSECTIONS)

LEVEL OF SERVICE	EQUIVALENT E_T, FOR:		
	LEVEL TERRAIN	ROLLING TERRAIN	MOUNTAINOUS TERRAIN
A	2	4	7
B and C	2.2	5	10
D and E	2	5	12

FREEWAYS AND MULTILANE HIGHWAYS
PASSENGER CAR EQUIVALENTS FOR TRUCKS
(INCLUDING UPGRADES, DOWNGRADES, AND LEVEL SUBSECTIONS)

LEVEL OF SERVICE	EQUIVALENT E_T, FOR:		
	LEVEL TERRAIN	ROLLING TERRAIN	MOUNTAINOUS TERRAIN
A	Widely variable, one or more trucks have same total effect, causing other traffic to shift to other lanes, use equivalent for remaining levels in problems.		
B through E	2	4	8

Figure 4-1. Refers to Paragraph 4-201(D)

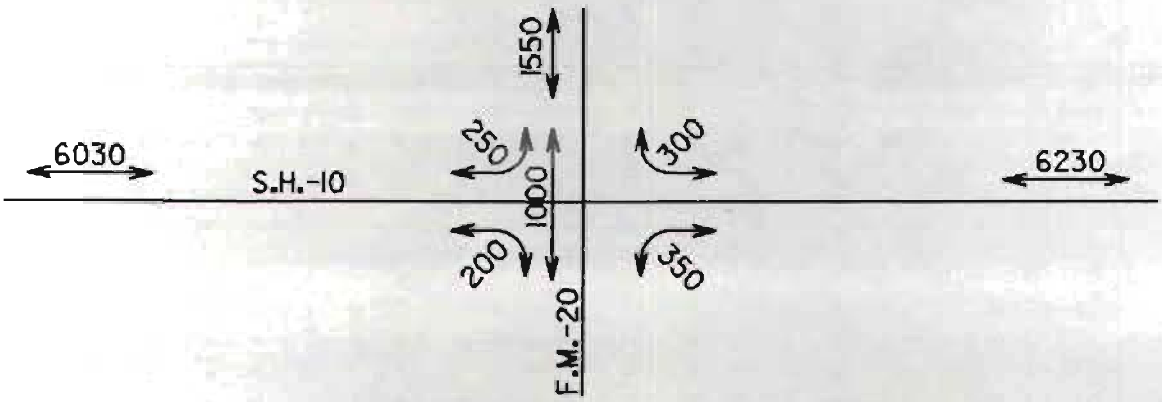
PASSENGER CAR EQUIVALENTS OF TRUCKS ON ORDINARY
MULTI-LANE HIGHWAYS, FREEWAYS AND EXPRESSWAYS ON SPECIFIC
INDIVIDUAL SUBSECTIONS OR GRADES

Grade (%)	Length (mi.)	E_T 4-Lane								6-8 Lane							
Percent Trucks		2	4	5	6	8	10	15	20	2	4	5	6	8	10	15	20
<1	All	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1	0-1/2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	1/2-1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	≥1	4	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3
2	0-1/4	4	4	4	3	3	3	3	3	4	4	4	3	3	3	3	3
	1/4-1/2	5	4	4	3	3	3	3	3	5	4	4	3	3	3	3	3
	1/2-3/4	6	5	5	4	4	4	4	4	6	5	5	4	4	4	4	4
	3/4-1 1/2	7	6	6	5	4	4	4	4	7	5	5	5	4	4	4	4
	≥1 1/ 2	8	6	6	6	5	5	4	4	8	6	6	5	4	4	4	4
3	0-1/4	6	5	5	5	4	4	4	3	6	5	5	5	4	4	4	3
	1/4-1/2	8	6	6	6	5	5	5	4	7	6	6	6	5	5	5	4
	1/2-1	9	7	7	6	5	5	5	5	9	7	7	6	5	5	5	5
	1-1 1/2	9	7	7	7	6	6	5	5	9	7	7	6	5	5	5	5
	≥1 1/2	10	7	7	7	6	6	5	5	10	7	7	6	5	5	5	5
4	0-1/4	7	6	6	5	4	4	4	4	7	6	6	5	4	4	4	4
	1/4-1/2	10	7	7	6	5	5	5	5	9	7	7	6	5	5	5	5
	1/2-1	12	8	8	7	6	6	6	6	10	8	7	6	5	5	5	5
	≥1	13	9	9	9	8	8	7	7	11	9	9	8	7	6	6	6
5	0-1/4	8	6	6	6	5	5	5	5	8	6	6	6	5	5	5	5
	1/4-1/2	10	8	8	7	6	6	6	6	8	7	7	6	5	5	5	5
	1/2-1	12	11	11	10	8	8	8	8	12	10	9	8	7	7	7	7
	≥1	14	11	11	10	8	8	8	8	12	10	9	8	7	7	7	7
6	0-1/4	9	7	7	7	6	6	6	6	9	7	7	6	5	5	5	5
	1/4-1/2	13	9	9	8	7	7	7	7	11	8	8	7	6	6	6	6
	1/2-3/4	13	9	9	8	7	7	7	7	11	9	9	8	7	6	6	6
	>3/4	17	12	12	11	9	9	9	9	13	10	10	9	8	8	8	8

NOTE: If the length of grade falls on a boundary value, use the equivalent for longer grade class. Any grade steeper than the percent stated must use the next higher grade category.

Figure 4-2. Refers to Paragraph 4-201(D)

Case I: Non-directional ADT given as shown on sketch, K = 14%, D = 60%, and T = 10%. A multilane highway is being considered on level terrain, hence select $E_t = 2$ from Figure 4-1.



The conversion formula for non-directional ADT to DHV is as follows:

$$DHV = (ADT)(K)(D)[1 + T(E_t - 1)]$$

Therefore, for the example problem,

$$DHV = (ADT)(0.14)(0.60)[1 + 0.10(2 - 1)]$$

$$= (ADT)(0.14)(0.60)(1.1)$$

$$DHV = (ADT)(0.092)$$

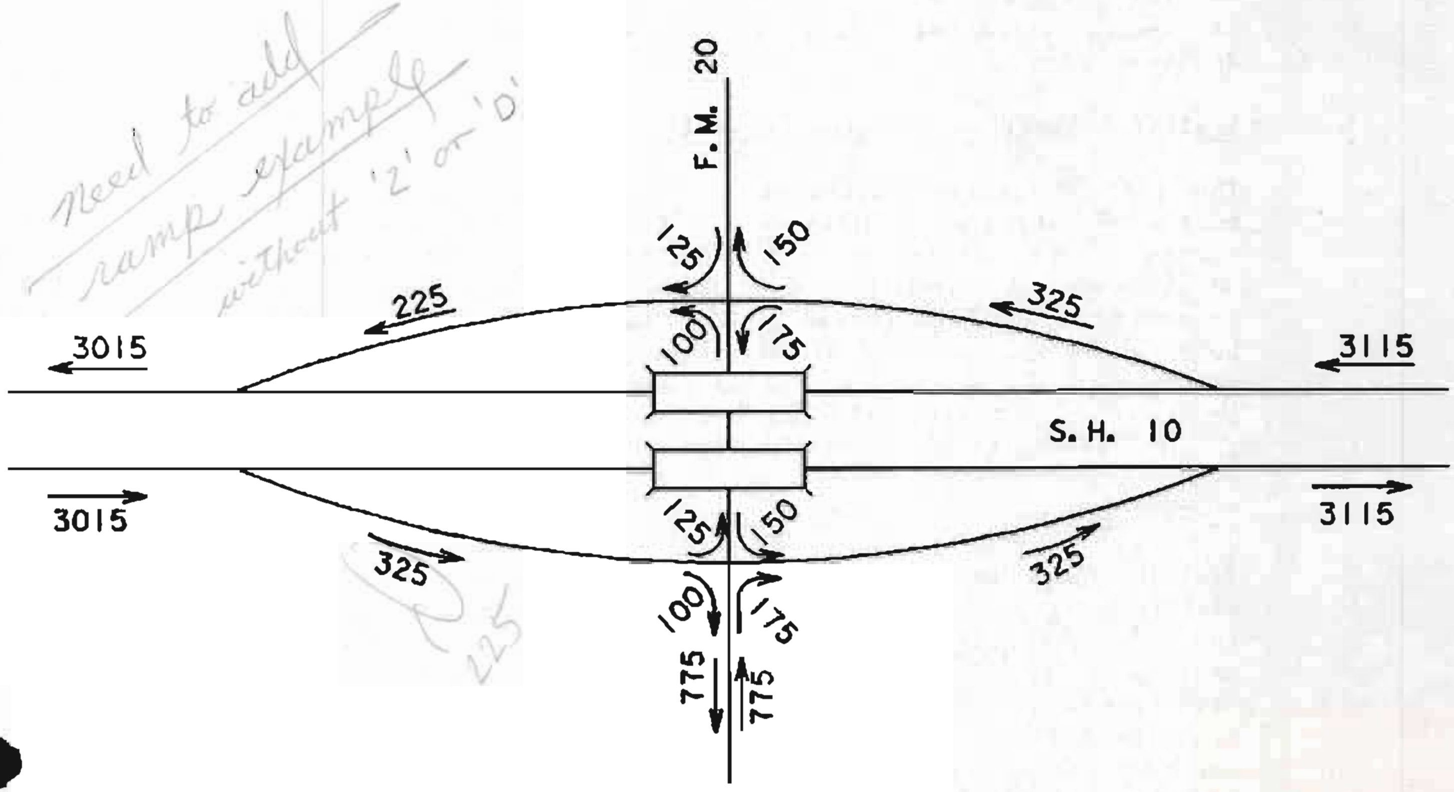
The value 0.092 becomes the computed conversion factor, accounting for the combined effects of trucks, directional flow, and rush hour peaking. This factor may be multiplied by the given non-directional ADT, either turning or non-turning, to determine DHV in passenger cars per hour in the predominant direction of flow.

Therefore, for a non-directional ADT = 6030 vehicles per day,

$$DHV = (6030)(0.092)$$

DHV = 557 passenger cars per hour in the predominant direction (i.e., one way).

Case II: Directional ADT given as shown on the sketch, K = 14%, D = 60%, T = 10%, and E_t of 2 has been selected.



The conversion formula for directional ADT to DHV is as follows:

$$DHV = 2(ADT)(K)(D)[1 + T(E_t - 1)]$$

Therefore, for the example problem,

$$DHV = 2(ADT)(0.14)(0.60)[1 + 0.10(2 - 1)]$$

$$= 2(ADT)(0.14)(0.60)(1.1)$$

$$= 2(ADT)(0.092)$$

$$DHV = (ADT)(0.184)$$

The value of 0.184 becomes the computed conversion factor, accounting for the combined effects of trucks, direction flow and peaking. Application of this factor to directional ADT values, either turning or non-turning, yields DHV in passenger cars per hour. Therefore, for a directional ADT of 3015 vehicles per day,

$$DHV = 3015(0.184)$$

$$DHV = 557 \text{ pcph.}$$

Traffic volumes are usually converted from ADT to DHV for an entire length of a proposed project. In DHV form, traffic volumes are readily usable for geometric design of intersections, for determining the type of facility which is appropriate and the number of lanes warranted, ramp merge-diverge analysis, and weaving analysis.

E. Traffic Volumes as a Design Control

Capacity is maximum number of vehicles passing a section (lane or roadway) during a given time

The term "capacity" pertains to the maximum number of vehicles reasonably expected to pass over a given section of lane or roadway during a given time period under prevailing roadway and traffic conditions. A knowledge of highway capacity is essential to the proper fitting of a planned highway to the requirements of traffic, both in the selection of highway type and in determining dimensional needs such as number of lanes and minimum lengths of weaving sections. Detailed information and level of service analysis procedures may be found in the Highway Capacity Manual.

F. Traffic Speed

Traffic speed is influenced by volume, capacity, design, weather, traffic control devices including legal limits and, of course, by individual driver preference. In the wake of national energy shortages, maximum legal speeds have been reduced to 55 mph, interrupting a long-term annual increase in average speed on rural highways for all vehicle types. Due to the uncertainties involved regarding future energy supplies, the permanence of the nationwide 55 mph speed limit cannot be predicted.

Low speed versus high speed

For design purposes, low speeds are 40 mph and below and high speeds are 50 mph and above. For speeds between 40 and 50 mph, the designer should select design controls (e.g., clear zone, superelevation) based on prevailing conditions, i.e., use high speed criteria for rural (uncurbed) cross sections and low speed criteria for urban (curbed) cross sections.

G. Design Speed

Design Speed is max. safe speed which can be maintained when design features govern.

Design speed is the maximum safe speed that can be maintained over a specified section of highway when the design features of the highway govern. All facilities should be designed with all elements in balance, consistent with an appropriate design speed. Design elements such as sight distance, vertical and horizontal alignment, lane and shoulder widths, roadside clearances, superelevation, etc., are influenced by design speed. It is therefore important that an appropriate design speed be selected.

Selection of design speed is influenced primarily by the character of terrain, economic considerations, extent of roadside development (i.e., urban or rural), and highway functional classification and type. For example, the design speed chosen would usually be somewhat less for rough terrain, or for an urban facility with frequent points of access, as opposed to a rural highway on level terrain. Choice should be influenced by the expectations of drivers which, in turn, are closely related to traffic volume conditions, potential traffic conflicts, and topographic features.

Appropriate design speed values for the various highway classes are presented in subsequent sections. Whenever mountainous conditions are encountered refer to <u>A Policy on Geometric Design for Streets and Highways</u>, AASHTO, 1984.

H. <u>Effects of Traffic Composition on Design of Turning Roadways and Intersection Corner Radii</u>

The width of turning roadways, such as between channelizing islands, and other intersection design features (median noses, corner radii, e.g.) are influenced by the volume of traffic and the vehicle types to be accommodated. Minimum designs for turning roadways and turning templates for various design vehicles are shown in Section 4-700, Miscellaneous Design Elements, Paragraph 4-710 "Minimum Designs for Truck Turns".

4-202 DESIGN ELEMENTS

A. <u>General</u>

Common to all types of highways and streets are several principal elements of design, such as sight distance, alignment, and pavement and shoulder cross slope.

B. <u>Sight Distance</u>

passing sight distance is applicable only in the design of two-lane rural highways.

Of utmost importance in highway design is the arrangement of geometric elements so that there is adequate sight distance for safe and efficient traffic operation assuming adequate light, clear atmospheric conditions, and drivers' visual acuity. For design, two types of sight distance are considered: that for overtaking vehicles, and that required for stopping. Passing sight distance is applicable only in the design of two-lane rural highways and therefore is presented in Paragraph 4-502(D).

C. <u>Stopping Sight Distance</u>

Minimum stopping sight distance is length of roadway required to enable a vehicle traveling at or near design speed to safely stop before reaching an object in its path. Based on driver's eye height of 3.5 feet and 0.5 feet height of object criteria, minimum stopping sight distance values for various design speeds are tabulated in Figure 4-3. These values are also recommended by AASHTO.

STOPPING SIGHT DISTANCE VALUES (WET PAVEMENTS)

Also recommended by AASHTO

DESIGN SPEED (mph)	STOPPING SIGHT DISTANCE (ft.)	
	MINIMUM	DESIRABLE
30	200	200
40	275	325
50	400	475
60	525	650
70	625	850

Figure 4-3. Refers to Paragraph 4-202(C)

After selection of design speed, stopping sight distance values become a controlling element for several basic design features such as roadway alignment and non-signalized intersection design. Greater than minimum stopping sight distances should normally be used, and minimum values used only in select instances where economic or other restrictive conditions dictate (Refer to Paragraph 4-101(A)).

D. Horizontal Alignment

1. Maximum Curvature

Maximum degree of curve, or minimum radius, is an important control value in designing for safe operation. Standards for curvature are shown in Figure 4-4.

2. Superelevation

As a vehicle traverses a horizontal curve, centrifugal force is counter-balanced by the vehicle weight component due to roadway superelevation and by the side friction between tires and surfacing as shown in the following equation:

$$e + f = V^2/15R$$

Where e = rate of superelevation, foot per foot

f = side friction factor

V = vehicle speed, mph

R = radius of curve, feet.

STANDARDS FOR CURVATURE OF HIGH SPEED HIGHWAYS AND CONNECTING ROADWAYS WITH SUPERELEVATION

Design Speed (mph)	Usual Max.[1] Degree of Curve (Radius of Curve)	Absolute Max.[1,2] Degree of Curve (Radius of Curve)
30	15°00'[3] (273')	22°45' (252')
40	10°00' (573')	12°15' (468')
50	6°00' (955')	7°30' (764')
60	3°00' (1910')	4°45' (1206')
70	2°00' (2865')	3°00' (1910')

1 Based on superelevation rate of e_{max}=0.08 ft./ft. For other maximum superelevation rates refer to AASHTO's A Policy on Geometric Design of Highways and Streets, 1984.

2 Absolute maximum values should be used only where unusual design circumstances dictate.

3 Applies to new location construction. For R-R-R or reconstruction, existing curvature equal to or flatter than absolute maximum value may be retained unless accident history warrants flattening curvature.

STANDARDS FOR CURVATURE OF HIGH SPEED HIGHWAYS WITHOUT SUPERELEVATION[1]

Design Speed (mph)	Max. Degree of Curve
50	0°30'
60	0°20'
70	0°15'
80	0°15'

1 Normal crown maintained. See Figure 4-6 for low speed streets.

Figure 4-4. Refers to Paragraph 4-202(D)1

Superelevation transition is change in cross slope from normal crown to full superelev. or vice versa. In general, 2/3 of transition is outside curve and 1/3 in the curve for simple circular curves.

Superelevation transition is the general term denoting the change in cross slope from a normal crown section to the full superelevated section or vice versa. To meet the requirements of comfort and safety, the superelevation transition should be effected over a length adequate for the usual travel speeds. In general, the location of the transition in respect to the end of a simple (circular) curve should be such that two-thirds of the transition is outside the curve and one-third within the limits of the curve. This results in two-thirds of the full superelevation at the beginning of the curve. On curves which are spiraled, the transition usually is distributed over the length of the spiral curve. Care must be exercised in the transition, especially in curbed sections or on bridges, to avoid drainage problems and unsightly curb or bridge rail profiles.

Profiles of both gutters or pavement edges should be plotted to insure proper drainage and smoothness throughout transition sections especially where these sections occur within vertical curvature of the profile grade line. A recommended and an alternate method for attaining superelevation is shown in Figure 4-5. Use of reverse parabolas as illustrated in the recommended method generally produces a gutter, pavement edge or bridge rail profile that is smooth, undistorted, and pleasing in appearance.

Rates of superelevation less for urban facilities.

There are practical limits to the rate of superelevation since high rates create steering problems for drivers traveling at lower speeds, particularly during ice or snow conditions. Additionally, on urban facilities lower maximum superelevation rates may be employed than on rural highways since adjacent buildings, lower design speeds, and frequent intersections are limiting factors. Maximum superelevation rates of 0.04 to 0.06 foot per foot are commonly used on urban streets without full access control. For urban freeways and all types of rural highways, rates 0.06 to 0.08 are generally used, and rates of 0.10 and 0.12 may be used for those instances where snow and ice are not factors.

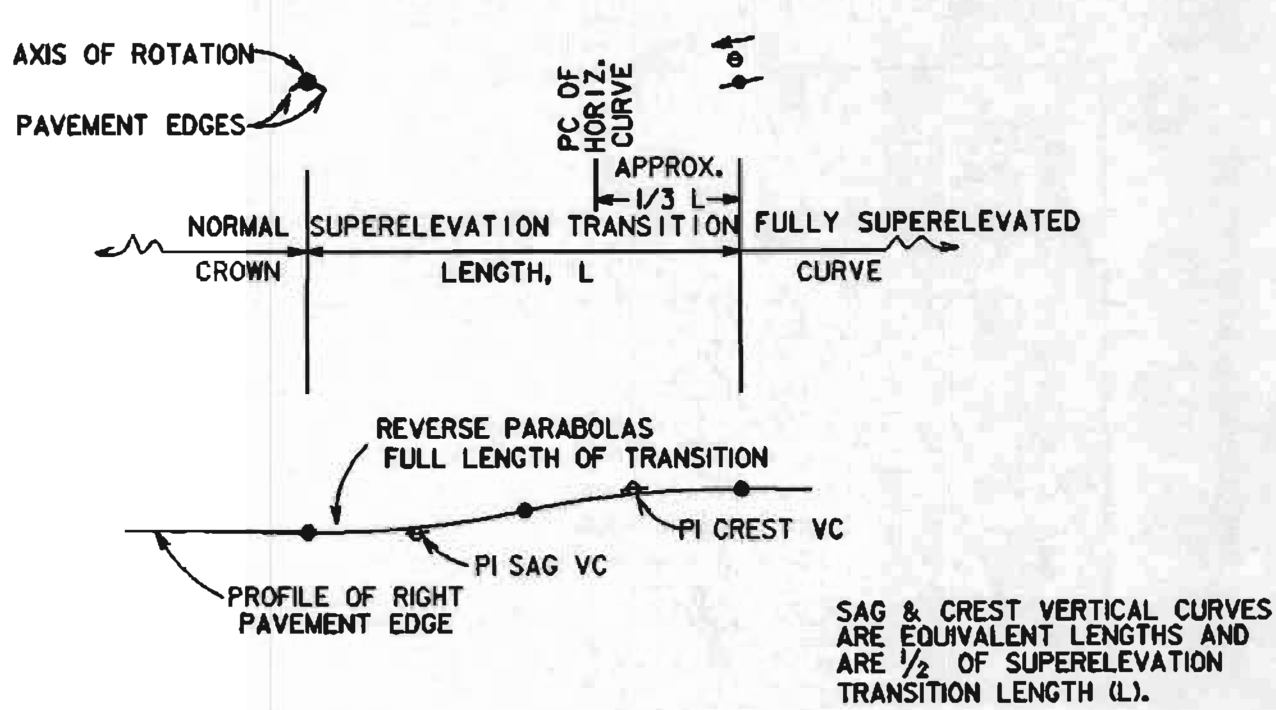
3. Superelevation on Low Speed Facilities

Superelevation omitted on low speed urban streets

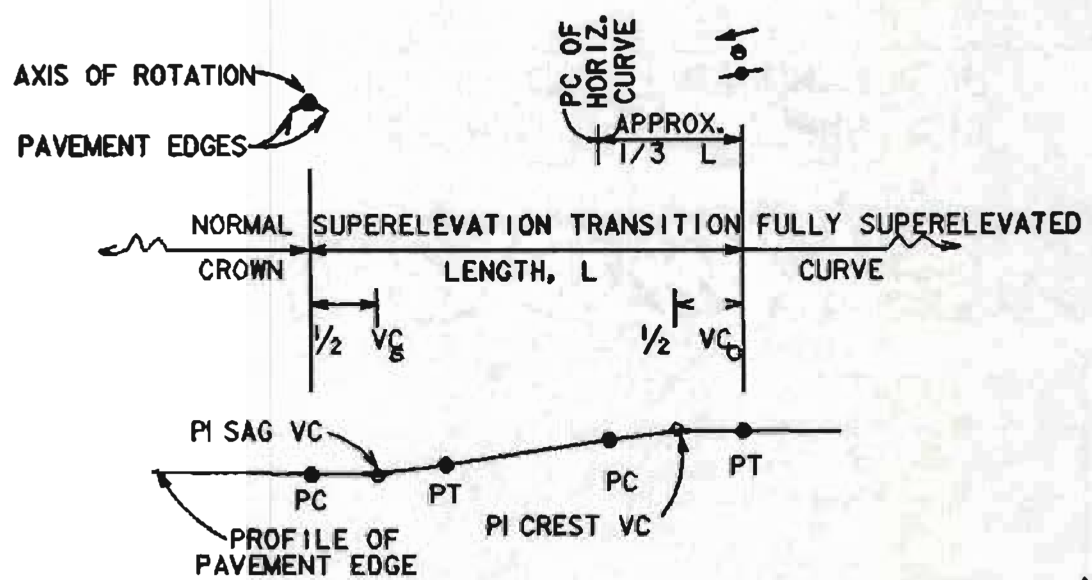
Although superelevation is advantageous for traffic operations, various factors often combine to make its use impractical in many built-up areas. These factors include wide pavement areas, surface drainage considerations, frequency of cross streets and driveways, and need to meet the grade of adjacent property. Therefore, horizontal curves on low speed streets in urban areas are frequently designed without superelevation and centrifugal force is counteracted solely with side friction.

Figure 4-6 shows maximum safe and comfortable vehicular speed for various pavement cross slopes for horizontal curves on low speed streets. For example, for a curve with radius of 350 feet

METHODS FOR ATTAINING SUPERELEVATION



RECOMMENDED METHOD, Reverse Parabolas Full Length of Transition

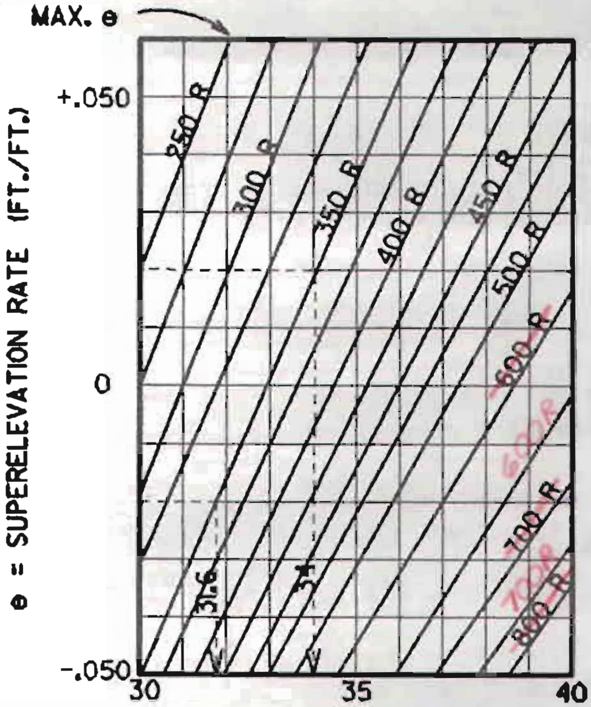


ALTERNATE METHOD, Reverse Parabolas Partial Length of Transition

Des. Speed mph	Min. VC Length Ft. Sag	Crest
50	45	55
60	55	85
70	60	115

Figure 4-5. Refers to Paragraph 4-202(D)2

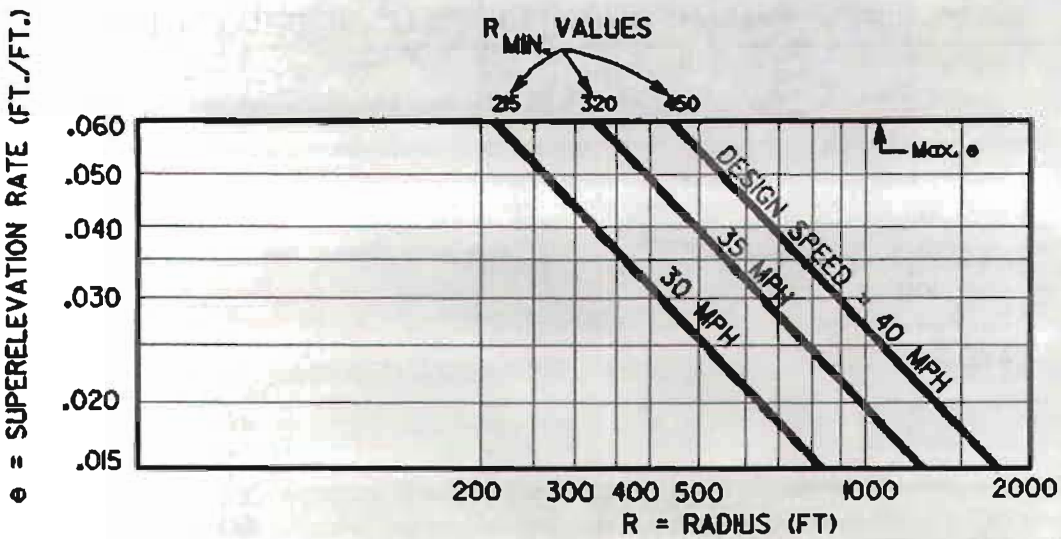
MAXIMUM SAFE AND COMFORTABLE SPEED (MPH) FOR HORIZONTAL CURVES ON LOW SPEED URBAN STREETS



FOR USE IN EVALUATING EXISTING CONDITIONS OR FOR CONSTRAINED CONDITIONS SUCH AS DETOURS.

Figure 4-6. Refers to Paragraph 4-202(D)3

DESIGN SUPERELEVATION FOR LOW SPEED URBAN STREETS



FOR RADII LARGER THAN MINIMUM, $e = \frac{R_{MIN.}}{R} \times e_{MAX.} = \frac{R_{MIN.}(0.06)}{R}$

Figure 4-7. Refers to Paragraph 4-202(D)3

and normal rooftop crown (0.02 ft./ft. cross slope each direction), the designer may enter Figure 4-6 and determine that the maximum safe and comfortable speed for travel is (a) 34 mph for positive crown condition, and (b) 31 to 32 mph for the negative crown condition. Maximum safe and comfortable speed should always equal or exceed design speed. This Figure should be used to evaluate existing conditions and may be used in design for constrained conditions, such as detours.

When superelevation is used on low speed streets, Figure 4-7 should be used to determine design superelevation rate for specific curvature and design speed conditions. For example, for a design speed of 40 mph and a 900 foot radius curve, Figure 4-7 shows that a 0.03 ft./ft. superelevation rate is appropriate.

Length of superelevation transition on roof-top crown, low speed, two lane streets with the centerline as the axis of rotation may be calculated using the formula:

$$L = 47.2(f)(V)/C$$

Where L = length of superelevation transition, ft.
f = side friction factor
V = design speed, mph
and C = rate of change of f, ft./sec^3

Using f values of 0.22 and 0.18 and C values of 3.5 and 3.0 at 30 and 40 mph design speeds, respectively, L values of 90 feet and 115 may be calculated for 30 and 40 mph design speeds.

Where the axis of rotation is an outside edge, or for wider streets, increased lengths as permitted by conditions should be used. For example, where a two lane pavement is to be rotated about an inside edge the length of transition shown in Figure 4-8 should be doubled. Also, for four or six lane pavements all length values should be doubled or tripled, respectively.

4. Superelevation on High Speed Facilities

Figures 4-9 and 4-10 show rates (max. 0.06 and 0.08 respectively) of superelevation for various design speeds and degrees of curvature. These Figures should be used for high speed facilities such as rural highways and urban freeways.

Desirable design values for length of superelevation transition on high speed facilities are based on using a maximum relative gradient of 0.5% (1:200) between profiles of the edge of pavement and axis of rotation subject to satisfying certain minimum values as subsequently discussed. Length of transition on this maximum relative gradient basis is directly proportional to the change in pavement edge elevation that is attributable to

MINIMUM RADII AND SUPERELEVATION TRANSITION

LENGTHS FOR LIMITING VALUES OF e AND f FOR

LOW SPEED URBAN STREETS

Design Speed (mph)	Max. e	Max. f	Min. R (ft)	C	Superelevation Transition Length[1], L (ft)
30	0.06	0.221	215	3.50	90
35	0.06	0.197	320	3.25	100
40	0.06	0.178	450	4.50	115
30	-0.02[2]	0.221	300	3.50	See
35	-0.02[2]	0.197	465	3.25	Footnote
40	-0.02[2]	0.178	675	4.50	2

[1] L based on two lane roadway rotated about centerline. For rotation about a pavement edge, or for multilane streets the design L is determined by multiplying the above tabulated L value times the number of lanes between the rotation axis and edge of pavement. Thus for 4 and 6 lane streets, with the centerline as the rotation axis, the design L is double and triple, respectively, the tabulated L.

[2] Superelevation is desirable and preferably should be used.

Figure 4-8. Refers to Paragraph 4-202(D)3

VALUES FOR SUPERELEVATION RATE RELATED
TO CURVATURE ON HIGH SPEED HIGHWAYS

		Superelevation Rate, e, for Design Speed of:			
D	Radius	40 mph	50 mph	60 mph	70 mph
0°15'	22918'	NC	NC	NC	NC
0°30'	11459'	NC	NC	RC NC	RC
0°45'	7639'	NC	NC RC	.021	.026
1°00'	5730'	RC NC	.020	.027	.033
1°30'	3820'	.020	.028	.037	.046
2°00'	2865'	.025	.035	.045	.055
2°30'	2292'	.030	.040	.051	.059
3°00'	1910'	.034	.045	.055	.060
3°30'	1637'	.038	.048	.058	
4°00'	1432'	.041	.052	.060	
5°00'	1146'	.046	.056		
6°00'	955'	.050	.059		
7°00'	819'	.053	.060		
8°00'	716'	.056			
9°00'	637'	.058			
10°00'	573'	.059			

e_{max} = 0.06 ft./ft.

NC = Normal Crown
RC = Reverse Crown

Figure 4-9. Refers to Paragraph 4-202(D)4

VALUES FOR SUPERELEVATION RATE RELATED
TO CURVATURE ON HIGH SPEED HIGHWAYS

		Superelevation Rate, e, for Design Speed of:			
D	Radius	40 mph	50 mph	60 mph	70 mph
0°15'	22918'	NC	NC	NC	NC
0°30'	11459'	NC	NC	RC	RC
0°45'	7639'	NC	RC	.022	.028
1°00'	5730'	RC —NC	.021	.029	.036
1°30'	3820'	.021	.030	.041	.051
2°00'	2865'	.027	.038	.051	.065
2°30'	2292'	.033	.046	.061	.075
3°00'	1910'	.038	.053	.068	.080
3°30'	1637'	.043	.058	.074	
4°00'	1432'	.047	.063	.078	
5°00'	1146'	.055	.071	.080	
6°00'	955'	.062	.077		
7°00'	819'	.067	.080		
8°00'	716'	.071			
9°00'	637'	.075			
10°00'	573'	.078			

e_{max} = 0.08 ft./ft.

NC = Normal Crown
RC = Reverse Crown

Figure 4-10. Refers to Paragraph 4-202(D)4

superelevation. Superelevation transition length therefore is directly proportional to the product of the change in pavement cross slope and the width of rotated pavement.

Example determinations of superelevation are shown in Figure 4-11. To calculate length of superelevation transition for any width pavement and superelevation rate, the designer should determine which pavement edge controls, calculate the necessary superelevation length L to provide a relative gradient of 0.5%, and use the greater of the calculated L or the minimum L specified in the subsequent paragraph.

minimum superelevation transition lengths

On high speed facilities, minimum transition lengths of 125, 150, 175, and 200 feet should be used for design speeds of 40, 50, 60, and 70 mph, respectively. Use of shorter transition lengths may result in an undesirable appearance.

Whenever the calculated (0.5% relative gradient basis) "desirable" value for length of superelevation transition controls but is impractical to provide, the length used should be as near as practical to the calculated desirable value.

Transition length overlap

Whenever reverse curves are closely spaced and superelevation transition lengths overlap, L values should be adjusted to prorate change in cross slope and to insure that roadways are cross sloped in the proper direction in each horizontal curve.

More detailed information regarding superelevation may be found in AASHTO's A Policy on Geometric Design of Highways and Streets, 1984.

5. Sight Distance on Horizontal Curves

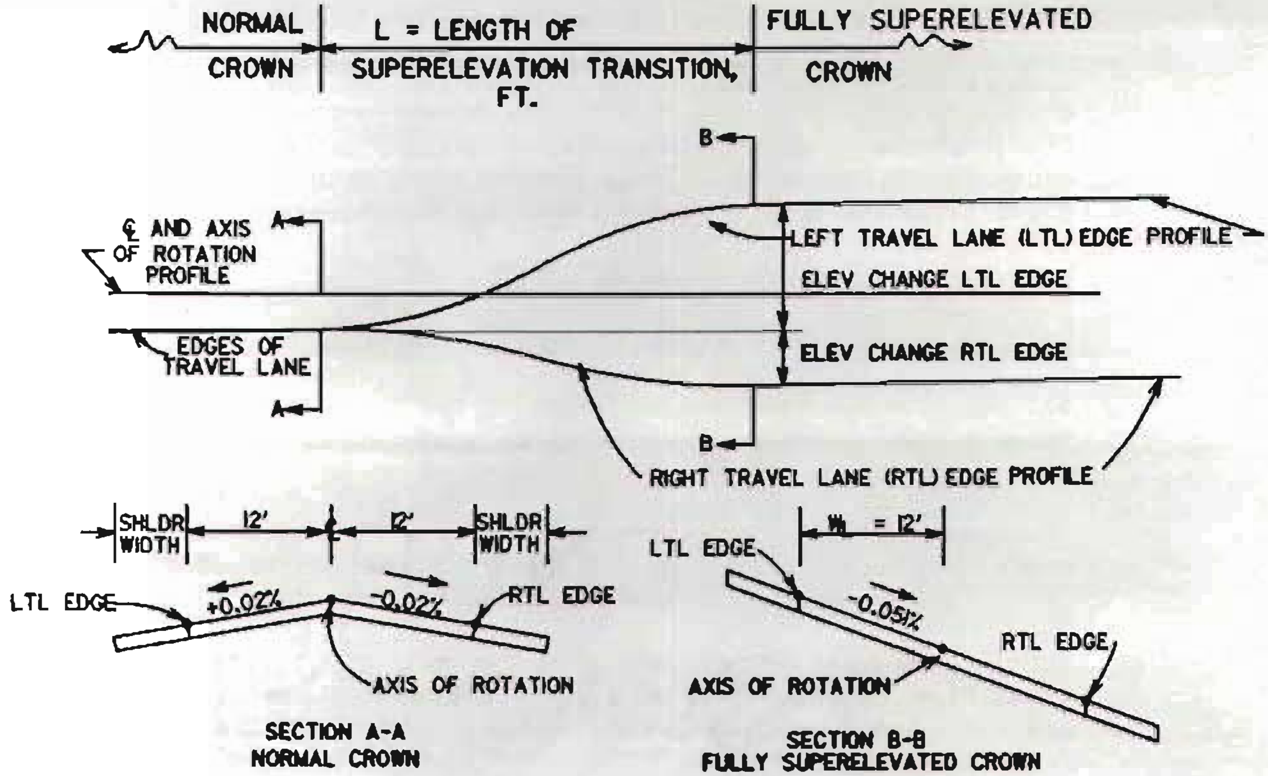
Where an object off the pavement, such as bridge pier, bridge railing, building, cut slope or natural growth restricts sight distance, the minimum radius of curvature is determined by the stopping distance.

Stopping sight distance on horizontal curves is obtained from Figure 4-12. It is assumed that the driver's eye is 3.5 feet above the center of the inside lane (inside with respect to curve) and the object is 0.5 foot high. The line of sight is assumed to intercept the view obstruction at the midpoint of the sight line and 2 feet above the center of the inside lane. The clear distance (m) is measured from the center of the inside lane to the obstruction.

6. General Consideration for Horizontal Alignment

In addition to the specific elements discussed previously, there are a number of general considerations which are important in

DETERMINATION OF DESIGN MINIMUM LENGTH OF SUPERELEVATION RUNOFF



EXAMPLE NO. 1:

GIVEN: RURAL TWO LANE HIGHWAY
DESIGN SPEED = 60 MPH
D = 2 DEGREES, TO THE RIGHT
℄ IS ROTATION AXIS
MAX. e = 0.08 FT./FT.

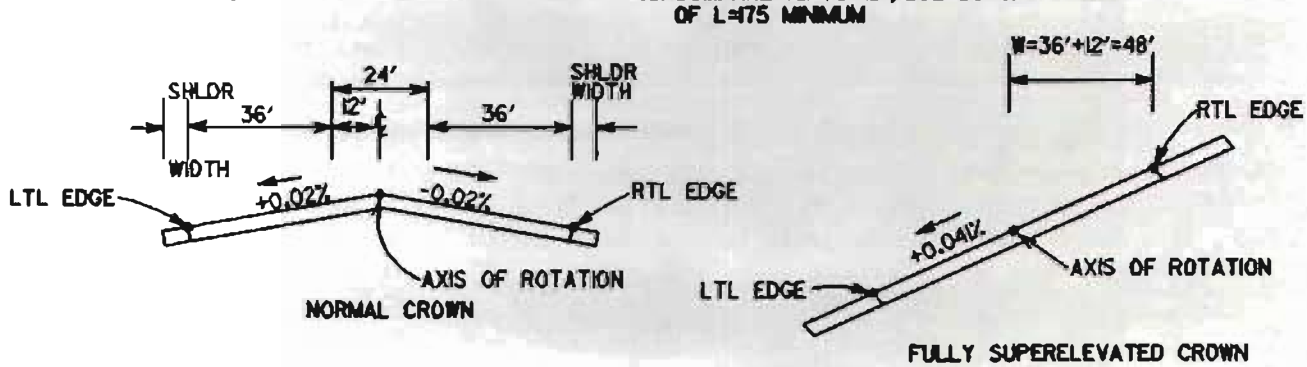
FIND: MINIMUM LENGTH OF SUPERELEVATION TRANSITION, L

SOLUTION:

(a) FROM PARAGRAPH 4-202(D)4 FOR V=60 MPH MINIMUM L=175 FT.

(b) CALCULATING MINIMUM L BASED ON 0.5% MAXIMUM RELATIVE GRADIENT:
L=(CHANGE IN CROSS SLOPE)(CRITICAL WIDTH)/0.005
L=[+0.02-(-0.051)](12)/0.005
L=170 FT.

(c) COMPARE (a) TO (b), USE LONGER VALUE OF L=175 MINIMUM



EXAMPLE NO. 2:

GIVEN: URBAN SIX LANE FREEWAY
DESIGN SPEED = 60 MPH
D = 1°30', TO THE LEFT
℄ IS ROTATION AXIS
MAX. e = 0.08 FT./FT.

FIND: MINIMUM LENGTH OF SUPERELEVATION TRANSITION, L

SOLUTION:

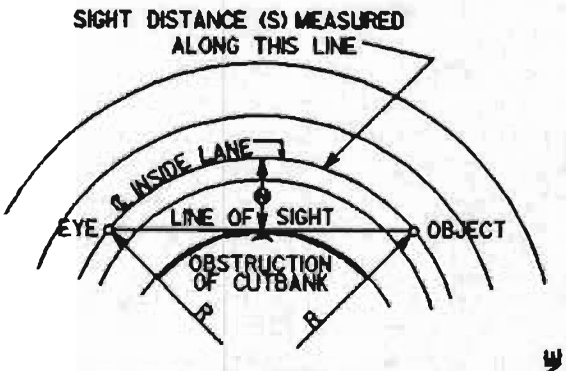
(a) FROM PARAGRAPH 4-202(D)4 FOR V=60 MPH MINIMUM L=175 FT.

(b) CALCULATING MINIMUM L BASED ON 0.5% MAXIMUM RELATIVE GRADIENT:
L=(CHANGE IN CROSS SLOPE)(CRITICAL WIDTH)/0.005
L=[-0.02-(+0.041)](48)/0.005
L=586 FT.

(c) COMPARE VALUES DETERMINED IN (a) AND (b) AND USE LONGER VALUE OF 586 FT.

Figure 4-11. Refers to Paragraph 4-202(D)4

STOPPING SIGHT DISTANCE ON HORIZONTAL CURVES



HEIGHT OF EYE 3.50 FEET.
HEIGHT OF OBJECT 0.5 FEET.

DESIGN SPEED M.P.H.	SIGHT DISTANCE FEET	
	MIN.	DES.
30	200	200
40	275	325
50	400	475
60	525	650
70	625	850

S = SIGHT DISTANCE IN FEET
R = RADIUS OF ℄ INSIDE LANE IN FEET
N = DISTANCE FROM INSIDE LANE IN FEET
V = DESIGN SPEED FOR S IN M.H.P.

ANGLE IS EXPRESSED IN DEGREES

$$N = R\left[\text{VERS}\left(\frac{28.65\ S}{R}\right)\right]$$

$$S = \frac{R}{28.65}\left[\cos^{-1}\left(\frac{R-N}{R}\right)\right]$$

FORMULA APPLIES ONLY WHEN S IS EQUAL TO OR LESS THAN LENGTH OF CURVE.

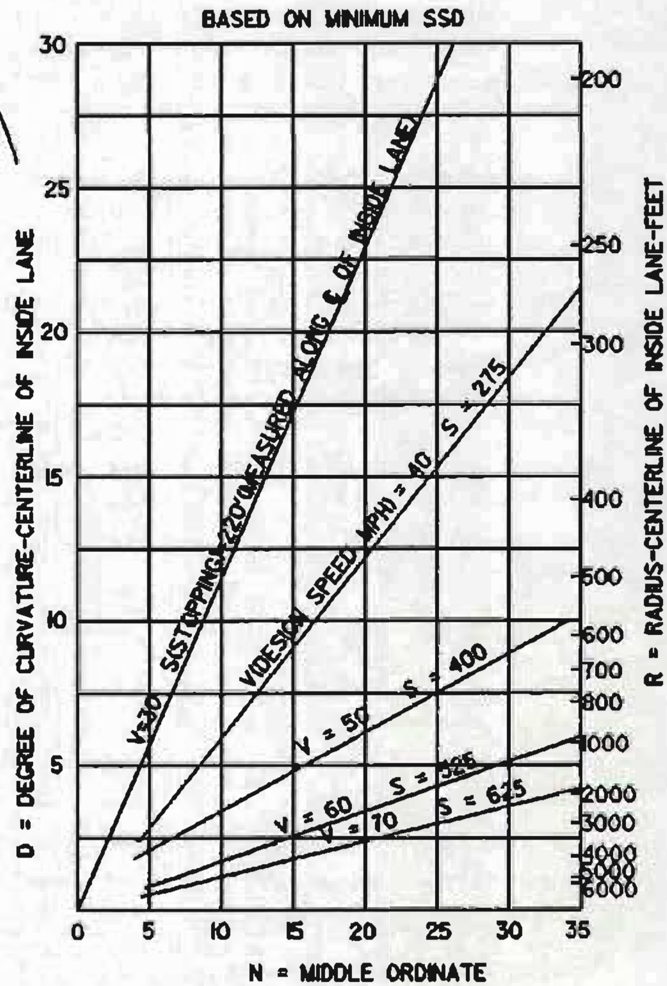


Figure 4-12. Refers to Paragraph 4-202(D)5

attaining safe, smooth flowing, and aesthetically pleasing facilities. These practices as outlined below are particularly applicable to high speed facilities.

a. Flatter than maximum curvature for a certain design speed should be used where possible, retaining the maximum standards for the most critical conditions.

b. Compound curves should be used with caution and should be avoided on mainlanes where conditions permit the use of flat (3°00' or flatter) simple curve. Where compound curves are used the radius of the flatter curve should not be more than 50 percent greater than the radius of the sharper curve for rural and urban open highway conditions. For intersections or other turning roadways, this percentage may be increased to 100%.

c. Reverse curves on high speed facilities should include an intervening tangent section of sufficient length to provide adequate superelevation transition between the curves.

d. Broken-back curves consist of two curves in the same direction connected with a short tangent and should not be used. This type of curve is unexpected by drivers and is not pleasing in appearance.

e. Horizontal alignment and its associated design speed should be consistent with other design features and topography. Coordination with vertical alignment is discussed in Paragraph 4-202(F).

E. Vertical Alignment

The two basic elements of vertical alignment are the tangents (grades) and vertical curves.

1. Grades

critical length of grade

The effects of rate and length are more pronounced on the operating characteristics of trucks than on passenger cars and thus may introduce hazardous speed differentials between the vehicle types. The term "critical length of grade" is used to indicate the maximum length of a specified ascending gradient upon which a loaded truck can operate without an unreasonable reduction (commonly 10 mph) in speed. Figure 4-13 shows the relationship of percent upgrade, length of grade, and truck speed reduction; where critical length of grade is exceeded for two-lane highways, climbing lanes should be considered as discussed in Paragraph 4-502(E) and Appendix D.

CRITICAL LENGTHS OF GRADE FOR DESIGN, ASSUMED TYPICAL HEAVY TRUCK OF 300 LB/HP, ENTERING SPEED = 55 MPH

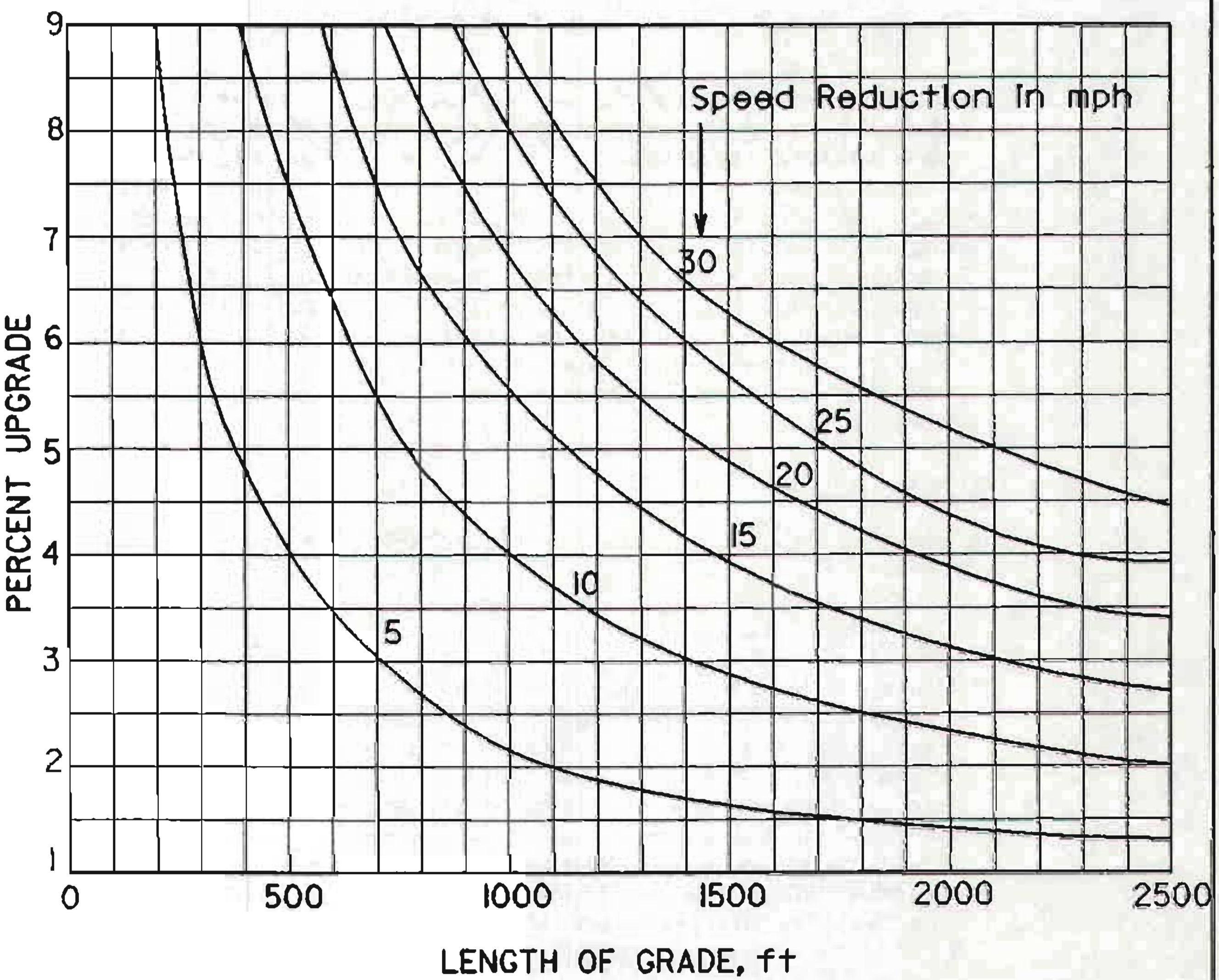


Figure 4-13. Refers to Paragraph 4-202(E)l

a. Maximum Grades

Figure 4-14 summarizes the maximum grade controls in terms of design speed. Generally, maximum design grade should be used infrequently rather than as a value to be used in most cases. However, for certain cases such as urban freeways, a maximum value may be applied in blanket fashion on interchange and grade separation approaches.

b. Minimum Grades

Flat or level grades on uncurbed pavements are satisfactory when the pavement is adequately crowned to drain the surface water laterally. When side ditches are required, the grade should seldom be less than 0.5 percent for unpaved ditches and 0.25 percent for lined channels. With curbed pavements, desirable minimum grades of 0.35 percent should be provided to facilitate surface drainage. Joint analysis of rainfall frequency and duration, the longitudinal grade, cross slope, curb inlet type and spacing of inlets or discharge points usually is required so that the width of water on the pavement surface during likely storms does not unduly interfere with traffic.

2. Vertical Curves

The simple parabola, as shown in Figure 4-15, is used in highway profile design.

a. Crest Vertical Curves

Minimum lengths of crest vertical curves, as controlled by stopping sight distance requirements, generally are satisfactory from the standpoint of safety, comfort, and appearance. The minimum lengths (L) of crest vertical curves for various algebraic differences in grade (A) to provide minimum stopping sight distances for various design speeds are shown in Figure 4-16. Longer than minimum lengths should be used wherever practical and feasible. Desirable values are shown in Figure 4-17.

'K' value indicates rate of vertical curvature.

The K (or L/A) value indicates the rate of vertical curvature, and the particular K values correspond with specific design speeds. Vertical curves on curbed facilities with 60 mph or greater design speed exceed a K value of 167 (drainage maximum) indicating that drainage near the apex needs to be carefully considered.

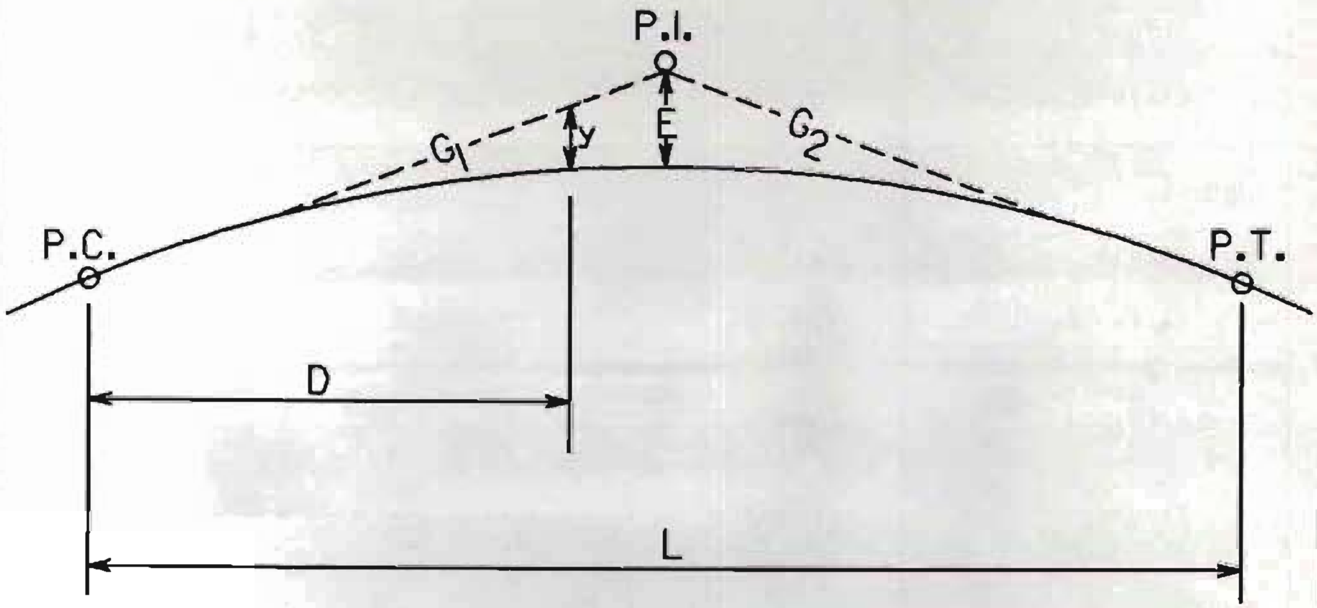
MAXIMUM GRADES

Functional Classification	Type of Terrain	Design Speed, mph 30	40	50	60	70
URBAN:						
Local[1]	All	≤15	≤15			
Collector	Level	7	7	6	--	--
	Rolling	9	8	7	--	--
Arterial	Level	7	7	6	5	--
	Rolling	9	8	7	6	--
Freeway	Level	--	--	4	3	3
	Rolling	--	--	5	4	4
RURAL:						
Local	Level	7	7	6	5	--
	Rolling	10	9	8	6	--
Collector	Level	7	7	6	5	--
	Rolling	9	8	7	6	--
Arterial	Level	--	--	--	3	3
	Rolling	--	--	--	4	4
Freeway	Level	--	--	4	3	3
	Rolling	--	--	5	4	4

[1] 8% maximum in commercial areas on local streets, desirably less than 5%. Flatter gradients should be used where practical.

Figure 4-14. Refers to Paragraph 4-202(E)1

VERTICAL CURVE



IN ANY VERTICAL CURVE:

1. $E = \frac{AL}{8}$

2. $y = (D)^2 \frac{E}{(1/2\ L)^2}$

   $y = D^2 \frac{A}{2L}$

If e = 0.08 (1") or less, then usually no vertical curve is required.

WHERE:

G_1, G_2 = TANGENT GRADES, IN PERCENT

E = ORDINATE FROM P.I. TO CURVE, IN FEET

A = $G_1 - G_2$, THE ALGEBRAIC DIFFERENCE IN GRADE

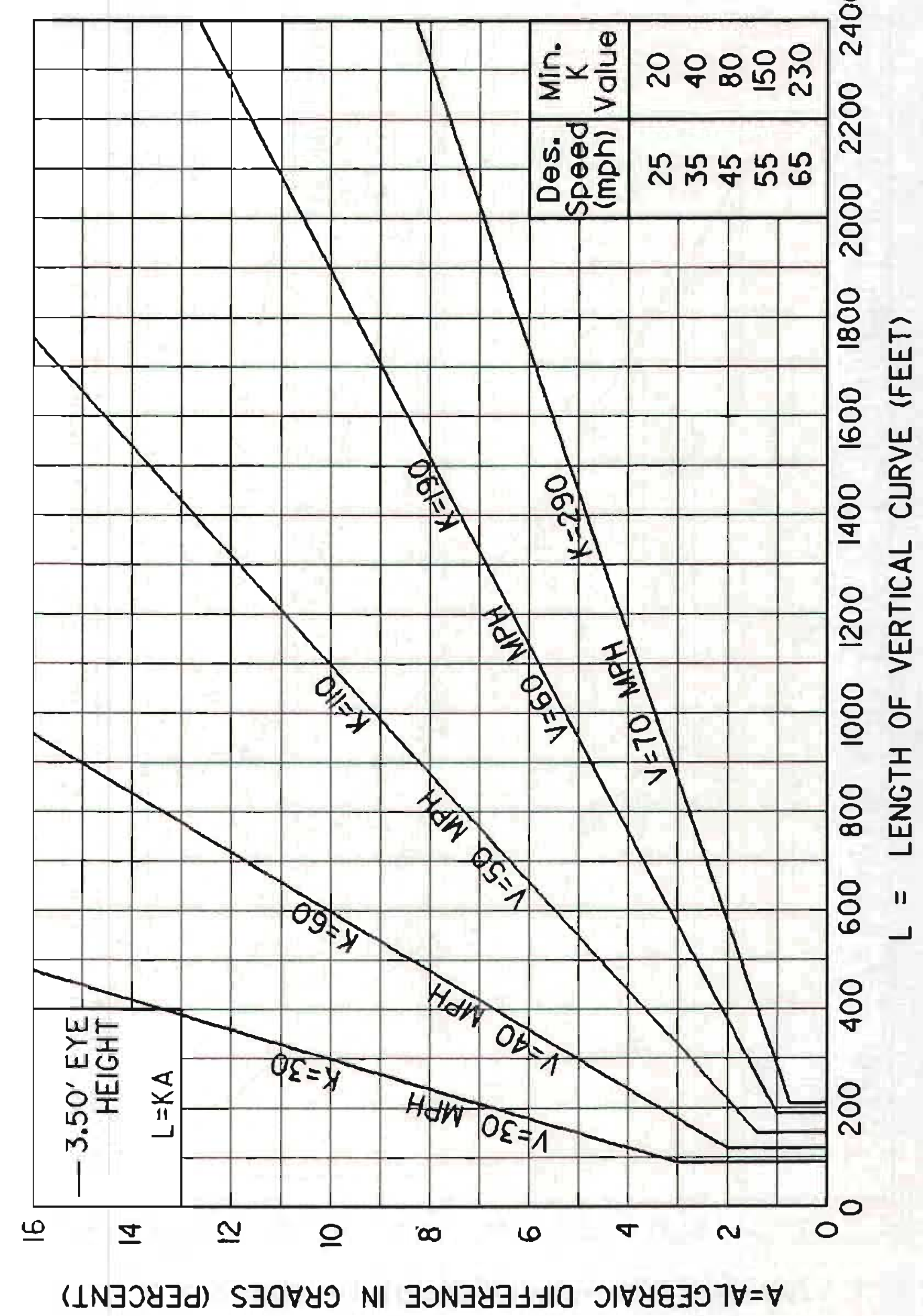
L = LENGTH OF CURVE, IN STATIONS

y = ORDINATE FROM TANGENT TO CURVE, IN FEET

D = DISTANCE FROM NEAREST P.C. OR P.T. TO ANY POINT ON CURVE

Figure 4-15. Refers to Paragraph 4-202(E)2

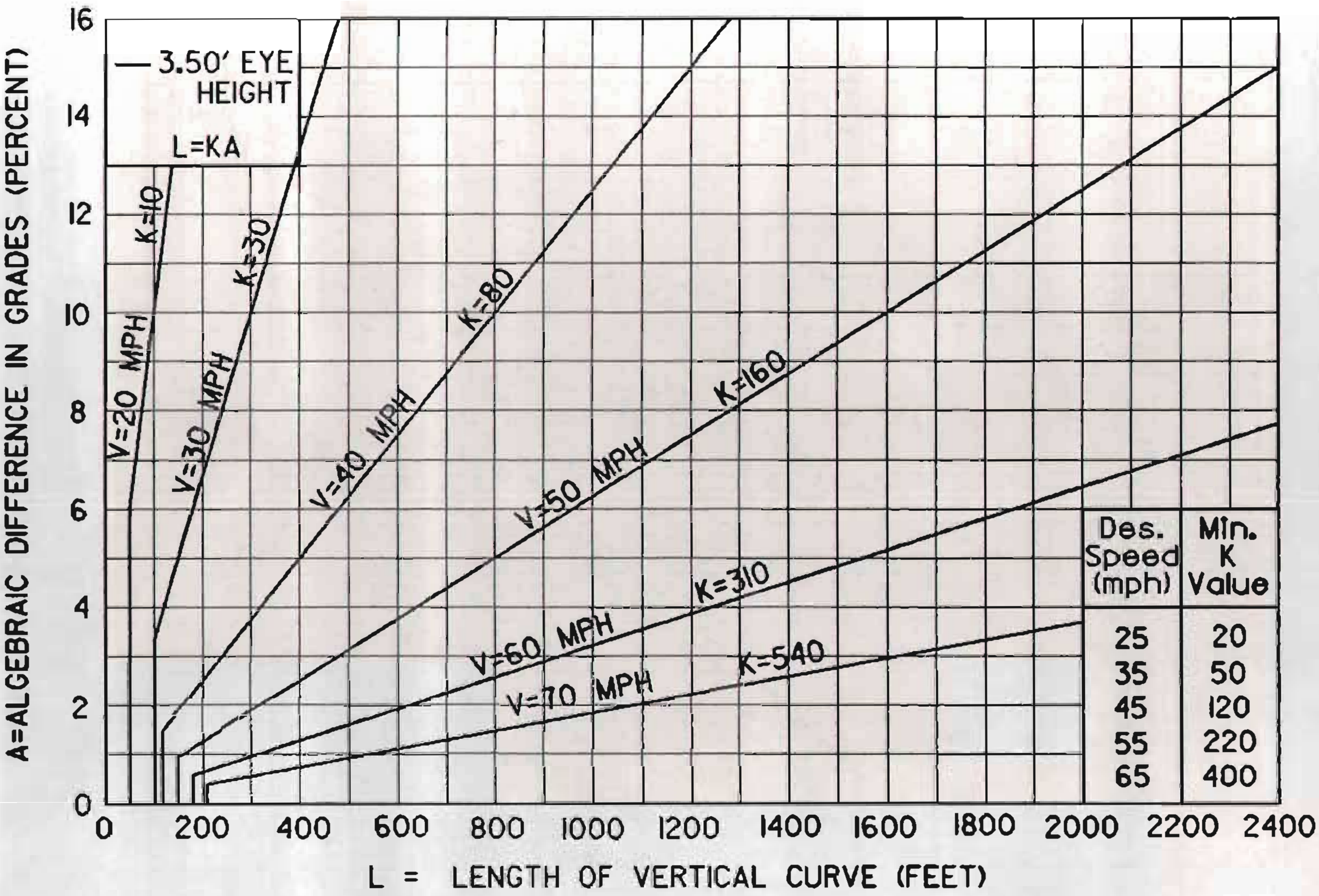
DESIGN LENGTHS FOR CREST VERTICAL CURVES
(MINIMUM* VALUES)



* SEE PARAGRAPHS 4-101(A) AND 4-202(E)2a.

Figure 4-16. Refers to Paragraph 4-202(E)2a

DESIGN LENGTHS FOR CREST VERTICAL CURVES
(DESIRABLE* VALUES)



Des. Speed (mph)	Min. K Value
25	20
35	50
45	120
55	220
65	400

*SEE PARAGRAPHS 4-101(A) AND 4-202(E)2a.

Figure 4-17. Refers to Paragraph 4-202(E)2a

b. Sag Vertical Curves

In the absence of continuous lighting, a sag vertical curve should be long enough so that the automobile light beam distance is nearly the same as stopping sight distance. Figure 4-18 shows minimum lengths for sag curves based on headlight distance for various design speeds and algebraic differences in grade. Desirable values may be determined from Figure 4-19.

Since energy conservation considerations are a factor in operating continuous lighting systems, headlight sight distance should be generally used in the design of sag vertical curves. Comfort control criteria is about 50% of the sag vertical curve lengths required by headlight distance and should be reserved for special use. Instances where the comfort control criteria may be appropriately used include ramp profiles where safety lighting is provided and for economical reasons in cases where an existing element, such as a structure not ready for replacement, controls the vertical profile. Comfort control criteria should be used sparingly on continuously lighted facilities since local, outside agencies often maintain and operate these systems and operations could be curtailed in the event of energy shortages.

Sag vertical curve design should check overhead sight obstructions

Care should be exercised in sag vertical curve design to insure that overhead sight obstructions such as structures for overpassing roadways, overhead sign bridges, tree crowns, etc., do not reduce stopping sight distance below the appropriate minimum value.

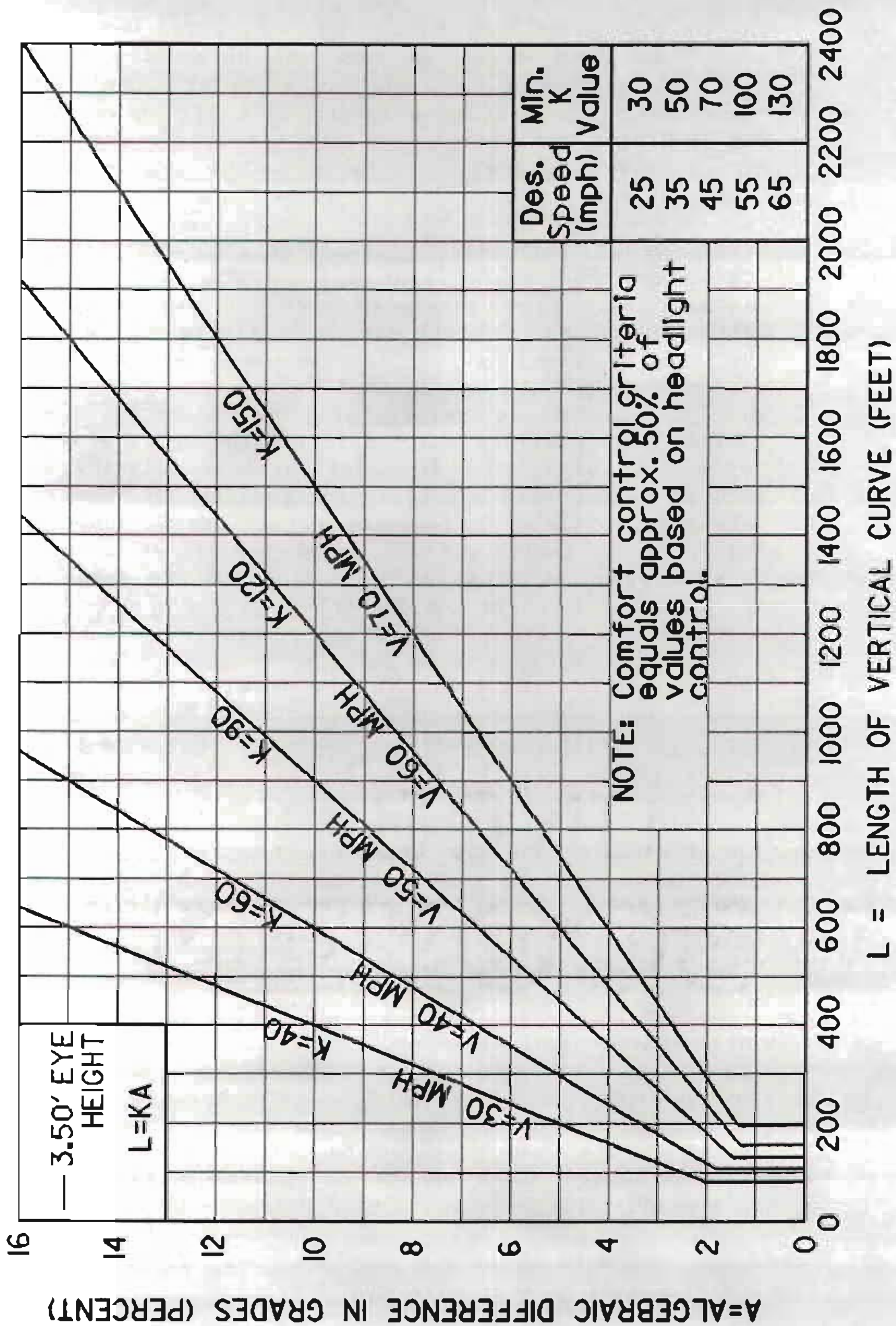
F. Combination of Vertical and Horizontal Alignment

Due to the near permanent nature of roadway alignment once constructed, it is important that the proper alignment be selected consistent with design speed, existing and future roadside development, subsurface conditions, topography, etc. The following factors are general considerations in obtaining a proper combination of horizontal and vertical alignment:

1. The design speed of both vertical and horizontal alignment should be compatible with longer vertical curves and flatter horizontal curves than dictated by minimum values used where practical. Design speed should be compatible with topography with the roadway fitting the terrain where feasible.

2. Alignment should be as flat a possible near intersections where sight distance is of extreme importance.

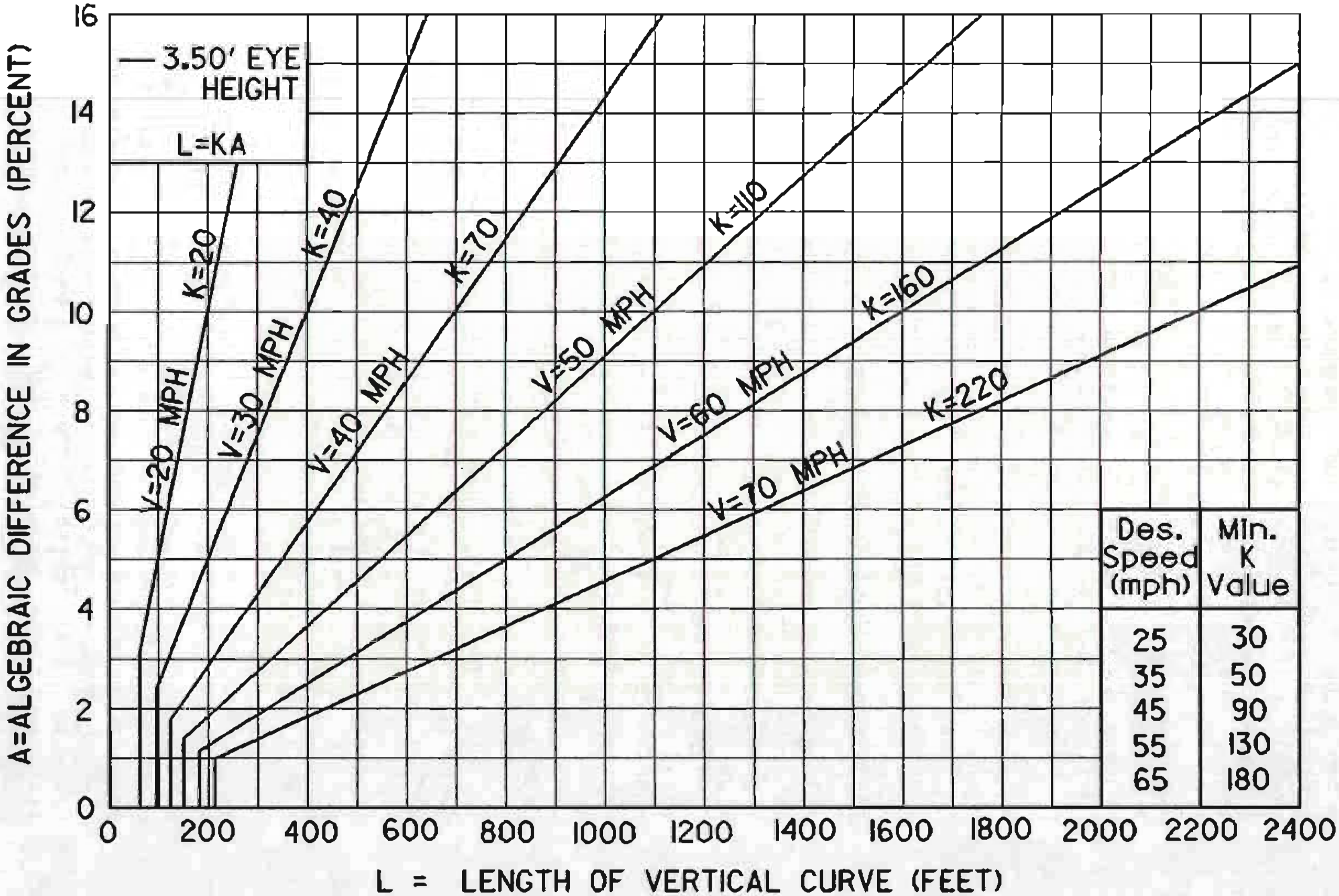
DESIGN LENGTHS FOR SAG VERTICAL CURVES
(MINIMUM* VALUES)



*SEE PARAGRAPHS 4-101(A) AND 4-202(E)2b.

Figure 4-18. Refers to Paragraph 4-202(E)2b

DESIGN LENGTHS FOR SAG VERTICAL CURVES
(DESIRABLE* VALUES)



*SEE PARAGRAPHS 4-101(A) AND 4-202(E)2b.

Figure 4-19. Refers to Paragraph 4-202(E)2b

3. For rural divided facilities, independent mainlane profiles are often more aesthetic and economical. Where used on non-controlled access facilities with narrow medians, care should be exercised in the location of median openings to minimize crossover grades and insure adequate sight distance for vehicles stopped therein.

4. For two-lane rural highways the need for safe passing sections at frequent intervals and on an appreciable percentage of the roadway length should be carefully considered in developing horizontal and vertical alignments.

G. Cross Sectional Elements

Cross sectional design elements include pavement and shoulder cross slopes, lane and shoulder widths, side slopes, curbs, median design, and roadside clearances. Pavement design is covered in Appendix F.

1. Pavement and Shoulder Cross Slope

The operating characteristics of vehicles on crowned pavements is such that on cross slopes up to 1/4 inch per foot the effect on steering is barely perceptible. A reasonably steep lateral slope is desirable to minimize water ponding on flat sections of uncurbed pavements due to imperfections or unequal settlement. With curbed pavements, a steep cross slope is desirable to contain the flow of water adjacent to the curb. The recommended pavement cross slope for usual conditions is 2.0% (1/4 inch per foot). In areas of high rainfall, steeper cross slopes may be used (see A Policy on Geometric Design of Highways and Streets, AASHTO, p. 357.)

On multilane divided highways, pavements with three or more lanes inclined in the same direction desirably should have greater slope across the outside lane(s) than across the two interior lanes. This increase in slope in the outer lane should be approximately 1/16 inch per foot (i.e., slope of 5/16"/ft. or 2.6%). In these cases the inside lane(s) may be sloped flatter than normal, typically at 3/16"/ft. or 1.5%, but not less than 1/8"/ft. or 1.04%.

In general, on divided highways on tangent, each pavement should have a uniform cross slope with the high point at the edge nearest the median. On rural sections with a wide median, the high point of the crown may be placed at the centerline of the pavement with cross slopes at 2% maximum (1.5% minimum) toward the edges at a uniform rate where snow removal is a usual operation. At intersections, interchange ramps or in unusual situations, the high point of the crown position may vary depending upon drainage or other controls.

Shoulders should be sloped sufficiently to drain surface water but not to the extent that vehicular use would be hazardous. Where shoulders are surfaced often the slope rate is identical to that used on the travel lanes although steeper slopes are permissible. Gravel or crushed rock shoulders should be sloped at 4 to 6% to facilitate drainage, and turf should be sloped at about 8 percent (12:1). Maximum shoulder slope should be 10% (10:1).

2. Slopes and Ditches

Flat slopes are safer than steep slopes. Rates of 6:1 or flatter on embankments can be negotiated by an errant vehicle with a good chance of recovery and should, where feasible, be provided. Steeper fill slopes, up to 3:1, are traversable without vehicle roll-over but the chance of recovery is substantially lessened. In this regard, guardrail should not be used solely for slope protection for rates of 3:1 or flatter since the barrier would be more hazardous than the slope. Also, since recovery is less likely on 3:1 and 4:1 slopes, fixed objects should not be present in the vicinity of the toe of these slopes. Recovery of high speed vehicles that encroach beyond the edge of shoulder may be expected to occur beyond the toe of slope.

Design guide values for the selection of earth fill slope rates in relation to height of fill are shown in Figure 4-20. Particularly difficult terrain or restricted right of way width may require deviation from these general guide values. Where conditions are favorable, it is desirable to use flatter slopes to enhance roadside safety.

The intersections of slope planes in the highway cross section should be well rounded for added safety, increased stability, and aesthetics. Side slopes, back slopes, and ditches should be sodded and/or seeded where feasible to promote stability and reduce erosion. In arid regions, concrete or rock retards may be necessary to prevent ditch erosion.

Where guardrail is placed on side slopes, the area between the roadway and barrier should be sloped at 10:1 or flatter.

maintenance of steep slopes.

For steeper slopes, rates of 3:1 (or flatter) facilitate efficient operation of construction and maintenance equipment. Difficulty in operation of such equipment is experienced at 2:1, and is virtually impossible for steeper slopes.

Roadside drainage ditches should have a minimum depth of two feet, as measured from the centerline profile grade, and generally should be at least six inches below the subgrade crown to insure stability of the base course. For additional information, see Section 4-202, Paragraph H(3), "Side Ditches", of Part IV.

EARTH FILL SLOPE RATES

Height of Fill (ft.)	Usual Max.[1] Slope Rate, Horizontal to Vertical	
	Type of Terrain	
	Flat or Gently Rolling	Rolling
0 - 5	6:1	4:1
5 - 10	4:1	4:1
10 - 15	4:1	3:1
15 and over	Subject to Stability Requirements	

[1] Deviation permitted for restrictive right-of-way or particularly difficult terrain conditions.

Figure 4-20. Refers to Paragraph 4-202(G)2

3. Median Design

A median (i.e., the area between opposing travel lane edges) is provided primarily to separate opposing traffic streams. The general range of median width is from 4 to 76 feet, with design width dependent on the type and location of the highway or street facility.

In rural areas, median sections are normally wider than in urban areas. For multilane rural highways without access control, a median width of 76 feet is desirable to provide complete shelter for trucks at median openings (crossovers). These wide, depressed medians are also effective in reducing headlight glare and providing a safety zone for run-off-the-road vehicle encroachments.

Where economically feasible, freeways in rural areas should desirably include a 76-foot median to minimize headlight glare and provide a wide safety zone. Since freeways by design do not allow at-grade crossings, median widths need not be sufficient to shelter crossing trucks. In this regard, where right-of-way costs are prohibitive, reduced (less than 76 feet) median widths may be appropriate for certain rural freeways. Statistical studies have shown that over 90 percent of median encroachments involve lateral distances traveled of 48 feet or less. In this regard, depressed medians on rural freeways sections should be 48 feet or more in width.

Urban freeways generally include narrower, flush medians with continuous longitudinal barriers. For urban freeways with flush median and six or more travel lanes, full (10-foot) inside shoulders should be provided to provide space for emergency parking. Median widths vary up to 30 feet, with 24 feet commonly used. For projects involving the rehabilitation and expansion of existing urban freeways, the provision of wide inside shoulders may not be feasible. Under these circumstances documentation for narrower shoulders should be submitted and a design exception requested.

For lower speed urban arterial streets, flush or curbed medians are used. A width of 14 feet will effectively accommodate left-turning traffic for either raised or flush medians. The two-way (continuous) left-turn lane design is appropriate where there exists (or is expected to exist) a high frequency of mid-block left turns. Median types for urban arterials without access control are further discussed in Paragraph 4-302(B).

4. Lane Widths

12' min. lane width for high speed facilities

For high speed facilities such as all freeways and most rural arterials, lane widths should be twelve feet minimum. For lower speed urban streets, eleven- or twelve-foot lanes are generally used. Subsequent sections of this publication identify appropriate lane widths for the various classes of highway and street facilities.

5. Shoulder Widths

Wide, surfaced shoulders provide a suitable, all-weather area for stopped vehicles to stand clear of the travel lanes. Shoulders are of considerable value on high speed facilities such as freeways and rural highways; however, on arterial streets, parking lanes are generally provided instead of shoulders. Shoulders, in addition to serving as emergency parking areas, lend lateral support to travel lane pavement structure, provide a maneuvering area, increase sight distance of horizontal curves, and give drivers a sense of safe, open roadway. Design shoulder widths for the various classes of highways are shown in the appropriate subsequent portions of this Manual.

6. Curb and Curb and Gutters

Curbs will be used primarily on frontage roads, crossroads, and low speed streets in urban areas. They should not be used in connection with the through, high speed traffic lanes or ramp areas except at the outer edge of the shoulder where needed for drainage, in which case they shall be of the mountable type.

In order to provide adequate and reasonable access for the safe and convenient movement of handicapped persons, including those in wheelchairs, curb ramps should be included at all pedestrian crosswalks. Curb ramps should be at least four feet in width, sloped at the rate of one inch per foot or flatter, and located on the pedestrian side of the curb face.

Curb ramps to provide access for the handicapped must be provided on each project where the following types of work are included:

1. Construction of curbs, curb and gutter and/or sidewalks.

2. Installation of traffic signals which include pedestrian signals.

3. Installation of pavement markings for pedestrian crosswalks.

7. Roadside Design

Of particular concern to the design engineer is the number of single-vehicle, run-off-the-road accidents which occur even on the safest facilities yet devised. In recent years, about one-third of all highway fatalities were associated with accidents of this nature. The configuration and condition of the roadside greatly affect the extent of damages and injuries for these accidents.

Increased safety may be realized through application of the following principles, particularly on high speed (see definitions in Section 4-201(F)) facilities.

a. A "forgiving" roadside should be provided, free of unyielding obstacles including landscaping, hazardous drainage facilities, steep slopes, utility poles, etc. For adequate safety, it is desirable to provide an unencumbered roadside recovery area that is as wide as practicable for the specific highway and traffic conditions.

b. For existing highways, treatment of obstacles should be considered in the following order: (1) elimination of the hazard; (2) reduction of the hazard severity through use of breakaway devices, (3) relocation of the hazard to a point where it is less likely to be struck, and (4) application of a cost-effective device to provide for redirection (longitudinal barrier) or severity reduction (impact attenuators). A decision to use guard fence should be

H. Safety of Drainage Facilities

In designing drainage systems, the primary objective, of course, is to properly accommodate surface run-off along and across highway right-of-way through the application of sound hydraulic principles. Consideration also must be given to a second important goal of incorporating safety into the design of drainage appurtenances. The best design would efficiently accommodate drainage and be traversable by an out-of-control vehicle without rollover or abrupt change in speed.

To meet safety needs, the designer may (1) design or treat drainage appurtenances so that they will be traversable by a vehicle without rollover or abrupt change in speed; (2) locate appurtenances a sufficient distance, consistent with traffic volume, from the travel lanes so as to reduce the likelihood of accidental collision; or (3) protect the driver through installation of traffic barrier shielding appurtenances when neither (1) or (2) is feasible.

The following guidelines are intended to improve roadside safety with respect to facilities accommodating drainage parallel to and crossing under highways. The guidelines apply to all rural, high speed facilities and other facilities where posted speed limit will be 45 mph or more and rural type (uncurbed) cross sections are utilized. Where reference is made to clear zone requirements in these guidelines, see Figure 4-21 for major construction projects and the discussions regarding slopes, roadside design, and horizontal clearances in Paragraphs 4-202(G)2, 4-202(G)7, and 4-202(G)8, respectively. Desirable values for clear zone width should be generally used, and minimum clear zone widths applied where unusual conditions are encountered. Site visits may be appropriate to ascertain terrain conditions and debris potential before arriving at design decisions for cross drainage culverts.

You are encouraged to address and resolve with involved parties culvert end treatment issues early in project development. If there are doubts about the proper application of criteria on a given project or group of projects then arrangements should be made for a predesign conference with D-8 and FHWA (where applicable) prior to in-depth development of P.S.&E.

1. Design Treatment of Cross Drainage Culvert Ends

Cross drainage culverts are defined as those handling drainage across and beneath the highway. Selection of an appropriate end treatment is primarily related to culvert size, culvert end location, side slope rate, terrain characteristics, drift conditions, right-of-way availability, and other considerations that may influence treatment selection at individual sites. Cross drainage culvert ends should: (1) be safety treated, or (2) meet clear zone requirements, or (3) be shielded with metal beam guard fence (MBGF).

a. General

Slope rate discussion

The path which an out-of-control vehicle follows after it leaves the traveled portion of the roadway is very difficult to predict and is related to a number of factors such as driver capabilities, slope rates, and vehicular speed. Accident data indicates that approximately 75% of reported encroachments do not exceed a lateral distance of 30 feet from the travel lane edge where roadside slopes are 6:1 or flatter -- slope rates that afford drivers significant opportunity for recovery. Crash test data further indicates that steeper (up to 3:1) are negotiable by drivers in that rollover does not occur, however, recovery of vehicular control on these steeper slopes is less likely. Accident data has not been collected on slopes steeper than 6:1, but it is reasonable to expect that the lateral distance of travel beyond the travel lane edge would be greater than that experienced on 6:1 slopes. The designer should be aware of this behavior of out-of-control vehicles and safety treat those fixed objects located within flat recovery zones and beyond the toe of slope area where relatively steep side slopes are involved, insofar as practical. Particular care should be taken in the treatment of man-made appurtenances such as culvert ends.

Roadside safety performance is therefore related to clear zone width and side slope rate. In developing a design cross section, it is usual practice to vary embankment side slope rate with height of embankment using the values shown in Figure 4-21. Where right-of-way availability and economic conditions permit, flatter slopes may be used.

Slope rate should be 6:1 or flatter within the clear zone.

Design values for clear zones are shown in Figure 4-21 for new location and major reconstruction projects. Whenever the clear zone concept is applied in design, side slopes should be 6:1 or flatter.

For nonfreeway RRR (Resurfacing, Restoration, or Rehabilitation) projects, guidelines shown in Part III apply; however, whenever treatment is required on 3R projects the design philosophy described herein should be helpful in selecting an appropriate treatment.

Small pipe culvert is 1 - 36" or less multiple - 30" or less

b. Small Pipe Culverts

A small pipe culvert is defined as a single round pipe with 36-inch or less diameter,[1] or multiple round pipes each with 30-inch or less diameter[1], each oriented on normal skew.

---

[1] For arch pipes, use span dimension instead of diameter.

Adjustments for skew

When skews are involved, the definition of a small pipe culvert is modified as tabulated below:

Skew	Max. Dia. of "Small" Pipe Culvert Single Pipe	Multiple Pipe
15°	30 in.	30 in.
30°	24 in.	24 in.
45°	24 in.	18 in.

Small pipe culverts with sloping, open ends have been crash tested and proven to be safely traversable by vehicles for a range of speeds. Pipe ends should be sloped to match side slopes with a maximum steepness rate of 3:1. Single box culverts on normal skew with spans of 3' or less may be effectively safety treated just as small pipes (open, match 3:1 or flatter slope).

When vulnerable (i.e., unshielded by MBGF) to run-off-the-road vehicles, sloped ends should be provided on small pipe culverts regardless of culvert end location with respect to clear zone dimensions.

For existing culverts, this often entails removing existing headwalls and may involve removing metal beam guard fence (MBGF) if no longer needed to protect a hazard other than a culvert end. The resultant culvert with sloped end is both safe and inexpensive.

For new culverts or existing culverts that may need adjusting, culvert pipe length should be controlled by the intercept of the small pipe and the side slope planes. Side slopes should not be warped or flattened near culvert locations. Headwalls should not be used.

In summary, whether a small pipe culvert be a new or an existing one, sloped open ends should normally be provided. Terrain in the vicinity of the culvert ends should be smooth and free of fixed objects.

c. Intermediate Size Single Box Culverts and (Single and Multiple) Pipe Culverts

Intermediate culverts defined

An intermediate size pipe culvert is defined as a single round pipe with more than 36 inch diameter[1] or multiple round pipes each with more than 30-inch diameter[1] but having maximum diameter of 60-inches. Single box culverts are defined as those having only one barrel with maximum height of 5 feet. Cross sectional area of the single box or individual pipe normally should not exceed 25 square feet.

Intermediate culvert treatment defined.

The openings of intermediate size single barrel box and pipe culverts are too large to be safely traversable by a vehicle. Treatment options include (a) sloping ends with safety pipe runners, (b) providing flat side slopes and locating the ends outside the clear zone, and (c) using MBGF to shield culvert ends.

Safety pipe runners

Sloping end treatments with safety pipe runners are preferred from a safety standpoint and are generally cost effective for both new and existing culverts of this size. These end treatments should be sloped at a 3:1 or flatter rate and should match side slope rate thereby providing a flush, traversable safety treatment. Terrain in the vicinity of the culvert end should be smoothly shaped and traversable, and headwalls should not be used.

For <u>new</u> single barrel box and pipe culverts that are intermediate size, the preferred design treatment is to provide a sloped end treatment with safety pipe runners regardless of end location with respect to clear zone criteria. Length of new culverts should be governed by the locations of the side slope plane/culvert intercepts rather than by clear zone criteria.

For <u>existing</u> single barrel box and pipe culverts that are intermediate size, no treatment is warranted for certain culvert end offsets and traffic volumes as shown on attached applicable Figure 4-21. Where an improved design is warranted using Figure 4-21, the removal of headwalls and installation of sloped ends with safety pipe runners is the preferred safety treatment.

Situations where safety pipe runners impractical

In certain situations (e.g., culvert skew exceeds 15 degrees, severe debris problems, etc.) treatment with safety pipe runners will be impractical. For these conditions locating intermediate size culvert ends to meet desirable clear zone values (see Figure 4-21) is preferred over shielding with MBGF.

The Bridge Division (File D-5) has prepared and previously (November, 1980) distributed safety end treatment standard sheets for the following conditions:

maximum length of safety pipe runner approximately 20'.

(1) All standard box sizes up to maximum 5-foot box height, and all standard pipes up to maximum 60-inch diameter

(2) 3:1, 4:1, and 6:1 slopes except as controlled by maximum (approximately 20 ft) length of safety pipe runner.

(3) Normal and 15 degree skew.

These designs have flared wingwalls with safety pipe runners oriented parallel to flow and spaced at 30-inches (maximum) center to center thereby minimizing debris problems.

The Bridge Division has prepared a standard sheet for small and intermediate size pipe culverts and single or multiple box culverts showing sloped ends with a single safety pipe runner on each pipe or box opening. It is anticipated that these simpler designs with straight wingwalls on box culverts as shown on sheet CD-SPR will provide a low cost safety treatment.

Standard sheet CD-SPR therefore shows details for safety pipe runner treatment for pipe diameters and single box heights up to 60 inches and should be used in construction plans. Companion standard sheet SWW shows reinforcing steel placement and methods to estimate concrete and reinforcing steel quantities for box culverts with straight wingwalls.

d. Multiple Box Culverts and Large Single Pipes or Boxes

multiply Box and large Single pipe defined

Multiple box culverts are defined as those with more than one barrel but with a total opening (i.e., distance) of twenty feet or less between extreme inside faces as measured along the highway centerline. Large single pipes or single boxes are defined as those with diameter or height exceeding 5 feet or cross sectional area exceeding 25 square feet.

Treatment Priority for Safety

From a safety standpoint alone, treatment is in the following priority for both new and existing installations: (1) provide safety pipe runners, (2) meet or exceed desirable clear zone value, and (3) shield with MBGF.

Problems with Safety pipe runners on these large boxes and pipes.

However, one should carefully consider several factors before opting to use safety pipe runners. First, multiple box culverts accommodate significantly greater flow quantities than single box or pipe culverts and often a defined channel crosses the highway right-of-way. Where a defined channel is present, it may be impossible or impractical to shape the terrain near the culvert end to provide for vehicular traversability. In other instances, debris may adversely affect hydraulic capacity and, considering the higher flow quantities, subject the highway or private property to inundation if safety pipe runners are used. Such circumstances as these would dictate that one select a more suitable, but lower priority, culvert end treatment.

Where safety pipe runners are suitable, Bridge Division standard sheets CD-SPR and SWW show details for treatment using straight wingwalls and extend interior walls for multiple boxes (height 5-foot or less).

If cost of added length is 3 times or more than MBGF, then MBGF is attractive.

Meeting clear zone criteria does not eliminate the culvert end hazard, rather the hazard is placed at a location where it is less likely to be struck. Although not as desirable as providing a traversable culvert end, it is preferred over MBGF treatment where there is sufficient right-of-way and where the cost of providing the necessary culvert length is reasonable. Where the cost of added length for new culverts or of extension of existing culverts is three or more times the cost of shielding with MBGF, treatment with MBGF becomes an attractive alternative.

For low volumes the lowest initial cost is usually most attractive.

For low volume (less than 750 current ADT) conditions, however, the treatment option that has the lowest initial (construction) cost is generally the most cost effective design if an improved design is warranted.

e. Bridge Class Drainage Culverts

Bridge class culverts defined

Bridge class culverts are defined as those having an opening (i.e., distance) of more than 20 feet between the extreme inside faces as measured along the highway centerline.

Bridge class culverts generally shielded with metal beam guard fence.

These large culverts should generally be shielded with MBGF on the approach and across the culvert. Guard fence across the structure should be as follows:

Depth of Cover	Post Spacing	Foundation
less than 38"	6'-3"	steel post welded to steel base plate and bolted to culvert ceiling
38" or more	6'-3"	standard embedment

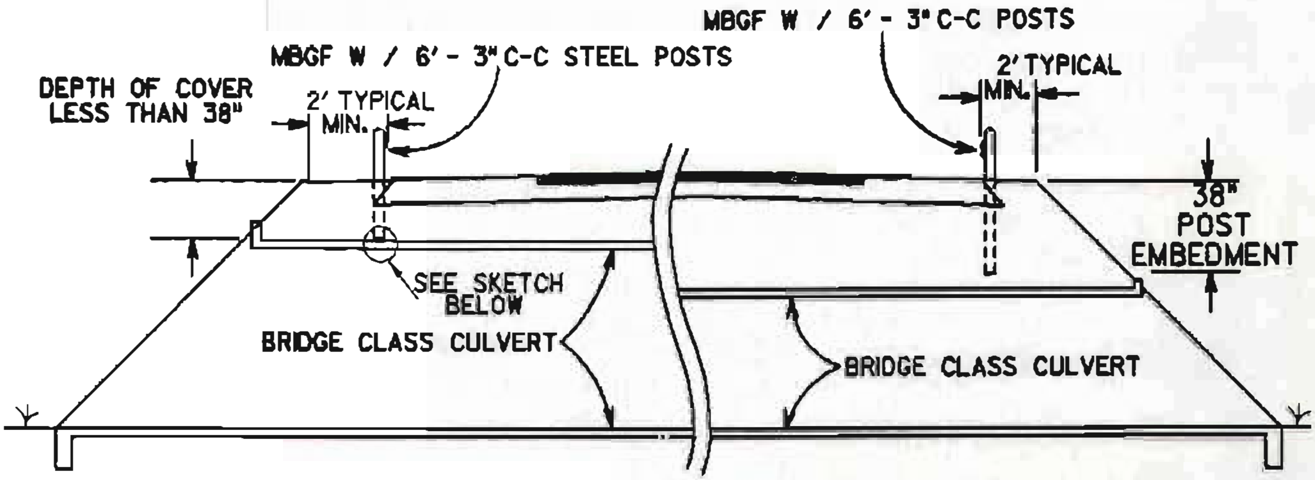
Lateral support shown in Figure 4-22

Where MBGF is carried across bridge class culverts, steep side slopes should be positioned to provide for lateral support of the guard fence, as shown on Figure 4-22.

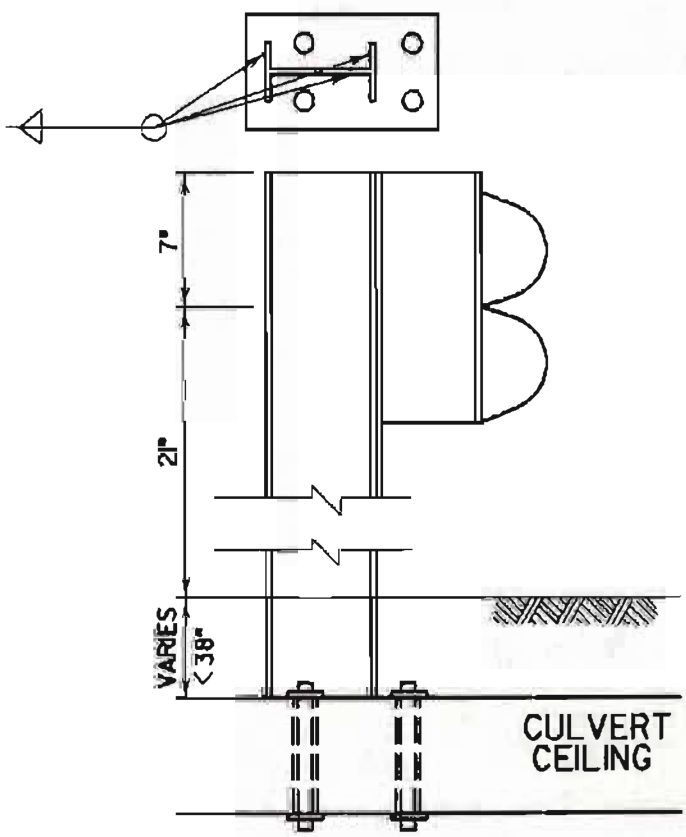
2. Parallel Drainage Culverts

The inlet and outlet points of culverts handling drainage parallel to the travel lanes, such as at driveways, side roads, and median crossovers, are concerns in providing a safe roadside environment. Flow quantities for these parallel drainage situations are generally low with drainage typically accommodated by a single pipe. The following guidelines apply to driveway, side road, and median crossover drainage facilities:

USE OF MBGF ON BRIDGE CLASS CULVERTS



BRIDGE CLASS CULVERTS SHIELDED WITH MBGF



NOTE: SEE GF(TD) STANDARD SHEET FOR MOUNTING DETAILS.

Figure 4-22. Refers to Paragraph 4-202(H)e

a. Within the clear zone there should be no culvert headwalls or vertical ends. Outside the clear zone, single pipe ends preferably should be sloped although not required.

b. Where used, sloped pipe ends should be at a rate of 6:1 or flatter. The sloping end may be terminated and a vertical section introduced at the top and bottom of the partial pipe section as shown in Figure 4-23.

c. Median crossover, side road, and driveway embankment slope should be 6:1 maximum steepness, with 8:1 preferred, within the clear zone.

d. Where large (greater than 30 inches in diameter) pipe ends are located within the clear zone, safety pipe runners should be provided with a maximum slope steepness of 6:1 with 8:1 preferred. Typical details for a driveway, side road, or median crossover grate are shown in Figure 4-24. Grates are not required on single, small (30 inches or less diameter) pipes regardless of end location with respect to clear zone requirements; however, the ends of small pipes should be sloped as described in paragraph (b) above and appropriate measures taken to control erosion and stabilize the pipe end.

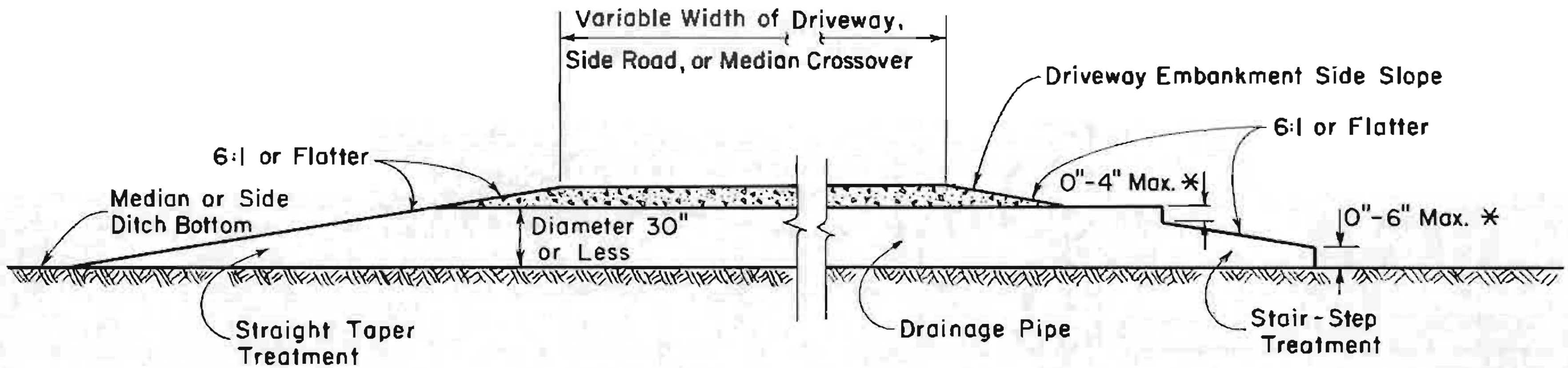
e. The use of paved dips, instead of pipes, is encouraged particularly at infrequently used driveways such as those serving unimproved private property.

f. For unusual situations, such as driveways on high fills or where multiple pipes or box culverts are necessary to accommodate side or median ditch drainage, the designer should consider the alternatives available and select an appropriate design.

3. Side Ditches

For side ditches, attention to cross section design can reduce the likelihood of serious injuries during vehicular encroachments. Ditches with the following cross sectional characteristics are preferred and should especially be sought when ditch location is within the clear zone. Where conditions dictate, such as insufficient existing right-of-way to accommodate the preferred ditch cross section or where ditches are located outside the clear zone, other ditch configurations may be used. Typically guard fence is not warranted where the preferred ditch cross sections are not provided.

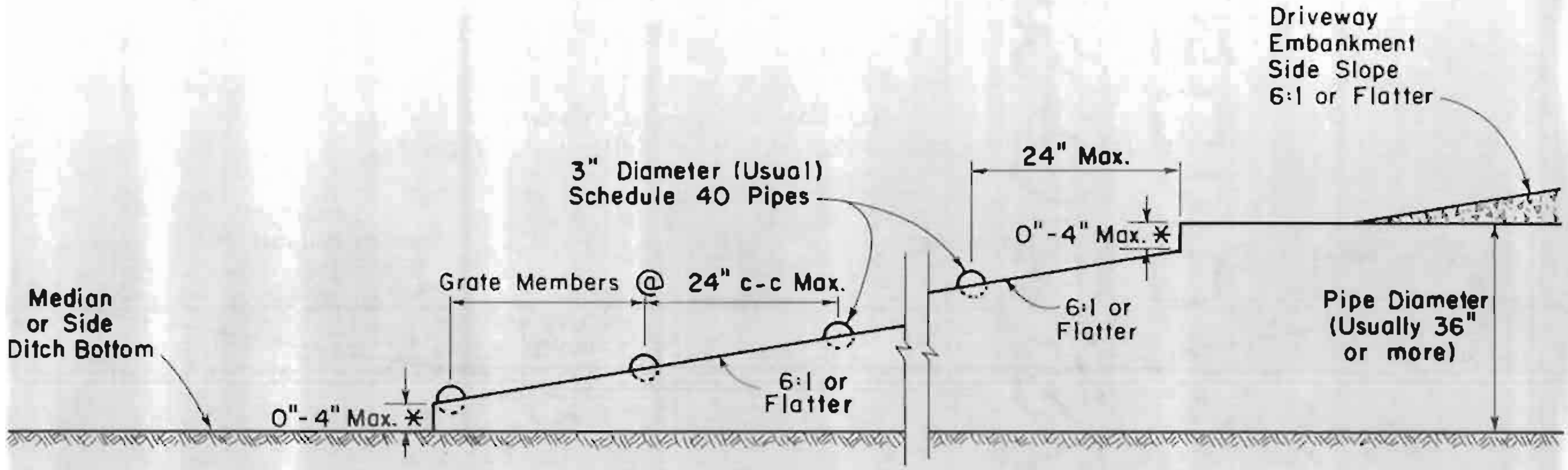
SMALL SLOPING PIPE ENDS - DRIVEWAYS, ETC. - WITHOUT GRATES



*NOTE: Stair-Step or Straight Taper treatment, or variant design thereof, may be used.

FIGURE 4-23. Refers to Paragraph 4-202(H)2

LARGE SLOPING PIPE ENDS - DRIVEWAYS, ETC. - WITH GRATES



*NOTE: Stair-Step or Straight Taper treatment, or variant design thereof, may be used.

FIGURE 4-24. Refers to Paragraph 4-202(H)2

PREFERRED DITCH CROSS SECTIONS

	Preferred Maximum Back Slope*	
Given Front Slope*	Vee-Shaped	Trapezoidal-Shaped
8:1	3.5:1	2.5:1
6:1	4:1	3:1
4:1	6:1	4:1
3:1	Level	8:1

*Horizontal:Vertical

Figure 4-25. Refers to Paragraph 4-202(G)3

Ditches which include retards to control erosion should be avoided inside the clear zone and should be located as far from the travel lanes as practical. Non-traversable catch or stilling basins should also be located outside the clear zone.

URBAN STREETS (4-300)

4-301 GENERAL

Urban Street defined

The term "Urban Street" as used in this publication refers to roadways in developed areas which provide access to abutting property as well as movement of vehicular traffic. Access for these facilities is controlled only through driveway locations, pavement markings, and the possible use of curbed medians where more positive medial access control is needed. Freeways, both urban and rural, are treated in a subsequent section.

4-302 BASIC DESIGN FEATURES

Figure 4-26 shows tabulated basic geometric design criteria for urban arterial, collector and local streets.

The basic design criteria shown in Figure 4-26 reflect minimum and desirable values which are applicable to projects on new location or major improvement projects such as widening to provide additional lanes. For minor rehabilitation projects where no additional lanes are proposed, existing curbed cross sections should be compared with the standard designs shown herein to determine the practicality and economic feasibility of minor widening to meet the prescribed standards. Where only minimal widening is required to conform with a standard design, it is often cost-effective to retain the existing street section thereby sparing the cost of removing and replacing concrete curb and gutter. For these type projects, 3R (Resurfacing, Restoration, and Rehabilitation) guidelines are usually applicable, see Part III.

A. Access Control

Frontage roads used in combination with urban streets introduce a hazard where the frontage road and arterial intersect a crossroad at-grade. The added hazard results in part from the increase in the number of conflicting movements and from the confusing pattern of roadways and separations which may lead to wrong-way entry. The multiple (usually three), closely spaced at-grade intersections inevitably introduce design and control problems which are far more complex than when the street is a single (i.e., not flanked by frontage roads) roadway intersecting a cross street. In this regard, frontage roads are generally inappropriate for use in urban areas except for application in freeway design.

Access driveways shall be installed in accordance with the Departmental publication Regulations for Access Driveways to State Highways.

B. Medians

Medians are desirable for urban streets with four or more traffic lanes primarily to provide storage space for left-turning vehicles. Medians may be curbed or flush.

GEOMETRIC DESIGN CRITERIA FOR URBAN STREETS

Item	Functional Class	Desirable	Minimum
Design Speed (mph)	All	Up to 60	30
Maximum Horiz. Curvature (degrees)	All	See Figure 4-48 Figure 4-8	
Maximum Gradient (%)	All	See Figure 4-14	
Stopping Sight Distance (ft.)	All	--	200
Width of Travel Lanes (ft.)	Arterial	12	11[1]
	Collector	12	10[2]
	Local	11 - 12	10[2,3]
Curb Parking Lane Width (ft.)	Arterial	12	10[4]
	Collector	10	7[5]
	Local	9	7[5]
Shoulder Width[6], Uncurbed New or uncurbed Completely Reconstructed Streets	Arterial	10	4
	Collector	8	3
	Local	--	2
Width of Refuge Lanes (ft.)	Art. & Coll.	11 - 12	10
	Local	10 - 12	9
Offset to Face of Curb (ft.)	All	2	1
Median Width (ft.)	All	See Sec. 4-302(B)1&2	
Border Width (ft.)	Arterial	12	8
	Collector	11	8
Right-of-Way Width (ft.)	All	Determined by Local Conditions	
Sidewalk Width (ft.)	All	6 - 8[7]	4
On-Street Bicycle Lane Width (ft.)	All	--	5
Superelevation	All	Yes	None
Clear Zone Width (ft.)	All	3	1.5 from curb face
Vertical Clearance for New Strs. (ft.)	All	16.5	16.5[8]
Turning Radii		See Section 4-710(D)	
Structure Widths (ft.)			
Curbed Streets	All	Curb face-to-curb face plus sidewalk(s)	
Uncurbed Streets	All	Approach Roadway Including Shoulders	
Culvert End Offset (ft.)	All	See Section 4-302(J)	

1 In highly restricted locations or where few trucks and 40 mph or less speeds, 10' permissible.

2 In industrial areas 12' usual, and 11' minimum for restricted R.O.W. conditions. In non-industrial areas, 10' minimum.

3 In residential areas, 9' minimum.

4 Where there is no demand for use as a future through lane, 8' minimum.

5 In commercial and industrial areas, 8' minimum.

6 Where only minimum width is provided, it should be fully surfaced. Where desirable width is provided, partial (not less than minimum width) surfacing or full width surfacing may be provided at the option of the designer.

7 Applicable for commercial areas, school routes, or other areas with concentrated pedestrian traffic.

8 Exceptional cases near as practical to 16.5' but never less than 14.5'. Existing structures that provide at least 14' may be retained.

Figure 4-26. Refers to Paragraph 4-302

1. Curbed Medians

A raised median with curbing is used on urban arterial (non-freeway) streets where it is desirable to prevent mid-block turns. Where the demand for mid-block turns is high, this design may be inappropriate since operational problems may result due to the heavy concentration of left turns at intersections. Curbed medians are more appropriate where driveways are infrequent and/or low volume, such as through residential areas, parks, etc. Curbed medians should be minimally 12 feet (10' storage lane plus 2' divider at restricted locations) and desirably up to 18 feet (12' storage lane plus 6' divider) in width. Wider medians are receptive to landscaping, but with widths exceeding 20 feet cross street left-turning traffic may cause intersection "lock-up" where both cross street approaches are served by a single signal phase.

widths for curbed medians

2. Flush Medians

Flush medians may include pavement markings delineating directional turning bays, or they may be used where appropriately marked as continuous two-way left-turn lanes (abbreviated TWLTL). The TWLTL design allows use of the flush median area for left turns by traffic from either direction on the street. The TWLTL is appropriate where there is a high demand for mid-block left runs, such as in areas with (or expected to experience) moderate or intense strip development. Used appropriately, the TWLTL design has improved the safety and operational characteristics of streets as demonstrated through reduced travel times and accident rates. The TWLTL design has offered added flexibility since, during spot maintenance activities, a travel lane may be barricaded with through traffic temporarily using the median lane. Recommended median lane widths for the TWLTL design are as shown below in Figure 4-27.

MEDIAN LANE WIDTHS FOR
TWO-WAY LEFT-TURN LANES

MAXIMUM LEGAL SPEED (mph)	WIDTH OF TWLTL (Ft.)	
	Usual	Minimum
0 - 30	12-14	11
35 - 40	12-14	11
45 - 50	14	12
over 50	16	14

widths for flush medians

Figure 4-27. Refers to Paragraph 4-302(B)2

In applying this criteria, the median lane width should not be less than twelve feet, and preferably the "usual" value shown in Figure 4-27, on new location projects or on reconstruction projects where widening necessitates the removal of exterior curbs. "Minimum" values as shown in Figure 4-27 are appropriate for restrictive right-of-way projects and improvement projects where attaining "usual" median lane width would necessitate removing and replacing exterior curbing to gain only a few feet of roadway width.

criteria for 3-lane section

Criteria that warrants the potential use of continuous two-way left turn lane (CTWLTL) with one travel lane in each direction design are summarized below:

1. ADT volume of 3000 or more
2. Side road plus driveway density of 20 or more entrances per mile
3. Speed limit of 45 mph or less
4. Length of three lane section of 1.5 miles or less

When at least three of the above warranting conditions are met, the site will be considered suitable for use of the three lane, including CTWLTL, design.

C. Borders and Sidewalks

sidewalk & border widths

The border, which accommodates sidewalks, utilities, etc., and separates traffic from privately owned areas, is the area between the roadway and right-of-way line. Every effort should be made to provide wide borders to serve functional needs, reduce traffic nuisances to adjacent development, and for aesthetics. Sidewalks should be 4 feet in width minimum with increased widths applicable near schools, commercial areas, or other areas with high pedestrian volumes. Border widths minimally are 8 feet and desirably 12 feet or more.

D. Bicycle Facilities

Bicycle facilities, both on-street and independently aligned, are discussed in Appendix H entitled "Bikeway Design Guidelines".

E. Grade Separations and Interchanges

Although grade separations and interchanges are not often provided on urban streets, they may be the only means available for providing sufficient capacity at critical intersections. Normally, a grade separation is part of an interchange (except grade separations with railroads); it is usually the diamond type where there are four legs. Locations considered include high volume intersections and where terrain conditions favor separation of grades.

The entire roadway width, including shoulders, should be carried across structures

The entire roadway width of the approach, including parking lanes or shoulders if applicable, should be carried across or under the separation. Interchange design elements may have lower dimensional values as compared to freeways due to the lower speeds involved. For example, diamond ramps may have lengths controlled by the minimum distance to overcome the elevation difference at suitable gradients.

Do not intermix facility types.

In some instances, it may be feasible to provide grade separations or interchanges at all major crossings for a lengthy section of arterial street. In these cases, the street assumes the operating characteristics and appearance of a freeway. In this regard, where right-of-way availability permits, it may be appropriate to eliminate the relatively few crossing at-grade and control access by design (i.e., provide continuous frontage roads) in the interest of safety. It is not desirable, however, to intermix facility types by providing intermittent sections of fully controlled and non-controlled access facilities.

F. Right-of-Way Width

The width of right-of-way for urban streets is influenced by traffic volume requirements, land use, cost, extent of ultimate expansion, and its availability. Width is the summation of the various cross sectional elements, including widths of travel lanes, shoulders or parking lanes, median, borders, and the area necessary to accommodate slopes and provide ramps or connecting roadways where interchanges are involved.

G. Intersections

The number, design, and spacing of intersections influence the capacity, speed, and safety on urban streets. Capacity analysis of signalized intersections is one of the most important considerations in intersection design. Dimensional layout or geometric design considerations are closely influenced by traffic volumes and operational characteristics and the type of traffic control measures used.

Because of the space limitations and lower operating speeds on urban streets, curve radii for turning movements are less than for rural highway intersections. Curb radii of 15 to 25 feet permit passenger cars to negotiate right turns with little or no encroachment on other lanes. Where heavy volumes of trucks or buses are present, increased curb radii of 30 or 50 feet expedite turns to and from through lanes. Where combination tractor-trailer units are anticipated in significant volume, reference should be made to the material in Section 4-710.

In general, intersection design should be rather simple, free of complicated channelization, to minimize driver confusion. Sight distance is an important consideration even in the design of signalized intersections since, during the low volume hours, flashing operation may be used.

H. Speed Change Lanes

On urban arterial streets, speed change lanes generally provide space for the deceleration and possibly storage of turning vehicles. Acceleration lanes are not usually provided on low speed urban streets.

Taper and storage lengths for left turns

Figure 4-28 shows taper and storage lengths for left turn lanes on urban streets. A short curve is desirable on each end of the taper, but may be omitted for construction ease. Where reverse curves are used, the intervening tangent should be one-third to one-half of the total taper length, and the turnoff curve should be about twice the radius of the second curve.

I. Parking

Where permitted, parking should be parallel on urban arterial streets. Where feasible, parking should be restricted at least during the peak hours and preferably at all times. Parking should be restricted in the vicinity of bus stops and at least 20 feet from intersection crosswalks.

In regard to Federal-aid construction projects involving angle parking, FHWA policy is as follows:

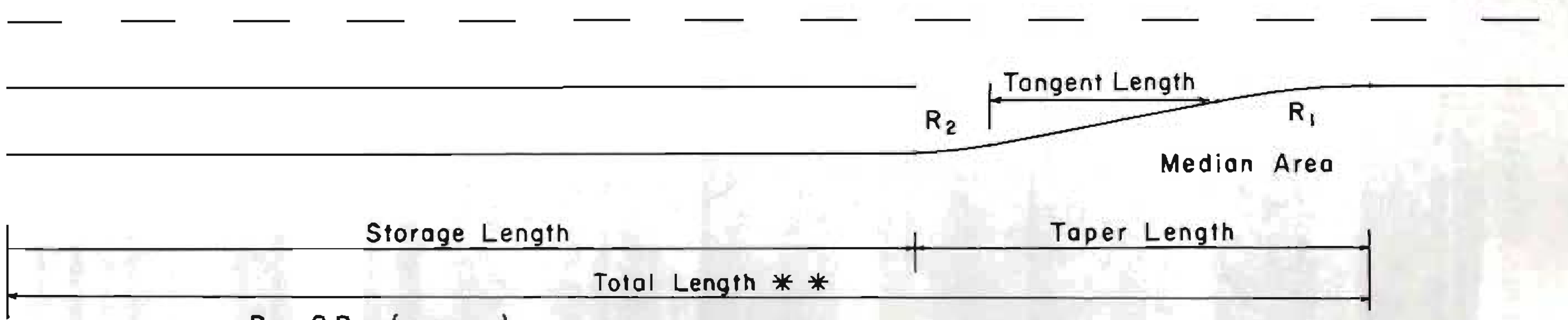
1. New angle parking will not be permitted.

2. The retention of flat-angle (22½ degrees or less) parking, or the conversion from angle parking to flat-angle parking, may be permitted after a field review by the FHWA.

3. Other angle parking may be retained if justified by an engineering study and if supported by FHWA field review. The study should include:

   a. Type of project
   b. Traffic volumes
   c. The number and width of lanes
   d. The street width, angle of parking stalls, and offset from travel lanes
   e. Accident records
   f. Results of Departmental efforts to eliminate angle parking
   g. Functional class of roadway

   The study should be commensurate with roadway type and traffic volume. For low volume facilities, the study may be simply a statement of facts without detailed calculations.



$R_1 = 2R_2$ (approx.)
Tangent Length = (1/3 To 1/2) (taper length)
Taper length and storage length from table.

LENGTHS OF LEFT TURN LANES - URBAN STREETS * * *

Design Speed (mph)	Taper Length (feet) minimum	Storage Length (feet) * * * *			
		Signalized		Non - Signalized	
		min.	des.	min.	des.
30	80	*See	170	50	170
40	125	note	245	75	245
50	180	below	320	100	320

* Based on design hour volume, Storage Length = 0.63 to 0.83 multiplied by left turn peak hour volume.

* * Total length of left turn lane = Storage Length + Taper Length

* * * Applicable to speed change lanes to accommodate left or U-turns at median openings or intersections; applies also to speed change lanes for right turns where desired.

* * * * Block spacing may dictate lesser values

FIG. 4-28. Refers to Paragraph 4-302(H)

For proposed Federal-aid projects unrelated to the travelway, such as illumination, signing, landscaping, guardrail, or similar work, the FHWA has advised that they will not object to the retention of angle parking.

J. For low speed (curbed 45 mph or less speeds, uncurbed 40 mph or less speeds) streets, cross drainage culvert ends minimally should be offset 4' from back of curb or 4' from outside edge of shoulder. The designer, however, should make the best use of available border width to obtain wider clearances from traffic particularly for speeds in the 40 to 45 mph range. Sloped open ends may be used to effectively safety treat small culverts.

4-303 BUS FACILITIES

Urban areas benefit from the effective bus utilization of downtown and radial arterial streets, and from the effective coordination of transit and traffic improvements. To maintain and increase bus patronage, bus priority treatments on arterial streets may be used to underscore the importance of transit use. Possible bus priority treatments on non-controlled access facilities include measures designed to separate car and bus movements and general traffic engineering improvements designed to expedite overall traffic flow.

A. Bus Lanes

Bus lanes are usually used exclusively by buses; however, in some instances carpools, taxis, or turning vehicles may share the lane. They may be located along curbs or in street medians and may operate with or counter to automobile flow.

1. Curb Bus Lanes (Normal Flow)

Curb bus lanes in the normal direction flow are usually in effect only during the peak periods. They are usually implemented in conjunction with removal of curb parking so that there is little adverse effect on existing street capacity. This type of operation may be difficult to enforce and may produce only marginal benefits to bus flow. In operation, right-turning vehicles conflict with buses.

2. Median Bus Lanes

Median bus lanes generally are in effect throughout the day. Wide medians are required to provide refuge for bus patrons, and passengers are required to cross active street lanes to reach bus stops. Additionally, left-turn traffic must be prohibited or controlled to minimize interference between transportation modes.

3. Contraflow Bus Lanes

Contraflow bus lanes, in which buses operate opposite to normal traffic flow, should be used only on one-way streets without parking. They are "self enforcing" with heavy transit traffic although a left-turn conflict is introduced with opposing traffic. In central business districts to other areas with closely spaced signalized intersections, buses may operate against signal progression. In certain instances, the lanes may complicate loading and access to adjoining properties.

B. Bus Streets

Reserving entire streets for the exclusive use of buses represents a major commitment to transit and generally is not feasible due to adverse effects on abutting properties and businesses, including parking garages or lots, drive-in banks, etc.

C. Traffic Engineering Improvements

Coordination of street improvement projects with bus service needs increases overall street efficiency. Street improvements that relieve bottlenecks improve transit operations as well as other traffic operations. The range of traffic engineering projects that enhance bus service include: street extensions or widening to improve bus routing continuity or increase traffic capacity; traffic signal improvements such as system coordination, modernization, and preemptions or overrides for buses; intersection improvement; provision of bus turnouts for loading and unloading, bus stop lengthening or relocation; and extension of parking regulations.

MULTILANE RURAL HIGHWAYS (4-400)

4-401 GENERAL

The general geometric features for multilane rural highways without access control are outlined in Figures 4-29, 4-30 and 4-31 and discussed in subsequent paragraphs. The guidelines apply for all functional classes. References to other applicable criteria are tabulated below:

Maximum Curvature	Figure 4-4
Maximum Gradient	Figure 4-14
Fill Slope Rates	Figure 4-20.

4-402 BASIC DESIGN FEATURES

A. Access Control

The installation of all access driveways along multilane facilities from adjacent property connecting to the main lanes shall be in accordance with the Departmental publication entitled Regulations for Access Driveways to State Highways.

For multilane highways constructed in developed (or expected to be developed) areas, such as by-passes in close proximity to urban areas, it may be desirable to control access to the mainlanes by design (i.e., provision of frontage roads). Where desired, control of access by design may be provided only in the interchange areas or continuously, depending on traffic volumes, the degree of roadside development, availability of right-of-way, economic conditions, etc.

B. Medians

Insofar as practical, wide (desirably 76 feet) medians should be used to provide sufficient storage space for tractor-trailer combination vehicles at median openings, reduce headlight glare, provide a pleasing appearance, and reduce the chances of head-on collisions.

1. Four-Lane Undivided Highways

4-lane undivided "Poor Boy"

Improvement of an existing two-lane highway to a four-lane highway facility preferably should include a median. Undivided highways may be constructed as betterment projects for existing two-lane highways to improve passing opportunities and traffic operation. Undivided highways are thus typically provided in rolling terrain, or where restricted right-of-way conditions and moderate traffic volumes (up to ADT of 7500 in design year) dictate. Figures 4-29 and 4-30 include the general geometric features for four-lane undivided highways.

STANDARDS OF DESIGN FOR MULTILANE RURAL HIGHWAYS
(NON-CONTROLLED ACCESS)(ALL FUNCTIONAL CLASSES)

HIGHWAY CLASS		CLASS 6L		CLASS 4L		CLASS 4L UNDIVIDED[1]	
Average Daily Traffic (ADT)[2]		20,000 or more		5000 to 20,000		Up to 7500	
Design Hourly Volume (DHV)[3]		1600 to 2400		400 to 1600		Up to 600	
Design Speed (Arterials)[4]		Des.	Min.	Des.	Min.	Des.	Min.
Flat		70	70[5]	70	70[5]	70	70[5]
Rolling		70	60[6]	70	60[6]	70	60[6]
Lane Width (Ft.)		12					
Median Width (Ft.)	Narrow (Surfaced)	16	4	16	4	0	
	Depressed	76	48	76	48		
Shoulder Outside (Ft.)		10	8[7]	10	8[7]	10	8[7]
Shoulder Inside (Ft.)		10	2[8] 4[9]	4	2[8]	Not Applicable	
Bridge Width (Ft.)	Narrow Med.	108	92	84	68	68	64[10]
	Depressed Med.	50	42[11]	38	30[11]		

1 Undivided section may be used on betterment projects of two lane highways to improve passing opportunities. Most appropriate for use for rolling terrain and/or restricted right of way conditions.

2 ADT at design year (equivalent passenger vehicles per day, flat terrain, ideal conditions, 20 years from date of construction).

3 One-way DHV (equivalent passenger vehicles per hour, flat terrain, ideal conditions, 20 years from date of construction).

4 For multilane collectors, minimum design speed values are 10 mph less than tabulated.

5 55 mph acceptable for heavy betterment under unusual circumstances. Otherwise, 70 mph should be minimum.

6 50 mph acceptable for heavy betterment under unusual circumstances. Otherwise, 60 mph should be minimum for rural design.

7 Applies to collector roads only. On Class 4L undivided highways, outside surfaced shoulder width may be decreased to 4 feet where flat (10:1), sodded front slopes are provided for a minimum distance of 4 feet from the shoulder edge.

8 Applicable only to 4 foot flush median.

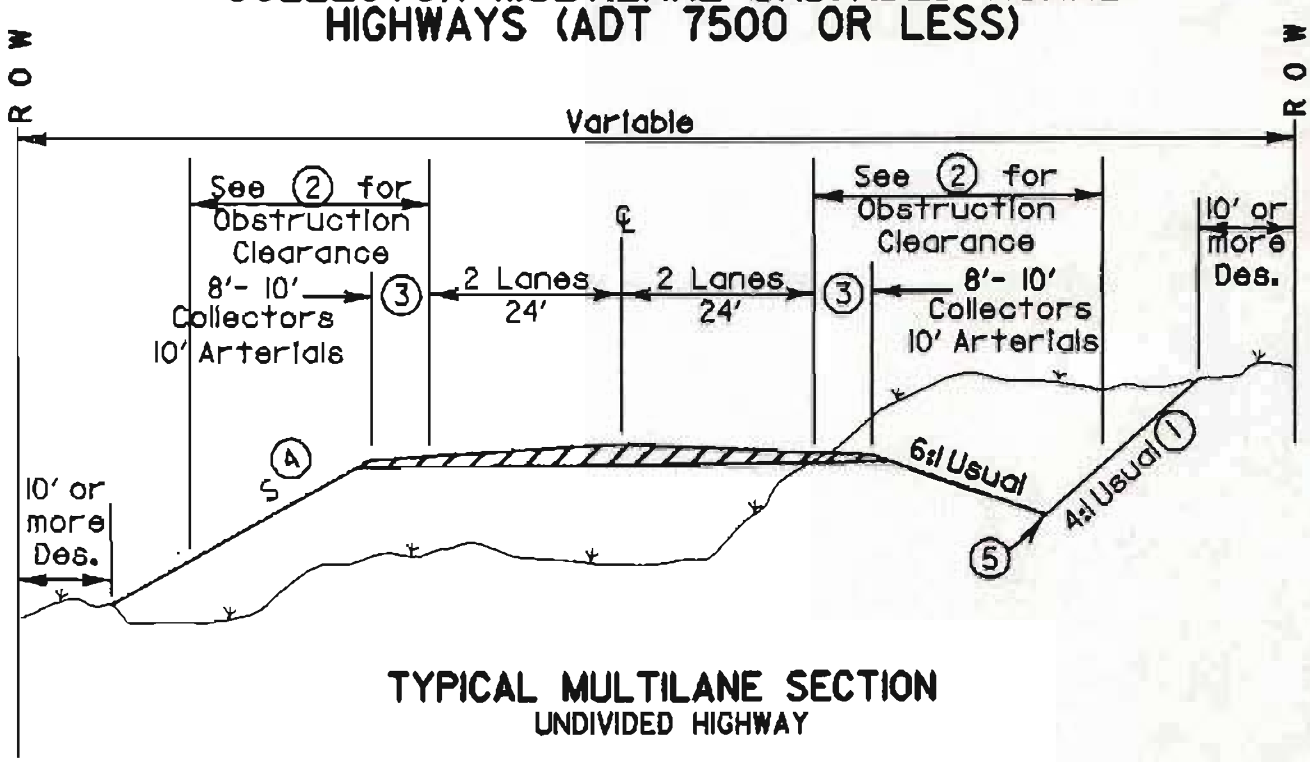
9 Minimum four foot surfaced for depressed medians.

10 Bridge width of 56 feet may be retained; all new or widened bridges to be width of approach roadway, including shoulders.

11 Pertains only to existing bridges to be retained. All new or widened bridges to be width of approach roadway, including shoulders.

Figure 4-29. Refers to Paragraph 4-401

CROSS SECTIONS FOR ARTERIAL AND COLLECTOR MULTILANE UNDIVIDED RURAL HIGHWAYS (ADT 7500 OR LESS)



TYPICAL MULTILANE SECTION
UNDIVIDED HIGHWAY

① Slope may be exceeded in rock cuts, for restrictive right of way or deep cut conditions, or where ditch is located at or beyond applicable clearance.

② 30' usual minimum for S=6:1, except for low volume facilities (see Paragraph 4-202(G)8 and related Figures 4-21 and 4-22). For steeper side slopes (thru 3:1 rate), an obstruction free area at the toe of slope preferably should be provided.

③ Shoulders fully surfaced for arterials. Partial shoulder surfacing 4' in width permissible for collectors where remaining shoulder width is stable (base or sodded, e.g.) and sloped at 10:1 (or flatter).

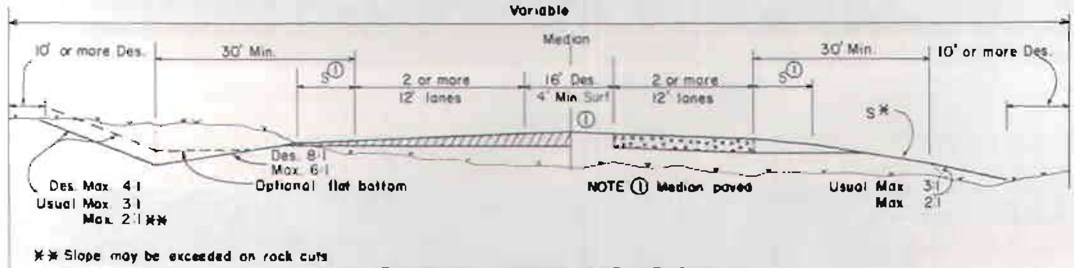
④ For Usual Maximum Design Slope Rate, See Figure 4-20 and Discussion in Section 4-202(G)2.

⑤ See discussion of preferred ditch sections in Section 4-202(H)3, and Figure 4-25.

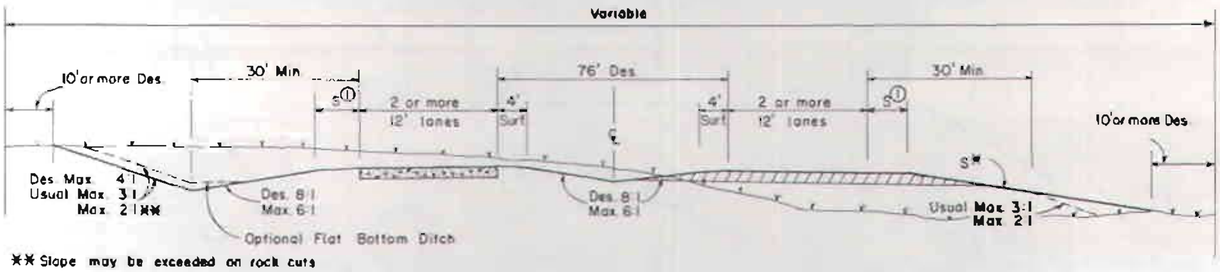
NOTE: All existing structures to be retained shall be 56' or wider. New or widened structures minimally shall be width of approach roadway including shoulders.

Figure 4-30. Refers to Paragraph 4-401

CROSS-SECTIONS FOR MULTILANE RURAL HIGHWAYS
(ADT 5000 OR MORE)



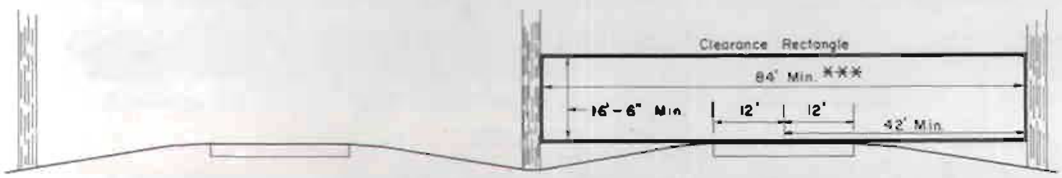
TYPICAL MULTILANE SECTION
Narrow Median



** Slope may be exceeded on rock cuts

* For usual maximum design side slope rate, see Figure 4-20 and discussion in Section 4-202(G)2

TYPICAL MULTILANE SECTION
Depressed Median

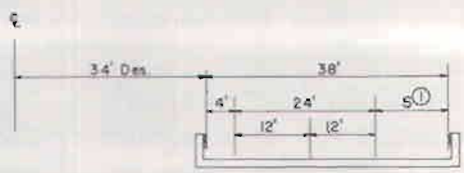


*** Where future lanes are anticipated, add 12' to width of clearance rectangle for each added lane

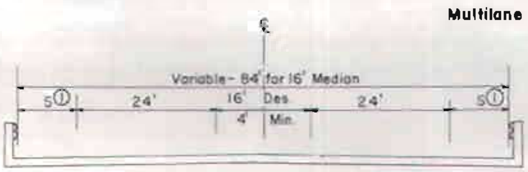
CLEARANCE REQUIREMENTS
MULTILANE HIGHWAY

NOTES ON OUTSIDE SHOULDERS

① On arterials outside shoulder(s) should be 10' in width and fully surfaced. On collectors outside shoulders should be 8' to 10' wide and fully surfaced.



STRUCTURE SECTION
Multilane Depressed Median



STRUCTURE SECTION
Multilane Narrow Median

FIGURE 4-31. Refers to Paragraph 4-401

2. Narrow Medians

narrow medians 4'-16'

Surfaced medians of 4' to 16' are classified as narrow medians and are used in restricted conditions. Medians 4' wide provide little separation of opposing traffic and a minimal refuge area for pedestrians. Narrow medians of 14' to 16' offer space for use by exiting traffic turning left, but do not offer protection for crossing vehicles. Narrow median designs are most appropriate in areas with roadside development.

3. Wide Medians

wide medians 76' desirably

Medians 76' wide significantly reduce headlight glare, are pleasing in appearance, reduce the chances of head-on collisions, and provide a sheltered storage area for crossing vehicles, including tractor-trailer combinations. Wide medians should be used whenever feasible.

C. Median Openings

median openings not less than 1/4 mile apart in rural areas

Median openings at close intervals on divided highways create undue hazard and interference with high speed through-traffic. The frequency of median openings varies with topographic restrictions and local requirements; however, as a general rule the minimum spacing should not be less than one-fourth mile in rural areas. Spacing often is selected so as to provide openings at all public roads and at major traffic generators such as industrial sites or shopping centers, with additional openings provided so as not to surpass a maximum one-half mile spacing. Left-turn bays should be provided at all median openings. At intersections with highways or other major public roads, speed change lanes for right-turning vehicles entering and exiting the highway desirably should be provided. For divided highways with independent mainlane alignment, particular care should be exercised at median openings to provide a satisfactory profile along the crossover with flat, platform approaches to the mainlanes.

median openings should not be less than 40' in width or the cross-road width plus 8'.

Median opening width should in no case be less than 40' nor less than crossroad pavement width plus 8'. Turning templates for a selected control radius and design vehicle are often used as the basis for minimum design of median openings, particularly for multilane crossroads and skewed intersections. See Section 4-710 for additional information.

D. Speed Change Lanes

1. Median Speed Change Lanes

Median speed change (deceleration) lanes provide deceleration and storage area for vehicles making left turns to leave a divided highway. Storage and taper lengths for design are summarized in Figure 4-32.

LENGTHS OF MEDIAN SPEED CHANGE LANES
MULTILANE RURAL HIGHWAYS

Turning ADT, vpd	150	300	500	750
Minimum Storage length, feet	50	100	175	250
Design Speed	50	60	70	
Taper length, feet	180	245	320	

Note: For low volume median openings, such as those serving private drives or U-turns, taper length of 180' may be used regardless of mainlane design speed.

Figure 4-32. Refers to Paragraph 4-202(D)

Perhaps, 2. should also refer to Figure 4-32. For unusual situations you might refer to Figure 4-33 and move 4-33 to ramp section under Freeways.

2. Right Speed Change Lane

Right side (12' wide lane with 4' wide adjacent shoulders) speed change lanes provide deceleration or acceleration area for right turning vehicles. Design criteria for right side speed change lanes are shown in Figure 4-33. There are no warrants for provision of these speed change lanes but generally they are used where high volume right turns and/or sight distance restrictions are involved. For low and moderate volume conditions 10' surfaced shoulders offer sufficient refuge from higher speed traffic.

E. Transition from Two-Lane to Four-Lane Divided

median openings should not be permitted within 1300' of transition areas of 2-lane to 4-lane

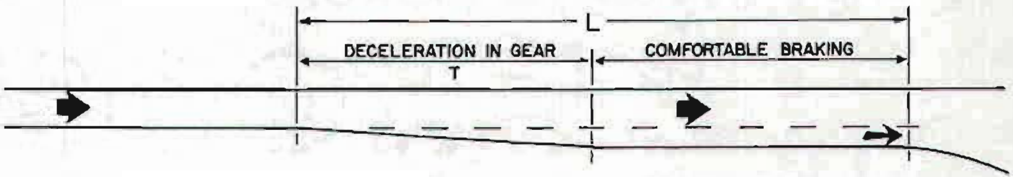
Typical transition from two-lane to four-lane divided are shown in Figure 4-34. The transition should be visible to the driver approaching from either direction and median openings should not be permitted within 1300' of the transition area. Transition areas should be located so that obstructions such as restrictive width bridges or underpasses or other fixed objects are not within the no-passing zone or the two-lane highway approach.

F. Pavements and Shoulders

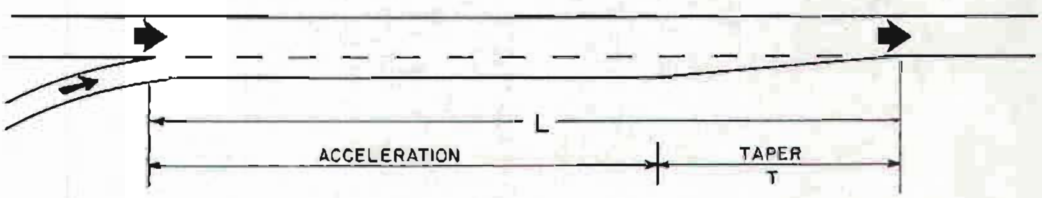
1. Pavements

Travel lanes should be twelve feet minimum width on rural multilane highways. For narrow, depressed median sections, it may be necessary to effect superelevation across the entire cross section to provide for safer operation at median openings.

LENGTHS OF RIGHT-TURN SPEED CHANGE LANES FOR NON-CONTROLLED ACCESS HIGHWAYS



HIGHWAY DESIGN SPEED MPH	MINIMUM LENGTH OF TAPER (FEET) T	L-LENGTH OF DECELERATION LANE-FEET FOR DESIGN SPEED OF EXIT CURVE-MPH								
		STOP CONDITION	15	20	25	30	35	40	45	50
		FOR AVERAGE RUNNING SPEED ON EXIT CURVE-MPH								
		0	14	18	22	26	30	36	40	44
30	150	235	185	160	140	—	—	—	—	—
40	190	315	295	265	235	185	155	—	—	—
50	230	435	405	385	355	315	285	225	175	—
60	270	530	500	490	460	430	410	340	300	240
65	290	570	540	530	490	480	430	380	330	280
70	300	615	590	570	550	510	490	430	390	340
75	315	660	630	610	590	560	530	470	440	390
80	330	700	680	660	640	610	580	530	490	450



HIGHWAY		L-LENGTH OF ACCELERATION LANE-FEET FOR ENTRANCE CURVE DESIGN SPEED, MPH								
DESIGN SPEED MPH	MINIMUM LENGTH OF TAPER (FEET) T	STOP CONDITION	15	20	25	30	35	40	45	50
		AND INITIAL SPEED, MPH								
		0	14	13	22	26	30	36	40	44
30	150	190	—	—	—	—	—	—	—	—
40	190	380	320	250	220	140	—	—	—	—
50	230	760	700	630	680	500	380	160	—	—
60	270	1,170	1,120	1,070	1,000	910	800	590	400	170
70	290	1,590	1,540	1,500	1,410	1,330	1,230	1,010	830	580

NOTE: Where lengths exceed 1,300 feet, or design speeds exceed 70 mph, uniform 50:1 tapers are recommended.

Figure 4-33. Refers to Paragraph 4-402(D)2

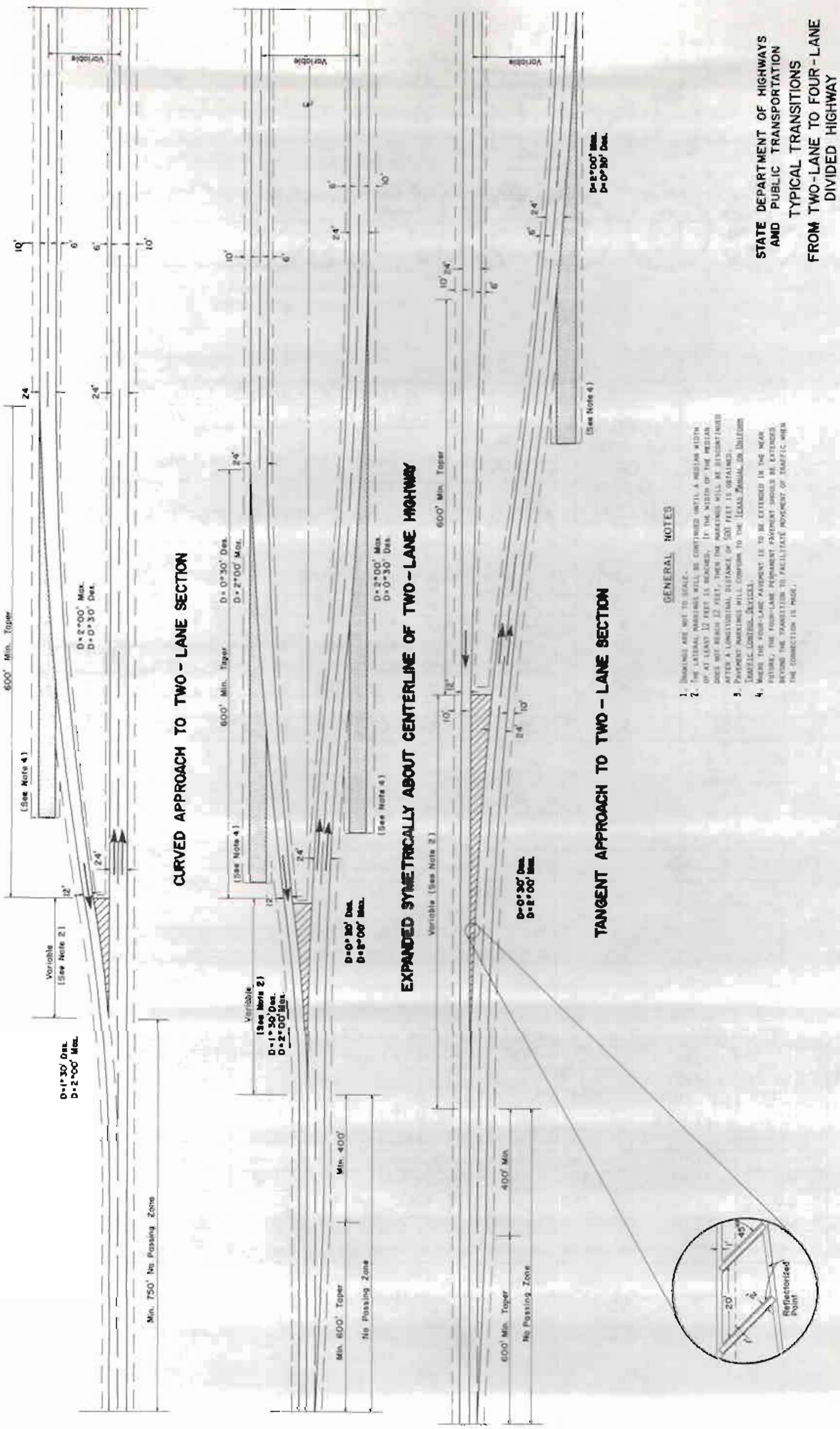


Figure 4-34. Refers to Paragraph 4-402(E)

2. Shoulders

Shoulders should always be provided with widths as shown in Figures 4-29, 4-30 and 4-31. Shoulders should be surfaced for all arterials and for all divided class collectors.

G. Intersections

when intersection skew angles exceed 60°, alignment modifications are generally necessary.

In the design of intersections, careful consideration should be given to the appearance of the intersection to the driver. In this regard, design should be rather simple to avoid driver confusion, and adequate sight distance should be provided throughout, especially in maneuver or conflict areas. Right angle crossings are preferred to skewed crossings, and where skew angles exceed 60° alignment modifications are generally necessary. Speed change lanes may be provided in accordance with Paragraph 4-202(D).

Section 4-710 Paragraphs A thru E provide information regarding the accommodation of various types of truck class vehicles in intersection design. Further information on intersection design may also be found in Chapter 9 of A Policy on Geometric Design of Highways and Streets, AASHTO, 1984.

Intersections formed at by-pass and existing route junctions should be designed so as not to mislead drivers as typified in Figure 4-35.

H. Grade Separations and Interchanges

Grade separations or interchanges on multilane rural highways may be provided at high volume highways, railroads, or to increase safety at accident-prone crossings. Where interchanges are provided in urban area fringes such as along by-pass routes, frontage roads may be appropriate to control access as discussed in Paragraph 4-202(A).

Further information on grade separations and interchanges may be found in Chapter 10 of A Policy on Geometric Design of Highways and Streets, AASHTO, 1984.

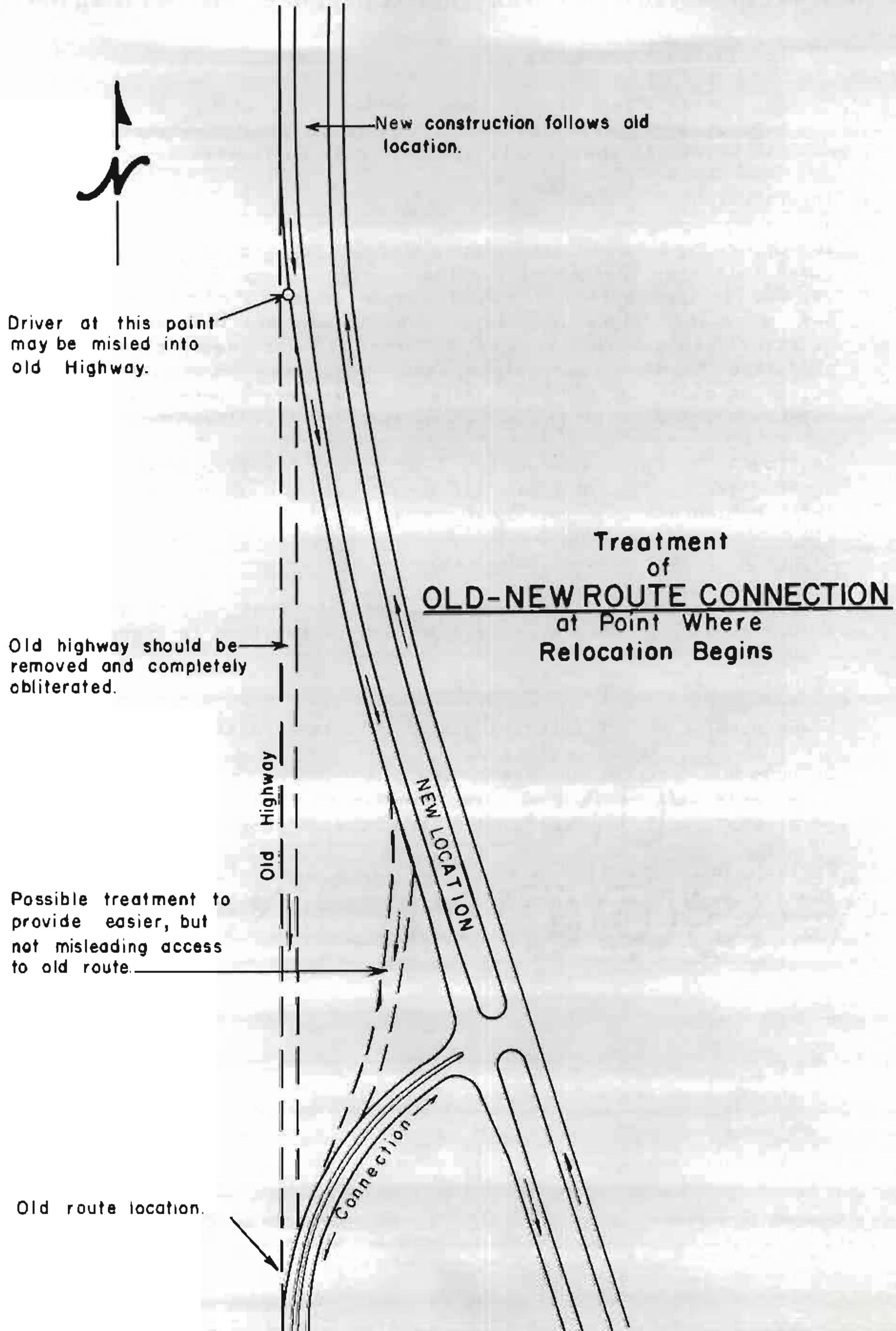


FIGURE 4-35. Refers to Paragraph 4-402(G)

TWO-LANE RURAL HIGHWAYS (4-500)

4-501 GENERAL

The general geometric features for two-lane rural highways are shown in Figures 4-36, 4-37, 4-38, and 4-40. The basic design criteria and cross sectional elements common to all highways, regardless of functional class, are shown in Figure 4-37. Figure 4-39 shows minimum structure widths that may remain in place.

4-502 BASIC DESIGN FEATURES

A. Access Control

Frontage roads or parallel service roads to serve small rural business communities or other developments should not be permitted along two-lane rural highways. To a driver unfamiliar with the local area, a frontage road takes on the appearance of a separate roadway of a multilane divided facility, thus resulting in the assumption that the two-way, two-lane highway is a one-way roadway. Where individual driveways are located within deep cut or high fill areas, driveways may be routed parallel to the highway for short distances to provide for a safe, economical junction with the highway.

The installation of access driveways along two-lane rural highways shall be in accordance with the Departmental publication Regulations for Access Driveways to State Highways.

B. Narrow Medians on Two-Lane Highways

Figure 4-41 depicts an experimental two-lane double-striped highway typical section which embodies a factor of safety not afforded by the conventional two-lane highway. The four-foot striped median provides a greater separation between opposing traffic and facilitates the introduction of channelization at intersections. It may be used as an alternate to the sections illustrated in Figure 4-40 for asphaltic concrete pavement overlay or seal coat projects, but only if all structures within the project length are crown width. For new construction or reconstruction full width shoulders should be provided.

C. Transitions to Four-Lane Divided Highways

Typical transitions from two-lane to four-lane divided highways are discussed in Paragraph 4-402(E) and illustrated in Figure 4-34.

D. Passing Sight Distance

Passing sight distance is the length of highway required to make a passing maneuver without cutting off the passed vehicle and before meeting an opposing vehicle which might subsequently appear.

MINIMUM DESIGN SPEED[1] RELATED TO FUNCTIONAL

CLASS, TERRAIN, AND TRAFFIC VOLUME

FOR RURAL TWO-LANE HIGHWAYS

Functional Class	Terrain	MIN. DESIGN SPEED (mph) FOR TRAFFIC VOLUME OF: Current 0-250 ADT	Current 250-400 ADT	Future 750-1500 ADT	Future 1500 or more ADT
Arterial	Level	70			
	Rolling	60			
Collector	Level	50[2]	50[2]	50	60
	Rolling	40[3]	40[3]	40	50
Local[4]	Level	30	40	50	50
	Rolling	30	30	40	40

[1] Applicable to projects on new location or regrading of existing highways.

[2] A 40 mph minimum design speed may be used where roadside environment or unusual design considerations dictate.

[3] A 30 mph minimum design speed may be used where roadside environment or unusual design considerations dictate.

[4] Applicable only to off-system routes that are not functionally classified at a higher classification.

Figure 4-36. Refers to Paragraph 4-501

GEOMETRIC DESIGN CRITERIA

FOR RURAL TWO-LANE HIGHWAYS

Geometric Design Element	Funct. Class	Reference or Design Value
Design Speed	All	Figure 4-36
Max. Horiz. Curvature	All	Figure 4-4
Max. Gradient	All	Figure 4-14
Stopping Sight Distance	All	Figure 4-3
Width of Travel Lanes	All	Figure 4-38
Width of Shoulders	All	Figure 4-38
Vertical Clearance, New Structures	All	16.5 ft.[1]
Width of New Structures	All	Approach Rdwy. (incl. shldrs.) or wider
Horizontal Clearance	All	Figure 4-21
Pavement Cross Slope	All	Paragraph 4-202(G)1
Fill Slope Rates	All	Figure 4-20
Right of Way Width	All	As necessary to accommodate design cross section and utilities.

[1] Exceptional cases near as practical to 16.5' but never less than 14.5'.

Figure 4-37. Refers to Paragraph 4-501

WIDTH OF TRAVEL LANES AND SHOULDERS ON RURAL TWO-LANE HIGHWAYS

Functional Class	Design Speed (mph)	MIN. WIDTH[1,2] (ft.) FOR TRAFFIC VOLUME OF:				
		Current 0-250 ADT[3]	Current 250-400 ADT[3]	Future 750-1500 ADT	Future 1500-3000 ADT	Future 3000 or more ADT
Arterial	All	LANES 12				
		SHOULDERS				
	All	4[4]	4[4]	6[4]	8-10[4]	10[4]
Bridges		34[8]	34[8]	38[8]	40-44	44
Collector		LANES				
	30	10	10	10	11	12
	40	10	10	11	11	12
	50	10	10	11	12	12
	60	11	11	11	12	12
		SHOULDERS				
	All	2[5,6]	2[5,6]	4[6]	8-10[6]	8-10[6]
Bridges		28-30[5]	28-30[5]	28-30	38-44[8]	40-44
Local[7]		LANES				
	30	10	10	10	10	12
	40	10	10	11	11	12
	50	10	10	11	11	12
		SHOULDERS				
	All	2	4	4	8	8
Bridges		24	28	28-30	36-38[8]	40

[1] Minimum surfacing width is 22' for all highway system routes.

[2] On high riprapped fills through reservoirs a minimum of two 12' lanes with 8' shoulders should be provided for both roadway sections and bridges. For arterials with 3000 or more future ADT in reservoir areas, two 12' lanes and with 10' shoulders should be used.

[3] Future ADT should be less than 750.

[4] On arterials, shoulders fully surfaced.

[5] On collectors, use minimum 4' shoulder width at locations where roadside barrier is utilized.

[6] For collectors, shoulders fully surfaced for future 3000 or more ADT. Shoulder surfacing not required but desirable even if partial width for collectors with lower volumes and all local roads.

[7] Applicable only to off-system routes that are not functionally classified at a higher classification.

[8] To maximize use of currently available bridge standard details, use a 34' bridge for a 32' approach roadway, a 38' bridge for a 36' approach roadway, and a 44' bridge for a 42' approach roadway, and widen crown on bridge approaches to accommodate guard fence.

Notes:
1. The minimum width of new or widened structures shall accommodate the approach roadway including shoulders.
2. See Figure 4-39 for minimum structure widths that may remain in place.

Figure 4-38. Refers to Paragraph 4-501

MINIMUM STRUCTURE WIDTHS FOR

BRIDGES TO REMAIN IN PLACE

ON RURAL TWO-LANE HIGHWAYS

	Roadway Clear Width[1] (ft)	
Current ADT (vpd)	Locals & Collectors	Arterials
Under 400	22	↑
400 to 4000	24	Traveled Way Plus 6'
Over 4000	30	↓

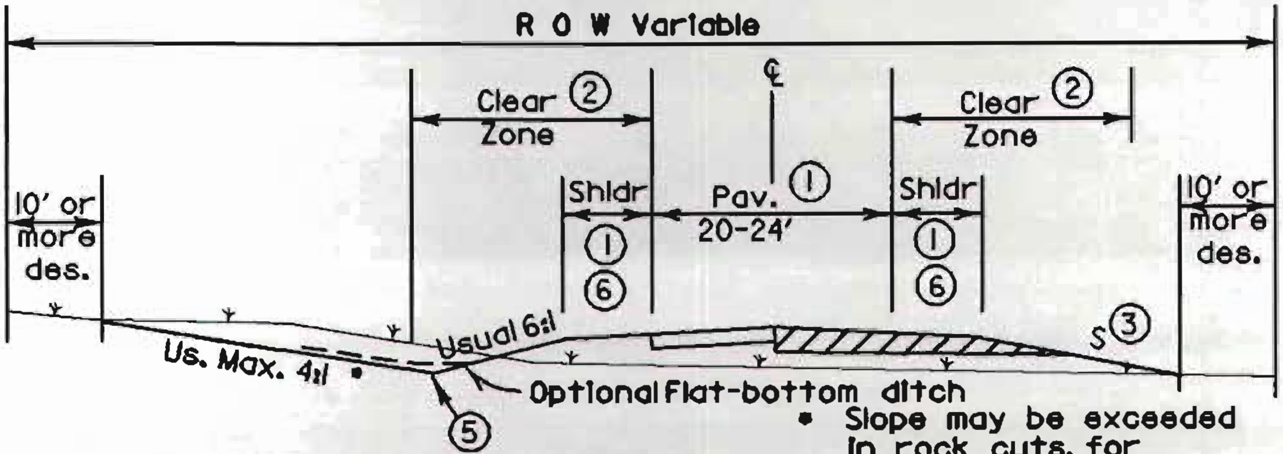
1 Clear width between curbs or rails, whichever is lesser, is considered to be at least the same as approach roadway clear width.

See footnote on pg 476 in 1990 Greenbook
use same footnote

(Travel way instead of roadway
use in the Green Book)

Figure 4-39. Refers to Paragraph 4-501

CROSS SECTIONS FOR ARTERIAL AND COLLECTOR TWO-LANE RURAL HIGHWAYS ①



* Slope may be exceeded in rock cuts, for restricted right of way, deep cut conditions, or where ditch is not within clear zone.

NORMAL SECTION

NOTES:

① For widths of travel lanes and shoulders, see Figure 4-38.

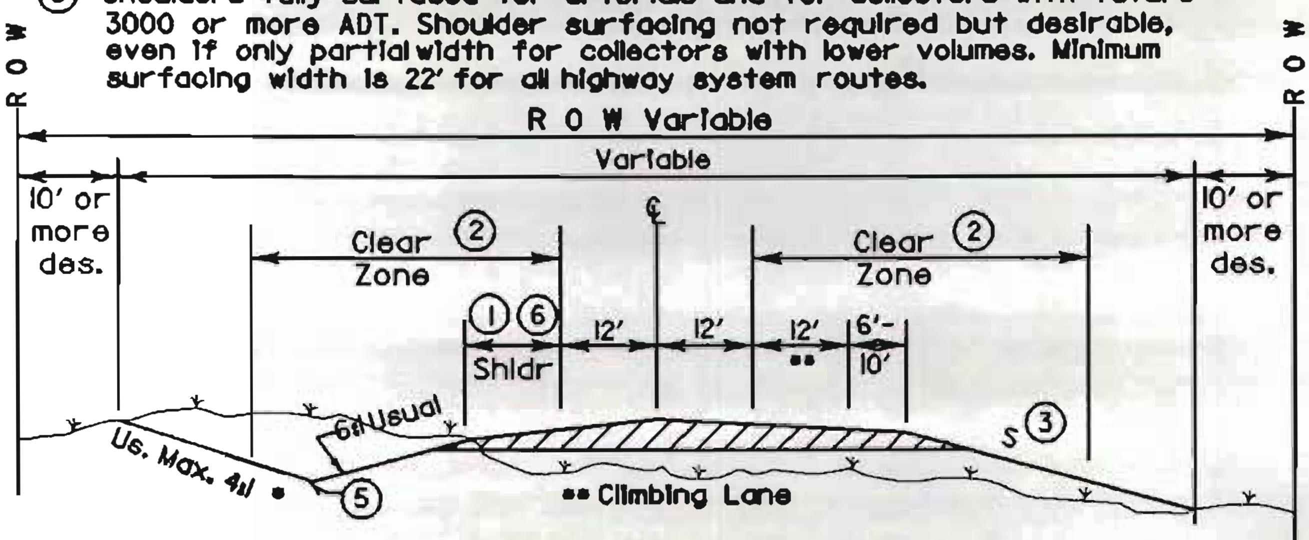
② See Figure 4-21. Where fill slope rate is steeper than 6:1 an obstruction free area preferably should be provided at the toe of slope.

③ See Figure 4-20 and discussion in Section 4-202(G)2.

④ R O W width based on sum of individual cross sectional elements for specific traffic volume, slope, obstruction clearance and terrain conditions.

⑤ See discussion of preferred ditch sections in Section 4-202(H)3, and Figure 4-25.

⑥ Shoulders fully surfaced for arterials and for collectors with future 3000 or more ADT. Shoulder surfacing not required but desirable, even if only partial width for collectors with lower volumes. Minimum surfacing width is 22' for all highway system routes.



CLIMBING LANE SECTION

Figure 4-40. Refers to Paragraph 4-501

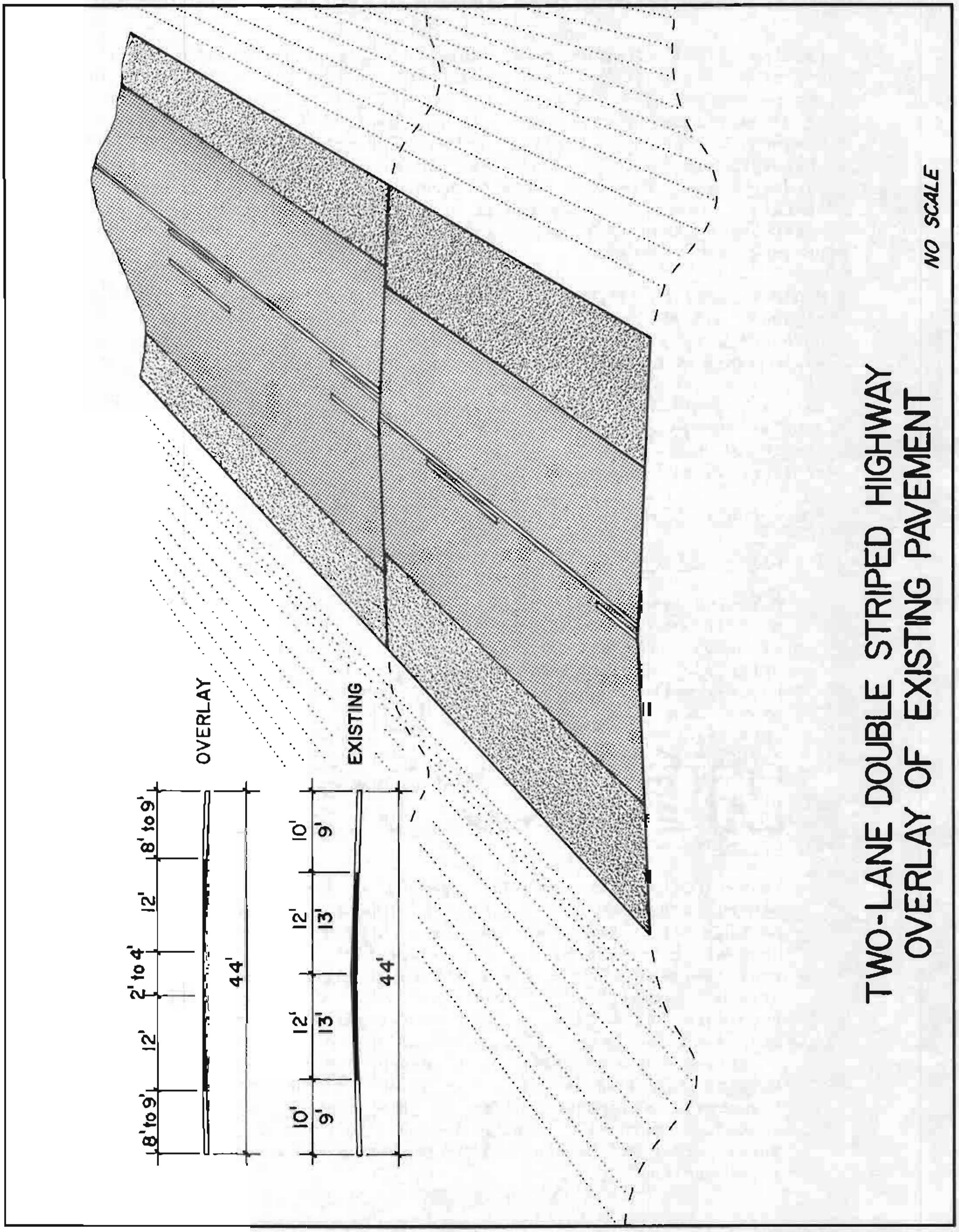


FIGURE 4-41. REFERS TO PARAGRAPH 4-502 (B)

Passing sight distance is, therefore, applicable to two-lane highways only. It is based on driver's eye height of 3.5 feet and the perception of an object 4.25 feet high, and a speed differential of 10 mph between vehicles. In the design of two-lane highways, minimum or greater passing sight distance should be provided wherever practical, since less than minimum distances reduce capacity and adversely affect level of service. For rolling terrain, provision of climbing lanes may be a more economical alternative than achieving a vertical alignment with adequate passing sight distance.

Minimum passing sight distance values for design of two-lane highways are shown in Figure 4-42. These distances are for design purposes only and should not be confused with other distances used as warrants for striping no-passing zones as shown in the TMUTCD. For the design of typical two-lane rural highways, except for level terrain, provision of near continuous passing sight distance (2500 feet at 70 mph design speed) is impractical. However, the designer should attempt to increase the length and frequency of passing sections where economically feasible.

E. Speed Change Lanes

1. Climbing Lanes

Climbing lanes should be provided on two-lane highways when they meet the warrants (10 mph speed reduction and inadequate level of service) as described in Appendix D, "Capacity and Level of Service". For projects on new location or where an existing highway will be regraded, the economics of providing an improved grade line in lieu of providing climbing lanes should be investigated. In design, attention should be given to the location of the climbing lane terminal. Such lanes should not end just prior to an obstruction such as a restrictive width bridge.

2. Left-Turn Bays

Left-turn bays on two-lane highways at intersecting crossroads generally are not economically justified. For certain moderate or high volume two-lane highways with heavy left-turn movements, however, left-turn bays may be justified in view of reduced road user accident costs. Delay and acceleration-deceleration costs are not significant economic factors where wide (10 feet) shoulders would permit nonturning traffic to by-pass a queue stored on the travel lanes. Where used, left-turn bays should be delineated with striping and pavement markers or jiggle bars. Passing should be restricted in advance of the intersection, and horizontal alignment shifts of the approaching travel lanes should be gradual. Figure 4-43 shows typical geometry for a rural two-lane highway with left-turn bays at a crossroad intersection.

PASSING SIGHT DISTANCE

K VALUES FOR DETERMINING LENGTH OF CREST VERTICAL CURVE

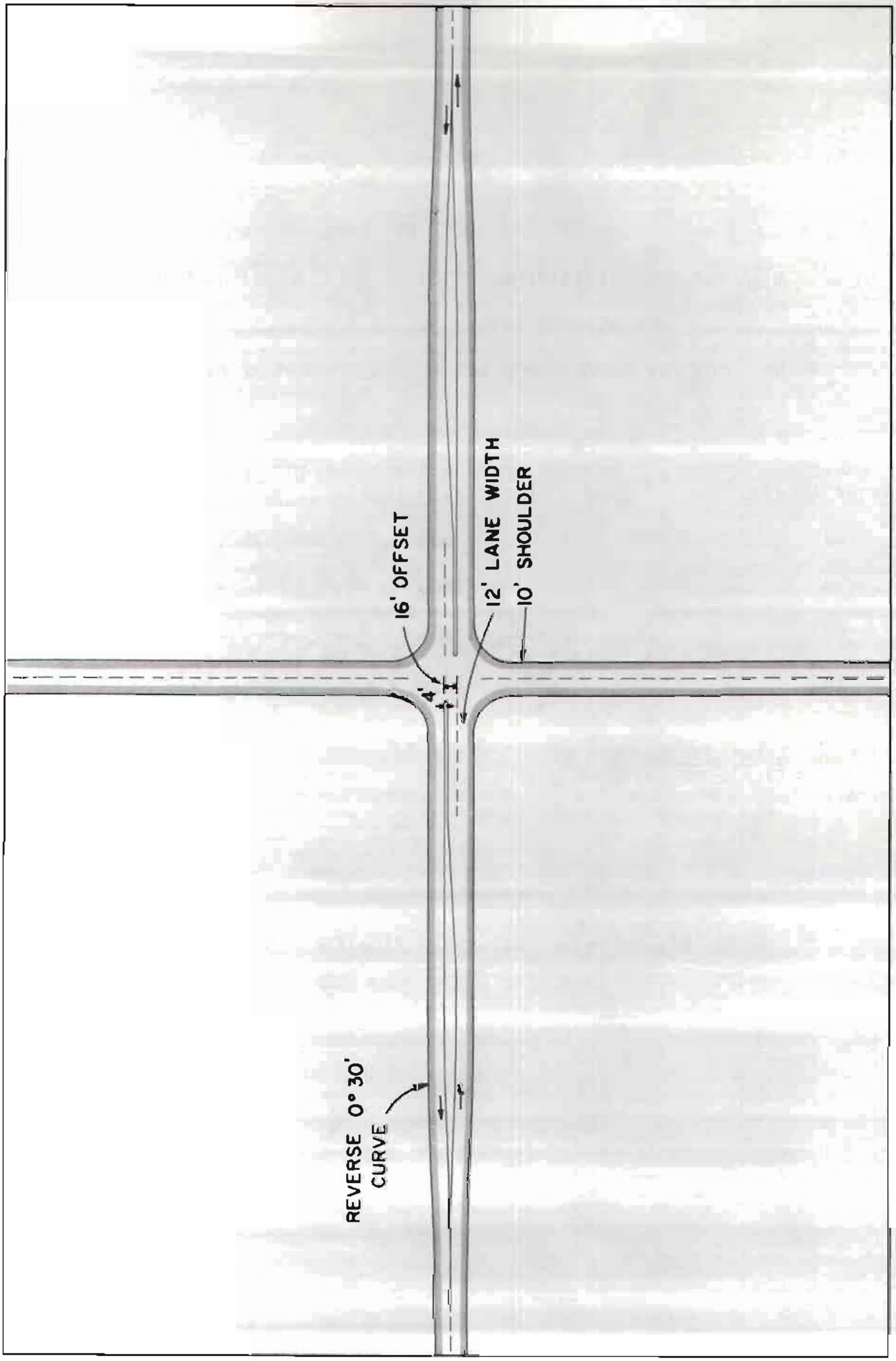
FOR VARIOUS PASSING SIGHT DISTANCES

BASED ON EYE HEIGHT OF 3.50' AND OBJECT HEIGHT OF 4.25'

Design Speed (MPH)	Minimum Passing Sight Distance For Design (Feet)	K* Value
40	1500	730
50	1800	1050
60	2100	1430
70	2500	2030

$$^{*}K = \frac{\text{Length of Crest Vertical Curve}}{\text{Algebraic Difference in Grades}}$$

Figure 4-42. Refers to Pararaph 4-502(D)



TYPICAL TWO-LANE HIGHWAY INTERSECTION
WITH LEFT TURN BAYS

FIGURE 4-43. Refers to Paragraph 4-502(E)2

3. Right-Turn Speed Change Lanes

Full (10 feet wide) shoulders alongside the traffic lanes generally provide sufficient area for acceleration or deceleration of right-turning vehicles. Where speed change lanes are used, however, they should be provided symmetrically along both sides of the highway for both directions of traffic, thus presenting drivers with a balanced section.

A deceleration-acceleration lane on one side of a two-lane highway, such as a "tee" intersection, results in the appearance of a three-lane highway and may produce confused, hazardous driving practices. In this regard, right-turn speed change lanes are generally inappropriate for "tee" intersection design except where a four lane (2 thru, 1 median left turn, 1 right acceleration/deceleration) section is provided.

F. Intersections

The provision of adequate sight distance is of utmost importance in the design of intersections along two-lane rural highways. Desirably, the roadways should cross at approximately right angles. Where crossroad skew is flatter than sixty degrees to the highway, the crossroad should be re-aligned to provide for a near perpendicular crossing.

G. Off-System Federal-Aid Highway Bridge Replacement and Rehabilitation Programs (HBRRP)

File D-5 (Bridge Division) is responsible for determining HBRRP project eligibility and for handling layout and data submissions.

Current ADT Greater Than 250

Where current ADT exceeds 250, or where the off-system road is not on the Federal-aid highway system but is on the designated state highway system or is likely to be added to our system, use design standards as appropriate for the class of highway as shown within Part IV of this *Manual*.

Current ADT 250 or Less

Design values selected for a particular project should satisfy and preferably exceed the minimum values shown below. Selected design values should be consistent and compatible with the prevalent design features on the existing off-system roadway.

1. Minimum Design Speed: 30 mph

2. Minimum Stopping Sight Distance: 200 Ft.

3. Vertical Curvature Controls, Minimum K Values:
   A. Crests - 30
   B. Sags - 40

4. Horizontal Curvature, Maximum Degree of Curve = 15° usual, 22°45' maximum based on e=0.08 ft./ft.

5. Maximum Grades:
   A. Level Terrain - 7%
   B. Rolling Terrain - 10%

6. Minimum Structure Width, Face to Face of Rail: 24 Ft.

7. Bridge End Guard Fence:
   A. Minimum Conditions - 25 ft. turndown section (only with T6 rail)
   B. Usual Maximum - 75 ft. guard fence plus 25 ft. turndown section

8. Approach Roadway:
   A. For minimum length of 50 ft. adjacent to bridge end, roadway crown should match clear width across structure (24 ft. min.) plus additional width to accommodate approach guard fence.
   B. An appropriate transition (minimum length 50 ft.) to county road width should be made in the sections of approach roadway located at the Federal project extremities.
   C. If roadway surfacing is used, minimum width should be 20 ft.

9. Traffic Control:
   A. Detours: As a minimum, match existing county road design features. Design details for detours should be shown in the plans and on the preliminary layouts where possible.
   B. Traffic control devices should be in conformance with the MUTCD and details should be included in the P.S.&E.

FREEWAYS (4-600)

4-601 GENERAL

Freeways are generally functionally classified as arterials but have unique design characteristics that set them apart from non-access controlled arterials.

A controlled access facility will generally be considered in a rural area when design year traffic volumes approach 15,000 vpd. In an urban area, the general warrants for freeways are not so clearly indicated since traffic operations and the capacity of the signal system control the volume of traffic that can be acceptably served on a more conventional facility. However, when design year volumes approach 18,000 vpd on a four-lane arterial or 30,000 vpd on a six-lane arterial, a freeway should be considered. For capacity and level of service evaluation, see the Highway Capacity Manual.

Geometric design criteria applicable to freeways as well as other facility types are shown in previous sections of Part IV. Specific references are tabulated below:

Design Item	Reference Figure No.
Grades	4-14
Horiz. Curvature	4-4
Vertical Curvature	4-16, 4-18
Fill Slopes	4-20
Pavement, Shoulder Slopes	Para. 4-202(G)1

4-602 BASIC DESIGN FEATURES

A. Frontage Roads and Access Control

1. General

Control of access is achieved (a) through deed restrictions whereby the rights of access to the highway from abutting property owners is denied with ingress and egress to the mainlanes only at selected interchange ramps, or (b) through construction of frontage roads to restore access to abutting properties, but permitting access to the mainlanes only at selected interchange ramps. In either case, direct access from private property to the mainlanes is prohibited without exception. In the case where frontage roads are provided, for safety and operational purposes access should be controlled at ramp junctions with frontage roads through the means of deed restrictions or the State's use of its police powers to control driveway location and design.

Figures 4-44 & 4-45 show preferred access control strategies for planned exit and entrance ramps, respectively.

A controlled access highway may be developed in either of two ways: by design or by designation.

a. Control of Access Solely By Design

If a highway is to be developed solely by design (non-House Bill 179), the SDHPT is not empowered to purchase access rights but must achieve access control by construction of continuous frontage roads and by the utilization of the State's police power to control driveways, particularly at locations such as ramp junctions with frontage roads.

In the interest of providing for highway safety and utility, the State may through its police powers regulate driveway location and design. Landlocking through complete denial of access is beyond the State's regulatory power (without Commission designation under H.B. 179) and the courts have held such action as compensable. The State, however, may effectively regulate driveway location in accordance with Statewide policy as long as (1) reasonable access is provided and (2) the impairment of access is not material and substantial. The Departmental publication entitled "Regulations for Access Driveways to State Highways" governs design and location of driveways.

b. Control of Access on Freeways Designated Under H.B. 179

Control of Access under HB 179

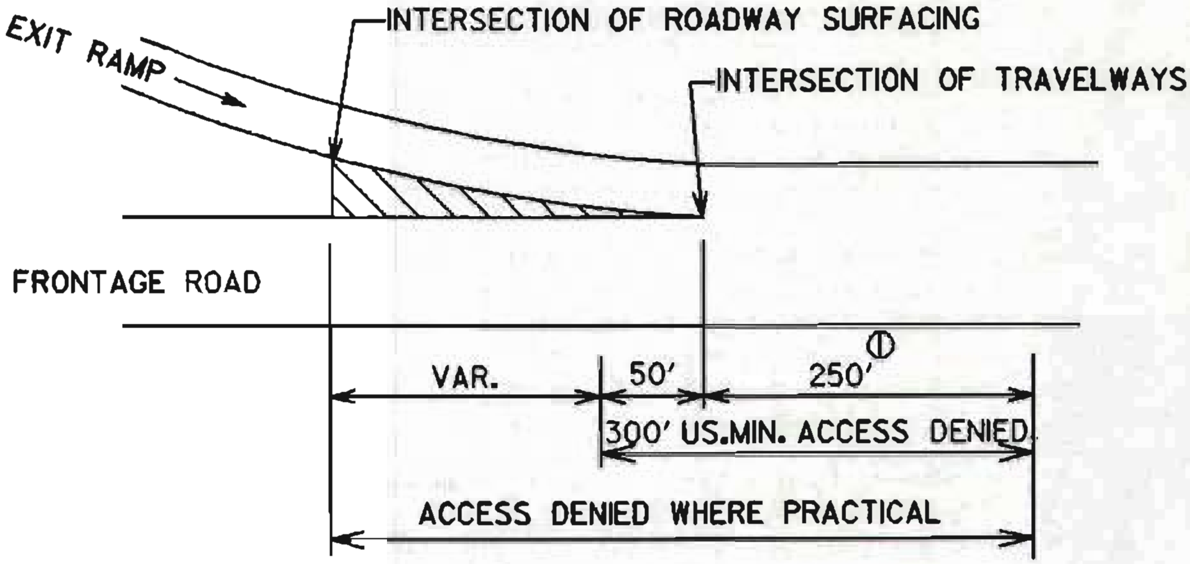
When a freeway is developed by State Highway and Public Transportation Commission designation under H.B. 179, the State is empowered to control access through deed restriction. All Interstate Highways are designated under H.B. 179 and certain other routes have been or may be designated. These designated H.B. 179 freeways may or may not have frontage roads, whichever arrangement is determined to be appropriate as discussed in Paragraph 4-602(B). Development of freeways by designation under H.B. 179, rather than solely by design, is the preferred design approach especially for all new location freeways.

2. Planned (Future) Freeways

a. H.B. 179 Planned Freeways, Location Not Along An Existing Public Road

Whenever H.B. 179 freeways include frontage roads and the planned location is not along an existing public road, preferably access should be controlled through deed restrictions at ramp junctions with frontage roads as shown on Figures 4-44 & 4-45.

PREFERRED ACCESS CONTROL AT EXIT RAMP JUNCTION WITH FRONTAGE ROAD



① Longer distance desirable particularly for high volume exit ramp and/or frontage road.

Figure 4-44. Refers to Paragraph 4-602(A)

NOTE: IT MAY BE DESIRABLE TO PLACE JIGGLE BARS IN CROSS-HATCHED AREA TO DISCOURAGE CROSSING.

PREFERRED ACCESS CONTROL AT ENTRANCE RAMP JUNCTION WITH FRONTAGE ROAD

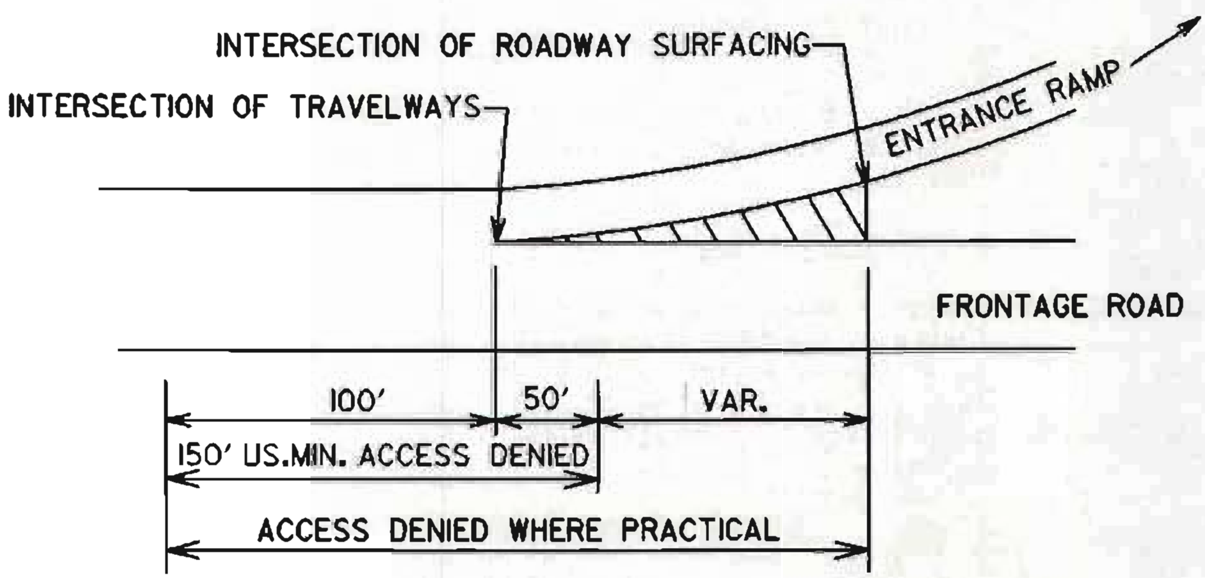


Figure 4-45. Refers to Paragraph 4-602(A)

Where no frontage roads are provided, access is controlled to the mainlanes by deed restriction.

b. H.B. 179 Planned Freeways, Location Along An Existing Public Road

Whenever a freeway developed under H.B. 179 is to be provided along the location of an existing public road, generally (subject to Paragraph 4-602(B)) frontage roads are provided to retain or restore existing access.

Access should be controlled by deed restriction in accordance with Figures 4-44 & 4-45 whenever all of the following conditions prevail:

1. Right-of-way is being obtained from the abutting property owner(s).

2. A landlocked condition does not result.

3. Control of access as shown in Figure 4-44 & 4-45 does not substantially and materially damage abutting property thereby resulting in unusually high cost to obtain access rights. Damages of this nature are generally only encountered where abutting property has planned or existing improvements with a driveway within the zone where access is to be denied.

Access may be controlled by use of the State's police power to control driveway location and design where any of the following conditions prevail:

1. No right of way is obtained from the abutting property owner(s).

2. Deed restricted access results in landlocking or other substantial and material damage to abutting property.

Whenever the State's police powers are used, the denial of access zone should be driveway free insofar as practical and feasible.

c. Non-H.B. 179 Planned Freeways

control of Access under HB 179 is preferably to control by design

Whenever access is to be controlled solely by provision of frontage roads, Departmental powers to regulate driveway location and design shall be utilized to control access near ramp junctions. However, where designation under H.B. 179 is practical, it is preferred over controlling access solely by design.

3. Improvements to Existing Freeways

Whenever new or relocated ramps are to be provided along existing freeways, the design philosophy shown in Paragraph 4-602(A)2b applies. Access should therefore be controlled at frontage road junctions through deed restriction as illustrated in Figures 4-44 & 4-45 if practical and feasible. The State's police power should be used where deed restrictions are impractical, such as where (1) no right of way is obtained from the abutting property owner(s) and/or (2) landlocking or other substantial and material damage results.

4. Access Control on Design Drawings

In the preparation of schematic drawings, care should be exercised to develop design in sufficient detail to accurately tie down the locations of ramp junctions with frontage roads and thus the location of access control limits. These drawings are often displayed at meetings and hearings and further become the basis for right of way instruments or, in some cases, the Department's regulation of driveway location.

In some instances ramps must be shifted to satisfy level of service considerations or geometric design controls. When this is necessary, the access control zone should also be shifted if right of way has not been previously purchased. Even where right of way has been acquired, in low cost instances it may be feasible to establish new access control limits, reappraise, and alter deeds. In other situations, new deed restricted limits for access control will not be feasible. In these instances the State's police power should be used to supplement or replace deed restricted control.

5. Consistency in Controlling Access

In establishing access control along freeways, the design must be consistent in either providing or restricting access to like areas within a project. Where at all possible, all quadrants of an interchange should be provided similar access control treatment and, desirably, access at all similar planned interchanges within a project should be identical. Only where traffic needs or unusually high cost of access rights (e.g., landlocking or other substantial and material damage) dictate a different arrangement should the designer establish dissimilar access control restrictions.

6. Exit Ramp to Cross Street Separation Distance

Experience has shown that exit ramps may experience operational problems and even blockage at their merge point with frontage roads due to queue storage from the frontage road intersection with the crossroad. An adequate separation distance between the ramp/frontage road juncture and the frontage road/cross street intersection provides for weaving of traffic, braking, and queue storage. Figure 4-46 shows exit ramp to cross street separation distances for minimum, preferred minimum, and desirable traffic operations for a range of traffic volume conditions.

7. Frontage Roads Parallel to Railroads

Where a freeway parallels a railroad and there is insufficient space to place a frontage road between an existing road and the adjacent railroad-highway right-of-way line, and necessary additional right-of-way cannot be secured from the railroad, a frontage road may be considered on the off-side of a railroad paralleling the freeway. However, Department Legal Counsel has advised that where through lanes are superimposed upon an old road parallel to a railroad and the frontage road is constructed on the off-side of the railroad, this in no way changes the status of the railroad as the owner of property abutting the old road. It is the opinion of the legal counsel that construction of the frontage road on the off-side of the railroad will not extinguish the company's rights of access to the through lanes. It will, therefore, be necessary that the railroad exercise a relinquishment of access rights to the through lanes in order to insure complete control of access.

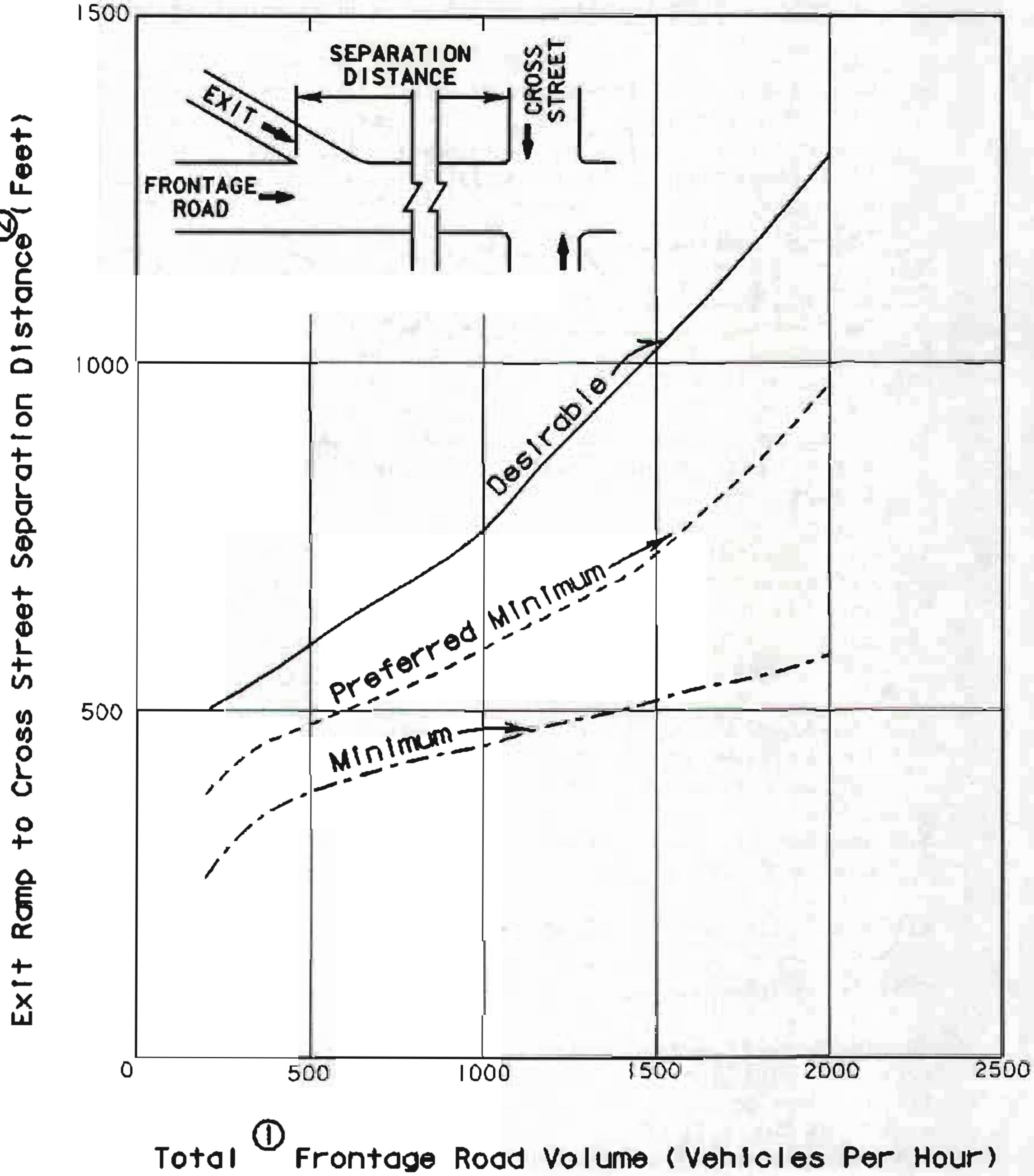
8. Frontage Roads Crossing Railroads

At railroad crossings, grade separations may be provided for frontage roads when vehicular traffic volume, train traffic volume and access considerations dictate. When frontage roads do not cross railroads and, where there are frontage roads alongside both mainlanes, they are passed over or under the mainlanes and connected to each other. When access and traffic circulation considerations dictate that frontage roads cross railroads at-grade, automatic railroad warning devices should be provided.

9. Other Purposes of Frontage Roads

Frontage roads serve a multitude of purposes other than controlling or providing access. Urban frontage roads are multi-functional as they reduce the "barrier" effect of urban freeways since the local street grid is not severed by the freeway. They become an extension of the surface street system, providing for continuity and traffic circulation, and result in a freeway corridor which serves local as well as intracity needs. They also serve as separate bus routes and express buses can exit from the freeway and use the frontage road to safely load and discharge passengers. They provide invaluable

EXIT RAMP TO CROSS STREET SEPARATION DISTANCE



① Includes exit ramp volume

② Based on accommodating traffic weaving, braking, and storage for typical traffic control and distribution conditions. For additional information, see Research Report 178-2F by C. J. Messer, et al, TTI, 1976.

Figure 4-46. Refers to Paragraph 4-602(A)6 operational flexibility, serving as detour routes when mainlane accidents occur, during major lane maintenance activity, or for over-height loads. For freeways which include freeway surveillance and control, continuous frontage roads provide the operational flexibility required to manage saturation.

In addition to the above-described purposes of frontage roads, many times they prove advantageous when used as the first stage of construction for a complete freeway facility. By constructing frontage roads prior to the mainlanes, interim traffic demands very often can be satisfied and a usable section of highway can be opened to the traveling public at a greatly reduced cost.

B. Frontage Road Policy

Frontage roads may be included in the planning stage of a designated controlled access highway when:

1. It is necessary to unlandlock the remainder of a parcel of land which has a value equal to or nearly equal to the cost of the frontage road.

2. The estimated reduction in right of way cost, i.e., the difference between the appraised values of the right of way with and without frontage roads, exceeds the cost of the frontage roads. (The estimated right of way costs are to be determined in accordance with the Appraisal and Review Manual.)

3. It is necessary to restore circulation of local traffic due to local roads or streets being severed or seriously impaired by the construction of the controlled access highway.

4. An economic analysis shows the benefits derived more than offset the costs of constructing and maintaining the frontage roads.

All such frontage road planning should first be cleared by the Highway Design Division (File D-8) and any exception to the above must be cleared with the Administration through File D-8.

In those instances where request for additional frontage roads are received during or subsequent to the planning stage or after the freeway has been constructed, they may be considered and placed in order of priority of highway needs in the District when the following conditions are met:

1. A usable section of frontage road shall be developed. The intent of a usable section would be a facility from a separation to a separation or connecting public roadway.

2. The construction of frontage roads shall not adversely affect the movement of traffic at the ramp terminals and crossroads.

3. The frontage road shall be constructed to Departmental specifications and standards.

4. The Department shall receive from the requesting agency or individual the actual construction cost, including all preliminary and construction engineering costs.

5. Any additional right-of-way shall be furnished free of cost and clear of utilities, and the requesting agency shall be responsible for any Relocation Assistance payments involved in the acquisition. The Department shall handle all relocation actions exclusive of monetary payments to insure compliance with Departmental policies and procedures.

For additional frontage roads requested subsequent to the planning stage or after the freeway has been constructed, control of access as originally conceived for the facility may be modified to allow access to the proposed frontage road only to the extent as may be permitted by safety considerations and in keeping with Departmental policies and procedures. As specified in Commission Minute Order 83658 and in the Right of Way Manual, subsequent changes in the control of access will be as shown on approved construction plans or as provided in instruments conveying right-of-way on authorized projects, or as may be authorized by Commission Minute Order. Where access is permitted to adjacent properties, ingress and egress will be governed by the issuance of permits to construct access driveway facilities as set forth in established Departmental policy which is designed to provide reasonable access, to insure traffic safety, and preserve the utility of highways.

C. Frontage Road Standards

The standard typical sections for rural and urban frontage roads are shown in Figure 4-47.

One-way operation if the area will be urban or suburban by the design year

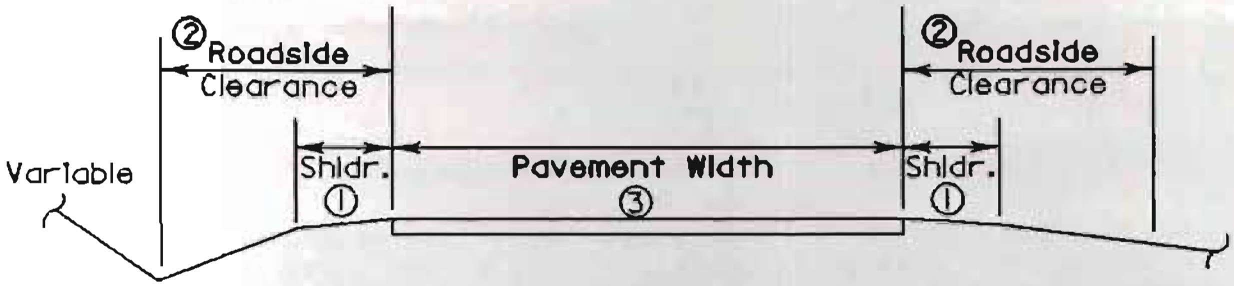
Any frontage road constructed within an area which is expected to be either urban or suburban in nature by the design year will be so designed to provide one-way operation initially. There may be exceptions to this policy in certain isolated instances; however, such exceptions will be considered only where, due to extraordinary circumstances, a one-way pattern would impose severe restrictions on circulation within an area. In those cases where such exceptions are considered, they will be cleared with the Administration through the Highway Design Division.

D. Lanes, Width and Number

The minimum and usual mainlane width shall be 12 feet. The number of lanes required is determined by the level of service evaluation as discussed in the Highway Capacity Manual.

TYPICAL SECTIONS FRONTAGE ROADS

① For pavement, shoulder, and structure widths for rural two-way frontage roads, see Figure 4-48. For one-way traffic operation use a 4' minimum width left shoulder and a 8' minimum width right shoulder.

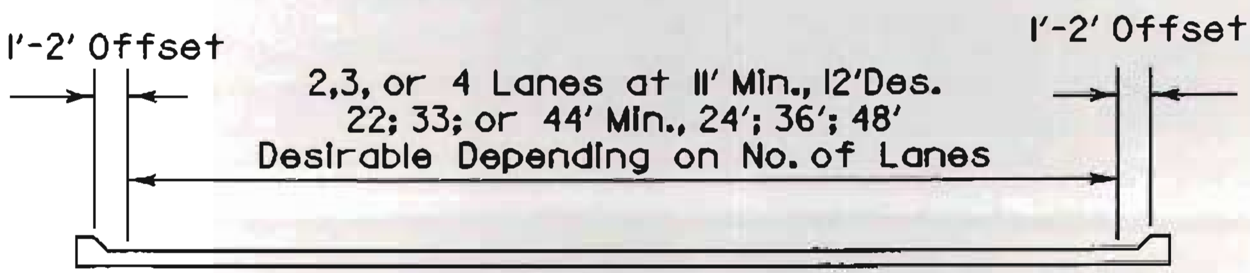


TYPICAL RURAL SECTION - ONE-WAY OR TWO-WAY

② For obstruction clearance, see Paragraph 4-202(G) and Figure 4-21 and use values for collectors.

③ Minimum surfacing width is 22'.

SECTION 1



TYPICAL URBAN OR SUBURBAN SECTION - USUALLY ONE-WAY

SECTION 2

NOTE: In suburban areas it may be desirable to curb property side of frontage road without corresponding curb on freeway side.
Whenever a frontage road is curbed on only one side, a shoulder (4 ft.(min) left or 8 ft.(min.) right) should be provided on the uncurbed side.

Figure 4-47. Refers to Paragraph 4-602(C)

STANDARDS OF DESIGN FOR RURAL TWO-WAY FRONTAGE ROADS

Design Speed[2] (mph)	Min. Width[1] for Traffic Volume of:			
	Current 0-400 ADT	Future 750-1500 ADT	Future 1500-3000 ADT	Future 3000 or more ADT
		LANES		
30	10	10	11	12
40	10	11	11	12
50	10	11	12	12
60	11	11	12	12
		SHOULDERS		
All	2[3]	4	8	8

[1] Minimum surfacing width is 22 feet.

[2] Use rural collector criteria (Figure 4-36) for determining minimum design speed.

[3] At locations where roadside barriers are provided, use minimum 4' offset from travel lane edge to barrier face.

Notes:

1. For one-way frontage roads with rural-type design, use 4' minimum left shoulder and 8' minimum right shoulder.

2. Minimum new or widened structure width is approach roadway width including shoulders. See Figure 4-39 for rural collector criteria for minimum widths of structures to remain.

Figure 4-48. Refers to Paragraph 4-602(C)

E. Shoulders

Continuous surfaced shoulders should be provided on each side of the mainlane roadways, both rural and urban, as shown in Figure 4-49. The minimum widths should be 10 feet on the outside and four feet on the median side of the pavement for four-lane freeways. On freeways of six lanes or more, 10-foot inside shoulders for emergency parking should be provided where flush medians are used. Where a six-lane freeway includes a depressed median design, four-foot shoulders may be used on the median side of the travel lanes. A 10-foot shoulder should be maintained along all speed change lanes with a six-foot shoulder considered in those instances where light weaving movements take place. All shoulders should be separated from the through traffic lanes by edge striping.

F. Medians

medians 76' desirably 48' minimum 24' w/ barriers

The width of the median is the distance between the inside edges of the travel lanes. For rural freeway sections, generally depressed medians 76 feet in width are used. Where topography, right-of-way, or other special considerations dictate, rural freeway medians may be reduced in width to less than 76 feet to a minimum of 48 feet. The typical urban freeway includes six or more travel lanes and a flush 24-foot median, resulting in a section providing 10-foot inside shoulders and a usual 2-foot offset to barrier centerline.

Due to the presence of high speed and volume traffic on urban freeways and the resulting adverse environment for accomplishing construction improvements thereon, it is the usual practice to construct the ultimate freeway section initially. Under those unusual circumstances where future additional lanes will be provided in the median area, the usual median width of 24 feet should be increased by the appropriate multiple of 12 in anticipation of need for additional lanes.

single structure if median is less than 30'

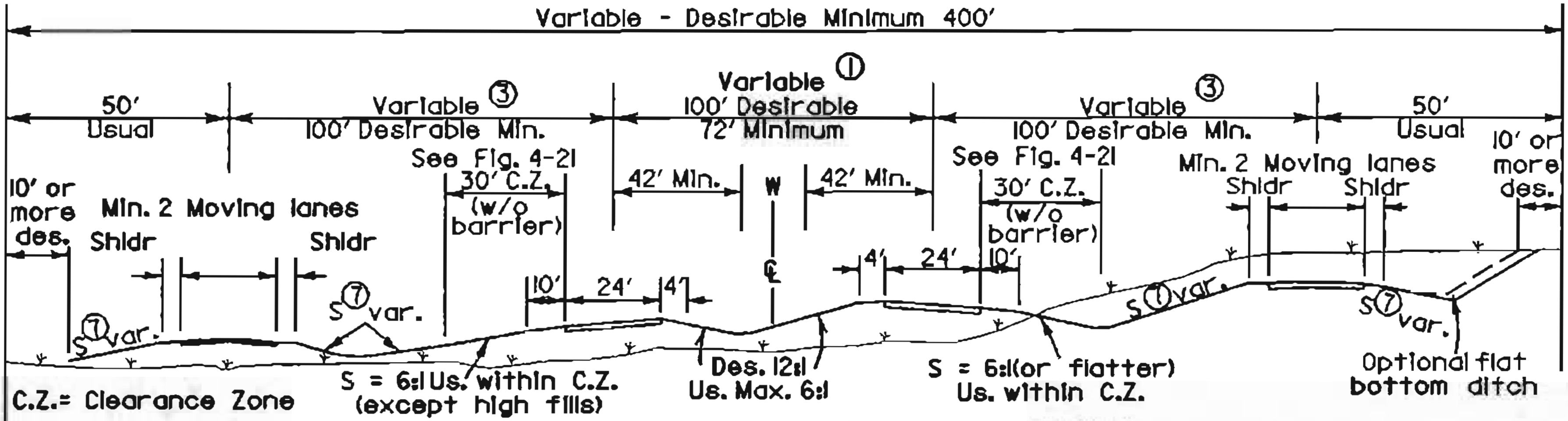
On elevated urban freeway sections, a single structure rather than twin mainlane structures should be used where median width is 30 feet or less.

At horizontal curves on freeways with narrow medians, a check should be made to insure that the median barrier does not restrict stopping sight distance to less than minimum values.

G. Outer Separation

The portion of the freeway between the mainlanes and frontage road, or right-of-way line where frontage roads are not provided, should be wide enough to accommodate shoulders, speed change lanes, side slopes, retaining walls and ramps, as well as the necessary signs and other appurtenances necessary for traffic control. Because of

TYPICAL FREEWAY SECTIONS



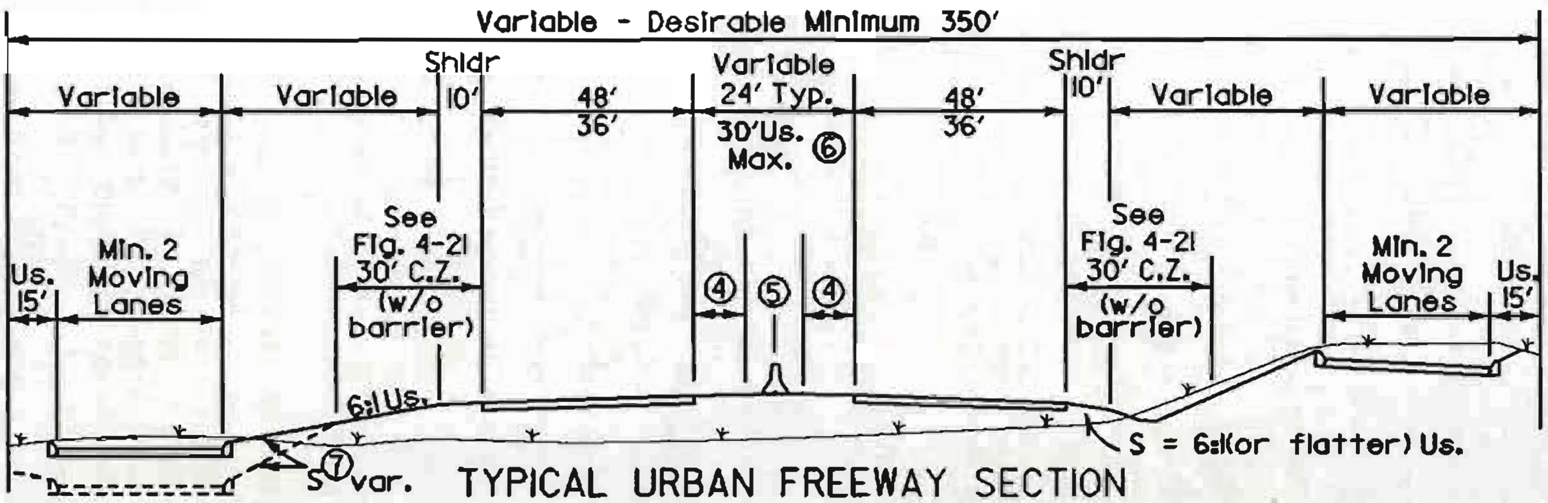
NOTE ① For min. 30' Clearance to obstruction in median, width ℄ to ℄ of 84' + W* is required.
* "W" is width of obstruction.

NOTE ② Backslope in cuts may be exceeded in rock.

NOTE ③ Additional Width required in interchange areas.

TYPICAL RURAL FREEWAY SECTION

WITH FRONTAGE ROADS



TYPICAL URBAN FREEWAY SECTION

NOTE ④ 10' Usual on six lanes with flush median. 10' Min. on eight lanes.

NOTE ⑤ Median barrier used only in medians of 30' or less.

NOTE ⑥ A 48' median is appropriate where a future additional lane in each direction is planned.

NOTE ⑦ See Fig. 4-20 and discussion in Section 4-202(G) for fill slope rates.

Figure 4-49. Refers to Paragraph 4-602(E)

STANDARDS OF DESIGN FOR CONTROLLED ACCESS FACILITIES

Average Daily Traffic (ADT)[1]	Over 15,000	
Design Hourly Volume (DHV)[2]	Over 1,200	
Design Speed (mph) Change to 70	Des.	Min.
Mainlanes - Urban	70	50
Frontage Roads - Urban	50	30
Mainlanes - Rural	--	70
Lane Width (Ft.)	12	
Median Width (Ft.)		
Urban	—	24 (usual)[3]
Rural	76	48
Shoulder Outside (Ft.)	10	
Inside Shoulder (Ft.)	4[4]	
Structure Widths	See Figure 4-51	

1 ADT at design year in equivalent passenger cars per day.

2 One-way DHV in equivalent passenger cars per hour.

3 Applicable to urban freeways with flush medians and six or more mainlanes.

4 Minimum 10' inside shoulders usually provided on urban freeways with flush medians and six or more lanes. For urban freeway rehabilitation and expansion, the provision of wide inside shoulders may not be feasible. Under these circumstances documentation for narrower shoulders should be submitted and a design exception requested.

Figure 4-50. Refers to Paragraph 4-602(E)

right-of-way limitations in urban areas, the other separation may oftentimes be narrower than desired; however, in rural areas, where opposing headlights along a two-way frontage road tend to reduce a driver's comfort and perception on the freeway, the outer separation should be as wide as possible.

H. Structures

Figures 4-26, 4-29, 4-38, 4-39, 4-48, and 4-51 show the appropriate roadway and structure widths for various types of roadways. For a more detailed discussion refer to the Bridge Division Operation and Planning Manual.

The crown slope on structures shall be the same as the approach pavement.

I. Horizontal and Vertical Clearance at Structures

Vertical

All new highway grade separation structures, including railroad underpasses, shall provide 16'-6" minimum vertical clearance over the usable roadway.

No exception shall be made to this policy for structures over mainlanes of Interstate or controlled access highways except within cities where the 16'-6" vertical clearance is provided on an Interstate Loop around the particular city. On all other systems of highways with separations involving interchange facilities, other highway, public roads, city streets or railroads, where this minimum clearance is impractical or excessively expensive to provide, exceptions may be made. In such cases, the vertical clearance shall be held as near as practicable to the 16'-6" minimum, but in no case shall it be less than 14'-6".

Vertical clearances for pedestrian crossover structures shall be approximately 1'-0" greater than that provided for other grade separation structures. This is due to the increased risk of personal injury upon impact by over-height loads and the relative weakness of such structures to resist lateral loads from vehicular impact.

The above-specified clearances apply over the entire width of roadway including usable shoulders and include an allowance of six inches for future pavement overlays. It is recognized that it is impractical to arrive at the exact clearance dimensions on the structure plans. However, the above clearances should not be exceeded by more than approximately three inches.

Vertical clearance for railroad overpasses is shown in Figure 4-52.

ROADWAY AND STRUCTURE WIDTHS

CONTROLLED ACCESS FACILITIES

<table>
<tr><th>Type of Roadway</th><th>Inside Shoulder Width</th><th colspan="2">Outside Shoulder Width[1]</th><th>Traffic Lanes</th><th colspan="2">Structure Width</th></tr>
<tr><td>Mainlanes:</td><td></td><td colspan="2"></td><td></td><td colspan="2"></td></tr>
<tr><td>4-Lane Divided</td><td>4'</td><td colspan="2">10'</td><td>24'</td><td colspan="2">38' Min.</td></tr>
<tr><td>6-Lane Divided</td><td>10'[2]</td><td colspan="2">10'</td><td>36'</td><td colspan="2">56' Min.[2]</td></tr>
<tr><td>8 Lanes or More</td><td>10'</td><td colspan="2">10'</td><td>48'[3]</td><td colspan="2">68' Min.[3]</td></tr>
<tr><td>1-Lane Direct Conn.</td><td>{2' Rdwy.
4' Str.} See Note 4</td><td colspan="2">8'</td><td>14'</td><td colspan="2">26' Min.</td></tr>
<tr><td>2-Lane Direct Conn.</td><td>{2' Rdwy.
4' Str.} See Note 4</td><td colspan="2">8'</td><td>24'</td><td colspan="2">36' Min.</td></tr>
<tr><td rowspan="2">Ramps</td><td rowspan="2">{2' Rdwy.
4' Str.} See Note 4</td><td>Min.</td><td>Des.</td><td rowspan="2">14'</td><td>Min.</td><td>Des.</td></tr>
<tr><td>6'</td><td>8'[5]</td><td>24'</td><td>26'[5]</td></tr>
</table>

[1] For auxiliary (speed change) lanes, see Paragraph 4-602(E) for outside shoulder width.

[2] Ten-foot shoulders appropriate for six-lane freeways with flush median. Six-lane freeways with depressed median may include 4' shoulders with 50' minimum structure width.

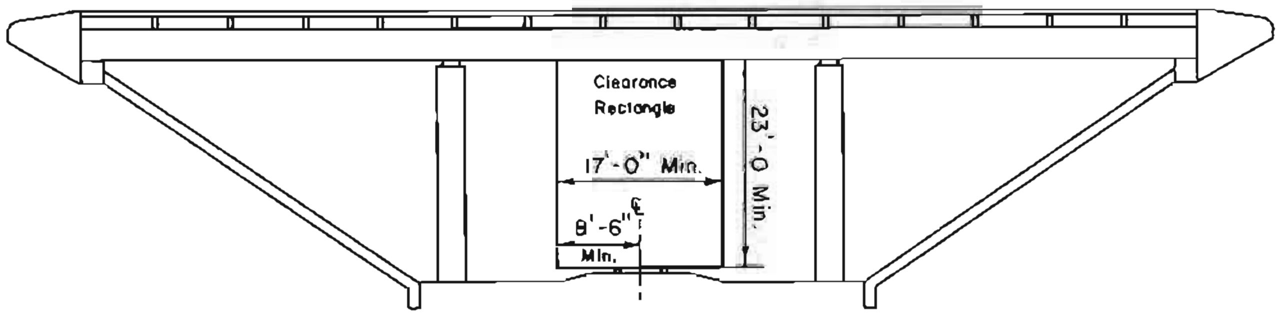
[3] For more than eight lanes, add 12' width per lane.

Delete

[4] Minimum inside shoulder width is 2' on uncurbed roadway sections and 4' on bridges and curbed roadways. All longitudinal traffic barriers, including bridge rail, wall, and guard fence, should be located a minimum of 4' from the travel lane edge.

[5] Desirable values should be used where there are sufficient combination type vehicles to govern design. Where ramp ADT includes greater than 10% five-axle (3S2) tractor-trailer vehicles, desirable values are appropriate for use.

Figure 4-51. Refers to Paragraph 4-602(H)



REQUIRED CLEARANCES

HORIZONTAL CLEARANCE
(℄ Track to Face of Pier)
8'-6" - Req'd Minimum
12'-0" - Des. Minimum
25'-0" ~~or less - Crash~~ Wall Minimum (new structure)
May be Req'd.

TYPICAL HIGHWAY RAILROAD OVERPASS

Use 17'-0" width rectangle for determination of vertical clearance. ~~23'-0" vertical clearance may be increased for Electric Power Trains.~~

FIGURE 4-52. Refers to Paragraph 4-602(I)

Horizontal

The minimum horizontal clearance to bridge parapets and piers will be as shown in Figures 4-21, 4-49, and 4-52.

J. Ramps and Direct Connections

1. General

All ramps and direct connections should be designed for one-lane operation with provision for emergency parking; however, if the anticipated volume exceeds the capacity of one freeway lane, two-lane operation may be provided. Several examples of ramps and connecting roadway arrangements are shown in Figure 4-53.

Once ramps have been located on a schematic layout and the same has been exhibited at a public hearing or the design has otherwise become a matter of public record, extreme caution should be exercised in making any subsequent changes in ramp location to better serve areas which may have developed after the original design was determined. In all cases, proposed changes should be submitted to the Highway Design Division, and another public hearing may be required.

Right-hand ramps preferred over left-hand ramp.

Right-hand ramps are markedly superior in their operational characteristics and safety to those that leave or enter on the left. With right-hand ramps, merging and diverging maneuvers are accomplished into or from the slower moving right travel lane. Since a high majority of ramps are right-hand, there is an inherent expectancy by drivers that all ramps will be right-hand, and violations of the expectancy may adversely affect operation and safety characteristics.

2. Design Speed

There should be a definite relationship between the design speed on a ramp or direct connection and the design speed on the intersecting highway. All ramps and connections shall be designed to enable vehicles to leave and enter the traveled way of the freeway at no less than 50% (70% usual, 85% desirable) of the freeway's design speed. Figure 4-54 shows guide values for ramp design speed.

Ramp design speed should generally be no less than frontage road design speed.

3. Sight Distance

On all ramps and direct connections, the combination of grade, vertical curves, alignments and clearance of lateral and corner obstructions to vision shall be such as to provide sight distance along such ramps and connections from terminal junctions along the freeway, consistent with the probable speeds of vehicle operation.

TYPICAL INTERCHANGES SHOWING RAMPS AND CONNECTING ROADWAYS

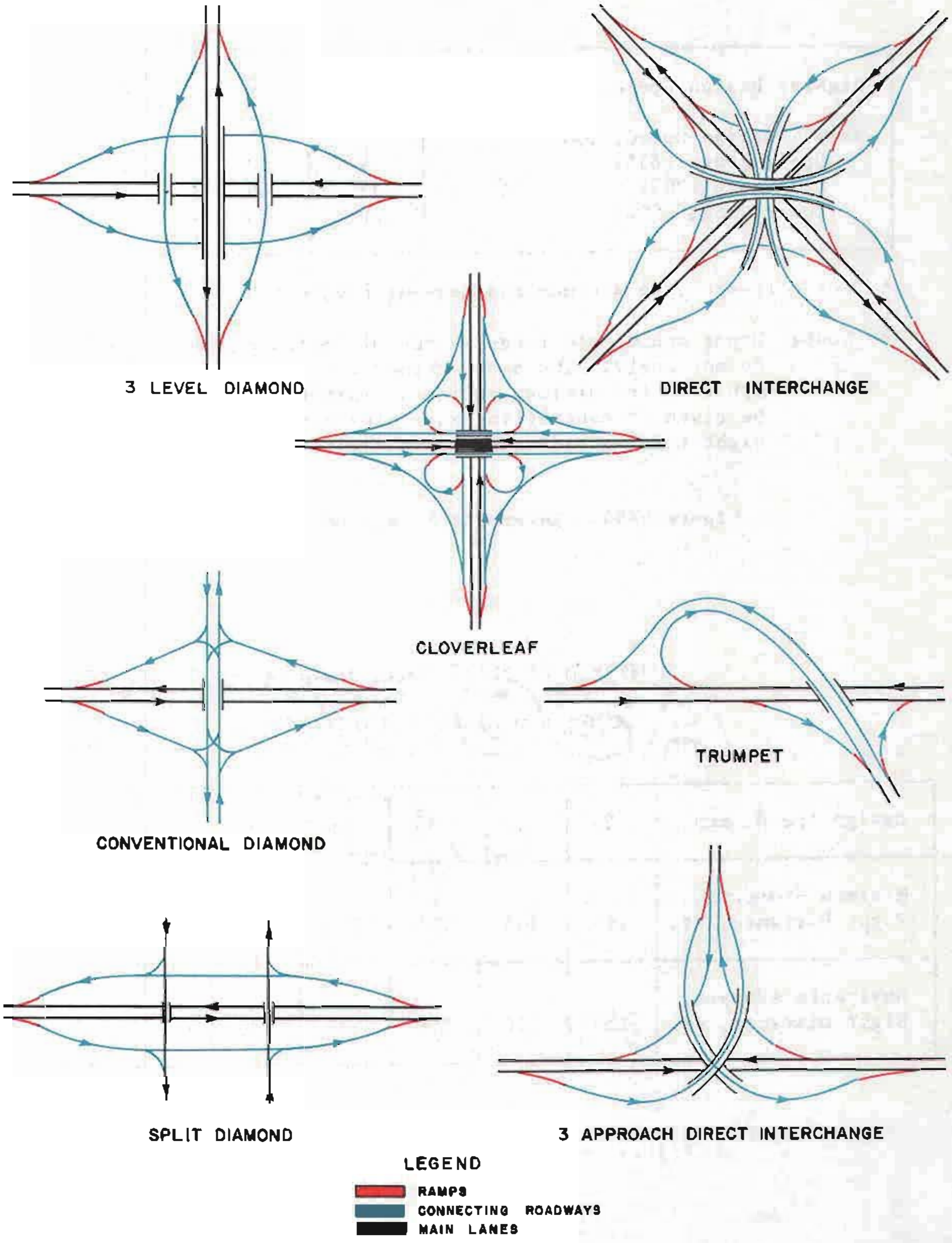


Figure 4-53. Refers to Paragraph 4-602(J)1

GUIDE VALUES FOR RAMP DESIGN SPEED

AS RELATED TO HIGHWAY DESIGN SPEED*

(DESIRABLE BASED ON MAX. "e" = 0.06 FT./FT.)

Highway Design Speed, mph	50	60	70
Ramp** Design Speed, mph			
Upper Range (85%)	45	50	60
Mid Range (70%)	35	45	50
Lower Range (50%)	25	30	35

* For corresponding minimum radius, see Figure 4-9.

** Loops: Upper and middle range values of design speed generally do not apply. The design speed on a loop is usually 25 mph (150 ft. minimum radius). Particular attention should be given to controlling superelevation on loops due to the tight turning radii and speed limitations.

Figure 4-54. Refers to Paragraph 4-602(J)2

MINIMUM STOPPING SIGHT DISTANCE

RAMPS AND DIRECT CONNECTIONS

Design Speed, mph	25	30	35	40	45	50	55	60
Minimum Stopping Sight Distance, Ft.	150	200	225	275	325	400	450	525
Desirable Stopping Sight Distance, Ft.	150	200	250	325	400	475	550	650

Figure 4-55. Refers to Paragraph 4-602(J)3

4. Grades and Profiles

Minimum lengths of crest and sag vertical curves on ramps may be obtained from Figure 4-56. Longer vertical curves with increased stopping sight distances should be provided wherever possible.

Ramp profiles generally consist of a section of tangent grade between two vertical curves. The tangent or controlling grade on ramps should be as flat as possible, and preferably should be limited to 4 percent or less.

5. Typical Sections

Exit and entrance ramp typical details are shown in Figures 4-57 through 4-63.

Channelized (braided) entrance and exit ramps, as typified in Figure 4-62, should be used only where ramp volumes are considerably greater than frontage road traffic such as where stub frontage roads occur. Where used, the exit ramp shall cross the frontage road at approximately ninety degrees to minimize wrong-way entry. Passing should be restricted between the crossroad and the channelized area.

6. Distance Between Successive Ramps and/or Connections

The minimum acceptable distance between ramps is dependent upon the merge, diverge and weaving operations which take place between ramps and distances required for signing. For analysis of these requirements, see the Highway Capacity Manual.

7. Cross Section and Cross Slopes

Superelevation rates, as related to curvature and design speed of the ramp or connecting roadway, are given in Figure 4-65. As high a rate as practicable should be used, preferably in the upper half or third of the indicated range, particularly in descending grades.

The cross slope on portions of connecting roadways or ramps on tangent normally is sloped one way at a practical minimum rate of 1.5%.

The change in pavement edge elevation per given length of connecting roadway or ramp should be that as shown in Figure 4-66. The maximum algebraic difference in pavement cross slope at connecting roadways or ramps should not exceed that set forth in Figure 4-67.

MINIMUM LENGTHS OF CREST VERTICAL CURVES ON CONNECTING ROADWAYS

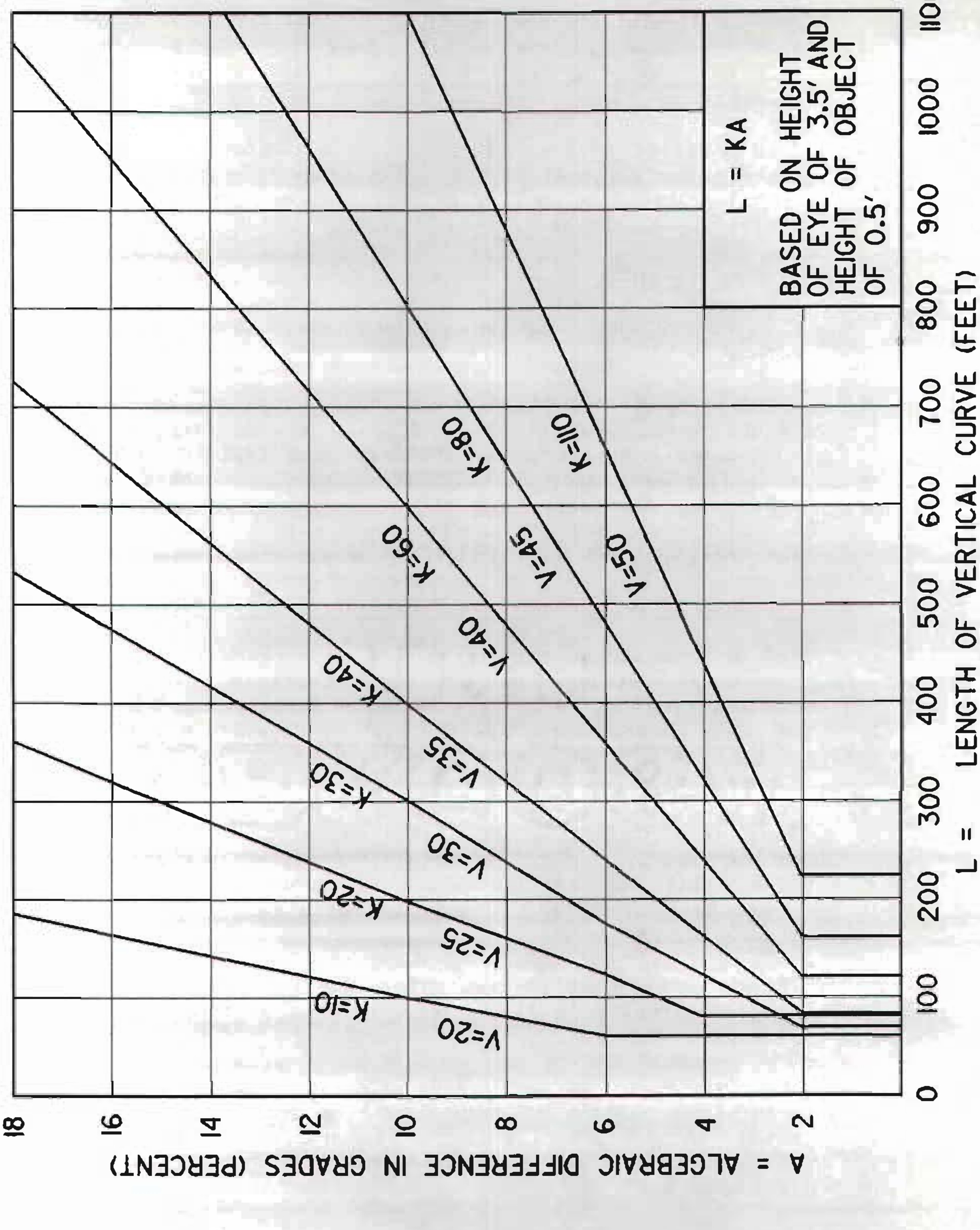


Figure 4-56. Refers to Paragraph 4-602(J)4

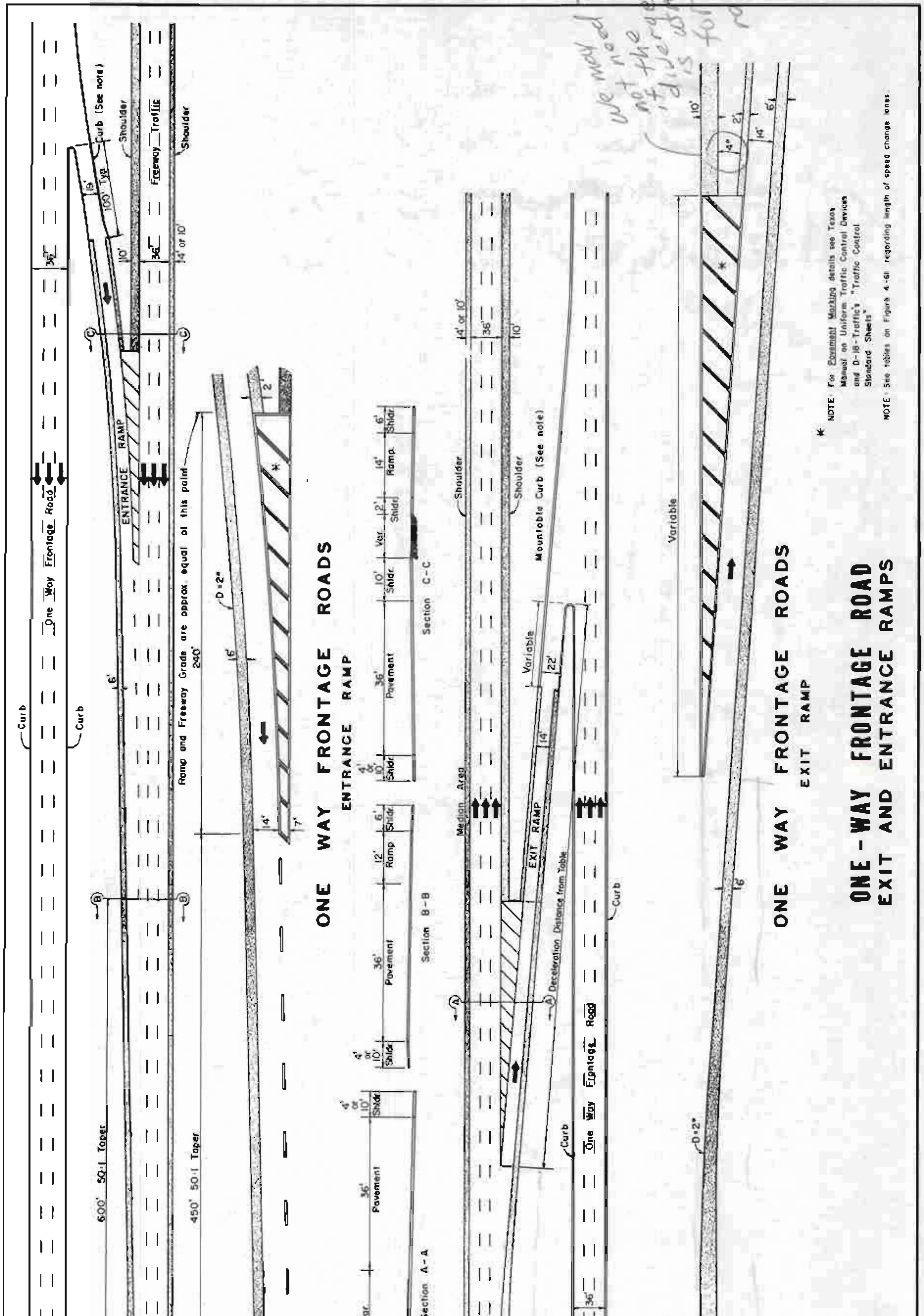


Figure 4-57. Refers to Paragraph 4-602(J)5

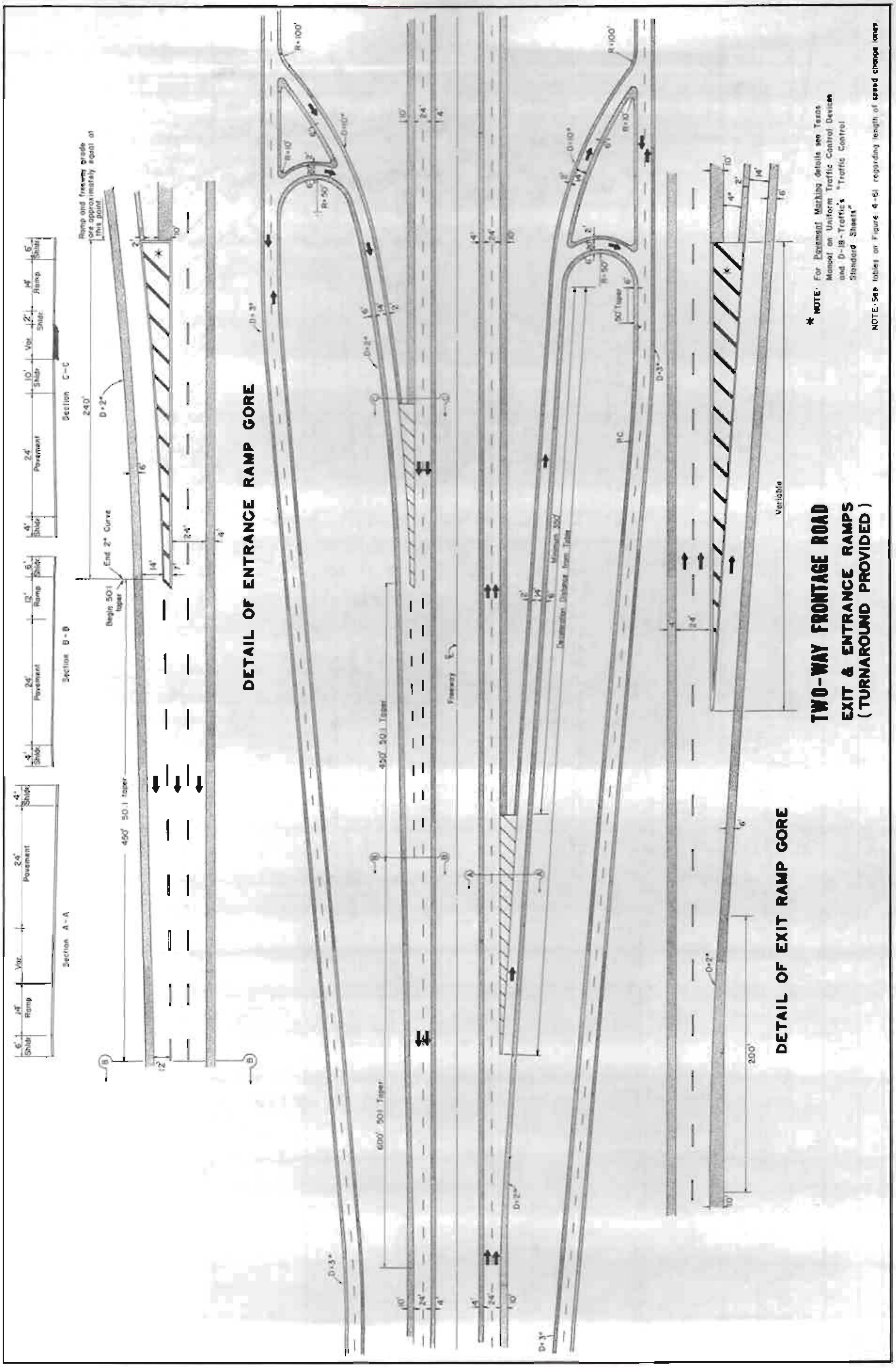


Figure 4-58. Refers to Paragraph 4-602(J)5

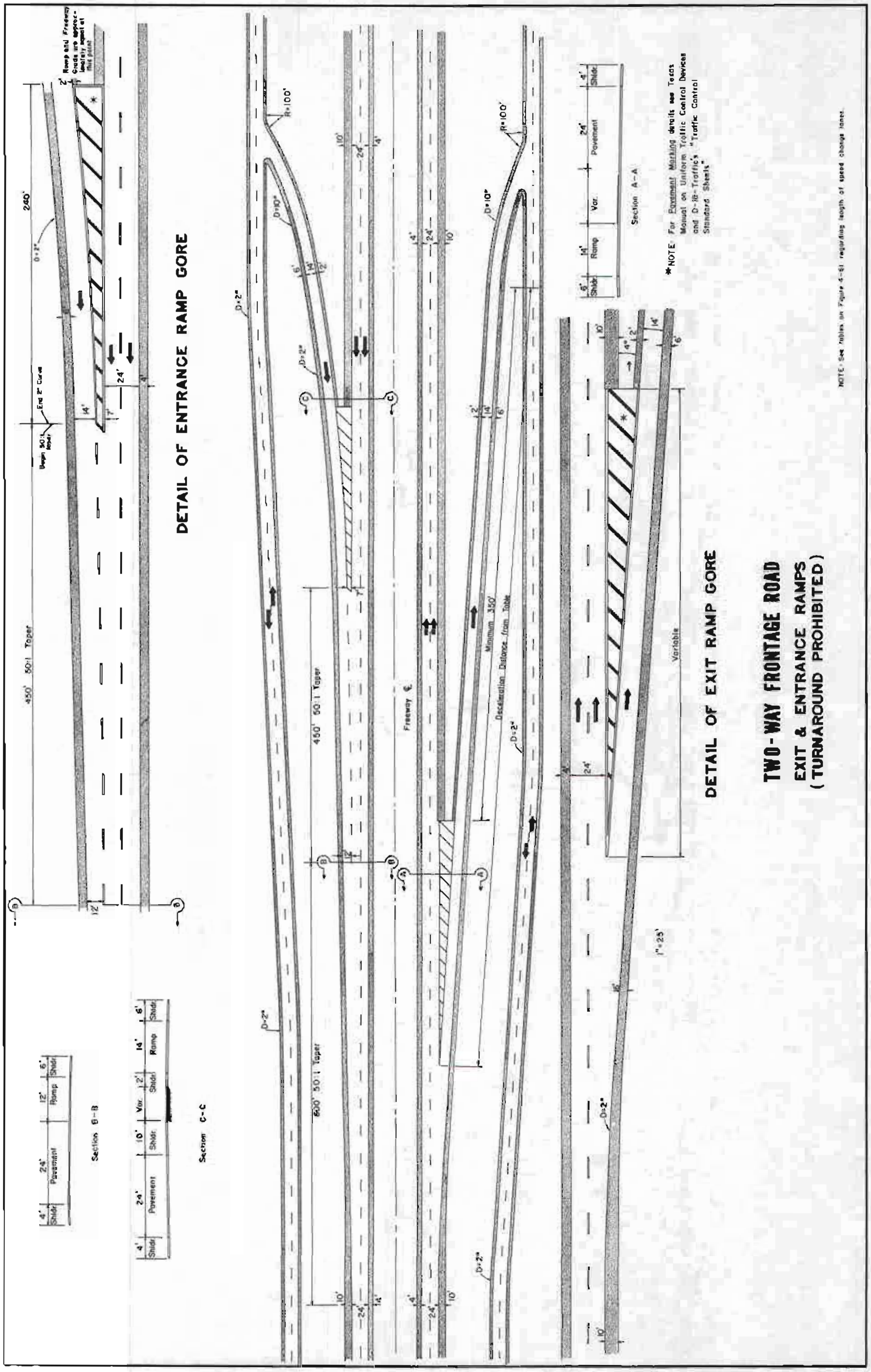


Figure 4-59. Refers to Paragraph 4-602(J)5

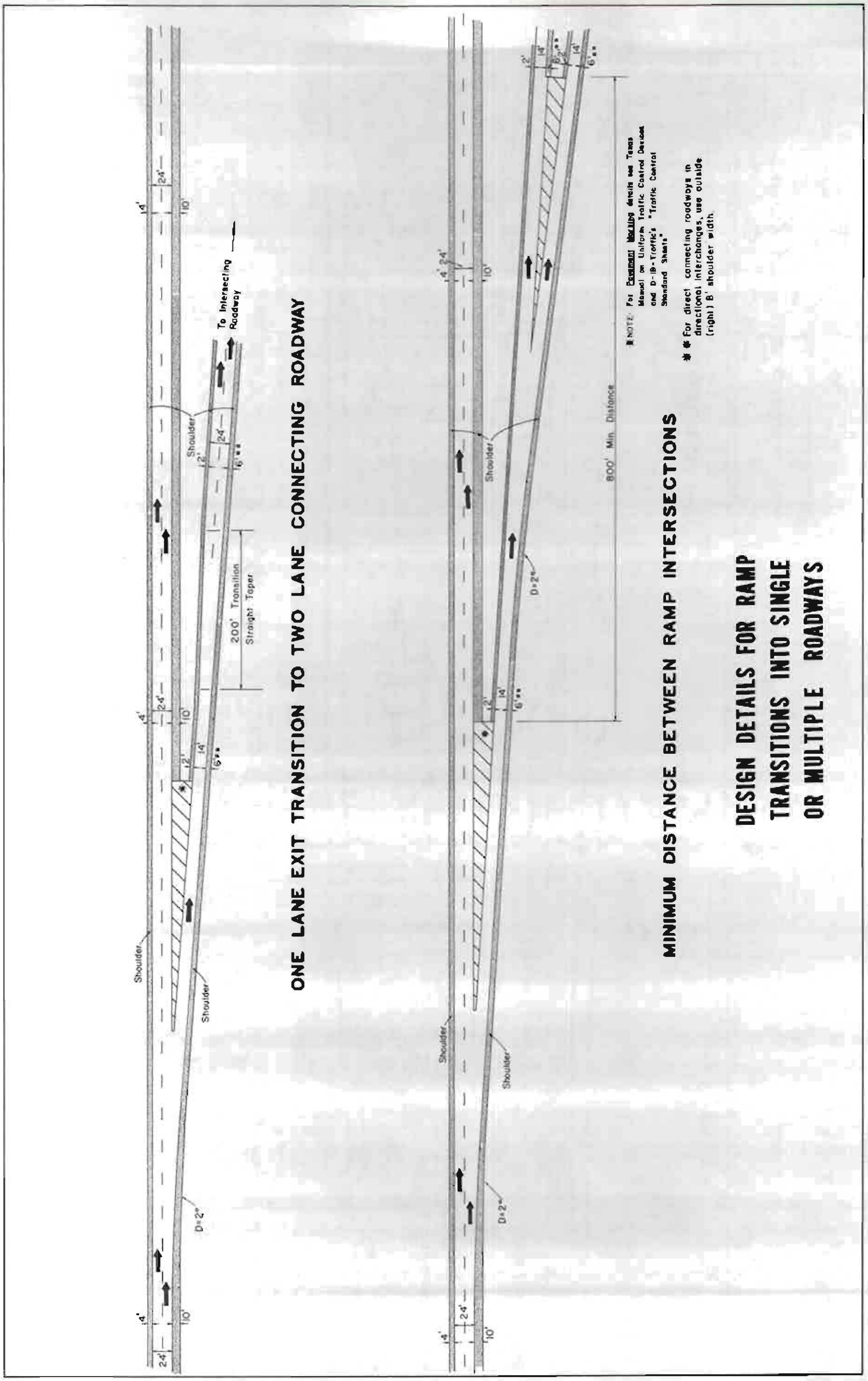
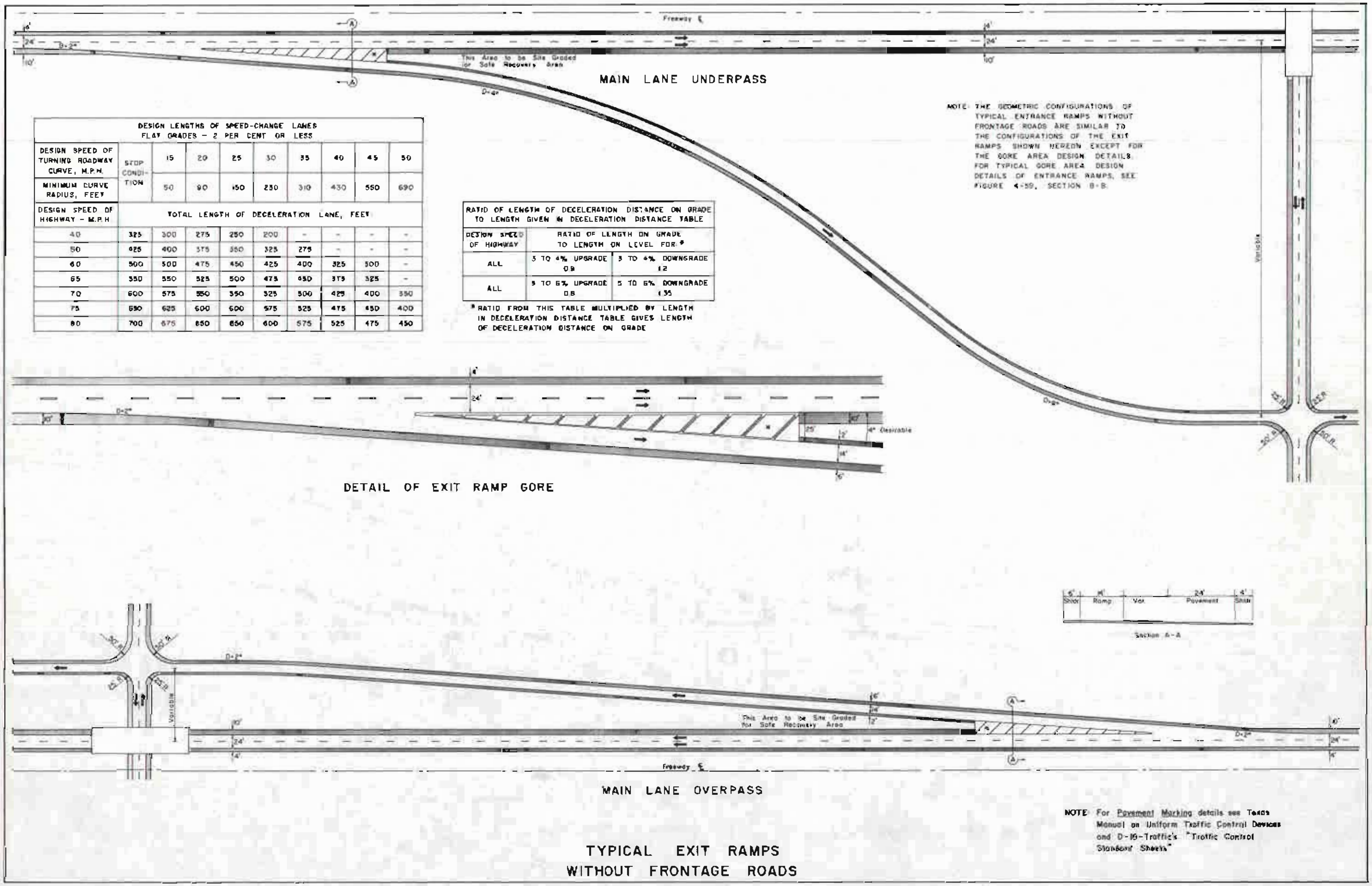


Figure 4-60. Refers to Paragraph 4-602(J)5



DESIGN LENGTHS OF SPEED-CHANGE LANES FLAT GRADES – 2 PER CENT OR LESS									
DESIGN SPEED OF TURNING ROADWAY CURVE, M.P.H.	STOP CONDITION	15	20	25	30	35	40	45	50
MINIMUM CURVE RADIUS, FEET		50	90	150	230	310	430	550	690
DESIGN SPEED OF HIGHWAY – M.P.H	TOTAL LENGTH OF DECELERATION LANE, FEET								
40	325	300	275	250	200	-	-	-	-
50	425	400	375	350	325	275	-	-	-
60	500	500	475	450	425	400	325	300	-
65	550	550	525	500	475	450	375	325	-
70	600	575	550	550	525	500	425	400	350
75	650	625	600	600	575	525	475	450	400
80	700	675	650	650	600	575	525	475	450

RATIO OF LENGTH OF DECELERATION DISTANCE ON GRADE TO LENGTH GIVEN IN DECELERATION DISTANCE TABLE		
DESIGN SPEED OF HIGHWAY	RATIO OF LENGTH ON GRADE TO LENGTH ON LEVEL FOR *	
ALL	3 TO 4% UPGRADE 0.9	3 TO 4% DOWNGRADE 1.2
ALL	5 TO 6% UPGRADE 0.8	5 TO 6% DOWNGRADE 1.35

* RATIO FROM THIS TABLE MULTIPLIED BY LENGTH IN DECELERATION DISTANCE TABLE GIVES LENGTH OF DECELERATION DISTANCE ON GRADE

Figure 4-61. Refers to Paragraph 4-602(J)5

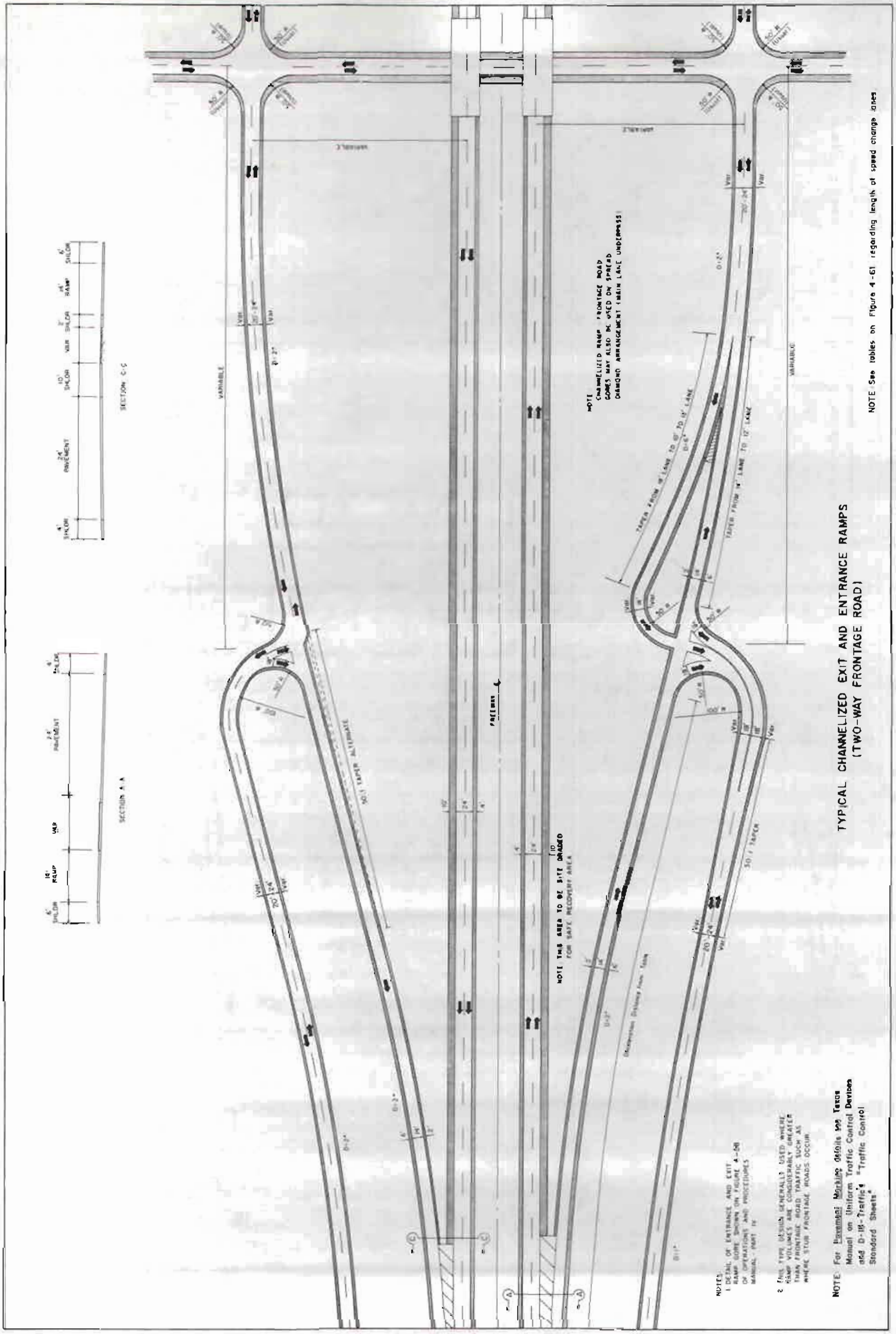


Figure 4-62. Refers to Paragraph 4-602(J)5

D-18 has changed the striping pm(1)-90. Eliminated recovery area

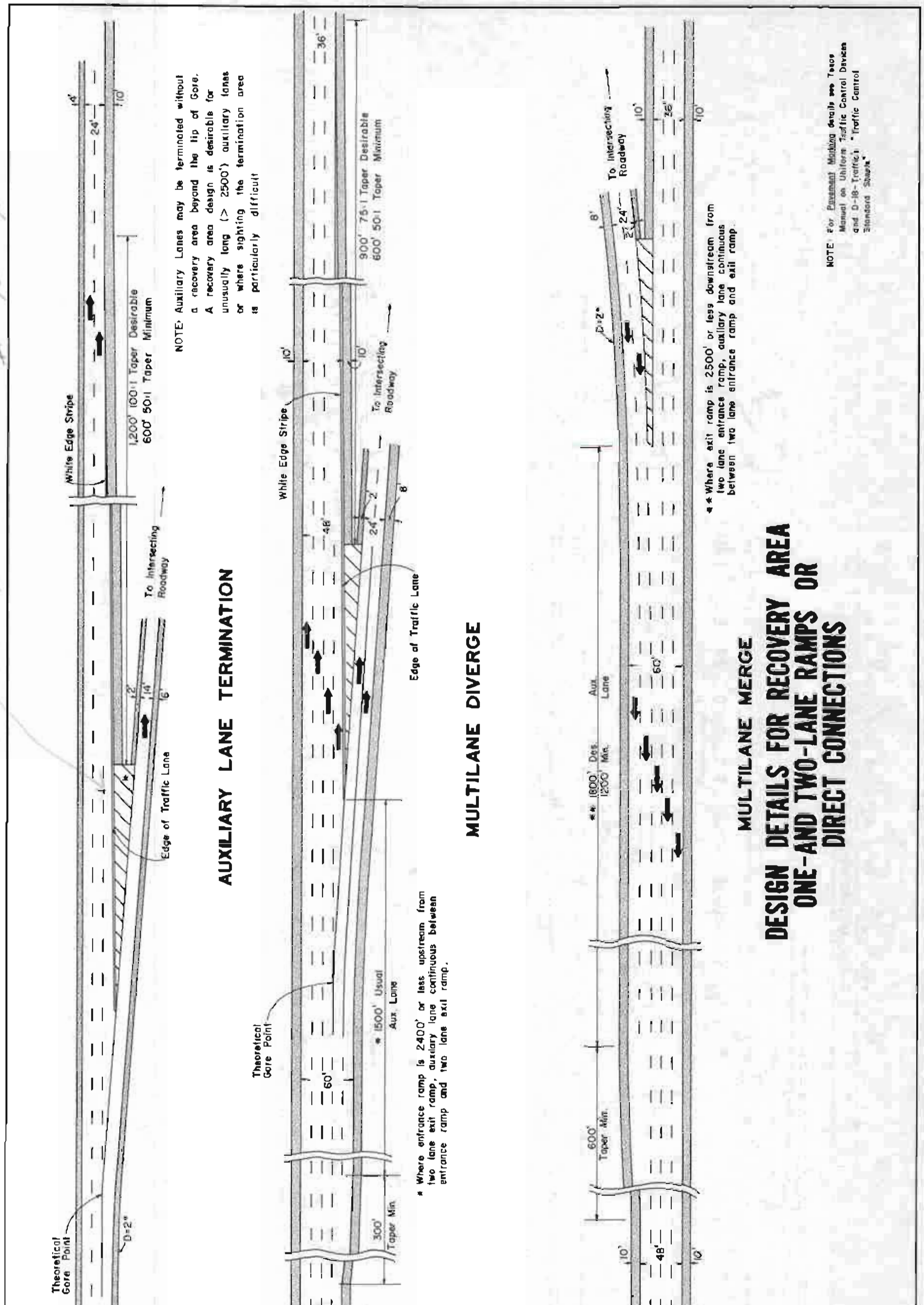


Figure 4-63. Refers to Paragraph 4-602(J)5

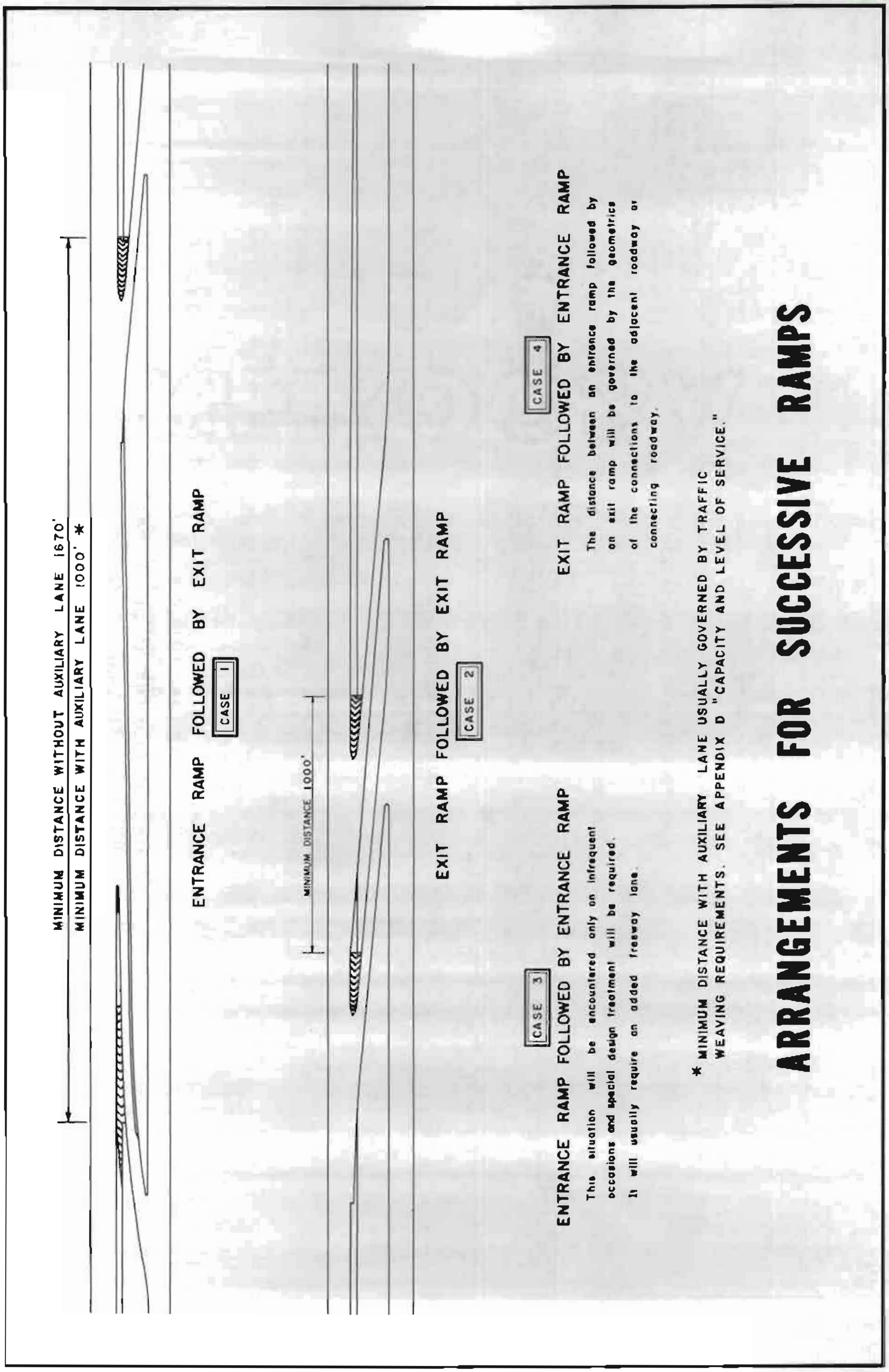


FIGURE 4-64. Refers to Paragraph 4-602(J)6

SUPERELEVATION RATES FOR CURVES ON CONNECTING ROADWAYS
RANGE IN DESIGN VALUES

Radius	Degree of Curve	Range in Superelevation Rate (ft. per ft.) For Connecting Roadways With Design Speed, MPH, of:			
		25	30	35	40
150	38.2	.04-.10			
230	24.8	.03-.08	.06-.10		
310	18.5	.03-.06	.05-.09	.08-.10	
430	13.3	.03-.05	.04-.07	.06-.09	.09-.10
600	9.6	.02-.04	.03-.05	.05-.07	.07-.09
1000	5.7	.02-.03	.03-.04	.04-.05	.05-.06
1500	3.8	.02	.02-.03	.03-.04	.04-.05
2000	2.9	.02	.02	.02-.03	.03-.04
3000	1.9	.02	.02	.02	.02-.03

Figure 4-65. Refers to Paragraph 4-602(J)7

DESIGN RATE OF CHANGE IN PAVEMENT EDGE ELEVATION
FOR CONNECTING ROADWAY CURVATURE

Design, Speed MPH	25	30	35 or more
Change in relative rate between centerline and pavement edge (24' width) per station (%)	0.71	0.67	0.65

Figure 4-66. Refers to Paragraph 4-602(J)7

MAXIMUM ALGEBRAIC DIFFERENCES IN PAVEMENT CROSS SLOPE
AT CONNECTING ROADWAY TERMINALS

Design Speed of Exit or Entrance Curve, mph	Maximum Algebraic Difference in Cross Slope at Crossover Crown Line, foot per foot
25 and 30	0.05 to 0.06
35 and over	0.04 to 0.05

Figure 4-67. Refers to Paragraph 4-602(J)7

Connecting roadways or ramps of appreciable length should provide width for two moving lanes plus shoulders. The lanes provide freedom and flexibility of movement and prevent the accumulation of queues of vehicles which will probably have difficulty entering the facility to which the connecting roadway is joined. Where transitions from the two lanes to one occur, the left lane should be continuous.

K. Collector-Distributor Roads

A collector-distributor road may be warranted within an interchange, through two adjacent interchanges or continuous for some distance along the freeway through several interchanges. Collector-distributor roads should be provided at all cloverleaf interchanges and particularly on such interchanges on controlled access facilities. A collector-distributor road is a valuable addition within interchanges which involve weaving. Where there is considerable demand for frequent ingress and egress, as in and near the business district of large cities, a collector-distributor road, continuous for some distance, should be provided.

L. Turnarounds

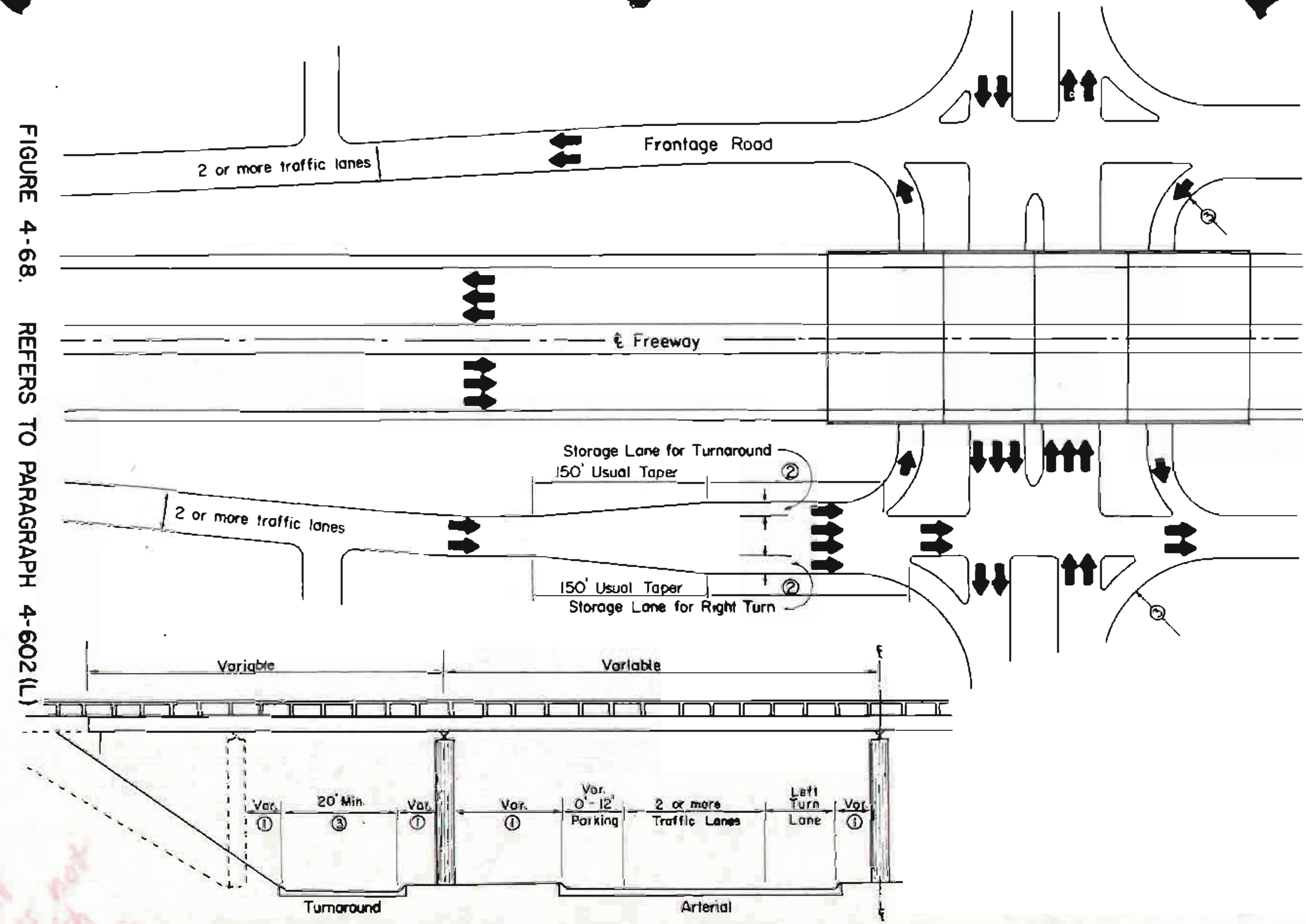
Turnaround lanes shall be provided at all interchanges with major arterials in urban and suburban areas where the freeway lanes are flanked by one-way frontage roads. Turnaround lanes will not be provided where two-way frontage roads are used. In all urban and suburban cases, the end spans of overpasses or grade line at underpasses should be so arranged that turnarounds may be added in the future when warranted. Figure 4-68 shows a typical turnaround at a diamond interchange.

The FHWA does not require benefit-cost documentation for turnarounds (or provision of space for future installation) which underpass the mainlanes at diamond interchanges in urbanized areas. U-turn structures which overpass the mainlanes are generally not warranted due to their high construction costs; therefore, benefit-cost data will be required for these unusual instances where elevated turnarounds are proposed.

M. Types of Interchanges

The decision to develop a facility to freeway standards becomes the warrant for providing highway grade separations or interchanges at the most important intersecting streets, roads, railroads and highways.

An interchange or series of interchanges on a freeway through a community may affect large continuous areas or even the entire community. For this reason, interchanges must be located and designed so that they will provide the best possible traffic



TYPICAL DIAMOND INTERCHANGE WITH TURNAROUNDS

NOTE 1 The face of new bridge columns should be located 6' or more from the face of curb. Where potential future expansion of the crossroad exists, applicable new bridge columns should be located 16' from the curb face.

NOTE 2 For desirable length of storage, multiply 0.63 by peak hour volume on adjacent lane. Conditions may dictate use of shorter lengths.

NOTE 3 Width and turning radius should be based on appropriate design vehicle. See Section 4-710.

Horizontal clearance does not agree with Fig. 4-21. If remaining should be identified as desirable or

FIGURE 4-68. REFERS TO PARAGRAPH 4-602(L) service. Drivers who have exited from a freeway expect to be able to re-enter in the same vicinity; therefore, partial interchanges which do not serve all desired traffic movements should be avoided.

Interchanges are classified in a general way, according to the number of approach roadways or intersection legs, as 3-leg, 4-leg and multi-leg interchanges. Through common usage, interchanges are descriptively called "Tee" (or Trumpet) for 3-leg design. Cloverleaf (full or partial) and Diamond for 4-leg, and Directional for three or more legs.

A brief description and some of the advantages and disadvantages of each type and variety are given in the following discussion.

1. Trumpet or "Tee"

   The most widely used 3-leg interchange is the trumpet type, Figure 4-69. This type of interchange is particularly suitable for the connection of a major facility and a freeway. Preference should be given to the major turning movements so that the directional roadway handles higher traffic volume and the loop the lower traffic volume.

2. Diamond

   The diamond interchange (Figure 4-69) is the most common interchange, especially in urban areas, since it requires less area than any other type. The diamond interchange is used almost exclusively for major-minor crossings since left-turn movements are made at-grade across conflicting traffic on the minor road. Because these conflicts tend to lower capacity of the interchange, modifications such as collector-distributor roads, pavement widening at the at-grade crossings, or "splitting" the diamond (i.e., each pair of ramps connect to a separate cross street about a block apart) are sometimes used.

3. Three-Level Diamond Interchange

   In urban areas, where the cross street carries a high volume of traffic, the three-level diamond interchange (Figure 4-70) may be warranted. The through movements of both the controlled access facility and the cross street flow is uninterrupted with only the turning movements requiring regulation by stop signs or traffic lights. This type interchange is not recommended for use as the ultimate design at the crossing of two controlled access facilities since it requires left-turn interchanging traffic to negotiate three traffic signals or stop controls.

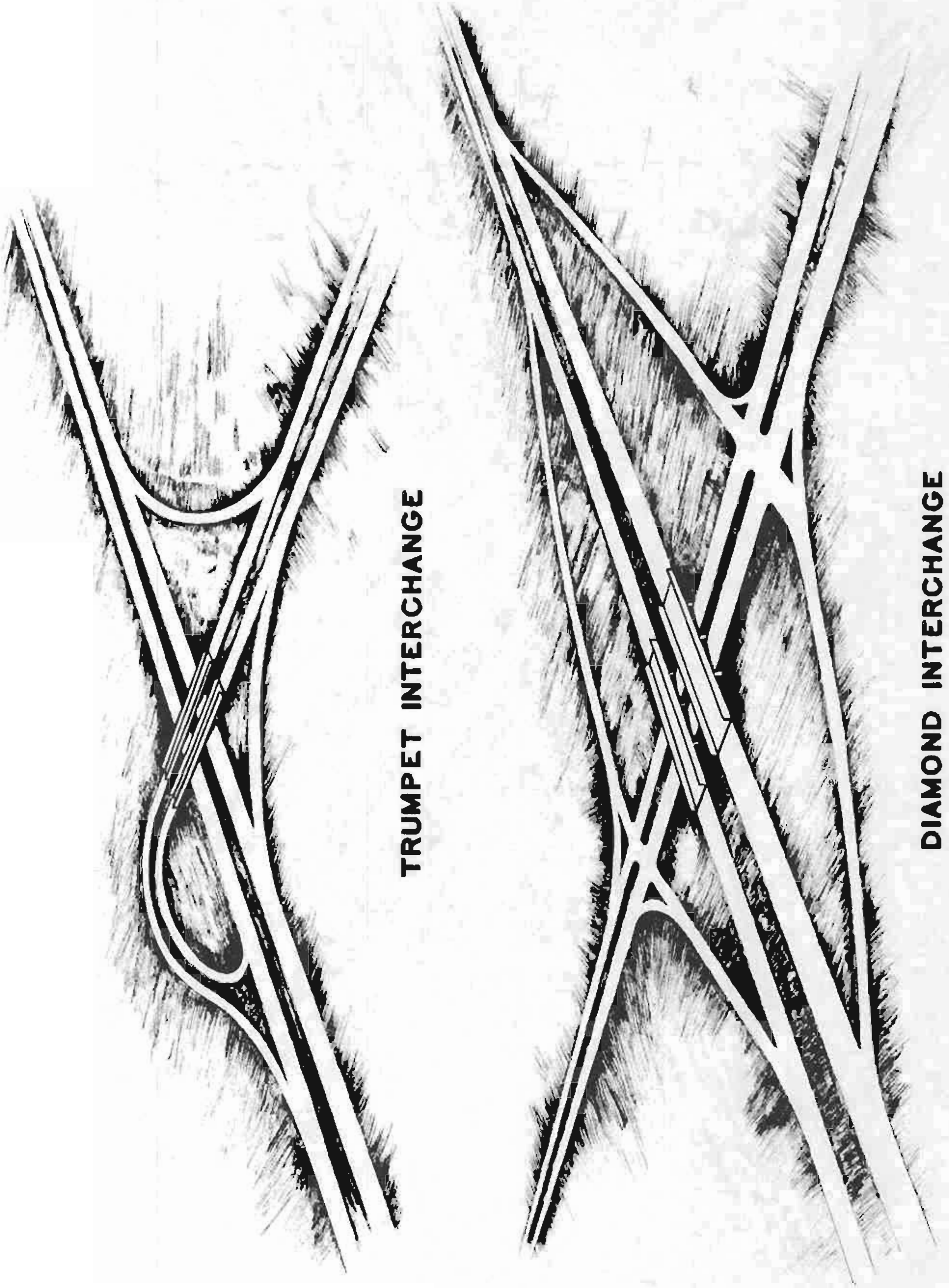
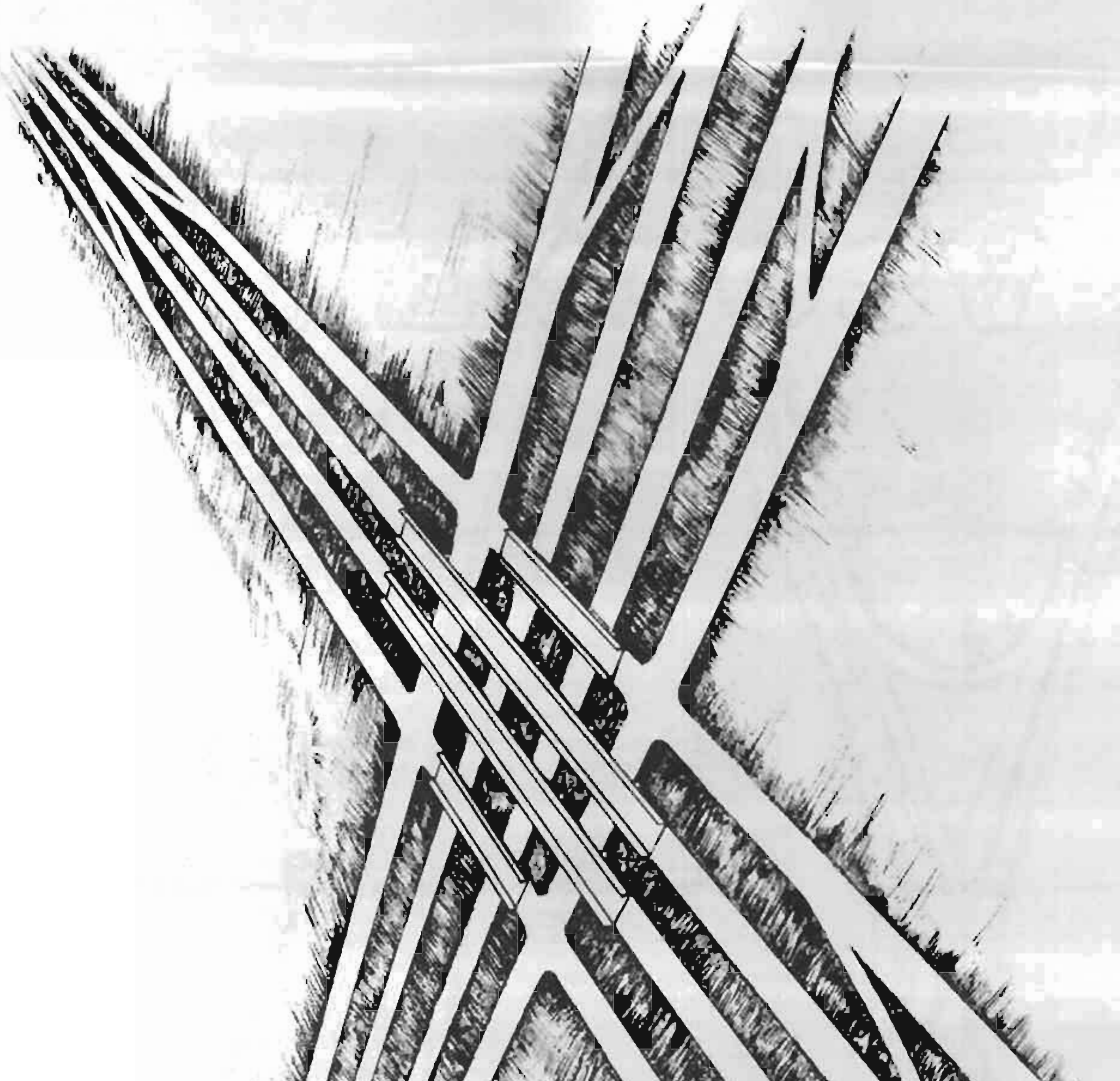


FIGURE 4-69. Refers to Paragraph 4-602(M)1&2



THREE-LEVEL DIAMOND

FIGURE 4-70. Refers to Paragraph 4-602(M)3

4. Cloverleaf

The four-quadrant, full cloverleaf (Figure 4-71) eliminates all left-turn conflicts through construction of a two-level interchange. Cloverleafs should not be used where left-turn volumes are high (exceed 1200 vph) since loop ramps are limited to one lane of operation and have restricted operating speeds. Due to their inherent capacity restrictions, cloverleafs are generally inappropriate for urban freeway-to-freeway interchanges, but may be appropriate for interchanging a freeway with a non-controlled access facility, or interchanging two facilities without access control. Collector-distributor roads should be used to accommodate weaving maneuvers. Primary disadvantages of the cloverleaf design are large right-of-way requirements, capacity restrictions of connections, short weaving length between loops, and the driver confusion resulting from the requirement that left turns must be executed by passing the grade separation structure and turning right.

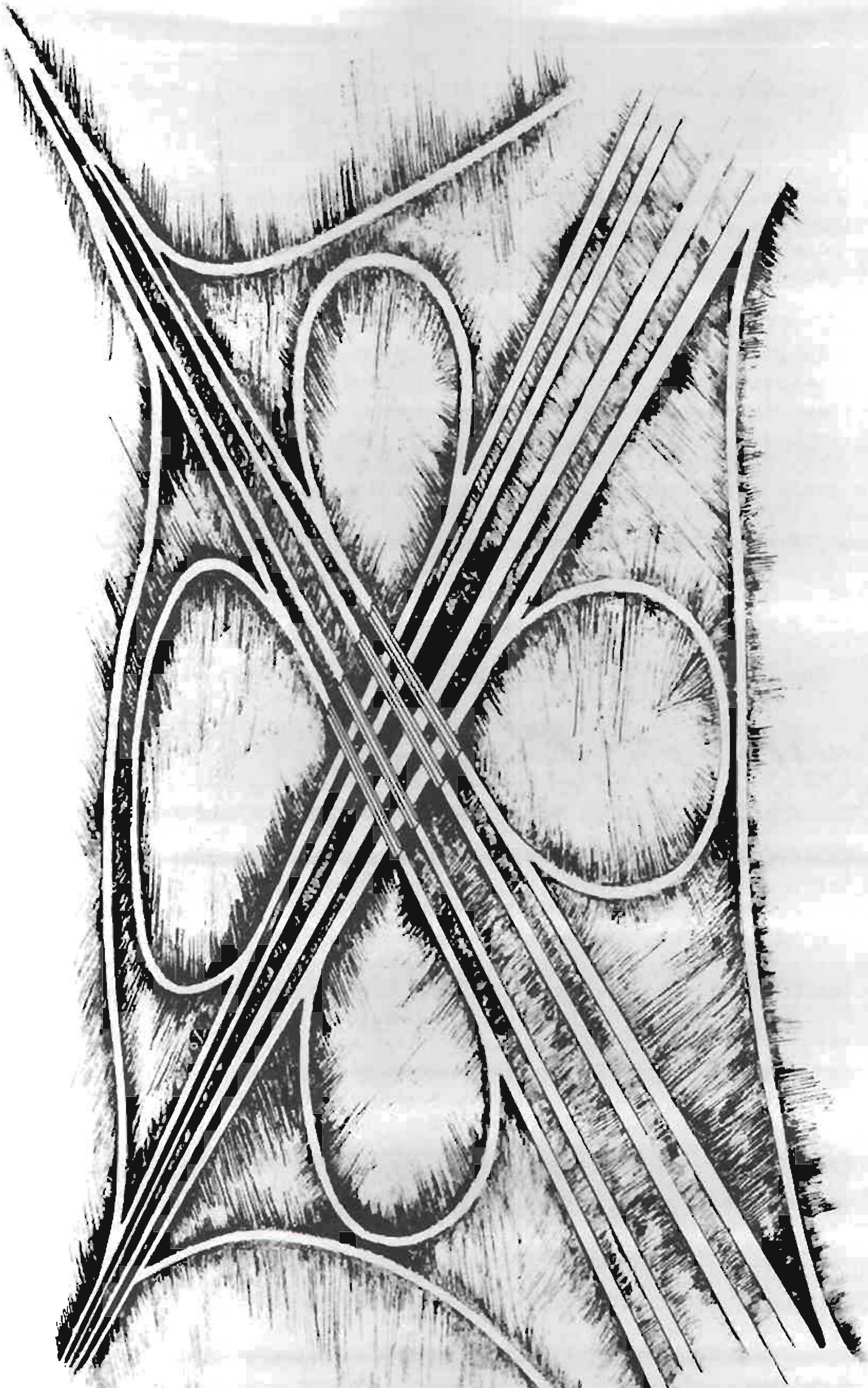
5. Partial Cloverleafs

A cloverleaf without ramps in all four quadrants (Figure 4-72) is sometimes used when site controls limit the number of loops and/or the traffic pattern is such that the left-turn conflicts caused by the absence of one or more loops are within tolerable limits. With such an arrangement, left-turn conflicts at the ramp intersections require that satisfactory approach sight distance be provided.

6. Directional

Interchanges which use direct or semi-direct connections for one or more left-turn movements are called "directional" interchanges (Figure 4-73). When all turning movements travel on direct or semi-direct ramps or direct connections, the interchange is referred to as "all directional". These direct or semi-direct connections are used for important turning movements instead of loops to reduce travel distance, increase speed and capacity, reduce weaving and avoid loss of direction in traversing a loop. "All-directional" interchanges are usually justified at the intersection of freeways.

The four-level directional interchange as depicted in Figure 4-73 includes direct connections for all freeway-to-freeway movements. In some instances, it may be desirable to continue the frontage roads through the interchange at the first or second level, producing a five-level directional interchange. Where frontage roads are made continuous through the interchange, the lower three levels are a three-level diamond configuration. Where stage construction is desired, the three-level diamond will adequately serve moderate traffic volumes



CLOVERLEAF INTERCHANGE WITH COLLECTOR - DISTRIBUTOR ROADS

FIGURE 4-71. Refers to Paragraph 4-602(M)4

PARTIAL CLOVERLEAF INTERCHANGE

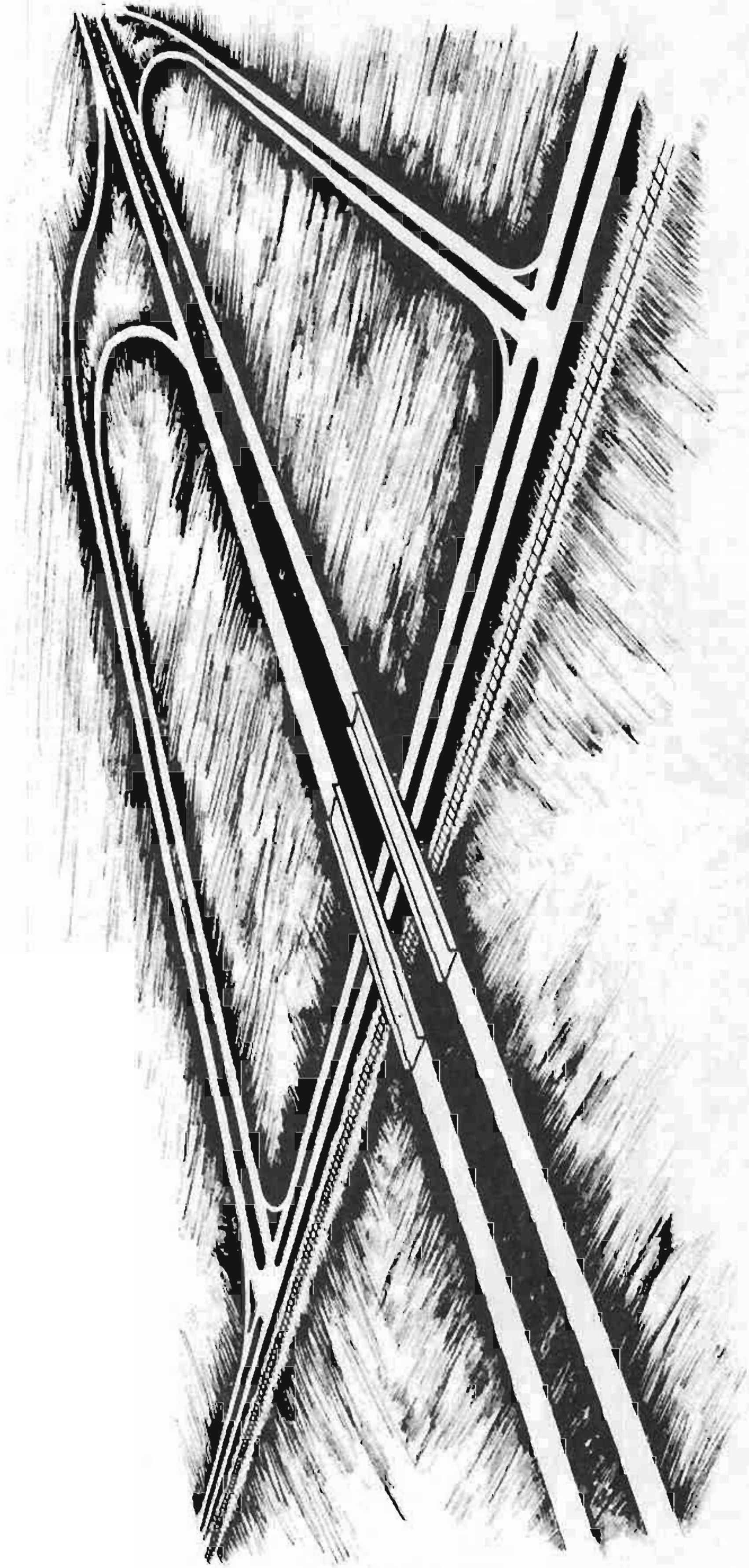


FIGURE 4-72. Refers to Paragraph 4-602(M)5

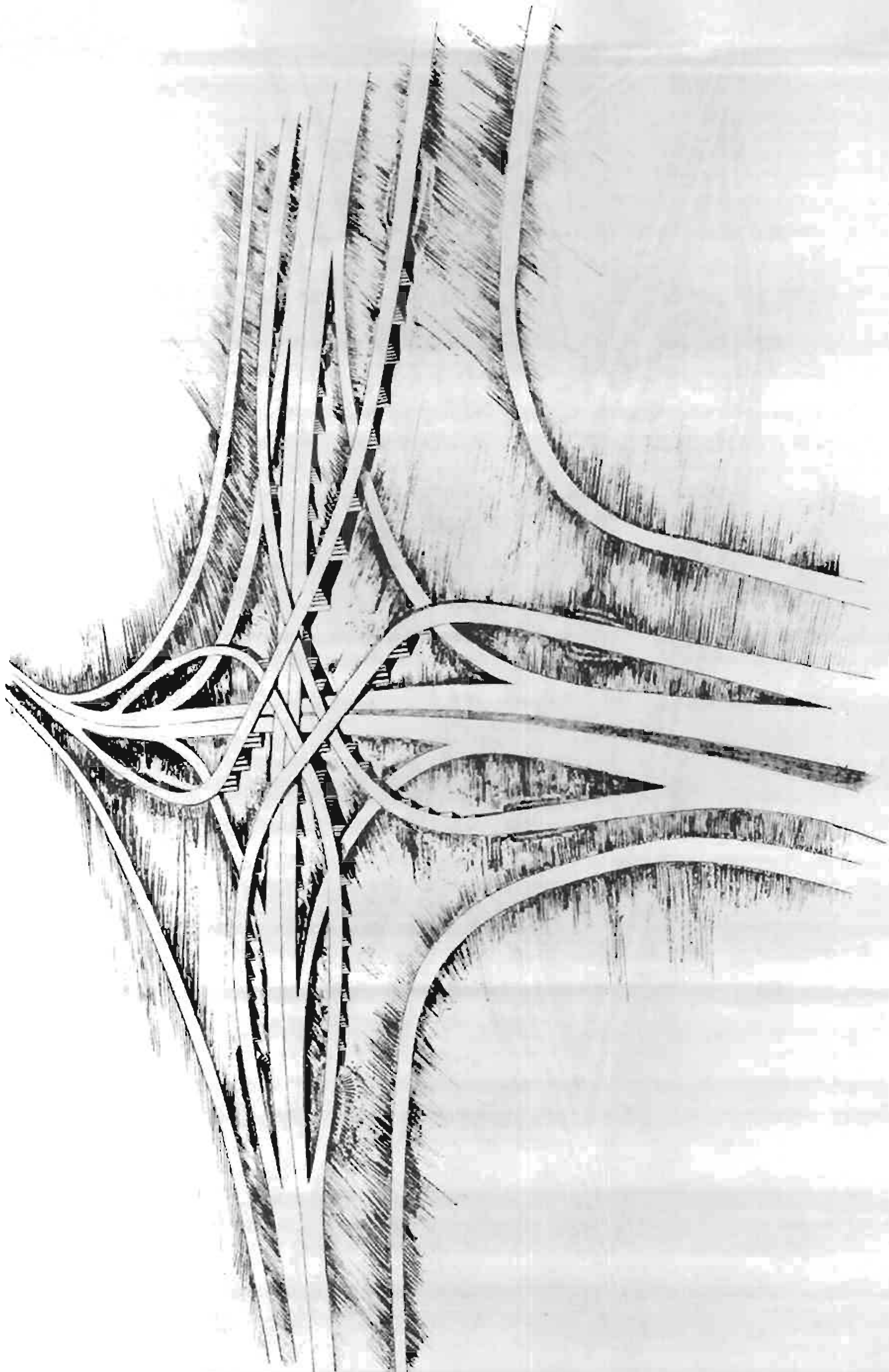


FIGURE 4-73. Refers to Paragraph 4-602(M)6

until the upper two levels of direct connections are constructed to complete the five-level interchange.

N. Requests for Additional Interchanges on Interstate Highways

Requests for additional interchanges on completed Interstate highways must be approved by the Federal Highway Administrator (Washington, D.C.). In the interest of expediting the processing of requests, documentation for justification of an additional interchange should normally include the following information (as appropriate) and any other data demonstrating public benefits or needs:

1. Present and design year traffic volumes for mainlanes, ramps, and proposed and existing impacted interchanges.

2. Number of lanes, present and anticipated future (design year).

3. Schematic showing proposed and existing alignment conditions, spacing of ramps, and proposed mainlane signing.

4. A level of service analysis for the mainlanes and ramps using present and design year traffic volumes.

New access points along Interstate Highways require approval at the FHWA Headquarters level (Washington, D.C.), therefore, it should be anticipated that action on a submission often will be a time consuming process.

4-603 FREEWAY RELATED TRANSITWAY TREATMENTS

A. General

Buses operate rapidly and efficiently on uncongested urban freeways. Many freeways, particularly radial routes leading to downtown areas, become routinely congested during peak hours, delaying buses as well as other freeway users. To improve bus travel, several general techniques may be considered, including busways on separate rights-of-way, busways on freeway rights-of-way, ramp metering and special bus ramps.

B. Planning and Design Criteria

Guidelines for the planning and design of various freeway related transitway treatments are shown in "Manual for Planning, Designing, and Operating Transitway Facilities in Texas", 1985.

MISCELLANEOUS DESIGN ELEMENTS (4-700)

4-701 GENERAL

Included in this section is information regarding fencing of right-of-way, control of access, median barriers, headlight barrier fence, and guard fence, pedestrian separations, roadside vegetation, signing, signals, pavement markings, and emergency median openings on freeways.

4-702 FENCING

A. Right-of-Way

The procedures for fencing highway right-of-way are set forth in the Right-of-Way Manual. Where additional right-of-way is not required for construction of improvements of existing highways, right-of-way (property) fencing shall be the entire responsibility of the land owner.

B. Control of Access Fencing on Freeways

Control of access fence shall be erected whenever it is necessary to prohibit unrestricted access to the through lanes by pedestrians, animals and/or vehicles. The prohibition of access to the through lanes shall be from private property, intercepted local roads and unauthorized crossings from frontage roads to the through lanes.

Where frontage roads are provided, control of access fence, when used, will be placed in the outer separation approximately equidistant between the mainlanes and frontage roads and at least 30 feet from edge of mainlane pavement. Where the control of access line is at the right-of-way line, the control of access fence will be located at the right-of-way line and will serve a dual function as a right-of-way fence.

The following types of fence shall be used for the condition indicated:

1. Urban and Suburban Areas

   Chain link fence of four feet usual height or six feet height where necessary for control of pedestrians.

2. Rural Conditions Where Both Large and Small Animals Exist

   The control of access fence, when used, will be located at the right-of-way line. A wire mesh fence with one or more strands of barbed wire.

3. Where Only Large Animals Exist

   A four-foot or five-foot barbed wire fence.

4. Where Control is for Vehicles Only

   A post and cable fence of closely spaced guard posts.

Department standard designs will be used where applicable. Specially designed fences may be necessary in certain areas where sandstorms and snowstorms occur and for other special conditions.

C. Median Barriers

1. Median barriers are necessary to prevent unlawful turns, to prevent out-of-control vehicles from entering the opposing traffic lanes and, in some cases, to prevent unlawful crossing of medians by pedestrians.

use of median barriers on non-controlled access facilities

2. On controlled access highways, median barriers will generally be provided in medians of 30 feet or less. On non-controlled access highways, median barriers may be used on medians of 30 feet or less; however, care should be exercised in their use in order to avoid the creation of a hazard or restriction in sight distance at median openings. Generally, the use of median barriers on non-controlled access facilities should be restricted to areas of potential hazard such as railroad separations or through areas where median constriction occurs.

3. Median barriers are generally comprised of fabricated steel rail, double W-beam guard fence, chain link fence, concrete or shrubbery. A post and cable fence serves the purpose of a median barrier on wide medians by controlling unauthorized crossings of the median; however, it falls more into the class of a control of access fence. Its use is not generally recommended since it is not a positive traffic barrier.

4. Median barriers should be included in the PS&E as a contract item and installed as part of the contract.

5. Medians for urban freeway sections generally are non-depressed and relatively narrow. For new construction, an urban freeway usually includes a 24-foot flush median (see Section 4-602(F)) with either slope-faced concrete or double steel beam median barrier.

In determining the type of barrier to be used for any project, the primary consideration is safety, both for vehicular impacts and during any maintenance activities. Field experience with concrete median barriers indicates that, unlike the double steel beam system, maintenance operations are not normally required following accidental vehicular encroachment. Accordingly, on new urban freeway sections with narrow medians (18 feet or less), a flexible median barrier system should not normally be used, since resulting maintenance activities would (a) create unduly hazardous exposure of maintenance crews to high speed and volume traffic, (b) usually necessitate blocking a travel lane thereby significantly disrupting traffic, causing delay, congestion, and a hazardous driving environment, and (c) result in high costs. Therefore, for projects involving new construction or complete reconstruction of a highway section, the determination of median barrier type should be in accordance with the guidelines shown in Figure 4-74.

SELECTION OF MEDIAN BARRIER TYPE

Barrier type determined by median width.

MEDIAN WIDTH	BARRIER TYPE
Up to 18 ft.	Concrete
18 to 30 ft.	Concrete or double steel beam

Special circumstances may dictate deviation from Figure 4-74

Figure 4-74. Refers to Paragraph 4-603(C)

Where there is a frequent presence of fixed objects such as continuous illumination systems in 18- to 30-foot medians the concrete barrier system offers advantages over double steel beam and should be used. Where the double steel beam barrier system is used, consideration should be given to special design treatments to increase barrier stiffness at fixed object locations. Special circumstances, such as the presence of blowing sand, may dictate deviation from the guidelines shown in Figure 4-74.

Reconstruction projects with median barriers should be considered on a project-by-project basis. Often the structural capability of existing bridges may make infeasible the use of concrete median barrier due to increased dead load.

D. Headlight Barrier Fence

For urban freeway conditions, headlight glare screen commonly has been mounted atop median barrier to reduce headlight glare and to discourage pedestrian crossings. Several factors suggest that the need for glare screen in future projects be more carefully considered. These factors are:

1. Most candidate freeway sections are continuously illuminated and headlight glare is not usually a serious problem due to the prevalent use of headlights on low beam.

2. The safety-shape concrete barrier currently is the type of median barrier most frequently installed. These median barriers are solid and 32 inches in height, thereby providing some reduction in headlight glare in comparison to metal beam median barriers used in the past.

3. Regardless of the type of median barrier, glare screen is often damaged in accidents, resulting in time-consuming, hazardous, and costly maintenance activities.

4. Construction cost of glare screen has increased in the past few years to the point that installations may not be cost effective.

5. Pedestrian crossings of medians generally are minimal due to the obvious hazards involved. Where a localized pedestrian crossing problem is evident, control of pedestrians at the right-of-way line, rather than the median, may be more appropriate.

6. The provision of glare screen has not been conclusively shown to affect nighttime accident rates.

The above factors should be carefully considered in the preparation of PS&E for those projects which could involve headlight glare screens. For projects which involve concrete median barrier and continuous illumination, the policy should be not to provide headlight glare screens unless a determination is made by the District Engineer that they are warranted.

E. Guard Fence

1. General

Guard fence is considered a protective device for the traveling public and is used at points on the highway where vehicles inadvertently leaving the facility would be subjected to considerable hazard. It is designed to resist impact by deflecting the vehicle so that it continues to move at a reduced velocity along the rail in the original direction of traffic. The limits of rail to be installed are shown on the plans; however, they may be adjusted in the field after the grading is completed. Guard fence is required only where the result of striking a fixed object or leaving the roadway would be more severe than the consequences resulting from impacting the rail.

2. Location

Guard fence should be installed in areas where the consequence of an errant vehicle leaving the roadway is judged to be more hazardous than impact with the guard fence (See "Metal Beam Guard Fence", Appendix A). It should be offset at least 2.5 feet and desirably five feet from the nearest edge of fixed objects.

At overpasses, guardrail should be anchored securely to the structure.

3. Standard Installations

Guard fence will be installed in accordance with the current Departmental standards (see "Metal Beam Guard Fence" in Appendix A).

4-703 PEDESTRIAN SEPARATIONS AND RAMPS

A. Pedestrian separations are generally limited to controlled access facilities since it is necessary that all at-grade pedestrian crossings be eliminated. Control-of-access fences and other means may be used to encourage pedestrians to cross at traffic separations. On highways other than freeways, pedestrian separations will be considered only in unusual circumstances.

Pedestrian structures may be warranted to provide for heavy pedestrian movements adjacent to factories, schools, parks, athletic fields, etc. If the location of traffic separations is such that their use would add an unreasonable pedestrian distance, a pedestrian structure may be considered for lower pedestrian volumes.

B. A pedestrian structure should be made as natural and convenient as possible. Either an overcrossing or undercrossing may be provided. All separations must be accessible to the handicapped unless alternate safe means are provided to enable mobility-limited persons to cross the roadway at that location, or unless it would be infeasible for mobility-limited persons to reach the structure because of unusual topographical or architectural obstacles unrelated to the roadway facility.

1. Overcrossings

All pedestrian overcrossings should be enclosed with wire fabric to discourge pedestrians from throwing debris on vehicles below the structure. Ramp gradients should not exceed 8.33 percent.

2. Undercrossings

Pedestrians avoid the use of undercrossings unless the underpass is in line with the approach sidewalk and continuous vision through the underpass from the approaching sidewalk is provided. Ample lighting, both day and night, is essential.

Undercrossings should be located only where ample police protection is available.

C. Pedestrian separation plans will be prepared by the SDHPT, working in close cooperation with the city in which the structure is located. All construction work will be performed by the State.

D. It will be the city's responsibility to bear the cost of power for operating lighting and for police protection.

E. Pedestrian ramps associated with roadway facilities such as pedestrian separations, parking lots, rest areas, curb cuts at cross walks, etc., must be accessible to handicapped persons and ramp gradients must not exceed 8.33 percent and platform spacing must not exceed 30 feet.

4-704 FRINGE PARKING LOTS

Fringe parking lots are generally located along express bus routes. These facilities are simply designed and usually charge a minimal or no fee. Based on present knowledge, it is difficult to predict the success or failure of park-and-ride lots. It is, therefore, often beneficial to use shopping center, stadium, drive-in theater, etc., lots if available or lease a site to establish the success or failure of a system before spending a relatively large amount on right-of-way, surfacing, etc., on a permanent lot.

Several items should be given careful consideration regarding fringe parking areas:

A. It is important that a fringe parking lot be located to serve a rather homogeneous socio-economic neighborhood.

B. The neighborhood served must have a high level of attraction for the destination (usually central business district). Conditions vary among different cities, but generally white collar, clerical, etc., workers will have a higher level of attraction than blue collar workers.

C. The quality of service must be attractive. More specifically, the time required to reach the destination point by bus must be comparable to or better than driving one's own car. In this regard, bus headways are an important factor, as well as delay and congestion to vehicular traffic in the corridor, access characteristics and aesthetics of the lot, etc. Location generally needs to be far enough out so that the time required to park one's car, board the bus, and travel is incidental to the time required merely to travel the total distance by automobile. Good access roads to the parking area to provide quick ingress and egress are important, and the parking arrangement should be designed to provide for maneuvering ease and a short walk to the bus boarding area.

For fringe parking areas within highway right-of-way, projects are generally developed as any other multiple use project. Where parking lots are proposed which are located outside of existing or proposed highway right-of-way, Commission approval is required.

Fringe parking lot projects are eligible for Federal-aid participation (Interstate, Urban System, Primary and Secondary). Projects will usually be located within or adjacent to highway right-of-way outside the central business district, but inside the urbanized area, and consistent with the urban transportation planning process. Operation and maintenance responsibilities should be assigned to local governmental agencies by agreement.

Planning and design guidelines for park-and-ride lots may be found in the publication entitled "Manual for Planning, Designing, and Operating Transitway Facilities in Texas", 1985.

4-705 PARKING ALONG HIGHWAYS

A. This section deals with parking as it pertains to the mainlanes of a controlled access highway, the frontage roads for such a facility and parking along urban and suburban arterials. Offstreet parking facilities provided within highway right-of-way are discussed in Paragraph 4-704 and Appendix G, "Multiple Use of Highway Right-of-Way". Safety rest areas as parking facilities are not considered in this section.

B. Parking on and adjacent to the mainlanes of a highway will not be permitted except for emergency situations. It is of paramount importance, however, that provision be made for emergency parking. Shoulders of adequate design provide for this required parking space.

Street parking can be provided by the provision of parking lanes on frontage roads or urban/suburban arterials. The design requirements for such lanes vary according to the characteristics of the abutting property, the areas served and the type of facility. In any instance, only parallel parking lanes shall be provided. Parking lanes ten feet wide are sufficient to provide space for parking on frontage roads and urban/suburban arterials. Parking shall be confined to the outer side of the arterial or frontage road. Where the need for street parking is localized, sections of parking lanes or parking inserts may be provided at that particular location.

Parking lanes in the vicinity of crossroad intersections, ramp terminals and on sections of channelized roadway require special consideration. Parking lanes should be continued their full width to an intersecting street but parking should be restricted a sufficient distance back from the intersection to allow for turning clearance and added capacity that might be required at the intersection.

4-706 ROADSIDE VEGETATION

A. Erosion Control

All construction slopes, 3:1 or flatter, should be adequately protected with vegetation to prevent erosion and downstream pollution. The most satisfactory form of vegetation is grass or turf for erosion control. This can be established where the average annual rainfall is approximately fifteen inches or greater.

Consideration should be given to preserving topsoil within construction limits to replace clay, caliche, shale, rock, and other similar slopes not capable of supporting vegetation.

On urban freeways, where possible, a neat, well-trimmed turf should be provided on the right-of-way. Where irrigation systems are necessary to sustain a turf, the water shall be furnished at no cost to the State.

B. Preservation of Native Growth

Consideration should be given to preservation of existing trees and shrubs to provide an interesting and pleasing highway whose safety is improved by proper plant groupings and the aesthetic appearance is enhanced. It is desirable to obtain right-of-way in excess of that needed for construction of cuts and fills to preserve some native growth. A variation in the profile grade along with a variable width median also permits the preservation of much desirable growth. The proper consideration for preservation of native growth will eliminate the need for future planting projects.

Generally, all growth is removed within the limits of cuts and fills which normally provide the desired thirty-foot recovery area. However, good judgment should be used in preserving trees within these limits that have scenic, historic or aesthetic value especially when they are located in the vicinity of homes. Tree wells in fills and retaining walls in cuts may be used to preserve outstanding specimens. Those trees located within the recovery area should be protected.

C. Planting Projects

Those sections of highway devoid of native growth should be considered for planting projects to provide for the comfort, safety and convenience of the traveling public. The design should be primarily functional in nature keeping ground covers and ornamental plantings to a minimum. Consideration should be given to screening of junkyards and unsightly areas where feasible. Assistance in the preparation of PS&E of this and other phases of landscape work will be furnished by the Landscape Section of the Safety and Maintenance Operations Division (File D-18L).

4-707 SIGNING AND PAVEMENT MARKINGS

A. Texas highways are designed to provide rapid, convenient and safe travel between and through traffic-generating centers. To achieve this design goal, it is necessary to provide a high-type system of highway signing that will be fully adequate for this high density, high speed, motor vehicle traffic.

B. All signing and pavement markings will be in accordance with the Texas Manual on Uniform Traffic Control Devices for Streets and Highways, Volume I, Signs, Markings and Barricades, as amended.

C. Rumble Strips

Recommendations relative to use of rumble strips and jiggle bars are as follows:

1. That they be used only across areas which are not intended for vehicular travel, such as emergency parking lanes on bridges, the triangular areas formed by pavement markings at the beginning of freeway off-ramps and on-ramps, paved shoulders on the approach to bridges not having full crown width, flush medians on four-lane divided highways, and the areas within the limits of pavement markings placed on the approach end treatments of median and channelizing islands.

2. That they never be used across the main traveled lanes of an Interstate Highway or any other freeway not designated as an Interstate Highway which is constructed to full control of access standards.

3. That they not be used, except as a last resort, across the traveled lanes of a conventional highway such as those having two or three lanes or across a four-lane divided highway which has intersections at-grade.

4-708 EMERGENCY MEDIAN OPENINGS ON FREEWAYS

A. Introduction

Median crossings between the mainlanes are sometimes necessary for proper law enforcement or for performance of highway maintenance on rural freeways. The construction of such median crossings is not encouraged since the necessary U-turns by such vehicles should be accomplished by using ramps at interchanges to the maximum extent feasible.

B. Warrants

Median crossings as turnarounds create undue hazard and interfere with through traffic and should be avoided. Normally the spacing of interchanges and layout of the highway provides for all necessary traffic movements, including those of emergency vehicles.

In unusual situations, where the distance between interchanges is great, emergency crossings may be provided with Administrative approval.

C. Spacing of Openings

Spacing of emergency median openings should not be less than 1 mile.

Due to the close spacing of interchanges on urban freeways, emergency median openings are not needed for the operation of official vehicles and, in general, they should not be provided. In rural areas where the spacing of interchanges is greater than approximately three miles, a U-turn median opening may be considered at a favorable location about halfway between interchanges. In no case shall emergency median openings be spaced at less than one-mile intervals. All emergency median openings should be at least one-half mile from any structure that overcrosses a freeway and at least one mile from any ramp terminal or other access connnection, such as those serving safety rest areas. They should be located where adequate stopping sight distance is available and where the median is sufficiently wide to permit an official vehicle to turn between the inner freeway lanes. The emergency median crossings should be as inconspicuous to the traveling public as possible.

D. Construction

Location and type of emergency median openings shall be made a part of the PS&E as a contract item and shall be installed as such.

4-709 SIGNALS

All traffic signals will be in accordance with the Texas Manual on Uniform Traffic Control Devices for Streets and Highways, Volume II, Signals.

4-710 MINIMUM DESIGNS FOR TRUCK TURNS

A. General

There are no firm guidelines governing the selection of the type of large vehicle to be used as a design vehicle. The type and frequency of use by large vehicles, consequences of encroachment into other lanes or the roadside, and availability of right-of-way are factors that influence design vehicle selection. Functional class of intersecting routes and location (urban versus rural) affect this selection in a general sense as discussed in subsequent paragraphs. Project-specific traffic data, specifically the frequency of use by the various design vehicle classes, is often the most important consideration in the selection process. The Transportation Planning Division (File D-10) may be contacted to obtain volume data for the various vehicle classes.

Minimum turning path templates for single unit trucks or buses, semi-trailer combinations with wheelbases of 40 and 50 feet, semi-trailer-trailer with wheelbase of 60 feet, and semi-trailer combination with wheelbase of 62 feet are shown in Figures 4-75, 4-76, 4-77, 4-78, 4-79 and 4-80 respectively. The 62-foot wheelbase design vehicle (see Figures 4-79 and 4-80) was legalized nationally by the 1982 Surface Transportation Act, and locally by subsequent State legislation. Although these vehicles are a minor portion of the truck fleet today, in future years their frequency will dramatically increase particularly on interregional and interstate routes. Where these vehicles are anticipated with frequency within the twenty year design life of a project, appropriate design measures should be taken.

B. Channelization

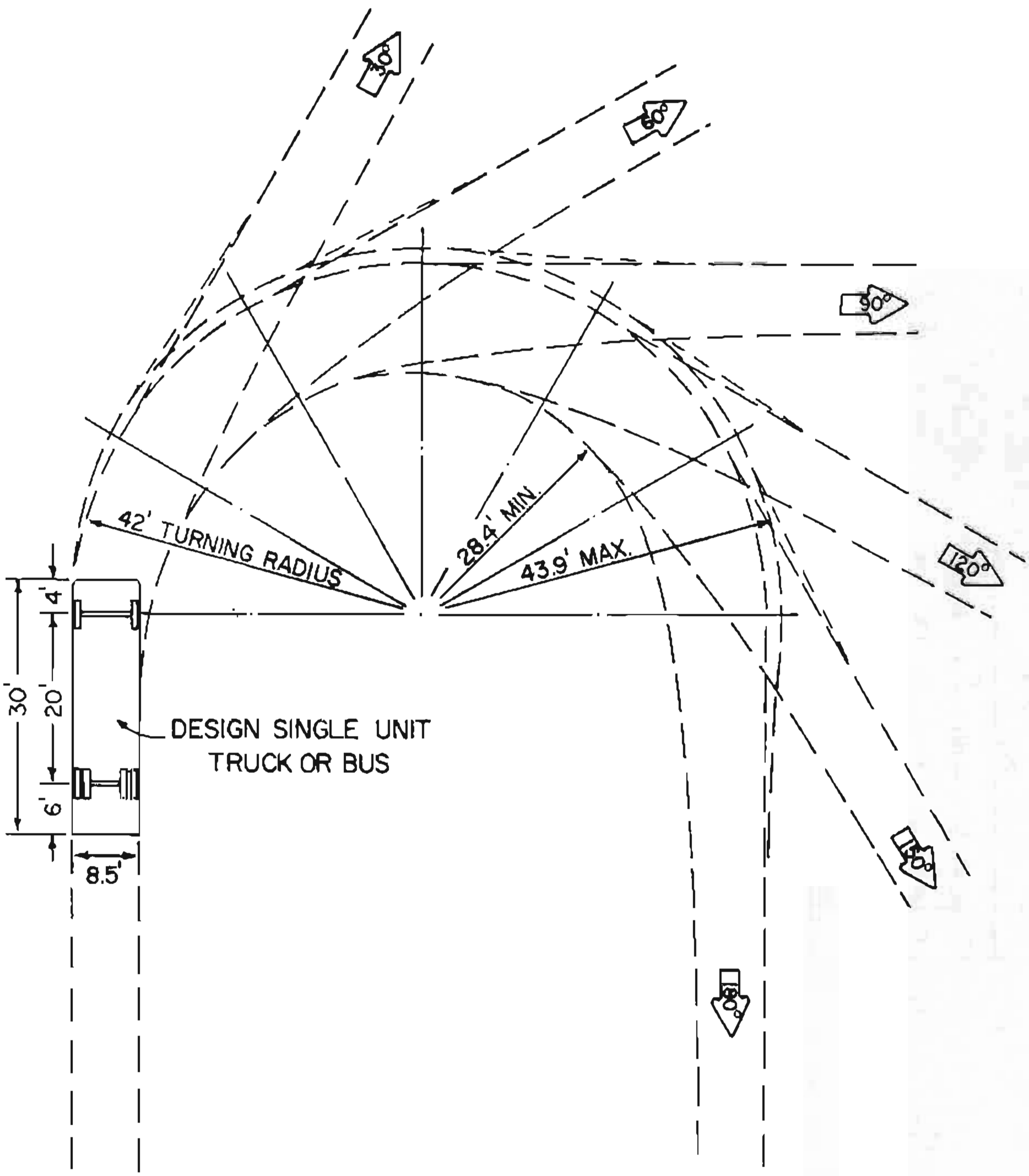
Where the inner edges of pavement for right turns at intersections are designed to accommodate semi-trailer combinations or where the design permits passenger vehicles to turn at 15 mph or more (i.e., 50 ft. or more radius), the pavement area at the intersection may become excessively large for proper control of traffic. In these cases, channelizing islands should be used to more effectively control, direct, and/or divide traffic paths. Physically islands should be at least 50 square feet in urban and 75 square feet for rural conditions (100 square feet preferable for both) in size and may range from a painted to a curbed area.

C. Alternatives to Simple Curvature

To accommodate the longest vehicles, offtracking characteristics in combination with the large (simple curve) radius that must be used results in a wide pavement area. In this regard, three-centered compound curves, or offset simple curves in combination with tapers, are preferred since they more closely fit the paths of vehicles. Figure 4-81 shows minimum edge of pavement designs for right turns to accommodate various design vehicles for turn angles varying from 60 to 120 degrees.

Figure 4-82 shows sample alternative (to simple curvature) edge of pavement geometry for a 90 degree turn using a WB-50 design vehicle. Although not shown in this Figure, a radius of 80 feet without channelizing island would be necessary to accommodate the wide, offtracking path of a WB-50 without undesirable encroachment. A geometric design of this sort is undesirable, however, since there would be a confusing, wide expanse of surfaced area; furthermore, there is no convenient, effective location for traffic control devices.

SU R = 42' 1" = 20'



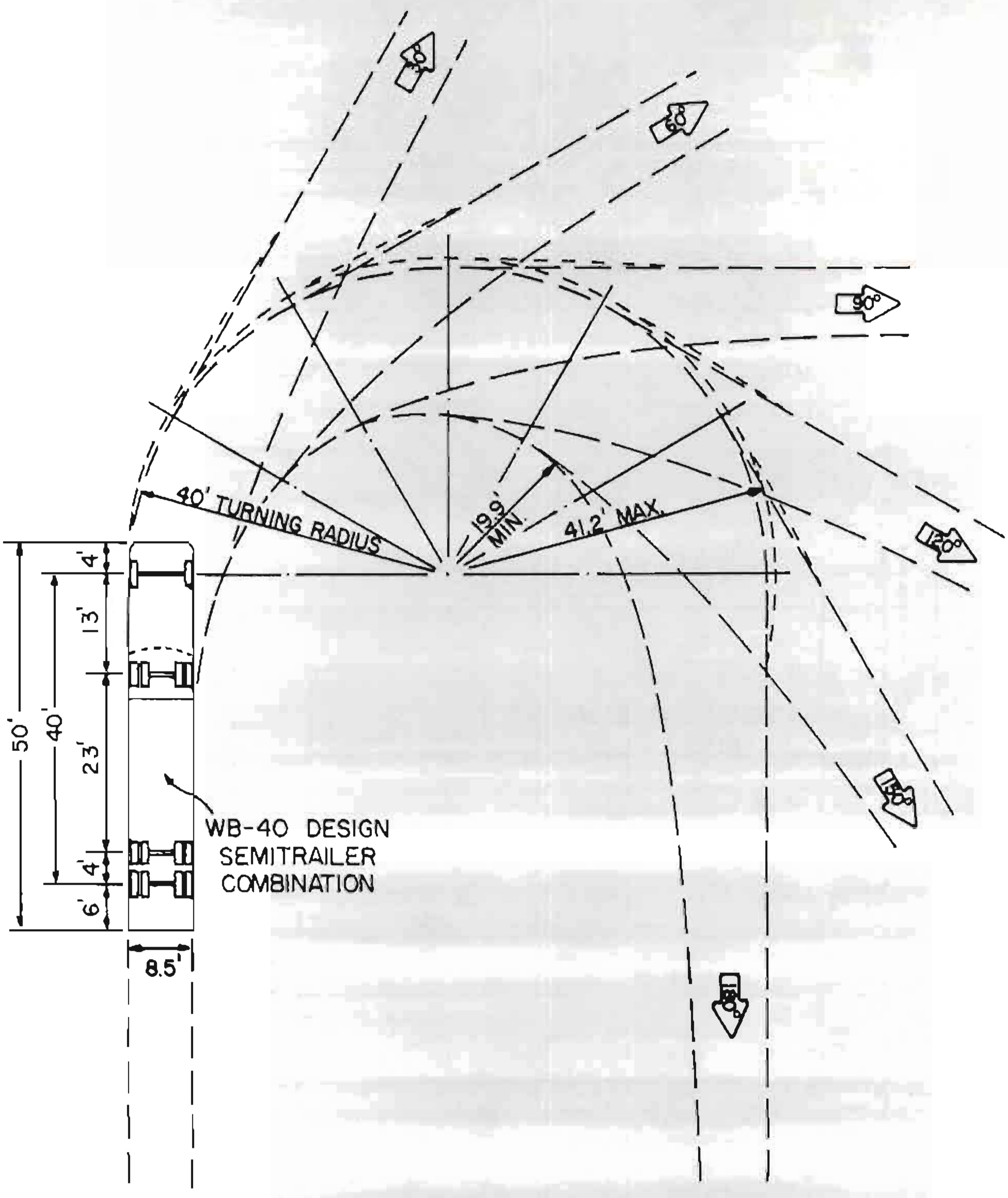
SU DESIGN VEHICLE

TURNING RADIUS = 42'

Scale 1" = 20'

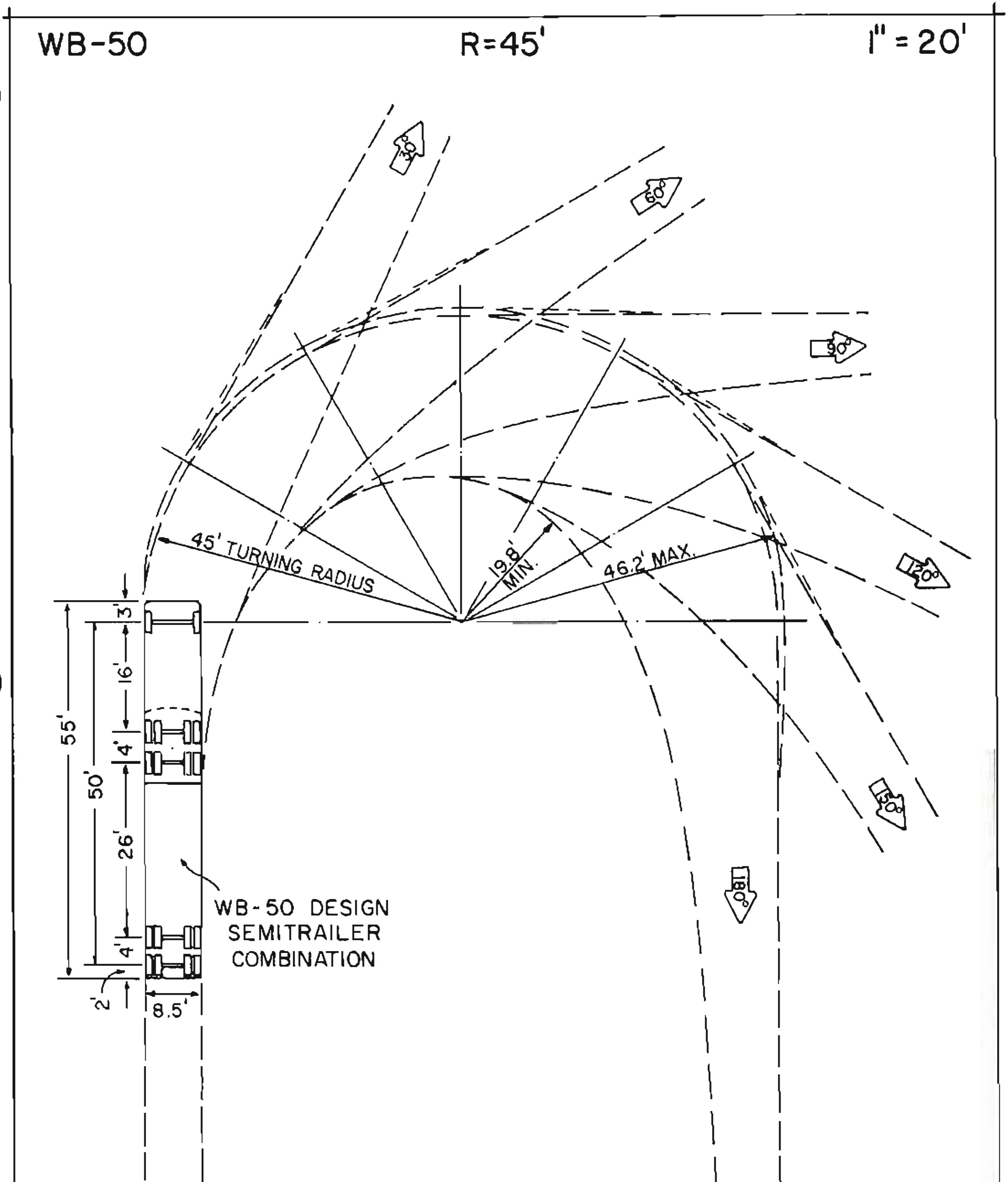
Figure 4-75. Refers to Paragraph 4-710

WB-40 R=40' 1" = 20'



WB-40 DESIGN VEHICLE
TURNING RADIUS = 40'
Scale 1" = 20'

Figure 4-76. Refers to Paragraph 4-710



WB-50 DESIGN VEHICLE
TURNING RADIUS = 45'
Scale 1" = 20'

Figure 4-77. Refers to Paragraph 4-710

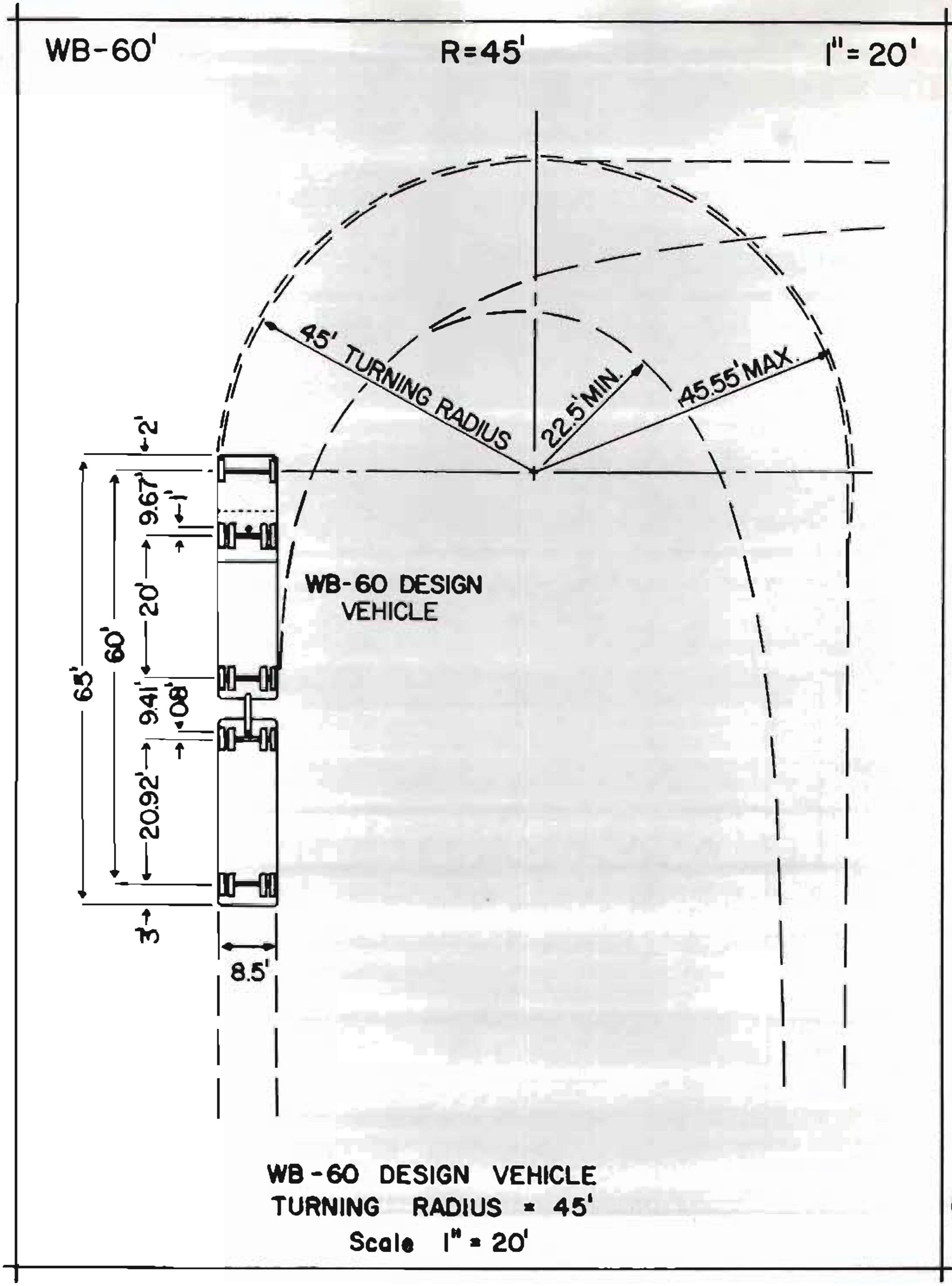


Figure 4-78. Refers to Paragraph 4-710

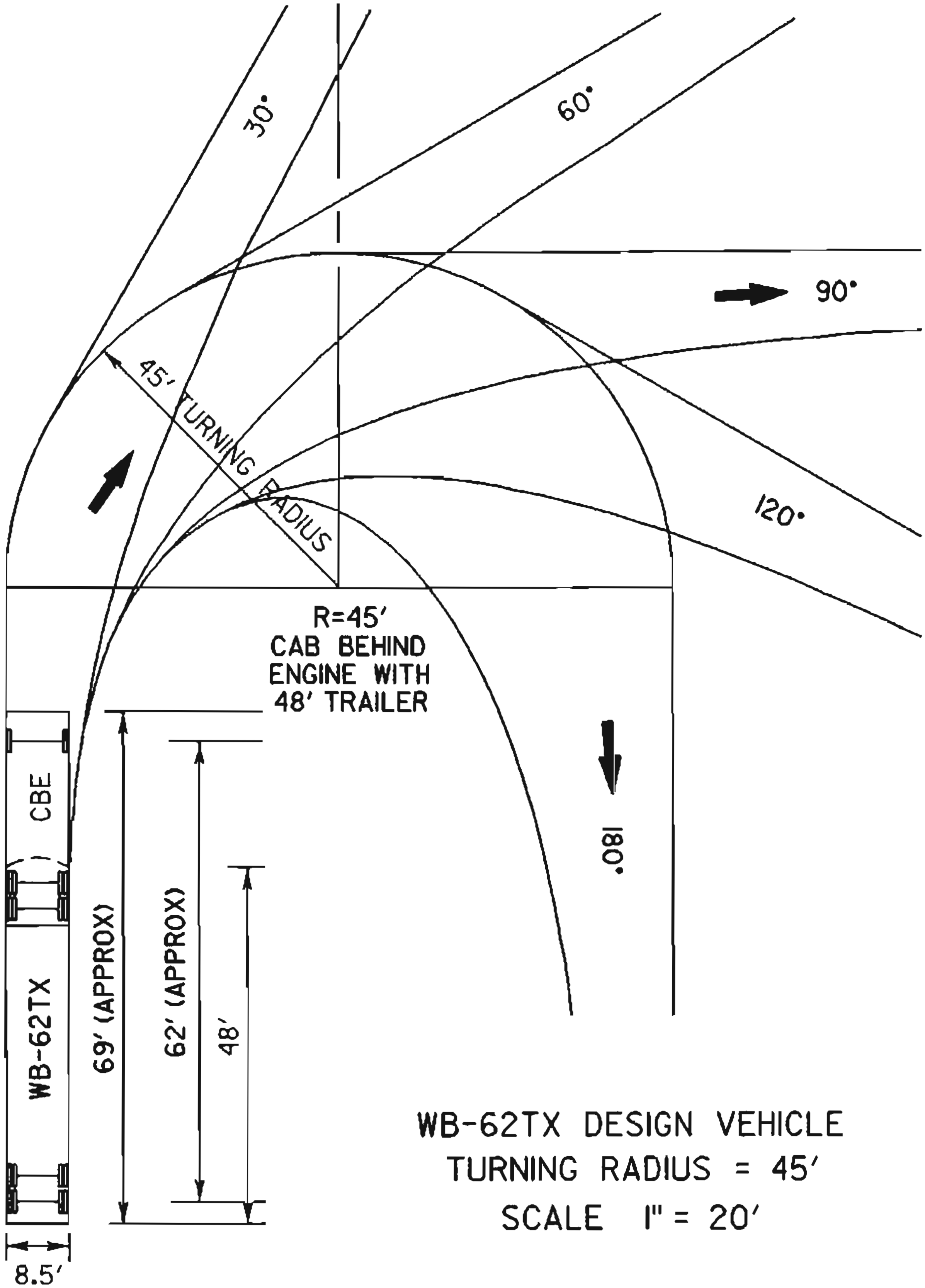


Figure 4-79. Refers to Paragraph 4-710

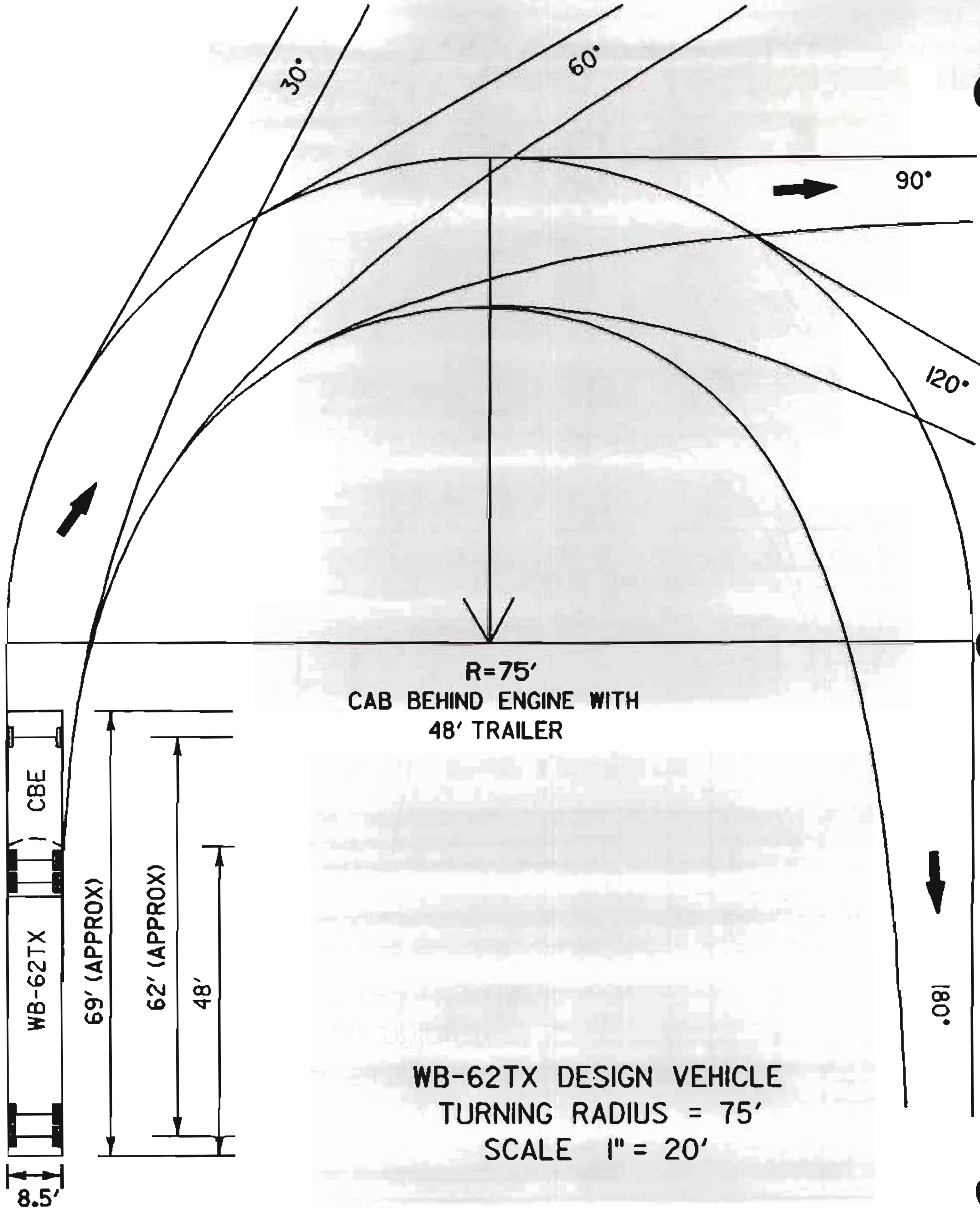


Figure 4-80. Refers to Paragraph 4-710

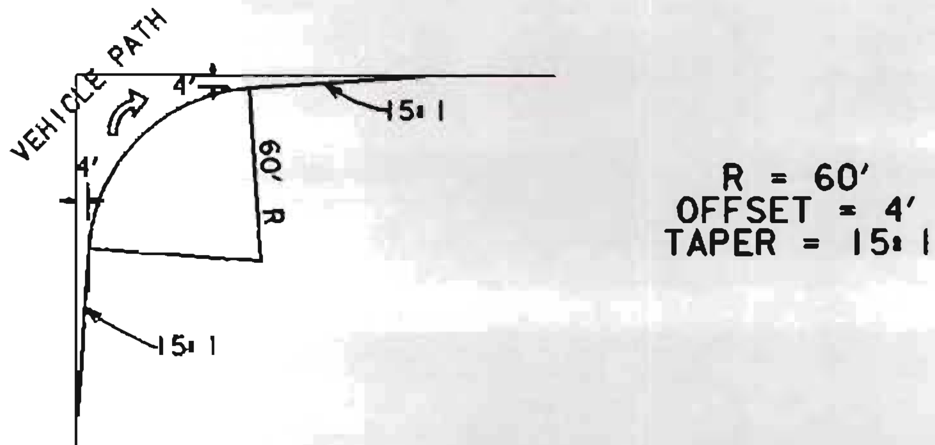
MINIMUM EDGE OF PAVEMENT DESIGNS AT INTERSECTIONS

Angle of Turn[1] (degrees)	Design Vehicle	Simple Curve Radius	Simple Curve Radius With Taper			3-Centered Compound Curve Symmetric		3-Centered Compound Curve Asymmetric	
			Radius (ft)	Offset (ft)	Taper (ft:ft)	Radii (ft)	Offset (ft)	Radii (ft)	Offset (ft)
60	P	40	--	--	--	--	--	--	--
	SU	60	--	--	--	--	--	--	--
	WB-40	90	--	--	--	--	--	--	--
	WB-50	--	95	3.0	15:1	200- 75-200	5.5	200- 75-275	2.0- 6.0
75	P	35	25	2.0	10:1	100- 25-100	2.0	--	--
	SU	55	45	2.0	10:1	120- 45-120	2.0	--	--
	WB-40	--	60	2.0	15:1	120- 45-120	5.0	120- 45-200	2.0- 6.5
	WB-50	--	65	3.0	15:1	150- 50-150	6.0	150- 50-225	2.0-10.0
90	P	30	20	2.5	10:1	100- 20-100	2.5	--	--
	SU	50	40	2.0	10:1	120- 40-120	2.0	--	--
	WB-40	--	45	4.0	10:1	120- 40-120	5.0	120- 40-200	2.0- 6.0
	WB-50	--	60	4.0	15:1	180- 40-180	6.0	120- 40-200	2.0-10.0
105	P	--	20	2.5	8:1	100- 20-100	2.5	--	--
	SU	--	35	3.0	10:1	100- 35-100	3.0	--	--
	WB-40	--	40	4.0	10:1	100- 35-100	5.0	100- 55-200	2.0- 8.0
	WB-50	--	55	4.0	15:1	180- 45-180	8.0	150- 40-210	2.0-10.0
120	P	--	20	2.0	10:1	100- 20-100	2.0	--	--
	SU	--	30	3.0	10:1	100- 30-100	3.0	--	--
	WB-40	--	35	5.0	8:1	120- 30-120	6.0	100- 30-180	2.0- 9.0
	WB-50	--	45	4.0	15:1	180- 40-180	8.5	150- 35-220	2.0-12.0

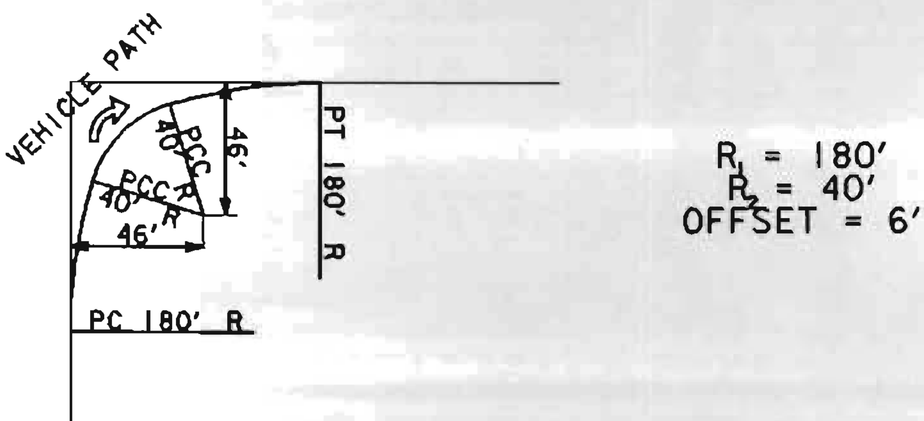
[1] "Angle of Turn" is the angle through which a vehicle travels in making a turn. It is measured from the extension of the tangent on which a vehicle approaches to the corresponding tangent on the intersecting road to which a vehicle turns. It is the same angle that is commonly called the delta angle in surveying terminology.

Figure 4-81. Refers to Paragraph 4-710

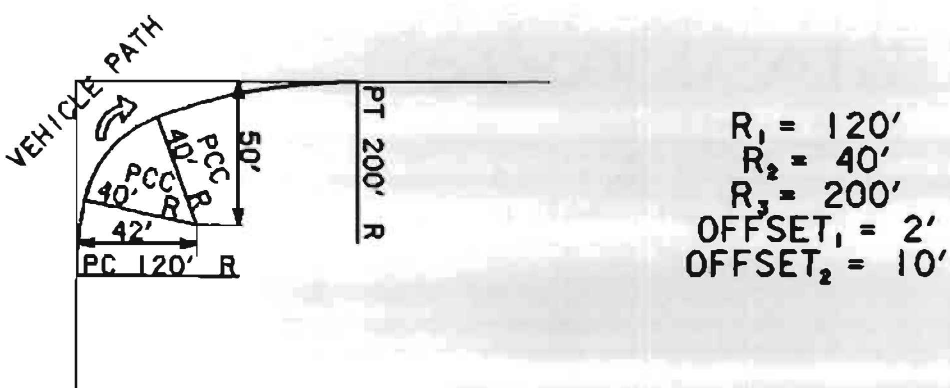
EXAMPLE PAVEMENT EDGE GEOMETRY
WB-50, 90 DEGREE TURN



(a) Simple Curve Radius With Taper



(b) 3-Centered Symmetric Compound Curve



(c) 3-Centered Asymmetric Compound Curve

Figure 4-82. Refers to Paragraph 4-710(C)

D. Urban Intersections

Because of space limitations and lower operating speeds in urban areas, curve radii for turning movements may be smaller than normally used in rural areas. Curvature or corner radius to accommodate turning movements depends largely on the number and types of turning vehicles.

For urban streets, standards for intersections with local streets provide for curb radii of 5 to 30 feet, typically 10 or 15 feet, and desirably 20 to 30 feet. At low speeds passenger cars on lanes 10 feet or more in width are able to negotiate a right turn with little encroachment in other lanes with a curb radius of 15 feet. To accommodate turns of most trucks and buses that are commonly found on collectors and arterials, radii of 30 to 50 feet are in order. Angle of turn, lane width, vehicle type, and turning speed affect actual vehicle paths and influence the selection of turning roadway width.

For arterial-arterial urban intersections, turning radii of 75 feet or more are desirable if frequent use is anticipated by the WB-62TX design vehicle. Where other types of truck combinations are used as the design vehicle, pavement edge geometry as shown in Figure 4-81 and 4-82 permit the use of lesser radii.

E. Rural Intersections

In rural areas space is generally more available and speeds higher. These factors suggest more liberal designs for truck turning even when the frequency of long vehicles may not be as great as in urban areas.

In the design of highway intersections with other (non-highway system) public roads, long vehicles are generally infrequent users. Minimally, the SU, or on some occasions the WB-40, design vehicle is appropriate for use unless special circumstances (location of a truck stop or terminal) influence the frequency of use by certain vehicle classes.

For highway-to-highway intersections, greater frequencies of longer trucks may be anticipated.

For arterial intersections with collectors, the WB-40 design vehicle is generally appropriate and the WB-50 should be used where specific circumstances warrant.

For arterial-arterial intersections, use by the WB-62TX design vehicle should be anticipated within project life. These vehicles include 48-foot trailers legalized by the 1982 Surface Transportation Act and subsequent State legislation. As trailer fleets are replaced with time, these vehicles will be present in greater numbers on the highway system, particularly arterial routes. Two template layouts, Figures 4-79 and 4-80, are shown with radii of 45 and 75 feet respectively. For turning roadway widths to be reasonable in width, a design radius of 75 feet or more is required. Where circumstances at a particular rural arterial-arterial intersection precludes the use of the WB-62TX design vehicle, the WB-50 should be used.

APPENDIX A-100

STANDARD DESIGN DETAILS (A-100)

TITLE	DESCRIPTION	PAGE
GF (TD)-87	Metal Beam Guard Fence	A- 4
MBGF (B)-74	Metal Beam Guard Fence (Barrier)	A- 5
GF(RRSP)-77	Metal Beam Guard Fence Railroad Signal Protection	A- 6
MBGF(B) OBS-74	Metal Beam Guard Fence (Barrier Obstruction)	A- 7
EMM HBF-74	Expanded Metal Mesh Headlight Barrier Fence	A- 8
CA HBF-69	Control of Access Headlight Barrier Fence	A- 9
BED(TWT)-84	Bridge End Details (Two-Way Traffic)	A-10
BED(OWT)-84	Bridge End Details (One-Way Traffic)	A-11
CLF-80	Chain Link Barrier Fence	A-13
WF-81(1)	Barbed Wire Fence and Woven Wire Fence (Timber Posts)	A-14
WF-69(2)	Barbed Wire Fence and Woven Wire Fence (Steel Posts)	A-15
BAS-75	Bridge Approach Slab	A-16
CPCR(B)-85	Concrete Pavement Details, Continuously Reinforced (Steel Bars)	A-17
CPJR(30B)-75	Concrete Pavement Details, Jointed Reinforced (Steel Bars)	A-21
CPCD-80(1)	Concrete Pavement Details, Contraction Design	A-22
CPCD-80(2)	Concrete Pavement Details, Contraction Design	A-23
CPSJ-75	Concrete Pavement Details, Skewed Transverse Joints (No Dowels)	A-24
TA(CPCR)-83	Terminal Anchorage for Concrete Pavement Continuously Reinforced	A-25
TA(CPJ)-83	Terminal Anchorage for Concrete Pavement Jointed	A-26
JS-75	Concrete Paving Details, Joint Seals	A-27
CCCG-75	Concrete Curb and Curb and Gutter	A-28
MXS-76	Metal Series Railroad Crossing Signs (Reflectorized)	A-29
BC(1)-82	Barricades and Construction Signs	A-30
BC(2)-82	Barricades and Construction Signs	A-31
BC(3)-82	Barricades and Construction Signs	A-32
BC(4)-82	Barricades and Construction Signs	A-33
BC(5)-82	Barricades and Construction Signs	A-34
BC(6)-82	Barricades and Construction Signs	A-35
BC(7)-82	Barricades and Construction Signs	A-36
M-83-A	Right-of-Way Markers	A-37
RID(1)-82	Roadway Illumination Details	A-38
RID(2)-82	Roadway Illumination Details	A-39
RID(3)-82	Roadway Illumination Details	A-40
RID(4)-82	Roadway Illumination Details	A-41
RID(5)-82	Roadway Illumination Details	A-42

STANDARD DESIGN DETAILS (A-100)

TITLE	DESCRIPTION	PAGE
HMID(1)-86	High Mast Illumination Details	A-43
HMID(2)-86	High Mast Illumination Details	A-44
HMID(3)-86	High Mast Illumination Details	A-45
HMID(4)-86	High Mast Illumination Details	A-46
HMID(5)-86	High Mast Illumination Details	A-47
HMID(6)-86	High Mast Illumination Details	A-48
HMID(7)-86	High Mast Illumination Details	A-48A
HMID(8)-86	High Mast Illumination Details	A-48B
HMID(9)-86	High Mast Illumination Details	A-48C
HMID(10)-86	High Mast Illumination Details	A-48D
VIA(CCD)-83	Crash Cushion Details	A-49
VIA(ST)-74	Sand-Tire Vehicle Impact Attenuator	A-50
CTBI(1)-85	Concrete Traffic Barrier (Type 1)	A-52
CTB(2)-81	Concrete Traffic Barrier (Type 2 & 3)	A-53
CTBI(3)-85	Concrete Traffic Barrier (Type 2)	A-54
CTBI(4)-81	Concrete Traffic Barrier	A-55
PCTB(1)-83	Precast Concrete Traffic Barrier - Type 2	A-56
PCTB(2)-85	Precast Concrete Traffic Barrier - Type 2	A-57
HBF(CTB)-81	Headlight Barrier Fence	A-58
CBR(P&P)-87	Concrete Barrier Rail (Portable and Precast)	A-59
TB(BMGF)-86	Temporary Barrier Barrel-Mounted Guard Fence	A-60
GREAT - 85	Guard Rail Energy Absorbing Terminal	A-61
SENTRE - 85	Safety Barrier End Treatment	A-62
HCC - 85	Hydraulic Crash Cushion (HCC) (Free Standing)	A-62A

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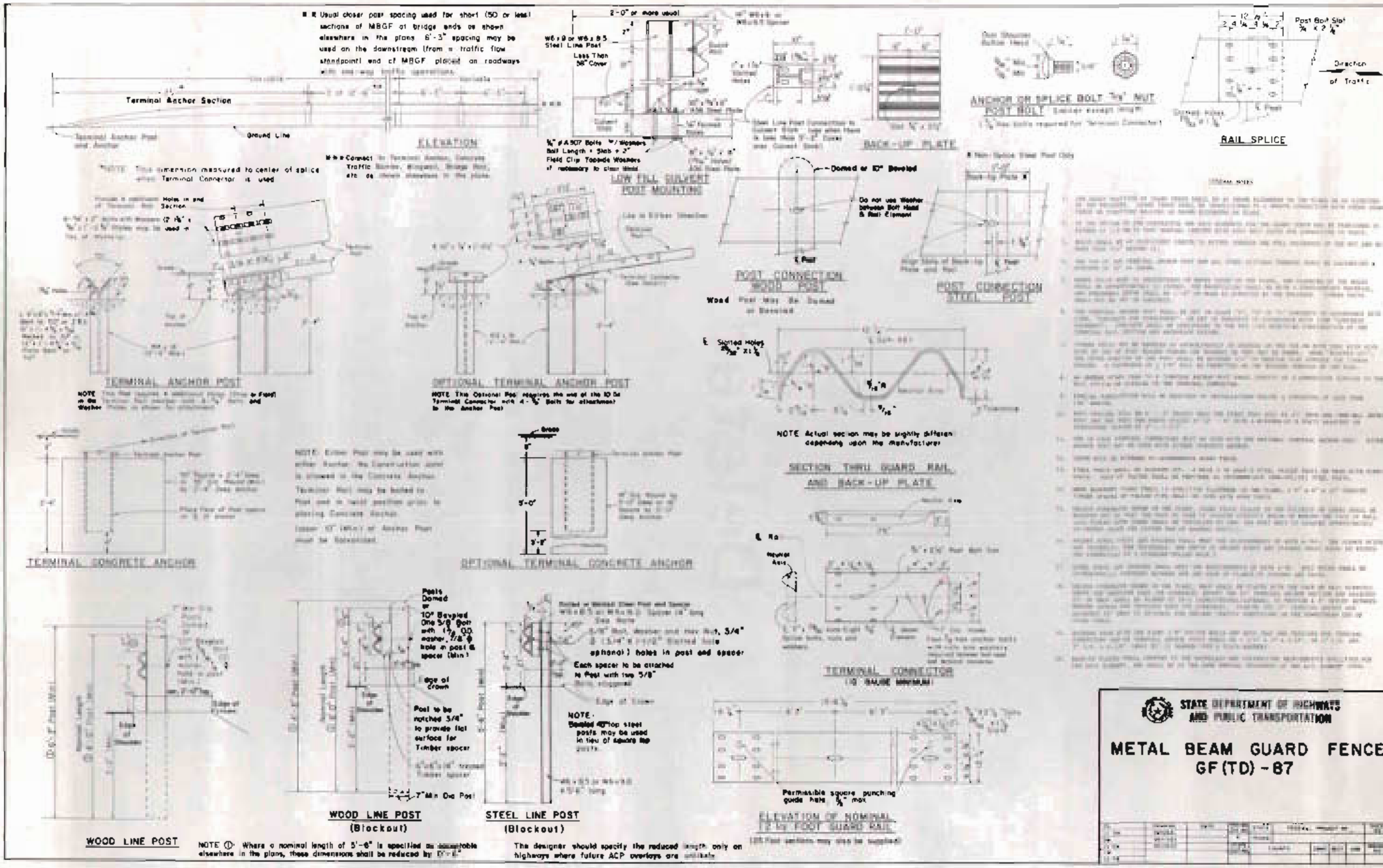
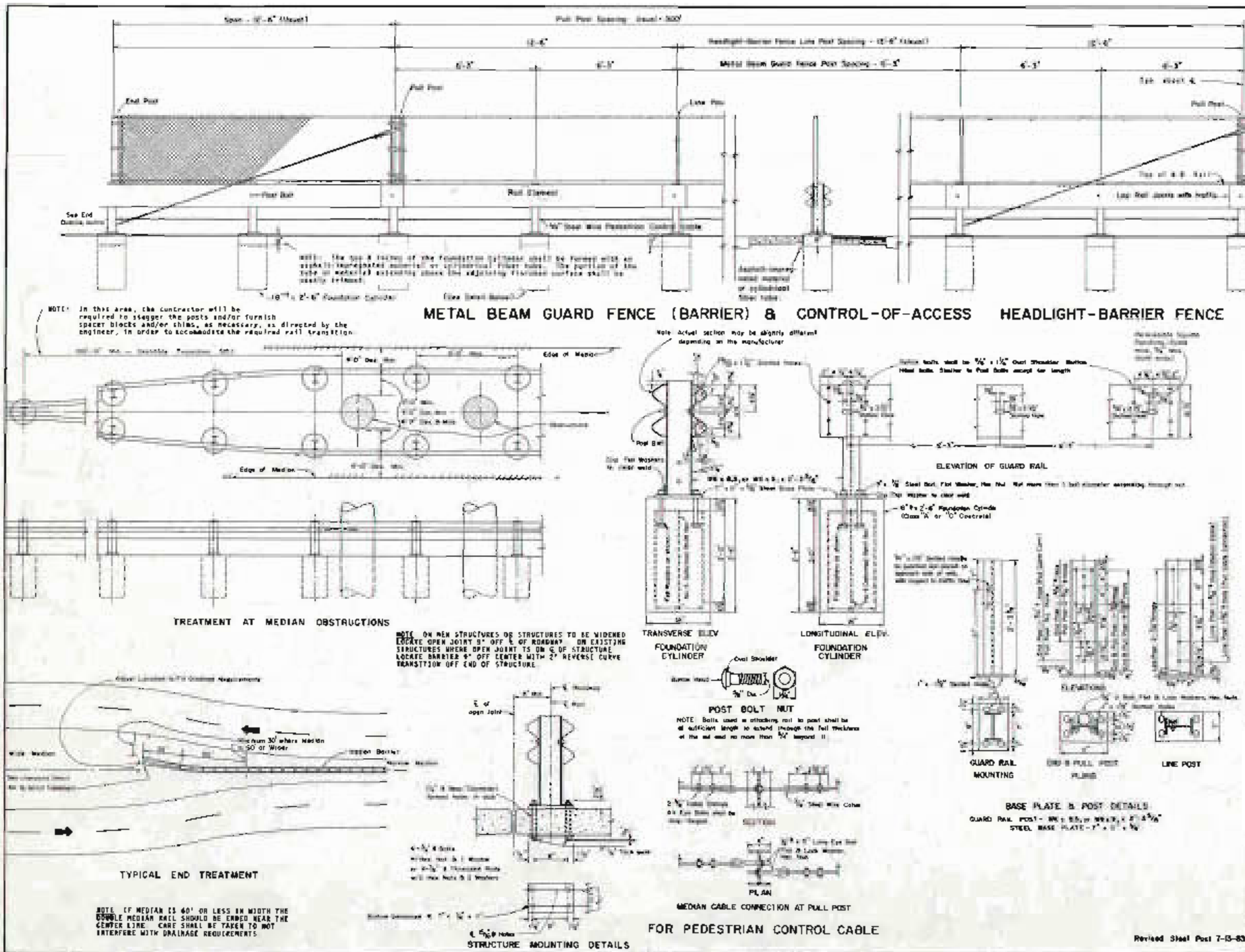
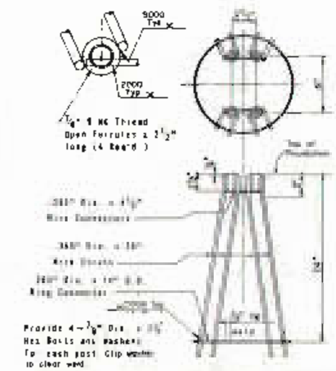
A-4


Terminal Anchor Section
Ground Line
ELEVATION
Usual closer post spacing used for short (50 or less) sections of MBGF at bridge ends or shown elsewhere in the plans. 6'-3" spacing may be used on the downstream (from a traffic flow standpoint) end of MBGF placed on roadways with one-way traffic operations.
2'-0" or more usual
W6 x 9 or W6 x 8.5 Steel Line Post
Less Than 38" Cover
LOW FILL CULVERT POST MOUNTING
BACK-UP PLATE
ANCHOR OR SPLICE BOLT 5/8" NUT
POST BOLT
RAIL SPLICE
Post Bolt Slot
Direction of Traffic
Domed or 10" Beveled
Do not use Washer between Bolt Head & Rail Element
POST CONNECTION WOOD POST
Wood Post May Be Domed or Beveled
POST CONNECTION STEEL POST
TERMINAL ANCHOR POST
OPTIONAL TERMINAL ANCHOR POST
NOTE: The Optional Post requires the use of the 10 Ga Terminal Connector with 4 - 5/8" Bolts for attachment to the Anchor Post
Slotted Holes
NOTE: Actual section may be slightly different depending upon the manufacturer
SECTION THRU GUARD RAIL AND BACK-UP PLATE
TERMINAL CONCRETE ANCHOR
OPTIONAL TERMINAL CONCRETE ANCHOR
5'-0"
TERMINAL CONNECTOR
(10 GAUGE MINIMUM)
Posts Domed or 10" Beveled
Edge of Crown
Post to be notched 3/4" to provide flat surface for Timber spacer
7" Min Dia Post
Each spacer to be attached to Post with two 5/8"
NOTE: Beveled 40" top steel posts may be used in lieu of square top posts.
WOOD LINE POST
WOOD LINE POST (Blockout)
STEEL LINE POST (Blockout)
Permissible square punching guide hole 5/8" max
ELEVATION OF NOMINAL 12 1/2 FOOT GUARD RAIL
NOTE ①: Where a nominal length of 5'-6" is specified as acceptable elsewhere in the plans, these dimensions shall be reduced by 0'-6".
The designer should specify the reduced length only on highways where future ACP overlays are unlikely.
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
METAL BEAM GUARD FENCE
GF(TD)-87





OPTIONAL PRESET ANCHORAGE SYSTEM

PRESET ANCHORAGE SYSTEM

At the option of the Contractor, the preset anchorage system shown above may be used in lieu of conventional anchor bolts and reinforcing steel for rail posts mounted on foundation cylinders.

Material for the preset anchorage shall be as follows:
Ferrules: Steel A.S.T.M. A108 Grade 12 L 14
Wire Connectors: Steel A.S.T.M. A510 Grade 1008
Struts: Steel A.S.T.M. A510 Grade 1032 or 1033
Contractor shall furnish certification that the material furnished meets the requirements of the A.S.T.M. designations.

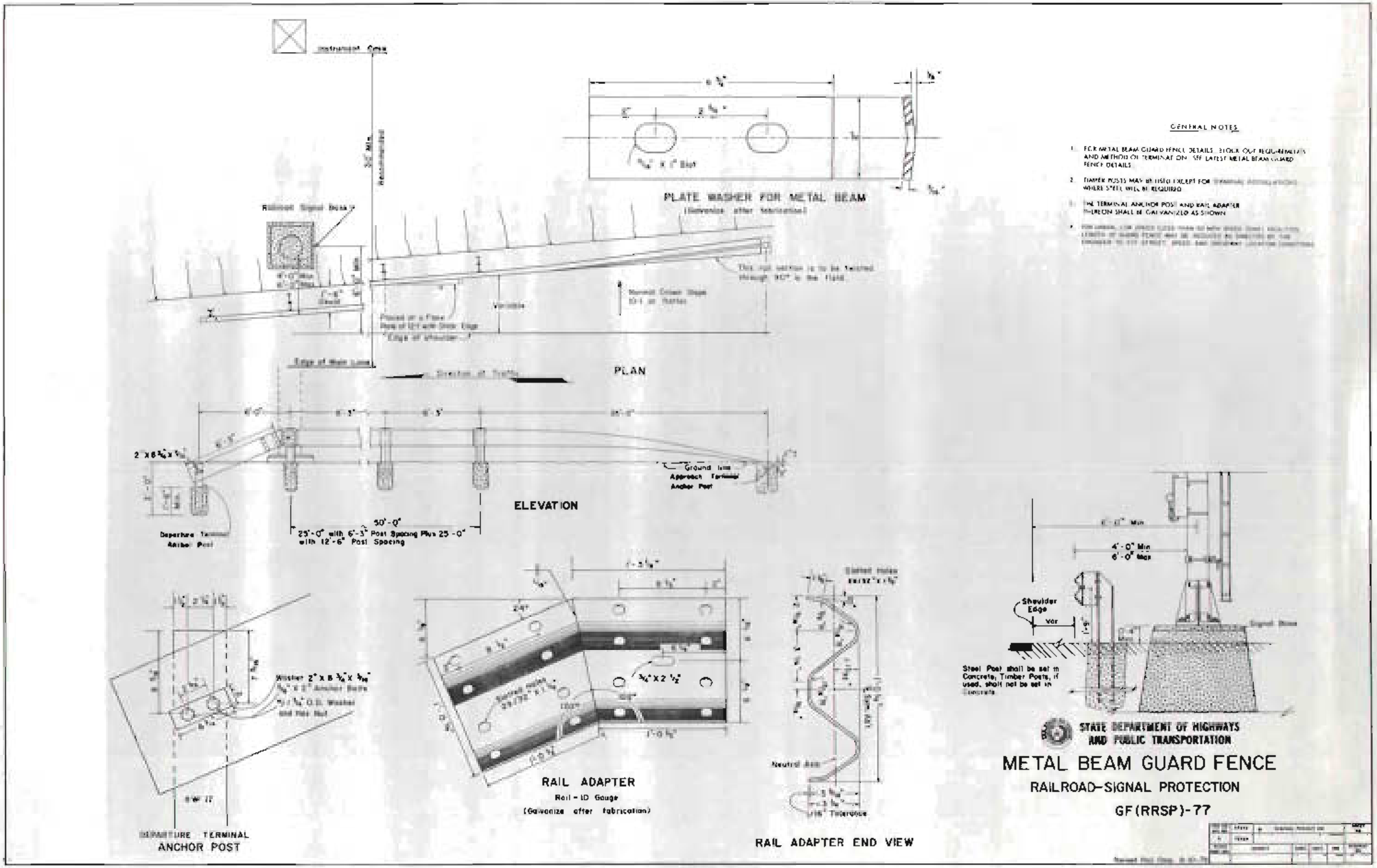
Other systems of similar design may be submitted to the Bridge Engineer for approval. Such proposed systems must be submitted and approved prior to their incorporation on shop drawings for any project. Approval shall be based on certified test results from an approved testing laboratory that the proposed anchorage satisfies the following requirements:
Minimum pull out strength 41,400 Lb. tension on 3 bolts
Minimum shear strength 40,400 Lb. shear on 4 bolts
Values based on 28 day comp. strength of Conc. = 3600 p.s.i.
An accurate description of the test set-ups shall be included with test results. Test set-ups shall be such that the forces exerted on the test specimen shall simulate those acting on a post mounted on a concrete foundation cylinder.

GENERAL NOTES:

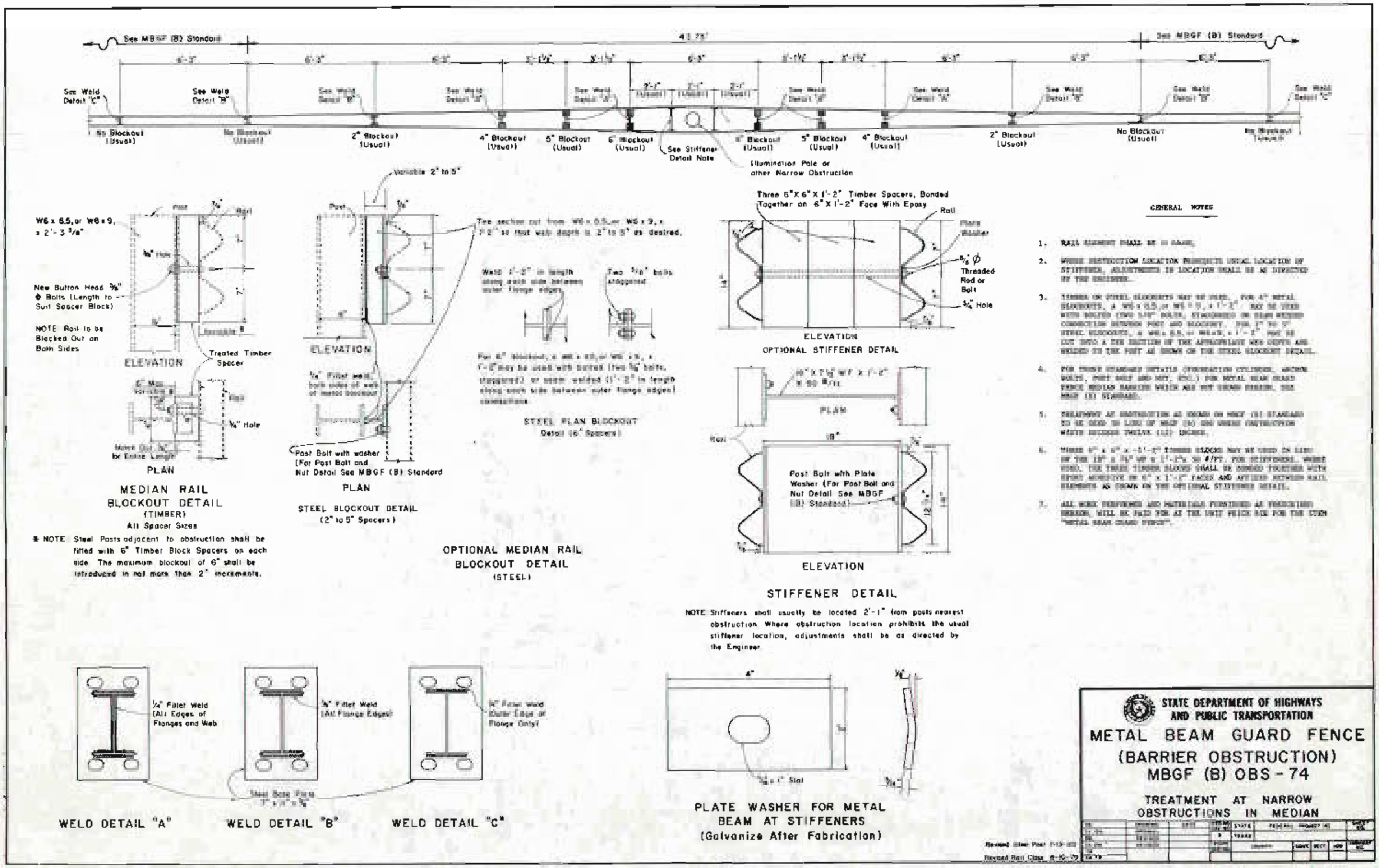
1. [illegible]
2. [illegible]
3. [illegible]
4. For control of access headlight barrier fence details see standard for control of access headlight barrier fence.
5. Unless otherwise so specified elsewhere on the plans, a 3/8" pedestrian control cable shall be placed through the posts as indicated.
6. Metal beam guard fence should maintain continuity of strength at all times. No special provisions for expansion at or near structures or at any other location is needed due to the ability of the rail to distribute such movement over considerable lengths of rail.

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

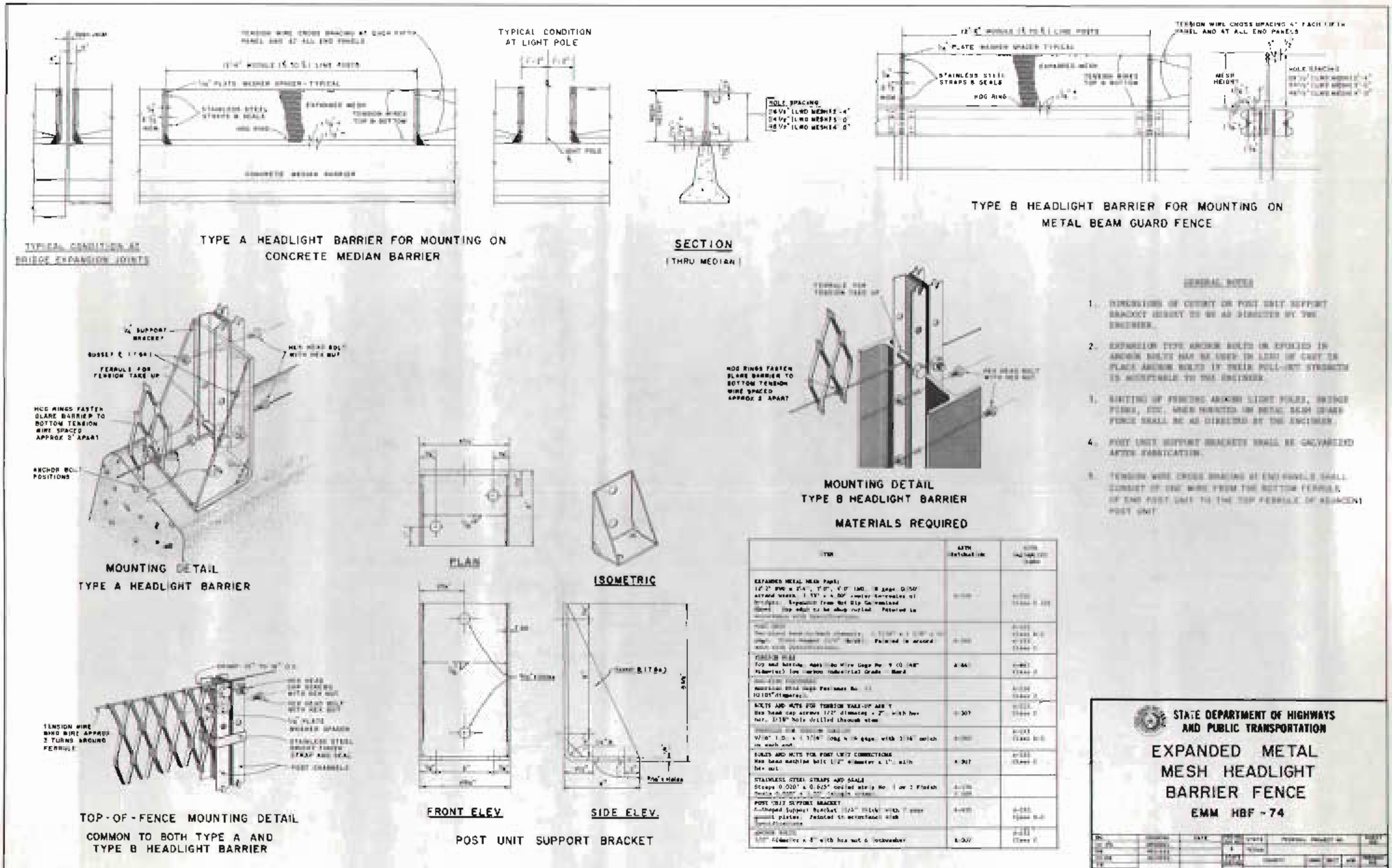
METAL BEAM GUARD FENCE (BARRIER)
MBGF (B)-74


Instrument Case
Railroad Signal Base
PLATE WASHER FOR METAL BEAM
PLAN
Direction of Traffic
Edge of Main Lane
ELEVATION
50'-0"
25'-0" with 6'-3" Post Spacing Plus 25'-0" with 12'-6" Post Spacing
Departure Terminal Anchor Post
Ground line
Approach Terminal Anchor Post
GENERAL NOTES
Washer 2" X 8 3/4" X 5/16"
DEPARTURE TERMINAL
ANCHOR POST
RAIL ADAPTER
Rail - 10 Gauge
(Galvanize after fabrication)
RAIL ADAPTER END VIEW
Slotted Holes
Neutral Axis
Shoulder Edge
Signal Base
4'-0" Min
6'-0" Max
Steel Post shall be set in Concrete; Timber Posts, if used, shall not be set in Concrete.
STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
METAL BEAM GUARD FENCE
RAILROAD-SIGNAL PROTECTION
GF(RRSP)-77

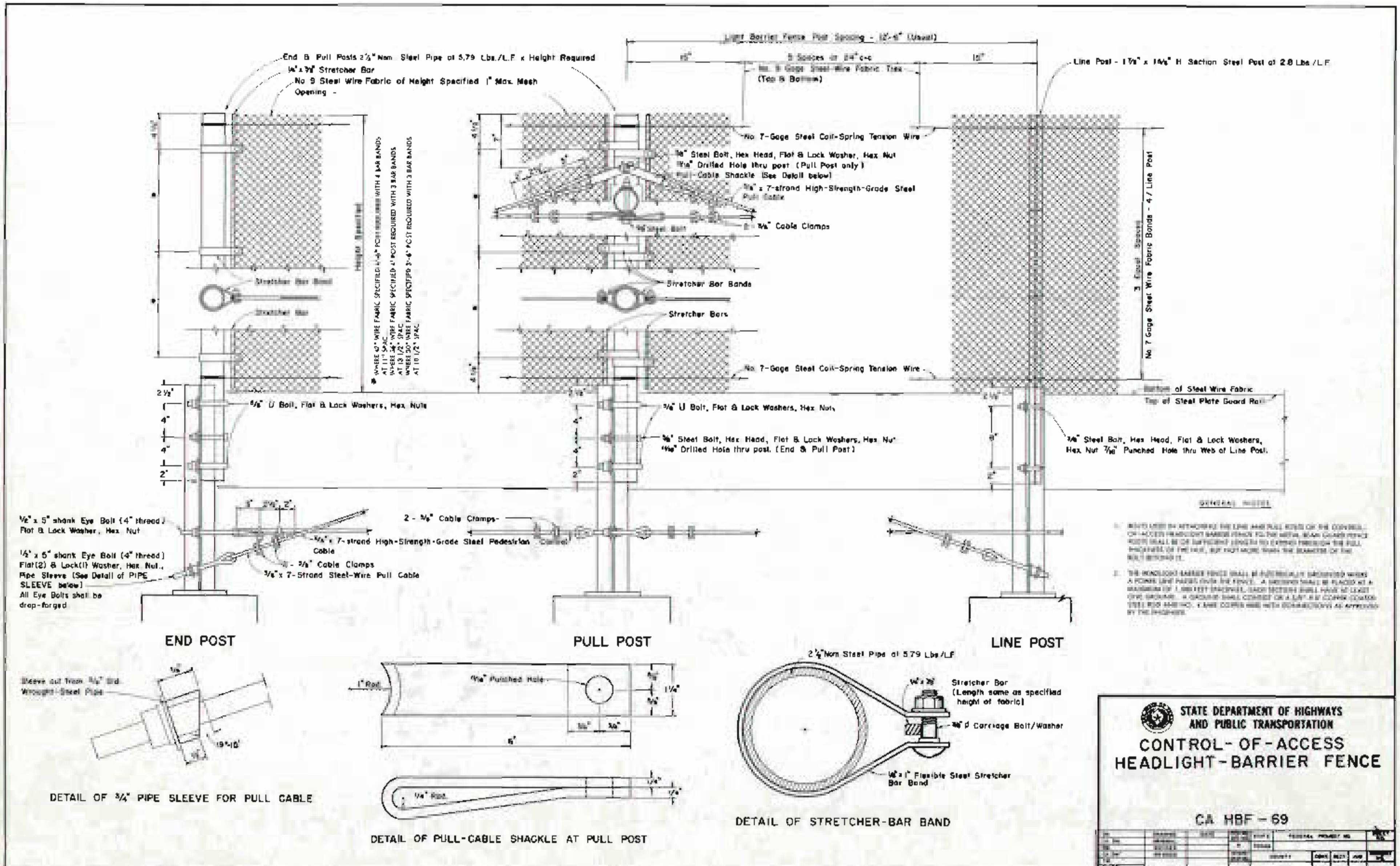
A-7



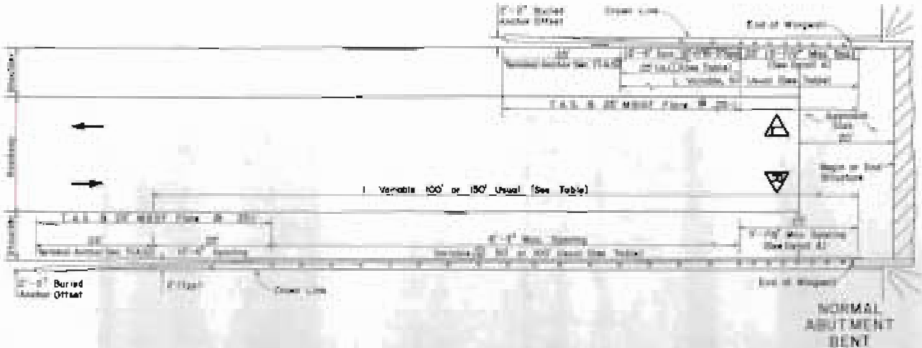
See MBGF (B) Standard
See MBGF (B) Standard
No Blockout (Usual)
2" Blockout (Usual)
4" Blockout (Usual)
5" Blockout (Usual)
6" Blockout (Usual)
See Stiffener Detail Note
Illumination Pole or other Narrow Obstruction
See Weld Detail "C"
See Weld Detail "B"
See Weld Detail "A"
W6 x 8.5, or W6 x 9, x 2'-3 3/8"
New Button Head 5/8" Φ Bolts (Length to Suit Spacer Block)
NOTE: Rail to be Blocked Out on Both Sides
Treated Timber Spacer
Post
Rail
ELEVATION
3/4" Hole
PLAN
MEDIAN RAIL BLOCKOUT DETAIL (TIMBER)
All Spacer Sizes
* NOTE: Steel Posts adjacent to obstruction shall be fitted with 6" Timber Block Spacers on each side. The maximum blockout of 6" shall be introduced in not more than 2" increments.
Variable 2" to 5"
Post Bolt with washer (For Post Bolt and Nut Detail See MBGF (B) Standard
STEEL BLOCKOUT DETAIL (2" to 5" Spacers)
OPTIONAL MEDIAN RAIL BLOCKOUT DETAIL (STEEL)
STEEL PLAN BLOCKOUT Detail (6" Spacers)
Three 6" X 6" X 1'-2" Timber Spacers, Bonded Together on 6" X 1'-2" Face With Epoxy
Plate Washer
Threaded Rod or Bolt
3/4" Hole
ELEVATION
OPTIONAL STIFFENER DETAIL
PLAN
Post Bolt with Plate Washer (For Post Bolt and Nut Detail See MBGF (B) Standard)
ELEVATION
STIFFENER DETAIL
NOTE: Stiffeners shall usually be located 2'-1" from posts nearest obstruction. Where obstruction location prohibits the usual stiffener location, adjustments shall be as directed by the Engineer.
GENERAL NOTES
1/4" Fillet Weld (All Edges of Flanges and Web)
3/8" Fillet Weld (All Flange Edges)
Steel Base Plate
WELD DETAIL "A"
WELD DETAIL "B"
WELD DETAIL "C"
PLATE WASHER FOR METAL BEAM AT STIFFENERS (Galvanize After Fabrication)
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
METAL BEAM GUARD FENCE (BARRIER OBSTRUCTION) MBGF (B) OBS - 74
TREATMENT AT NARROW OBSTRUCTIONS IN MEDIAN



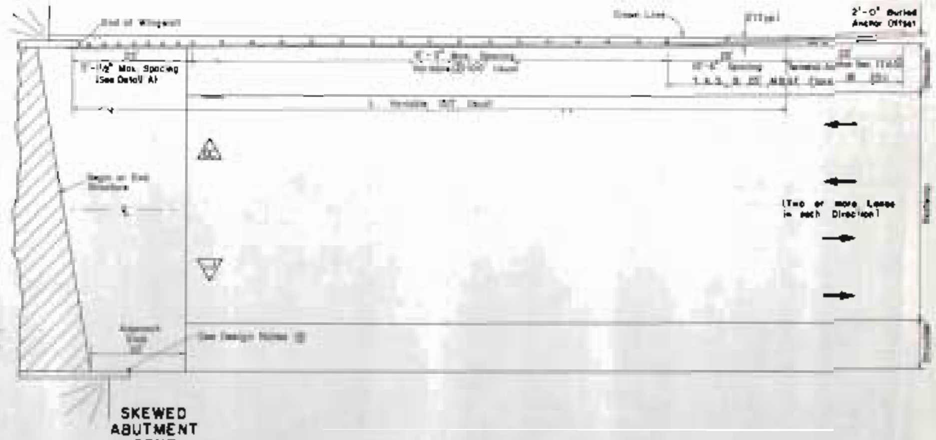
TYPICAL CONDITION AT LIGHT POLE
CONCRETE MEDIAN BARRIER
TYPICAL CONDITION AT BRIDGE EXPANSION JOINTS
TYPE A HEADLIGHT BARRIER FOR MOUNTING ON CONCRETE MEDIAN BARRIER
SECTION
(THRU MEDIAN)
BOLT SPACING
TYPE B HEADLIGHT BARRIER FOR MOUNTING ON METAL BEAM GUARD FENCE
STAINLESS STEEL STRAPS & SEALS
HOG RING
MOUNTING DETAIL
TYPE A HEADLIGHT BARRIER
MOUNTING DETAIL
TYPE B HEADLIGHT BARRIER
HOG RINGS FASTEN GLARE BARRIER TO BOTTOM TENSION WIRE SPACED APPROX 2' APART
ANCHOR BOLT POSITIONS
PLAN
ISOMETRIC
FRONT ELEV
SIDE ELEV.
POST UNIT SUPPORT BRACKET
TOP-OF-FENCE MOUNTING DETAIL
COMMON TO BOTH TYPE A AND TYPE B HEADLIGHT BARRIER
MATERIALS REQUIRED
GENERAL NOTES
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
EXPANDED METAL MESH HEADLIGHT BARRIER FENCE
EMM HBF-74



Light Barrier Fence Post Spacing - 12'-6" (Usual)
5 Spaces at 24" c-c
End & Pull Posts 2 1/2" Nom. Steel Pipe at 5.79 Lbs./L.F. x Height Required
1/4" x 3/4" Stretcher Bar
No 9 Steel Wire Fabric of Height Specified 1" Max. Mesh Opening
Line Post - 1 7/8" x 1 5/8" H Section Steel Post at 2.8 Lbs./L.F.
No. 9 Gage Steel-Wire Fabric Ties (Top & Bottom)
No. 7-Gage Steel Coil-Spring Tension Wire
3/8" Steel Bolt, Hex Head, Flat & Lock Washer, Hex Nut
7/16" Drilled Hole thru post (Pull Post only)
Pull-Cable Shackle (See Detail below)
3/8" x 7-strand High-Strength-Grade Steel Pull Cable
2 - 3/8" Cable Clamps
Stretcher Bar Band
Stretcher Bar
Stretcher Bar Bands
Stretcher Bars
Height Specified
3 Equal Spaces
No 7 Gage Steel Wire Fabric Bands - 4 / Line Post
Bottom of Steel Wire Fabric
Top of Steel Plate Guard Rail
5/8" U Bolt, Flat & Lock Washers, Hex Nuts
5/8" Steel Bolt, Hex Head, Flat & Lock Washers, Hex Nut
11/16" Drilled Hole thru post (End & Pull Post)
5/8" Steel Bolt, Hex Head, Flat & Lock Washers, Hex Nut 7/16" Punched Hole thru Web of Line Post.
1/2" x 5" shank Eye Bolt (4" thread) Flat & Lock Washer, Hex Nut
1/2" x 5" shank Eye Bolt (4" thread) Flat(2) & Lock(1) Washer, Hex Nut, Pipe Sleeve (See Detail of PIPE SLEEVE below)
All Eye Bolts shall be drop-forged
2 - 3/8" Cable Clamps
3/8" x 7-Strand Steel-Wire Pull Cable
3/8" x 7-strand High-Strength-Grade Steel Pedestrian Cable
GENERAL NOTES
END POST
PULL POST
LINE POST
Sleeve cut from 3/4" Std. Wrought-Steel Pipe
DETAIL OF 3/4" PIPE SLEEVE FOR PULL CABLE
1" Rad.
7/16" Punched Hole
1/4" Rad.
DETAIL OF PULL-CABLE SHACKLE AT PULL POST
2 1/2" Nom Steel Pipe at 5.79 Lbs./LF
Stretcher Bar (Length same as specified height of fabric)
3/8" d Carriage Bolt/Washer
1/8" x 1" Flexible Steel Stretcher Bar Band
DETAIL OF STRETCHER-BAR BAND
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
CONTROL-OF-ACCESS HEADLIGHT-BARRIER FENCE
CA HBF - 69



TWO LANE (RURAL) HIGHWAY



MULTILANE UNDIVIDED (RURAL) HIGHWAYS

CROWN WIDTH BRIDGE

SEE DESIGN NOTE ⑤ FOR RESTRICTIVE WIDTH BRIDGE

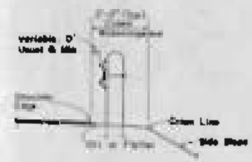
LENGTH⊗ OF NEED, L, Ft

TWO LANE HIGHWAYS				MULTILANE UNDIVIDED HWYS	
750 or less ADT		more than 750 ADT		all ADT's	
◁ side	▷ side	◁ side	▷ side	◁ side	▷ side
50①	100	50①	150	0	150

⊗ Lengths are for typical cross sectional and placement conditions. For unusual conditions, a custom design should be developed.

◁ Indicates left side of traffic approaching bridge.

▷ Indicates right side of traffic approaching bridge.

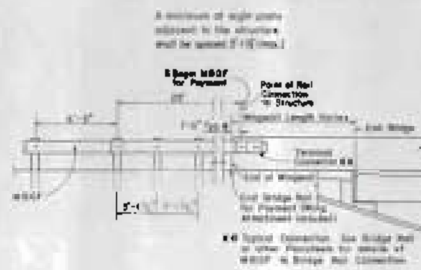


TYPICAL CROSS SECTION

**** Applies to Construction on New Alignment or Where Existing Roadway Cross Section is to be Widened to Increase Roadway Width. Does not Apply to Rehabilitation Work Where Existing Roadway Crown Width is to be Retained.

GENERAL NOTES

DESIGN NOTES



POST TREATMENT AT STRUCTURES

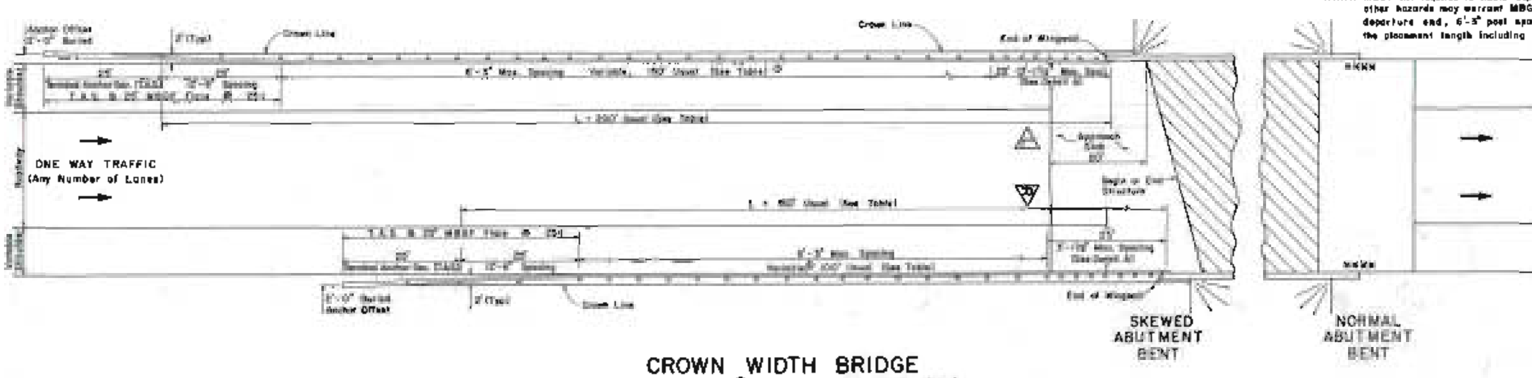
DETAIL A

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

BRIDGE END DETAILS (TWO - WAY TRAFFIC)

BED (TWT) - 84

**** MBGF not required to shield departure end of Bridge; other hazards may warrant MBGF. Where installed on the departure end, 6'-3" post spacing is acceptable throughout the placement length including adjacent to the bridge end.



CROWN WIDTH BRIDGE

(SEE DESIGN NOTE ② FOR RESTRICTIVE WIDTH BRIDGE)

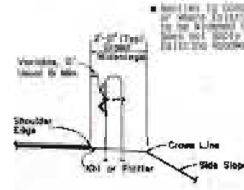
LENGTH⊛ OF NEED, L, Ft.

SHOULDER WIDTH	LEFT OR RIGHT SIDE
4	200
6	200
8	175
10	150

⊛ Lengths are for typical cross sectional and placement conditions. For unusual conditions, a custom design should be developed.

◁ Indicates left side of traffic approaching bridge.

▷ Indicates right side of traffic approaching bridge.



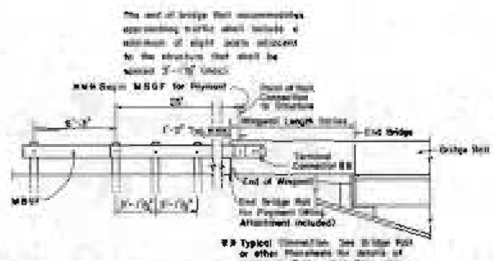
TYPICAL CROSS SECTION

GENERAL NOTES

DESIGN NOTES

①

②



POST TREATMENT AT STRUCTURES

DETAIL A

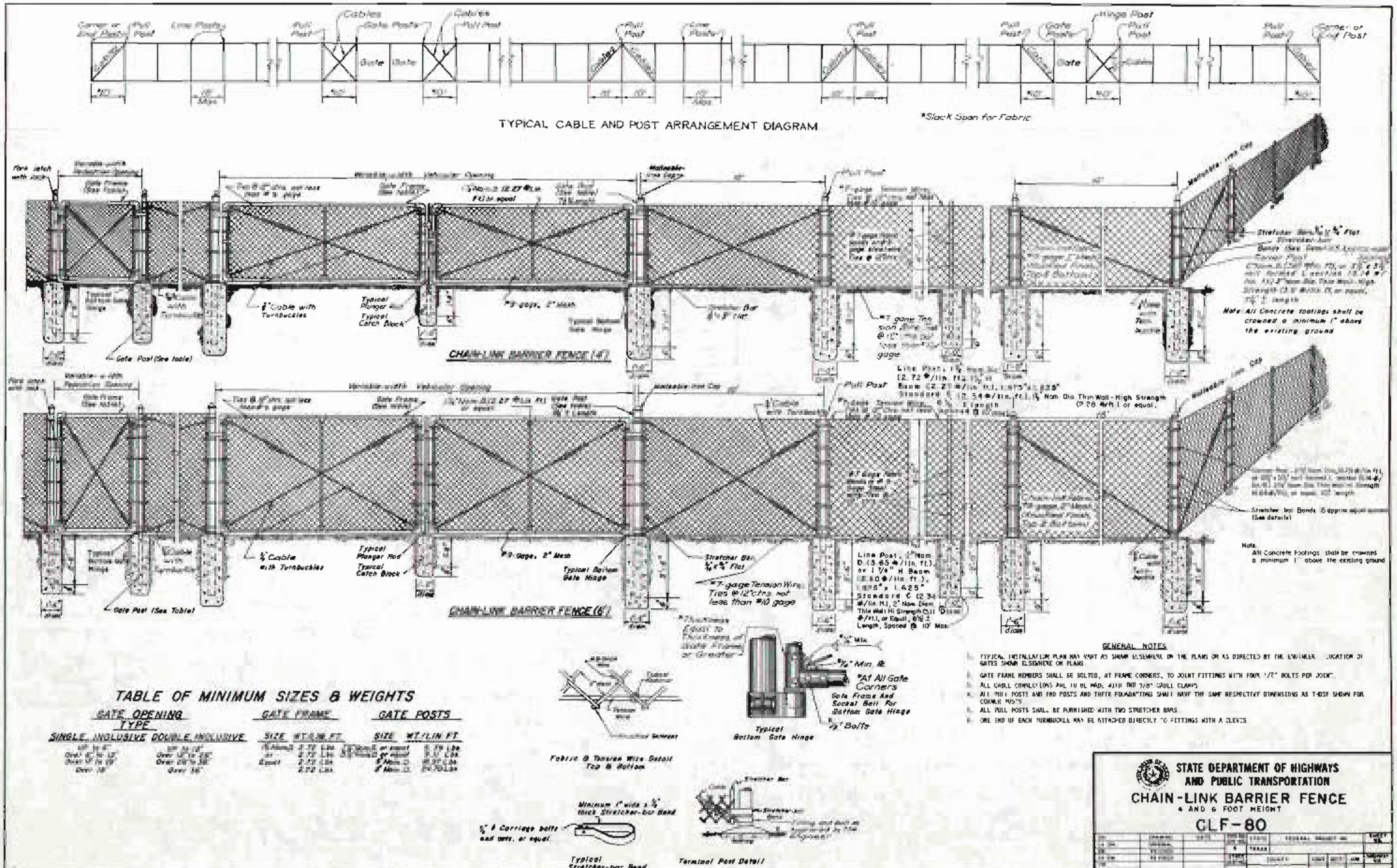
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

BRIDGE END DETAILS

(ONE-WAY TRAFFIC)

BED (OWT) - 84

Rev. 8-84


TYPICAL CABLE AND POST ARRANGEMENT DIAGRAM
*Slack Span for Fabric
Cables
Gate Posts
Pull Post
Line Posts
Corner or End Post
Hinge Post
Gate
CHAIN-LINK BARRIER FENCE (4')
CHAIN-LINK BARRIER FENCE (6')
Variable-width Vehicular Opening
Malleable-iron Cap
Pull Post
Gate Post (See table)
Typical Plunger Rod
Typical Catch Block
Typical Bottom Gate Hinge
$\frac{3}{8}$" Cable with Turnbuckles
#9 Gage, 2" Mesh
Stretcher Bar
Note: All Concrete footings shall be crowned a minimum 1" above the existing ground
TABLE OF MINIMUM SIZES & WEIGHTS
GATE OPENING TYPE
SINGLE INCLUSIVE
DOUBLE INCLUSIVE
GATE FRAME
SIZE
WT./LIN. FT.
GATE POSTS
SIZE
WT./LIN. FT.
Fabric & Tension Wire Detail Top & Bottom
Typical Bottom Gate Hinge
*At All Gate Corners
Typical Stretcher-bar Band
Terminal Post Detail
GENERAL NOTES
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
CHAIN-LINK BARRIER FENCE
4 AND 6 FOOT HEIGHT
CLF-80

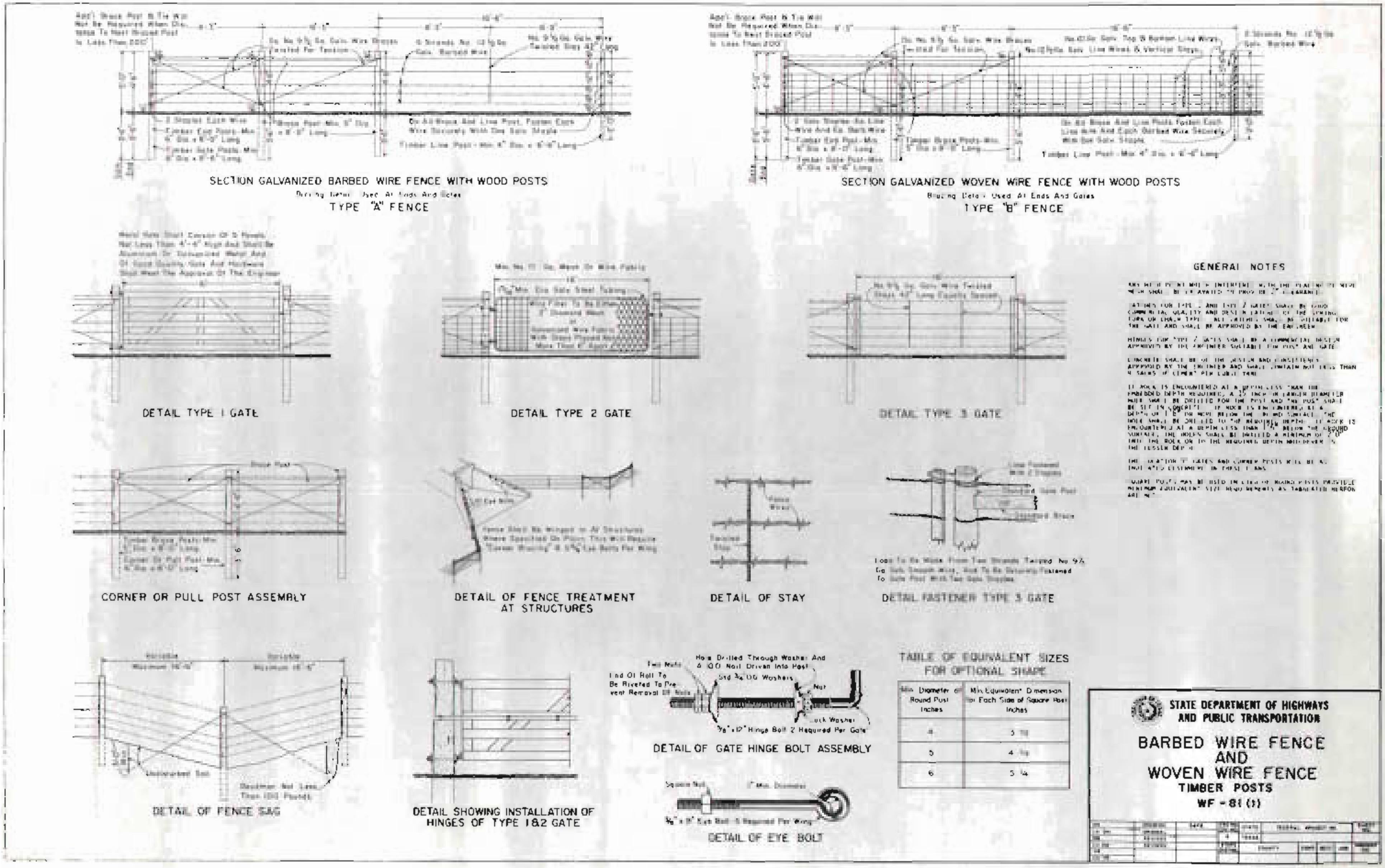
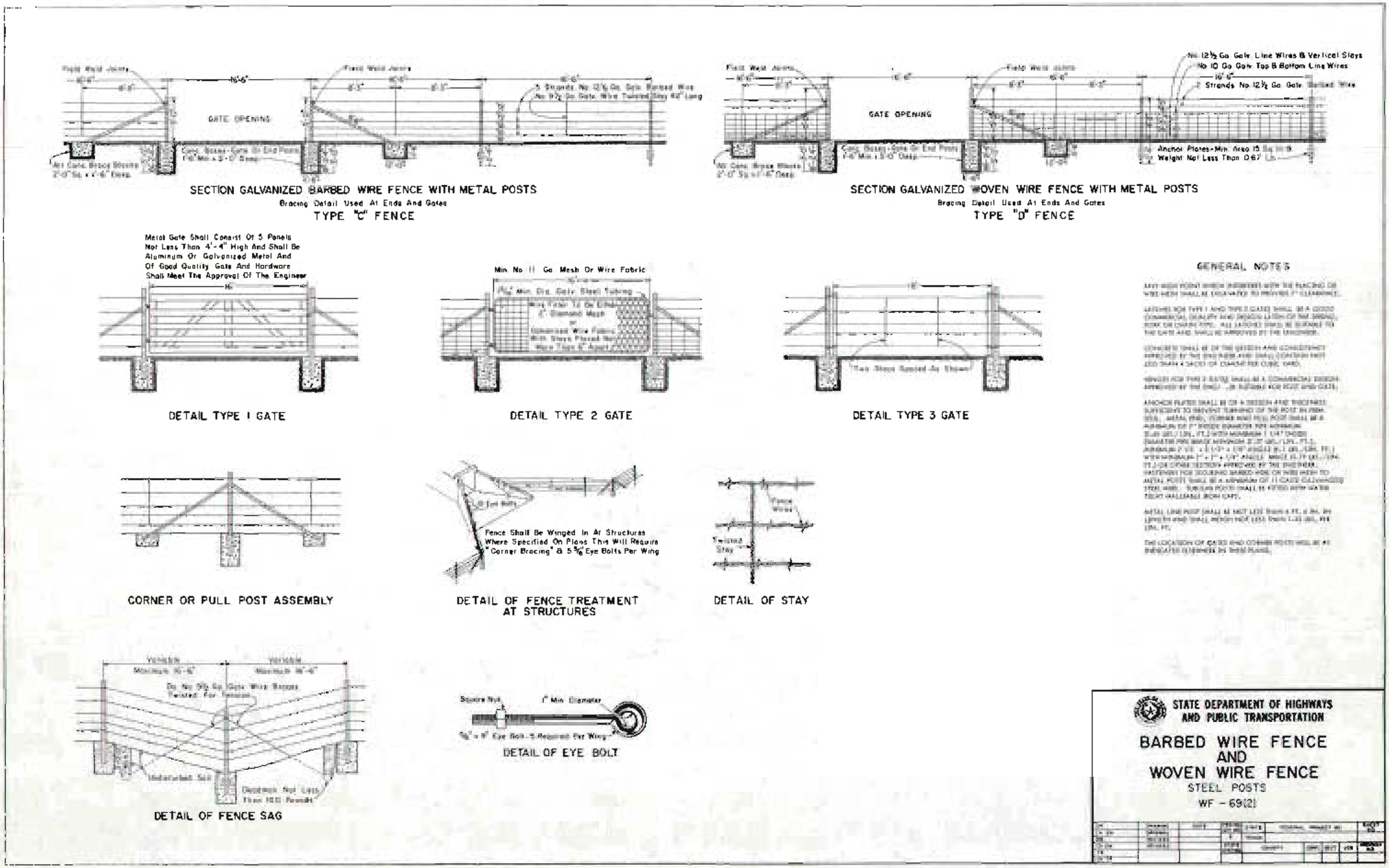


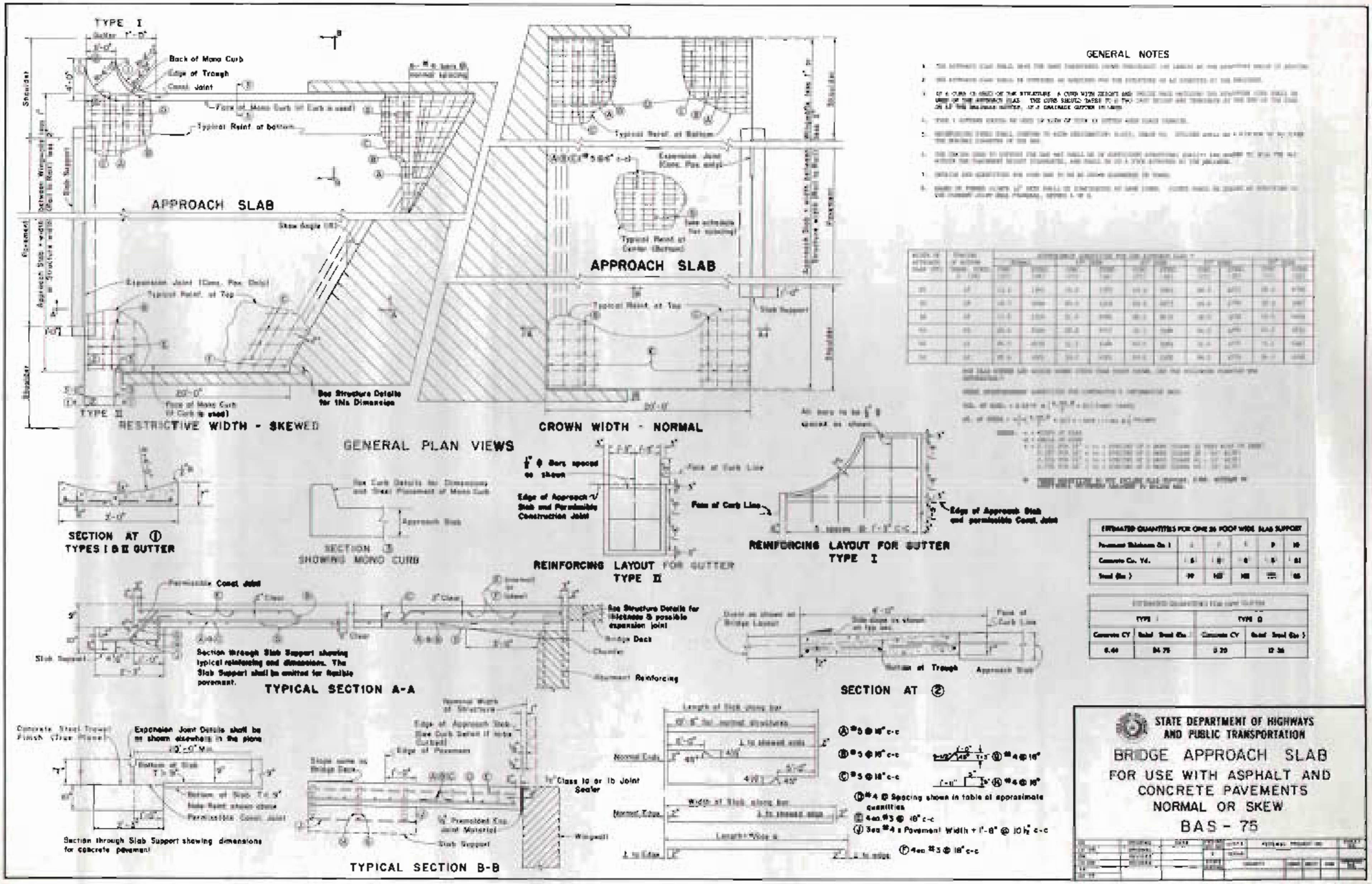
TABLE OF EQUIVALENT SIZES FOR OPTIONAL SHAPE

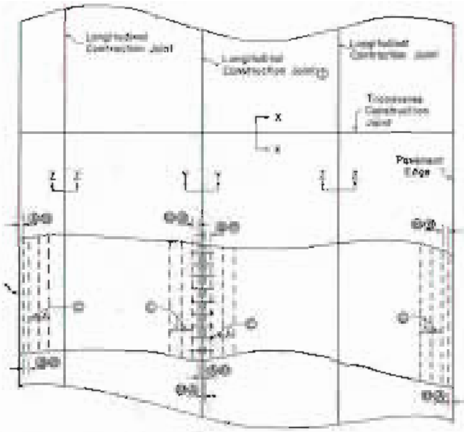
Min. Diameter of Round Post Inches	Min. Equivalent Dimension for Each Side of Square Post Inches
4	3 ½
5	4 ½
6	5 ¼



Field Weld Joints
16'-6"
GATE OPENING
Conc. Bases - Gate Or End Posts 1'-6" Min. x 3'-0" Deep
5 Strands No. 12½ Ga. Galv. Barbed Wire
No. 9½ Ga. Galv. Wire Twisted Stay 40" Long
SECTION GALVANIZED BARBED WIRE FENCE WITH METAL POSTS
Bracing Detail Used At Ends And Gates
TYPE "C" FENCE
No. 12½ Ga. Galv. Line Wires & Vertical Stays
No. 10 Ga. Galv. Top & Bottom Line Wires
2 Strands No. 12½ Ga. Galv. Barbed Wire
Anchor Plates - Min. Area 15 Sq. In. &
Weight Not Less Than 0.67 Lb.
SECTION GALVANIZED WOVEN WIRE FENCE WITH METAL POSTS
Bracing Detail Used At Ends And Gates
TYPE "D" FENCE
Metal Gate Shall Consist Of 5 Panels Not Less Than 4'-4" High And Shall Be Aluminum Or Galvanized Metal And Of Good Quality. Gate And Hardware Shall Meet The Approval Of The Engineer
DETAIL TYPE 1 GATE
Min. No. 11 Ga. Mesh Or Wire Fabric
DETAIL TYPE 2 GATE
DETAIL TYPE 3 GATE
GENERAL NOTES
CORNER OR PULL POST ASSEMBLY
Fence Shall Be Winged In At Structures Where Specified On Plans. This Will Require "Corner Bracing" & 5 ⅝" Eye Bolts Per Wing
DETAIL OF FENCE TREATMENT AT STRUCTURES
Twisted Stay
DETAIL OF STAY
DETAIL OF FENCE SAG
Square Nut
1" Min. Diameter
DETAIL OF EYE BOLT
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
BARBED WIRE FENCE AND WOVEN WIRE FENCE
STEEL POSTS
WF - 69(2)

A-15


TYPE I
Back of Mono Curb
Edge of Trough
Const. Joint
Face of Mono Curb (if Curb is used)
Typical Reinf. at bottom
APPROACH SLAB
Skew Angle
Expansion Joint (Conc. Pav. Only)
Typical Reinf. at Top
TYPE II
Face of Mono Curb (if Curb is used)
See Structure Details for this Dimension
RESTRICTIVE WIDTH - SKEWED
Shoulder
Pavement
Typical Reinf. at Bottom
Expansion Joint (Conc. Pav. only)
Typical Reinf. at Center (Bottom)
APPROACH SLAB
Typical Reinf. at Top
Slab Support
CROWN WIDTH - NORMAL
GENERAL PLAN VIEWS
GENERAL NOTES
SECTION AT ①
TYPES I & II GUTTER
SECTION ③
SHOWING MONO CURB
Approach Slab
Face of Curb Line
Edge of Approach Slab and Permissible Construction Joint
REINFORCING LAYOUT FOR GUTTER
TYPE II
All bars to be spaced as shown
Face of Curb Line
Edge of Approach Slab and permissible Const. Joint
REINFORCING LAYOUT FOR GUTTER
TYPE I
Permissible Const. Joint
See Structure Details for thickness & possible expansion joint
Bridge Deck
Abutment Reinforcing
Slab Support
Section through Slab Support showing typical reinforcing and dimensions. The Slab Support shall be omitted for flexible pavement.
TYPICAL SECTION A-A
Bottom of Trough
Approach Slab
SECTION AT ②
Concrete Steel Trowel Finish (True Plane)
Expansion Joint Details shall be as shown elsewhere in the plans
Bottom of Slab
Permissible Const. Joint
Section through Slab Support showing dimensions for concrete pavement
Edge of Approach Slab
Edge of Pavement
Slope same as Bridge Deck
Class Ia or Ib Joint Sealer
Premolded Exp. Joint Material
Slab Support
Wingwall
TYPICAL SECTION B-B
Normal Ends
Normal Edges
Width of Slab along bar
Ⓐ #5 @ 18" c-c
Ⓑ #5 @ 18" c-c
Ⓒ #5 @ 18" c-c
Ⓓ #4 @ Spacing shown in table of approximate quantities
Ⓔ 4ea. #5 @ 18" c-c
Ⓕ 4ea. #5 @ 18" c-c
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
BRIDGE APPROACH SLAB
FOR USE WITH ASPHALT AND CONCRETE PAVEMENTS
NORMAL OR SKEW
BAS - 75



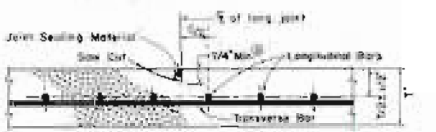
TWO LANE PAVEMENT PLAN
(38' PLACEMENT OR 16' & 22' PLACEMENT ⑦)

Spacing (in.)	NUMBER OF BARS Required for Various Typical Placement Widths (ft.) ⑩						
	[illegible]	[illegible]	[illegible]	[illegible]	27	34	[illegible]
[illegible]	24	[illegible]	[illegible]	[illegible]	54	68	[illegible]
[illegible]	21	[illegible]	[illegible]	[illegible]	46	58	[illegible]
[illegible]	18	[illegible]	[illegible]	[illegible]	41	51	[illegible]
[illegible]	16	[illegible]	[illegible]	[illegible]	36	46	[illegible]

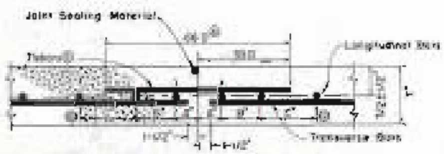
X①	T (in.)	Longitudinal Bar Size	Spacing (in.)	Trans Bar Size	Maximum Allowable ③ Pavement Width (ft.) for Given Transverse Steel Spacings (in.)			B_sW ④ (in.-ft.)
					[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	6	[illegible]	4 5 6	123 185 [illegible]	[illegible] [illegible] [illegible]	40 52 [illegible]	[illegible] [illegible] [illegible]
	9	6	8	4 5 6	105 165 234	[illegible] 82 117	[illegible] [illegible] [illegible]	[illegible] [illegible] [illegible]
	[illegible]	6	[illegible]	4 5 6	[illegible] [illegible] [illegible]	[illegible] [illegible] [illegible]	[illegible] 49 [illegible]	[illegible] [illegible] [illegible]
	[illegible]	6 4②	7 6	4 5 6	[illegible] [illegible] [illegible]	[illegible] 67 36	[illegible] [illegible] [illegible]	[illegible] [illegible] [illegible]
	[illegible]	6 5②	[illegible] 3	4 5 6	[illegible] [illegible] 176	40 52 88	[illegible] [illegible] [illegible]	[illegible] [illegible] [illegible]
	13	7 [illegible]	[illegible] [illegible]	4 5 6	[illegible] [illegible] [illegible]	[illegible] [illegible] [illegible]	[illegible] [illegible] [illegible]	[illegible] [illegible] [illegible]
	14	7 5②	[illegible] [illegible]	4 5 6	[illegible] 106 [illegible]	[illegible] 53 [illegible]	[illegible] [illegible] [illegible]	[illegible] [illegible] [illegible]
	15	7 5②	7 7	4 5 6	[illegible] 99 140	[illegible] [illegible] [illegible]	21 33 46	[illegible] 99 140

GENERAL NOTES

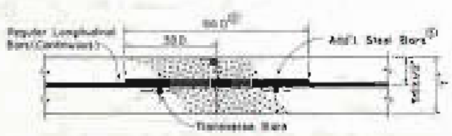
1. No expansion joints will be used except [illegible] objects as shown elsewhere in the plans.
2. For further information [illegible] forcement refer to [illegible]
3. [illegible]
4. [illegible]
5. [illegible]
6. [illegible]
7. [illegible]
8. [illegible]
9. [illegible]
10. [illegible]
11. [illegible]
12. [illegible]
13. [illegible]
14. [illegible]



LONGITUDINAL CONTRACTION JOINT
Section Z-Z



LONGITUDINAL CONSTRUCTION JOINT
Section Y-Y



TRANSVERSE CONSTRUCTION JOINT
Section X-X

NOTE ① Longitudinal and Transverse Bars shall be deformed steel conforming to ASTM A 615 or ASTM A-615 (Grade 60) as noted in the standard specifications and therefore the percentage of steel required is higher than that for wire mats. (Grade 70 steel)

② For pavements greater than 11" in thickness, contractors may have the option of placing two layers of steel. The smaller longitudinal bar sizes indicated are only to be used when two layers of steel are placed. For transverse bars, if all other variables are held constant, the maximum allowable pavement width may be doubled when two layers of steel are used.

When the "Double [illegible]" procedure [illegible] will be required to support [illegible]

③ [illegible]

④ [illegible]

⑤ [illegible]

⑥ [illegible]

⑦ The longitudinal construction joint can be relocated or may be replaced by a longitudinal [illegible] depending on the placement width.

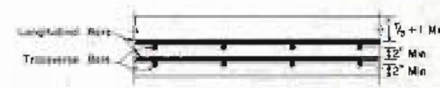
⑧ If siliceous river gravel is used [illegible]

⑨ When machine-placing of steel reinforcement is used, the use of chairs shall not be [illegible] transverse steel may be placed above or below the longitudinal steel.

⑩ The number of bars required for the various placement [illegible] "B" spacing on both sides with an overhang "A".

"A" spacing shall be between 3" and 4".
"B" spacing shall be between 3" and 9".

The two spacings combined ("A" and "B"), located at both longitudinal edges of the pour, shall provide for the remaining space and steel location to round out the placement width.



OPTIONAL STEEL PLACEMENT ②

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

CONCRETE PAVEMENT DETAILS

CONTINUOUSLY REINFORCED STEEL BARS

CRCP (B) - 85

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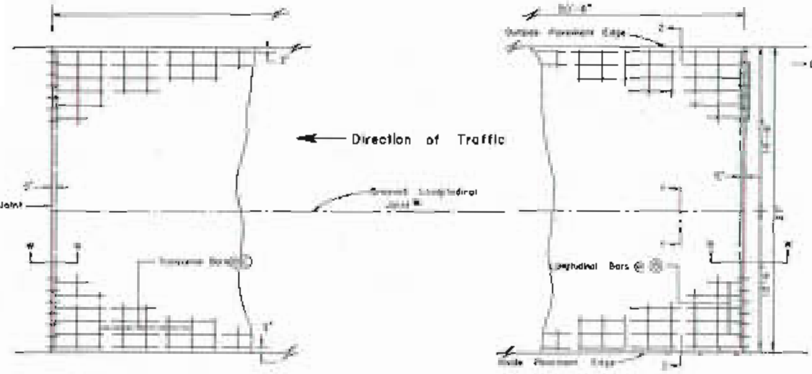


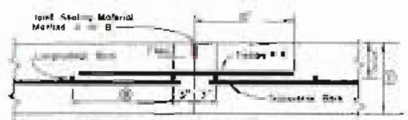
TWO LANE PAVEMENT PLAN
(27 ft Placement)

TABLE FOR TRANSVERSE AND LONGITUDINAL REINFORCEMENTS AND DOWEL BARS

Pavement Thickness T (Inches)	Spacing for #? Bars (27' Placement Width): Longitudinal No. of Bars	Space (TN)	Transverse No. of Bars	Space (IN)	Steel	Spacing for #? Bars (12'-6" Placement Width): Longitudinal No. of Bars	Space (IN)	Transverse No. of Bars	Space	Steel #/SY	Spacing for #? Bars (14'-6" Placement Width): Longitudinal No. of Bars	Space	Transverse No. of Bars	Space	Steel #/SY	Dowels (Smooth Bars): Size	Spac.	Wt.	Tiebars (Deformed): Size	Avg.	[illegible]
[illegible]	[illegible]	[illegible]	16	85	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	55
[illegible]	[illegible]	[illegible]	15	[illegible]	5.69	9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15	[illegible]	[illegible]	1 1/8 x 18"	[illegible]	5.69	[illegible]	[illegible]	58
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9	27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	# 4 x 30"	[illegible]	[illegible]
[illegible]	[illegible]	16 3/4	[illegible]	[illegible]	4.63	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	42	19	5.05	1 1/4 x 22"	[illegible]	[illegible]	[illegible]	40	[illegible]
[illegible]	[illegible]	? 3/8	25	[illegible]	5.60	[illegible]	[illegible]	[illegible]	17	5.59	[illegible]	[illegible]	[illegible]	15	5.64	[illegible]	[illegible]	7.60	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	25	[illegible]	[illegible]	[illegible]	15	25	[illegible]	5.90	15	[illegible]	[illegible]	15	[illegible]	[illegible]	[illegible]	7.65	[illegible]	[illegible]	[illegible]

CONTRACTION JOINT

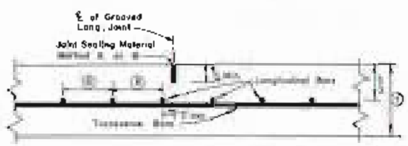
Section W — W



* WITH THE APPROVAL OF THE ENGINEER, MULTIPLE PIECE TIEBARS (THREADED COUPLING OR OTHER ADEQUATE DEVICE) MAY BE USED TO FACILITATE CONSTRUCTION PROVIDED THE SYSTEM DEVELOPS A FORCE EQUAL TO 1 1/2 TIMES THE ... THE SPACINGS FOR THE ... ALLOWED FOR BARS ...

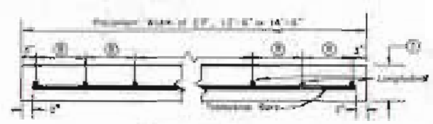
LONGITUDINAL CONSTRUCTION JOINT

Section Y — Y



GROOVED LONGITUDINAL JOINT

Section Y — Y



TYPICAL SECTION

Section Z — Z

GENERAL NOTES

1. [illegible]

2. CONSTRUCTION JOINTS MAY BE FORMED BY THE USE OF METAL OR WOOD FORMS EQUAL IN DEPTH TO THE NOMINAL DEPTH OF THE PAVEMENT, OR BY OTHER MEANS WHICH HAVE BEEN APPROVED BY THE ENGINEER PRIOR TO THEIR USE.

3. TREATMENT OF [illegible] IN THE PLANS.

4. FOR FURTHER INFORMATION REGARDING THE PLACEMENT OF CONCRETE [illegible] TO THE GOVERNING SPECIFICATIONS FOR "CONCRETE PAVEMENT".

5. DETAILS AS TO PAVEMENT WIDTH, PAVEMENT [illegible] AS SHOWN ELSEWHERE IN THE PLANS.

6. LONGITUDINAL AND TRANSVERSE BARS SHALL BE OF STEEL CONFORMING TO ASTM DESIGNATIONS, A-615 OR ASTM A 616 (GRADE 60) AS NOTED IN THE SPECIFICATIONS. THE SIZE AND SPACING SHALL BE IN ACCORDANCE WITH TABLE SHOWN BELOW.

7. BARS OF ASTM DESIGNATION A-615 OR A-616, GRADE 60, SHALL NOT BE BENT. IF THE CONTRACTOR ELECTS TO BEND THE TIE BARS, THEY SHALL BE STEEL CONFORMING TO ASTM DESIGNATION, A-615, GRADE 40.

8. IT IS THE INTENT OF THIS DESIGN THAT THE LONGITUDINAL STEEL BE AT THE CENTER OF THE SLAB. IT SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO TAKE ALL NECESSARY PRECAUTIONS TO INSURE THAT THE FINAL POSITION OF THE STEEL IS WITHIN 1/2 INCH OF THE SLAB CENTER.

9. CONCRETE SHALL NOT BE DISCHARGED FROM THE MIXER DIREC[illegible] THE JOINT ASSEMBLY.

10. ANY APPROVED CHAIR TYPE OR DESIGN, WHICH WILL SATISFY THE REQUIREMENTS NOTED HEREON WILL BE PERMITTED. CHAIR SPACINGS SHALL NOT BE GREATER THAN 60" C-C MEASURED PARALLEL TO THE PAVEMENT CENTER LINE AND 30" C-C MEASURED PERPENDICULAR TO THE PAVEMENT CENTER LINE. ADDITIONAL CHAIRS SHALL BE USED IF NECESSARY TO MEET THE STEEL PLACEMENT REQUIREMENT.

11. LONGITUDINAL AND TRANSVERSE STEEL SPACING SHALL [illegible] SPACING SHOWN HEREON.

1. [illegible] STEEL WILL BE ACCEPTED IN ANY CROSS SECTION, PROVIDED NO SPACING ARE GREATER THAN 35".

2. [illegible] OF LONGITUDINAL AND TRANSVERSE BARS.

3. [illegible]

4. [illegible]

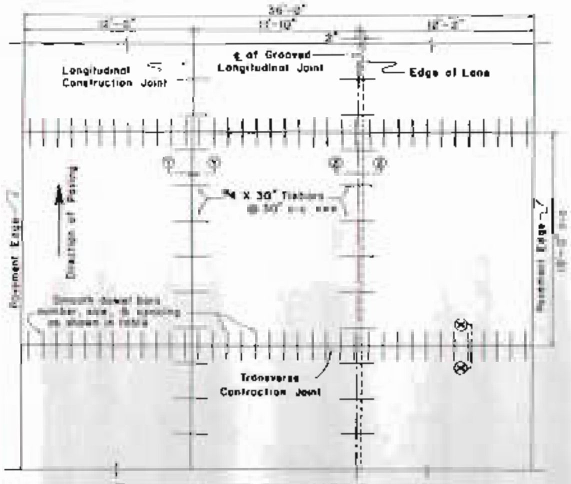
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

CONCRETE PAVEMENT DETAILS

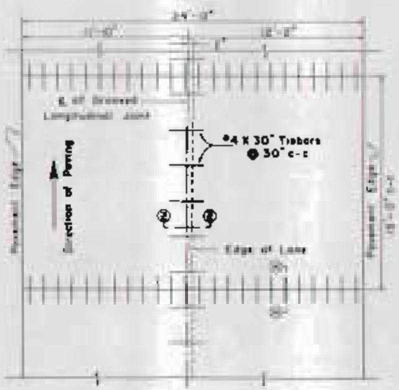
JOINTED REINFORCED STEEL BARS

CPJR (30 B) - 75

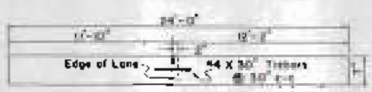
*** At locations where the pavement width is greater than 40 feet but less than 50 feet the tie bar spacing shall be 24" center to center. At locations where pavement width is greater than 50 feet #5 tie bars 36" long shall be 24" center to center.



THREE LANE PAVEMENT PLAN
(12 ft & 24 ft Placement) **

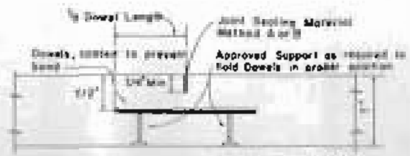


TWO LANE PAVEMENT PLAN

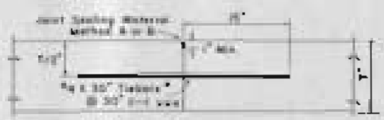


TYPICAL SECTION
(24 ft. Placement) **

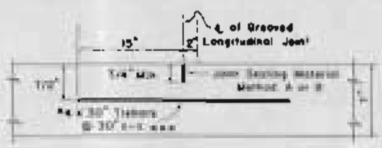
** Lane widths are for illustrative purposes only and should not be used if in conflict with typical cross sections shown elsewhere in the plans.



TRANSVERSE CONTRACTION JOINT
Section X-X



LONGITUDINAL CONSTRUCTION JOINT
Section Y-Y



GROOVED LONGITUDINAL JOINT
Section Z-Z

GENERAL NOTES

1. NO EXPANSION JOINTS [illegible] WHERE IN THE PLANS.
2. FOR FURTHER INFORMATION REGARDING THE PLACEMENT OF CONCRETE AND LOAD TRANSFER DEVICES REFER TO THE GOVERNING SPECIFICATIONS FOR "CONCRETE PAVEMENT".
3. DETAILS AS TO PAVEMENT WIDTH, PAVEMENT THICKNESS, AND THE [illegible] SHOWN ELSEWHERE IN THE PLANS.
4. [illegible]
5. TIEBARS SHALL BE SECURED PARALLEL TO [illegible]
   (a) [illegible]
   (b) [illegible]
   (c) [illegible]
6. [illegible]
7. [illegible] BEYOND [illegible]
8. WHERE A MONOLITHIC CURB IS SPECIFIED, THE JOINT IN THE CURB SHALL COINCIDE WITH PAVEMENT JOINTS AND MAY BE FORMED BY ANY MEANS WHICH, PRIOR TO ITS USE, HAS BEEN APPROVED BY THE ENGINEER.
9. [illegible] DEPTH TO THE [illegible] BY THE [illegible]
10. [illegible]
11. [illegible]

DEPTH OF PAVEMENT (INCHES)	DOWELS (SMOOTH BARS)		
	SIZE AND LENGTH	AVERAGE SPACING (INCHES)	WEIGHT PER FOOT OF JOINT (LBS.)
8	[illegible] X 18"	12	4.01
9	[illegible] X 20"	12	5.85
10	[illegible] X 22"	12	7.65
11	[illegible] X 24"	12	10.10

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

CONCRETE PAVEMENT DETAILS
CONTRACTION DESIGN
CPCD - 80 (1)

GENERAL NOTES

1. [illegible] AS SHOWN ELSEWHERE IN THE PLANS.

2. [illegible] TRANSFER DEVICES [illegible] "CONCRETE PAVEMENT".

3. [illegible] SHALL BE AS SHOWN ELSEWHERE IN THE PLANS.

4. [illegible] SHALL BE AS SHOWN ELSEWHERE IN THE PLANS.

5. [illegible] TO THE CENTERLINE BY:

(a) [illegible]
(b) [illegible]
(c) [illegible] APPROVED BY THE ENGINEER.

6. [illegible]

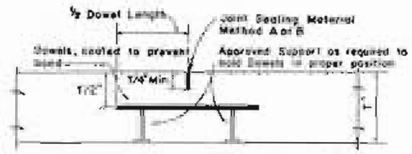
7. [illegible]

8. [illegible]

9. CONSTRUCTION JOINTS MAY BE FORMED BY USE OF METAL OR WOOD FORMS EQUAL IN DEPTH TO THE NOMINAL DEPTH OF THE PAVEMENT, OR BY OTHER MEANS WHICH HAVE BEEN APPROVED BY THE ENGINEER PRIOR TO THEIR USE.

10. [illegible] SHOWN HEREON.

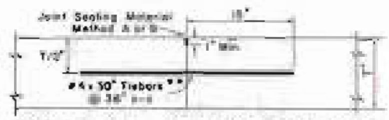
11. [illegible] GRADE 60, [illegible]



TRANSVERSE CONTRACTION JOINT

Section X-X

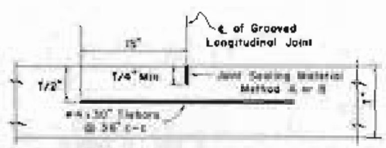
* WITH THE APPROVAL OF THE ENGINEER, THE CONTRACTOR MAY CONSTRUCT IN PLACEMENT WIDTHS OF 12'-6" AND 14'-6" IF SO PLACED THE GROOVED LONGITUDINAL JOINT SHOWN SHALL BE REPLACED BY A LONGITUDINAL CONSTRUCTION JOINT. A MINIMUM CLEARANCE OF 3" MUST BE MAINTAINED BETWEEN DOWEL BARS AND LONGITUDINAL JOINT OR PAVEMENT EDGE



LONGITUDINAL CONSTRUCTION JOINT

Section Z-Z

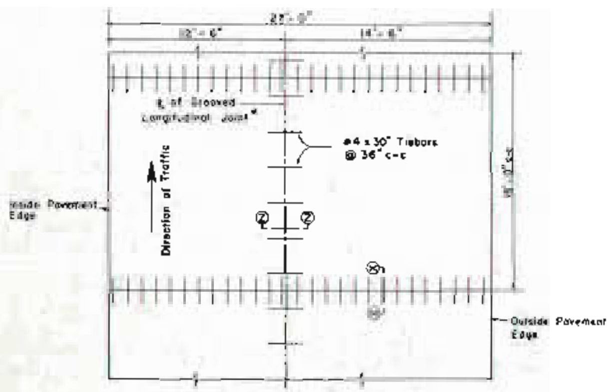
** WITH THE APPROVAL OF THE ENGINEER, [illegible]



GROOVED LONGITUDINAL JOINT

Section Z-Z

DEPTH OF PAVEMENT (INCHES)	DOWELS (SMOOTH BARS)			TIE BARS
	SIZE AND LENGTH	AVERAGE SPACING (INCHES)	WEIGHT PER FOOT OF JOINT (LBS)	SPACE AND SIZE
8	1" X 18"	12	4.01	#4 X 30" @ 36" C-C
9	1¼ X 20"	12	5.63	" "
10	1¼ X 22"	12	7.65	" "
11	1½ X 22"	12	7.65	" "
12 - 14	1½" X 22"	12	7.65	#5 X 36" @ 36" C-C



TWO LANE PAVEMENT PLAN

TYPICAL SECTION

(27 ft. Placement)

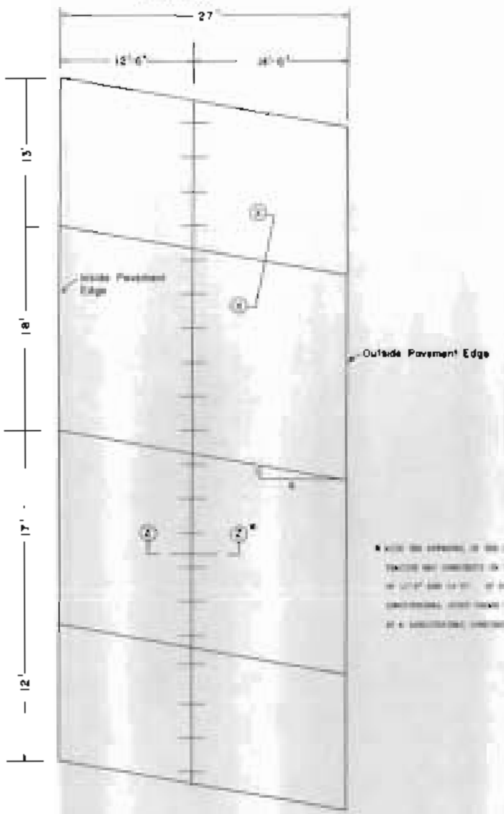
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

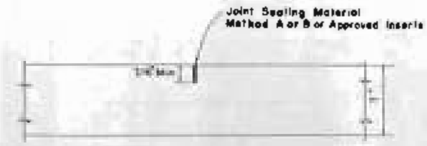
CONCRETE PAVEMENT DETAILS

CONTRACTION DESIGN

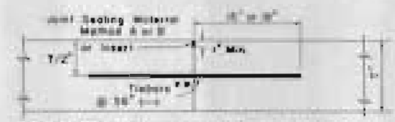
CPCD-80 (2)

PAVEMENT PLAN

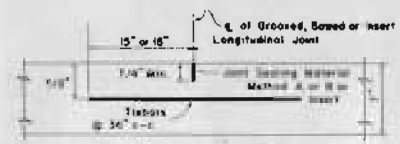




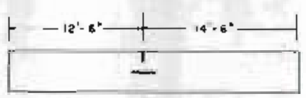
TRANSVERSE CONTRACTION JOINT
Section X-X



LONGITUDINAL CONSTRUCTION JOINT
Section Z-Z



LONGITUDINAL JOINT
Section Z-Z



TWO LANE TYPICAL SECTION

GENERAL NOTES

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.

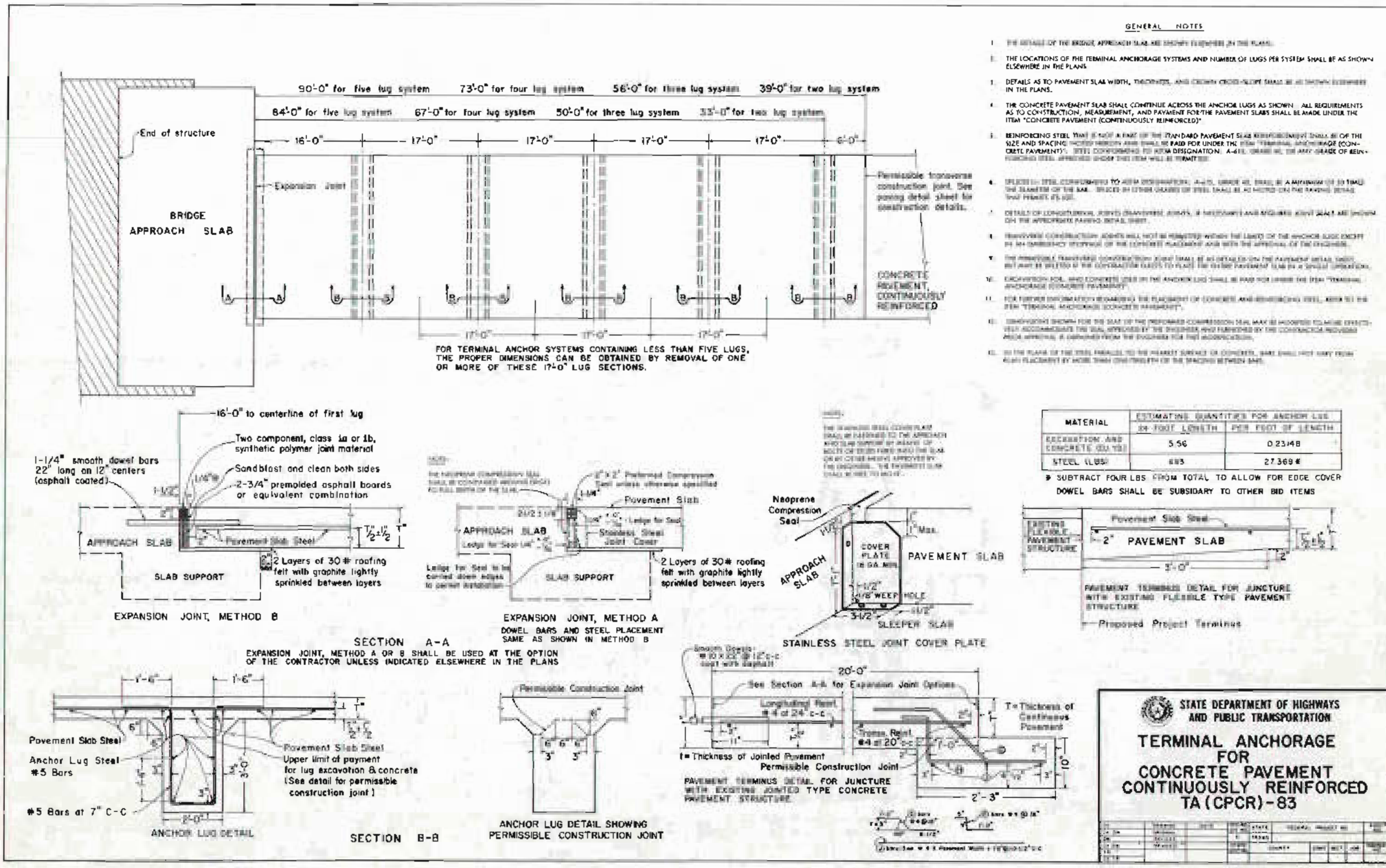
THICKNESS (T) OF PAVEMENT	TIE BARS			
	SIZE	LENGTH	GRADE	SPACING
6"-11"	#4	30"	60	36"
12"-16"	#5	36"	60	36"

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

CONCRETE PAVEMENT DETAILS
SKEWED TRANSVERSE JOINTS
(NO DOWELS)

CPSJ-75

A-25

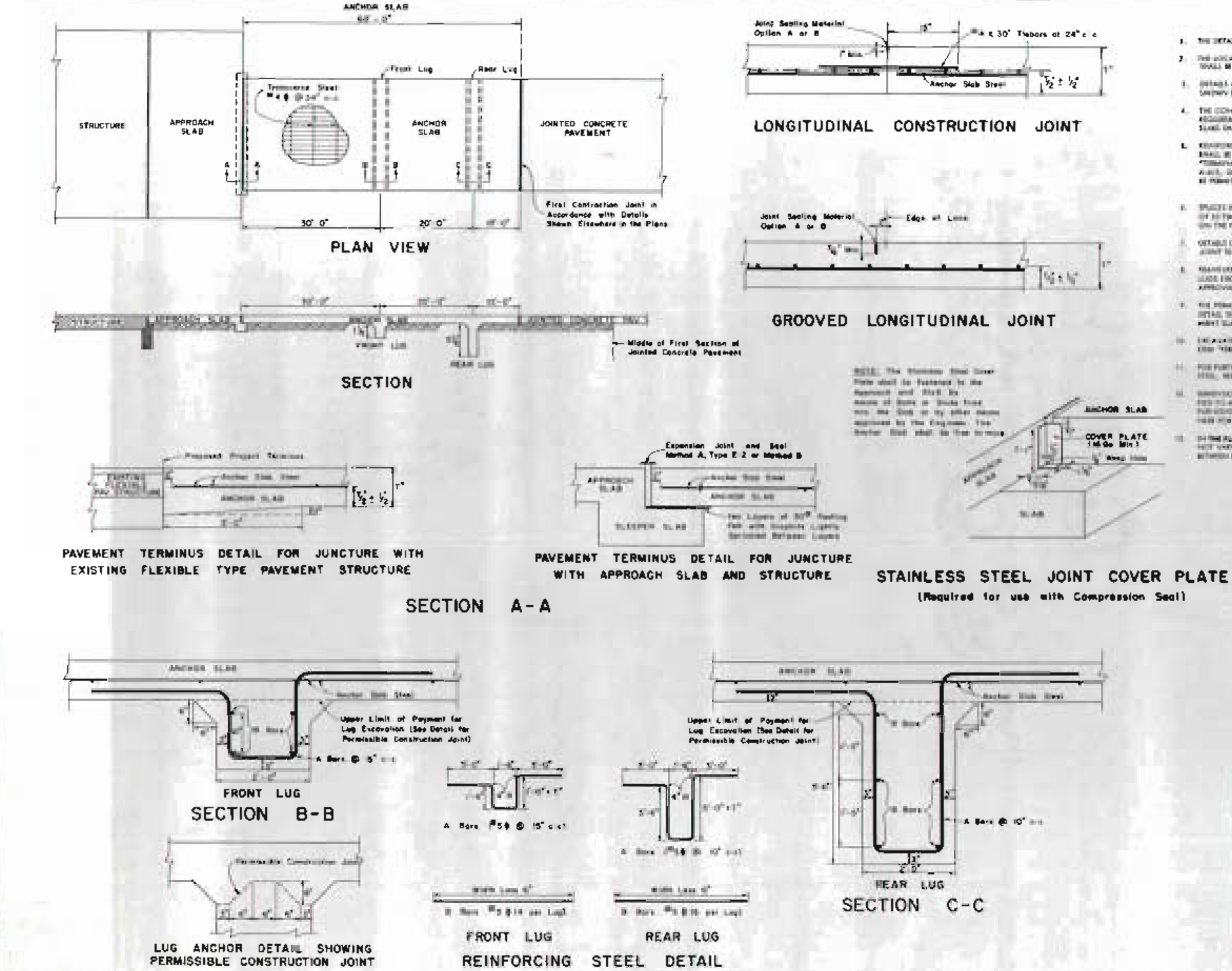


MATERIAL	ESTIMATING QUANTITIES FOR ANCHOR LUG	
	24-FOOT LENGTH	PER FOOT OF LENGTH
EXCAVATION AND CONCRETE (CU. YD.)	5.56	0.23148
STEEL (LBS)	683	27.369 *

* SUBTRACT FOUR LBS FROM TOTAL TO ALLOW FOR EDGE COVER

DOWEL BARS SHALL BE SUBSIDIARY TO OTHER BID ITEMS

Rev. 4-1-83



GENERAL NOTES

1. THE DETAILS OF THE BRIDGE APPROACH SLAB ARE SHOWN ELSEWHERE IN THE PLANS.
2. [illegible]
3. [illegible]
4. [illegible]
5. [illegible]
6. [illegible]
7. [illegible]
8. [illegible]
9. [illegible]
10. [illegible]
11. [illegible]
12. [illegible]
13. [illegible]

ESTIMATED QUANTITIES FOR ONE 24 FOOT WIDE TERMINAL ANCHORAGE

ITEM	PAVEMENT THICKNESS (in.)	CONCRETE (CU. YD.)	STEEL (LBS.)	EXCAVATION (CU. YD.)
FRONT ANCHOR LUG	ALL	2.67		2.67
REAR ANCHOR LUG	ALL	6.22		6.22
ANCHOR SLAB	8	35.4 *		0
	9	40.0 *		0
	10	44.4 *		0

* For pavement terminus with existing flexible pavement structure, the concrete quantity should be increased by 0.2 C.Y. to include the thickened end detail.

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

TEXAS HIGHWAY DEPARTMENT

TERMINAL ANCHORAGE FOR CONCRETE PAVEMENT JOINTED

TA(CPJ) - 83

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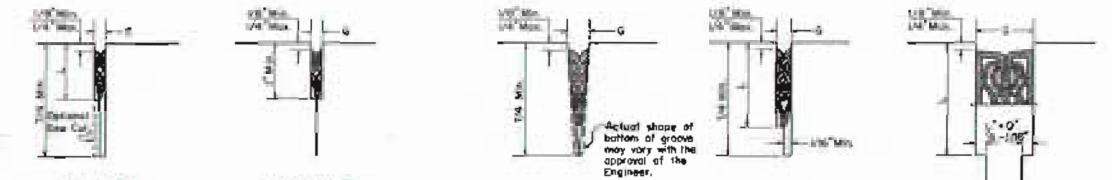
A-26

A-27



GROOVED LONGITUDINAL JOINT (TYPES L-1 or L-2)

LONGITUDINAL CONSTRUCTION JOINT (TYPE L-2)

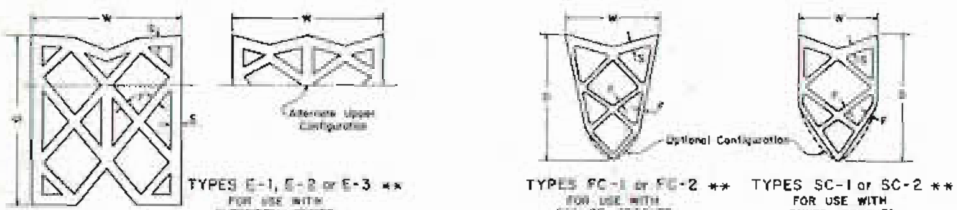
FORMED CONTRACTION JOINT (TYPES FC-1 or FC-2)

SAWED CONTRACTION JOINT (TYPES SC-1 or SC-2)

EXPANSION JOINT (TYPES E-1, E-2 or E-3)

LONGITUDINAL JOINT SEALS

TRANSVERSE JOINT SEALS



TYPES E-1, E-2 or E-3 ** FOR USE WITH EXPANSION JOINTS

TYPES FC-1 or FC-2 ** FOR USE WITH FORMED GROOVES

TYPES SC-1 or SC-2 ** FOR USE WITH SAWED GROOVES

PREFORMED COMPRESSION SEAL TYPES

** See General Note No 6

METHOD A: PREFORMED COMPRESSION SEALS

JOINT TYPE	JOINT GROOVE WIDTH G (in.)	JOINT GROOVE DEPTH L (in.)	MINIMUM JOINT SEAL SIZE TO BE USED [2] WIDTH W (in.)	DEPTH D (in.)	MAX WID. LAT. COMP.	THICK S (in.)	TOLER.[3] S (in.)	THICK. F (in.)	TOLER.[3] F (in.)	SEAL DESIGNATION & TYPE
LONGITUDINAL JOINT	1/8 −0 +1/16	7/8	5/16	5/8	1/8	0.040	-0.005	0.040	[illegible]	L-1
	1/4 ± 1/32	1	7/16	23/32	7/32	0.062	-0.005	[illegible]	[illegible]	L-2
SAWED TRANSVERSE CONTRACTION JOINT	1/4 −0 +1/16	1-1/2	11/16	1-1/8	1/4	0.080	-0.012	[illegible]	[illegible]	SC-1
	3/8 −0 +1/16	1-3/4	13/16	1-1/8	5/16	0.080	-0.012	[illegible]	[illegible]	SC-2
FORMED TRANSVERSE CONTRACTION JOINT	3/8	N/A	13/16	1-1/8	5/16	0.080	-0.012	[illegible]	[illegible]	FC-1
	5/8	N/A	1-1/4	1-1/2	5/8	0.080	[illegible]	[illegible]	[illegible]	FC-2
EXPANSION JOINTS	1 *	2-1/8	1-5/8	1-5/8	7/8	0.094	[illegible]	[illegible]	[illegible]	E-1
	1-1/4 *	2-3/4	2	2	[illegible]	0.125	-0.016	0.110	[illegible]	E-2
	[illegible]	[illegible]	[illegible]	2-3/4	1-1/4	[illegible]	-0.016	[illegible]	[illegible]	E-3

* THIS GROOVE WIDTH IS FOR SUMMER CONCRETE PLACEMENT. WHEN CONCRETE IS PLACED DURING THE WINTER SEASON, THIS GROOVE SHALL BE INCREASED 1/8".

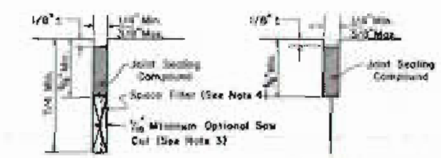
1. DUE TO SMALL VARIATIONS IN SEAL SIZES, THIS DIMENSION MAY HAVE TO BE MODIFIED SLIGHTLY TO INSURE PROPER INSTALLATION. THIS DIMENSION IS APPLICABLE ONLY WHEN A STEPPED GROOVE IS USED. N/A: NOT APPLICABLE.

2. THESE DIMENSIONS ARE MINIMUM DIMENSIONS. DIMENSIONS GREATER THAN THOSE SHOWN MAY BE USED IF APPROVED BY THE ENGINEER AND IF THEY PERMIT INSTALLATION IN A WORKMANLIKE MANNER AT NO EXTRA EXPENSE TO THE STATE.

3. ONLY MINIMUM TOLERANCES ARE SHOWN. ANY REASONABLE OVERSIZE WILL BE ACCEPTED PROVIDED PROPER INSTALLATION IS POSSIBLE.

GENERAL NOTES FOR METHOD "A"

1. A SAMPLE OF EACH SIZE AND TYPE OF SEAL PROPOSED FOR USE SHALL BE APPROVED BY THE ENGINEER PRIOR TO INSTALLATION.
2. THE SEALS SHOWN AS METHOD "A" OR METHOD "B" MAY BE USED AT ANY JOINT REQUIRING A SEAL, HOWEVER, THE SAME SEAL SHALL BE USED THROUGHOUT THE PROJECT UNLESS OTHERWISE AUTHORIZED BY THE ENGINEER.
3. LONGITUDINAL JOINTS SHALL BE SAWED STRAIGHT AND TRUE TO LINE AS DETAILED IN THE STANDARD SPECIFICATIONS.
4. TRANSVERSE JOINTS MAY BE SAWED OR FORMED AND SHALL BE PLACED AS SHOWN ELSEWHERE IN THE PLANS.
5. THE SEALS DESIGNATED L-1 AND L-2 SHALL HAVE A CONFIGURATION SIMILAR TO THE TYPE FC OR SC.
6. ** OTHER [illegible] CONFIGURATIONS MAY BE USED PROVIDED THE MATERIAL MEETS ALL OF THE REQUIREMENTS OF THE SPECIFICATIONS AND AS OTHERWISE SHOWN HEREON OR ELSEWHERE IN THE PLANS. THE NUMBER OF INTERIOR CELLS AND/OR THE THICKNESS OF THE EXTERIOR AND INTERIOR WALLS SHALL BE SUCH AS TO PROVIDE AN ADEQUATE COMPRESSION FORCE TO MAINTAIN A POSITIVE SEAL.
7. UNLESS OTHERWISE SPECIFIED, THE SIDES OF THE FORMED CONTRACTION JOINT MAY BE FORMED PARALLEL, BUT IF SO FORMED, THE SEAL SHALL BE AN APPROPRIATE TYPE SC SEAL APPROVED BY THE ENGINEER.
8. UNLESS THE GROOVE AND SEAL COMBINATION IS SPECIFICALLY DESIGNATED ELSEWHERE IN THE PLANS, ANY GROOVE AND SEAL COMBINATION SHOWN IN THE TABLE FOR A PARTICULAR TYPE JOINT MAY BE USED, BUT MUST BE APPROVED BY THE ENGINEER.

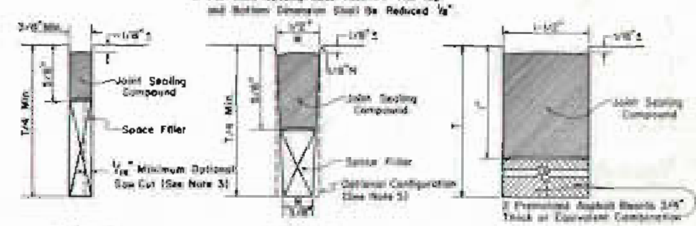


GROOVED LONGITUDINAL JOINT

LONGITUDINAL CONSTRUCTION JOINT

LONGITUDINAL JOINT SEALS

* For Joint Spacing Less Than 20' The Top and Bottom Dimension Shall Be Reduced 1/8"



SAWED CONTRACTION JOINT

FORMED CONTRACTION JOINT (Joint Spacing Greater Than 20')

EXPANSION JOINT

TRANSVERSE JOINT SEALS

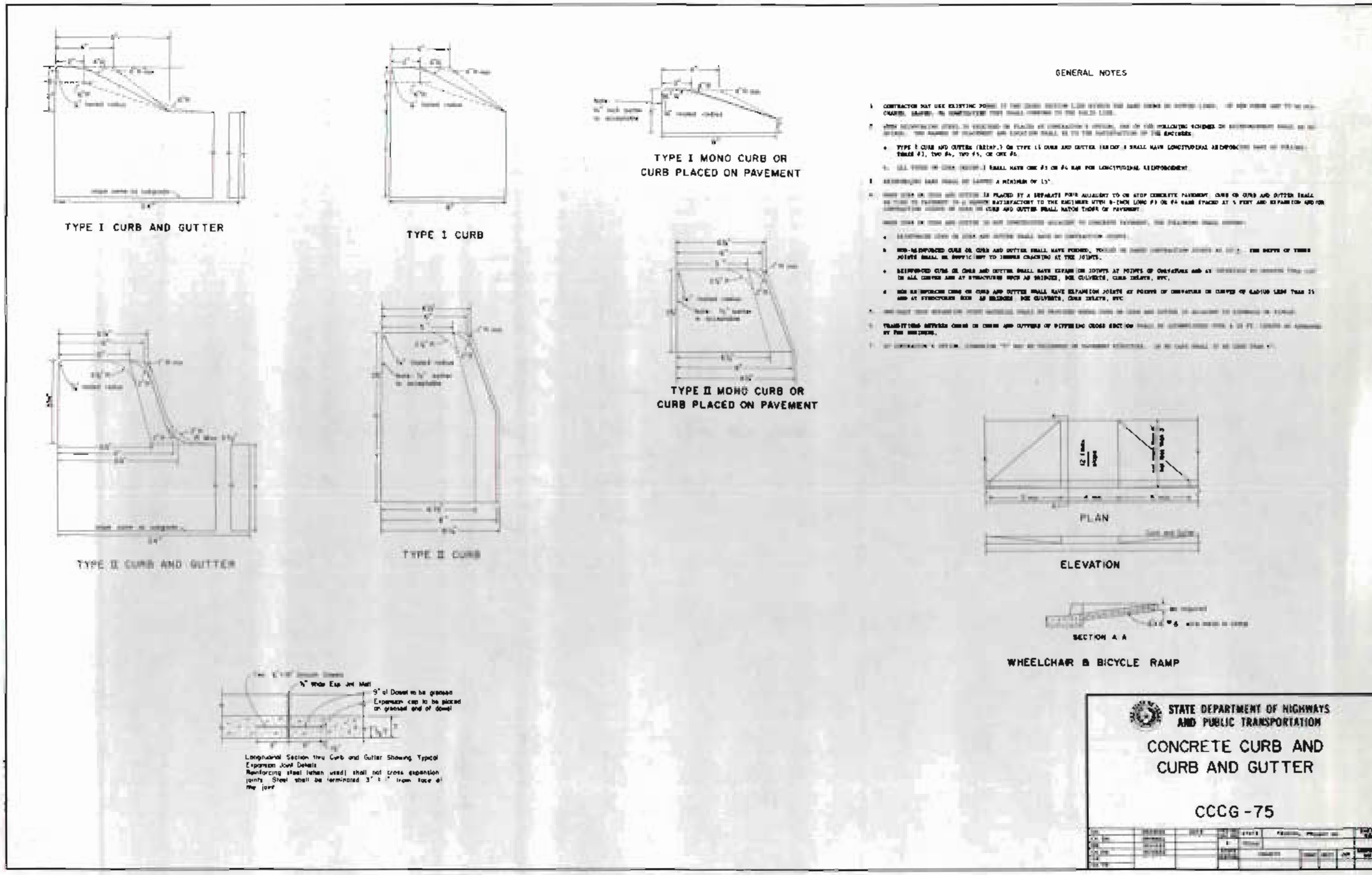
METHOD B: JOINT SEALING COMPOUND

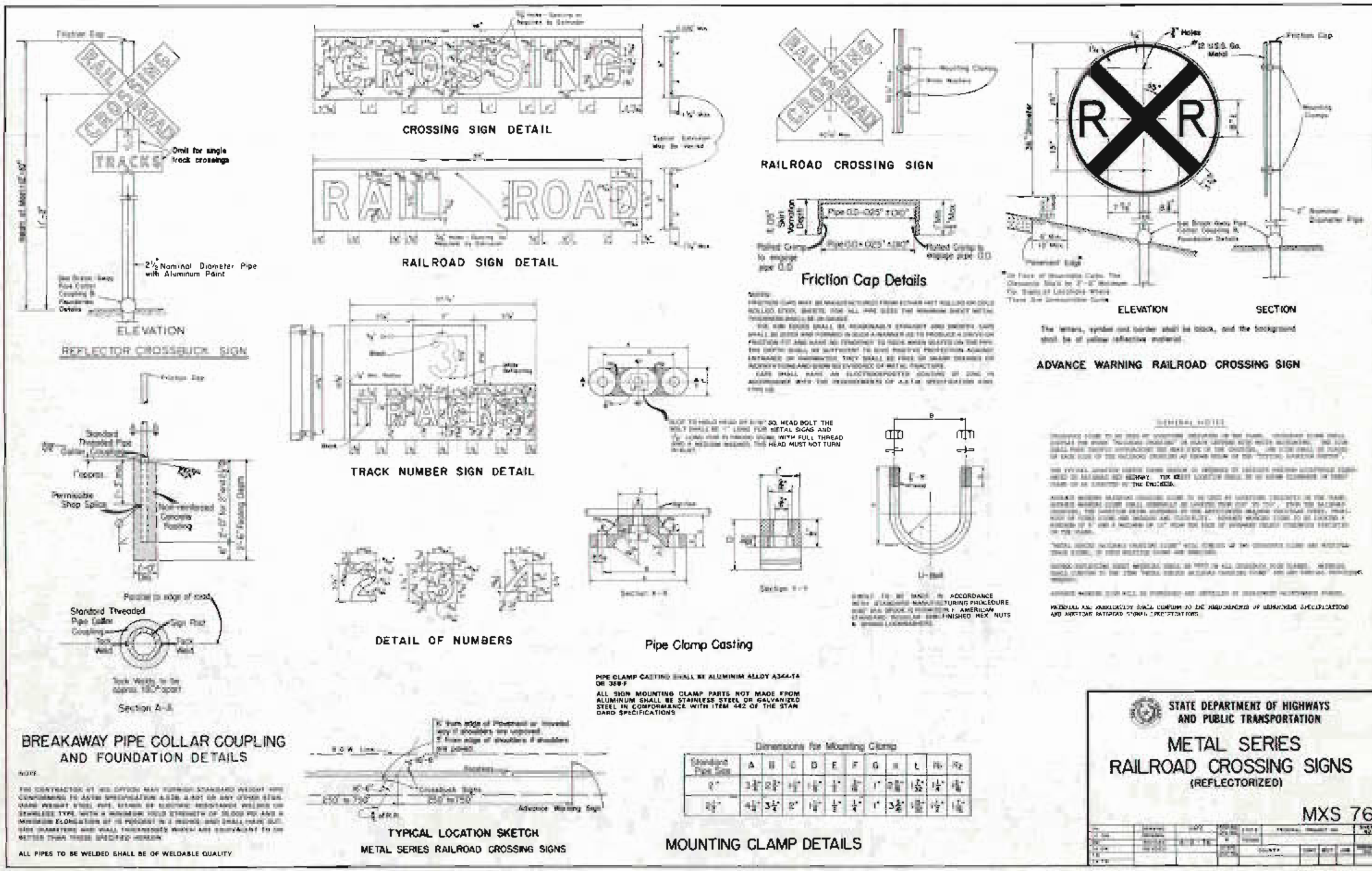
GENERAL NOTES FOR METHOD "B"

1. LONGITUDINAL JOINTS MAY BE SAWED OR FORMED AS DETAILED IN THE STANDARD SPECIFICATIONS.
2. TRANSVERSE JOINTS MAY BE SAWED OR FORMED AND SHALL BE PLACED AS SHOWN ELSEWHERE IN THE PLANS.
3. A SUITABLE SPACE FILLER SHALL BE USED WHERE SHOWN AND THE JOINT SEAL COMPOUND POURED TO THE DEPTH INDICATED EXCEPT THAT IF THE MINIMUM SAW CUT IS USED, THE SPACE FILLER MAY BE DELETED.
4. AT THE OPTION OF THE CONTRACTOR, THE SPACE FILLER MAY BE OMITTED IN THE LONGITUDINAL JOINT ONLY AND THE JOINT SEALING COMPOUND POURED FULL DEPTH.
5. UNLESS OTHERWISE SPECIFIED, THE SIDES OF THE FORMED CONTRACTION JOINT MAY BE FORMED PARALLEL AT THE OPTION OF THE CONTRACTOR.
6. UNLESS OTHERWISE SHOWN IN THE PLANS, EITHER METHOD "A" OR METHOD "B" MAY BE USED.

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

CONCRETE PAVING DETAILS
JOINT SEALS
JS-75


TYPE I CURB AND GUTTER
TYPE I CURB
TYPE I MONO CURB OR CURB PLACED ON PAVEMENT
GENERAL NOTES
TYPE II CURB AND GUTTER
TYPE II CURB
TYPE II MONO CURB OR CURB PLACED ON PAVEMENT
PLAN
ELEVATION
SECTION A-A
WHEELCHAIR & BICYCLE RAMP
Longitudinal Section thru Curb and Gutter Showing Typical Expansion Joint Details
Reinforcing steel (when used) shall not cross expansion joints. Steel shall be terminated 3" ± 1" from face of the joint
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
CONCRETE CURB AND CURB AND GUTTER
CCCG-75



Dimensions for Mounting Clamp

Standard Pipe Size	A	B	C	D	E	F	G	H	L	R₁	R₂
2"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1"	[illegible]	$1\frac{7}{32}$"	$1\frac{1}{4}$"	[illegible]
$2\frac{1}{2}$"	[illegible]	$3\frac{1}{4}$"	2"	[illegible]	$\frac{1}{2}$"	$\frac{1}{4}$"	1"	[illegible]	[illegible]	$1\frac{1}{2}$"	[illegible]

CONSTRUCTION PAVEMENT MARKINGS

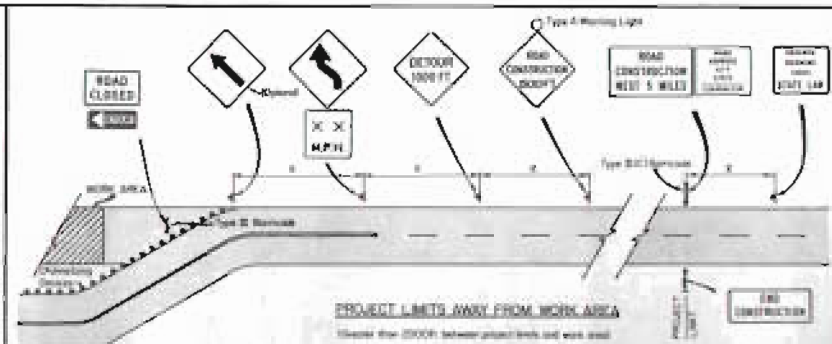
When required elsewhere in the plans, the Contractor will be responsible for maintaining pavement markings on all roadways that are open to traffic within the limits of the project. On projects involving roadway surfacing which will require pavement marking for control of traffic during construction, the markings may include both standard and abbreviated markings as defined below:

1. Standard Pavement Markings - Standard markings placed in conformance with the requirements of the Texas MUTCD. [illegible]
2. Abbreviated Pavement Markings - Abbreviated pavement markings are shorter in length than standard markings. [illegible]

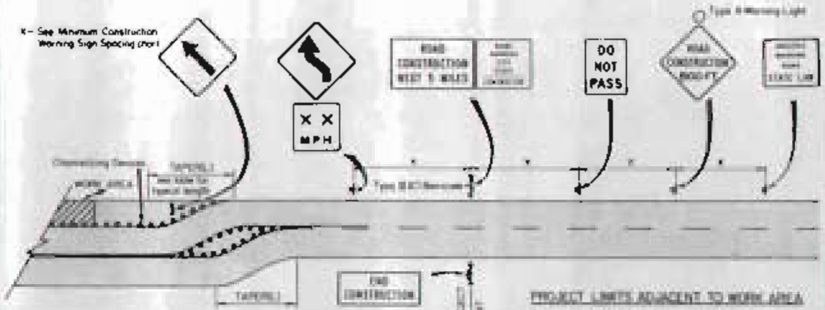
When abbreviated pavement markings are used, a DO NOT PASS sign shall be used to mark the beginning of the section where passing is to be prohibited and a PASS WITH CARE sign shall be used to mark the beginning of a section where passing is permitted.

REMOVAL OF PAVEMENT MARKINGS

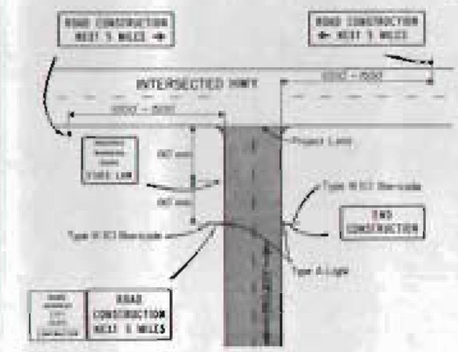
[illegible]



PROJECT LIMITS AWAY FROM WORK AREA



PROJECT LIMITS ADJACENT TO WORK AREA



PROJECT LIMITS AT T-INTERSECTION

SPECIAL NOTES:

1. The ROAD CONSTRUCTION NEXT 5 MILES [illegible]
2. On the intersected highway, additional traffic control devices, [illegible]

Project Limit Traffic Control Devices

GENERAL NOTES

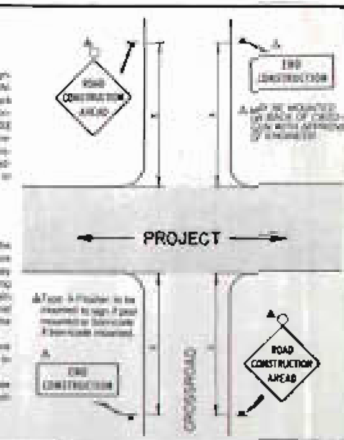
1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]
5. [illegible]
6. [illegible]

CROSSROAD SIGNING AND BARRICADING

[illegible]

EXCEPTIONS - TO BE NOTED ELSEWHERE IN THE PLANS

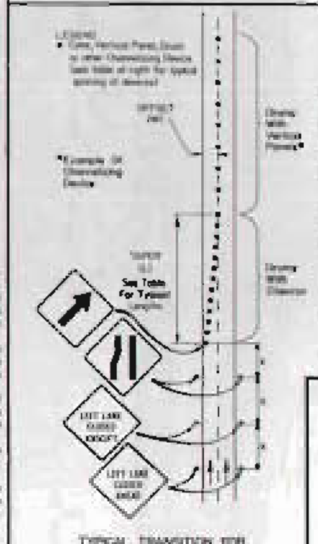
1. [illegible]
2. [illegible]
3. [illegible]



MINIMUM CONSTRUCTION WARNING SIGN SPACING

POSTED SPEED OR 85% SPEED	30 or less	35	40	45	50	55 [1]
X MINIMUM DISTANCE (FT.)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[1] For roads with a 55 MPH posted speed limit, advance warning signs should be placed approximately 1,500 feet in advance of the condition to which they are calling attention. [illegible]



TYPICAL TRANSITION FOR SHORT DURATION LANE CLOSURE

For Long Duration Lane Closure, Pavement Markings in the Transition Area Shall Be Removed.

TYPICAL TRANSITION LENGTHS AND SUGGESTED MAXIMUM SPACING OF CHANNELIZING DEVICES

Posted Speed*	Formula	Minimum Desirable Taper Lengths** 10' Offset	11' Offset	12' Offset	Suggested Maximum Spacing of Devices On a Taper	On a Tangent
30	$L=\frac{WS^2}{60}$	150	[illegible]	[illegible]	30'	60 - 75'
35		205	225	[illegible]	35	70 - 90'
40		265'	295'	[illegible]	40'	80 - 100'
45	$L=WS$	450	495	[illegible]	[illegible]	90 - 110'
50		500'	550'	[illegible]	[illegible]	100 - 125'
55		550	605'	660	55'	110 - 140'
60		600'	660'	720'	60'	120 - 150

*[illegible] traffic speeds normally [illegible]
**[illegible]
L=Length of Taper (FT.) W=Width of Offset (FT.) S=Posted Speed (MPH)

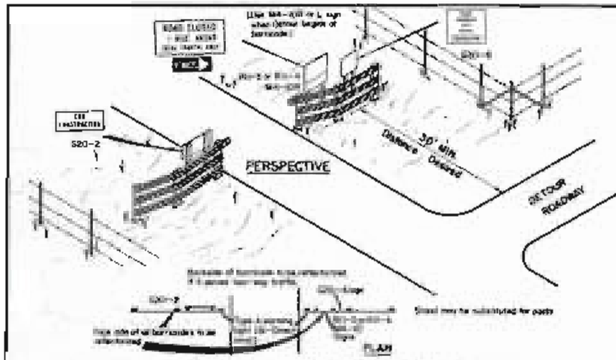
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

BARRICADE AND CONSTRUCTION STANDARDS

ADVANCE SIGNING
CROSSROAD SIGNING
PAVEMENT MARKINGS

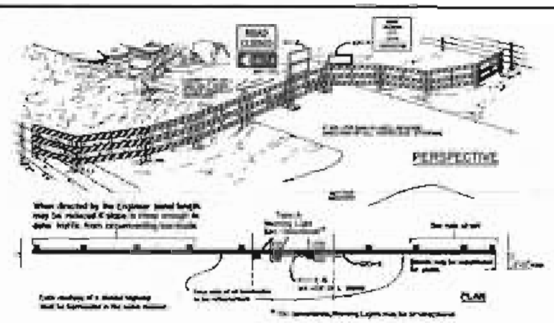
BC(1)-82

Rev. 82



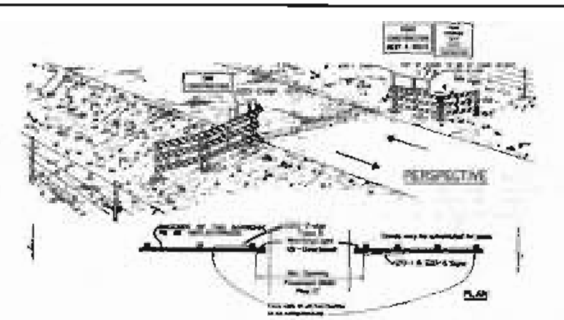
TYPE III (A) BARRICADE

1. The plan shown above is to be used when local traffic is permitted inside project or permitted to use the road beyond the intersection with the temporary route. Other signs and barricades (Type I, II or III) may be required inside the project limits based upon the contractor's sequence of work and other conditions.
2. Where conditions will permit, minimum length of barricade on each side of roadway should be 12 feet.
3. First barricade panel on each side of roadway should be approximately level. Additional panels, if needed, may follow contour of right-of-way
4. Advance signing, including construction warning signs, and detour signing shall be as specified elsewhere in the plans

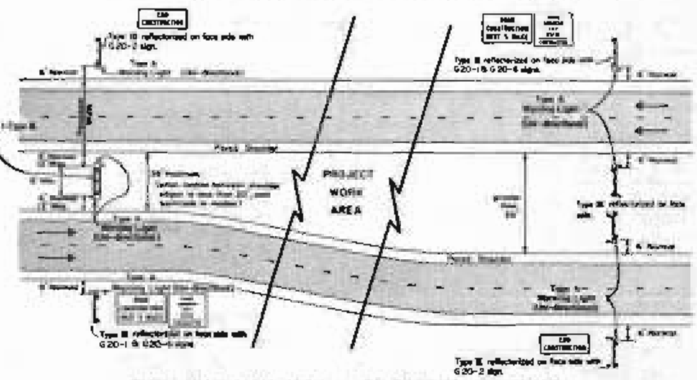


TYPE III(B) BARRICADE

1. The plan shown above is to be used when no local traffic is permitted inside the project. Contractor may leave his access gate anywhere in barricade except at center of roadway where R11-2 and M4-10 signs must be mounted on fixed barricade section.
2. Advance signing, including construction warning signs, and detour signing shall be as specified elsewhere in the plans.



TYPE III(C) BARRICADE FOR TWO WAY UNDIVIDED ROADWAY



TYPE III(C) BARRICADE FOR DIVIDED HIGHWAYS

NOTES FOR TYPE III (C) BARRICADES

1. The plans shown above are to be used when all traffic is maintained through the project. The signs shown apply to the first and last barricades of a project. Other signs and barricades (Types I, II or III) will be required inside the project limits based upon the contractor's sequence of work and other conditions.
2. Where conditions will permit, minimum length of barricade on each side of roadway should be 12 feet except as noted.
3. First barricade panel on each side of roadway should be approximately level. Additional panels, if needed, may follow contour of right-of-way

GENERAL NOTES FOR TYPES I, II & III BARRICADES

Type I or II Barricades (see Sheet BC(3)) are for temporary use to control traffic within the limits of a project whenever it is necessary to confine traffic to a specific area because of some particular construction operation. Type I Barricades would normally be used on conventional roads or urban streets and arterials. As Type II Barricades have more reflective area, they are intended for use on expressway and freeways or other high speed roadways.

Type III(A) Barricades and accompanying signs are to be used at each end of construction projects closed to all but local traffic.

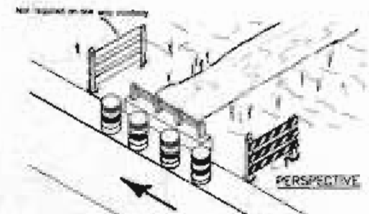
Type III(B) Barricades and accompanying signs are to be used at each end of construction projects closed to all traffic.

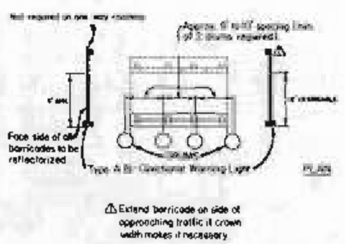
Type III(C) Barricades and accompanying signs are to be used at each end of construction projects where traffic is maintained through the project. Type III(C) Barricades may also be used where traffic from other highways, county roads or city streets is permitted to enter the project area. Typical signing for Type III(C) Barricades is shown on Sheet BC(1).

Type III(D) Barricades are to be used on culvert widening projects where traffic is routed over the structure. They shall be erected so as to provide the maximum roadway width for traffic and to allow sufficient space for construction operations behind the barricades.

Warning Lights placed on Type III(A), (B) or (C) barricades should be mounted at a minimum height of 36 inches to the bottom of the lens and may be attached to the barricade or mounted on a separate channelizing device. Barricades used at each end of the project shall be supplemented with warning lights as detailed on this sheet. For all other barricades, used at night, warning lights are to be used as detailed on Sheet BC(3).

For dimensions of barricade panels see Sheet BC(3).



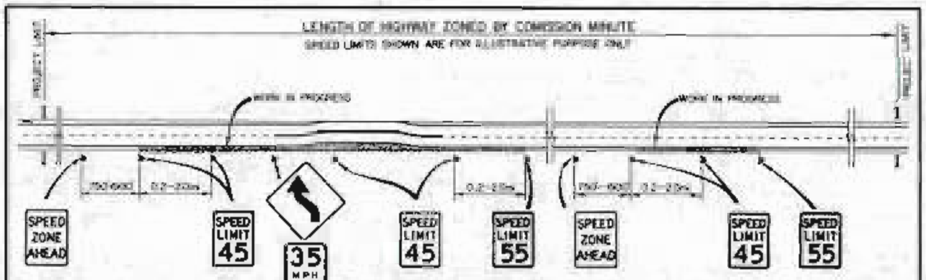


TYPE III (D) BARRICADE

FOR CULVERT WIDENING SITE WITHIN THE PROJECT LIMITS

NOTES

1. Where positive redirectional capability is provided, drums and barricades may be omitted.
2. On streets or roads with posted speeds of 35 MPH or less, Type II Barricades may be used in lieu of barrels where necessary for pedestrian safety.



TYPICAL APPLICATION OF SPEED ZONE SIGNS

NOTES

- Frequency of speed limit signs should be every 0.2 to 2.0 miles for speeds 40 MPH and above and 0.2 to 1.0 miles for speeds 35 MPH and below
  Reduce speeds when required should only be posted in the vicinity of work being performed or other areas when needed rather than throughout the entire project
- SPEED ZONE SIGNS ARE ILLUSTRATED FOR ONE DIRECTION OF TRAVEL ONLY AND ARE NORMALLY POSTED FOR EACH DIRECTION OF TRAVEL
- REGULATORY CLASS SPEED ZONE SIGNS SHALL HAVE BLACK LEGEND ON A WHITE REFLECTIVE BACKGROUND

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

BARRICADE AND CONSTRUCTION STANDARDS

BARRICADES
SPEED ZONING

BC(2)-82

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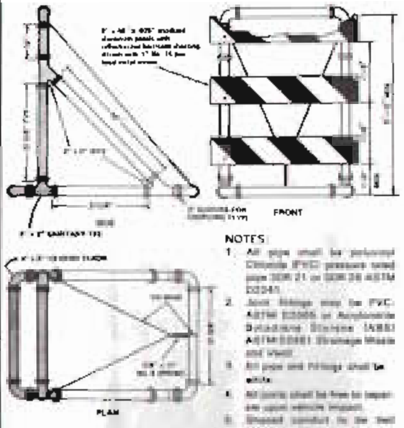


NOTES:

1. All pipe shall be polyvinyl Chloride (PVC) pressure rated pipe SDR 21 or SDR 26 ASTM D2241.
2. Joint fittings may be PVC ASTM D2665 or Acrylonitrile Butadiene Styrene (ABS) ASTM D2661 Drainage Waste and Vent.
3. All pipe and fittings shall be white.
4. All joints shall be free to separate upon vehicle impact.
5. Shaped conduit to be tied together with pipe threaded into pipe insert. Use 5/16" No. 6 solid braided nylon or equivalent.
6. A fixed triangle pavement connection is preferred. Sand Bags may be substituted.

OPTIONAL
TYPE III PVC BARRICADES
TYPICAL DESIGN DETAILS

May be used at the option of the Contractor

STRIPING FOR BARRICADE

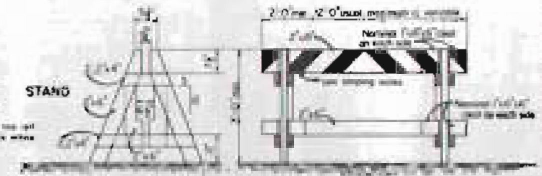
[illegible]

BARRICADE DETAILS

[illegible]

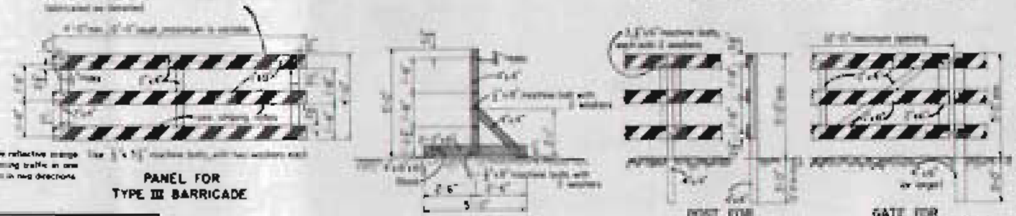
BARRICADE NOTES

[illegible]



TYPE I BARRICADE

TYPE II BARRICADE



When Wood Barricades are used and when orange and white stripes are required on the barricade, a 2" x 8" rail may be used in lieu of the 1" x 8" rail and 2" x 4" stiffener. Otherwise the rail should be fabricated as detailed.

TYPE III BARRICADE

PANEL FOR TYPE III BARRICADE

STAND FOR TYPE III BARRICADE

POST FOR TYPE III BARRICADE

GATE FOR TYPE III BARRICADE

GENERAL NOTES

REFLECTORIZATION

The reflectorized white and reflectorized orange stripes for barricades, drums and vertical panels shall be constructed of retroreflective sheeting in conformance with project specifications and shall be maintained to meet the appearance, color, and reflectivity requirements of those specifications.

WARNING LIGHTS

[illegible] ... to warn the driver that he is approaching a hazardous area. [illegible]

[illegible] ... supplement other traffic control devices used to delineate the edge of the traveled way on detour curves, lane changes, lane closures, shoulder [illegible] and other similar conditions or hazards. The series of Steady Burn Lights should have a Type B High Intensity Flashing Warning Light at the beginning and end of the series to mark the hazard. Where Steady Burn Lights are to be used for delineation, the contractor may at his option utilize delineators.

Contractors shall furnish [illegible] a certification from the manufacturer of the lights that the warning lights meet the requirements of the ITE Standard For Flashing and Steady Burn Warning Lights as contained in the latest edition of the "Texas Manual on Uniform Traffic Control Devices for Streets and Highways."

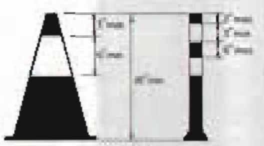
DELINEATORS

[illegible] ... BARRICADES, SIGNS AND TRAFFIC HANDLING [illegible]

SPACING OF DELINEATORS

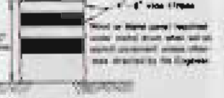
[illegible] ... Spacing of delineators on tangent sections should normally be between 100 and 200 feet with the closer spacing for lower speeds and greater spacing for higher speeds.

RADIUS OF CURVE (FEET)	[illegible]	[illegible]	200	250	300	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
APPROX SPACING ON CURVE (FEET)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



CONES

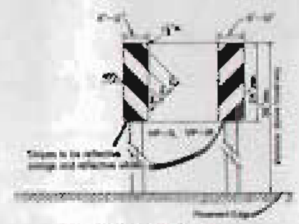
[illegible]



DRUMS

[illegible]

CW1-6 CHEVRON signs, CW1-6A ARROW signs or VP-1 Vertical Panels mounted above drums may be used as supplements to drum delineation.

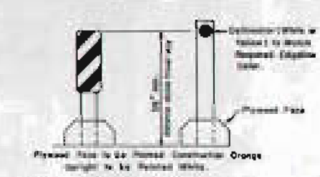


VERTICAL PANELS (VP)

[illegible]

CHANNELIZING DEVICES

The Type or Types of Channelizing Devices used are to be as specified by the Engineer.



TYPICAL PORTABLE VERTICAL PANEL OR DELINEATOR MOUNTING

Other similar supports may be used when approved or directed by the Engineer.

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

BARRICADE AND CONSTRUCTION STANDARDS

BARRICADE DETAILS
DELINEATORS & VERTICAL PANELS
DRUMS & CONES
REFLECTORIZATION
WARNING LIGHTS

BC(3)-82

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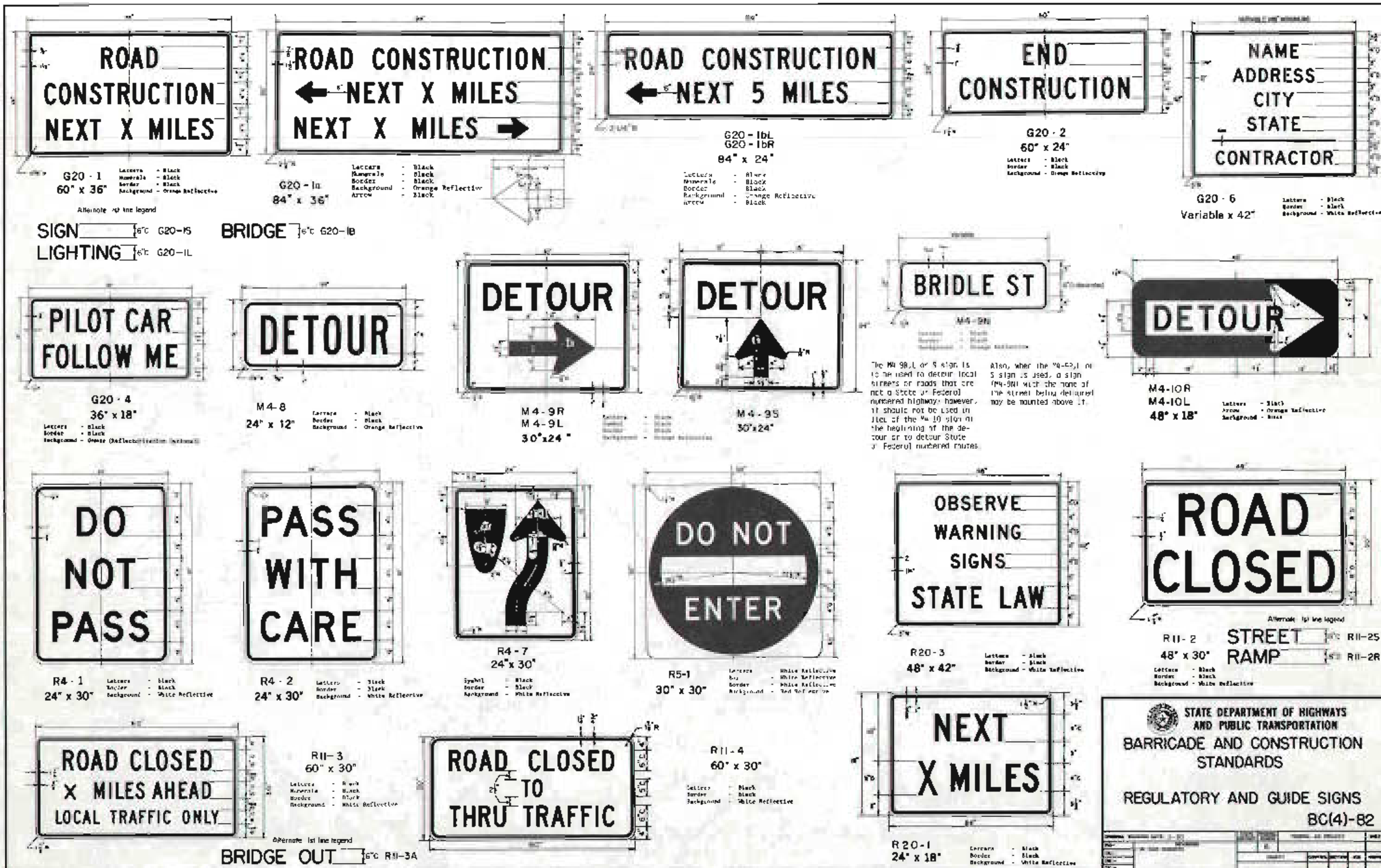
ROAD CONSTRUCTION NEXT X MILES
G20 - 1
60" x 36"
Alternate 1st line legend
SIGN G20-1S
LIGHTING G20-1L
ROAD CONSTRUCTION ← NEXT X MILES
NEXT X MILES →
G20 - 1a
84" x 36"
Letters - Black
Numerals - Black
Border - Black
Background - Orange Reflective
Arrow - Black
BRIDGE G20-1B
ROAD CONSTRUCTION ← NEXT 5 MILES
G20 - 1bL
G20 - 1bR
84" x 24"
END CONSTRUCTION
G20 - 2
60" x 24"
NAME
ADDRESS
CITY
STATE
CONTRACTOR
G20 - 6
Variable x 42"
PILOT CAR FOLLOW ME
G20 - 4
36" x 18"
DETOUR
M4-8
24" x 12"
DETOUR
M4-9R
M4-9L
30"x24"
DETOUR
M4-9S
30"x24"
BRIDLE ST
M4-9N
The M4-9R,L or S sign is to be used to detour local streets or roads that are not a State or Federal numbered highway; however, it should not be used in lieu of the M4-10 sign at the beginning of the detour or to detour State or Federal numbered routes.
Also, when the M4-9R,L or S sign is used, a sign (M4-9N) with the name of the street being detoured may be mounted above it.
DETOUR
M4-10R
M4-10L
48" x 18"
DO NOT PASS
R4 - 1
24" x 30"
PASS WITH CARE
R4 - 2
24" x 30"
R4 - 7
24" x 30"
DO NOT ENTER
R5-1
30" x 30"
OBSERVE WARNING SIGNS STATE LAW
R20-3
48" x 42"
ROAD CLOSED
Alternate 1st line legend
R11 - 2
48" x 30"
STREET R11-2S
RAMP R11-2R
ROAD CLOSED X MILES AHEAD LOCAL TRAFFIC ONLY
R11-3
60" x 30"
Alternate 1st line legend
BRIDGE OUT R11-3A
ROAD CLOSED TO THRU TRAFFIC
R11-4
60" x 30"
NEXT X MILES
R20-1
24" x 18"
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
BARRICADE AND CONSTRUCTION STANDARDS
REGULATORY AND GUIDE SIGNS
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A.34

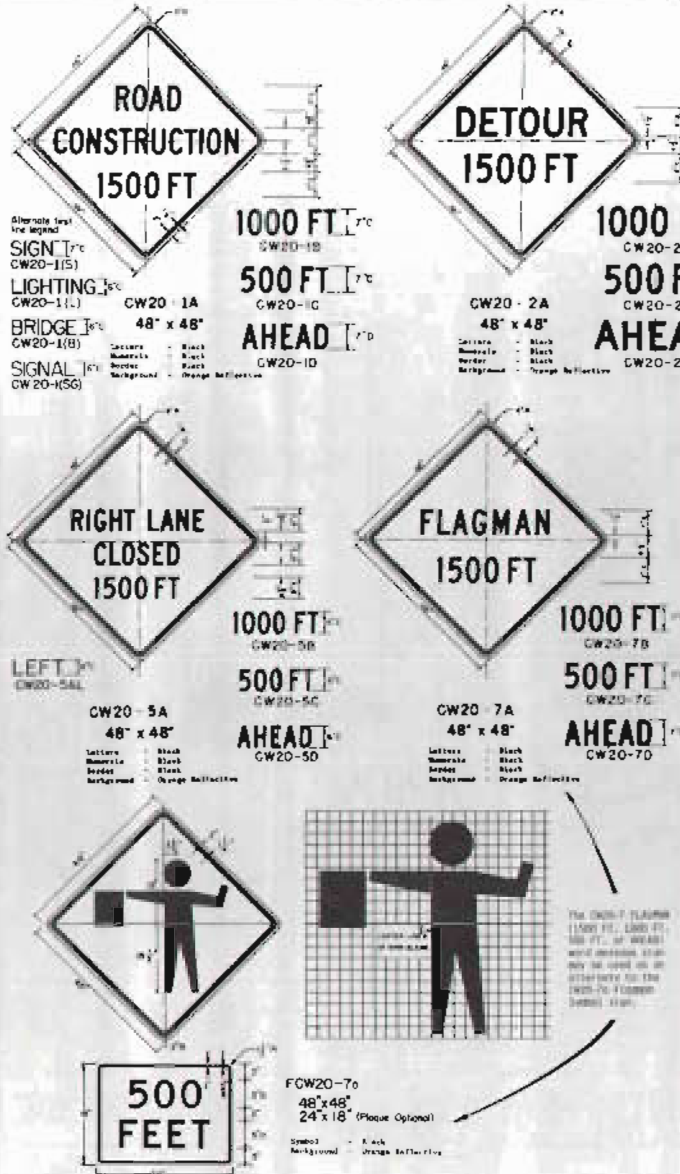
CONSTRUCTION SIGN NOTES

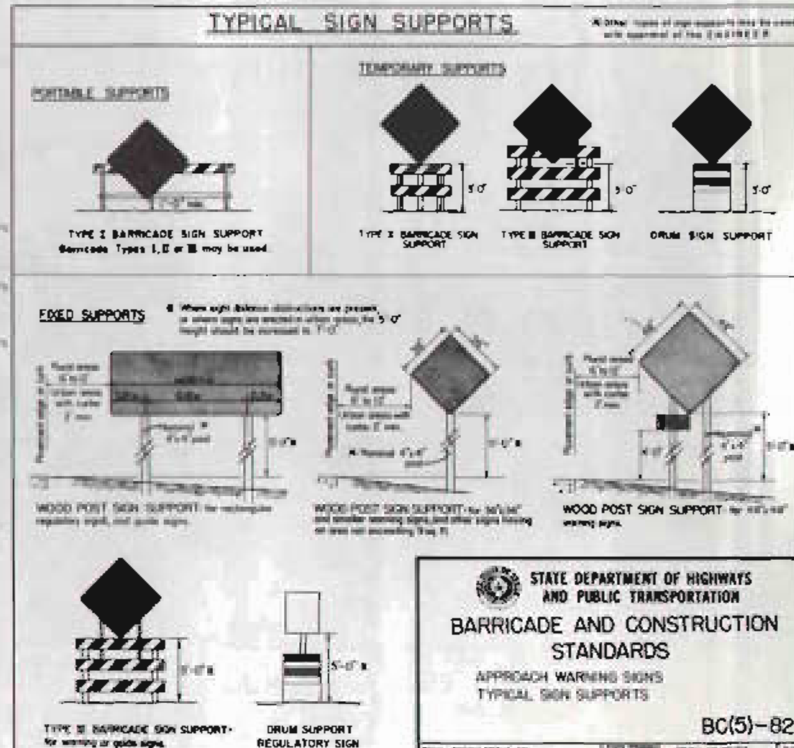
[illegible]

Where portable or temporary supports require the use of weights to keep a sign or barricade from turning over, the use of some type of sandbag is recommended. The use of pieces of concrete, rocks, [illegible] steel or other solid objects will not be permitted.

[illegible]

[illegible] the Engineer.





STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

BARRICADE AND CONSTRUCTION STANDARDS

APPROACH WARNING SIGNS
TYPICAL SIGN SUPPORTS

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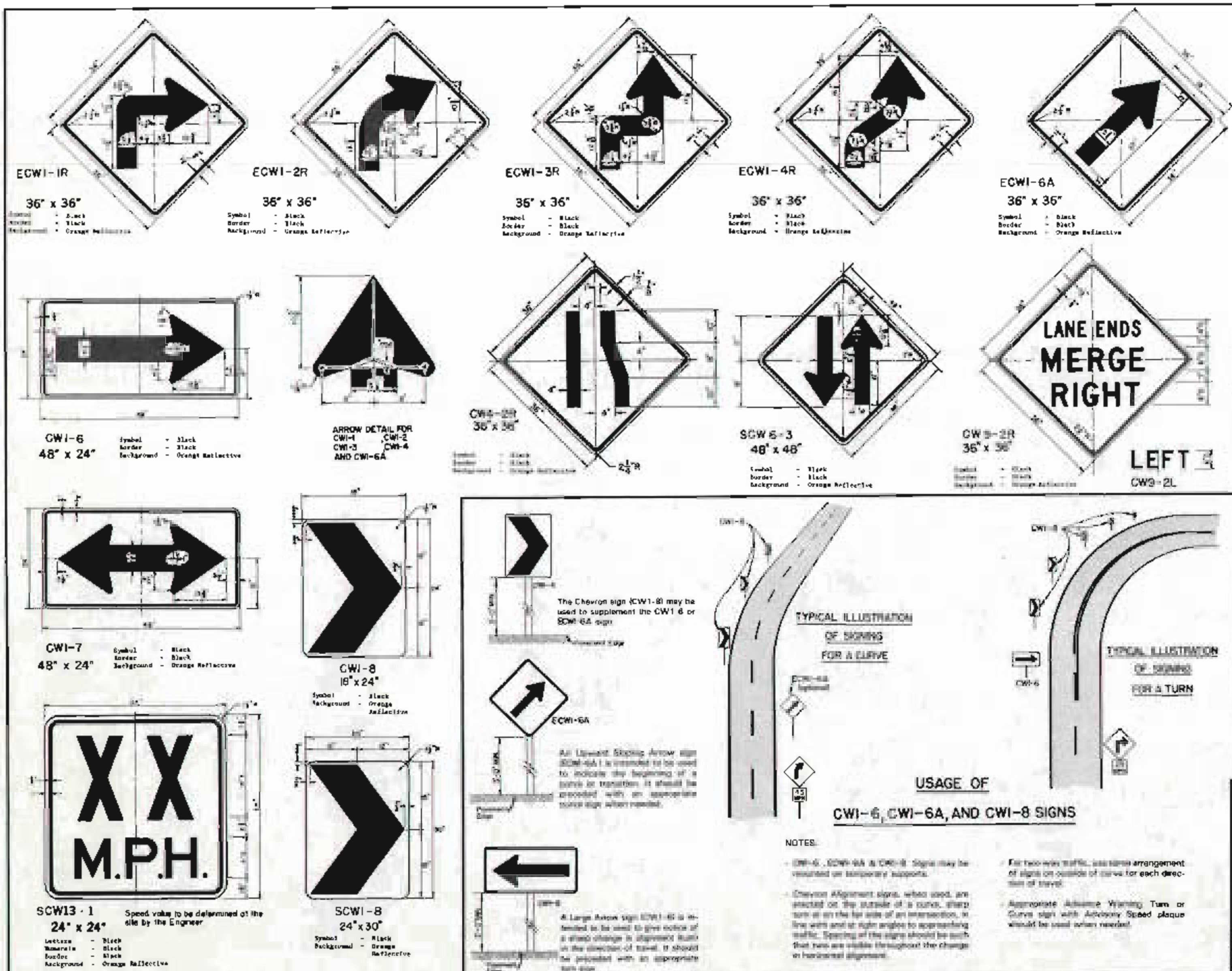
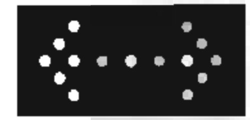


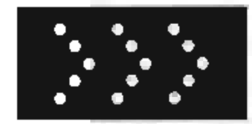
USAGE OF

CWI-6, CWI-6A, AND CWI-8 SIGNS

NOTES:



FLASHING ARROW PANEL



SEQUENCING ARROW PANEL

ADVANCE WARNING FLASHING OR SEQUENCING ARROW PANELS

Arrow panels shall be capable of minimum 50 percent dimming from rated lamp voltage. The flashing rate of the lamps shall not be less than 25 times per minute.

REQUIREMENTS

TYPE	MINIMUM SIZE	MINIMUM NUMBER OF PANEL LAMPS	MINIMUM VISIBILITY DISTANCE
B	30" x 54"	13	¾ mile
C	48" x 96"	15	1 mile

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

BARRICADE AND CONSTRUCTION STANDARDS

CONSTRUCTION WARNING SIGNS
ADVANCE WARNING ARROW PANELS

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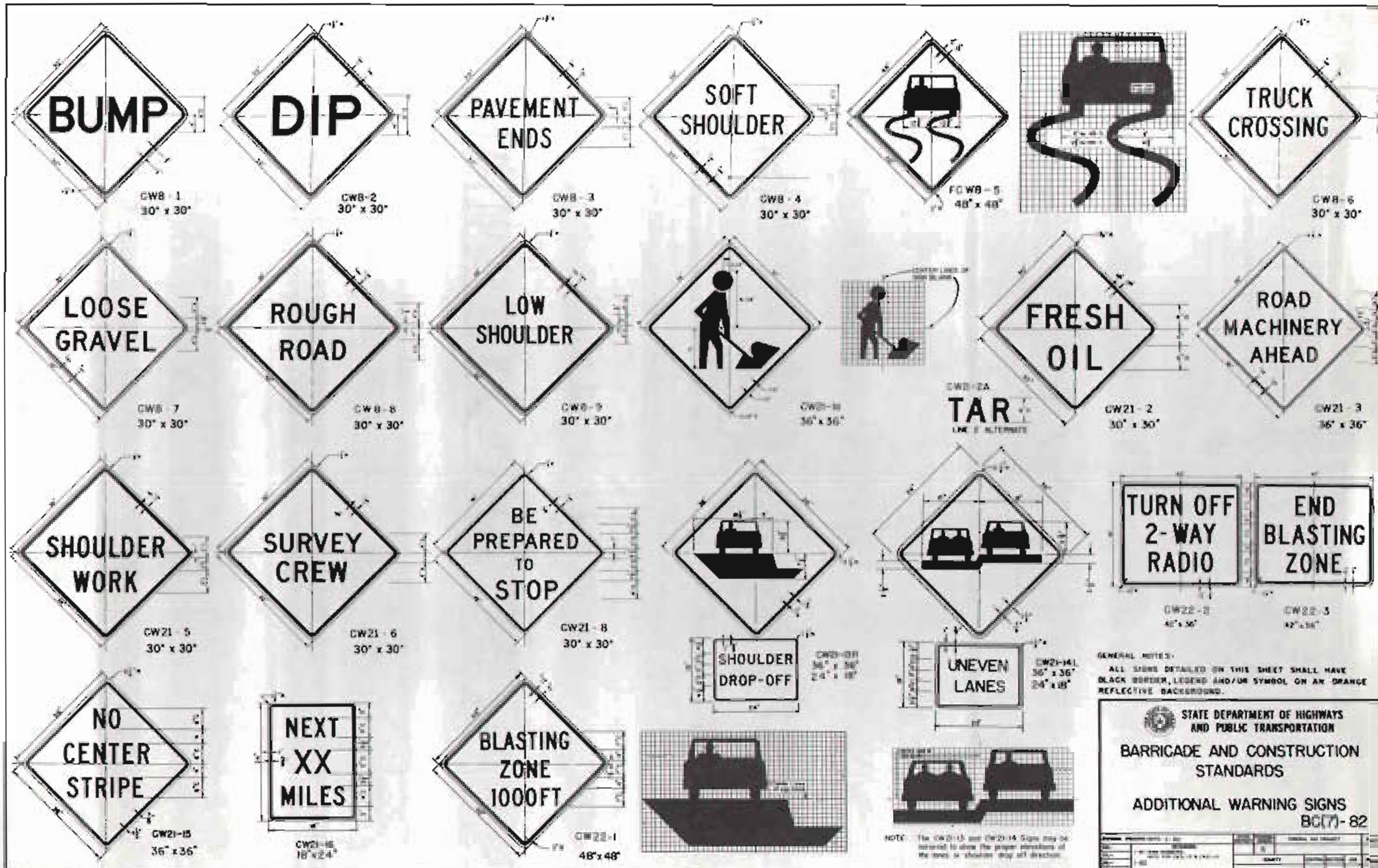
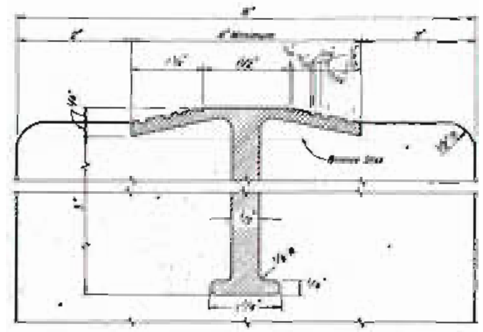

BUMP
CW8-1 30" x 30"
DIP
CW8-2 30" x 30"
PAVEMENT ENDS
CW8-3 30" x 30"
SOFT SHOULDER
CW8-4 30" x 30"
FCW8-5 48" x 48"
TRUCK CROSSING
CW8-6 30" x 30"
LOOSE GRAVEL
CW8-7 30" x 30"
ROUGH ROAD
CW8-8 30" x 30"
LOW SHOULDER
CW8-9 30" x 30"
CW21-1 36" x 36"
CW21-2A
TAR
FRESH OIL
CW21-2 30" x 30"
ROAD MACHINERY AHEAD
CW21-3 36" x 36"
SHOULDER WORK
CW21-5 30" x 30"
SURVEY CREW
CW21-6 30" x 30"
BE PREPARED TO STOP
CW21-8 30" x 30"
TURN OFF 2-WAY RADIO
CW22-2
END BLASTING ZONE
CW22-3
SHOULDER DROP-OFF
UNEVEN LANES
NO CENTER STRIPE
CW21-15 36" x 36"
NEXT XX MILES
BLASTING ZONE 1000 FT
CW22-1 48"x48"
GENERAL NOTES:
ALL SIGNS DETAILED ON THIS SHEET SHALL HAVE BLACK BORDER, LEGEND AND/OR SYMBOL ON AN ORANGE REFLECTIVE BACKGROUND.
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
BARRICADE AND CONSTRUCTION STANDARDS
ADDITIONAL WARNING SIGNS
BC(7)-82

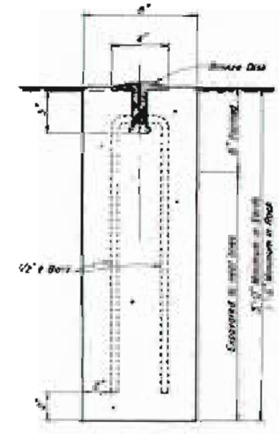
GENERAL NOTES

THE REQUIREMENTS FOR THE ABSOLUTE VOLUME MIX DESIGN AND THE WEIGHING OF THE INGREDIENTS FOR THE CONCRETE IN ALL MARKERS WILL BE WAIVED. MIXING OF CONCRETE MAY BE ACCOMPLISHED IN ANY MANNER SATISFACTORY TO THE ENGINEER.

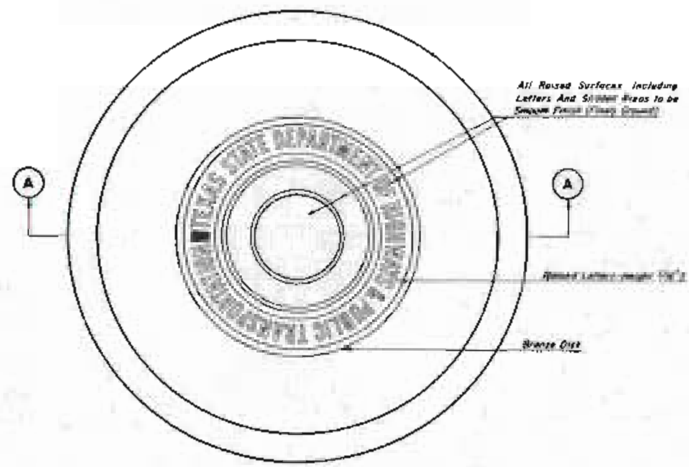
THE WORK PERFORMED AND MATERIALS FURNISHED IN CONSTRUCTING RIGHT-OF-WAY MARKERS MEASURED AS PROVIDED IN ITEM 530 OF THE STANDARD SPECIFICATIONS SHALL BE PAID FOR AT CONTRACT UNIT PRICE BID FOR "RIGHT-OF-WAY MARKERS (TYPE I)," OR "RIGHT-OF-WAY MARKERS (TYPE II)."



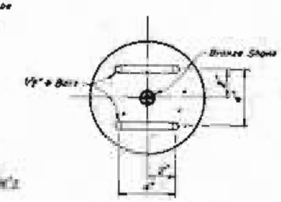
SECTION THRU TOP OF MARKER



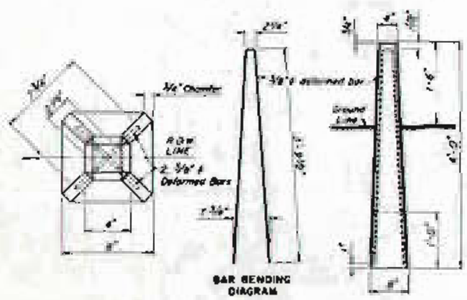
SECTION AA



TOP VIEW OF MARKER



CROSS SECTION THRU MARKER



RIGHT-OF-WAY MARKER - TYPE I

Type I Right-of-Way Markers shall be precast concrete, and shall be installed at designated points to the depth, lines, and grades established by the Engineer.

In case the material to be excavated consists of rock or hard clay, this Marker may be shortened 12" if so directed by the Engineer.

RIGHT-OF-WAY MARKER - TYPE II

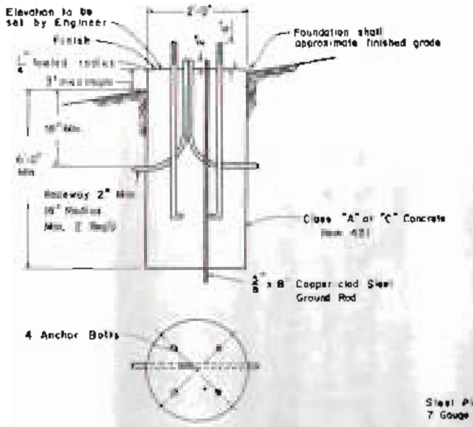
TYPE II RIGHT-OF-WAY MARKERS SHALL BE POURED IN PLACE CONCRETE, AND BRONZE DISKS SHALL BE SET TO CORRECT LINE AND GRADE AS DIRECTED BY THE ENGINEER.

BRONZE DISKS SHALL BE OF ARCHITECTURAL BRONZE HAVING THE FOLLOWING COMPOSITION: COPPER 85%, TIN 5%, LEAD 5%, ZINC 5%. EXCAVATION FOR MARKERS SHALL BE MADE TO NEAT LINES EXCEPT FOR THE TOP 6" OF THE MARKER WHICH SHALL BE FORMED WITH REMOVABLE FORMS OF SHEET METAL OR OTHER SUITABLE MATERIAL. THE TOP PART OF THE MARKER AROUND THE BRONZE DISK SHALL RECEIVE A STEEL TROWEL FINISH.

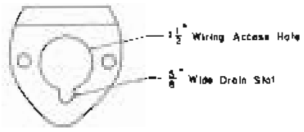
AFTER THE CONCRETE HAS TAKEN ITS FINAL SET, THE ENGINEER WILL STENCIL REQUIRED SURVEY DATA AND, WITH CHISEL OR CENTER PUNCH, CUT CROSS MARKING EXACT LOCATION OF RIGHT-OF-WAY LINE IN THE BRONZE DISK.

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

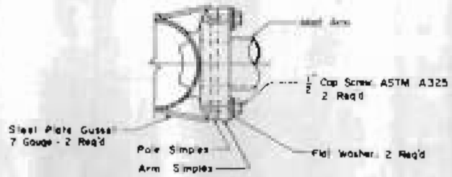
RIGHT-OF-WAY MARKERS
M-83A



FOUNDATION DETAIL (TYPE A)

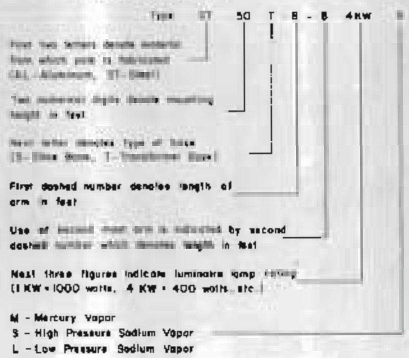


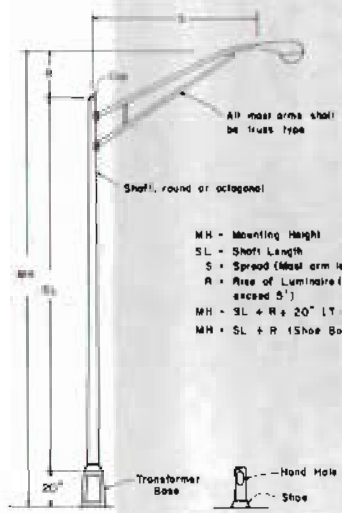
MAST ARM CONNECTOR



MAST ARM TO POLE SHAFT CONNECTION

EXPLANATION OF ROADWAY ILLUMINATION ASSEMBLY DESIGNATIONS





ROADWAY ILLUMINATION ASSEMBLY

GENERAL NOTES:

I SCOPE

Details herein apply to roadway lighting installations bid under the following Specification Items: Roadway Illumination Assemblies, Roadway Illumination Assembly Foundations, Electrical Conductor, Duct Cable, Circuit Protector Assembly, Service Poles, Transformer Stations and Special Specifications relating to lighting and electrical items. All work, materials and services not shown on the plans which may be necessary for complete and proper construction shall be performed, furnished and installed by the Contractor. Faulty fabrication or poor workmanship in any material, equipment and installation will be considered justification for rejection. Materials and installation shall comply with the applicable provisions of the National Electrical Code and National Electrical Manufacturers Association standards.

II MATERIALS

A. General. All materials shall be new and unused and shall be of the latest design.

B. Roadway Illumination Assembly

1. Structural Support Design for Mast-Arm Mounted Luminaires

Lighting standards shall be designed in accordance with the latest issue of AASHTO's "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals", using wind loads based on a 50-year mean recurrence interval. The Engineer may require design calculations to be submitted.

2. Slip Joint Poles. Poles may be fabricated in two sections and field-assembled by the lap-joint method. The two sections shall telescope together with a lap length of not less than 1 1/2 times the shaft diameter at the lap joint. The longitudinal seam weld within 12 inches of the slip joint shall be a full penetration weld.

3. Mast Arm Attachments. All poles shall be designed to support the various mast arm-luminaire combinations. All mast arms for supporting high pressure luminaires shall be designed for a [illegible]-pound luminaire having an effective projected area of 1.6 square feet. All mast arms for supporting low pressure sodium luminaires shall be designed for a [illegible]-pound luminaire having an effective projected area of 1.96 square feet.

4. Minor Damage Repair. The finished pole shall have a smooth, uniform finish free of pits, blisters or other defects. Scratched, chipped, or damaged areas on galvanized poles and mast arms shall be thoroughly cleaned by wire brushing. The cleaned area shall be painted with two coats of zinc dust-zinc oxide paint conforming to the requirements of Federal Specifications TT-P-641b, or repaired by the application of repair compounds meeting Federal Specification [illegible] (stick only) in accordance with the manufacturer's recommendations.

5. Straightness of Shaft. At any time prior to erection the pole shaft may be inspected for straightness. A deviation in excess of 1/4 inch in ten feet shall be considered cause for rejection.

6. Pole Bonding Means. All poles for shoe base mounting, including poles on concrete traffic barriers, shall have a grounding lug with ½-13 NC threads inside the pole near the hand hole.

7. Hand Holes. All poles for shoe base mounting shall have hand holes with reinforcing frames and covers. The openings on all poles shall be approximately 4" x 6½" located approximately 18" from the bottom of the pole and, except for poles mounted on concrete traffic barrier, shall be placed 90 degrees to mast arm unless otherwise noted on the plans.

8. CTB Poles. Poles installed on concrete traffic barrier shall also meet the requirements of CTB details.

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

ROADWAY ILLUMINATION DETAILS

RID (1)-82

GENERAL NOTES:

9. Steel Poles

a. Steel poles shall be fabricated in accordance with the Item "Steel Structures." Longitudinal seam welds for pole sections shall have 60% minimum penetration. The pole shaft to base flange connection shall be open-ended to allow proper draining during galvanizing. All welding shall be in accordance with Departmental Construction Bulletin C-5. Two-section poles joined by circumferential welds will not be permitted.

b. Pole components shall be constructed using the following materials:

Shaft: ASTM A-570 Grade 45 or ASTM A-607 Grade 45 or ASTM A-595 galvanized in accordance with ASTM A-123.

Base Flange: ASTM A-27 Grade 65-35 or ASTM A-36 - galvanized in accordance with ASTM A-123.

Mast Arm Fittings: ASTM A-27 Grade 65-35 - galvanized in accordance with ASTM A-153.

Mast Arms: Steel Pipe ASTM A-53 Grade A or B - galvanized in accordance with ASTM A-123.

Pole Cap: ASTM A-27 or ASTM A-48, galvanized in accordance with ASTM A-153; or aluminum alloy ASTM B-26 or B-108 [illegible], secured by three machine screws.

Pole Hardware: All fasteners except mast arm connection bolts shall be stainless steel or standard steel machine bolt galvanized ASTM A-153. Mast arm connection bolts shall be ASTM A-325, ASTM A-321 or ASTM A-193 Grade B-7, galvanized ASTM A-153. Lock washers shall be provided for mast arm connection bolts. Nuts and washers shall be compatible with the bolts and shall be stainless steel or steel, galvanized ASTM A-153.

Alternate material equal to or better than those specified may be substituted with the approval of the Engineer.

10. Aluminum Poles

a. Aluminum poles shall be fabricated in accordance with AASHTO's "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals."

b. Pole components shall be constructed using the following material:

Shaft: ASTM B-221 or B-241 [illegible], ASTM B-209 [illegible], ASTM B-221 [illegible].

Base Flange: ASTM B-108 or B-26 [illegible]; ASTM B-108 [illegible].

Mast Arm Attachments: ASTM B-209 [illegible]; ASTM B-221 [illegible].

Mast Arms: ASTM B-241 6061-T6 or 6063-T6.

Cap: ASTM B-209 [illegible]; ASTM B-108 or B-26 [illegible].

Bolts: Stainless Steel AISI 300. Bolts threading into aluminum threads shall be treated with anti-seize compound; Never-Seez Compound or Permatex 133K or equal.

Alternate material equal to or better than those specified may be substituted with the approval of the Engineer.

C. Foundations

1. Concrete for foundations will be included for payment under Item "Roadway Illumination Assembly Foundations" only.

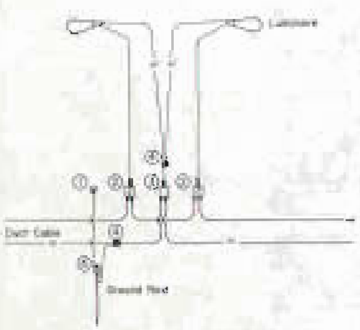
2. Anchor bolts for all poles except CTB-mounted poles shall be steel, ASTM A-36. Anchor bolts for CTB-mounted poles shall be steel, ASTM A-325. The top 8" of anchor bolts shall be galvanized. Alternate material equal to or better than material specified may be substituted with the approval of the Engineer.

3. Anchor bolts shall be [illegible] x 48" with top threaded not less than 5 inches and furnished with galvanized hexagon nuts, flat and lock washers. The lower end of the bolt shall be bent at a right angle or threaded and furnished with nut and washer. When bolts with rolled threads are furnished, bolt body need not be full size.

4. The bolt circle in foundations for shafts 36 feet and less shall be 13 inches in diameter. The bolt circle in foundations for shafts in excess of 36 feet shall be 17½ inches in diameter if a transformer base is used and 15 inches if a shoe base mounting is used. Poles placed on existing bridge brackets or foundations shall be coordinated with anchor bolts in place.

D. Transformer Base

1. Transformer base shall be cast from aluminum alloy ASTM B-108 or B-26 356.0T6 and shall be furnished with four galvanized anchor lugs ½ inch thick (minimum) and shaped to conform with the transformer base flange. Transformer base shall have a bolt circle at the bottom to match bolt circle of the foundation and a bolt circle at the top to match bolt circle of the pole. The transformer base shall be approximately 20 inches high and shall have a door approximately 13" x 8" x [illegible]. Screws or bolts for attachment of door to base shall be treated with anti-seize compound: Never-Seez Compound, Permatex 133K or equal. Four anchor bolts with four nuts, eight flat washers and four lock washers, galvanized ASTM A-153, shall be provided with each transformer base. A ½-13 NC grounding lug shall be provided inside the transformer base.



FOR TWO-WIRE GROUNDED CIRCUITS

NOTES

① Pole Bonding Connector - Blackburn *TTC3 or Weaver *[illegible] or equal

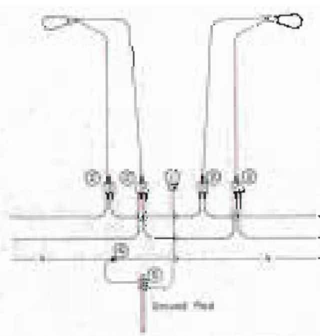
② Fused Connector - [illegible] or equal

*③ Un-fused Connector - [illegible] X8920 or equal

④ Split Bolt Connector

⑤ Ground Rod Clamp - 2 Required - Blackburn GG 5/8H, [illegible] or equal

*For Transformer Base Poles. On Shoe Base Poles, connect Luminaire neutral to Pole Bonding Connector.



FOR THREE-WIRE CIRCUIT CENTER GROUNDED

TYPICAL WIRING - ROADWAY ILLUMINATION ASSEMBLY
Twin Luminaire Shown - Single Luminaire Similar

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

ROADWAY ILLUMINATION DETAILS

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GENERAL NOTES:

D. Transformer bases shall meet the breakaway requirements of AASHTO's "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals," 1975 edition, and shall have been tested by FHWA-approved methods. Bases shall also have been tested to meet the design load for a 15-foot mast arm pole in a 90 mph wind. Certification for both tests shall be submitted with the shop drawings.

E. All Luminaires

1. The luminaire housing shall be cast or drawn from a non-ferrous alloy and shall be free of cracks and excessive porosity. All nuts, screws, clips, washers and attaching hardware shall be made of stainless steel or steel electro-zinc-plated, minimum thickness 0.0002 inch with olive drab or yellow chromate conversion coating, except that brackets may be made from pre-galvanized steel. All threaded surfaces used in the housing shall be lubricated with a silicone grease.

2. The slipfitter shall securely clamp the luminaire to the mast arm. A positive means of vertical adjustment shall be provided. The refractor shall be crystal-clear pressed glass. The optic assembly shall be provided with resilient gaskets and so constructed that a positive seal against weather and other contaminants will be maintained. The luminaire shall be designed to permit ready removal of the refractor from the luminaire but shall provide a positive means of preventing an unintentional separation. The latch shall provide a positive means of maintaining closure of the luminaire. The socket shell shall be rigidly attached to a high grade porcelain base which shall extend and completely enclose the metal shell. A locking means shall be incorporated in the shell of the socket to positively resist the removal of the lamp.

3. Mast-arm mounted luminaires shall be provided with a leveling device which is clearly visible from the ground. Unless otherwise directed by the Engineer, mast-arm mounted luminaires will be tested and installed in the level position.

4. The underpass luminaire shall have mounting provisions to attach the luminaire directly to the wall or to an outlet box. Wiring entries into the luminaire shall be made through threaded holes or water-tight hubs. Luminaire housing, raceway fittings and attaching hardware shall be installed in such a manner as to prevent water entry into the luminaire or ballast housing. A protective guard shall be provided for the refractor.

F. High Pressure Sodium Vapor Luminaires

1. Photometrics

a. The 250-watt luminaire, when mounted 40 feet above the midpoint of either long side of a rectangular area 200 feet by 50 feet, shall provide a measured minimum intensity of 0.1 footcandle at any point on the surface of this area. Light intensities measured in footcandles along a line parallel to and 20 feet in from the long side of the previously defined rectangular area above which the luminaire is mounted shall decrease at a rate not to exceed 0.8 footcandle in any ten-foot interval along the aforementioned line from 10 to 70 feet on both sides of the luminaire.

The uniformity factor "F" shall be not less than 7.0 when calculated from the equation:

$$F = \frac{L\ (I\ Min.)}{I\ Max.}$$

Where: F = the uniformity factor
L = 200
I Min. = minimum measured intensity within the rectangle
I Max. = maximum measured intensity within the rectangle

b. The 400-watt luminaire, when mounted 50 feet above the midpoint of either long side of a rectangular area 230 feet by 80 feet, shall provide a measured minimum intensity of 0.1 footcandle at any point on the surface of this area. Light intensities measured in footcandles along a line parallel to and 30 feet in from the long side of the previously defined rectangle above which the luminaire is mounted shall decrease at a rate not to exceed 0.8 footcandle in any ten-foot interval along the aforementioned line from 10 to 70 feet on both sides of the luminaire.

The uniformity factor "F" shall be not less than 7.0 when calculated from the equation:

$$F = \frac{L\ (I\ Min.)}{I\ Max.}$$

Where: F = the uniformity factor
L = 230
I Min. = minimum measured intensity within the rectangle
I Max. = maximum measured intensity within the rectangle

c. The luminaires shall meet the photometric requirements of paragraphs F.1a or F.1b when energized at 90 percent of rated line voltage.

2. Ballasts

a. The ballast shall be regulated-type with isolated windings and shall be designed to operate high pressure sodium lamps.

b. When the circuit voltage indicated in the plans is applied, the ballast input wattage during fluctuations of the test voltage of +5 and -10 percent shall not exceed the following:

Nominal Lamp Rating, Watts	Maximum Wattage Input
150	220
250	400
400	512

c. During fluctuation of the test voltage of +5 and -10 percent, the lamp wattage fluctuation shall not exceed a total of 20 percent and ballast shall maintain lamp wattage within the following limits:

Nominal Lamp Watts	Minimum Lamp Watts	Maximum Lamp Watts
150	110	180
250	175	370
400	288	475

d. The power factor of any ballast when tested at circuit voltage indicated in the plans shall be not less than 90 percent.

e. The electronic starting aid shall provide a starting pulse with an amplitude of 2500 volts minimum, 4000 volts maximum. The pulse width shall be a minimum of 0.9 microseconds at 2250 volts. The pulse shall occur when the open-circuit voltage is equal to or greater than 90 percent of peak open-circuit voltage. Pulse repetition rate shall be a minimum of one per cycle and pulse current shall be a minimum of 0.18 amperes. Electronic starting aids for mast-arm mounted poles shall be replaceable without the use of tools.

f. Ballasts shall permanently and clearly indicate the following: lamp type, catalog number, voltage rating, connection diagram, and manufacturer. Capacitors in all luminaires shall be non-PCB type.

3. Lamps

a. All lamps shall be new and shall have been manufactured within six months of the date the project is awarded.

b. High Pressure Sodium vapor lamps in the wattage range of 150 to 400 watts inclusive shall have a lamp voltage not greater than 108 volts when tested after thirty minutes' burn-in.

4. Testing

a. Ballasts and luminaires will be tested using a lamp furnished for the same project.

b. Luminaires, ballasts, and lamps will be sampled and tested in accordance with the Texas Highway Department Manual of Testing Procedures.

G. Wood Poles. For projects requiring more than 10 transformer and/or service poles, poles shall be creosote-treated to eight pounds per cubic foot-retention, or pentachlorophenol-treated to 0.4 pounds per cubic foot-retention in accordance with Item "Timber Preservation and Treatment."

For projects requiring ten or fewer poles, treatment shall be as stated above and Contractor may purchase poles locally if source and treatment are documented. Poles shall meet the requirements of ANSI O5.1-1972.

H. Electrical Conductors

1. All conductors shall be of annealed copper meeting the requirements of ASTM B-3 or B-33 and the NEC. All insulated conductors shall be stranded. Bare conductors No. 8 AWG and smaller shall be solid.

2. Insulated conductors shall be NEC Types TW, THW, THWN or XHHW. Where project plans specify Type TW or THW, any of the other types may be substituted. Conductors in circuits containing two or more insulated conductors shall be color-coded throughout the entire circuit. Color-coding will be required on pre-conduitized duct cable containing two or more insulated conductors.

3. Insulated conductors shall be marked in accordance with Article 310 of the NEC, and shall meet the requirements of Underwriters Laboratories' Standards.

I. Conduit and Fittings

1. Conduit must be UL Approved for the intended use shown on plan sheets. Aluminum conduit will not be permitted. Where project plans call for rigid metal conduit, NEC Type IMC conduit may be substituted, unless prohibited by plan note.

2. Fittings for Steel conduit shall be steel or malleable iron, threaded or threadless, rain-tight. Die cast, set screw, indenter or push-on locknut fittings will not be permitted.

3. Insulating-type fittings shall be used on all metallic conduit entries into sheet metal boxes or enclosures.

4. Expansion joints for metallic conduit shall be provided with a grounding strap. Expansion joints shall be Appleton UNYL 50 Series, OZ AX Series or equal, with expansion capacity as shown in plans.

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ROADWAY ILLUMINATION DETAILS
RID(3)-82

Rev. 82

GENERAL NOTES:

I. [illegible]

1. [illegible] ground boxes shall [illegible] 12" deep. [illegible] shall be construc[illegible] The cover shall be cast [illegible] with "ILLUMINAT[illegible]" [illegible] 18 [illegible] shall be provided under [illegible]

2. A [illegible] meeting [illegible] may be used if permitted by plan note:

   a. It shall be manufactured from [illegible] a [illegible] polyester resin and an aggregate.

   b. [illegible] inside dimensions (LxW[illegible]) [illegible] Type [illegible] Bottom edge of box or extension shall be [illegible]

   c. APM ground boxes shall be designed for AASHTO H20 loading (32,000 lb single axle load over 10"x 20" area)

   d. Cover shall be steel, hot-dipped galvanized, with "ELECTRIC" imprint

   e. A [illegible] gravel fill of 18 inches shall be placed under each ground box.

K. [illegible]

1. [illegible], hot-dipped galvanized, unless otherwise noted on plans.

2. [illegible] 1½" and larger shall be Crouse Hinds Type WAB, OZ Type YS, with [illegible], or approved equal. For conduit 1" or smaller, surface-mounted [illegible] 2" deep, Crouse Hinds Type CRFA, Appleton Type JBDX or approved equal.

3. [illegible] in concrete structures shall be Crouse Hinds, Appleton or approved equal, [illegible], but for flush mounting.

4. [illegible] made weathertight using threaded fittings or hubs, or with sealing [illegible]

L. [illegible]

1. [illegible] lighting pole conductors to line shall be Plastimold, Joy or equal.

2. [illegible] pole shall be stud-type, Blackburn CTC3, Weaver IGC3 or equal.

3. [illegible] conductors will be [illegible]

4. [illegible] permitted by the [illegible], insulated with [illegible] compound kit [illegible] applied sealant.

III [illegible]

A. [illegible] of poles, [illegible] and service poles is [illegible] and may be shifted [illegible]

B. [illegible]

1. Roadway illumination assembly poles shall be erected plumb and [illegible] shall be struck level and shims used to plumb pole, except that for shoe base poles le[illegible] used. Grout will not be placed between base flange and the foundation unless noted on pl[illegible] required by plan note, two 3/8" drain holes will be provided in the grouting.

2. In each pole, continuous, color-coded stranded No. 12 AWG Copper [illegible] in accordance with paragraph H.2. shall be connected to the line side of each ballast.

3. A fused connector assembly or fuse-holder as specified shall be [illegible] wire on the line side of each ballast. Luminaires on poles will be fused using quick-d[illegible] as shown in details. Underpass luminaires shall be fused internally. All fuses shall [illegible]

4. For median-mounted poles placed on concrete median barrier, all [illegible] holes) shall be on same side of the median.

5. Acorn nuts will not be allowed for attaching pole to transformer [illegible]

C. Duct Cable

1. Duct cable shall be placed by the open trench method, except where otherwise noted, at a depth of approximately 18 inches unless otherwise indicated.

2. Ends of all ducts shall be sealed with duct sealing compound. All ducts entering ground boxes shall be securely lashed together in a vertical position.

D. Conduit

1. Continuous runs of conduit in excess of 150 feet attached to structures shall have expansion joints at mid-span or 150-foot intervals and at structure expansion joints or as shown in plans.

2. Spacing of conduit hangers shall be as specified in the current issue of the NEC. Hange[illegible] Series J1200, Globe Series 450 or equal unless otherwise indicated in the plans.

3. Conduit hangers shall not be attached directly to prestressed concrete girders.

4. Conduit placement beneath existing paved surfaces shall be accomplished by jacking or boring in accordance with the pertinent provisions of Article 476.3 "Construction" of the Item "Jacking, Boring or Tunneling Pipe," unless otherwise noted on plans. Jacking, boring, or trenching will not be paid for directly but will be subsidiary to the Item "Conduit." Duct cable shall be extended through the conduit in one continuous length or conductors shall be encased in a continuous length of conduit where passing under an exist[illegible] burial of conductor will not be allowed.

E. [illegible]

1. [illegible] and prior to connecting ends, each continuous run of insulated [illegible] resistance of one megohm when tested at 500 volts D.C.

2. [illegible] system may be tested at the Engineer's option. Conductors exhibiting an insulation [illegible] one megohm shall be replaced by the Contractor at his own expense.

F. [illegible]

1. [illegible] that all exposed metal containing electrical conductors is bonded and grounded, us[illegible] ground rods, grounding bushings and locknuts and other fittings as necessary.

2. Metallic conduit, lighting poles, and luminaires on bridge structures shall be grounded. At each end of the structure a 5/8" x 8' copper-clad ground rod shall be driven in the ground and a No. 8 AWG copper grounding conductor shall be installed from the ground rod to the grounded conductor of the lighting circuit. The grounding conductor shall be bare or, if insulated, shall be green. Ground rods, connectors and grounding conductors will not be paid for separately, but will be subsidiary to the various bid items.

3. Lightning arrester grounding conductor shall be tied directly to the pole-grounding conductor.

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ROADWAY ILLUMINATION DETAILS

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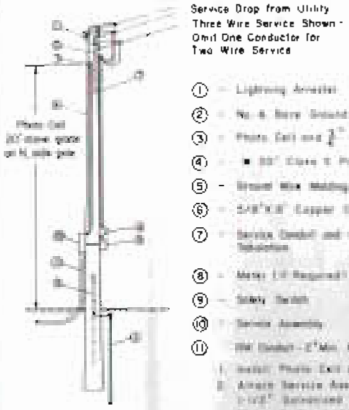
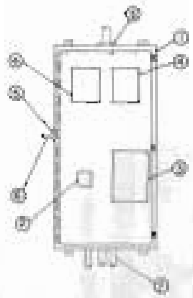


① - Lightning Arrester
② - No. 6 Bare Ground Wire
③ - Photo Cell and 1/2" RM Conduit - See Detail
④ - * 30' Class 5 Pole
⑤ - Ground Wire Molding - 8' Min.
⑥ - 5/8"x8' Copper Clad Ground Rod
⑦ - Service Conduit and Conductors - See Tabulation
⑧ - Meter (if Required)
⑨ - Safety Switch
⑩ - Service Assembly
⑪ - RM Conduit - 2" Min. for Duct Cable

1. Install Photo Cell on North Side of Pole.
2. Attach Service Assembly with 1-1/2" x 1-1/2" Galvanized Channel. Span Pole Two Places to Provide Flat Surfaces.

* Or As Required By NESC and Utility Company

TYPICAL SERVICE POLE
See Service Pole Schematic For Types



① - Enclosure with vertical piano hinge
② - Control Unit
③ - Lighting Contactor
④ - Circuit Breakers
⑤ - Conduit Hub
⑥ - Conduit to Photo Cell
⑦ Conduit as required

NOTE: If Utility provides controlled service, omit photo cell, control unit and contactor

SERVICE ASSEMBLY DETAIL

DETAIL
PHOTO CELL MOUNTING

GENERAL NOTES:

SERVICE POLE AND CIRCUIT PROTECTOR ASSEMBLY

1. Service Assembly Enclosure. NEMA 3 enclosure consisting of NEMA 12 enclosure with drip shield and conversion hardware, constructed of 14-gauge steel, with piano hinge and resilient gasket. Door held with clamps with provisions for padlocking. Equipment-mounting panel 12-gauge steel, primed and painted white. Enclosure shall be galvanized outside and primed and painted white inside.

2. Lighting Contactor. Electrically-held, of type designed to control tungsten, mercury vapor and other lighting loads, Square D Class 8903 Type S, Allen Bradley 702L or approved equal.

3. Control Unit. Standard duty 3-position (Auto-Manual-Off) control station in NEMA 1 enclosure.

4. Photo-Cell Control. Dry-type hermetically sealed cadmium sulfide cell, expulsion arrester and electro-mechanical relay, mounted in weatherproof plastic housing having twist-lock base. Turn-on range of 0.5 to 5 footcandles, factory-set at 1 ± ½ footcandle. Turn-off 2 footcandles higher than turn-on. Voltage range 100 to 285. Control circuit to be fused with enclosed in-line fuseholder and 5 ampere fuse.

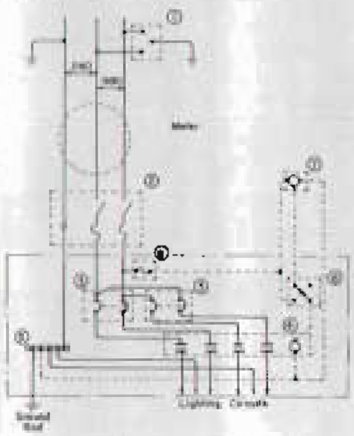
5. Lightning Arrester. Valve-type, 0-650 volt with bracket for pole mounting.

6. Circuit Breakers for a three-wire center-grounded 240/480 service shall be rated 277/480 volts. Circuit breakers for a two-wire 480 volt system shall be rated 480 volts, and shall control only one circuit. Circuit breakers for 120/240 volt systems shall be rated 240 volts.

7. Fusible Safety Switch shall be heavy-duty type, two-pole, rated 480 volts with a solid neutral assembly in a NEMA 3R enclosure. Switches for 240 volt systems shall be same except rated 120/240 volts. All fuses shall be time-delay type. When required by the Engineer, Contractor shall modify switch to allow padlocking in the "ON" position.

8. Metering. Where metering is required, utility company will provide the meter base. Contractor shall install the base. Some utility companies require the meter base to be installed on the load side of the safety switch. Contractor shall consult with the utility company before making up the service poles.

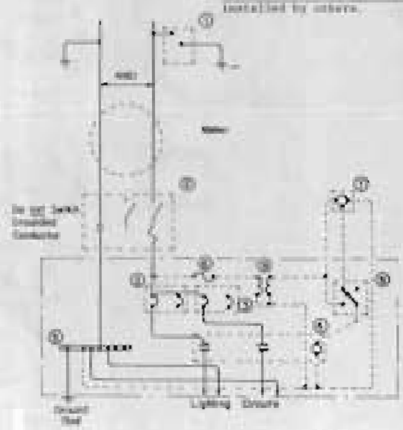
9. Circuit Protector Assemblies shall be similar to service poles except that wood poles will be furnished and installed by others.



SERVICE POLE TYPE A
240/480 VOLTS - THREE WIRE

1. Lightning Arrester
2. Fusible Safety Switch
3. Circuit Breaker, NEMA I Enclosure
4. Lighting Contactor
5. Factory-made Ground Bus
6. Insulated Fuseholder, 5 Amp Fuse
7. Photo-Electric Control
8. Control Unit - "Manual-Off-Automatic"
9. Control Transformer

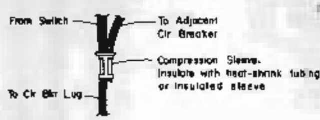
——— Power Wiring
- - - - Control Wiring



SERVICE POLE TYPE B
480 VOLTS - TWO WIRE

SERVICE POLES

Service Pole Designation	Type	Service Conduit Size	Service Conductors No./Size	Fuse/Switch Rating	Circuit Breakers	Contactor Poles/Amps	KVA Load



DETAIL
CONNECTION TO CIRCUIT BREAKER LUGS

SERVICE POLE SCHEMATIC

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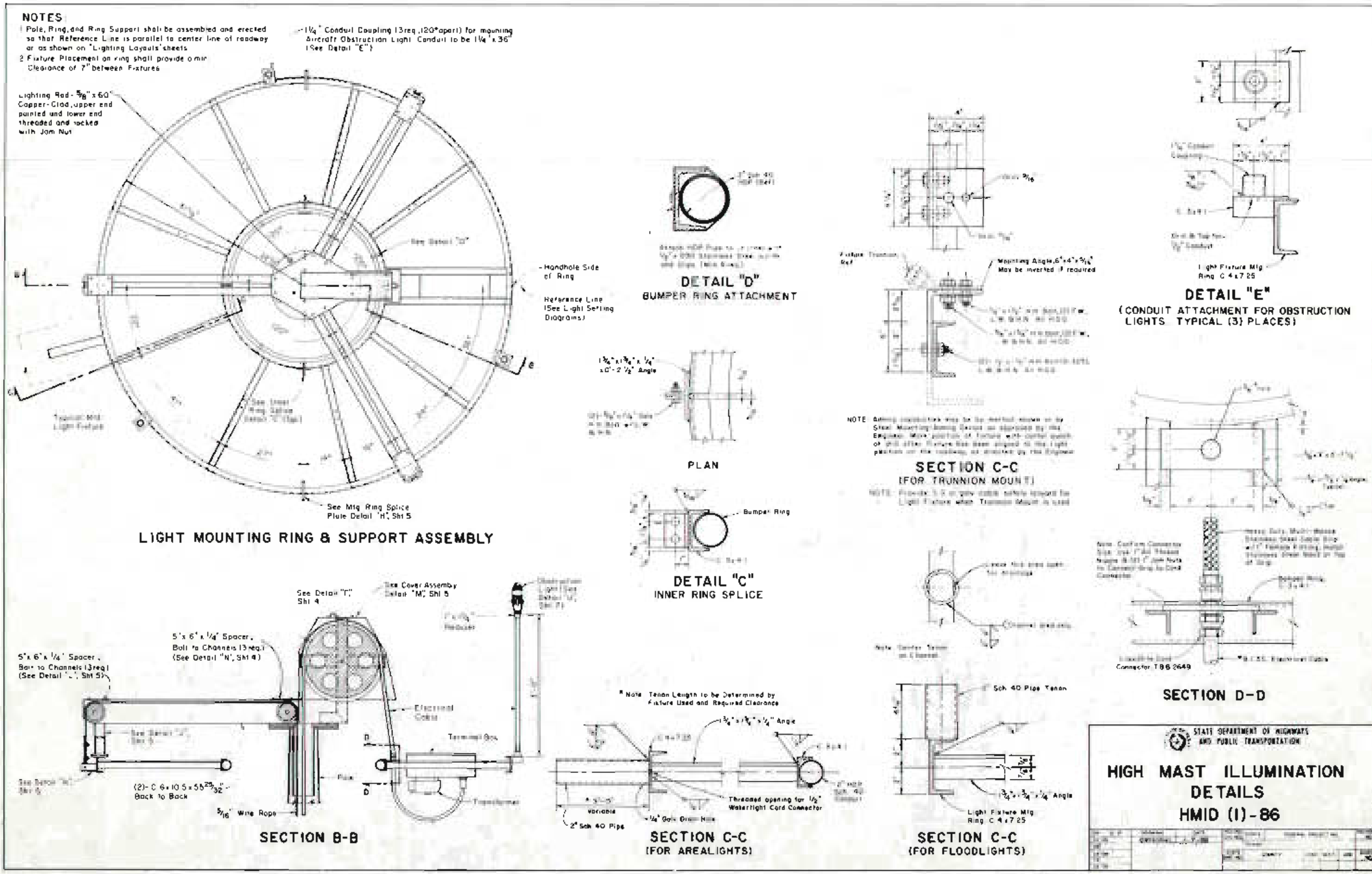
NOTES
1 Pole, Ring, and Ring Support shall be assembled and erected so that Reference Line is parallel to center line of roadway or as shown on "Lighting Layouts" sheets
2 Fixture Placement on ring shall provide a min Clearance of 7" between Fixtures
1¼" Conduit Coupling (3 req. 120° apart) for mounting Aircraft Obstruction Light. Conduit to be 1¼" x 36" (See Detail "E")
Lighting Rod - 5/8" x 60" Copper-Clad, upper end pointed and lower end threaded and locked with Jam Nut
Handhole Side of Ring
Reference Line (See Light Setting Diagrams)
See Mtg Ring Splice Plate Detail "H", Sht 5
LIGHT MOUNTING RING & SUPPORT ASSEMBLY
DETAIL "D"
BUMPER RING ATTACHMENT
PLAN
Bumper Ring
DETAIL "C"
INNER RING SPLICE
Mounting Angle, 6" x 4" x 5/16"
May be inverted if required
SECTION C-C
(FOR TRUNNION MOUNT)
DETAIL "E"
(CONDUIT ATTACHMENT FOR OBSTRUCTION LIGHTS TYPICAL (3) PLACES)
Light Fixture Mtg Ring C 4 x 7.25
SECTION D-D
Connector TBB 2649
See Detail "T" Sht 4
Side Cover Assembly Detail "M", Sht 5
5" x 6" x ¼" Spacer, Bolt to Channels (3 req.) (See Detail "N", Sht 4)
5" x 6" x ¼" Spacer, Bolt to Channels (3 req.) (See Detail "L", Sht 5)
Electrical Cable
Terminal Box
Pole
Transformer
(2)- C 6 x 10.5 x 55 23/32" - Back to Back
5/16" Wire Rope
SECTION B-B
* Note: Tenon Length to be Determined by Fixture Used and Required Clearance
1¾" x 1¾" x ¼" Angle
Threaded opening for ½" Watertight Cord Connector
¼" Galv. Drain Hole
2" Sch 40 Pipe
SECTION C-C
(FOR AREALIGHTS)
2" Sch 40 Pipe Tenon
1¾" x 1¾" x ¼" Angle
Light Fixture Mtg Ring C 4 x 7.25
SECTION C-C
(FOR FLOODLIGHTS)
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
HIGH MAST ILLUMINATION DETAILS
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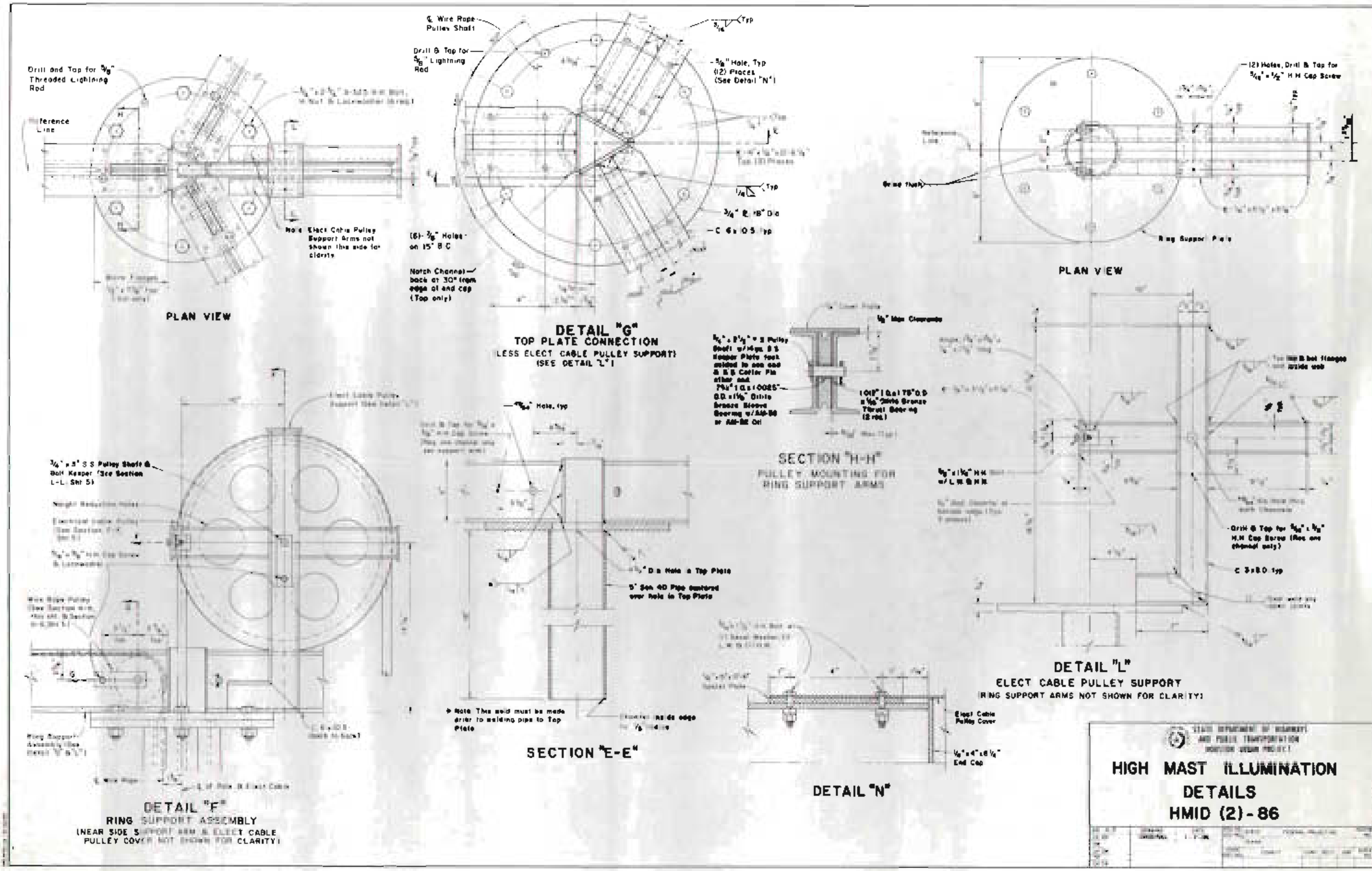
PLAN VIEW
Drill and Tap for 5/8" Threaded Lightning Rod
Reference Line
Note: Elect Cable Pulley Support Arms not shown this side for clarity
DETAIL "G"
TOP PLATE CONNECTION
(LESS ELECT CABLE PULLEY SUPPORT)
(SEE DETAIL "L")
℄ Wire Rope Pulley Shaft
Drill & Tap for 5/8" Lightning Rod
5/8" Hole, Typ (12) Places (See Detail "N")
(6)-7/8" Holes on 15" B.C.
Notch Channel back at 30° from edge of end cap (Top only)
3/4" ℞ 18" Dia
C 6 x 10.5 typ
PLAN VIEW
(2) Holes, Drill & Tap for 5/16" x 1/2" H H Cap Screw
Ring Support Plate
DETAIL "F"
RING SUPPORT ASSEMBLY
(NEAR SIDE SUPPORT ARM & ELECT CABLE PULLEY COVER NOT SHOWN FOR CLARITY)
SECTION "E-E"
5" Sch 40 Pipe centered over hole in Top Plate
SECTION "H-H"
PULLEY MOUNTING FOR RING SUPPORT ARMS
DETAIL "N"
Elect Cable Pulley Cover
End Cap
DETAIL "L"
ELECT CABLE PULLEY SUPPORT
(RING SUPPORT ARMS NOT SHOWN FOR CLARITY)
C 3 x 5.0 typ
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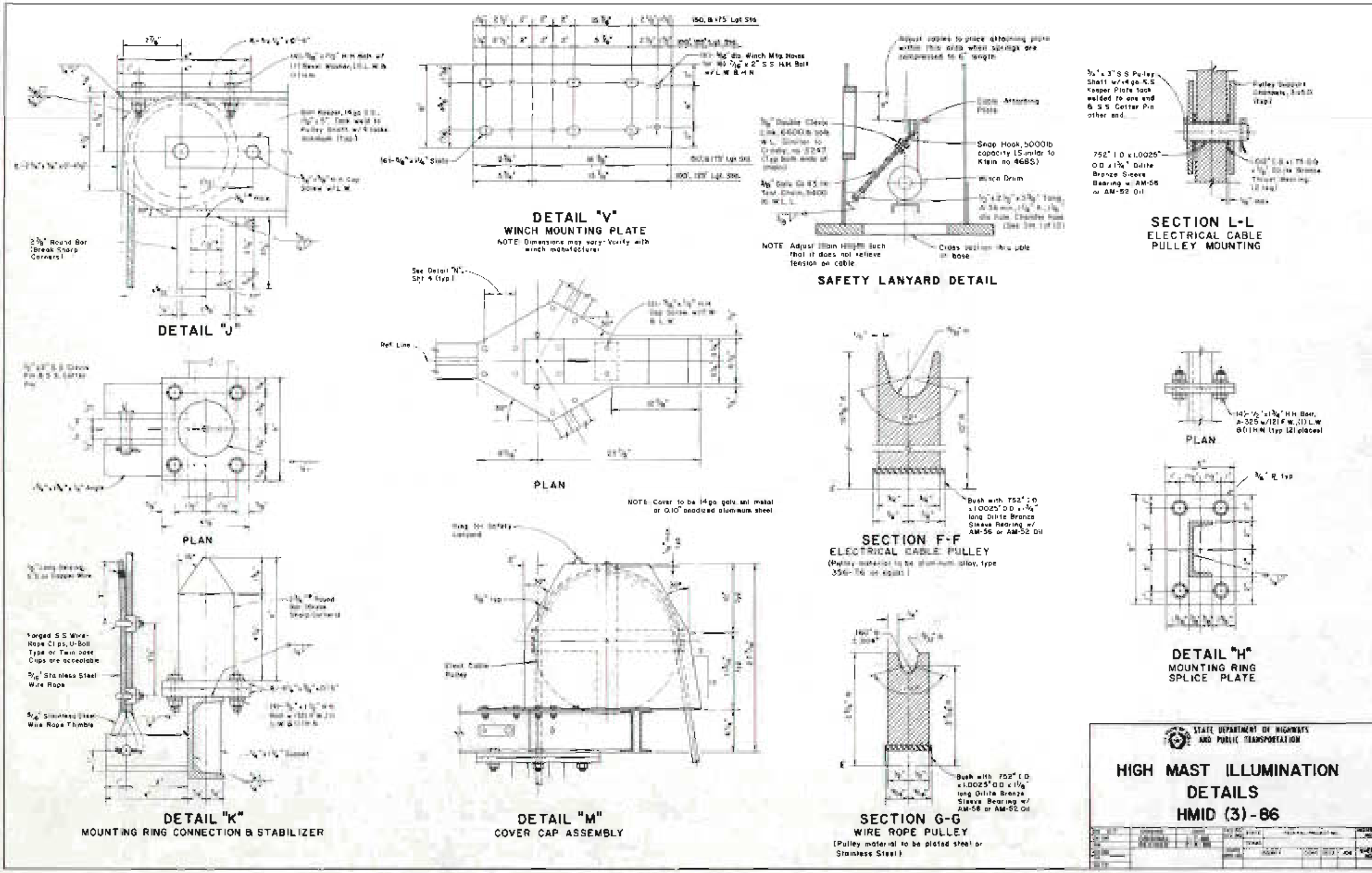
DETAIL "J"
PLAN
DETAIL "K"
MOUNTING RING CONNECTION & STABILIZER
DETAIL "V"
WINCH MOUNTING PLATE
NOTE: Dimensions may vary. Verify with winch manufacturer.
PLAN
NOTE: Cover to be 14ga galv. snt metal or 0.10" anodized aluminum sheet
DETAIL "M"
COVER CAP ASSEMBLY
SAFETY LANYARD DETAIL
SECTION F-F
ELECTRICAL CABLE PULLEY
SECTION G-G
WIRE ROPE PULLEY
(Pulley material to be plated steel or Stainless Steel)
SECTION L-L
ELECTRICAL CABLE PULLEY MOUNTING
PLAN
DETAIL "H"
MOUNTING RING SPLICE PLATE
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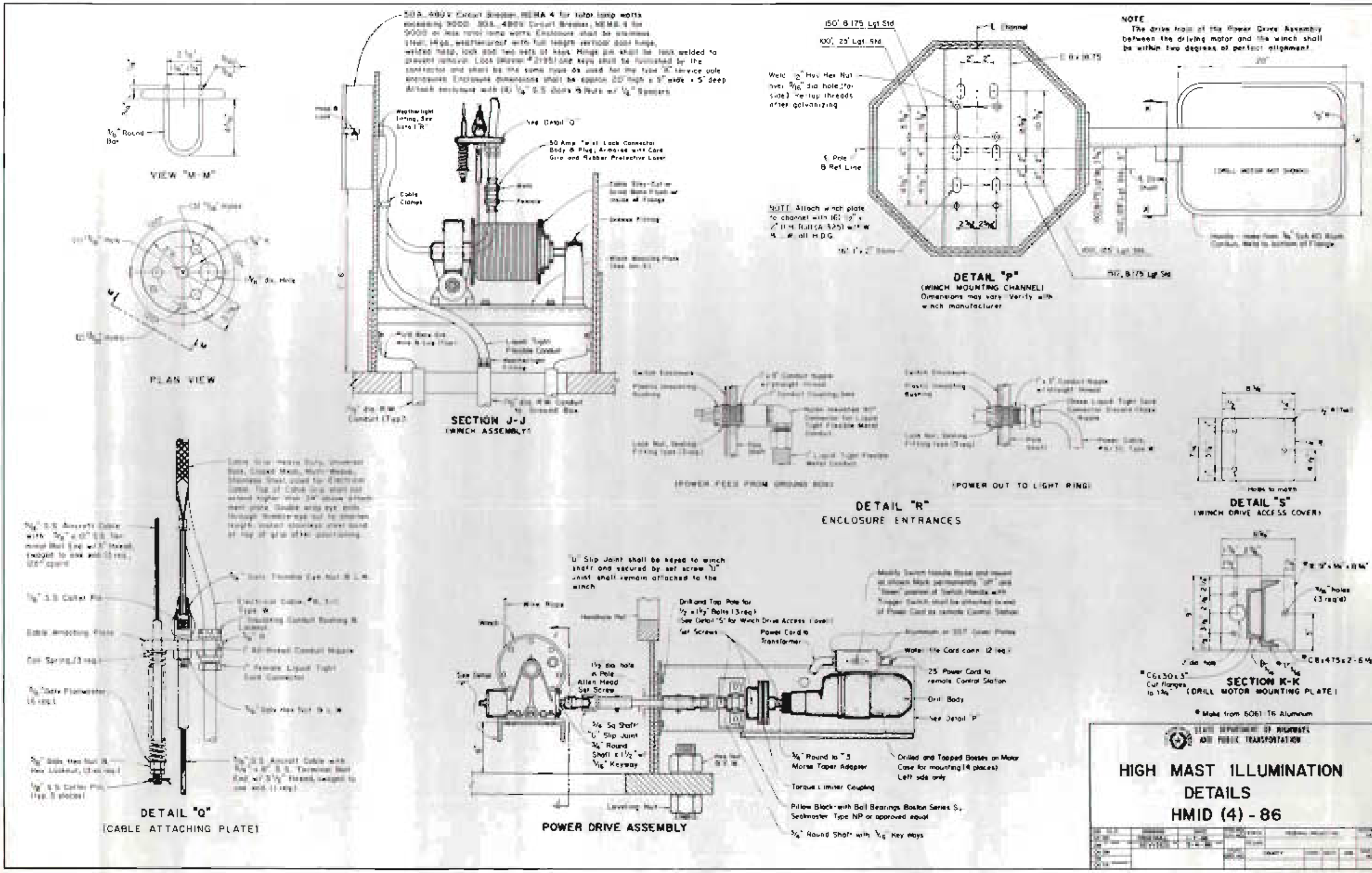
VIEW "M-M"
PLAN VIEW
SECTION J-J
(WINCH ASSEMBLY)
NOTE
The drive train of the Power Drive Assembly between the driving motor and the winch shall be within two degrees of perfect alignment.
DETAIL "P"
(WINCH MOUNTING CHANNEL)
Dimensions may vary - Verify with winch manufacturer
(POWER FEED FROM GROUND BOX)
(POWER OUT TO LIGHT RING)
DETAIL "R"
ENCLOSURE ENTRANCES
DETAIL "S"
(WINCH DRIVE ACCESS COVER)
SECTION K-K
(DRILL MOTOR MOUNTING PLATE)
Make from 6061 T6 Aluminum
DETAIL "Q"
(CABLE ATTACHING PLATE)
POWER DRIVE ASSEMBLY
Torque Limiter Coupling
Pillow Block-with Ball Bearings Boston Series S, Sealmaster Type NP or approved equal
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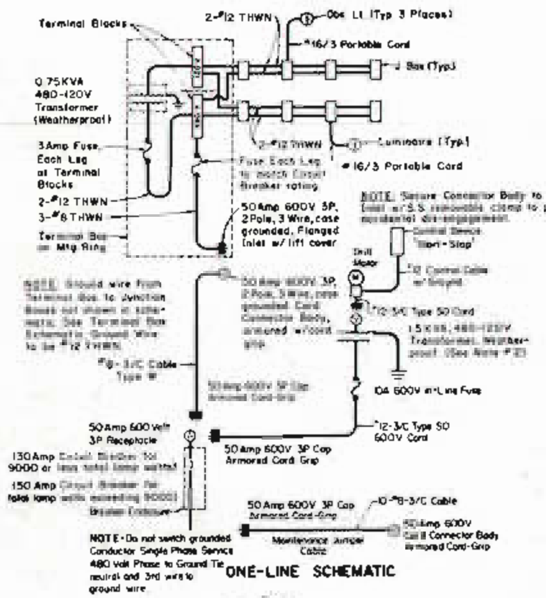
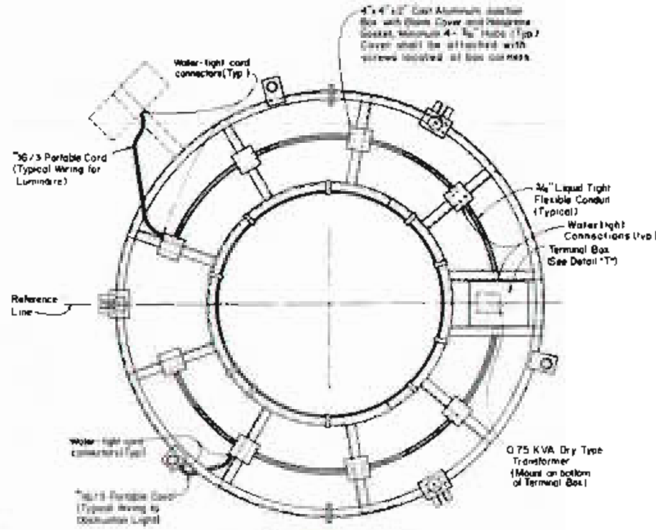
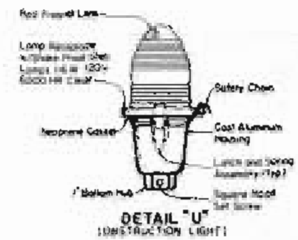


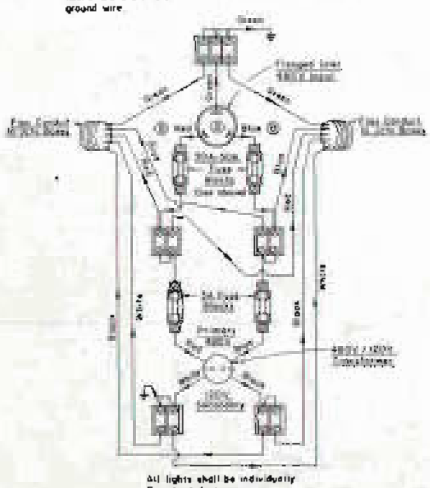
ONE-LINE SCHEMATIC



LIGHT MOUNTING RING



DETAIL "U"
(OBSTRUCTION LIGHT)

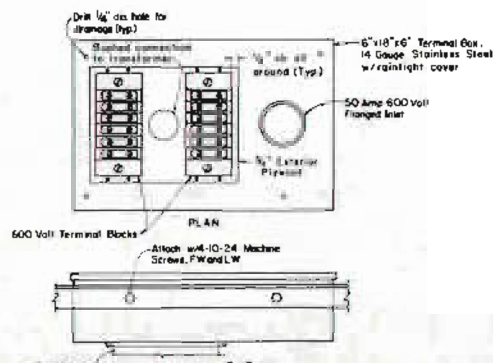


All lights shall be individually Fused at fixture

TERMINAL BOX SCHEMATIC

NOTES:

1. Obstruction Lights Color Code: From secondary side of transformer through [illegible]
2. Power Supply Cord to Flanged Inlet: [illegible]
3. Wire size from Power Supply to Terminal Blocks shall be [illegible]
4. Wire size from Terminal Blocks to Junction Boxes shall be [illegible] AWG.
5. Mount Terminal Blocks on 3/4" exterior grade plywood.
6. For 3-Wire, 480V Service, [illegible] in grounded conductor.



DETAIL "T"
(TERMINAL BOX)

GENERAL NOTES

1. All caps, connector bodies and flanged inlets shall be "twist-lock" type, 3 prong, rated at 50 amps for 480V and 20 amps for 120V. 50 amp connectors shall be 3-wire grounding, armored, with cord grip. 20 amp connectors shall be 3-wire grounding with cord grip, NEMA Type L5-20.
2. Provide handle on 1.5KVA transformer for portability. (See One-Line Schematic above)
3. Circuit breakers shall be ITE #E43B030 or #E43B050, Square "D" #FAL24030 S/N or #FAL24050 S/N, or equal.
4. Conduit entries into Terminal Box shall be made with hubs in the side of the box.

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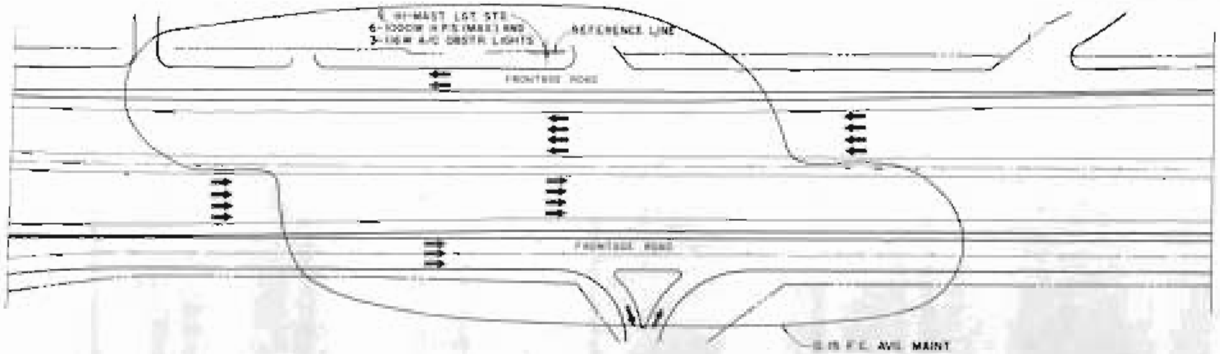
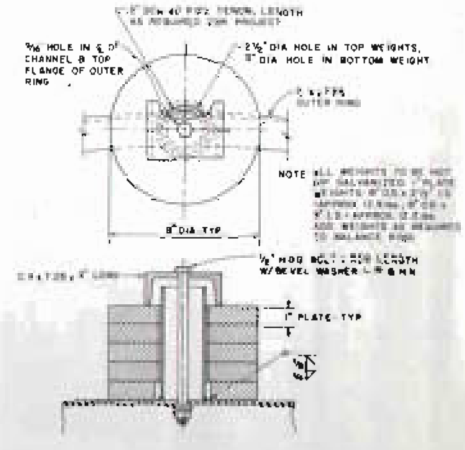
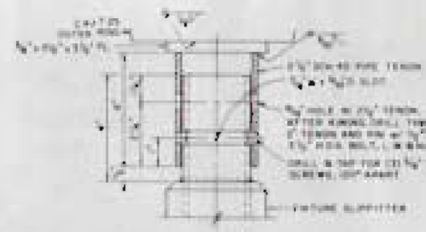


TYPICAL REVERSE "Z" PATTERN ARRAY

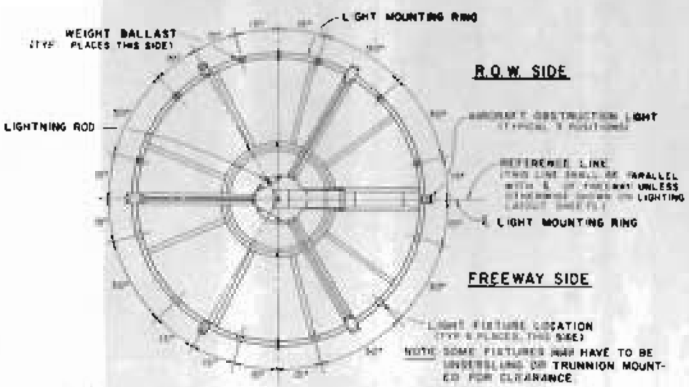
NOTES:
1. THE ABOVE PATTERN IS THE APPROXIMATE SIZE AND TYPE OF PATTERN TO BE PRODUCED BY EACH POLE. REVERSE "Z" PATTERN IS REQUIRED TO MINIMIZE GLARE TO THE ONCOMING MOTORIST.
2. SIX FIXTURES ARE THE MAXIMUM NUMBER ALLOWED PER POLE TO PRODUCE THE "Z" PATTERN. A LESSER NUMBER OF FIXTURES PER POLE WILL BE ALLOWED IF TESTING PROVES THAT THE LESSER NUMBER OF FIXTURES WILL PRODUCE THE REQUIRED PHOTOMETRICS.



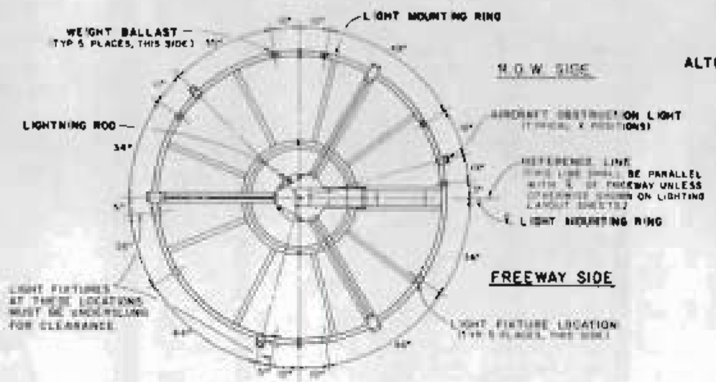
SUGGESTED COUNTERWEIGHT DETAIL



ALTERNATE UNDERSLUNG FIXTURE TENON DETAIL



LIGHT MOUNTING RING & SUPPORT ASSEMBLY (6 LIGHT "Z" PATTERN)



LIGHT MOUNTING RING & SUPPORT ASSEMBLY (5 LIGHT "Z" PATTERN)

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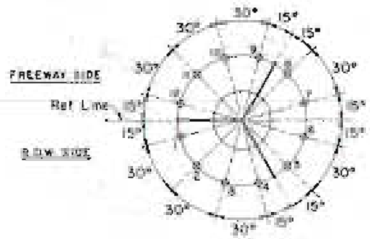
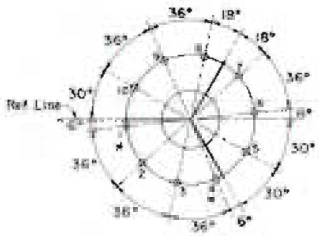
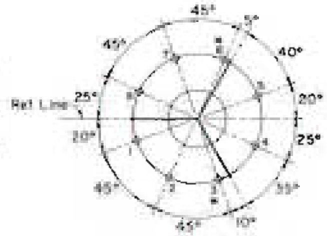


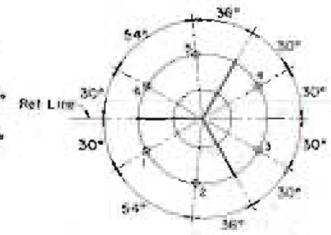
12-LIGHT SETTING



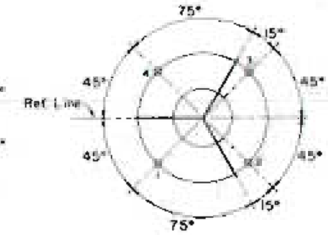
10-LIGHT SETTING



8-LIGHT SETTING



6-LIGHT SETTING



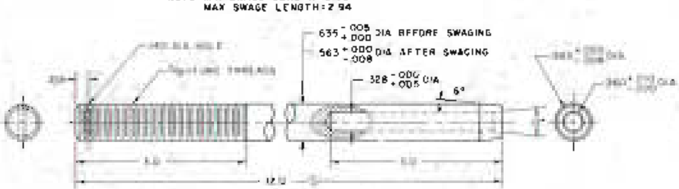
4-LIGHT SETTING

LUMINAIRE LOCATIONS

* - NOTE: FIXTURES AT THESE LOCATIONS MAY HAVE TO BE UNDERSLUNG TO CLEAR SUPPORT ARM. THIS WILL BE DETERMINED BY FIXTURE SUPPLIES AND MOUNTING REQUIREMENTS.

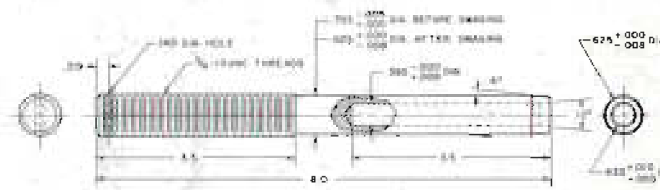
NOTE: Aircraft Obstruction Light locations not shown. Three are required located approx. (120° apart). Locations will vary dependent on the light setting used.

NOTE: MIN SWAGE LENGTH = 2.06
MAX SWAGE LENGTH = 2.94



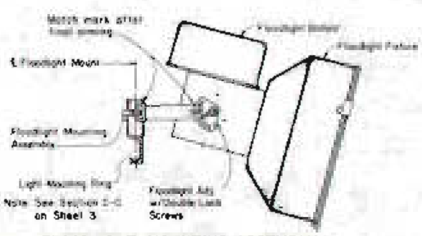
TERMINAL FOR 5/16" WIRE ROPE
MATERIAL: STAINLESS STEEL, TYPE 303SE OR 304 WITH 115,000 p.s.i. MAX ULTIMATE TENSILE STRENGTH

NOTE: MIN SWAGE LENGTH = 3.12
MAX SWAGE LENGTH = 3.44

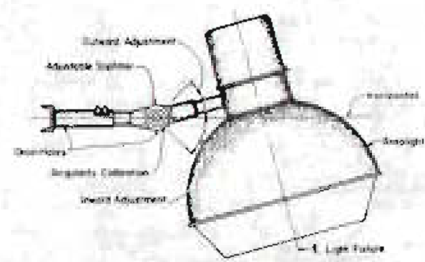


TERMINAL FOR 3/8" WIRE ROPE
MATERIAL: STAINLESS STEEL, TYPE 303SE OR 304 WITH 115,000 p.s.i. MAX ULTIMATE TENSILE STRENGTH

FLOODLIGHT MOUNTING ASSEMBLY
(UNDERSLUNG TRUNNION TYPE)



FLOODLIGHT MOUNTING ASSEMBLY
(METHOD OF MOUNTING MAY VARY)



AREALIGHT MOUNTING ASSEMBLY
(SYMMETRIC AND ASYMMETRIC)

NOTES: Adjustable Slipfitter to be furnished only on Arealight units noted and only if aiming capabilities are not built into lighting units provided for this project.
See schedule for Light Fixtures to be adjusted.
Final adjustment shall be made in the field as directed by the Engineer.
If Asymmetric Fixtures are used, the Refractors shall be oriented to properly illuminate the adjacent roadways. Orientation shall be as shown in plans.

GENERAL NOTES:

1. After final aiming has been completed and approved by the Engineer, fixtures must be locked in position. Contractor must submit proposed locking scheme with the fixture submittal.

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1. AREA LIGHTING

A. Area lighting shall be Symmetric, Asymmetric or Area Floodlights. The number and wattages of the fixtures on each pole shall be as shown on the lighting layouts. The lighting pattern for symmetric fixtures shall be IES Type V, for asymmetric fixtures, IES Type IV.

B. The lighting systems shall produce an average initial horizontal foot-candle level of 1.1 fc on main lanes, direct connections, and other areas shown on plans. The average to minimum ratio shall be no greater than 3 to 1. Light intensities along the roadway shall decrease at a rate not to exceed 1.0 footcandles when measured on a 15 foot grid. The minimum initial intensity on areas described above shall be not less than 0.4 horizontal footcandles except at outer perimeters of HM-lighted areas. For area floodlights, Contractor shall furnish aiming charts. Photometric performance will be determined on the roadway after installation, or at the Engineer's option, will be tested at the Department's test facility.

C. Symmetric and Asymmetric fixtures shall meet the following requirements:

(1) Ballast housing shall be cast aluminum with horizontal slipfitter for 2 inch pipe tenon. Slipfitter shall provide ± 3 adjustment for leveling fixture.

(2) The optic assembly shall be either of the assemblies listed below or approved variation thereof:

a. A pressed prismatic annealed borosilicate glass reflector with spun-sealed metal cover and open borosilicate refractor.
b. A sealed unit with aluminum alzak reflector and equipped with a tempered door glass.

(3) Lamp sockets shall be mogul and porcelain-enclosed with a lamp-gripping device. Lamp socket mounting shall be adjustable. Fixture shall include an end lamp support opposite the base. All bolts, nuts and screws shall be stainless steel or hot-dipped galvanized.

(4) Fixture weight, including ballast, shall not exceed 70 pounds and effective projected area shall not exceed 2.5 square feet.

D. Area floodlights shall meet the following requirements:

(1) Area floodlights shall meet the photometric requirements stated in paragraph 1.B above, using a maximum of 12 - 400 watt HPS units per pole. Vertical aiming angles and candela distribution shall be such as to restrict maximum candela at 80 degrees above nadir to 12,500. Contractor shall submit for approval iso-candela curves and candela traces showing vertical and horizontal distribution through the zero axis of the floodlights. Where less than 12 floodlights are used, Contractor shall provide counterweights to balance the support ring.

(2) Floodlights shall have permanently marked scales for horizontal and vertical aiming. Scales will be in 5 increments. Contractor shall, after all aiming adjustments are made, mark final aiming settings on all floodlights.

(3) Floodlights shall be NEMA Class HDB (heavy duty with integral ballast), except that, where permitted by plan note, floodlights with fiberglass housings may be used. Lens retainer, slipfitter and trunnion-mounting bolts and all machine screws exterior and interior shall be stainless steel or hot-dipped galvanized. Floodlights shall have silicone rubber or elastomer gasket between door and housing. Lens shall be fully gasketed with high-temperature non-hardening pressure-applied mastic to insure a positive seal. Lens shall be heat and impact-resistance tempered glass. Reflector shall be removable. Lamp sockets shall be porcelain-enclosed with lamp-gripping device.

(4) Floodlight mounting may be trunnion or slipfitter types. Trunnions shall be constructed of 2" x 1/4" steel, hot-dipped galvanized or painted with two coats of ZRC paint. Trunnion length shall be as approved by the Engineer. Floodlights shall be fitted with a watertight cord connector for #16/3 portable cord. A grounding terminal shall be provided inside fixture housing.

(5) Area floodlights shall have an effective projected area not to exceed 3.3 square feet, except where floodlight with fiberglass housing is permitted, EPA may be 4.3 square feet.

2. Z-PATTERN LIGHTING

A. The number of units per pole shall be as required to produce the Z pattern. The beam spreads of the fixtures on each pole may be varied to produce the required lighting pattern shown on the plans and produce an initial average footcandle level of 1.1 on the travelways with the pole spacing and mounting height shown on the lighting layouts. The average to minimum ratio shall be no greater than 3 to 1 nor shall the maximum to average ratio exceed 3 to 1. Light intensities along the travelways shall decrease at a rate not to exceed 1.0 footcandles based on a 15 ft. grid. Initial spill light shall not exceed 0.15 horizontal footcandles at any point 100 feet outside the right of way on either side of the freeway facility. Photometric requirements specified will be determined on the roadway after installation or, at the Engineer's option, by testing at the Department's test facility.

B. Prior to approval of the floodlights for use on the project, the manufacturer, through the Contractor, shall submit to the Department complete fixture angle and aiming diagrams, aiming instructions and computer lighting arrays. In addition, the manufacturer shall submit test or experience data, acceptable to the Engineer, showing that the equipment to be furnished will provide roadway illumination that meets the specification requirements. Extrapolated, interpolated, or computer generated data will not be considered as satisfactory data.

C. Fixture shall be NEMA Type HDB aluminum and so constructed or sealed to prevent entrance of dirt, insects and other contaminants. Lens retainer, slipfitter and trunnion-mounting bolts and all machine screws exterior and interior shall be stainless steel or hot-dipped galvanized. Total weight of the fixtures and ballasts on each ring, not including the counterweights, shall not exceed 650 pounds. Maximum total projected area of the fixtures and ballast on each ring, not including counterweights, shall not exceed 22.0 square feet.

D. Floodlights shall be aimable and be equipped with permanently attached angularity aiming devices complete with vertical and horizontal degree scales. Contractor shall permanently mark the aiming angles for each floodlight.

E. Access for relamping or cleaning shall be by means of a hinged housing door, or side access cover, positively secured to prevent accidental separation.

F. Lens shall be heat and impact-resistant tempered glass.

G. Reflector shall be removable and shall have contours to produce the required beam pattern.

H. Gasket shall be extruded silicone or elastomer material between lens and door, and between door and housing in such a manner as to maintain a positive seal of the optic assembly against contaminants.

I. Socket shall be mogul with shake-proof shell and spring-loaded center contact. The socket shall properly locate the light source relative to the optic assembly.

J. Attachment of fixture to mounting ring shall be by means of slipfitter or trunnion mounts. Slipfitter shall be two inch with a minimum of two set screws. Trunnion shall have a minimum of two locking screws. Trunnions shall be constructed of 2" x 1/4" steel, hot-dipped galvanized or painted with two coats of ZRC paint. Trunnion length shall be as approved by the Engineer. Floodlights shall be fitted with a watertight cord connector for #16/3 portable cord. A grounding terminal shall be provided inside fixture housing.

K. If required to reduce stray light, back light and objectional glare, fixtures shall be equipped with internal aluminum louvers and/or external aluminum shields. Louvers and shields shall be attached so that it will not be necessary to remove them when relamping. If external shields are used, the total projected area of the fixtures, ballasts and shields shall not exceed specification limits.

L. 1000 watt fixtures shall include an end lamp support opposite the base.

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3. BALLASTS

A. Ballasts for 1000 watt HPS lamps shall be regulated auto-transformer type (CWA) rated 480 volts. Ballasts for 400 watt HPS lamps shall be regulated isolated winding type (CW) rated 480 volts. Ballasts shall be capable of starting lamps at an ambient temperature of -20 F. Ballast wiring shall include a grounding terminal bonded to metal housing. Ballasts shall be fused with time-delay fuses in insulated fuse holders, 8 amp for 1000 watt, 5 amp for 400 watt. Fuse holders shall be internal to the housing. Ballast wiring to terminal board shall be through a quick-disconnect plug. Ballast nameplate shall permanently and clearly indicate the following: Manufacturer's name, catalog number, voltage rating, lamp type, and connection diagram.

B. When the circuit voltage indicated on the plans is applied, the ballast input wattage during fluctuations of the test voltage of plus 5 percent and minus 10 percent shall not exceed the following:

Lamp Wattage	Maximum Wattage Input
400	552 Watts
1000	1400 Watts

C. During fluctuation of the line voltage of plus 5 percent or minus 10 percent, the lamp wattage fluctuation shall not exceed a total of 20 percent and ballast shall maintain lamp wattage within the following limits:

Nom. Lamp Watts	Minimum Lamp Watts	Maximum Lamp Watts
400	280	475
1000	750	1200

D. The power factor for all ballasts when tested at nominal line voltage shall be not less than 90 percent.

E. The electronic starting aid shall meet the following requirements:

	400 Watts	1000 Watts
Starting pulse amplitude, volts	2500 - 4000	3000 - 5000
Pulse width, minimum	1.0 micro-sec. at 2250 volts	4 micro-sec. at 2700 volts
Pulse peak current, min. amps	0.2	0.2
Pulse repetition rate, min.	50 per sec.	50 per sec.

Starting pulse position shall be between 90 percent of peak open circuit voltage (leading edge) and 20 electrical degrees beyond center of open circuit wave form, measured at 70 percent of peak voltage.

4. LAMPS

A. Lamps shall be high pressure sodium, 400 watt or 1000 watt as specified in the plans. Lamps shall have been manufactured no earlier than six months prior to date contract was awarded.

B. High pressure sodium lamps shall have the following characteristics:

Wattage	Average Initial Lumens	Average Rated Life (Hrs.)
400	50,000	24,000
1000	140,000	24,000

5. TESTING

A. Fixtures, lamps and ballasts will be sampled and tested in accordance with the Department Manual of Testing Procedures except as noted in these specifications.

B. Ballasts and fixtures will be tested using lamps furnished for the same project.

C. The Department will bear the cost of all testing of equipment that complies with the specification requirements. However, the source of supply of fixtures and ballasts must be approved as required in Article 6.1 of the Standard Specifications. Such approval will be contingent on the supplier agreeing to bear the cost of testing any equipment that fails to comply with the specification requirements listed in this specification.

D. All other equipment will be tested in accordance with Item 614 of the Standard Specifications and Materials and Test Division Test Standards.

E. After High Mast Assembly has been completely assembled, the Engineer may require to fully lower and raise each HM ring one time to demonstrate proper operation of the lowering mechanism. If any malfunction occurs, the problem shall be corrected at the Contractor's expense and the lowering test will be repeated.

6. MOUNTING RING AND SUPPORT ASSEMBLY

A. Ring and support assembly shall be fabricated from steel having a minimum yield strength of 36 KSI.

B. Cover assemblies, fittings and miscellaneous parts shall be as outlined on the plans.

C. All hardware shall be hot-dipped galvanized per ASTM A153 or shall be stainless steel, unless noted otherwise on plans.

7. WINCH

A. Housing shall be high tensile strength die-cast silicone aluminum. Cable drum shall be fabricated from seamless steel tubing with stamped steel flanges and shall be hot-dipped galvanized. Drum and flanges shall be sized so that, when the floodlight mounting ring is in the raised position, the cable will fill the drum to no more than two-thirds of full capacity. Drum shaft shall be ground from stainless steel and made of nickel-bronze and worm shaft shall be high-strength stress-proofed steel, ground and polished and supported by tapered roller bearings.

B. Gear ratio shall be 30:1 with safe hoisting capacity of not less than 4000 pounds.

C. Winch shall incorporate adjustable automatic brake to assure positive load suspension. Brake shall be multiple disc with friction plates running in oil bath and one-direction clutch which operates only when load is suspended or lowered. Winch shall not have throw-out clutch.

8. WIRE ROPE AND TERMINALS

A. Wire rope shall be 7 x 19 IWRC stainless steel, (Federal Specification RR-W-410D Type VI, Class 3), except where shown on plans, wire rope on winch shall be 19 x 7 rotation resistant stainless steel, (Federal Specification RR-W-410D Type IV, Class 2). All wire rope shall be preformed and factory lubricated. Wire rope shall meet the mechanical and chemical requirements of the applicable specifications. Quality Assurance testing shall be the responsibility of the manufacturer and shall meet recognized wire rope industry standards. No special tensile or torsion testing will be required. Mill test reports shall be furnished.

B. Winch cable shall be of sufficient length to leave a minimum of one full layer of cable on the drum when the floodlight mounting ring is in the full down position.

C. Wire rope terminals shall be stainless steel, solid stud type, as shown on HMID(7)-86 drawing. All terminals shall be drilled for cotter pins. Material to be 303 SE or 304 stainless steel with a maximum tensile strength of 115,000 psi. Mill test reports shall be furnished.

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D. All terminals shall be proof-tested by the manufacturer to 40% of rated strength of the wire rope. Each terminal shall be identified by manufacturer's logo permanently incised on terminal. Manufacturer shall furnish certification of tests. Contractor shall also furnish one sample of each size of terminal with 5' of wire rope for load tests by the State. Samples tested must withstand test load not less than 100 percent of rated breaking strength of wire rope. If sample fails test, all terminals of same size will be rejected.

9. SPRINGS

A. Provide three steel springs as shown on plans.

B. Springs shall have an uncompressed length of approximately 8 inches and shall compress 3 inches under 700-pound load.

C. Springs shall contain approximately 19 total coils with ID of 0.875 and OD of 1.375 inches. Ends shall be closed and ground. Springs shall be zinc-plated.

D. Springs shall be made from 1/4" diameter oil-tempered MB Steel treated for overstress. Springs shall not develop permanent set from 3-inch compression.

10. ELECTRICAL POWER CABLE

Power cable shall be No. 8AWG three-conductor round Type W, rated 90 C and 600 volts. Each conductor shall be copper and shall consist of 133 strands. Insulation shall be ethylene propylene rubber or other approved compound. Jacket shall be chlorosulfonated poly ethylene or other approved compound reinforced with glass fiber cord. Nominal diameter shall be approximately 0.91". Filler shall be rubber compound.

11. LUMINAIRE ELECTRICAL CORD

A. Portable cord for connecting luminaire to junction boxes shall be No. 16 AWG three-conductor portable cord rated 90 C and 600 volts.

B. Each conductor shall be copper and shall consist of 65 No. 34 strands.

C. Insulation shall consist of 2/64" of cross-linked reinforced modified DCP tripolymer compound. Jacket shall consist of 0.063" of cross-linked PTR elastomer. Nominal diameter of the cable shall be approximately 0.405".

12. POWER DRIVE ASSEMBLY (ONE ONLY THIS CONTRACT)

A. Drive Motor
- (1) Drive motor shall be 1-1/4" heavy-duty reversible portable electric drill modified as shown on plans.
- (2) Shall have 6 radial ball bearings, one ball-thrust bearing and one lubricant-impregnated bearing.
- (3) Shall have No. 3 Morse Taper socket.
- (4) Shall be designed for 115 volt 60 Hertz single phase operation 250 RPM at no load.
- (5) Shall be designed for continuous rated duty at 160 RPM and 12 amperes at 115 volts with delivery of 33-foot pounds of torque.
- (6) Shall develop 325 foot-pounds of torque at stalled rotor condition.

B. Torque Limiter Coupling
- (1) Torque limiter coupling shall consist of standard torque limiter with Type A sprocket center member coupled to a Type B sprocket by an ASA double strand roller chain. Type A sprocket shall be chrome-plated.
- (2) Coupling shall have torque capacity minimum of 15 pound-feet and a maximum of 55 pound-feet.
- (3) Limiter section of coupling shall consist of integral hub and pressure plate, two friction facings, sintered iron bushing, pilot plate, disk spring, lock washer and hex adjustment nut. All major components except spring and friction facings shall be cadmium-plated with dichromate treatment.
- (4) Type A center sprocket shall have ground face (63 micro-inch) and shall be run-in for 4 minutes at approximately 60 RPM at a torque setting of 70% to 80% of spring rating. Contractor shall provide written certification that run-in has been accomplished.
- (5) The torque limiter coupling shall, after run-in, be set to a torque limit of 35 pound-feet or as directed by the Engineer. The proper setting of the coupling shall be demonstrated to the Engineer.

C. Universal Joints
- (1) Shall be slip-type with 4-inch barrel. A grease fitting shall be so located in the spider that all caps and needle bearings will be adequately serviced. The assembly shall be disassembled and zinc-plated, then reassembled and properly lubricated.
- (2) Shall have a minimum torque rating of 1230 inch-pounds at 200 RPM.
- (3) Shall have set screw and keyed coupling as shown on plans.

13. CONSTRUCTION METHODS

A. Fabrication
- (1) Fabrication and welding shall be in accordance with the Item "Steel Structures", and Department Bulletin C-5.
- (2) All holes supporting pulley shafts shall be drilled (not punched) prior to galvanizing.
- (3) All component parts shall be galvanized where galvanizing is applicable, after fabrication.
- (4) Galvanizing on all parts which have become scratched, chipped or otherwise damaged shall be thoroughly cleaned and the cleaned area painted with two coats of zinc dust-zinc oxide paint conforming to the requirements of repair compounds meeting Federal Specification TT-P-641b.
- (5) Mounting rings and ring support assemblies shall be fabricated with the use of jigs that have been inspected and approved by Materials and Test Division personnel prior to their usage.
- (6) The fabricator shall submit his proposed welding procedures as a part of the required shop prints.

B. Installing Wire Rope
- (1) Prior to installation of winches and wire ropes, all wire ropes shall be extended full length in a clean area. Any wire rope that does not lie straight or that has other evidence of set, kinks, or other damage shall be rejected.
- (2) Extreme care shall be used to prevent wire rope from kinking, nicking, or from sustaining other damage during installation. Rope shall not be installed by pulling from flat coil, but shall be carefully unreeled its full length or placed on a horizontal axle and unreeled according to wire rope industry standards.
- (3) For right lay rope, the rope shall be attached to the drum on the end opposite the winch gear train, and wound on drum so that the free end of the rope comes off the backside of the drum during normal operation of the winch. Rope must be unreeled carefully as stated above. Care must be taken to insure that all layers lay full and tight on drum.
- (4) Installation of all wire rope shall be accomplished only under direct supervision of the Engineer or his authorized representative. Contractor shall not remove wire rope from manufacturer's reel until authorized by the Engineer. Installation of wire rope on winch shall be in accordance with the above and accepted industry practice. Installation of the three hoist cables shall be made from the top end of the pole and as directed by the Engineer or his representative.

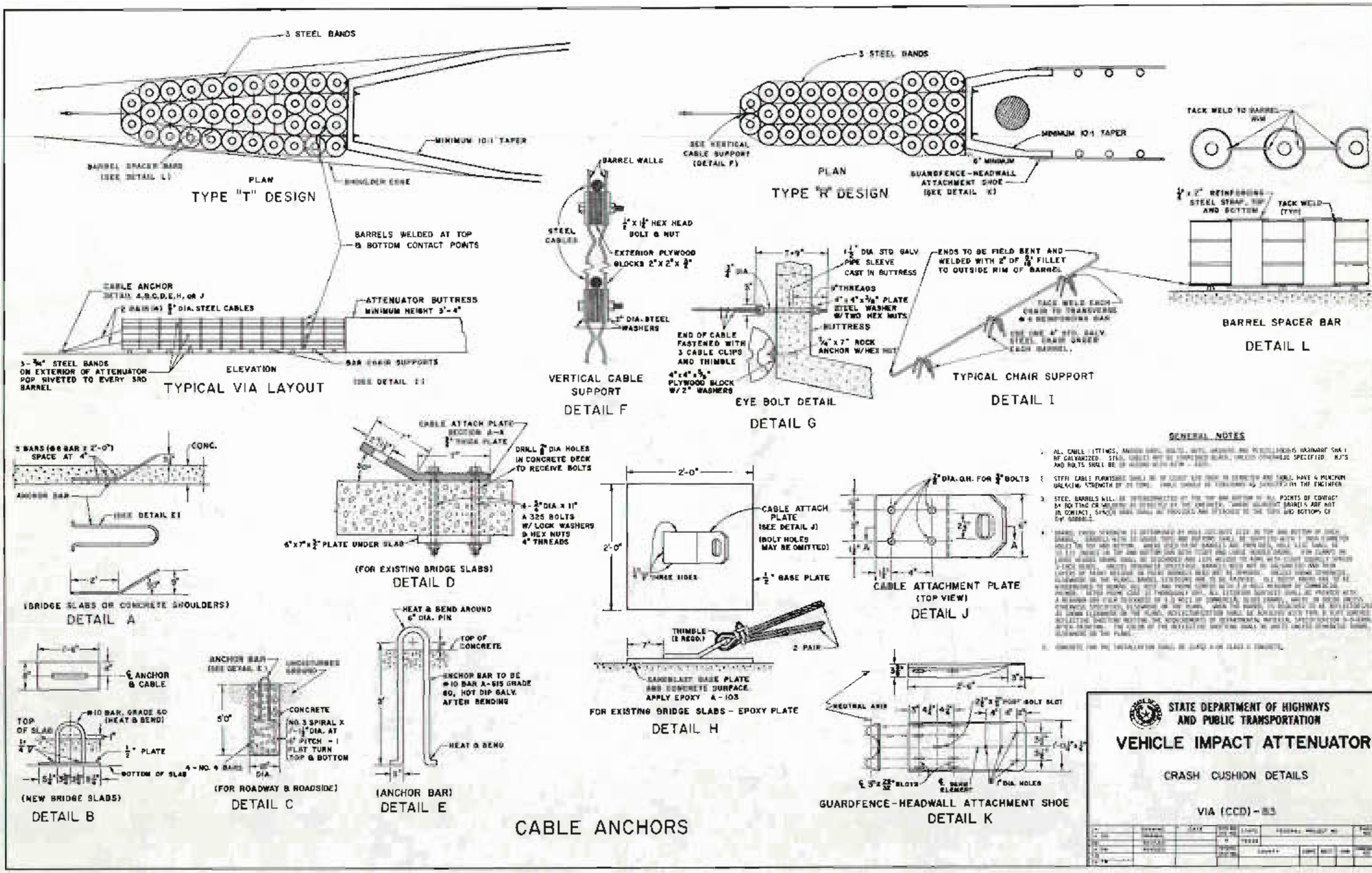
C. Installing Wire Rope Clips
- (1) Turn back minimum 7" of rope, measured from the top of thimble. Apply first clip one base width from the dead end of the wire rope with U-bolt over dead end and live end in clip saddle. Tighten nuts evenly to 30 pound-feet of torque, or as recommended by manufacturer.
- (2) Install second clip as near loop as possible, take out slack and torque nuts evenly to 30 pound-feet or as recommended by manufacturer.
- (3) After final erection and assembly of the pole and HM assembly, retighten nuts to required torque.

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

HIGH MAST ILLUMINATION DETAILS

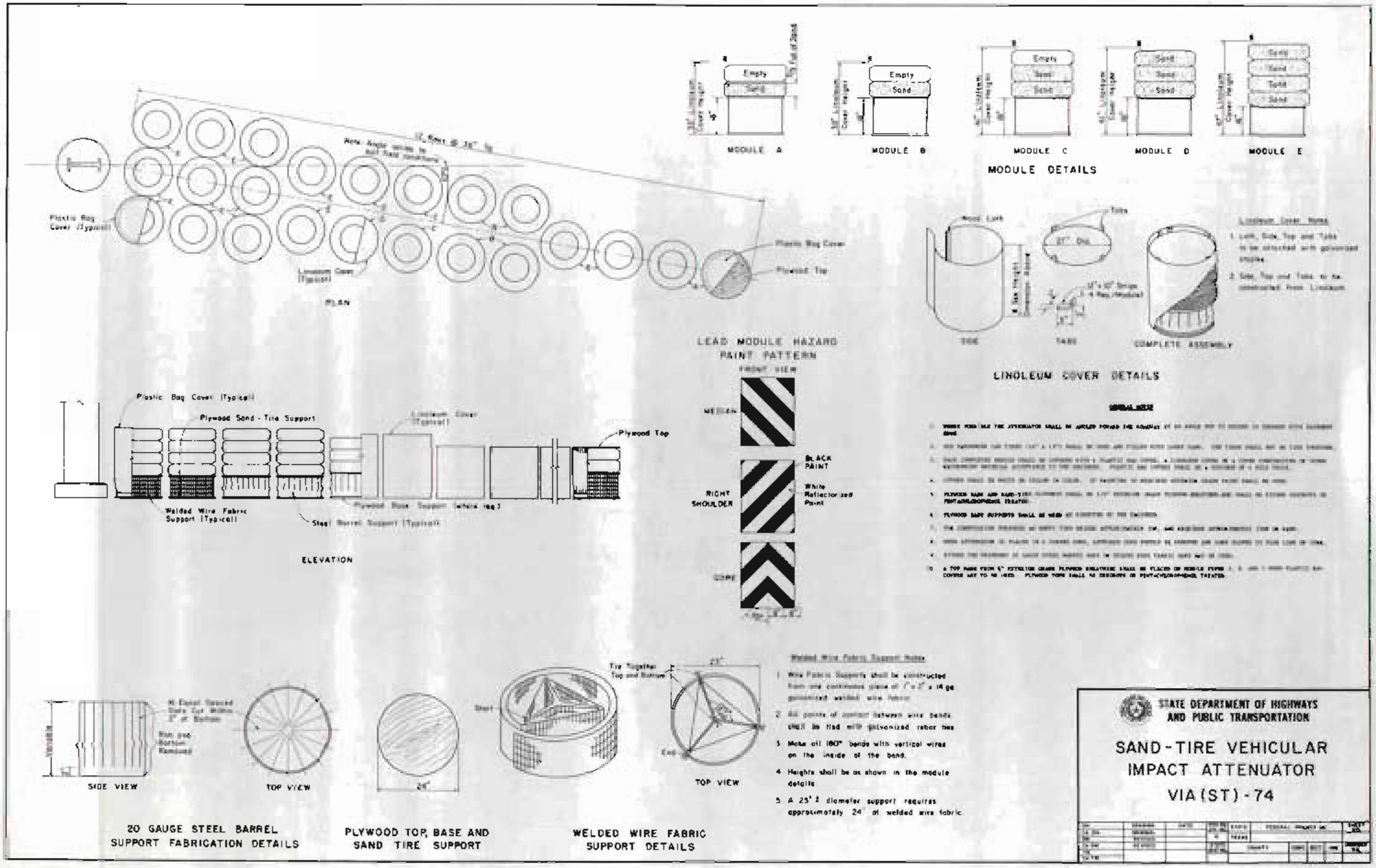
HMID (10) - 86

Rev. 4-86



3 STEEL BANDS
MINIMUM 10:1 TAPER
PLAN
TYPE "T" DESIGN
BARRELS WELDED AT TOP & BOTTOM CONTACT POINTS
CABLE ANCHOR
ATTENUATOR BUTTRESS MINIMUM HEIGHT 3'-4"
ELEVATION
TYPICAL VIA LAYOUT
BARREL WALLS
STEEL CABLES
EXTERIOR PLYWOOD BLOCKS
VERTICAL CABLE SUPPORT
DETAIL F
PLAN
TYPE "R" DESIGN
GUARDFENCE-HEADWALL ATTACHMENT SHOE (SEE DETAIL K)
TACK WELD TO BARREL RIM
TACK WELD (TYP)
BARREL SPACER BAR
DETAIL L
BUTTRESS
EYE BOLT DETAIL
DETAIL G
ENDS TO BE FIELD BENT AND WELDED WITH 2" OF 3/8" FILLET TO OUTSIDE RIM OF BARREL
TYPICAL CHAIR SUPPORT
DETAIL I
(BRIDGE SLABS OR CONCRETE SHOULDERS)
DETAIL A
CABLE ATTACH PLATE
DRILL 7/8" DIA HOLES IN CONCRETE DECK TO RECEIVE BOLTS
(FOR EXISTING BRIDGE SLABS)
DETAIL D
CABLE ATTACH PLATE (SEE DETAIL J)
(BOLT HOLES MAY BE OMITTED)
1/2" BASE PLATE
CABLE ATTACHMENT PLATE (TOP VIEW)
DETAIL J
GENERAL NOTES
THIMBLE
2 PAIR
FOR EXISTING BRIDGE SLABS - EPOXY PLATE
DETAIL H
ANCHOR & CABLE
(NEW BRIDGE SLABS)
DETAIL B
CONCRETE
(FOR ROADWAY & ROADSIDE)
DETAIL C
HEAT & BEND AROUND 6" DIA. PIN
TOP OF CONCRETE
HEAT & BEND
(ANCHOR BAR)
DETAIL E
CABLE ANCHORS
NEUTRAL AXIS
GUARDFENCE-HEADWALL ATTACHMENT SHOE
DETAIL K
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
VEHICLE IMPACT ATTENUATOR
CRASH CUSHION DETAILS
VIA (CCD)-83
Rev. 1-85

A-49


MODULE A
MODULE B
MODULE C
MODULE D
MODULE E
MODULE DETAILS
Empty
Sand
PLAN
Plastic Bag Cover (Typical)
Linoleum Cover (Typical)
Plastic Bag Cover
Plywood Top
LEAD MODULE HAZARD
PAINT PATTERN
FRONT VIEW
MEDIAN
RIGHT SHOULDER
GORE
BLACK PAINT
White Reflectorized Paint
LINOLEUM COVER DETAILS
SIDE
TABS
COMPLETE ASSEMBLY
Plastic Bag Cover (Typical)
Plywood Sand - Tire Support
Linoleum Cover (Typical)
Plywood Top
Welded Wire Fabric Support (Typical)
Steel Barrel Support (Typical)
ELEVATION
SIDE VIEW
TOP VIEW
20 GAUGE STEEL BARREL
SUPPORT FABRICATION DETAILS
24"
PLYWOOD TOP, BASE AND
SAND TIRE SUPPORT
TOP VIEW
WELDED WIRE FABRIC
SUPPORT DETAILS
Welded Wire Fabric Support Notes
1. Wire Fabric Supports shall be constructed from one continuous piece of 2" x 2" x 14 ga galvanized welded wire fabric.
2. All points of contact between wire bends shall be tied with galvanized rebar ties.
3. Make all 180° bends with vertical wires on the inside of the bend.
4. Heights shall be as shown in the module details.
5. A 23" ± diameter support requires approximately 24" of welded wire fabric.
STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
SAND-TIRE VEHICULAR
IMPACT ATTENUATOR
VIA (ST) - 74

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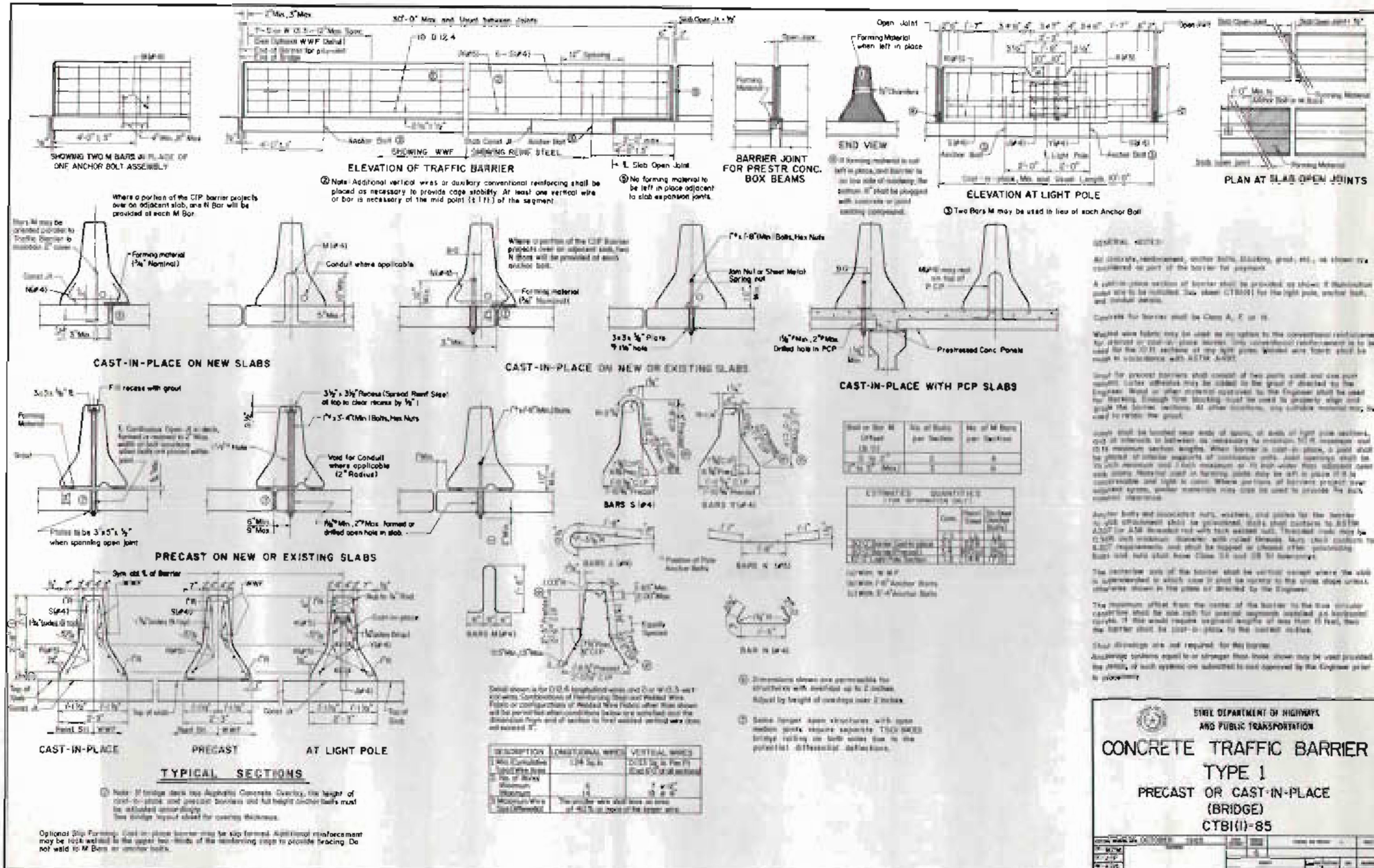
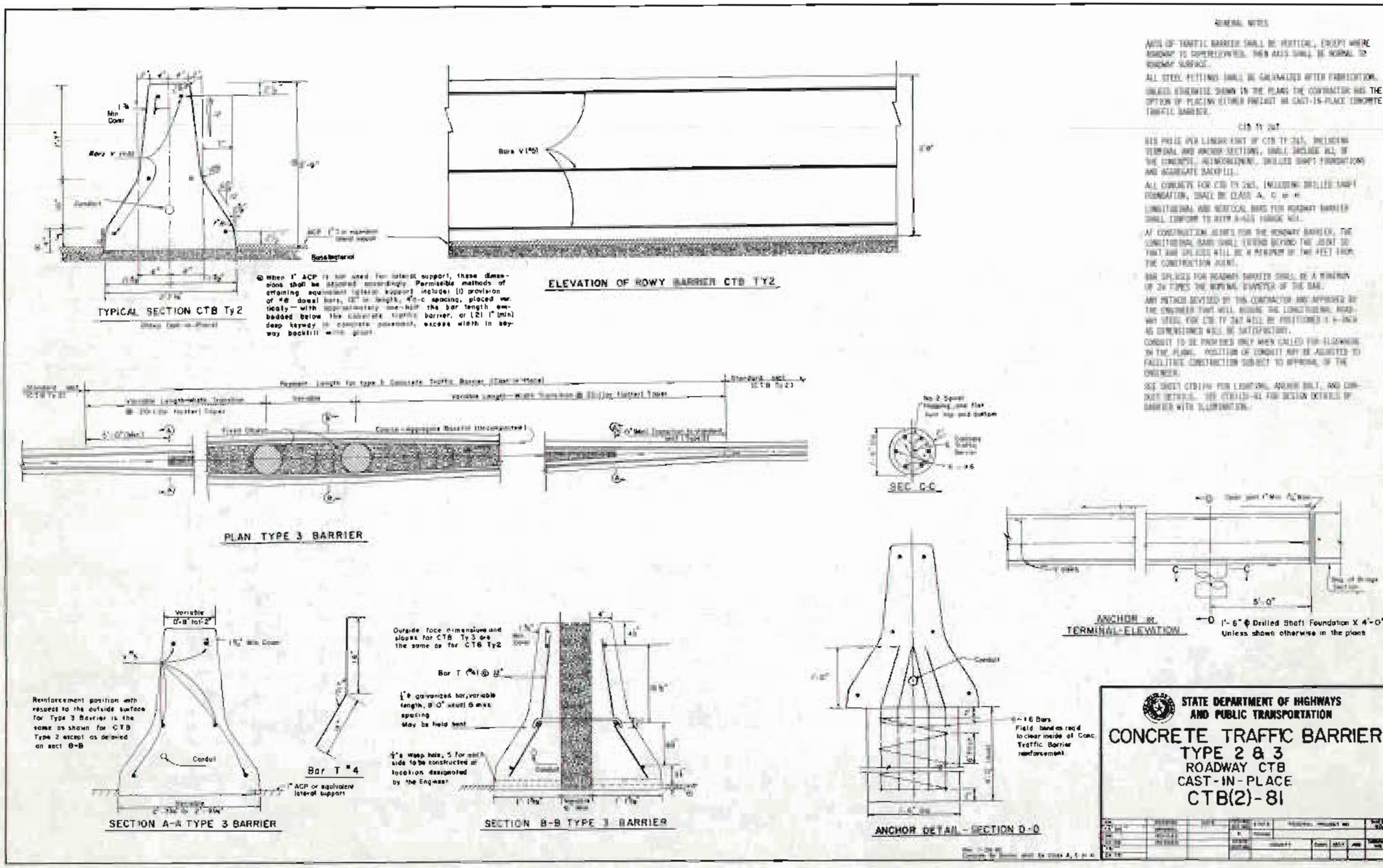
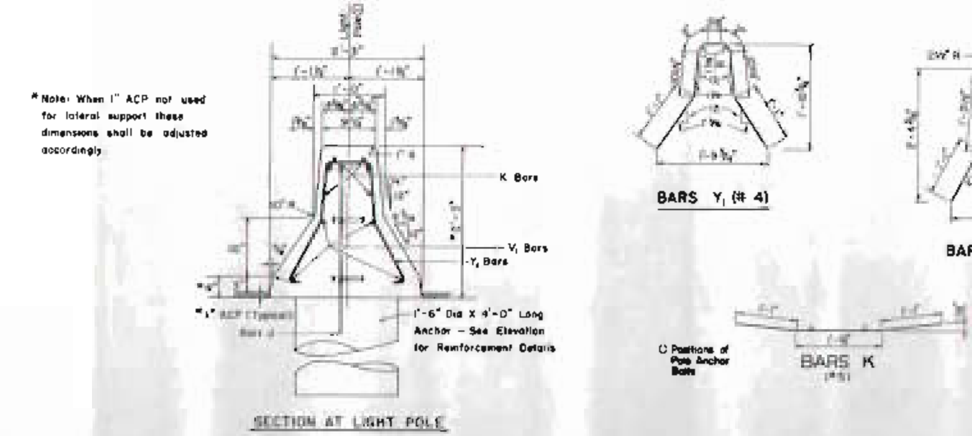
A-52


SHOWING TWO M BARS IN PLACE OF ONE ANCHOR BOLT ASSEMBLY
ELEVATION OF TRAFFIC BARRIER
SHOWING WWF
SHOWING REINF STEEL
Anchor Bolt
② Note: Additional vertical wires or auxiliary conventional reinforcing shall be placed as necessary to provide cage stability. At least one vertical wire or bar is necessary at the mid point (± 1 ft) of the segment.
℄ Slab Open Joint
⑤ No forming material to be left in place adjacent to slab expansion joints.
BARRIER JOINT FOR PRESTR. CONC. BOX BEAMS
Open Joint
Forming Material when left in place
END VIEW
ELEVATION AT LIGHT POLE
③ Two Bars M may be used in lieu of each Anchor Bolt
PLAN AT SLAB OPEN JOINTS
Where a portion of the CIP barrier projects over an adjacent slab, one N Bar will be provided at each M Bar.
Forming material (3/4" Nominal)
Conduit where applicable
CAST-IN-PLACE ON NEW SLABS
CAST-IN-PLACE ON NEW OR EXISTING SLABS
3 x 3 x 3/8" Plate 9 1/16" hole
1 1/8" Min, 2" Max Drilled hole in PCP
Prestressed Conc Panels
CAST-IN-PLACE WITH PCP SLABS
Fill recess with grout
3 1/2" x 3 1/2" Recess (Spread Reinf Steel at top to clear recess by 1/2")
Void for Conduit where applicable (2" Radius)
Plates to be 3" x 5" x 1/2" when spanning open joint
PRECAST ON NEW OR EXISTING SLABS
BARS S (#4)
CAST-IN-PLACE
PRECAST
AT LIGHT POLE
TYPICAL SECTIONS
Optional Slip Forming: Cast-in-place barrier may be slip formed. Additional reinforcement may be tack welded to the upper two-thirds of the reinforcing cage to provide bracing. Do not weld to M Bars or anchor bolts.
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
CONCRETE TRAFFIC BARRIER
TYPE 1
PRECAST OR CAST-IN-PLACE
(BRIDGE)
CTB1(1)-85

Rev 1-86



GENERAL NOTES
ALL STEEL FITTINGS SHALL BE GALVANIZED AFTER FABRICATION.
UNLESS OTHERWISE SHOWN IN THE PLANS THE CONTRACTOR HAS THE OPTION OF PLACING EITHER PRECAST OR CAST-IN-PLACE CONCRETE TRAFFIC BARRIER.
CTB TY 2&3
TYPICAL SECTION CTB Ty 2
ELEVATION OF ROWY BARRIER CTB TY2
PLAN TYPE 3 BARRIER
SEC C-C
ANCHOR at TERMINAL-ELEVATION
1'-6" ϕ Drilled Shaft Foundation X 4'-0" Unless shown otherwise in the plans
Reinforcement position with respect to the outside surface for Type 3 Barrier is the same as shown for CTB Type 2 except as detailed on sect B-B
Conduit
Bar T #4
1" ACP or equivalent lateral support
SECTION A-A TYPE 3 BARRIER
Outside face dimensions and slopes for CTB Ty 3 are the same as for CTB Ty2
Bar T (#4) @ 18"
Conduit
SECTION B-B TYPE 3 BARRIER
ANCHOR DETAIL - SECTION D-D
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
CONCRETE TRAFFIC BARRIER
TYPE 2 & 3
ROADWAY CTB
CAST-IN-PLACE
CTB(2)-81

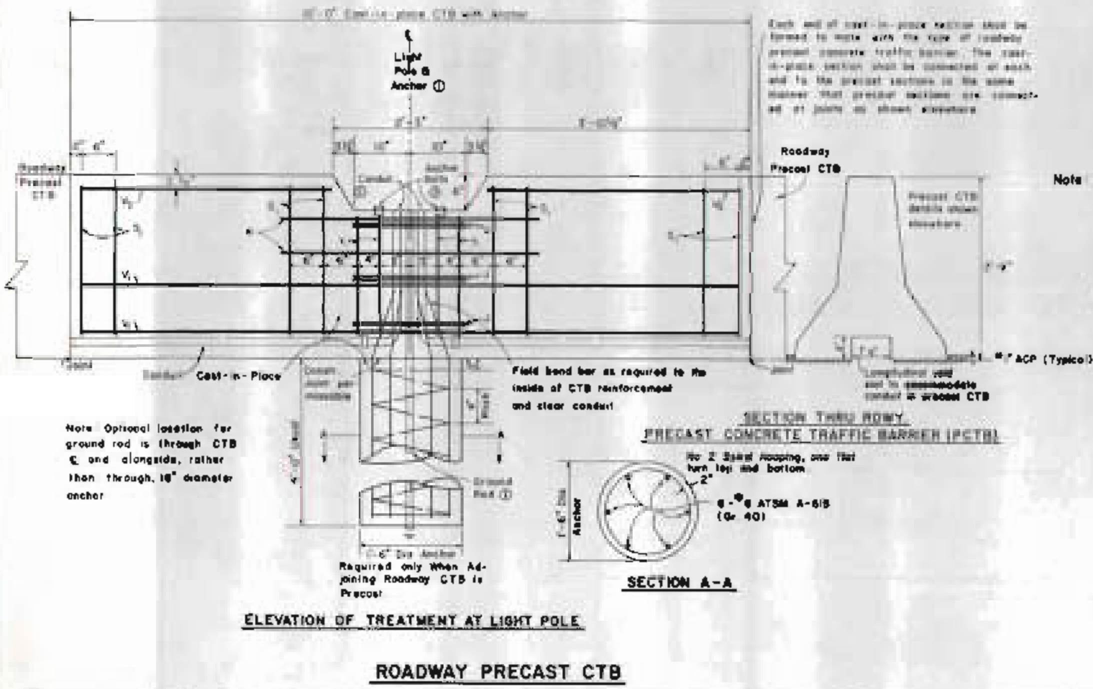


GENERAL NOTES

1. ALL CONCRETE FOR CONCRETE TRAFFIC BARRIER (CTB), INCLUDING ANCHOR WHERE REQUIRED, SHALL BE CLASS A, C or H.
2. DETAILS FOR BRIDGE CTB AT LIGHT POLES SHOWN ON SHEET CTBI(1).
3. DRILLED SHAFT ANCHORS WHEN REQUIRED SHALL NOT BE PAID FOR DIRECTLY BUT WILL BE CONSIDERED SUBSIDIARY TO THE UNIT PRICE BID FOR CTB.

Schedule of Reinforcement for Each 10' Cast-in-place Section at Light Poles (Excl. Anchor)

BAR	SIZE	QUANTITY	LENGTH
Y_1	#4	4	see
S_1	#4	8	details
J	#4	8	hereon
K	#5	4	
[illegible]	#5	4	[illegible]
V_1	#5	4	[illegible]



Note: Where roadway CTB is cast-in-place, 1'-6" diameter anchor is not required under barrier at light pole locations, and barrier shall be continuous (without open joint). Reinforcement of the CTB within 5 feet of the pole in either direction shall be as detailed hereon.
Where roadway CTB is precast, 10' cast-in-place section with 1'-6" diameter anchor shall be provided as detailed hereon.

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

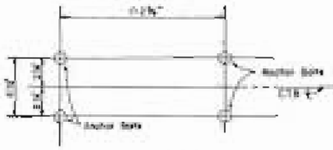
CONCRETE TRAFFIC BARRIER

TYPE 2

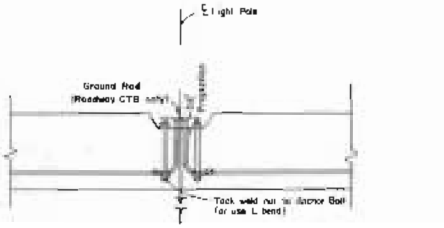
ROADWAY CTB AT LIGHT POLES

CTBI(3)-85

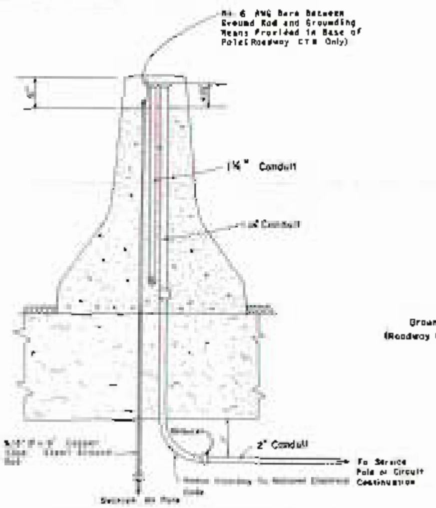
Rev. 1-86



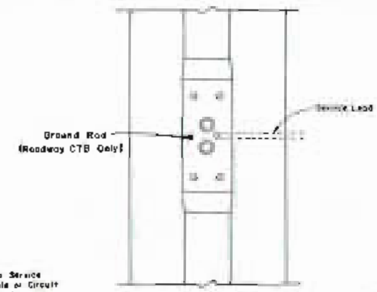
TOP VIEW (ALL CTB TYPES)
ANCHOR BOLT PATTERN



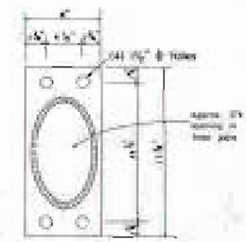
DETAILS AT LIGHT POLE ON BRIDGES AND ROADWAY
(CAST - IN - PLACE)



SERVICE LEAD AND GROUND
DETAIL (ROADWAY CTB*) * CAST-IN PLACE AND PRECAST

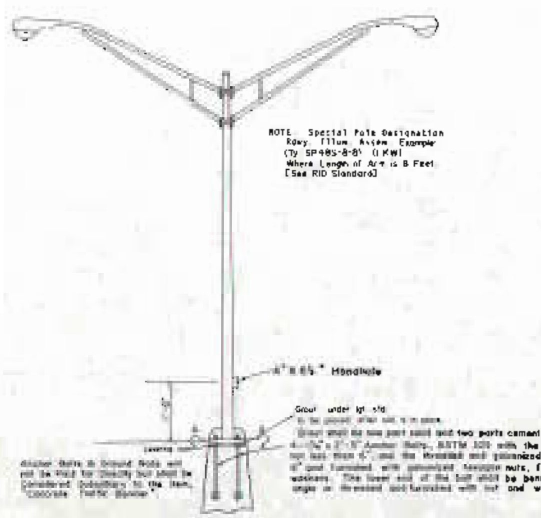


PLAN VIEW



Section A-A

[Shape of pole may be Elliptical
or Polygonal]



POLE DETAIL

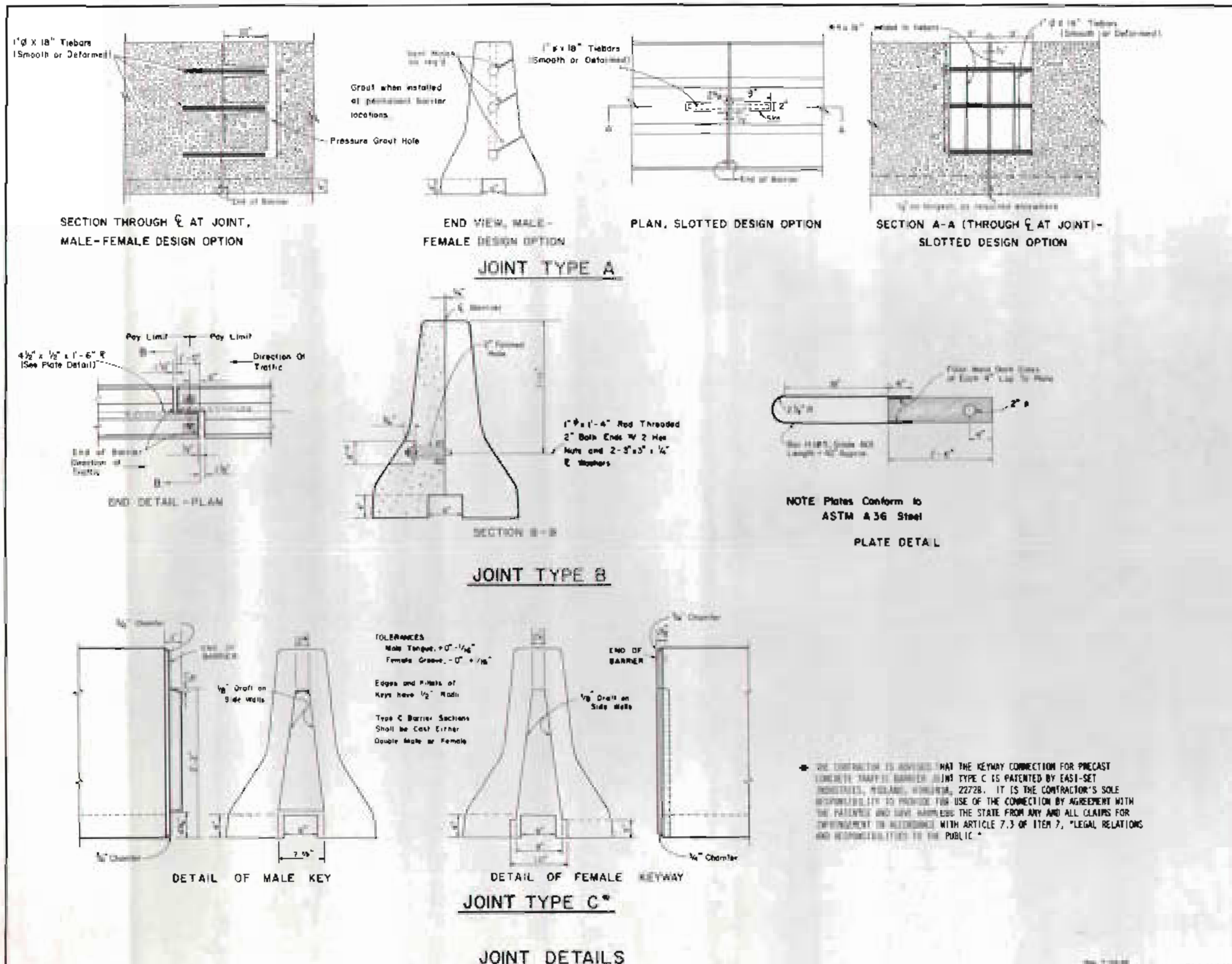
STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

CONCRETE TRAFFIC BARRIER

BRIDGE AND ROADWAY WITH ILLUMINATION,
POLE, CONDUIT, AND ANCHOR BOLT DETAILS

CTBI(4)-81

A-55



GENERAL NOTES

1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]
5. [illegible]
6. [illegible]
7. [illegible]
8. [illegible]
9. [illegible]
10. [illegible]
11. [illegible]

* [illegible] THAT THE KEYWAY CONNECTION FOR PRECAST [illegible] JOINT TYPE C IS PATENTED BY EASI-SET [illegible] 22728. IT IS THE CONTRACTOR'S SOLE [illegible] USE OF THE CONNECTION BY AGREEMENT WITH [illegible] THE STATE FROM ANY AND ALL CLAIMS FOR [illegible] WITH ARTICLE 7.3 OF ITEM 7, "LEGAL RELATIONS [illegible] PUBLIC."

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

PRECAST CONCRETE TRAFFIC BARRIER TYPE 2

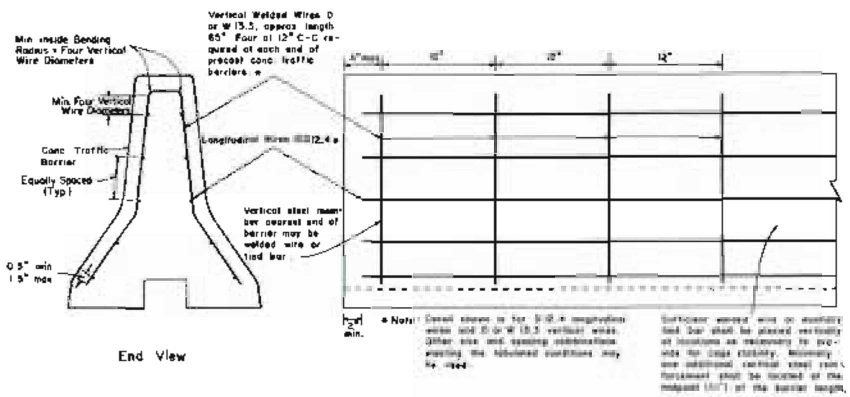
PCTB(I)-83

Rev. 4-1-83

GOVERNING SPECIFICATIONS FOR BOTH WIRE AND WELDED WIRE FABRIC SHALL BE ASTM A 82, ASTM A 185, ASTM A 496 AND ASTM A 497. WIRE FABRIC WILL NOT BE PAID FOR DIRECTLY AND WILL BE CONSIDERED SUBSIDIARY TO THE BID ITEM FOR CONCRETE TRAFFIC BARRIER

CONFIGURATIONS OF WELDED WIRE FABRIC OTHER THAN AS SHOWN IN THE WWF DETAIL WILL BE PERMITTED WHEN THE CONDITIONS TABULATED BELOW ARE SATISFIED.

DESCRIPTION	LONGITUDINAL WIRES	VERTICAL WIRES
1. WIRE TYPE	DEFORMED	SMOOTH OR DEFORMED
2. MINIMUM (CUMULATIVE TOTAL) WIRE AREA	1.29 SQ. IN.	0.133 SQ. IN. PER FT. (REQ'D ONLY IN END 1'-4" OF PRECAST SECTIONS)
3. NO. OF WIRES MINIMUM MAXIMUM	 6 [illegible]	 [illegible] @ 12" CC EA. PRECAST END [illegible] @ 4" CC EA. PRECAST END
4. BENDING RADIUS	N/A	MINIMUM RADIUS = TWO VERTICAL WIRE DIAMETERS
5. WIRE PLACEMENT A. TOP WIRES	NOT LESS THAN 4 NOR MORE THAN 5 VERTICAL WIRE DIAMETERS FROM THE UPPER BENDS IN THE VERTICAL WIRES	N/A
B. BOTTOM WIRES	4" PLUS OR MINUS ½" FROM BOTTOM OF BARRIER	N/A
C. OTHER WIRES	UNIFORMLY AND SYMMETRICALLY SPACED ALONG FACES OF BARRIER	MINIMUM SPACING 4" MAXIMUM SPACING 12"
6. MAXIMUM WIRE SIZE DIFFERENTIAL	THE SMALLER WIRE SHALL HAVE AN AREA OF 40% OR MORE OF THE LARGER WIRE.	

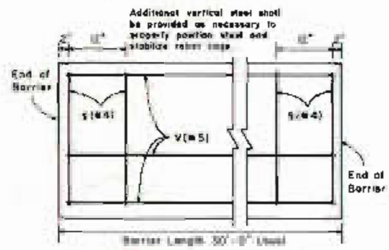


Elevation - Each end of Concrete Traffic Barrier

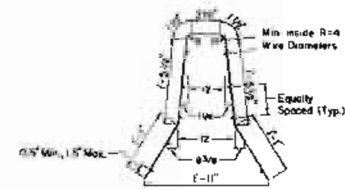
DETAILS OF WELDED WIRE FABRIC OPTION

GENERAL NOTES

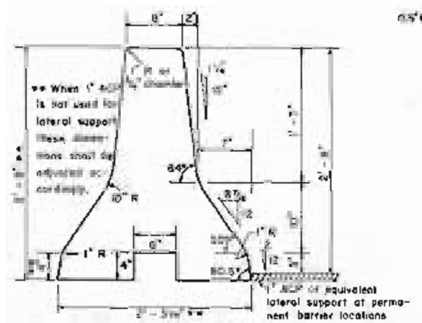
1. WHERE USED, REBAR REINFORCEMENT SHALL CONFORM TO ASTM A-615 GRADE 40.
2. BARRIER LENGTH SHALL BE 30 FEET (+/-4 INCHES) UNLESS OTHERWISE SPECIFIED IN THE PLANS.



Elevation Near End of Barrier

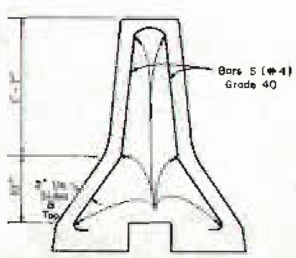


VERTICAL WIRE DETAILS



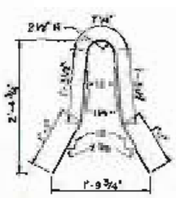
DETAILS OF BARRIER SHAPE

★★ WHEN 1" ACP IS NOT USED FOR LATERAL SUPPORT THESE DIMENSIONS SHALL BE ADJUSTED ACCORDINGLY



Section Near End of Barrier

DETAILS OF REBAR OPTION



BARS S
(#4)

# APPROXIMATE [illegible] QUANTITIES		
CONCRETE	CY.	[illegible]
REBAR	LB.	[illegible]
WELDED WIRE FABRIC	LB.	[illegible]

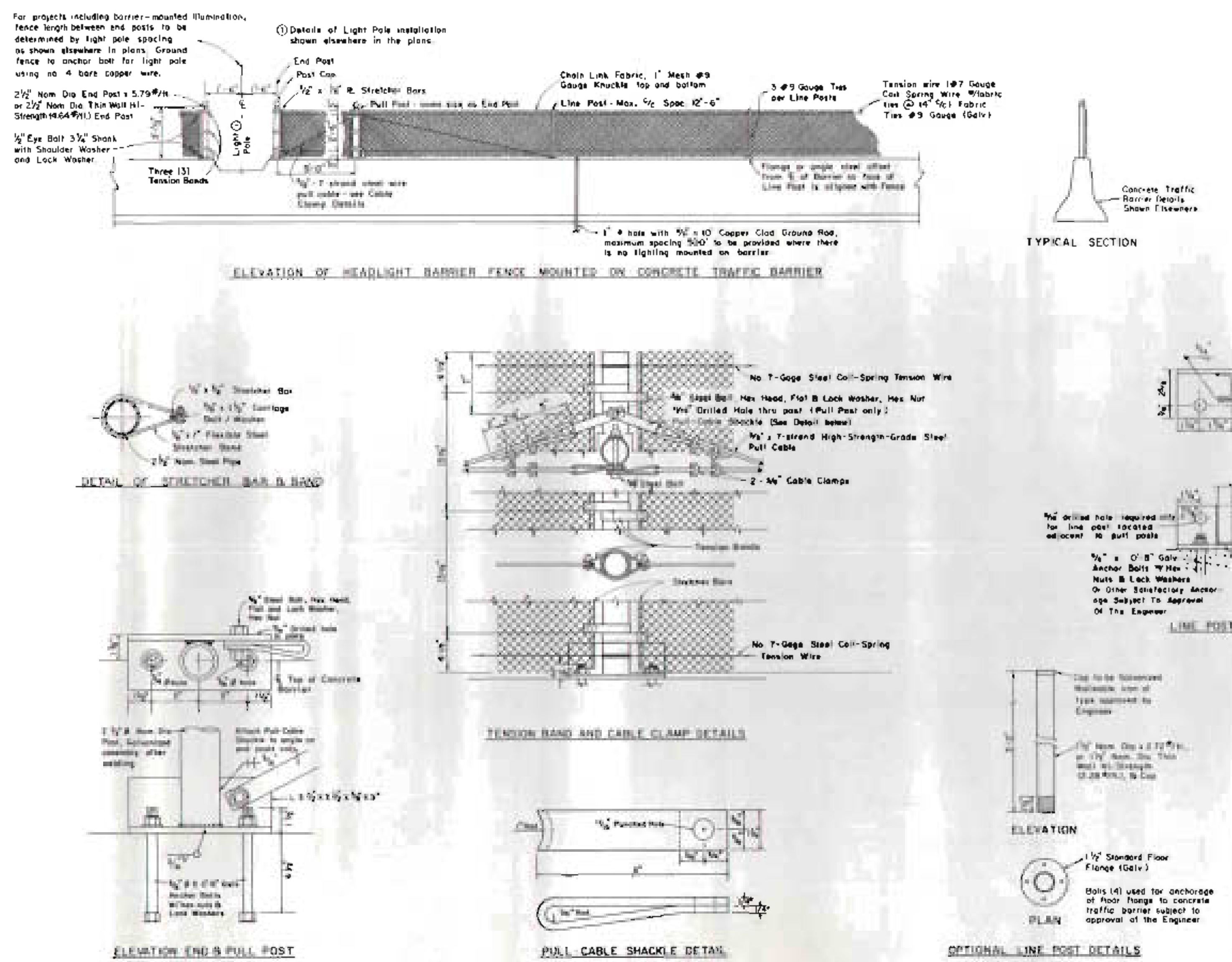
FOR CONTRACTOR'S INFORMATION ONLY

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

PRECAST
CONCRETE TRAFFIC BARRIER
TYPE 2

PCTB (2)-85

Rev. 1-86



GENERAL NOTES

1. THE HEADLIGHT BARRIER FENCE SHALL BE ELECTRICALLY GROUNDED. A GROUND SHALL BE PLACED AT A MAXIMUM SPACING OF 500 FEET EXCEPT WHERE LONG BRIDGES PRECLUDE ATTAINING THIS SCALE AND EACH INDEPENDENT SECTION SHALL HAVE AT LEAST ONE GROUND AT OR BETWEEN END POSTS REGARDLESS OF LENGTH. A GROUND SHALL CONSIST OF 5/8" X 8' COPPER CLAD STEEL ROD AND NO. 4 BARE COPPER WIRE WITH GROUND ROD CLAMP.
2. FOR PROJECTS INVOLVING ILLUMINATION MOUNTED ON CONCRETE TRAFFIC BARRIER, A COMMON GROUND MAY BE USED FOR A LIGHT POLE AND SECTIONS OF HEADLIGHT BARRIER FENCE. FOR THESE CONDITIONS INVOLVING ILLUMINATION, NO. 4 BARE COPPER WIRES SHALL BE CONNECTED FROM THE ADJACENT SECTIONS OF HEADLIGHT BARRIER FENCE TO ILLUMINATION POLE ANCHOR BOLTS.
3. CONCRETE TRAFFIC BARRIER DETAILS SHOWN ELSEWHERE IN THE PLANS.

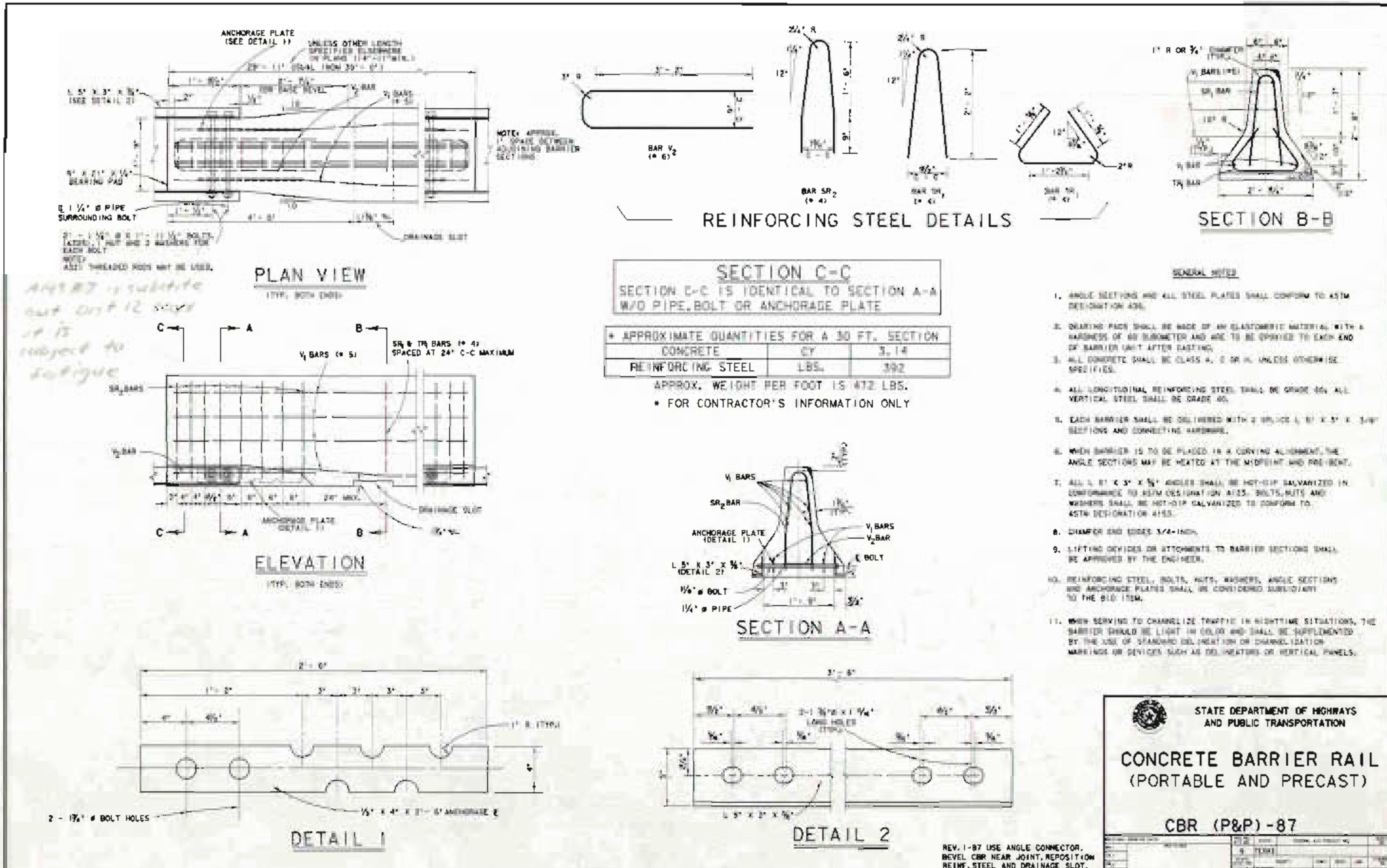
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

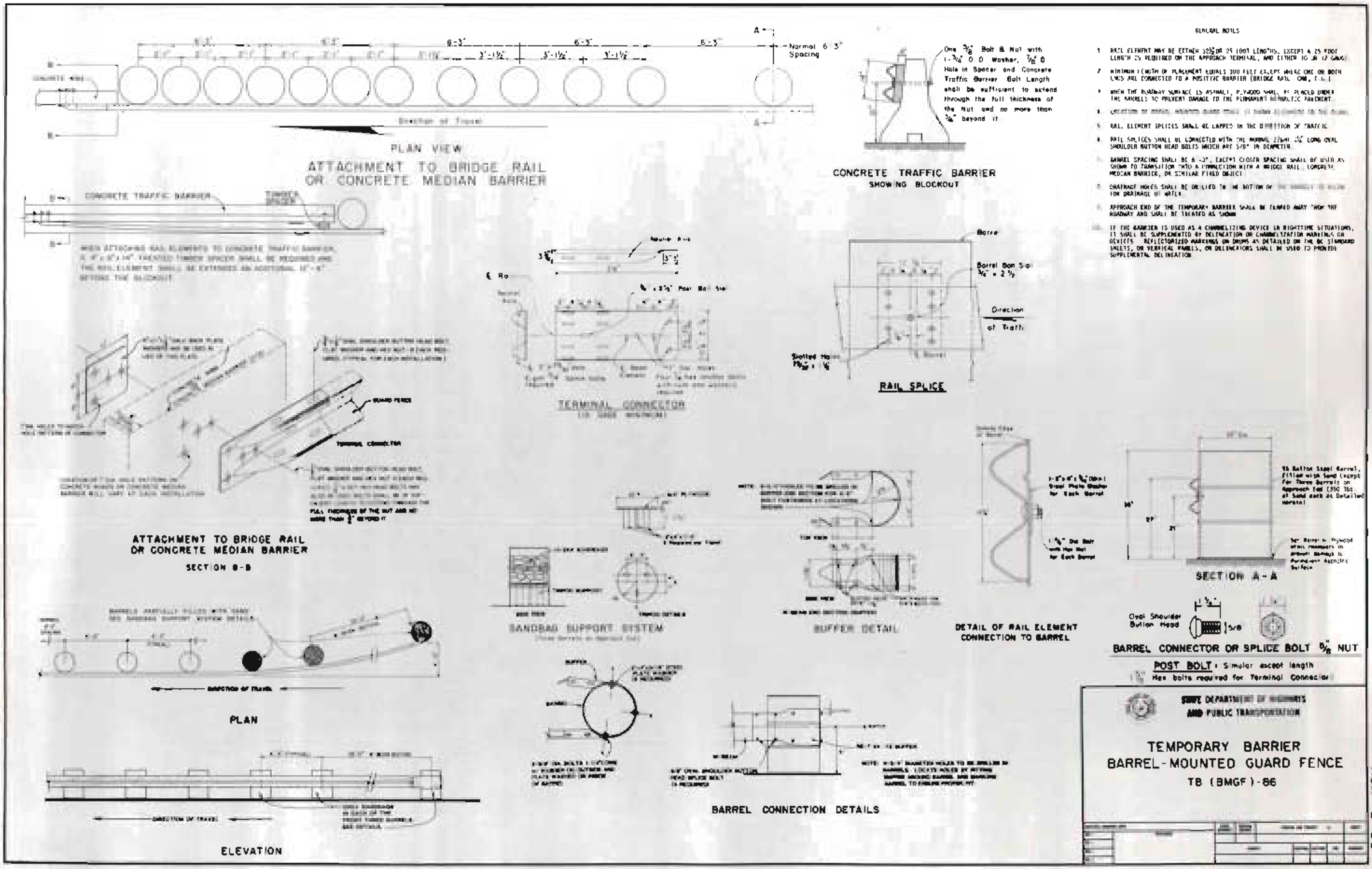
HEADLIGHT BARRIER FENCE

MOUNTED ON CONCRETE TRAFFIC BARRIER

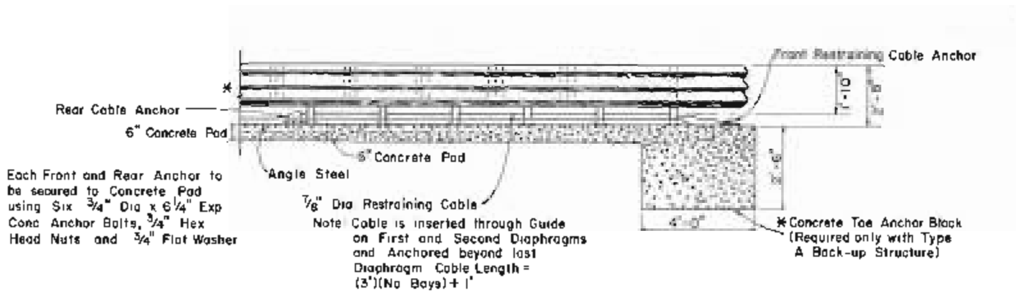
HBF (CTB) - 81

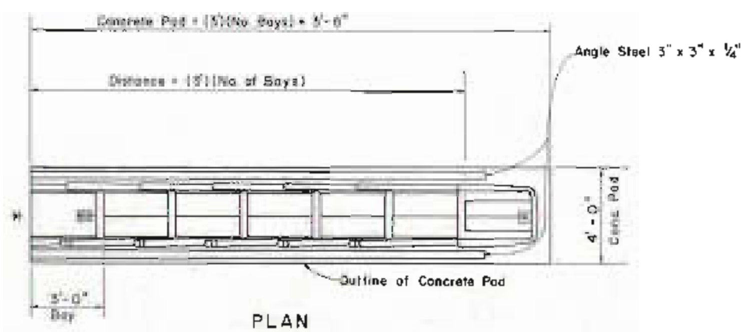
A-59


PLAN VIEW
(TYP. BOTH ENDS)
ANCHORAGE PLATE (SEE DETAIL 1)
NOTE: APPROX. 1" SPACE BETWEEN ADJOINING BARRIER SECTIONS
1 1/4" ø PIPE SURROUNDING BOLT
DRAINAGE SLOT
ELEVATION
(TYP. BOTH ENDS)
V1 BARS (# 5)
SR1 & TR1 BARS (# 4) SPACED AT 24" C-C MAXIMUM
SR2 BARS
V2 BAR
DRAINAGE SLOT
ANCHORAGE PLATE (DETAIL 1)
BAR V2 (# 6)
BAR SR2 (# 4)
BAR SR1 (# 4)
BAR TR1 (# 4)
REINFORCING STEEL DETAILS
SECTION B-B
SECTION C-C
SECTION C-C IS IDENTICAL TO SECTION A-A W/O PIPE, BOLT OR ANCHORAGE PLATE
* APPROXIMATE QUANTITIES FOR A 30 FT. SECTION
CONCRETE | CY | 3.14
REINFORCING STEEL | LBS. | 392
APPROX. WEIGHT PER FOOT IS 472 LBS.
* FOR CONTRACTOR'S INFORMATION ONLY
V1 BARS
SR2 BAR
ANCHORAGE PLATE (DETAIL 1)
L 5" X 3" X 3/8" (DETAIL 2)
1 1/8" ø BOLT
1 1/4" ø PIPE
V1 BARS
V2 BAR
℄ BOLT
SECTION A-A
GENERAL NOTES
1. ANGLE SECTIONS AND ALL STEEL PLATES SHALL CONFORM TO ASTM DESIGNATION A36.
2. BEARING PADS SHALL BE MADE OF AN ELASTOMERIC MATERIAL WITH A HARDNESS OF 60 DUROMETER AND ARE TO BE EPOXIED TO EACH END OF BARRIER UNIT AFTER CASTING.
3. ALL CONCRETE SHALL BE CLASS A, C OR H, UNLESS OTHERWISE SPECIFIED.
4. ALL LONGITUDINAL REINFORCING STEEL SHALL BE GRADE 60. ALL VERTICAL STEEL SHALL BE GRADE 40.
5. EACH BARRIER SHALL BE DELIVERED WITH 2 SPLICE L 5" X 3" X 3/8" SECTIONS AND CONNECTING HARDWARE.
6. WHEN BARRIER IS TO BE PLACED IN A CURVING ALIGNMENT, THE ANGLE SECTIONS MAY BE HEATED AT THE MIDPOINT AND PRE-BENT.
7. ALL L 5" X 3" X 3/8" ANGLES SHALL BE HOT-DIP GALVANIZED IN CONFORMANCE TO ASTM DESIGNATION A123. BOLTS, NUTS AND WASHERS SHALL BE HOT-DIP GALVANIZED TO CONFORM TO ASTM DESIGNATION A153.
8. CHAMFER END EDGES 3/4-INCH.
9. LIFTING DEVICES OR ATTACHMENTS TO BARRIER SECTIONS SHALL BE APPROVED BY THE ENGINEER.
10. REINFORCING STEEL, BOLTS, NUTS, WASHERS, ANGLE SECTIONS AND ANCHORAGE PLATES SHALL BE CONSIDERED SUBSIDIARY TO THE BID ITEM.
11. WHEN SERVING TO CHANNELIZE TRAFFIC IN NIGHTTIME SITUATIONS, THE BARRIER SHOULD BE LIGHT IN COLOR AND SHALL BE SUPPLEMENTED BY THE USE OF STANDARD DELINEATION OR CHANNELIZATION MARKINGS OR DEVICES SUCH AS DELINEATORS OR VERTICAL PANELS.
2 - 1 3/4" ø BOLT HOLES
DETAIL 1
L 5" X 3" X 3/8"
DETAIL 2
REV. 1-87 USE ANGLE CONNECTOR. BEVEL CBR NEAR JOINT. REPOSITION REINF. STEEL AND DRAINAGE SLOT.
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
CONCRETE BARRIER RAIL
(PORTABLE AND PRECAST)
CBR (P&P)-87
Rev. 1-87


PLAN VIEW
ATTACHMENT TO BRIDGE RAIL
OR CONCRETE MEDIAN BARRIER
Normal 6'-3" Spacing
One 5/8" Bolt & Nut with 1-3/4" O.D. Washer, 7/8" Ø Hole in Spacer and Concrete Traffic Barrier. Bolt Length shall be sufficient to extend through the full thickness of the Nut and no more than 3/8" beyond it.
CONCRETE TRAFFIC BARRIER
SHOWING BLOCKOUT
CONCRETE TRAFFIC BARRIER
TERMINAL CONNECTOR
RAIL SPLICE
Direction of Traffic
ATTACHMENT TO BRIDGE RAIL
OR CONCRETE MEDIAN BARRIER
SECTION B-B
SANDBAG SUPPORT SYSTEM
BUFFER DETAIL
DETAIL OF RAIL ELEMENT
CONNECTION TO BARREL
SECTION A-A
Oval Shoulder Button Head
BARREL CONNECTOR OR SPLICE BOLT 5/8" NUT
POST BOLT: Similar except length
PLAN
ELEVATION
BARREL CONNECTION DETAILS
STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
TEMPORARY BARRIER
BARREL-MOUNTED GUARD FENCE
TB (BMGF)-86

Rev. 6-86





PLAN

* See Note for Back-up Structure Information

DESIGN SPEED (mph)	NO.* OF BAYS
40 or less	3
45	4
50	5
55	6
60	8
65	10

* Based on maximum deceleration force of 6 G's.

BACK-UP STRUCTURE INFORMATION

TYPE A [illegible] G.R.E.A.T. Unit. [illegible]

TYPE B Cast-In-Place Concrete: [illegible] G.R.E.A.T. Unit, and 2' - 0" [illegible] Re-forced with a steel cage. Precast Concrete Median Barrier [illegible] the G.R.E.A.T. Unit

TYPE C Wide Flange Back-Up. Consists of two 6WF25 x 6'2" Steel Post [illegible] at rear of G.R.E.A.T. Unit. Posts are set in a Cast-In-Place, reinforced concrete foundation which is 4' - 0" x 2' - 0" x 3' - 0", with the 3' 0" [illegible]

TYPE CZ Construction Zone Back-Up: [illegible] concrete

NOTES: Type of Back-Up Structure for each location specified elsewhere in the Plans

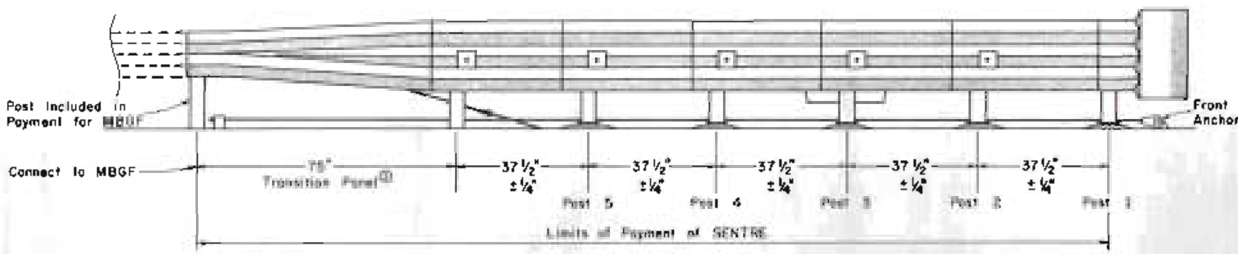
Details of components in the Guard Rail Energy Absorbing Terminal will be shown on shop drawings furnished to the Engineer by the Manufacturer.

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

GUARD RAIL ENERGY ABSORBING TERMINAL

GREAT - 85

Rev. 1-86



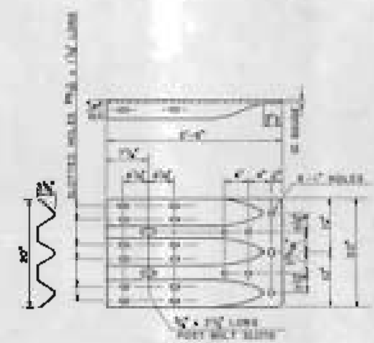
FLARED OR STRAIGHT UNIT

ELEVATION

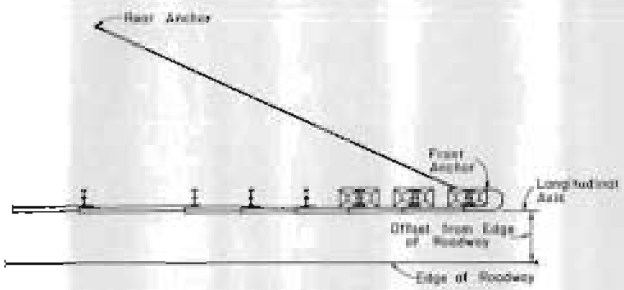
GENERAL NOTES

Details of Components in the SAFETY BARRIER END TREATMENT will be shown on Shop Drawings Furnished to the Engineer by the Manufacturer.

NOTE: All Units are for Typical Right-Hand Shoulder Installations

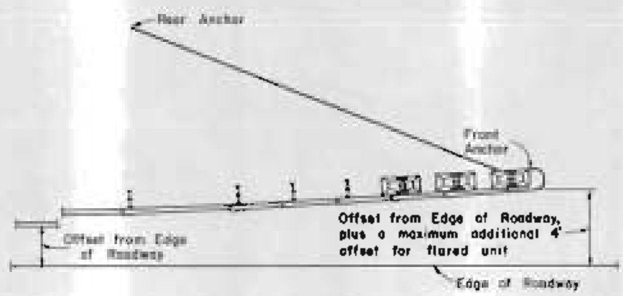


TERMINAL CONNECTOR①



STRAIGHT UNIT

PLAN



FLARED UNIT

PLAN

① In lieu of the Transition Panel, a 6'-3" nominal length (C-C of Post Bolt Holes) of Triple Corrugated Guard Rail plus a Terminal Connector shall be provided whenever the SENTRE unit is to be connected directly to a Concrete Wall or Railing.

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

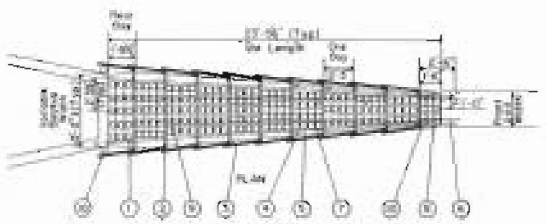
SAFETY BARRIER END TREATMENT

SENTRE - 85

Rev. 1-86

A-62A

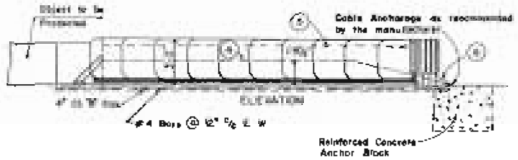
NOTE Length varied as dictated by design speed and available space; see table for listing of lengths for standard installations



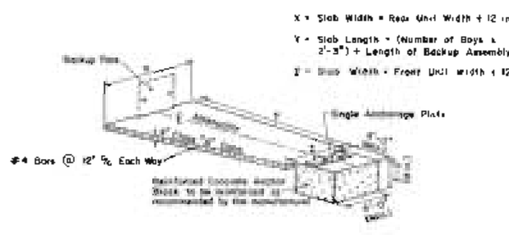
TYPICAL CELL SANDWICH INSTALLATION (Water Filled Cells)

KEY

1. Water Filled Cells
2. Diaphragms
3. Fender Panels
4. Restraining Cables
5. Pull-Out Cables
6. Secondary Cables
7. Slide Straps
8. Flexible Nose Cover
9. Interior Panels
10. Standard Vinyl Cells



H.C.C ON ROADWAY

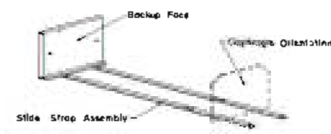


TYPICAL FOUNDATION PAD AND ANCHOR BLOCK ON ROADWAY ONLY

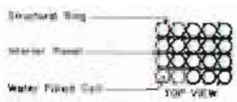
BACKUP FACE, AND SINGLE ANCHOR PLATE ON ROADWAY OR BRIDGE

GENERAL NOTES

1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]
5. [illegible]



TYPICAL SLIDE STRAP ASSEMBLY



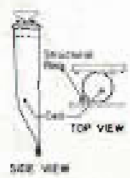
TYPICAL BAY ASSEMBLY

TABLE

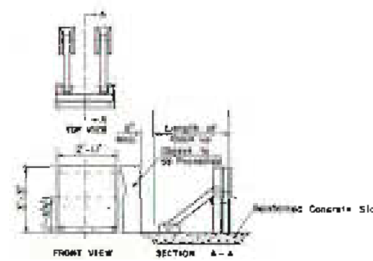
SYSTEM TYPE	LENGTH *	NO. OF BAYS	MAXIMUM DESIGN SPEED	AVERAGE "G" FORCES **
HYDRAULIC CRASH CUSHION	12'-2½"	5	40 MPH	5.8
	14'-5½"	6	40 MPH	4.9
	16'-8½"	7	45 MPH	5.4
	18'-11½"	8	50 MPH	5.9
	21'-2½"	9	50 MPH	5.3
	23'-5½"	10	50 MPH	4.7
	25'-8½"	11	50 MPH	4.3
	27'-11½"	12	60 MPH	5.7

* TOTAL LENGTH OF UNIT AS MEASURED FROM FRONT FACE OF BACKUP TO FORWARD EDGE OF FRONT CELLS.

** AVERAGED OVER ENTIRE HCC SYSTEM LENGTH; 50 MILLISECOND PEAK "G" FORCES EXCEED THESE VALUES.



TYPICAL CELL



TYPICAL DIAGONAL BRACED BACKUP ASSEMBLY ON ROADWAY OR BRIDGE

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

HYDRAULIC CRASH CUSHION (HCC) (FREE STANDING)

HCC - 85

Rev. 1-86

APPENDIX A-200

Brief reference on pp 4-127 & 4-128

METAL BEAM GUARD FENCE (A-200)

A-201 GENERAL

The objectives of this Appendix are to make available data and guidelines for the use of roadside traffic barriers (typically metal beam guard fence) in a consolidated and understandable form. These guidelines should be supplemented by sound engineering judgment.

A. Introduction

The area adjacent to the traveled way plays an important role in the safe operation of a high speed facility. Accident statistics show that a significant portion of accidents on rural roads are the single vehicle, run-off-the-road type. Provision of an obstacle free zone and the effective use of barriers to shield objects that cannot otherwise be removed or safety treated are important considerations for enhancing safety performance.

B. Barrier Need

Priority for barrier need.

Traffic barriers are needed only when the hazard without the barrier is greater than the hazard of the barrier itself.

Should a roadside hazard exist, treatment should be considered in the following priority:

1. Eliminate the hazard.

2. Treat the hazard to reduce accident severity, i.e., use flush or yielding designs.

3. Relocate the hazard outside the obstruction free zone to reduce the likelihood that it will be struck.

4. Shield the hazard with a barrier (median barrier, roadside barrier, or crash cushion).

There are three basic types of ~~hazards~~ objects that are commonly shielded using roadside barriers: 1) slopes, lateral dropoffs, or terrain features, 2) bridge ends and the areas alongside bridges, and 3) other roadside obstacles that cannot be eliminated, made breakaway or otherwise traversible, or relocated.

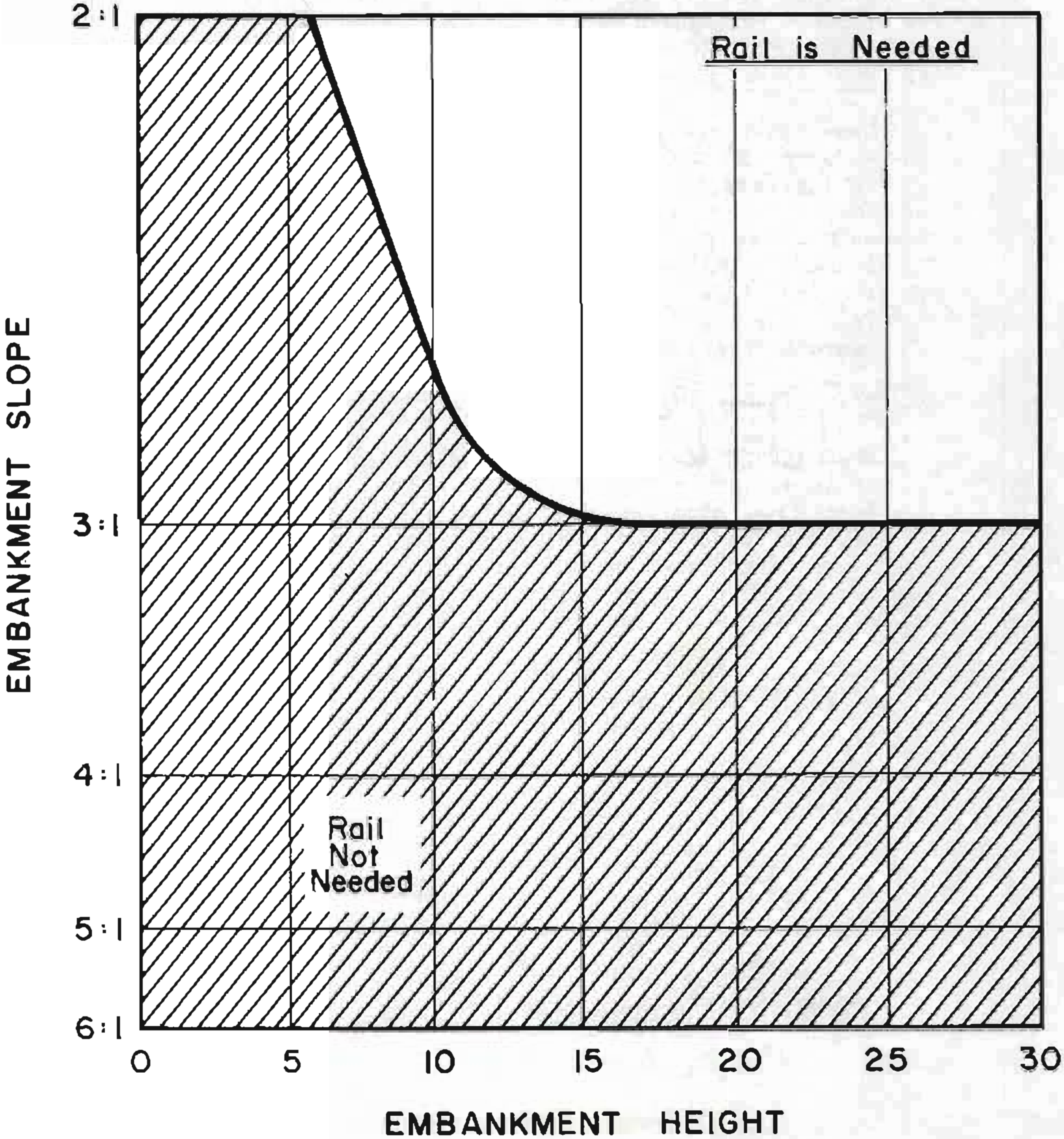
Figure A-1 shows a summary of roadside features that are commonly shielded with metal beam guard fence.

The combination of embankment height and side slope rate may warrant barrier protection as shown in Figure A-2. For low fill heights a more abrupt slope rate is tolerable than at high fill heights. Since 4:1 and steeper side slopes provide little opportunity for drivers to redirect vehicles at high speeds, in the absence of guard fence an area free of obstructions should be provided by the designer beyond the toe of slope.

ROADSIDE FEATURE	WARRANTING CONDITIONS
<u>Terrain Features</u>:	
Steep Embankment Slope	cz[a], See Figure A-2
Rough Rock Cut	cz
Boulders	cz, dia. exceeds 6 inches
Water Body	cz & depth exceeds 2 ft., permanent
Lateral Drop-off	cz & steeper than 1:1 and depth exceeds 2 ft.
Side Ditches	cz & unsafe cross section[b]
<u>Bridges</u>:	
Parapet Wall/Wingwall/ Bridge Rail End	cz & approaching traffic
Area Alongside Bridges	cz & approaching traffic
<u>Roadside Obstacles</u>:	
Trees	cz & dia. exceeds 6 inches
Culvert Headwall	cz & size of opening exceeds 36 inch (w.o. safety grates only)
Wood Poles, Posts	cz & cross section/area exceeds 50 sq. inches
Bridge Piers, Abutments at Underpasses	cz
Signal, Sign, Luminaire Supports	cz (non-breakaway supports only)
Retaining Walls	cz & not parallel to travelway

Notes:
a. cz - Within clear zone for highway class and traffic volume conditions.
b. For preferred ditch cross sections, see Section 4-202H3 in Part IV.

Figure A-1. WARRANTING CONDITIONS FOR ROADSIDE BARRIERS



GUIDE FOR USE OF GUARD FENCE FOR EMBANKMENT HEIGHTS AND SLOPES

FIGURE A-2

A-202 STRUCTURAL CONSIDERATIONS

Post spacing, rail shape and thickness, splice strength, post embedment, and rail anchorage are all important factors that influence the structural integrity of metal beam guard fence.

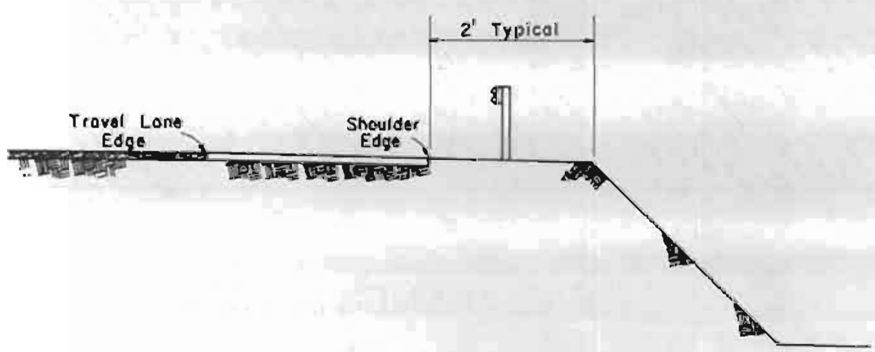
A. Post Spacing

Usual post spacing is 6'-3" for metal beam guard fence (MBGF). Reduced (3'-1½") spacing for a length of 25 feet should be used to increase lateral strength, and thus prevent pocketing during impact, when transitioning from flexible MBGF to rigid barrier such as at bridge ends, concrete barriers, or retaining walls. Increased (12'-6") post spacing is generally used in the 25-foot section of rail located adjacent to the terminal anchor section. This increased post spacing lessens barrier rigidity and improves performance in the event of end impact.

B. Post Embedment and Lateral Support

Where guard fence is to be placed at or near the shoulder edge, it is desirable that the roadway crown be widened, typically two feet from shoulder edge as shown in Figure A-3, to provide lateral support for the posts. Locating the roadway crown/side slope hinge point behind the rail also provides a platform that increases vehicular stability in the event of impacts that straddle the end section.

Embedment depth is shown on the standard plansheet for both timber and steel posts.



CROWN WIDENING TO ACCOMODATE MBGF

FIGURE A-3

C. Rail Element

Guardrail is fabricated in a deep (approximately 3 inches) beam shape to provide for bending strength. Nominal thickness of the rail is 10 or 12 gauge. Buried terminals, wingwalls, retaining walls, etc. provide firm rail anchorage. With full splice connections, the anchored rail has sufficient tensile and flexural strength to contain and redirect impacting vehicles.

Top of rail [illegible]

To insure satisfactory performance for a range of vehicle sizes, rail should be mounted at 27 inches (top of W-section) height as measured from shoulder surface, gutter pan, or widened crown.

Pavement overlays effectively reduce existing rail height. When rail height is more than three inches from standard height, steps should be taken to restore the rail to the standard dimension to reduce the possibility of vehicular vaulting or post snagging.

For existing MBGF with steel posts, the existing rail may be raised by stairstepping the blockout or by using an innovative shape of blockout as shown in Figures A-4(a) and A-4(b) respectively.

Where existing posts are timber, to raise existing rail the posts should be removed and replaced if rotted or otherwise deteriorated. Where existing timber posts are in good condition and embedded in cohesionless soils, the posts may be pulled (jacked) up to four inches. These partially extracted posts should be restrained at ground line to preclude settlement, and the resultant rail height is increased up to four inches. For cohesive soil conditions or where more than four inches height increase is desired, timber posts should be removed and replaced.

additional 6" above rail for future height adjustments.

The specified length on the standard details for new timber posts allows for six inches of post to protrude above the rail while retaining the traditionally used thirty eight inches embedment depth. The six inches above the rail permits easy future rail height adjustments without post disturbance.

D. Deflection Considerations

MBGF is a flexibly barrier system

Barrier to hazard distance 2.5' minimum 5.0' or more desirably

Metal beam guard fence is a flexible barrier system. The amount of dynamic deflection varies primarily with weight of impacting vehicle, its speed, and its encroachment angle. Guard fence should be laterally positioned to provide a clear shoulder width while maintaining a distance from a fixed object hazard that is greater than the dynamic deflection of the rail. Based on crash test data, this barrier-to-hazard distance should be 2.5 feet or more as diagrammed in Figure A-5. Where conditions permit, a barrier-to-hazard distance of 5 or more feet is desirable to accommodate heavy vehicle impacts and so that a vehicle impacting the terminal section and straddling the rail can pass by the fixed object.

A-203 PLACEMENT OF GUARD FENCE

The placement of guard fence pertains to the lateral and longitudinal positioning of guard fence.

A. Lateral Placement at Shoulder Edge or Curb Face (Figure A-6)

25:1 flare for last 50' provides a 2' offset.

Typically the face of rail is placed at the shoulder edge or curb face throughout most of its length and flared near terminals as shown in Figure A-6. Flaring the 25-foot terminal anchor section and the adjacent 25-foot of metal beam guard fence at 25:1 (longitudinal: lateral) provides a 2' offset to buried end. The offset and angled terminal reduce the likelihood of end section impacts. Where there is no approach traffic (i.e., one-way traffic operations, downstream terminal) the 50-foot flared section is of little value and continued placement at the shoulder edge or curb face is satisfactory.

Rail placed over curb - run post bolt approximately 21" above gutter pan or roadway surface

Where traffic speeds are 45 mph or more, guard fence placed in the vicinity of curbs should be blocked out so that the face of curb is usually (exception: flare near terminal anchor acceptable) located below or behind the face of rail. Rail placed over curbs should be installed so that the post bolt is located approximately 21-inches above the gutter pan or roadway surface.

Reference to "Barrier Guide"

When conditions dictate that MBGF be placed behind curbs for high speed conditions, Appendix F of the AASHTO "Guide for Selecting, Locating, and Designing Traffic Barriers" provides information regarding the influences of vehicle size and speed and curb geometry on vehicle trajectory. Using this information, a MBGF location that enhances the likelihood of normal impact may be selected. Transitioning a barrier curb to a rollover or mountable design will reduce the likelihood of vehicle vaulting whenever guard rail is located behind, rather than over, curb.

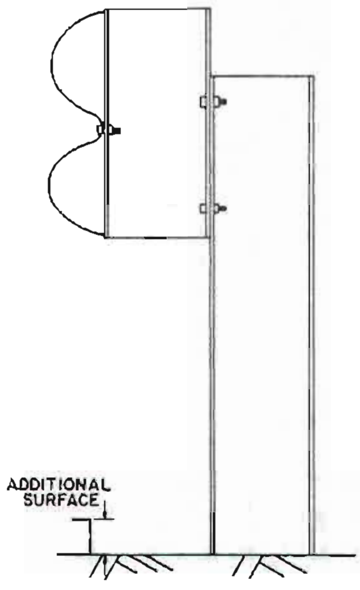
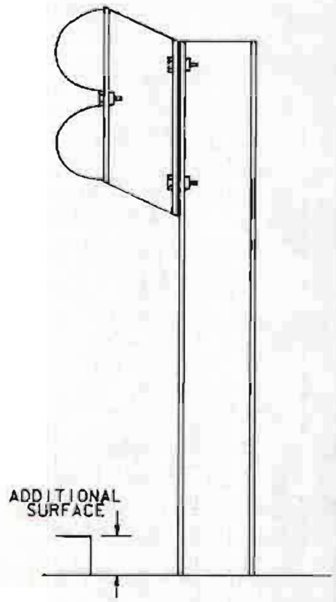
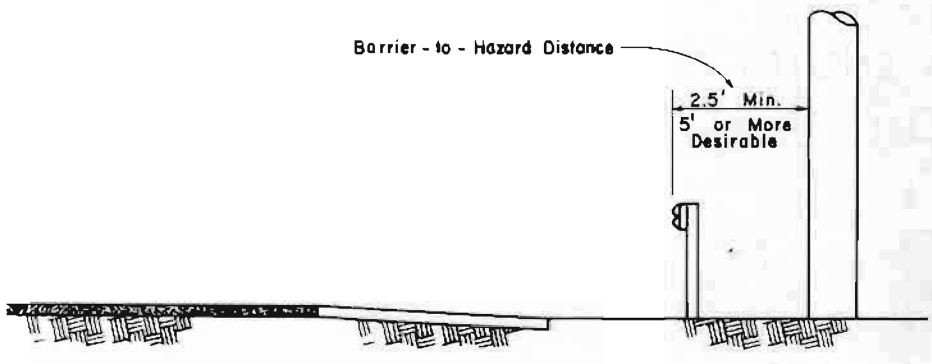


FIGURE A-4(a)



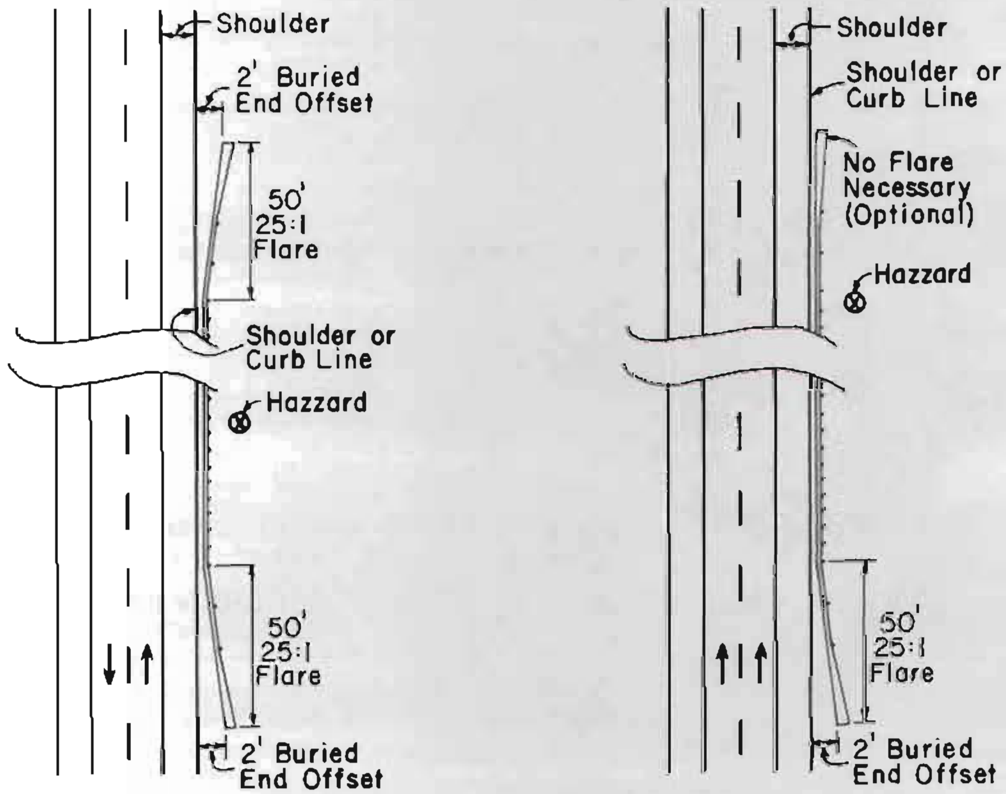
ADJUSTMENT OF RAIL HEIGHT ON EXISTING STEEL POSTS

FIGURE A-4(b)



ALLOWANCE FOR DEFLECTION OF MBGF

FIGURE A-5



(A) TWO WAY TRAFFIC (B) ONE WAY TRAFFIC

PLACEMENT AT SHOULDER EDGE OR CURB FACE

FIGURE A-6

For 40 mph (or less) speed conditions, MBGF may be located behind the face of curb.

B. Lateral Placement Away From the Shoulder Edge (Figure A-7)

In certain instances it is desirable to place guard fence near the hazard rather than at the shoulder edge or curb face. Placement in this manner can substantially reduce the length of rail required to shield a given hazard and minimize the probability of impact, but undesirably encroachment angles may increase. This manner of placement is most applicable to small areas of concern -- point type hazards such as overhead sign bridge supports, bridge piers, etc.

Guard Fence placed anywhere on 10:1 or flatter slopes. Should be placed within 3' of shoulder edge if steeper than 10:1.

To preclude vaulting or impacting at an undesirable position by errant vehicles, care should be exercised in selecting placement location of MBGF with respect to slope conditions. As a general rule, guard fence may be placed at any lateral location on side slopes if the slope rate is 10:1 or flatter. Whenever side slopes are steeper than 10:1, new guard fence usually should be placed within three feet of the shoulder edge rather than on the slope, as shown in Figure A-7. Existing guard fence on slopes as steep as 6:1 are not a high priority for replacement and may remain since it will perform well for most impacts.

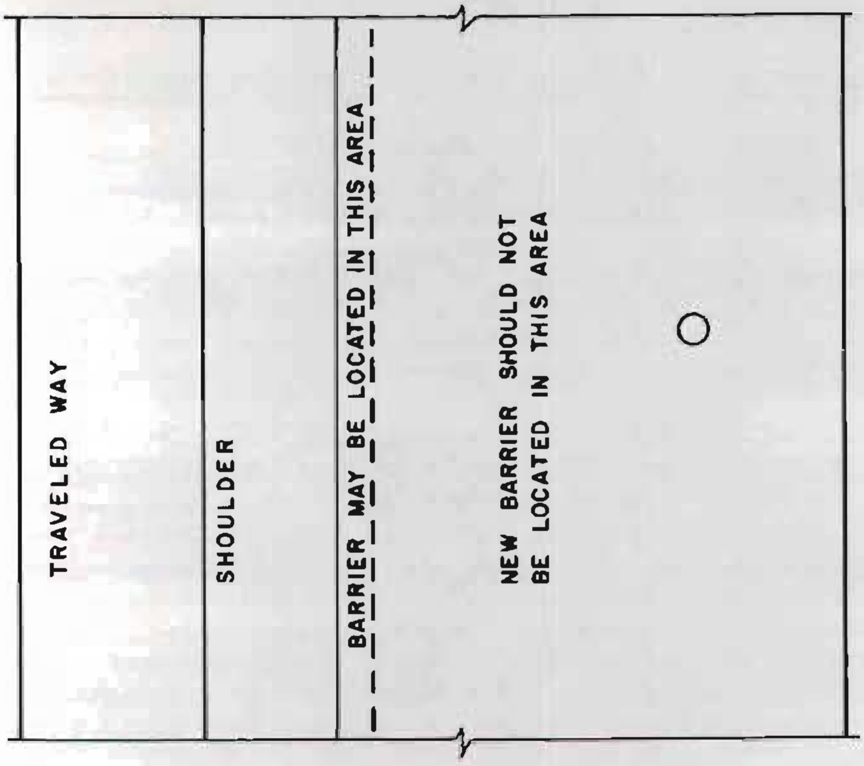
A-204 END TREATMENT OF MBGF

End treatment of guard fence should anchor the system at both ends to buried terminals, wingwalls, concrete traffic barriers, etc., so that full tensile strength of the rail may be developed. The end treatment further should not spear nor excessively vault or decelerate impacting vehicles.

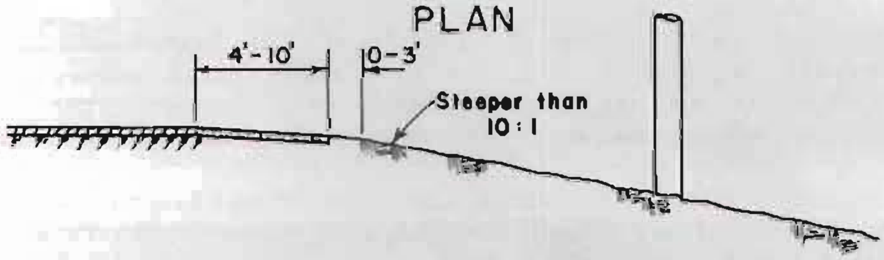
Long term accident data has shown that the twisted, buried end provides acceptable impact and anchorage performance; however, improved treatments will be sought through research efforts.

A modified, falldown turndown end treatment has been developed that reduces the potential for vehicular vaulting or rollover upon impact. However, certain installation and maintenance problems have been experienced when using this experimental end treatment.

In isolated instances where an extraordinarily high frequency of roadside encroachments are expected or have been experienced, higher performance (and cost) end treatments should be considered. Crash cushions and proprietary (e.g., SENTRE) systems are candidate treatments.



PLAN



ELEVATION

LOCATION OF ROADSIDE MBGF

FIGURE A-7

A-205 DETERMINING LENGTH OF NEED OF BARRIER

The shape of the hazard, its location with respect to travel lanes, the volume of traffic and its corresponding clear zone width are the primary variables influencing length of MBGF need.

A. Involved Variables

After all practical means to free the roadside of obstacles have been exhausted, certain areas may remain which constitute a hazard to traffic. These areas, as illustrated in Figure A-8, will be referred to as an "area of concern".

Figure A-9 illustrates the variables of interest in the layout of approach barrier to shield an area of concern. Length of need is equal to the sum of the (a) length of upstream barrier, L_u, (b) length of barrier parallel to the area of concern, L_p, and (c) the length of downstream barrier, L_d.

For roadways serving one-way traffic operations, $L_d=0$. L_d is greater than zero for two-way operations when the area of concern lies within the clear zone of opposing (northbound in Figure A-9) traffic as measured from the centerline pavement markings.

In certain instances judgment should be exercised to supplement design chart solutions and provide for public safety. For example, high severity fixed objects (e.g., bridge columns) may warrant minimum MBGF treatment where located slightly outside the clear zone if geometric conditions (steep fill slope, outside or horizontal curvature, e.g.) increase the likelihood of roadside encroachments.

B. Design Charts

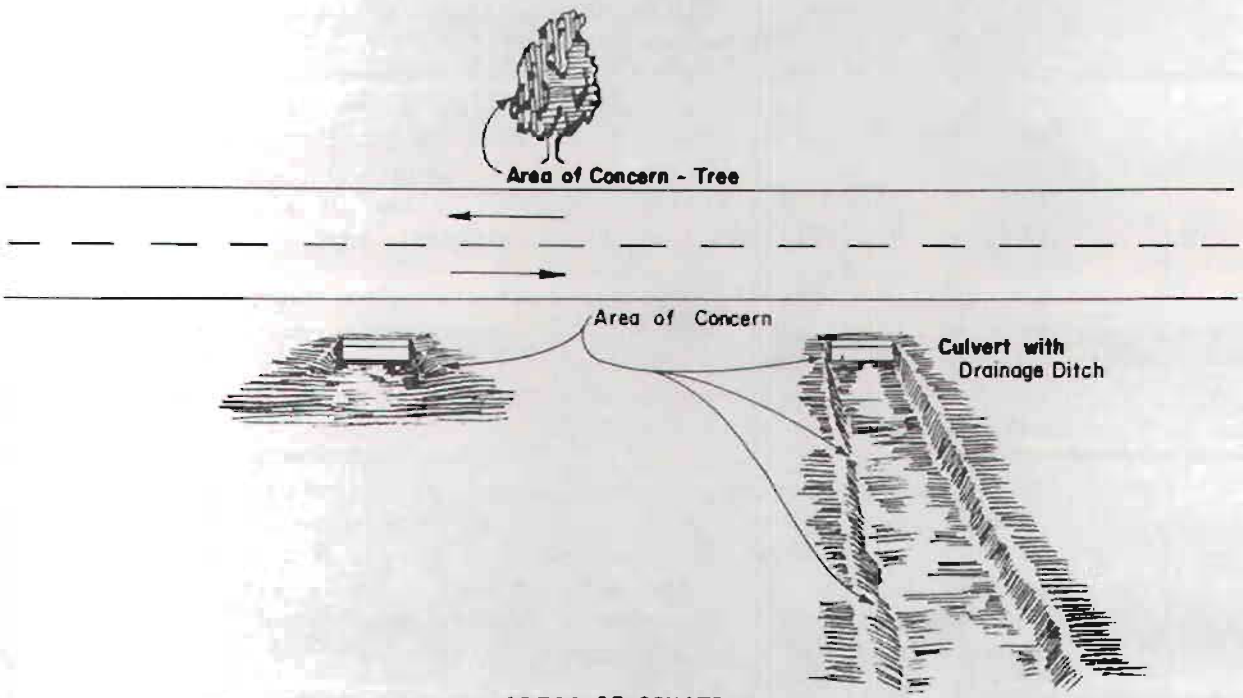
To determine needed length of guard fence for a given hazard, design charts have been formulated for low volume (ADT 750 or less) and higher volume (ADT more than 750) conditions. A clear zone width of 16 feet and length of roadside travel of 200 feet are incorporated in the low volume design chart. For higher volumes, a clear zone width of 30 feet and length of roadside travel of 250 feet are incorporated into the design chart.

Figure A-10 shows the design chart for present ADT volume of 750 or less, and Figure A-11 shows the design chart for higher volumes.

C. Using a Design Chart

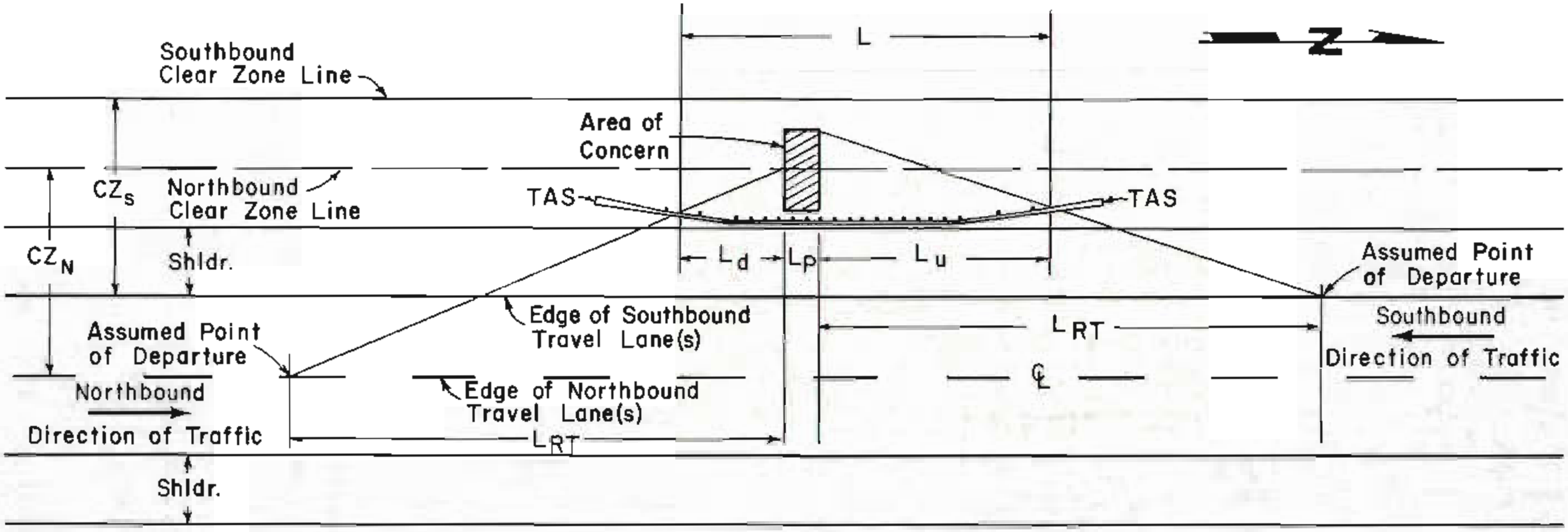
Before determining length of guard fence, the designer should assemble all pertinent data including:

Present ADT volume
Traffic operations (one-way or two-way)
Lateral and longitudinal dimension of the area of concern
Shoulder width



AREAS OF CONCERN

FIGURE A-8



CURRENT ADT	CZ	L_{RT}
750' or less	16'	200'
More than 750'	30'	250'

Abbreviations:

CZ = Clear Zone Width

CZ_s = Clear Zone for Southbound Traffic

CZ_N = Clear Zone for Northbound Traffic

L_{RT} = Length of Roadside Travel

TAS = Terminal Anchor Section

L_u = MBGF Length Upstream of Area of Concern

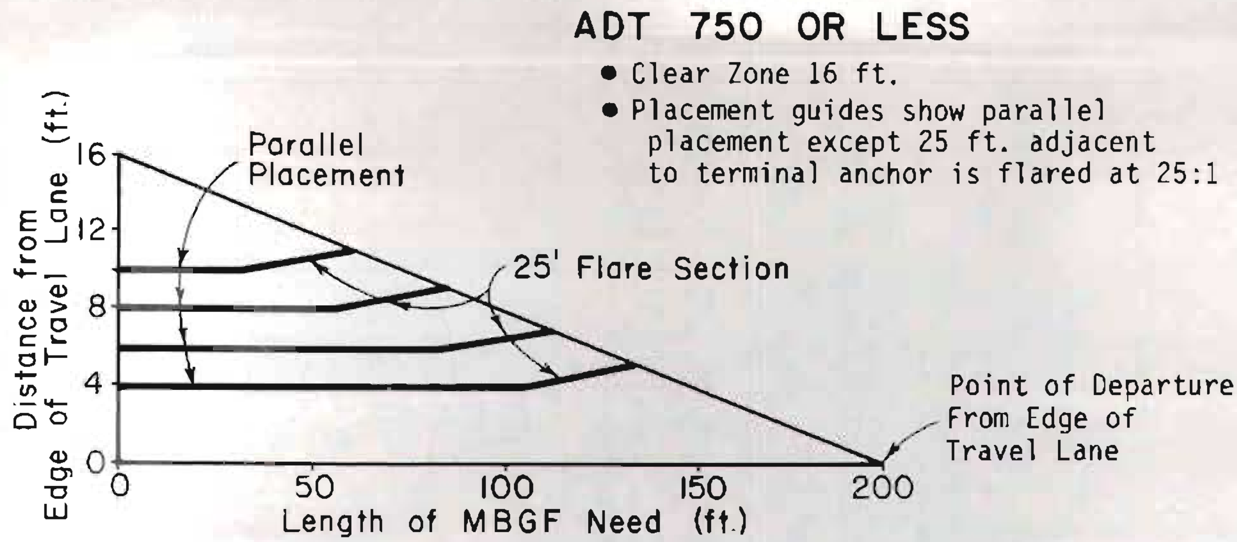
L_p = MBGF Length Parallel to Area of Concern

L_d = MBGF Length Downstream of Area of Concern

L = Length of MBGF Need = $L_u+L_p+L_d$

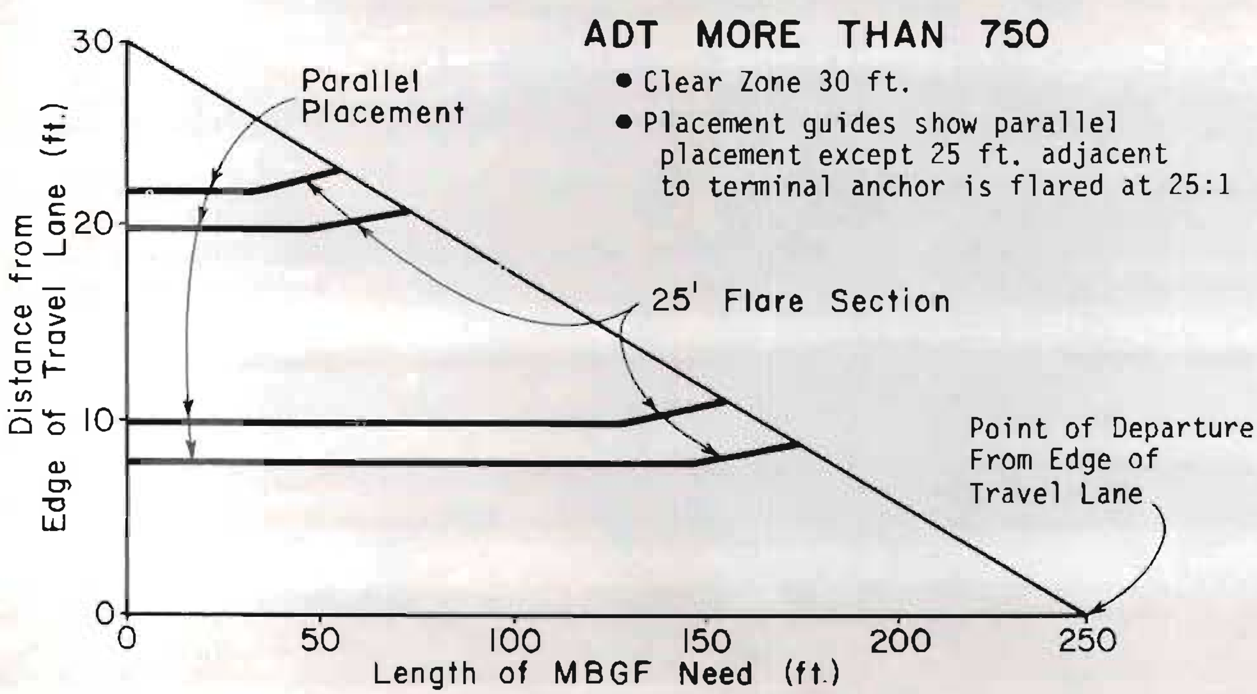
VARIABLES INVOLVED IN BARRIER LAYOUT

FIGURE A-9



DESIGN CHART FOR LOW VOLUME HIGHWAYS

Figure A-10



DESIGN CHART FOR MODERATE AND HIGH VOLUME HIGHWAYS

Figure A-11

Offset distance of the area of concern from the edge of travel lane (including from the centerline markings for two-way traffic operations)

Design slope conditions, i.e. will slopes be 10:1 or flatter? Steeper than 6:1?

Placement location (alongside shoulder vs. near object, flared, etc.)

Presence of other nearby areas of concern which should be considered simultaneously.

Once this design data has been assembled, the appropriate chart may be used.

Figures A-12, A-13, and A-14 are example solutions using the design charts.

D. Minimum Length of Roadside Barrier (Non-Bridge End)

The minimum length of MBGF that is located within both of the clear zones of two-way traffic is 75 feet. Post spacing should be 12'-6" for each 25 feet adjacent to a terminal anchor section and 6'-3" for the intervening 25 feet of MBGF.

The minimum length of MBGF that is located within the clear zone of only one direction of flow is 50 feet. Post spacing should be 12'-6" for the 25 feet nearest approaching traffic and 6'-3" for the remaining 25 feet.

A-206 BARRIERS ON BRIDGE APPROACHES

For approaches to bridges, design chart solutions have been made for various clear zone widths (i.e., ADT volume levels), shoulder widths, and for one-way and two-way traffic operations. Minimum lengths of approach MBGF are shown on the Bridge End Detail (BED) standard sheets shown in Appendix A-100. Where other hazards are present, longer lengths may be required as dictated by customized solutions using the design chart.

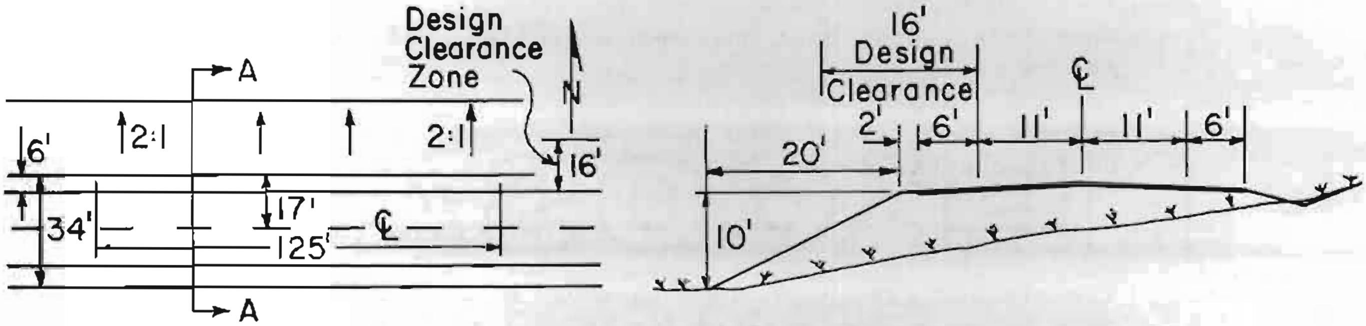
The lengths shown on the BED standard sheets are for traffic operating at high speed conditions. For low speed conditions, typified by urban street operations, shorter lengths suffice. For these conditions, it is typically desirable to provide 50 to 75 feet of approach MBGF. Access driveways should be located beyond the terminal anchor whenever practical.

A-207 MEDIAN BARRIERS

Section 4-702C in Part IV includes a discussion of median barriers. Standard sheets for median barrier are shown in Appendix A-100.

Figure A-12 Example Problem 1

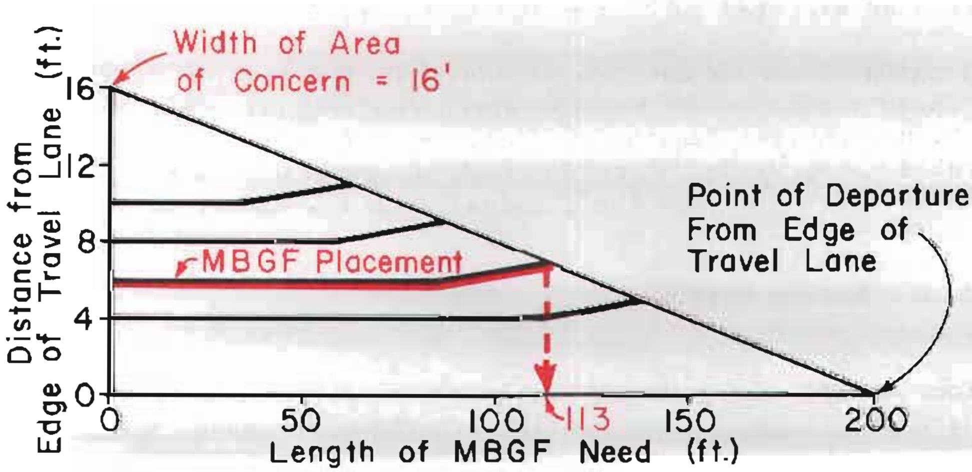
Given. Rural two lane highway with current 500 ADT, six-foot wide shoulders. Area of concern is 16' design clear zone that includes 2:1 side slopes on 10 feet high embankment section that is 125 feet in length alongside highway.



PLAN

CROSS SECTION A-A

Solution. Refer to Figure A-2 and find "rail is needed". As shown in Figure A-9, length of need is $L=L_u+L_p+L_d$. L_p = 125 feet from given information. Since ADT is less than 750, Figure A-10 should be used to solve for L_u and L_d (if necessary).



For the upstream (westbound traffic) direction, the area of concern is full (16 ft) clear zone width. Using placement of MBGF alongside the 6 foot-wide shoulder with the terminal anchor and adjoining 25 feet flared at 25:1, L_u = 113 feet.

The length of MBGF need in the downstream (eastbound traffic) is zero since the offset distance from the edge of travel lane (centerline marking) to the area of concern is greater than the design clear zone (17 ft. greater than 16 ft.). L_d therefore is zero.

Design placement therefore is 125 feet of MBGF adjacent to the hazard plus 113 (round to 125) feet shielding westbound traffic upstream of the hazard. These lengths of need do not include terminal anchor sections. The approach end terminals and adjacent 25 feet of MBGF will be flared at 25:1.

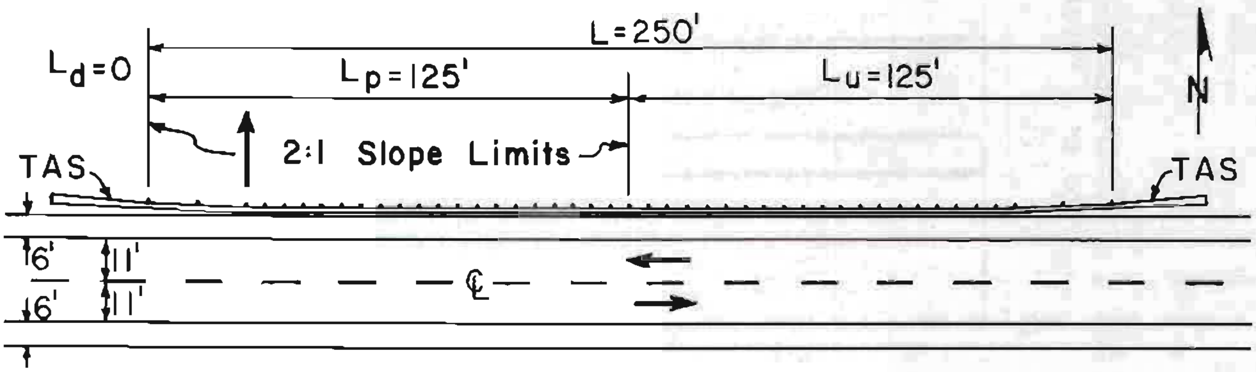
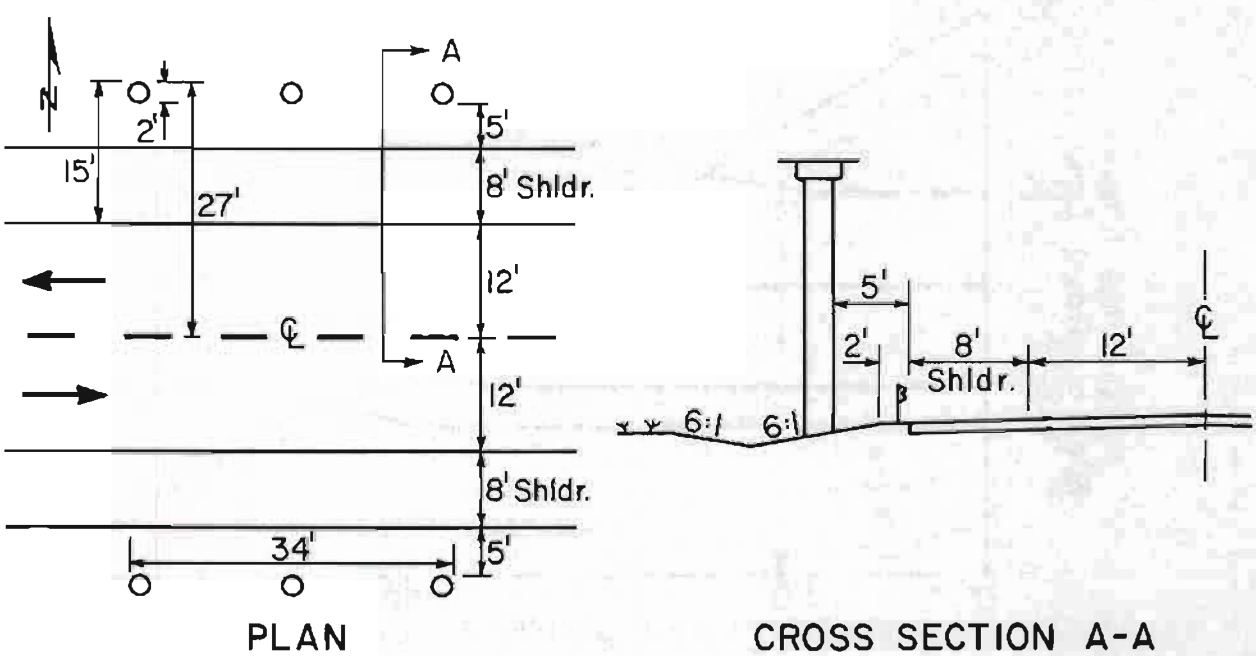
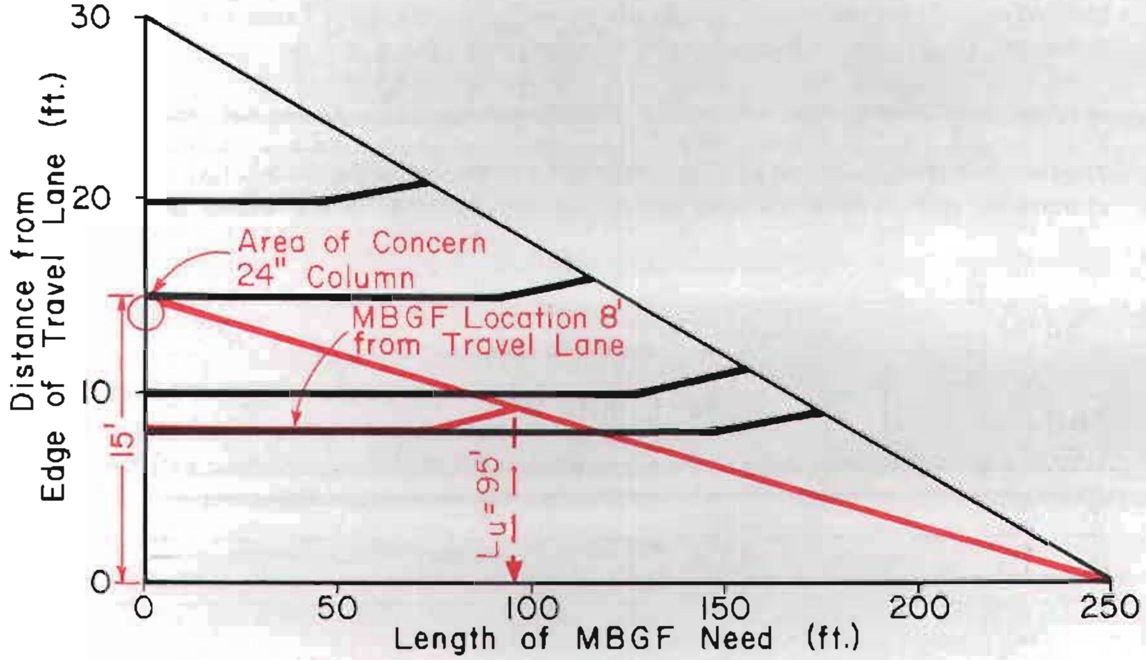


Figure A-13. Example Problem 2

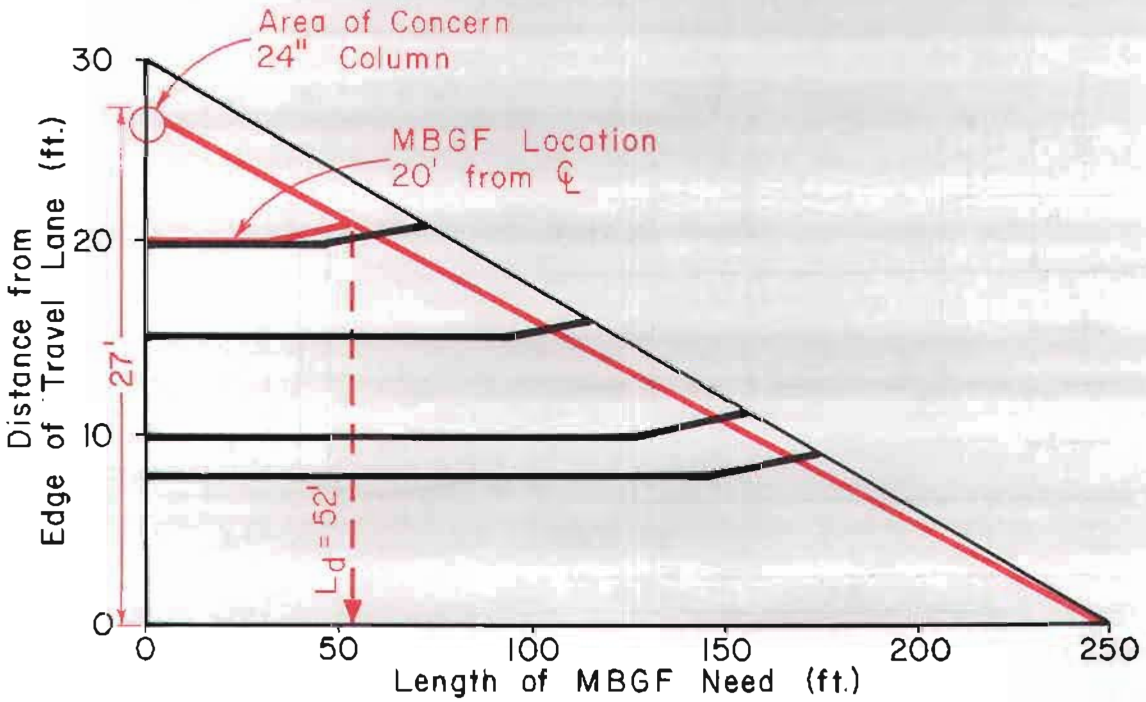
Given. Rural two lane highway, shoulder width of 8 feet, current ADT 3500. Areas of concern are bridge bents located 5 feet from edge of shoulder. Side slopes are 6:1.



Solution. (Northside of roadway). Referring to Figure A-1, bridge piers within the clear zone (30 ft. in this case) warrant MBGF placement. As shown in Figure A-9, Length of need is $L=L_u+L_p+L_d$. L_p is 34 feet from the given (see plan sketch) information. Since ADT is greater than 750, use Figure A-11 to find L_u and L_d (if necessary).



Upstream length (L_u) is 95 feet if placement is at the shoulder edge and if the terminal anchor section and adjacent 25 feet of MBGF is flared at 25:1.



Downstream (westbound traffic) length of MBGF is 52 feet, based on shoulder edge placement. For westbound traffic, the centerline is the edge of travel lane and thus MBGF will be placed 20 feet (12 ft. lane plus 8 ft. shoulder) from the edge of travel lane.

Total length of MBGF, $L_u+L_p+L_d$, thus is 95 ft. + 34 ft. + 52 ft. or 181 ft.; round to 175 feet.

The solution for the south side of the roadway yields the same results, hence placement should be as shown below:

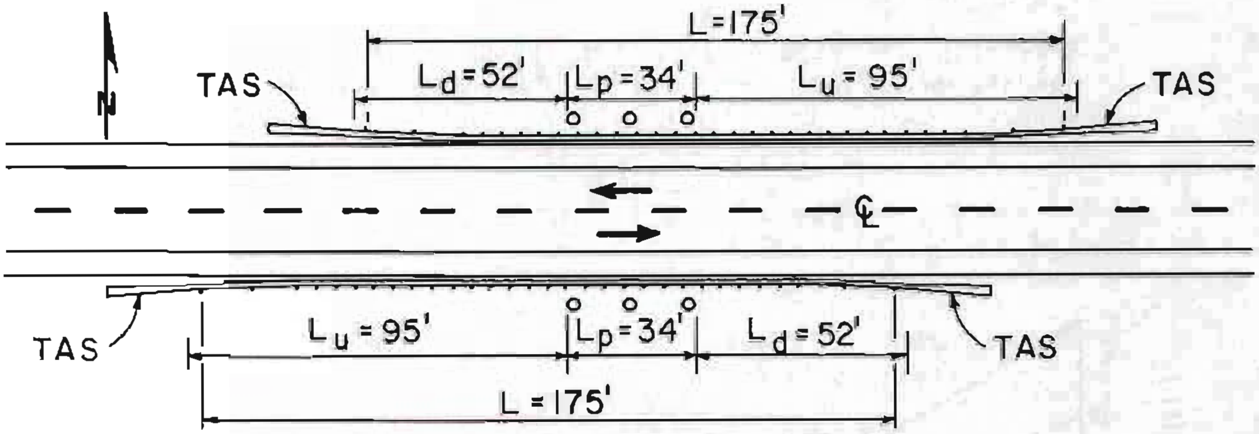
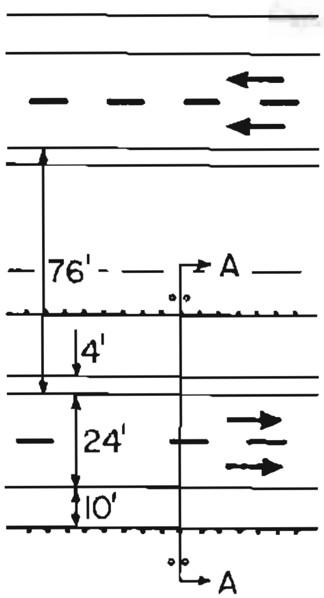
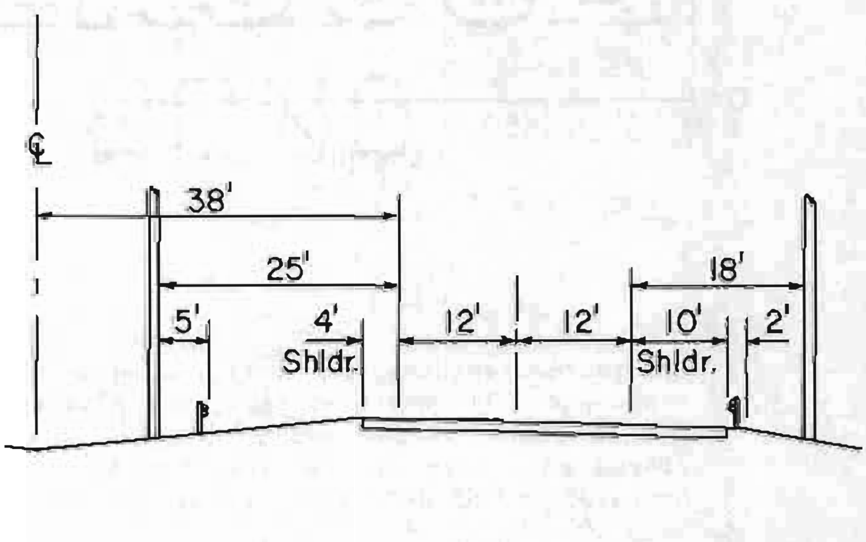


Figure A-14. Example Problem 3

Given. Divided (76' median) highway with 4 ft. left and 10 ft. right shoulder widths. Median slopes are 10:1, outside side slopes 6:1. The cross sectional design allows for addition of a future lane on the median side of the present lanes. The areas of concern are overhead sign bridge supports offset 25 ft. left and 18 ft. right from edge of travel lanes as shown below. ADT is 10,000.



PLAN

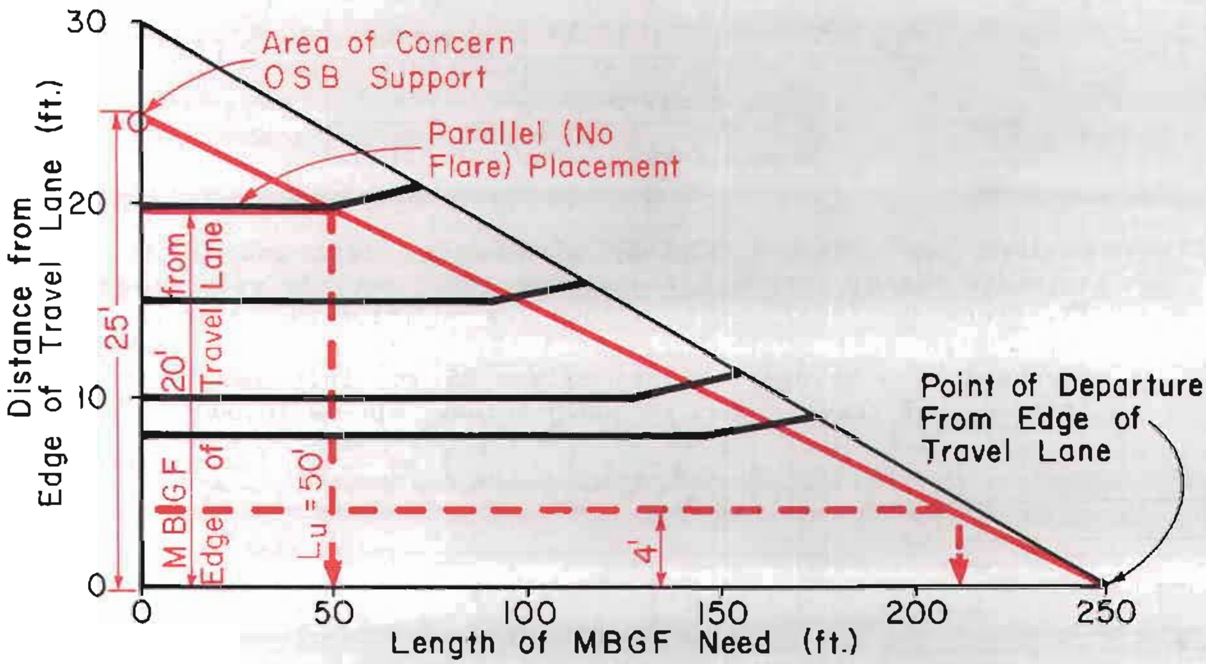


CROSS SECTION A-A

Solution: Crash cushions in lieu of MBGF, should be considered, particularly for facilities with higher than 10,000 ADT. For this example problem assume crash cushions are not cost effective.

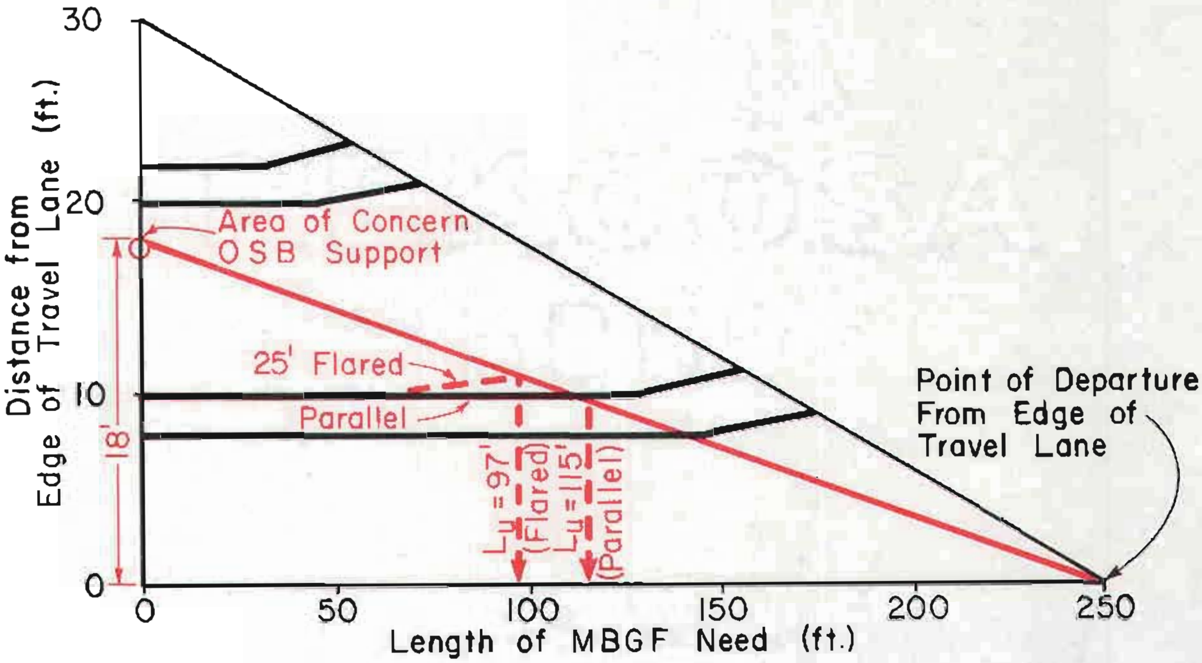
Since the median is sloped at 10:1, MBGF may be placed thereon (Reference Figure A-7). Place MBGF 5 ft. in front of the median overhead sign bridge support, i.e., 20 ft. from the edge of travel lanes. Use no flare (entire length of MBGF placed parallel).

Referring to Figure A-9, $L=L_u+L_p+L_d$. For one-way traffic operations, $L_d=0$, furthermore, for the overhead sign bridge support, $L_p=0$. Use Figure A-11 to find L_u since ADT is greater than 750.



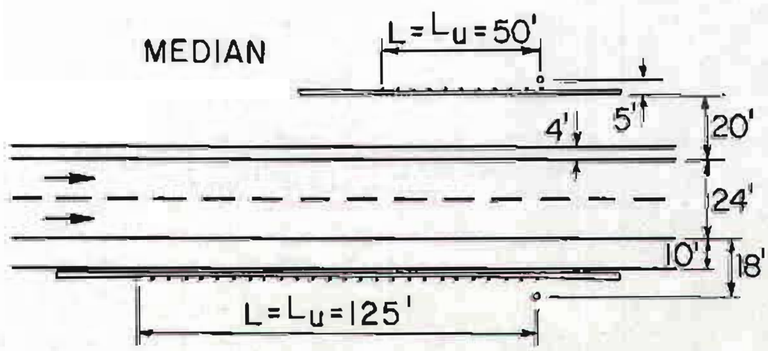
For the median side, L_u=50 ft. based on parallel (no flared end) placement full length of need, and placement on the 10:1 slope 5 ft. in front of the fixed object. In contrast, parallel (no flared end) placement at the shoulder edge would have required over 200 ft. of MBGF as shown by the dashed line.

For the right side of traffic, MBGF must be placed at the shoulder edge (Reference Figure A-7).



Using parallel placement for the entire length, L_u=115 ft. which should be rounded to 125 feet. If the 25 ft. adjacent to the terminal anchor section were flared, L_u=97 ft., which would be rounded to 100 feet.

Using parallel placement (no flared ends) for the entire length of MBGF for both the median and left side, placement would be as shown below:



PART V

PLANS, SPECIFICATIONS AND ESTIMATE SUBMISSIONS

PART V

PREPARATION FOR SUBMISSIONS (5-100)

The supporting papers for a construction project are an integral part of the project submission. Omission of some of the papers or incomplete or improperly prepared papers may delay processing of the project to the desired letting. The PS&E and supporting papers should be submitted together.

The purpose of this Section is to present instructions regarding the preparation of the required supporting papers.

5-101 SUPPORTING PAPERS

A. The PS&E Submission Data Sheet

The PS&E Submission Data Sheet is essentially a supporting papers' checklist to be used by the District in preparing the PS&E and to provide the Austin Office with a record of all papers contained in the submission. This form should be completed and carefully checked when preparing the submission to avoid overlooking any of the supporting papers. Information as to the status of the missing papers should be on the form and in the letter of transmittal.

B. Letter of Transmittal

All PS&E proposed for contracting should be submitted to File D-8. An informative, well-prepared letter of transmittal should be addressed to File D-8. Under the lines of responsibility established by the Administration there are several items for which responsibility must be acknowledged by the District. Unusual design features or innovations should also be discussed in the letter of transmittal. A letter of three or more pages will not be uncommon. A carefully prepared letter aids in project review and is beneficial in eliminating "second guessing."

In preparing the letter of transmittal, consideration should be given to the following items:

1. Preliminary Approval

During preliminary planning for most projects, schematic layouts, typical sections, basic design-value sheets and/or preliminary bridge layouts and hydraulic data, if any, have been submitted to the Austin Office for concurrence by the responsible Division. Further study during plan preparation often leads to changes in major design features which should be reviewed by all concerned. However, if prior approval of revisions has not been obtained, the conditions warranting the changes should be fully explained in the letter of transmittal. A thorough review of all past correspondence should be made prior to PS&E submission to ascertain that all design questions have been settled and project authorization is assured.

2. Special Provisions and Special Specifications

In order to expedite handling and approval of specifications, it is requested that special provisions and special specifications be submitted to the Austin Office for consideration of the Specification Committee prior to submission of PS&E where possible. This is necessary to provide the affected design division and the Specification Committee with sufficient time to evaluate and consider the specification.

Special specifications and special provisions transmitted to the appropriate design division for approval should be listed in a transmittal letter or on the PS&E Submission Data Sheet. They should be submitted immediately after the final draft is prepared. In order to facilitate action on these special specifications, the letter should contain a condensed statement setting out the condition or conditions that created the need for the new specification and a brief summary of their content. A brief statement giving the need for, and the benefit to be derived from, special provisions which may be construed as special specifications or are a major variation from the original specifications will also aid in obtaining approval and should be included in the transmittal letter.

For unusual job conditions, a special provision or a special specification may be necessary for use only on that project. This should be so noted in the transmittal letter. If this item is approved, it will not be valid for subsequent projects. In order to expedite processing a PS&E containing items without prior approval, the new items may be approved for use on that project only, pending a more in-depth review by the Specifications Committee.

3. Relocation Assistance, Right-of-Way Certification and Utility Adjustments

Where relocation assistance is involved it will be necessary that a certification, signed by the District Engineer, be included with the letter of transmittal for the PS&E.

a. No relocation advisory assistance or payments are required for the project.

> "This is to certify that this project did not cause any displacement and the steps relative to relocation advisory assistance and payments under the current FHWA directive(s) covering the administration of the Highway Relocation Assistance Program were not required."

b. Relocation advisory assistance and/or payments are required for the project and are completed.

> "This is to certify that all relocation advisory assistance and payments were provided and that all individuals and families have been relocated to decent, safe and sanitary housing or the State has made available to relocatees adequate replacement housing in accordance with the current FHWA directive(s) covering the administration of the Highway Relocation Assistance Program."

c. All relocation assistance services and/or payments are complete, except for one or more parcels, at the time of PS&E submission. State in full the certification comments under (b) above and continue with the following after the last word, Program.

"...Program, except those displacees identified for the parcels listed below. These displacees will be relocated in accordance with applicable FHWA directive(s)."

Provide full explanation and reasons for the use of this certification, the basis for your determination that it is in the public interest to proceed, a list of the excepted parcel(s) and displacee(s), and the following information as appropriate with substantiation that the dates involved are realistic; that is, specifically when the relocation services and payments will be completed.

(1) Specific dates for the termination of business operations.

(2) Specific dates for the vacation of residentially improved properties.

If specific dates cannot be determined and substantiated, please provide full explanation and reasons therefor in support of your finding that it is in the public interest to proceed under the waiver necessary in accordance with FHPM paragraph 5c (3)b. No project will be advertised for bids where persons are still living on the right-of-way except where very unusual circumstances prevail.

Complete information regarding the status of right-of-way must be furnished. In accordance with Federal regulations, the following applicable statement, signed by the District Engineer, must be attached to the PS&E letter of transmittal.

a. No additional right-of-way was acquired for the project.

"This is to certify that acquisition of right-of-way was not required for this project."

b. All right-of-way has been acquired at the time of PS&E submission (see FHPM 6-4-2-1, par. 5c(11)).

"This is to certify that all of the right-of-way has been acquired in accordance with the current FHWA directive(s) covering the acquisition of real property."

c. All right-of-way has been acquired, except for one or more parcels, at the time of PS&E submission.

"This is to certify that all right-of-way has been acquired in accordance with the current FHWA directive(s) covering the acquisition of real property, except those parcel(s) listed below which will be acquired in accordance with the FHWA directive(s)."

List the excepted parcel(s) and provide the following information as appropriate:

(1) For those parcels that have not been fully acquired, but the right to occupy and to use all rights-of-way required for the proper execution of the project has been acquired:

LIST PARCELS

(2) For those parcels that have not been acquired and there is not a right to occupy and use the right-of-way, provide full explanation and reasons for the use of this certification, the basis for your determination that it is in the public interest to proceed, a list of the parcel(s), and indicate the estimated date (with substantiation that such date is realistic) for each parcel when physical occupancy and use will be obtained. Please note that appropriate notification shall be provided in the bid proposals in accordance with FHPM 6-4-1-6, subparagraph 7h.

A statement should be included in the letter of transmittal advising that all utility adjustments that will interfere with construction or maintenance are either complete or incomplete. In the event that all right-of-way has not been acquired or necessary utility adjustments are not completed, a special provision must accompany the letter of transmittal listing each parcel and/or description of improvements and utilities, approximate station numbers and whether the Contractor, or others, is to remove improvements. In order to receive FHWA approval, the letter of transmittal must state the reasons for going to contract before all right-of-way is available.

Proceeding to contract before all right-of-way is clear is to be done only in unusual cases. For Federal-aid projects a statement should be included outlining the reason all right-of-way has not been acquired.

If all utilities have not been completely adjusted, a Utility Adjustment Status Form (included in the attachments) should be attached to the PS&E letter of transmittal and include the following information:

(1) Owner

(2) Description of the utility that has not been adjusted (type, including whether overhead, underground, crossing, etc., size, location, etc.)

(3) Indicate if work has started on the adjustment or when work is expected to start.

(4) Amount of work completed

(5) Amount of work remaining

(6) Estimated date of completion

(7) Indicate whether work will be by contract, utility's own forces or State forces. If by contract, list contractor and whether work has been let.

This form must be updated prior to PS&E submission to the FHWA. If utility adjustments are to be made by others, it is recommended that documentation by letter be furnished by those responsible for the adjustment. The letter should include dates adjustments will commence and be completed.

C. List of Governing Specifications and Special Provisions

Each standard specification item, special provision and special specification proposed for the project should be listed. When more than one project is combined for contracting purposes only one list should be prepared with particular care taken to insure that all items are included. This list is used in contract preparation and becomes a part of the contract. Only the current standard specifications will be used.

The list of specifications is divided into three sections and should be prepared as follows:

1. Standard Specifications

The list of standard specification items includes Items 1 through 9 and the number and title of each standard specification item for which payment is to be made under the construction contract. The title of each item as indicated in the Specifications Book should be used.

Reference items should be given the proper attention in preparation of the list of specifications. In order for a nonpay item to be included in the executed contract, it must be shown as a reference to one of the items listed. This is shown by adding the number of the referenced specification in parentheses after the pay item.

Each pay item should be examined carefully to insure that not only those items referred to directly are included but also those items which are referred to in the reference item itself. For example Item 364 refers to Item 421 for concrete and concrete ingredients; however, it is also necessary to list Item 437 for admixtures and Item 522 for ready-mix concrete plants, etc.

It is not necessary to include reference items which are also listed as one of the pay items. Also, the reference item should be indicated only once and should appear after the first applicable pay item.

There are other instances where it is necessary to show items as reference items although they are not referred to in any of the other specifications. This frequently occurs when minor work is required by a note on the plans and a specification is referred to for materials or construction requirements. An example is requiring backfill of a conduit trench in accordance with Item 401. In order to have the specification governing this work in the contract it will be necessary to list it as a reference item and cover it by a note on the plans.

2. Special Provisions

Each required contract provision and special provision to a standard pay item, a standard reference item or to a special specification should be listed under "Special Provisions." Under the present system for computer tabulation of bids, only one special provision to any one bid item description can be used, with the following exception. An alternate bid item description may have different special provisions from its base bid item.

3. Special Specifications

All special specifications under which payment is to be made or which are used as reference items should be listed by number and title as required for standard specifications. Particular attention should be given to insure that any standard items referred to in the special specifications are indicated as reference items.

D. Special Provisions and Special Specifications

A Specifications Committee composed of the Highway Design, Bridge, Maintenance, Materials and Tests and Construction Division Heads considers proposed special provisions and special specifications. One purpose of the Committee is to carefully screen all special provisions and special specifications for conformance with Departmental policies and construction practices and to approve only those deemed essential. The Committee also recommends special provisions and special specifications affecting Departmental policy to the Engineer-Director for his approval. The Committee also has liaison with legitimate highway-industry associations and representatives for the purpose of discussing and/or clarifying specifications affecting those institutions.

The following general guides regarding the preparation of special provisions and special specifications have been established by the Committee.

Special provisions and special specifications should be submitted only when it has been determined that construction under the standard specifications will not achieve the desired results or will prove to be uneconomical.

Special provisions should modify the standard specification only to the extent necessary to accomplish the desired results. When voiding portions of an article the remainder should be reinserted exactly as it appears in the standard specification. While condensation and simplification may result in a more concise special provision, this practice has too often resulted in misinterpretation and important standard specification requirements being unintentionally omitted.

The same general format and wording used in the standard specifications should be followed in preparing special specifications. This can most readily be accomplished by using a similar standard item as a guide and substituting the desired wording where appropriate. The measurement and payment paragraphs in particular should be essentially the same as similar standard items. This is necessary since conflicts or vagueness in these paragraphs are often the basis for claims against the Department.

During the preparation of both special provisions and special specifications, considerable thought should be given toward requirements and wording which will permit the use of the special provisions or special specifications on other projects having slightly different conditions. By relegating certain features such as density and gradation requirements to the plans and exercising foresight in preparing the measurement and payment paragraphs this end can be achieved. The repeated use of desirable special provisions and special specifications is most beneficial in that it results in progress in construction methods and materials and uniform interpretation of specification requirements.

E. Material Option Agreements

Two forms for securing material option agreements to purchase local materials for construction projects are in current use: "Agreement for Purchase of Road Material," for material intended for use in the roadway pavement structure; and "Agreement for Purchase of Road Material (Borrow)" for materials going into the road embankments. Material option agreements should be obtained when possible on the appropriate form and six copies should be submitted with the PS&E or, under some circumstances in advance of PS&E. The forms are largely self-explanatory; however, some of the more important features are discussed below.

1. Name of Owner

If the owner is a married individual, the spouse's name should also appear and both should sign the instrument. If only a woman signs the instrument, the letter of transmittal should contain a statement indicating that she is a "femme sole."

Material option agreements for material on land lying in an estate should bear the estate name and administrator's name. Each individual having an interest in the estate or someone empowered to sign for each must sign the instrument. Corporation-owned lands should be optioned in the corporate name and signed by officials properly authorized to execute agreements for the corporation.

Signatures of individuals must be identical to their name as it appears as the Party of the First Part.

2. Term

Careful consideration should be given the term of the material option agreement to anticipate delays in acquisition of right-of-way, completion of PS&E and letting of the contract.

3. Royalty Price

The unit royalty price established should generally be comparable to royalty for other similar materials in the same geographical area. Should a higher price be proposed, justifying information is to be submitted with the material option agreement. Surface damage payments are not eligible for deduction from a Monthly Estimate.

4. Method of Measurement

The unit of measure and method of measurement for borrow, flexible base, admixtures, etc., shall be the same as will be used in the construction contract. Long-term material option agreements secured for use on several projects should contain provisions for different units of measure and methods of measurement if it is apparent that project conditions will warrant such action. The wording "by the ton of 2000 pounds dry weight" should be used for measurement by the ton.

5. Special Conditions

The material option agreement form should ordinarily be executed without variations or additional conditions; however, it is sometimes necessary to insert special clauses in order to secure the owner's signature. Minor requirements pertaining to watchmen, cattleguards, fences, etc., are permissible though undesirable. Unusual conditions should receive advance Administrative approval as legal statutes or Departmental policy may dictate that other material sources be obtained. Since the construction contract does not require the Contractor to operate a listed or designated source, care should be taken in wording special clauses to avoid obligating the State if the option if not exercised.

6. Certification of Value for Borrow Materials

The form, "Agreement for Purchase of Road Material (Borrow)," includes a statement for the District Engineer's signature which certifies that the cost of the borrow materials does not exceed the normal land value of the source. This certification is required except for unusual conditions which will be considered on an individual basis, and exceptions must receive Administrative approval. If the cost of borrow exceeds 75 percent of the estimated value of the land, appraisals by staff appraisers may be made to substantiate the estimated value. This appraisal may be charged to IPE authorizations.

Consideration should be given to damages to the remaining property as well as severance damages in determining the land value.

It is not the intent of this policy to provide for the actual purchase of land to obtain borrow sources. This policy does not pertain to materials going into the pavement, such as select borrow, roadbed treatment, admixtures, etc., as the value of these materials is not considered in relation to the value of the land. The policy is applicable to borrow sources obtained under the "Easement for Purpose of Producing and Hauling Materials" and submission of this easement should be accompanied by a separate certification of value.

Where overburden of a flexible base source is to be used as embankment material rather than be disposed of as stripping, certification of value is not necessary and the form "Agreement for Purchase of Road Materials," may be used to option both materials.

7. General

In accordance with Attorney General Opinion No. M-625 the State may not lawfully issue a warrant, in payment for material from material sources, to a member of the Legislature or to a firm or partnership of which a member of the Legislature is a member, when the warrant is to be charged to funds appropriated by the Legislature during the term for which said member was elected to office. Administrative approval of sources on land owned by State, County or City officials is necessary.

F. Easement for Purpose of Producing and Hauling Materials

Local material deposits may be secured by obtaining an easement in the name of the State ("Easement for the Purpose of Producing and Hauling Materials" form) but this procedure should be resorted to only in those areas where a genuine shortage of acceptable materials exist or is anticipated. Where easements are being considered it should be borne in mind that the Federal Highway Administration will not necessarily approve use of an easement as a required source.

The easement, when properly executed and recorded, constitutes a binding legal document. The same care should be given the preparation of the easement as any other right-of-way instrument as outlined in the *Right-of-Way Manual.*

The consideration for the easement must be a fixed sum based on the current royalty price in the area and a specified quantity of material and a unit price for additional quantities. The fixed sum should be determined only after thorough investigation has revealed the quantity of acceptable material available and deductions for loss have been made. Results of this investigation should be submitted with the easement to enable the appropriate Division to concur in the purchase.

If the material to be secured consists of borrow, certification of value is required as described for material option agreements.

G. Material Sources, Land Contract with Veterans' Land Board

Where investigation indicates that a proposed material option agreement or easement is on land under purchase contract with the Veterans' Land Board, the following procedure is to be followed:

Material option agreements sought under the subject circumstances should be prepared to reflect the Veteran as the Party of the First Part and the Veterans' Land Board as approving the option but not as a Party of the First Part. The material option agreement should provide that payment of one-half of the amount due for the material purchased be paid directly to the Veterans' Land Board and the other one-half royalty be paid directly to the Veteran. Where the Veteran is delinquent in his loan repayment, the full royalty payment will be made to the Veterans' Land Board. Any delinquency notice will be forwarded to the District Office by the Austin Office. These payment requirements are as covered by Article 5421m, Section 18 and other provisions of the Veterans' Land Act.

Approval of the material option agreement by the Veterans' Land Board will be obtained by the Austin Office when the material option agreements are forwarded to Austin.

Monthly Statements and requisitions should be prepared to accomplish the objectives outlined above. The Veterans' Land Board will require that the source be described by metes-and-bounds description and that sketches of the pit accompany the agreement.

H. Material Sources on Properties Owned by Other State Agencies

Material option agreements permitting the Department to take material from properties belonging to other State agencies should be prepared in the same manner as described above for private owners except that metes-and-bounds descriptions should be used in all cases and a sketch should be submitted. If the State agency concerned wants payment for materials taken from their land the Department shall pay them the same price as would be paid any other property owner. If they do not want payment, the Department should secure a material option agreement, or other agreement acceptable to both parties, permitting the Department to use the material without cost.

The following procedure should be followed:

1. The standard material option agreement, or other agreement acceptable to both parties, should be used to buy material or to permit its use without cost to the Department. In either case the material should be obtained under the provisions of Art. 6674w-3 (which is the same as Sec. 4-2 of HB 179, Acts 55th Legislature, 1957). Only one payment should be made after all material used on the project has been taken from the pit. The language, "Authorized by Art. 6674w-3, does not require approval by the State Board of Control," should be shown on the face of the material option agreement, or other agreement, and on the form "Monthly Statement," when it is submitted for payment on a District Payroll. A copy of the material option agreement should be attached to the Finance Division's copy of the "Monthly Statement" form. This language will give notice to the Comptroller that the approval of the Board of Control is not required on such purchase of material.

2. If the agency does not have area agents or representatives authorized to secure approval of the material option agreement, such as the General Land Office, the required number of copies should be forwarded by the District to the appropriate design division of the Austin Office, which will secure approval from the agency concerned, approve it and return the required number of copies to the District.

3. After all material used on the project has been taken from the pit, the Resident Engineer should prepare the form, "Monthly Statement." The form should show correct quantities for which payment is to be made. He should sign it as to receipt of goods, and forward it to the agency concerned with the letter requesting that the affidavit be executed and statement be returned to the District office. The Monthly Statement should then be included on a material and supply voucher.

I. Special Provision for Local Material Sources

Three forms are provided to facilitate submission of an adequate provision to control the use of materials from sources on which the Department holds material option agreements or easements.

1. Designated Sources

The form, "Special Provision Local Material Sources (Designated Sources)," should be used for Designated Sources, which are defined as those covered by approved material option agreements from which adequate quantities of material meeting the specifications can be produced.

When Designated Material Sources are shown on the plans and in the special provisions, the State guarantees the quantity of acceptable material in the pit and will be responsible for providing another pit if it develops that the pit as designated does not contain a sufficient quantity of satisfactory material.

Therefore, it is incumbent upon the State to perform adequate preliminary testing so as to keep to a minimum the probability of an investigation for another pit, and consequent moving of the Contractor's equipment. The State will compensate the Contractor for additional cost in producing the material from the new source. This additional compensation may include the cost of equipment moves and setups, additional haul and additional cost in producing the material. The change in pits and the determination of additional cost involved shall be in accordance with an agreement acceptable to the State and the Contractor. Work may be performed on a force-account basis if unit prices cannot be agreed upon. Since the Engineer has the responsibility for controlling the areas of operation in the pit, extreme care should be taken to insure that all available suitable material is secured before the Contractor is authorized to move to a new source involving additional cost to the State. Changes in formations in the pits and other factors affecting production should not be used as the reasons for abandoning the pit so long as acceptable material can be produced within the original concept of the item as bid.

2. Listed Sources

The form "Special Provision Local Material Sources (Listed Sources)," should be used for Listed Sources, which are the same as designated sources with one exception, i.e., a paragraph is added thereto indicating such sources are available if the Contractor elects to use them and can produce material meeting the requirements of the specifications. This form should be used in conjunction with the "delivered-material" specification if and when their use is considered desirable. When this type of material source is shown on the plans and the special provisions, the State assumes no responsibility whatever as to the quantity of acceptable material in the pit. It is the Contractor's sole responsibility to make any investigation to satisfy himself as to the availability of acceptable material. When showing a prospective bidder over the project, it should be made clear that these pits are shown for information purposes only; that they are available for use under the terms of the material-option agreements; that the State only assumes responsibility for right of entry and the right to move material from the pit in accordance with the terms of the material option agreement and should the quantity of acceptable material in any listed pit prove inadequate, the Contractor must provide material meeting the specifications from another source at no additional cost to the State regardless of the cost to the Contractor.

If preliminary tests have been made on materials secured from local material sources, such tests may be made available to prospective bidders with the understanding that such information does not void or change any part of the applicable special provision for local material sources, nor does such information void or change any part or requirement of any other specification item.

3. Required Sources

The form, "Special Provision Local Material Sources (Required Sources)," should be used for Required Sources which are to be used only when it is desired to require the Contractor to produce material from a particular source as would be the case when an easement is held. Where more than one type of source is involved on an individual project, separate special provisions must be prepared for each type of source.

On Federal-aid projects, if the form "Special Provision Local Material Sources (Required Sources)," is used requiring the Contractor to operate a particular source or use State-owned stockpiled base, justifying information must be submitted for transmittal to the Federal Highway Administration for prior approval. It is necessary that the justifying information indicates that use of the source is in the public interest.

The Federal Highway Administration will generally approve the use of required borrow sources where it is necessary to replace the storage capacity lost by construction of embankment, in wet weather lakes; however, that agency will not consistently approve the use of State-owned stockpiles base material as a required source. The Federal Highway Administration will sometimes approve the use of required sources where unusual circumstances exist, such as a need to increase ponding capacity to satisfy hydraulics requirements, etc. When easements for the purpose of producing local materials are being considered it should be borne in mind that the Federal Highway Administration will not necessarily approve the use of an easement as a required source.

4. General

All material sources are to be indicated on the special provision including those which are royalty-free. The special provision should be checked against the material option agreements or easements to insure that the owner's name is exactly as it appears on the instrument and that the unit of measurement and royalty price are the same as those on the instrument. Special conditions regarding operation of the source contained in the material option agreement should be indicated in the special provision and, if more than one source is being used, referenced to the correct source.

5. Archaeological - Historical Clearances Required for Material Sources, Borrow Pits and Waste Sites

Certification is required that all material sources have been investigated and determined to be clear of cultural resources. (In addition to material sources this also includes borrow pits, waste areas, haul roads, storage areas or other disturbances to the natural ground that will be necessary to develop a specific project.) Certification of this investigation should be submitted with other project documents (Form 1619) and forwarded to File D-8E. Archaeological-Historical investigations of these locations are to be conducted by District personnel who have been trained for this work by professional archeologists of the Highway Design Division. District personnel should only certify that cultural resources are not present. If evidence of cultural recources is discovered, the Archaeology Section of the Highway Design Division will determine the significance of cultural materials and will also determine measures necessary to mitigate damage to these resources. When cultural resources are involved, the Highway Design Division will coordinate with the State Historic Preservation Officer and obtain clearance on Federal-aid projects from the FHWA.

J. Request for Construction Speed Zoning

If construction speed zoning is desired for projects or portions of a project outside the limits of incorporated cities, the "Request for Construction Speed Zone" form should be prepared and submitted for Commission action. The form is self-explanatory with instructions contained on the reverse side. Cities have the authority to establish construction speed zones within their corporate limits and this should be encouraged since the city will likely be responsible for enforcement. If, however, a city desires the Commission to establish the zones, then a written statement from the city is required.

K. Project Agreement Estimate

The Project Agreement Estimate is to be prepared in accordance with the requirements listed below for State and Federal-aid projects. Cooperation in following this procedure will eliminate the time consuming-operation of revising the estimate in the Austin Office.

Estimated prices should be based on recent comparable projects of approximately the same magnitude with study given to the factors peculiar to each individual project. Particular attention should be given projects that require complicated sequences of work, projects that are to be done under large volumes of traffic, projects involving specialty work, projects in commercial areas, etc. When more than one project number is included with the proposed work, a separate estimate must be prepared for each individual project. Each of these estimates must be further separated into roadway and bridge quantities with each structure of bridge classification listed individually. However, certain bridges may be combined in the estimate as follow:

1. Quantities for Multiple Box Culverts (MBC) of bridge classification on freeway-type projects should be combined in two groups; those under the main lanes in one group and those under frontage roads in another. The name of stream, location, description and length should be listed for each structure in the group. Also, quantities for all MBC's of bridge classification on other projects should be combined with the above data given for each structure.

2. Parallel twin structures on the main lanes or frontage roads should have their quanitities combined, preceded by a description of each structure. Do not combine main lane and frontage road structures.

In addition to the foregoing general requirements, the Project Agreement Estimate should be prepared as follows:

1. If the Federal project number covers more than one State control, quantities for each control must be shown separately. In addition to the entire length and limits of the project, it will be necessary to include the physical limits and length of each separate control.

2. Contract items to be financed by a city, county or any other agency must be shown separately unless fixed-sum participation is involved, in which case the participating items should be included in the main body of the estimate. Administrative approval must be obtained before any agreement is made with the city, county or other agency.

3. For Federal-aid projects, contract items that are non-participating in Federal-aid should be listed separately and noted on the estimate quantity sheet as such. These include such items as cleaning culvert barrels and materials to be stockpiled for future use.

4. Railroad force account work and work to be done by State forces should not be included in the main body of the estimate. These items should be shown separately under their appropriate control or project.

5. Metal series railroad crossing signs on Federal-aid projects must be separated from the roadway portion of the estimate and be shown as a railroad crossing protective device participating in Federal-aid. It will not be necessary to separate this item on State projects.

6. Material to be furnished by the State must be shown on the estimate so that funds will be made available to pay for the initial cost of the material.

   If base materials are to be obtained from a stockpile, the materials should be listed on a cubic yard or ton basis and the unit price derived from the actual stockpiling costs plus allowances for loss during stockpiling, loading and hauling and including charges for engineering and contingencies. For Federal-aid projects this price must be approved by the Federal Highway Administration.

   An item involving salvaging and stockpiling base material from the existing roadway and not to be used as part of the new construction on the contract project must be charged to the District's stock account. This will also assist in establishing stockpiling costs referred to above.

   To be eligible for Federal participation, any materials, other than local natural materials, to be purchased by the Department and furnished to the Contractor for mandatory use, must have been acquired on the basis of competitive bidding, except when there is a finding of public interest justifying the use of another method of acquisition.

   Pay item code numbers, description and unit of measurement, item numbers and alternates should be identical to those on the estimate quantity sheet of the plans and preferably in the same order of appearance.

   Engineering and contingency charges should be approximately 10 percent of the subtotal, but not over 10 percent and adjusted downward to reflect a total to the nearest 100 dollars.

7. State law requires that materials salvaged cannot be given to contractors. Therefore, when the salvaged material is to be sold to the Contractor a credit bid item is to be included in the contract. This applies to all projects.

8. For all projects (State and Federal-aid) on which work is necessary for water pollution control, it must be worded in the Project Agreement Estimate and on the Estimate and Quantity Sheet as follows:

    Contractor Force Account or

    Agreed Unit Price (Part) or (Non-Part)

    (Federal Participation Based on Actual Cost Basis)

    Temp. Erosion, Sediment and Water Pollution Control

9. The amounts should be prorated over the applicable projects if more than one project is included.

For Federal-aid projects on which job training is to be provided, it must be worded in the Project Agreement Estimate and on the Estimate and Quantity Sheet as follows:

Force Account by Contractor (Part)

(Federal Participation Based on Actual Cost Basis)

Job Training (______ Trainees)

All Job Training should be charged to the Federal-aid project having the largest estimated cost.

10. Other force account work must be worded as follows either as participating or non-participating in Federal-aid.

    State Force Account Work

    (Non-Part)

    State Force Acct. Work (Part)

    (Federal Participation Based on Actual Cost Basis)

L. Programming Data for Federal-aid Projects at the Contruction Stage

Under the new program procedures recently introduced by the Federal Highway Administration, no program approval will be required at the construction stage on certain projects. Accordingly, it will not be necessary to submit Forms 1088 and 1089R with PS&E for Interstate, Primary, Urban System, Bridge Replacement on the Primary System, safety-related projects and similar type projects where a formal submission of PS&E is made to the FHWA for their review and approval. The above forms (an original and one copy) togther with a sketch map will still be required on Rural Secondary, Safer Off System, Bridge Replacement on the Secondary System and similar type projects where PS&E are not submitted to the FHWA.

The following information is provided regarding completion of these forms.

1. Request for Programming of Federal-aid Project (Form 1089R)

   This form and the form, "Programming Supporting Data Federal-aid____________ ____________________ Funds," must be submitted for each Federal-aid project. Should more than one Federal-aid project number be involved, separate forms must be submitted with each showing the notation that the projects are to be combined for contracting. Most of the required data is self-explanatory and may be inserted by referring to the example forms; however, the following information may be useful.

   a. Traffic

      The actual average daily traffic from the latest count should be inserted. For projects on new location zero should be used. Twenty-year projected ADT should be used for the future traffic, except for Federal-aid secondary projects developed under the FM and RM design standards where 2-year traffic projections or traffic upon completion is sufficient.

   b. Bridges

      The total number of structures of bridge classification, other than grade separations, and their combined length should be indicated. List each grade separation structure and its length separately. Twin structures would be counted as two structures with two separate lengths.

   c. Estimated Cost

      Participating funds such as city, county or railroad are to be shown. The cost of any items which are to be non-participating in Federal-aid should not be included.

2. Program Supporting Data Federal-aid Funds (Form 1088)

   This form is to be submitted for each project. Additional information to aid in its completion is listed below.

   a. Road Connections

      Roadway features and conditions at each end of the project should be inserted. If the project ends at a "T" intersection or an interchange, conditions on the crossroad should be used.

   b. Bridge Data

      Data on existing bridges only is necessary.

   c. Remarks

      In addition to data necessary to explain answers to other questions, information regarding public hearings should be inserted. When applicable a statement should be included affirming notification of area-wide review agencies.

M. Hydraulics Computations

Pertinent hydrologic and hydraulics design data for bridges, culverts and storm sewers shall be shown in the plans rather than on separate calculation sheets submitted with the PS&E. This not only facilitates review of the PS&E but assures a permanent record. See *Bridge Division Operation and Planning Manual* and *Hydraulic Manual* for minimum requirements.

N. Load Zoning in Conjunction with Construction Work

The Department has reserved the right to load-zone highways in accordance with the law whenever and wherever a highway is about to be subjected to loads which will destroy it. The need for load-zoning that will affect the Contractor on proposed construction work should be determined during the time the PS&E are being prepared. Requests for load-zoning where possible should be submitted to the Maintenance Operations Division in sufficient time for official action to be taken thereon prior to advertising projects that will be affected.

O. Lead Time for Accumulation of Materials for Illumination, Traffic Signal and for Interstate Signing and Delineation Projects

To provide realistically for securing materials that are critical, there is a need to provide for considerable lead time for traffic signal, signing and delineation projects that are let independently of other work such as grading, structures and/or surfacing. Providing a realistic lead time tends to establish a uniform practice in time charges.

The PS&E for Interstate signing and delineation projects that are to be contracted independently of other work such as grading, structures and/or surfacing should provide a minimum lead time of 120 days unless there is some reason that would make it imperative to not do so. A lead time of 180 days should be considered for traffic signal projects if specialized equipment and/or steel poles are required.

Adequate lead time for illumination projects (usually 60 or 90 days) should be provided.

P. Municipal Construction and Maintenance Agreements

The following regulations governing municipal construction and maintenance agreements are in force.

1. For controlled access highways designated under the provisions of House Bill 179, no agreements are required.

2. For all projects which consist of maintenance type work or heavy betterment, no agreements are required.

3. For all projects where the responsibilities of the Department and the affected municipalities have been outlined in a Minute Order tendered by the Department and accepted by the municipality, no agreements are required. (Offer to accept terms of maintenance agreement included in the Minute Order.)

4. Agreements will be required for projects not included under either (1.) or (2.) above and on which it is not practicable to outline the responsibilities of the Department and the affected municipalities in the Minute Order tendered by the Department with acceptance by the municipality.

5. Special agreements will be required for the installation of illumination systems, irrigation systems, parking facilities, traffic signals and any other items of work in which the municipality participates in the maintenance operations.

5-102 PS&E SUBMISSION SCHEDULE

The purpose of this Section is to discuss plan requirements of the Department or the Federal Highway Administration.

Each year a PS&E Submission and Processing Schedule will be furnished the Districts. In accordance with this schedule, two weeks prior to the PS&E submission deadline, Districts will notify the Highway Design Division by computergram of all projects that will be ready for letting. If no projects are ready for letting, the District should report accordingly. Computergram notification for projects ready to be let can be accomplished by two methods: first, if the information on the PHAST File is current and fully describes the proposed project, all that is needed on the computergram is the county and IPE number; second, if the project is not listed in the PHAST File, or if PHAST data is not current, the information listed below should be furnished by computergram.

DISTRICT COMPUTERGRAM

ATTENTION: D8-0 FILE D-48

DISTRICT (NUMBER)

CONTROL-SECTION (NUMBER)

PROJECT (NUMBER, IF AVAILABLE)

COUNTY

HIGHWAY (NUMBER)

PROJECT LENGTH (MILES)

LIMITS: FROM ....

LIMITS: TO ....

TYPE OF WORK

WORKING DAYS

IPE OR PD (NUMBER)

TOTAL ESTIMATED COST (DOLLARS) (INDICATE ANY CITY, COUNTY OR OTHER AGENCY FUNDS)

AUTHORIZED BY (MINUTE NUMBER, 20-YEAR PROJ. DEVEL. AND CONTROL PLAN, PROGRAM, ETC.)

AUTHORIZED FUNDS (DOLLARS)

ROW STATUS (NUMBER OF PARCELS REQUIRED ____________

NUMBER OF PARCELS ACQUIRED ____________

ROW NOT REQ

CLEAR

WILL BE CLEAR BY ____________ DATE)

UTILITY ADJUSTMENTS (NUMBER TO BE ADJUSTED ____________

NUMBER ADJUSTED ____________

CLEAR

WILL BE CLEAR BY ____________ DATE)

NEEDED AGREEMENTS (RAILROAD, MUNICIPAL, ETC. INDICATE STATUS)

Districts will be advised by computergram in approximately one week which projects are approved for letting.

PS&E with estimate computer card deck, tracings, review prints, and supporting papers for all contract projects should be received by the respective Engineer of Field Coordination or the Engineer of Secondary Roads on or before the date specified for receipt of plans. Farm to Market projects and Highway Safety projects should be received by the Engineer of Secondary Roads.

The number of copies of review prints, supporting papers and estimate print-outs will be furnished as follows:

Usual Federal-aid Projects:		
Without signing, traffic control devices, etc.	- 3	(FAS - 2)
With signing, traffic control devices, etc.	- 4	(FAS - 3)
Highway Safety Projects:	- 3	
Usual State Projects:		
Without signing, traffic control devices, etc.	- 2	
With signing, traffic control devices, etc.	- 3	

Usual Farm to Market Projects: - 2

Usual Farm to Market and State Projects
Combined: -2

The method of transporting PS&E to Austin continues to be optional with the Districts. However, when appropriate, delivery by District personnel or other messengers is encouraged. Where it is necessary to use mail or other public carrier services, the District should notify their respective D-8 Sections by telephone to advise the method of transportation.

Only PS&E for projects approved for monthly letting should be sent to Austin. These PS&E should be complete and should contain all structural details and all standards except those standards that are routinely added in Austin. The project should be ready to let from the standpoint of public hearing and environmental requirements, right-of-way and utilities clearance, railroad agreements, 404 permits and Coast Guard permits.

In the event the reproduction requirements for review prints or the recommended delivery process creates an extreme hardship, please contact the Highway Design Division.

The submission of preliminary design data well in advance of PS&E submissions should enable the Design Division to concur in basic designs in accordance with established design criteria and policy. Therefore, it is requested that the Districts submit typical sections, preliminary structure layouts, storm sewer layouts, hydraulics calculations and other basic design data as early as possible after work is authorized for review by the affected design division. This data should in all cases be submitted far enough in advance of PS&E submission to give sufficient time for its study and review without delay to the development of the PS&E in the districts.

A. Measurement and Payment for Contract Work

1. Use of Subsidiary Items

As a general rule, direct payment should be made for all work covered by the standard specifications. However, showing estimated rates or quantities for non-pay items is desirable provided these rates and quantities are accurate and are shown to be for the Contractor's information only.

2. Plan Quantity for Roadway Excavation

Payment based on plan quantity will not be permitted for roadway excavation; measurement for payment shall be subsequent to completion of the work. Exceptions to this policy require Administrative approval and will only be considered on individual projects for unusual conditions.

B. Control of Access

Control of access lines must be indicated on all turnkey or Unit I (Grading and Structures) Interstate projects and other turnkey or Unit I projects which have been designated controlled access by law and either labeled as such or identified by symbol. The lines may be eliminated from Unit II (Base, Pavement, Signing, etc.) projects if a note is added to the title sheet referring to the previous project or projects where control of access was indicated.

The control of access should be exactly as indicated on the right-of-way map and in the conveyances. Should deviations be warranted, full documentation must be furnished, preferably prior to PS&E submission.

C. Haul Roads and Dust Nuisances

It is the policy to eliminate all plan notes or specifications penalizing the Contractor for hauling legal loads over public roads or streets. Maintenance on public roads by the terms of the contract should be limited to sprinkling to settle dust. Contract restrictions on private roads used for haul roads should be the minimum required to satisfy the agreements authorizing their use.

D. Traffic Safety in Highway and Street Work Zones

A Traffic Control Plan (TCP) is a plan for the handling of traffic through a construction project. These plans may range in scope from a very detailed TCP for a specific project to a reference to standard plans and/or a reference to a section of the *Texas Manual on Uniform Traffic Control Devices (TMUTCD).* The TCP should be developed during the planning and design phases of the project. On major projects, where complicated movement of traffic is required, a layout of detours and a sequence of work along with a signing layout should be included in the PS&E. On minor projects, the TCP can usually be handled by a Special Provision or shown on the Specification Data Sheets.

In addition to the necessary barricades, pavement markings, warning signs and other traffic control devices, the TCP should include temporary barriers and illumination where applicable.

The Department will develop the TCP; however, the Contractor may propose his own TCP and use it after approval by the Department. On Federal-aid projects, approval of any major revision to the TCP will also require approval of the Federal Highway Administration (FHWA).

When conditions warrant, minor or emergency changes to the TCP may be authorized immediately by the Department's responsible person. If substantial changes are made, the changes should be documented and submitted for review.

The Engineer will designate a qualified Departmental person to observe implementation of the Traffic Control Plan with authority to assure compliance on each project. This person shall make frequent inspections of the traffic control devices including night inspections which include a check of reflectivity of the traffic control devices. In addition, the District Safety Review Team and the District Traffic Control Coordinator will periodically review the project for compliance with the TCP.

Contractors will be required to designate a competent employee on each contract to be readily available to assure compliance with the approved TCP.

Provision for temporary pavement markings should be included in all projects where pavement markings will be required to be placed during construction such as on detours or in pavement overlays, level-up and seal coat projects. The temporary pavement markings should be placed on a daily basis on the sections where traffic is allowed and where standard markings are not in place. This is intended to prevent traffic being required to utilize unmarked pavements and to also allow more efficient scheduling of standard marking placement by striping crews. On Federal-aid projects this is a requirement and is eligible for Federal reimbursement.

E. County Participation in Construction Costs

Occasionally a county desires to participate in cost of curb and gutter, storm sewers, etc., usually as an economical substitute for wider right-of-way on which to develop a rural section.

Passage of a Minute Order for county acceptance is not required. County participation in cost must receive Administrative approval and an escrow agreement is necessary. Fixed-sum participation must also receive Administrative approval.

F. Municipal Construction

1. Non-Controlled Access Highways

Where it is desired to construct an urban section with curb and gutter, the Department will provide for the construction or widening of pavement and its support, including support of curb and gutter.

The construction of curb and gutter, driveways, sidewalks (except where these are existing) and storm sewers on most projects, other than freeway facilities, is the responsibility of the city or town involved. Usually there are optional methods by which the city may discharge its obligations. The most generally used method is the inclusion of such work in the State's contract. This method has several advantages over the other methods and its use is to be encouraged.

For projects on which the municipality decides to construct the curb and gutter and/or storm sewer with its own forces or by separate contract, a special provision to Item 8 should clearly set out the Contractor's responsibility for cooperating with the city forces or the city's Contractor and for accepting the responsibility of repairing or replacing any of the city's construction work which is damaged or destroyed by the Contractor's operations or neglect, as well as provisions for adequate handling of traffic during construction and any other special conditions on the project. Either by the timing of the letting or by a statement in this special provision, the bidders should be given reasonable assurance that the Contractor will not be unduly delayed due to lack of progress of the city's work.

In all cases where this type of work is proposed, it is required that the work be authorized by Minute Order. The Minute Order will be in the form of a proposal to the City outlining its responsibilities and requiring the City's acceptance.

The time of passage of the Minute Order by the Commission and its acceptance by the City is important and should be when the project first appears on a program or authority for its development is requested by the District. When the project appears in a construction program, the Minute Order should be tendered to the City after the construction program is approved by the Commission. In the event a Minute Order is not tendered to the City at the time the construction program is approved and it is later found desirable to provide a street section, complete details of the proposed work should be forwarded to the program Engineer as soon as possible for Commission passage of a Minute Order. Data must be furnished in sufficient time for passage of the Minute Order, acceptance by the City, execution of the escrow agreement and receipt of escrow before bids are received.

When the municipality desires inclusion of curb and gutter, storm sewers, etc., in the State's contract, an escrow agreement is required. When fixed-sum participation in cost is desired, Administrative approval must be secured. The District should not assure the city of this type of payment or the exact amount or extent of the city's obligation prior to receiving this approval. These funds shall be placed in escrow prior to receiving bids on the project.

Where city, county or other agencies desire to make their construction responsibilities a part of our construction contract on a unit cost basis, it is deemed desirable that they be made aware that their costs may be greater than originally estimated. Particularly in the case where their obligation is to be satisfied on a fixed-sum basis of participation, it should be made explicitly clear their cost will be based upon up-to-date, realistic estimated prices that may prevail at the time of letting.

2. Controlled Access Highways

The Department will provide on freeways, both Interstate and non-interstate, within areas which are expected to be either urban or suburban in nature by the design year, the cost of all necessary storm sewers and appurtenances, including curb and gutter, to be constructed within the highway right-of-way as well as all outfall costs for all natural drainage that reaches the project.

In the event the local government unit involved expresses a desire to join the Department in the drainage system in order to divert drainage into the storm sewer system, the local government unit shall pay for the entire cost of collecting and carrying the diverted water to the State's system and shall contribute its proportional share of the cost of the storm sewer and outfall based on the cubic feet per second of additional water diverted to the sewer when compared to the total cubic feet per second of water to be carried by the sewer and outfall. The local unit of government requesting the drainage diversion shall indemnify the State against damages or claims for damages resulting from such diversion. Indemnification may also be required when design criteria is compromised to reduce cost of the project.

The local government shall contribute the cost of diverted drainage on the basis outlined above prior to receiving bids on the project. The Engineer-Director has been authorized to enter into agreement with the local government unit for such work and its cost as may be agreed upon.

Inquiries regarding municipal construction relative to curb and gutter, sidewalks, driveways, etc., should be directed to File D-8, and those concerning storm sewers and drainage to File D-5.

G. Cross Section Data

On some construction projects the nature of the work cannot be clearly depicted by the typical cross sections in the plans. In such cases design cross section data should be made available to the field forces and the Contractor during construction. This will ordinarily apply to all multilane projects and others involving complex interchanges or intersections. Plans for these projects should contain a note that one copy of the design cross section data will be furnished the Contractor free of charge. If he should desire additional copies, they will be at his own expense. This information will be required for all projects for which the Contractor is to furnish field engineering.

On projects using original cross section data developed photogrammetrically where cross sectioning by conventional field methods will not be performed before beginning excavation work, a note similar to the following advising the Contractor of this shall be included on the Specification Data Sheet of the plans.

> "Original cross section data used in estimating quantities for roadway excavation has been developed photogrammetrically and will be used in determining final pay quantities."

Where final cross section data will be developed photogrammetrically, an appropriate note advising the Contractor of this shall also be included.

H. Asphaltic Concrete Pavement

The base course under the wearing surface should be designed for adequacy for the type, volume and weight of the traffic involved. Materials for such base course should be selected from any and all materials available to provide base adequacy at minimum cost.

When asphaltic concrete is specified for the wearing surface, it shall be hot mix asphaltic concrete pavement if the existing traffic exceeds 2,000 vehicles per day per lane. A base bid and two alternate bids shall be provided in the PS & E on those facilities where asphaltic concrete is specified for the wearing surface and existing traffic is 2,000 vehicles per day per lane or less. The wearing surface shall not exceed one and one-half inches in thickness.

When asphaltic concrete is specified in the design for the wearing surface and the quantity of asphaltic concrete materials is small, the asphaltic concrete may be bid as a Contractor's option provided the option permits the use of hot mix asphaltic concrete, hot mix-cold laid asphaltic concrete and limestone rock asphalt.

Exceptions to this policy may be authorized by the Chief Engineer, Highway Design, where unusual or special circumstances are involved.

I. Polish Value

In order to provide a desirable skid resistance performance, minimum polish values should be specified for asphaltic concrete, seal coat and surface treatment aggregates as follow:

Present ADT or Type of Highway	Minimum Required Polish Value of Aggregate for Flexible Pavements
Below 750	No Requirements
750 - 2000	28
2000 - 5000	30
5000 - and above	32

In cases where the District elects to deviate from the above requirements, special justification based on performance history of similar mix designs should be furnished for approval in advance of PS&E submission.

J. Field Engineering (Construction Staking)

When conditions such as work load of construction personnel, the area work load and the complexity of projects are considered to constitute sufficient warrants, the District Engineer is authorized to require construction staking by the contractor. This may be accomplished by including the appropriate Special Provision to Article 5 in the List of Governing Specifications. All other construction engineering will be performed by Departmental personnel.

K. Plans

Plan sheets have been divided into nine categories: title sheet, typical sections, specification data sheets, estimate and quantity sheet, plan profile, roadway details, bridge and culvert details, hydraulic data, and standards. Each of these sheets is discussed below in regard to Departmental and Federal Highway Administration requirements.

1. Title Sheet

The purpose of the title sheet is to establish the location of the project and to describe the nature of the work proposed by the plans. The former is easily accomplished by selecting a layout scale commensurate with the length of the project and nature of the surroundings. The CSJ number should be shown to facilitate processing in the Austin Office.

The description of the work should list the basic units of work proposed. Where flexible base is to be stabilized it should be indicated as such with the type of stabilization also shown. The type of surfacing, e.g., one or two course surface treatment, asphaltic concrete pavement or concrete pavement, must be shown rather than such terms as asphaltic surfacing. When rest area driveway construction is proposed and Federal-aid is to be used, the title sheet description of work should reflect this work.

In addition to index of sheets and other data contained on the standard title sheet tracings, the following information must be indicated.

a. The adoption date of the governing specifications and, if a Federal-aid project, the title and date of the appropriate required contract provisions must be shown. On State projects indicate: "Special Labor Provisions for State Projects."

b. It is not necessary that total mileage be broken to indicate rural and urban lengths. However, if a project enters an incorporated city with a population of 5,000 or more (as of latest official U.S. Census), the section outside the urban limit is on the Federal-Aid Secondary System and FAS funds will be utilized for the construction, the FAS project must end at the urban limit and the mileage shown accordingly.

c. If city, county, irrigation or water district, Corps of Engineers or other participation is involved, the signature of the appropriate official is required.

d. The net length of the project for roadway and bridges further separated by State control and Federal-aid projects must be shown.

e. The limits of the project, preferably as contained in the program authorization, are required. It is desirable to reference the beginning (or end) of project by the distance from a town, county line, highway, stream, etc., rather than from end of previously completed project.

f. Barricades and warning signs should be shown as outlined in 5-102D.

g. A signature block entitled "For Chief Engineer of Highway Design" should be provided on the title sheet of the plans for all projects submitted. A signature block for "Bridge Engineer" should also be provided when the project involves bridge classification structures on Federal-aid projects.

h. A signature block for "Engineer of Traffic" should be provided when only a part of the project involves traffic signals or signing and delineation.

i. A signature block for "Chief Engineer, of Safety and Maintenance Operations" should be provided when the project involves only traffic signals, signing and delineation, comfort stations, etc.

2. Typical Sections

The typical sections should be as simple as possible and still provide the necessary construction data. A general representation of the nature of construction in each portion of the project is necessary, but a multitude of details are confusing and may best be relegated to roadway detail sheets. Particular emphasis should be placed on the following items:

a. The approximate depth, in inches, of each layer in the pavement structure.

b. Each material should be clearly identified and, if stabilization is proposed, indicated as such.

c. The dimensions of the subgrade crown, base crown, pavement width, pavement width for stabilized material, etc.

d. The station limits of each typical section should be checked to insure that a section has been shown for all of the project roadway and that roadway widths correspond with those shown on the plan profile.

e. The approximate quantities of base material per station for each section should be shown.

f. A section is necessary for such features as ramps, detours, cross roads, etc.

3. Specification Data Sheets

The purpose of specification data sheets is to provide, in one section of the plans, the various supplemental data required by the specifications. This consists of base material, grading requirements, density requirements and surface treatment data. The sheets are also intended for general design notes such as variations in slopes, superelevation of curves, concrete surface finish, paint price list, protection system for structures and type of bedding for concrete pipe. (The type of bedding for concrete pipe should be shown in the Culvert Summary where different structures require different bedding.) Specification data sheets have consistently been included in bidding proposals for ready reference of contractors, materials suppliers, etc. This use of specification data sheets has successfully provided for the recording of such data as closed season dates for the application of asphaltic materials and minor modification of grading requirements which are available in acceptable usage.

The use of notes furnishing information regarding quantities that are subject to change because of sequence of construction operations, such as designating portions of unclassified road excavation as rock excavation or foundation course, has resulted in confusion in interpretation and in some cases litigation in which the Department has been successfully contested. Where quantities for subsidiary items are available and are accurate, they should be shown, but should be labeled as for the Contractor's information only.

All acceptable notes proposed to be placed in the plans should be so worded that they are clear, concise and can have only one meaning.

Minor modifications of specifications such as the closed season on asphaltic materials, curing required for base materials, etc., may be placed on the specification data sheets; however, special provisions are necessary for major specification revisions. The use of specification data sheets to modify methods of measurement or basis of payment is not permissible. All notes should be referred to the specification to which they apply.

Special provisions take precedence over specification data sheet notes, in case of a conflict, in accordance with Article 5.5 of the Standard Specifications.

Specification data sheet notes prepared on plan-size sheets should be of a quality and size to permit their clear and legible reproduction at a reduced scale for insertion in the proposal. This reduction in scale can best be accomplished by dividing the plan sheet in half. Preferably, the specification data sheets should be computer-run or typed on 8-1/2 x 11-inch specification data sheet forms with reproduction and enlarging done in the Austin Office. After the forms have been reproduced for insertion in the proposal, a tracing of plan sheet size can be reproduced and included in the construction plans.

Specification data sheets should never be used to reiterate that which is already covered in the standard specification, special provision and/or special specification. The use of these sheets should be kept to an absolute minimum.

4. Basis of Estimate Sheet, Summary Sheets and Estimate and Quantity Sheets

The basis of estimate sheet is necessary for plans preparation and review, for basis of bid preparation and for control of construction. This sheet should show the basis for estimating each of the pay quantities of the contract which cannot be directly measured from the plans. These include such items as sprinkling, rolling, blading, lime, fertilizer, asphalt, aggregate, etc., and should include compaction factors and unit weight for flexible base and embankment items when this information is needed for estimating purposes. When the basis of estimate contains data that will significantly affect the Contractor's bid preparation, it is desirable to prepare this information in the manner prescribed in 5-102 K3, "Specification Data Sheets." This will allow this data to become a part of the proposal which means the Contractor will have ready reference to this information.

Summary sheets are used to indicate type, quantity and/or location of work for individual items of the proposed project. Properly drawn, they summarize the work to be done and simplify the plans. The number of summary sheets developed will depend on the type of work. Summary sheets are often employed in lieu of Plan Profile Sheet totals. Other specialized usages of summary sheets are for location and quantity of such items as "Blading," "Road Grader Work," "Scraper Work," "Guard Fence," "Removing Old Concrete," "Conduit," etc. Conduit and structure summary sheets should be provided as outlined in the Bridge Division Manual. When the work includes more than one control, more than one project, City or County participation, nonparticipation in Federal-aid or other sub-divisions, the summary sheets should so indicate.

The estimate and quantity sheets are to be used to provide a list of all the pay items and estimated quantities under the contract. Such other information as force account work by the Contractor, work to be done by railroads, cities, counties, state forces and for others to be charged to the construction appropriation must be shown. In addition to separation of roadway and bridge quantities, the quantities must be further separated by controls and projects.

The item number, descriptive code and any special provision number should be listed followed by the item description, the unit of measure and the estimated quantity. The item description must be limited to 39 space bars and should be abbreviated in accordance with the Department Manual, *Index and Code to Specification Bid Items*. It is desirable, but not necessary, to list bid items in numerical sequence. It is suggested that additional lines be available for the addition of bid items. The item description must agree with the measurement and payment articles of the applicable specification.

Alternate numbers should be shown to the left of the item number in the base bid and must appear in the same sequence as the alternate bid. Base bid items involved in alternates do not necessarily have to be grouped together.

For highway illumination, schedules of various types, sizes, etc., for each item should be contained in the body of the plans, along with estimated quantities, but only one pay unit should be provided for each item.

5. Plan Profile Sheets

Clarity and completeness should be the rule to follow in the preparation of plan profile sheets. On all projects it is desirable to show sheet totals for clearing and grubbing, preparation of right-of-way, earthwork, curb and gutter, erosion control items and other items which are difficult or impossible to compute from information contained in the plans.

Areas to be measured for payment for clearing and grubbing or preparing right-of-way must be indicated as should concrete to be removed.

On all Federal-aid projects where existing bridges located adjacent to or within the project limits are to remain in place without change, the following data should be indicated on the plan profile sheet adjacent to each structure: location (stationing), type, span lengths, overall length of structure, roadway width, vertical clearance on through-truss spans, rail-to-rail horizontal clearance and estimated design capacity.

6. Roadway Details

Roadway detail sheets should contain the numerous design details necessary to complement the typical sections and plan profiles.

Details of concrete pavement, each type of curb or curb and gutter proposed, sidewalk details, geometric details of intersections and ramps and side road or driveway design are but a few of the multitude of details necessary for expressway-type contracts. A careful check should be made prior to PS&E submission to determine that all necessary details have been included and clearly referenced on the plan profile sheets or on the title sheet index.

7. Bridge and Culvert Details

These items should conform to the requirements set forth in the *Bridge Division Operation and Planning Manual*. Bridge layouts should conform closely to those previously approved by the Federal Highway Administration. Slopes at the abutments and thickness and limits of riprap should be shown. For grade separations this thickness should usually be four inches and for stream crossings, five inches. Actual calculated minimum vertical clearances for grade separations and maximum highwater elevations for stream crossings (bridge and bridge-classification culverts) should be shown. Soil data and penetrometer test data should be indicated on the profile at the location of the test holes. Bridge details should be sufficient to clearly indicate the work to be done. The pertinent AASHTO design specifications and loading should be noted on the details.

Calculated pile load (shaft load) or footing pressure (for spread footings) should be shown on substructure details. The length of all large skewed MBC's should be checked for bridge length.

8. Hydraulic Data

Hydraulic information should be presented in the construction plans as outlined in the *Bridge Division Operation and Planning Manual.*

9. Standard Sheets

The title sheet index should be checked carefully to insure that all standard tracings to be inserted by the Austin Office have been listed. Current standard sheets should be used as much as possible. Modifications to the standard sheets should be held to a minimum in the interest of economy in construction.

The Highway Design Division's standard sheets are identified by letters abbreviating the standard name plus the year the standard was issued. When these sheets are modified, the following notations shall be used:

a. When the sheet is modified in a minor way, the notation "(MOD)" shall be placed after the date in the sheet title and the modifications made are to be listed and dated on the sheet.

b. When major changes are made, the date shall be removed from the title and replaced with the notation "(SPL)". No changes need be listed.

c. Occasionally, a District may desire to prepare a roadway design standard for repetitive use in their area. If so, it should be named and dated similar to the Statewide standards together with the addition of the District number. From that point on, the above steps shall apply when changes are made.

L. Changes in Plans and Specifications

On occasion for various reasons it is necessary that changes be made in plans or specifications after proposals have been released to prospective bidders. On occasion the Austin Office has had requests from the Districts to advise prospective bidders of circumstances not reflected in the PS&E that would affect bidding. Prospective bidders looking at work should never be told that they could do certain things not strictly in accordance with the plans and specifications.

If it becomes absolutely necessary to make a revision to the PS&E for a Federal-aid project during the advertising period, such change must be forwarded to the appropriate Austin division in order to secure approval of the FHWA Division Administrator. Additionally, before bid opening, the Construction Division must assure the FHWA Division Administrator, in writing, that all bidders have acknowledged receipt of the change. Failure to comply will require that the project be removed from that month's letting and re-advertised. As a definition of advertising period, this shall be the period after issuance of a letter of authority to advertise for construction by the FHWA. For State projects, this shall be after the proposals are released.

M. Federal-aid Participation in Future Interstate Construction

Federal-aid Interstate participation on future improvements and/or additions to a completed Interstate highway can be approved by the Federal Highway Administration only if these future additions were approved by their office prior to the time the initial construction project was authorized.

In order that Federal-aid Interstate participation on contemplated additions can be assured, it is imperative that all such additional features be indicated on the PS&E for the initial construction contract. This matter should receive most careful consideration during the planning stage on all Interstate projects.

N. State Force Account Work in Conjunction with Federal-aid Contract Work

It is sometimes desirable to utilize State forces in conjunction with contract work. Temporary and permanent signing, temporary and permanent pavement markings, furnishing and erecting temporary barricades, temporary illumination and traffic handling are only some of the items of work that have been found to be economical for State forces work.

1. Signing, Delineation and Pavement Markings

All signing, delineation and pavement markings, temporary and/or permanent, required as a result of a construction project, should be considered as construction items. This work will usually be included in the PS&E with other construction items, either by bid item or State force account. However, this work may be handled as a separate project if the size is sufficient to be attractive for contracting. On Federal-aid projects, Federal participation should be requested in either case.

When requesting construction authorization, financing or programming, the work items for signing, delineation and pavement markings will generally be considered incidental to roadway construction projects and would not be indicated. However, if any of these items would be considered a major item as defined in Standard Specification Item 4, it should be indicated in program submissions and requests for authorization and finance.

Justification for the use of State forces should be furnished and a public interest letter is to be forwarded to the FHWA for approval when a State force account item is utilized for the construction of freeway and expressway signs, signs other than conventional signs (*Texas MUTCD,* Sections B, C & D) or items considered a major item as defined in Standard Specification Item 4. The use of State force account for all other signing and pavement marking has been approved by the FHWA to be in the public interest.

2. Miscellaneous Items of Work

All items of work, temporary and/or permanent, required as a result of a construction project should be considered as construction items and Federal participation may be requested. When it is planned to perform miscellaneous items of work by State force account, justification for use of State forces should be furnished and a public interest letter is to be forwarded to the FHWA for approval. Exceptions which have received prior FHWA approval are temporary pipes on detours and temporary guard fence for Interstate projects; minor work such as guard fence, embankment material, conduit installation, etc., on Grade Crossing Protection and Planking Projects; and all work on Safety projects.

Any work to be performed by State force account should be listed in the plans estimate to show the general types of work proposed, with an actual cost estimate for each type of work. Cost for the work will be charged to funds authorized for the project.

O. Contractor Liability to Third Parties

Plan notes, special specifications or special provisions which make the Contractor liable to utility companies or others for damages as third parties to contracts should not be used. In

order to avoid discrepancies that might be brought about by variable plan notes or special specification or special provision requirements on this subject, Article 7.11 of the Standard Specifications should be relied upon for this purpose.

P. Temporary Erosion, Sediment and Water-Pollution Control

PS&E should include provisions and details for temporary erosion, sediment and water-pollution control. When applicable, specially coded bid items for this work should be used. Examples of these bid items are: blading, bulldozer work, baled hay-placement, pipe, etc. These bid items should be separated from other bid items in the plans and estimate by adding the suffix: "(Erosion Control)." It is also recommended that an item be included in the PS&E for providing for unforeseen temporary controls, where applicable.

Q. Local Lettings

1. General Work

A contract may be let locally if the work is authorized and the estimated cost without Engineering and Contingencies (E & C) is less than $100,000. Advertising for local lettings may be limited to two successive issues of any newspaper published in the county in which the work is to be done and, if there is no newspaper in the county in which the work is to be done, then said advertising shall be for publication in some newspaper in some county nearest the county seat of the county in which the work is to be done. Approval by the appropriate Austin division and the Administration will be required prior to the preparation of PS&E. Upon completion, PS&E should be submitted to File D-8 and/or D-18 for review and further handling.

The number of sets and size of plans and the number of proposals needed for the letting must be specified in the letter of transmittal. Upon receipt of bids, a list of bidders accompanied by the low bidder's proposal should be forwarded to the Division that processed the PS&E. Since action by the Commission in the award of the contract or rejection of the bid is necessary, sufficient time for processing the low bid, etc., should be allowed between the time of the receipt of bids and the subsequent meeting of the Commission. Bids of $100,000 or more will be rejected.

2. Major Maintenance Contracts Expedited Procedure.

The procedures outlined above under General Work will be followed except for the following.

a. Plans. The minimum requirement for a set of plans will be Title Sheet, Specification Data Sheet, Estimate and Quantity Sheet and the List of Governing Specifications. Basis of estimate, typical sections, etc., may be combined on one sheet. Plans shall be on 8½" x 11" sheets in word format. Only approved specifications, special provisions and/or special specifications shall be utilized. If it is desired to modify any approved specification, normal approval procedures shall be followed prior to submission of PS&E to the Austin Office. Special Items 1 to 9 as approved by the Administration for Major Maintenance Contracts shall be used.

b. Advertising. Newspaper advertisement for the letting of the proposed work should include the following statement:

> A bid for this work will not be considered unless the bidder shall have filed a "Bidders Questionnaire" with the State Department of Highways and Public Transportation at least 10 days prior to the date upon which bids are to be submitted.

c. Proposals returned by bidders. All proposals (incomplete or otherwise), all proposal guaranties and a listing of all bidding irregularities are to be sent to D-6 with a recommendation for awarding the contract or rejecting the bids.

d. Plans must be received in D-8 at least 60 calendar days prior to the scheduled Commission meeting at which the contract is to be awarded. Letting documents must be in D-6 at least 10 calendar days prior to the Commission meeting.

R. <u>Data Requirements to Be Submitted with PS&E</u>

1. PS&E Submission Data Sheet
2. Governing Specifications and Special Provisions
3. Material - Option Agreement - If Applicable
4. Request for Construction Speed Zoning - If Applicable
5. Request for Programming of Federal-aid Project
   (Needed for Secondary and Off System Projects Only)
6. Right-of-Way and Relocation Certification

S. Specification Data Requirements of Standard Specification Items

ITEM NO.	TITLE & REQUIREMENTS
100	PREPARING RIGHT OF WAY (1) Limits must be shown on plans.
102	CLEARING AND GRUBBING (1) Limits must be shown on plans. (2) Clearing and Grubbing (Palm) and Clearing and Grubbing (Tree) size must be specified. (3) Limits of national forest must be shown on plans.
104	REMOVING OLD CONCRETE (1) Limits of removal must be shown on plans. (2) Type must be specified.
110	ROADWAY EXCAVATION (1) Waste must be indicated on plans. (2) Show limits and depth of select material on plans. (3) When hauling of material is subsidiary it must be specified on plans.
120	CHANNEL EXCAVATION Same as Item 110
130	BORROW (1) Location and depth for use of select material must be shown. (2) When special material is desired, soils requirements must be shown on plans. (3) When hauling of materials is subsidiary, it must be specified on plans.
131	BORROW (DELIVERED) (1) Type and class must be shown.
132	EMBANKMENT (1) Under ordinary compaction type and rate of rolling and rate of sprinkling must be shown.
140	OVERHAUL No special requirement to be shown by note.
150	BLADING No special requirements.
152	ROAD GRADER WORK (1) Limits of work shall be shown on plans. (2) Minimum length of road grader work section is 5 consecutive stations.

ITEM NO.	TITLE & REQUIREMENTS
154	SCRAPER WORK No special requirements.
156	BULLDOZER WORK No special requirements to be shown on plans.
158	EXCAVATION WORK FOR EROSION CONTROL (1) Work performed by this item must have a suffix of "Erosion Control" shown on the bid item.
160	FURNISHING AND PLACING TOPSOIL (1) Location and depth of topsoil to be placed must be shown on plans.
162	SODDING FOR EROSION CONTROL (1) Dimensions for grass retards must be shown on plans. (2) Type and grade of tacking agent must be shown on plans.
164	SEEDING FOR EROSION CONTROL No special requirements.
166	FERTILIZER No special requirements.
168	SPRINKLE IRRIGATION No special requirements.
169	SOIL RETENTION BLANKET No special requirements.
170	OBLITERATING ABANDONED ROAD (1) Sections to be obliterated shown on plans.
190	ROADSIDE PLANTING (1) Size of plants must be shown on plans. (2) Size of special plants like roses, vines and ground covers will be measured as specified on the plans. (3) Size of ball shall be shown on plans. (4) Bracing shall be of the type shown on the plans. (5) Backfill shall be mixed in proportions shown on plans. (6) Tree wrapping shall be of the type shown on the plans. (7) Fertilizer shall be type and quantity shown on plans. (8) Special sized holes shall be shown on plans.

ITEM NO.	TITLE & REQUIREMENTS
200	STRIPPING No special requirements.
204	SPRINKLING (1) Rate and use shown on plans.
210	ROLLING (FLAT WHEEL) (1) Rate and use shown on plans.
211	ROLLING (TAMPING) (1) Rate and use shown on plans.
212	ROLLING (HEAVY TAMPING) (1) Rate and use shown on plans.
213	ROLLING (PNEUMATIC TIRE) (1) Rate and use shown on plans.
214	ROLLING (HEAVY PNEUMATIC TIRE) (1) Rate and use shown on plans.
215	ROLLING (GRID) (1) Rate and use shown on plans.
216	ROLLING (PROOF) No special requirements.
230	ROADBED TREATMENT (1) Type must be shown on plans. (2) Type C material must have specification requirements shown on plans. (3) For Density Control, percent density must be shown. (4) When stripping subsidiary, must be shown on plans. (5) For Ordinary Compaction, type and rate of rolling and rate of sprinkling must be shown. (6) When additional quarter mile haul is subsidiary, must be shown on plans.
246	FOUNDATION COURSE (1) When stockpiling is required on plans the location, height, depth of layer, size, etc., must be shown. (2) For Ordinary Compaction type and rate of rolling and rate of sprinkling must be shown. (3) For Density Control the percent density must be shown on plans.

ITEM NO.	TITLE & REQUIREMENTS
	(4) When haul is to be subsidiary the plans must so state. (5) Material meet requirements shown on plans. (6) When stripping is subsidiary, the plans must so state.
248	FLEXIBLE BASE (1) Number of courses as shown on typical section. (2) Physical requirements for Grade 4 as shown on plans. (3) For Ordinary Compaction type and rate of rolling and rate of sprinkling must be shown. (4) For Density Control percent density must be shown. (5) When stockpiling is required on plans the location, height, depth of layers, size, etc. must be shown. (6) If type of material is not specified, Contractor has the option to use any type. (7) When stripping is subsidiary, plans must so state.
249	FLEXIBLE BASE (DELIVERED) Same as Item 248, except no stripping under Item 249.
250	SCARIFYING AND RESHAPING BASE COURSES (1) For Ordinary Compaction type and rate of rolling and rate of sprinkling must be shown. (2) For Density Control percent density must be shown. (3) Depth of material to be scarified must be specified.
252	SALVAGING AND REPLACING BASE (1) Amount of material to be salvaged per station must be shown on plans. (2) If Ordinary Compaction is indicated on the plans type and rate of rolling and rate of sprinkling must be shown. (3) If Density Control is indicated percent density must be shown. (4) Width & depth of material must be shown.
254	SCARIFYING EXISTING PAVEMENT No special requirements to be shown by note.

ITEM NO.	TITLE & REQUIREMENTS
256	SALVAGING AND STOCKPILING BASE MATERIAL (1) Measurement is by CY in Vehicles unless indicated on plans as CY in stockpile, or CY in original position, or by ton.
260	LIME TREATMENT FOR MATERIALS IN PLACE (1) Type of lime must be specified. (2) If Ordinary Compaction is indicated type and rate of rolling and rate of sprinkling must be shown. (3) If Density Control is indicated and percent densities changed from that shown in specification the new rate of compaction must be shown. (4) Lateral limits of treated area must be shown on typical section. (5) Rate of application of lime should be shown on plans. (6) When Ty A Lime is specified, Contractor may use either dry or slurry placement unless otherwise specified on plans. (7) Depth of treatment must be specified.
262	LIME TREATMENT FOR BASE COURSES Same as Item 260, except depth does not apply.
264	HYDRATED LIME AND LIME SLURRY No special requirements to be shown on plans.
270	PORTLAND CEMENT TREATMENT FOR MATERIALS IN PLACE (1) Percent density must be shown on plans. (2) Length of curing must be shown on plans. (3) Depth of treatment must be shown on plans. (4) Limits of treated area should be shown on typical section.
272	PORTLAND CEMENT TREATMENT FOR BASE COURSES Same as Item 270.
274	CEMENT STABILIZED BASE (1) Gradation for Type G base material must be shown on plans. (2) Under Ordinary Compaction, type of rolling must be shown on plans. (3) If asphalt curing is required, type and grade asphalt must be shown. (4) Depth of stabilization must be shown on plans.

ITEM NO.	TITLE & REQUIREMENTS
292	ASPHALT STABILIZED BASE (PLANT MIX) (1) Grade 4 requirements must be shown on plans. (2) Required method of control for design percent asphalt must be shown on plans. (3) Any required strength, laboratory density and in-place density must be shown on plans. (4) No. of bins should be shown on plans. (5) Acceptable percent of variation between asphalt used and the design amount should be shown on plans. (6) Number of layers or lifts should be shown on plans. (7) Plans shall outline provision for opening to traffic. (8) When it is desired that spreading and finishing machine be equipped with automatic screed control, the plans must indicate.
300	ASPHALTS, OILS AND EMULSIONS No special requirements to be shown on plans.
302	AGGREGATE FOR SURFACE TREATMENTS (1) Polish value for surface or finish course for travel lanes shall be shown on plans. (2) Flakiness index shall be shown on plans. (3) Type F as shown on plans.
303	AGGREGATE FOR SURFACE TREATMENTS (LIGHTWEIGHT) (1) Polish value for surface or finish course for travel lanes shall be shown on plans.
304	AGGREGATE FOR SURFACE TREATMENTS (PRECOATED) (1) Polish value for surface or finish course for travel lanes shall be shown on plans. (2) Flakiness index shall be shown on plans. (3) Type PF as shown on plans.
310	PRIME COAT (ASPHALTIC MATERIAL ONLY) (1) Type, grade and rate of asphaltic material must be shown on plans.
312	PRIME COAT (ASPHALTIC MATERIAL AND SAND) (1) Type, grade and rate of asphaltic material must be shown on plans.
314	EMULSIFIED ASPHALT TREATMENT (1) Type of emulsified asphalt must be shown on plans.

ITEM NO.	TITLE & REQUIREMENTS
	(2) Percent of emulsified asphalt in mix must be shown on plans. (3) Rate of application must be shown on plans. (4) When mixing with base or subbase is required, depth and width should be shown on plans.
316	SEAL COAT (1) Type and rate of asphalt must be shown on plans. (2) Type, grade and rate of aggregate must be shown on plans. (3) Type of rollers must be shown on plans. (4) When state furnished aggregate, stockpile locations must be shown on plans.
320	ONE COURSE SURFACE TREATMENT (1) Type, grade and rate of asphalt must be shown on plans. (2) Type, grade and rate of aggregate must be shown on plans. (3) Type of rollers must be shown on plans.
322	TWO COURSE SURFACE TREATMENT Same requirements as Item 320.
324	THREE COURSE SURFACE TREATMENT Same requirements as Item 320.
330	COLD MIX LIMESTONE ROCK ASPHALT PAVEMENT (CLASS A) (1) Courses and details to be shown on plans. (2) Type and amount of mixture used shall be specified on the plans. (3) If spreading and finishing machine required, show on plans. (4) If automatic screed control required, show on plans. (5) If polish value required, shall be shown on plans. (6) If in-place compaction requirement is required, the plans shall indicate minimum value.
332	COLD MIX LIMESTONE ROCK ASPHALT PAVEMENT (CLASS B) Same requirements as Item 330.

ITEM NO.	TITLE & REQUIREMENTS
340	HOT MIX ASPHALTIC CONCRETE PAVEMENT (1) Courses and details to be shown on plans. (2) Polish value of aggregate shown on plans. (3) Type G and other special mixes gradation and asphalt content shown on plans. (4) Number of bins for Type G and special mixes shown on plans. (5) If automatic screed control is required must show on plans. (6) Percent of theoretical density or percent of laboratory molded specimen density shown on plans.
350	HOT MIX COLD LAID ASPHALTIC CONCRETE PAVEMENT (1) Courses and details to be shown on plans. (2) Polish value of aggregate shown on plans. (3) Type G and other special mixes gradation and asphalt content shown on plans. (4) Number of bins for Type G and special mixes shown on plans. (5) If automatic screed control is required must show on plans. (6) Percent of theoretical density of percent of laboratory molded specimen density shown on plans, when placed hot.
360	CONCRETE PAVEMENT (WATER CEMENT RATIO) (1) Type of concrete pavement or base of portland cement concrete must be shown on plans. (2) Thickness and typical section must be shown on plans. (3) Bituminous material, when required, for sealing joints shall be the type and grade shown on plans. (4) Boards for joint filler shall be the size, shape and type shown on plans. (5) Size, type and location of dowel bars must be shown on plans. (6) Metal installing devices for joint assembly will be as shown on plans. (7) Reinforcing steel shall be placed, spaced and secured as shown on plans. (8) When emulsified asphalt is used for curing concrete base the type and grade must be shown on plans. (9) Transverse and longitudinal joints shall be of the type and location as shown on the plans. (10) Location of longitudinal joints should be shown on plans. (11) Joint-filler boards shall be anchored as indicated on the plans.

ITEM NO.	TITLE & REQUIREMENTS
364	CONCRETE PAVEMENT (CLASS A CONCRETE) (1) Typical cross section shown on plans. (2) Reinforcing requirements shown on plans. (3) Joint requirements shown on plans. (4) Check reference sections of Item 421 and Item 360 for additional required notes.
366	CONCRETE PAVEMENT (CONTINUOUSLY REINFORCED) (1) Same notes as Item 360. (2) Transverse wires in prefabricated deformed wire mats shall project beyond centerline of edge longitudinal wire as specified on plans. (3) Where deformed wire mats are specified wire splicing shall conform to requirements set forth in the plans. (4) Spacing of bar splicing shall be distributed and conform to the requirements in the plans.
368	TERMINAL ANCHORAGE (CONCRETE PAVEMENT) (1) Details as shown on plans.
500	MOBILIZATION None
502	BARRICADES, SIGNS AND TRAFFIC HANDLING None
504	STRUCTURE FOR FIELD OFFICE AND LABORATORY (1) Type D structure shall be as described on plans.
506	TEMPORARY EROSION, SEDIMENT AND WATER POLLUTION CONTROL None
508	CONSTRUCTING DETOURS (1) Location, length, lines, grades and typical cross section shown on plans.
510	ONE-WAY TRAFFIC CONTROL None
512	PORTABLE CONCRETE TRAFFIC BARRIER (1) Placing and replacing locations designated on plans. (2) Dimensions and cross sections shown on plans. (3) Constructed and installed in accordance with details shown on plans.

ITEM NO.	TITLE & REQUIREMENTS
	(4) Class of concrete shown on plans. (5) Any storage site needed shall be shown on plans.
514	CONCRETE TRAFFIC BARRIER (1) Details, locations, lines and grades shown on the plans. (2) Reinforcing details shown on the plans. (3) Details of drilled shaft foundations, when requested, shown on plans. (4) Installed in accordance with details shown on plans. (5) Type specified on plans.
516	VEHICULAR IMPACT ATTENUATOR ASSEMBLY (STEEL BARREL) (1) Construction details shown on plans. (2) Locations shown on plans. (3) Fabricated and installed in accordance with details shown on plans.
518	VEHICULAR IMPACT ATTENUATOR ASSEMBLY (SAND-FILLED PLASTIC BARRELS) (1) Layout details shown on plans. (2) Location shown on plans. (3) Fabrication and installation details shown on plans.
520	WEIGHING AND MEASURING EQUIPMENT No specific requirements.
522	READY-MIX PLANTS No specific requirements.
524	HYDRAULIC CEMENT No specific requirements.
526	MEMBRANE CURING No specific requirements.
528	AUTOMATIC SCREED CONTROLS FOR ASPHALTIC-CONCRETE SPREADING AND FINISHING MACHINE No specific requirements.
530	CONCRETE CURB, GUTTER, CURB AND GUTTER, SIDEWALKS AND DRIVEWAYS (1) Details must be shown on the plans. (2) The reinforcing steel, if required, shall be placed in position as required by the plans.

ITEM NO.	TITLE & REQUIREMENTS
	(3) Sidewalks constructed in sections of lengths shown on plans. Premolded or board joint of the thickness shown on plans.
	(4) Joints between sections of curbs, gutters and curb and gutter shall be of the type as directed and specified on the plans.
532	CONCRETE RETARDS
	(1) Details for concrete retards will be shown on plans.
	(2) When plans indicate that use of base-course material as aggregate will be permitted, porportions of cement and aggregate will be as shown on plans.
534	CONCRETE FOR STRUCTURE APPROACH SLABS
	(1) Details for approach slabs will be as shown on plans.
536	CONCRETE MEDIANS AND DIRECTIONAL ISLANDS
	(1) Details for medians and directional islands will be as shown on plans.
	(2) Class of concrete must be shown on plans.
538	RIGHT OF WAY MARKERS
	(1) Location of markers as shown on plans.
	(2) For Ty II, price of bronze disks may be purchased from the Department at price shown on plans.
	(3) Details of the markers shall be as shown on plans.
	(4) When using "Installing ROW Markers," markers furnished at sources indicated on plans.
540	METAL BEAM GUARD FENCE
	(1) Details of guard fence must be shown on plans.
	(2) The gauge of the rail shall be as shown on plans.
	(3) Type of posts shall be as shown on plans.
	(4) Length of posts shall be as shown on plans, the bottom and the top shall be fabricated as shown on plans.
	(5) When posts are furnished Contractor by State, location of source must be shown on plans.

ITEM NO.	TITLE & REQUIREMENTS
542	REMOVING METAL BEAM GUARD FENCE (1) Location of guard fence to be removed must be shown on plans.
544	REMOVING TIMBER POST GUARD FENCE None
550	CHAIN LINK BARRIER FENCE (1) Location shown on plans. (2) Details shown on plans. (3) Fabric width and height shall be as shown on plans. (4) Height of fence shall be height above grade as shown on plans. (5) Bands and wire ties shall conform to gauge and spacing shown on plans. (6) All posts shall be of the weight and length as shown on plans. (7) Bolts and nuts shall be of size and spacing shown on plans. (8) Gate frames shall be fabricated from sections of size and weight specified on plans. (9) Cables shall be installed on terminal posts, as shown on plans. (10) Minimum size of concrete footings will be as shown on plans. (11) Corner and pull posts shall have horizontal braces and tie rods as indicated on plans. (12) The type, height and opening for gates shall be specified in bid item.
552	WIRE FENCE (1) Details of wire fence shown on plans. (2) Location of wire fence shown on plans. (3) The fence shall consist of barbed wire or a combination of woven fence and barbed wire as specified on plans. (4) Weight and length of posts and braces will be shown on plans. (5) Anchor plates shall be of the area, size and weight shown on plans. (6) Posts set in concrete shall be as shown on plans. (7) Minimum diameter of wood posts shall be as shown on plans. (8) Gates and gate posts shall be of the material and dimensions detailed on plans.

ITEM NO.	TITLE & REQUIREMENTS
	(9) The wire mesh shall be of the height and design as shown on plans. (10) Fence posts shall be spaced at the intervals and set to the depth shown on plans. (11) Timber post braces shall be notched as shown on plans. (12) Deadmen buried in the ground as shown on plans. (13) The barbed wire and wire fabric shall be drawn taut and fastened to posts with galvanized ties and staples as specified on plans.
556	PIPE UNDERDRAINS (1) Type and size of pipe shall be shown on plans and proposal. (2) Filter material shall be placed to depth shown on plans. (3) When required by plans, concrete riprap or headwalls shall be of dimensions shown on plans.
575	EPOXY None
610	ROADWAY ILLUMINATION ASSEMBLIES (1) Details shown on plans. (2) Types illumination assemblies shown on plans. (3) Location shown on plans.
612	RELOCATING ROADWAY ILLUMINATION ASSEMBLIES (1) Details of material shown on plans. (2) Details of foundations shown on plans. (3) Relocated position shown on plans.
613	HIGH MAST ILLUMINATION POLES (1) Details and dimensions shown on plans.
614	HIGH MAST ILLUMINATION ASSEMBLIES (1) Details shown on plans.
616	ROADWAY ILLUMINATION ASSEMBLY FOUNDATIONS (1) Types shown on plans. (2) Details shown on plans.
618	CONDUIT (1) Type and size indicated on plans. (2) Details and dimensions shown on plans. (3) Location shown on plans.

ITEM NO.	TITLE & REQUIREMENTS
620	ELECTRICAL CONDUCTOR (1) Size and type indicated on plans.
622	DUCT CABLE (1) Type and size specified on plans. (2) Depth of installation shown on plans except at locations where duct cable is to be enclosed in conduit.
624	GROUND BOX (1) Locations shown on plans. (2) Details shown on plans.
626	CIRCUIT PROTECTOR ASSEMBLY (1) Details of circuit-protector assembly must be shown on plans. (2) CPA shall be assembled and placed in accordance with details and dimensions shown on plans.
628	SERVICE POLES (1) Location shown on plans. (2) Details of service pole shown on plans. (3) Service pole shall be assembled and placed in accordance with details and dimensions shown on plans.
630	TRANSFORMER STATIONS (1) Details of transformer stations must be shown on plans. (2) Transformer stations shall be assembled and placed in accordance with details and dimensions shown on plans.

T. List of Current Forms for PS&E Submissions

FORM NO.	TITLE
1002	PS&E Submission Data
567R	Agreement for Purchase of Road Material
1080R	Agreement for Purchase of Road Material (Borrow)
271	Easement for the Purpose of Producing and Hauling Material
8.92	Special Provision Local Material Sources (Required Sources)
8.93	Special Provision Local Material Sources (Listed Sources)
8.94	Special Provision Local Material Sources (Designated Sources)
1088	Program Supporting Data
	Federal-aid ______________________ Funds
1089R	Request for Programming of Federal-aid Projects
1204-1&2	Request for Construction Speed Zone
—	Utility Adjustment Status Form
—	Project Specific Archaeological Survey Form

Form 1002
Rev. 1-87

P.S.&E. SUBMISSION DATA

Date_______________

(This form should be completed and submitted with supporting papers; complete this form for each individual project in contract.)

County_______________ Project_______________ Letting Date _______________

Highway_______________ CSJ(s)_______________

Limits: _______________

If one or more projects, for which separate plans are prepared, are to be combined with this project for contracting, list data for other projects below.

PROJECT	CSJ	HIGHWAY	COUNTY

1\. CHECK LIST:

	DESCRIPTION	NO. COPIES REQUIRED	NO. COPIES ATTACHED
(1)	Letter of Transmittal	*	....
(2)	Plans Estimate	*	....
(3)	List of Governing Specifications and Special Provisions (ROSCOE Key, Prefix, and File Name:_______________)	*	....
(4)	General Notes and Specification Data (ROSCOE Key, Prefix, and File Name: _______________)	*	....
(5)	Request for Construction Speed Zone	3	....
(6)	Request for Programming of Federal-aid Secondary Projects	2	....
(7)	Relocation Certification	3	....
(8)	Right of Way Certification	3	....
(9)	Utility Adjustment Status	3	....
(10)	Material Sources and Archaeological Certification	1	....
(11)	Financial Clearance Statement for Maintenance Contracts	1	....

The number of copies of review plans prints will be furnished as follows (* the number of supporting papers and estimate printouts will be one more than the number of review plans prints):

Federal-aid Projects (except HES): 5

Federal-aid HES Projects: 6

Usual State Projects: 4

Seal Coat and ACP Projects: 3

Traffic Signal and Signing Projects: 3

2. FINANCING:
(a) Auth. Funds $__________ (b) Est. Cost (Excluding Special Funds) $__________
(c) Program __________

(d) Amount & Percent of Overrun or Underrun $__________ (____%)
(e) Reasons for Overrun & Suggested Method of Financing __________

(f) Special Funds:

	Amount	Fixed-Sum or Actual Cost	Type of Work	Authorization Minute No.
County	$			
City	$			
Others	$			

( )

(g) Force-Account Work

State	Amount	
	$	
	$	
Contractor	$	Temp Erosn, Sedmt & Wtr Pol Cont

3. TRAFFIC: Present ADT ______ Projected ADT ______ Year ____

4. MATERIAL-SOURCE OPTION AGREEMENTS:

Previously Submitted ______, for Project ______;
with PS&E______ To be Submitted ______
Female Property Owners Femme Soles? ______

5. NEW SPECIAL PROVISIONS AND SPECIAL SPECIFICATIONS: (If modification is made to an existing spec. please furnish reference; and include OETC Prefix and File Name(s).)
(a) Reason for Need and Changes from Standard Specification: ______

(b) Are any Specifications for patented or proprietary use?
Yes _____ No _____ (If "Yes", list reasons for use:) _______

(c) Special Provision(s) and/or Special Specification(s) has (have) been set up on OETC. (Include OETC Prefix and File Name(s)):

6. USCG PERMIT required? Yes _____ No _____

7. SECTION 404 PERMIT required? Yes _____ No _____

8. SECTION 404 NATIONWIDE PERMIT apply? Yes _____ No _____

9. STATUS OF RIGHT OF WAY (as of P.S.&E. Submission):
Adjustments Required? Yes _____ No _____
(If "Yes", Special Provision is required.)

10. STATUS OF UTILITIES (as of P.S.&E. Submission):
Adjustments Required? Yes _____ No _____
(If "Yes", Special Provision is required.)

11. RAILROAD AGREEMENTS: Required? _____ Name of RR: _____________

If not executed, date request sent to D-5 _____________

12. OTHER AGREEMENTS REQUIRED: Yes_____ No_____ Name of Agency__________
_____________ Purpose:_____________
Status: Executed: Yes (Date) _____________; No, Handled by D-_____

13. WORK TIME FOR TOTAL CONTRACT: _____________ Days. Prospective

Bidder may see plans at office of _____________

Engineer, at _____________,
(Complete Mailing Address)
_____________, Texas _____________, _____________
(Zip) (Area Code and Phone)

14. REMARKS (Expansion of above items. Use additional sheet when necessary):

Form 567 R
Rev. 8-77

AGREEMENT

for purchase of

ROAD MATERIAL

by and between

the

STATE OF TEXAS
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

and

____
(Name)

____
(Mailing Address)

Control ______________________________

Project ______________________________

Highway No. ______________________________

______________________________County

Type of Material:

____

Type of Proposed Work:

____

____

____

This material or lesser amounts will be used only when haul makes it most economical source and may be secured on basis of lesser amounts or none.

Form 567 R
Rev. 8-77

STATE OF TEXAS, COUNTY OF ______________________________

This agreement is made this ______ Day of ______________________________, 19 ___, by and between ____ his/their executors, administrators, heirs, successors or assigns, hereinafter referred to as the Party of the First Part, and the State of Texas, State Department of Highways and Public Transportation, acting through its Engineer-Director, hereinafter referred to as the Party of the Second Part.

Whereas, preliminary investigations have indicated that acceptable material is available from lands hereinafter described, owned/controlled by the Party of the First Part, and

Whereas, the Party of the First Part desires to sell any or all of this acceptable material.

Witnesseth: The Party of the First Part for, and in consideration of one dollar ($1.00) and other valuable considerations, receipt of which is hereby acknowledged, does hereby agree to hold for the exclusive use of the Party of the Second Part, its agent or Contractor, all ________ material occuring on said lands, hereinafter described, and to sell any or all of this material that may prove acceptable to the Party of the Second Part at the unit royalty price of __________ per __________. The Party of the First Part hereby further agrees to indemnify and save harmless the Party of the Second Part from any and all damage, or loss, that may develop from existing mortgages or liens on the lands hereinafter described.

The Party of the Second Part agrees to pay for all accepted material at the unit royalty rate designated above by the Party of the First Part. Royalty payment(s) will be made (1) monthly as material is removed, (2) only once for each contract involved, such payment to be made after all material needed from this quarry for such contract has been removed, (3) as follows: _____
____
____

No royalty payment will be made for strippings of quarry or other unsuitable material, whether at quarry or delivered on the road.

It is mutually agreed that payment will be made only for acceptable material, measured as provided for in the governing specification, and delivered at points designated by the duly authorized representative of the Party of the Second Part. The governing specification requires that the material be measured

____
____

It is further mutually agreed and understood that the agents of Contractors for the Party of the Second Part are to have free ingress to and egress from said lands, hereinafter described, for the purpose of excavating and removing said material. All fences, gates and other existing improvements on the said lands, hereinafter described, after removal of all material desired by the Party of the Second Part, shall be placed in a condition comparable in repair to their former state by the Party of the Second Part, its agent or Contractor. All equipment placed on said lands by the Party of the Second Part, its agent or Contractor, to assist in the removal of said material, shall be removed by the Party of the Second Part, its agent or Contractor, upon the abandonment of the quarry.

It is further mutually agreed and understood that should the Party of the First Part at any time consider the maintenance of watchmen or the erection of additional fences, cattle guards, etc., against possible damage or loss during quarry operations, all arrangements and costs incident thereto shall be the entire responsibility of the Party of the First Part. Any such safeguards considered necessary by the Party of the Second Part shall be the entire responsibility of the Party of the Second Part.

This agreement shall expire ______ year(s) from the date of execution unless the Party of the Second Part at that time has under contract or has issued work order for construction of the project or projects hereinbefore described, in which event this agreement shall remain in effect until all such material desired by the Party of the Second Part for construction of said project or projects has been removed and the conditions hereinbefore stated have been fulfilled.

Location and description of lands hereinbefore mentioned (Give such information as is necessary to establish the location and limits of the source of material in a manner satisfactory and understandable to both parties):

Form 567 R
Rev. 8-77

IN WITNESS WHEREOF, the Parties concerned hereto have set their hands the date herein named.

Party of the First Part

____

____

____

____

(If married, both husband and wife should sign)

Witness:

____

____

STATE OF TEXAS

Party of the Second Part

Certified as being executed for the purpose and effect of activating and/or carrying out the orders, established policies, or work programs heretofore approved and authorized by the State Highway and Public Transportation Commission:

BY ____________________

Assistant Engineer-Director

Recommended for approval:

____

Resident Engineer

____

District Engineer

____

Chief Engineer of Highway Design

AGREEMENT

for purchase of

ROAD MATERIAL (BORROW)

by and between

the

STATE OF TEXAS
STATE DEPARTMENT OF HIGHWAYS AND
PUBLIC TRANSPORTATION

and

____
(Name)

____
(Mailing Address)

Control ______________________________________

Project ______________________________________

Highway No. __________________________________

______________________________________ County

Type of Material:

____

Type of Proposed Work:

____

____

____

This material or lesser amounts will be used only when haul makes it most economical source and may be secured on basis of lesser amounts or none.

Form 1080 R
Rev. Sept. 1975

STATE OF TEXAS, COUNTY OF ______________________

This agreement is made this ______ Day of ______________________________, 19 ___, by and between ____ his/their executors, administrators, heirs, successors or assigns, hereinafter referred to as the Party of the First Part, and the State of Texas, State Department of Highways and Public Transportation, acting through its Engineer-Director, hereinafter referred to as the Party of the Second Part.

Whereas, preliminary investigations have indicated that acceptable material is available from lands hereinafter described, owned controlled by the Party of the First Part, and

Whereas, the Party of the First Part desires to sell any or all of this acceptable material.

Witnesseth: The Party of the First Part for, and in consideration of one dollar ($1.00) and other valuable considerations, receipt of which is hereby acknowledged, does hereby agree to hold for the exclusive use of the Party of the Second Part, its agent or Contractor, all borrow material occuring on said lands, hereinafter described, and to sell any or all of this material that may prove acceptable to the Party of the Second Part at the unit royalty price of __________ per __________ . The Party of the First Part hereby further agrees to indemnify and save harmless the Party of the Second Part from any and all damage, or loss, that may develop from existing mortgages, leases, or liens on the lands hereinafter described.

The Party of the Second Part agrees to pay for all accepted material at the unit royalty rate designated above by the Party of the First Part. Royalty payment(s) will be made (1) monthly as material is removed, (2) only once for each contract involved, such payment to be made after all material needed from this pit for such contract has been removed, (3) as follows: __________

____

____

No royalty payment will be made for strippings of pit or other unsuitable material, whether at pit or delivered on the road.

It is mutually agreed that payment will be made only for acceptable material, measured as provided for in the governing specification, and delivered at points designated by the duly authorized representative of the Party of the Second Part. The governing specification requires that the material be measured in its original position and the volume computed in cubic yards by the method of average end areas.

It is further mutually agreed and understood that the agents of Contractors for the Party of the Second Part are to have free ingress to and egress from said lands, hereinafter described, for the purpose of excavating and removing said material. All fences, gates and other existing improvements on the said lands, hereinafter described, after removal of all material desired by the Party of the Second Part, shall be placed in a condition comparable in repair to their former state by the Party of the Second Part, its agent or Contractor. All equipment placed on said lands by the Party of the Second Part, its agent or Contractor, to assist in the removal of said material, shall be removed by the Party of the Second Part, its agent or Contractor, upon the abandonment of the pit.

It is further mutually agreed and understood that should the Party of the First Part at any time consider the maintenance of watchmen or the erection of additional fences, cattle guards, etc., against possible damage or loss during pit operations, all arrangements and costs incident thereto shall be the entire responsibility of the Party of the First Part. Any such safeguards considered necessary by the Party of the Second Part shall be the entire responsibility of the Party of the Second Part.

This agreement shall expire _____ year(s) from the date of execution unless the Party of the Second Part at that time has under contract or has issued work order for construction of the project or projects hereinbefore described, in which event this agreement shall remain in affect until all such material desired by the Party of the Second Part for construction of said project or projects has been removed and the conditions hereinbefore stated have been fulfilled.

Location and description of lands hereinbefore mentioned (Give such information as is necessary to establish the location and limits of the source of material in a manner satisfactory and understandable to both parties):

IN WITNESS WHEREOF, the Parties concerned hereto have set their hands the date herein named.

STATE OF TEXAS

Party of the First Part

____

____

____

____

(If married, both husband and wife should sign)

Witness:

____

____

Party of the Second Part

Certified as being executed for the purpose and effect of activating and/or carrying out the orders, established policies, or work programs heretofore approved and authorized by the State Highway and Public Transportation Commission:

BY ______________________

Assistant Engineer-Director

Recommended for approval:

____

Resident Engineer

____

District Engineer

____

Chief Engineer of Highway Design

____

Engineer, Secondary Roads

CERTIFICATION OF VALUE, after having made necessary investigation of the land I certify that the total royalty cost for the material to be used from this pit will not exceed the normal value of the land.

____

District Engineer, State Department of Highways and Public Transportation

Form 1080 R
Rev. Sept. 1975

State Department of Highways
and Public Transportation
Form 271
Page 1 of 4
Rev. 7-75

EASEMENT FOR PURPOSE OF PRODUCING AND HAULING MATERIALS

STATE OF TEXAS)(
)(
COUNTY OF ________________)(KNOW ALL MEN BY THESE PRESENTS:

That ____

____

____

of ______________________________, in consideration of the sum of __________
____ ($________________________)
Dollars, and other good and valuable consideration in hand paid by the State of Texas, acting through the State Highway and Public Transportation Commission, receipt of which is hereby acknowledged, do by these presents, Grant, Bargain, Sell and Convey unto the State of Texas, the free and uninterrupted use, liberty and privilege of the passage in, along, upon and across the following described premises in ________________________ County, Texas, more particularly described as follows, to wit:

For the purpose of removing and processing materials therefrom either upon or under the surface, with the right and privilege at all times of the State, its agents, employees, workmen, contractors, and representatives having ingress to and egress from, along, upon and across said premises and adjoining property of the grantor. It is specifically understood that the State and its assigns shall be vested with the title to and the right to take and use, without additional compensation, any stone, earth, gravel, caliche, iron ore gravel, or any materials or minerals upon, in and under said land, except oil, gas and sulphur, for the construction and maintenance of the Highway System of Texas.

It is understood that all fences, gates and other existing improvements on the herein described lands, after removal of all material desired by the State, its agents or contractors, as disturbed by the removal of said materials, shall be placed in a condition comparable in repair to their former state by the State, its agents or contractors. All equipment placed on said lands by the State, its agents or contractors, to assist in the removal of said material, shall remain the property of the State, its agents or contractors, and shall be removed on or prior to the expiration date of this easement as herein specified.

It is further understood that should the Grantor herein at any time consider the maintenance of watchmen or the erection of additional fences, cattleguards, etc., necessary to safeguard his-their lands, improvements, livestock, etc., against possible damage during quarry operations and removal of said materials, all arrangements and cost incident thereto shall be the entire responsibility of the grantor herein. Any such safeguards required by the State, its agents or contractors, shall be the entire responsibility of the State, its agents or contractors. The grantor shall permit the State to erect a sign on the herein described property giving notice of the State's ownership of the materials herein.

The grantor agrees to indemnify and save harmles the State of Texas, its agents or contractors, from any and all damage, or loss, that may develop from the grantor's non-ownership of the land, or existing mortgages, liens or easements on the land therein described.

This easement shall expire ________________ year(s) from the date of execution unless the State, its agents or contractor, is actually engaged in removing materials, in which event it shall remain in effect until all such material desired by the State has been removed and the conditions hereinbefore stated have been fulfilled.

TO HAVE AND TO HOLD unto the said State of Texas as aforesaid for the purposes aforesaid the premises above described.

IN WITNESS WHEREOF, this instrument is executed on this the ____________ day of ______________________________, 19 _____.

______________________________ ______________________________

______________________________ ______________________________

______________________________ ______________________________

SINGLE ACKNOWLEDGMENT

THE STATE OF TEXAS
County of ______________________________

Before me, ______________________________, a notary public in and for said County and State, on this day personally appeared ______________________________
______________________________, known to me (or proved to me on the oath of ______________________________, a credible witness) to be the person ____ whose name ____ ________subscribed to the foregoing instrument and acknowledged to me that __he__ executed the same for the purposes and consideration therein expressed.

Given under my hand and seal of office, this the ________ day of ________________ 19 ____

____

Notary Public in and for ______________________________ County, Texas.

SINGLE ACKNOWLEDGMENT

THE STATE OF TEXAS
County of ______________________________

Before me, ______________________________, a notary public in and for said County and State, on this day personally appeared ______________________________
______________________________, known to me (or proved to me on the oath of ______________________________, a credible witness) to be the person ____ whose name ____ ________subscribed to the foregoing instrument and acknowledged to me that __he__ executed the same for the purposes and consideration therein expressed.

Given under my hand and seal of office, this the ________ day of ________________ 19 ____

____

Notary Public in and for ______________________________ County, Texas.

CORPORATION ACKNOWLEDGMENT

STATE OF TEXAS }
County of ________________ }

BEFORE ME, the undersigned authority, a notary public in and for ________________ County, Texas, on this day personally appeared ________________, ________________, of ________________, known to me to be the person and officer whose name is subscribed to the foregoing instrument and acknowledged to me that the same was the act of the said ________________, a corporation and that he executed the same as the act of such corporation for the purposes and consideration therein expressed, and in the capacity therein stated.

Given under my hand and seal of office, this the ______ day of ________________, 19______.

____

Notary Public in and for ________________ County, Texas.

Tract No. ______

County ______

Highway No. ______

Control ______ Sec. ______ Job ______

Federal No. ______

Between ______

______ and

EASEMENT FOR PURPOSE OF
PRODUCING & HAULING MATERIALS

TO

THE STATE OF TEXAS

Filed for Record

This ______ day of ______

A. D. 19 ______, at ______ o'clock ______ M.

Recorded

This ______ day of ______

A. D. 19 ______, in

County, Texas, Records of Deeds,

Book ______ Page ______

______ Clerk.

______ Deputy.

ENDORSEMENTS

THE STATE OF TEXAS, }
County of ________________ }

I, ________________, Clerk of the County Court of said County, do hereby certify that the foregoing instrument of writing, dated the ______ day of ________________ A. D. 19______ with its authentication, was filed for record in my office on the ______ day of ________________, A. D. 19______ at ______ o'clock ______ M., and duly recorded this the ______ day of ________________, A. D. 19______ at ______ o'clock ______ M., in the Deed Records of said County, in Volume ______ on Page ______.

Witness my hand and the seal of the County Court of said County, at office in ________________, Texas, the day and year last above written.

____

Clerk of Court, ________________ County, Texas.

By ________________ Deputy.

SPECIAL PROVISION

LOCAL MATERIAL SOURCES
(Required Sources)

The Department holds options or easements on or owns the following local material sources. The Contractor shall secure the materials from these sources, and he shall comply with those provisions of the option as outlined below.

Owner's Name	Approximate Location of Optioned Material Source	Item Number, Type and Grade	Option Price Per

Acceptable material will be measured as provided for in the governing specifications.

The Department will make payments to the lessors and the Contractor shall reimburse the State at the option price as indicated above for each separate material source. Reimbursements will be made to the State by making deductions from the Contractor's estimates as material is placed based upon the amount shown in the estimates and the option-agreement prices shown above.

Overburden and other unsatisfactory material shall be placed in designated spoil banks or shall otherwise be disposed of as directed, in such manner as not to create an unsightly or objectionable condition.

All fences, gates and other existing improvements shall be placed in a condition comparable to their condition at the time of inaugurating work.

All equipment used in the removal of the material shall be removed from the property upon the abandonment of the quarry or pit.

COMPENSATION: All royalty costs and work required by these provisions will not be paid for directly, but shall be considered as subsidiary work pertaining to the various bid items of this contract.

SPECIAL PROVISION

LOCAL MATERIAL SOURCES
(Listed Sources)

The Department holds options or easements on the following local material sources. The Contractor may, if he elects and providing in his mining operation he can produce material meeting the specification requirements for the items listed below, operate these material sources, after the material requirements for other items for which the sources may be designated have been met. If the Contractor elects to use these sources he shall comply with those provisions of the option as outlined below. It is specifically understood that the State assumes no responsibility for either the quality or the quantity of material in these sources.

Owner's Name	Approximate Location of Optioned Material Source	Item Number, Type and Grade	Option Price Per

Acceptable material will be measured as provided for in the governing specifications.

The Department will make payments to the lessors and the Contractor shall reimburse the State at the option price as indicated above for each separate material source. Reimbursements will be made to the State by making deductions from the Contractor's estimates as material is placed based upon the amount shown in the estimates and the option-agreement prices shown above.

Overburden and other unsatisfactory material shall be placed in designated spoil banks or shall otherwise be disposed of as directed in such manner as not to create an unsightly or objectionable condition.

All fences, gates and other existing improvements shall be placed in a condition comparable to their condition at the time of inaugurating work.

All equipment used in the removal of the material shall be removed from the property upon the abandonment of the quarry or pit.

COMPENSATION: All royalty costs and work required by these provisions will not be paid for directly, but shall be considered as subsidiary work pertaining to the various bid items of this contract.

Form 8.93
Rev. 4-79

SPECIAL PROVISION

LOCAL MATERIAL SOURCES
(Designated Sources)

The Department holds options or easements on the following local material sources. If the Contractor elects to operate these material sources, he shall comply with those provisions of the option as outlined below.

Owner's Name	Approximate Location of Optioned Material Source	Item Number, Type and Grade	Option Price Per ______

Acceptable material will be measured as provided for in the governing specifications.

The Department will make payments to the lessors and the Contractor shall reimburse the State at the option price as indicated above for each separate material source. Reimbursements will be made to the State by making deductions from the Contractor's estimates as material is placed based upon the amount shown in the estimates and the option-agreement prices shown above.

Overburden and other unsatisfactory material shall be placed in designated spoil banks or shall otherwise be disposed of as directed in such manner as not to create an unsightly or objectionable condition.

All fences, gates and other existing improvements shall be placed in a condition comparable to their condition at the time of inaugurating work.

All equipment used in the removal of the material shall be removed from the property upon the abandonment of the quarry or pit.

Should the Contractor elect to operate sources other than those shown on the plans and set forth herein, he will notify the Engineer sufficiently far in advance to permit performance of required quality tests and will secure the approval of the Engineer in writing for use of said sources. He will be responsible for any royalty payments and other agreements made with the property owner. If these sources result in alteration of the plans or specifications, necessary negotiations will be made with the Contractor prior to the Engineer's approval of the proposed new source. In no case will approval of a source be given which would result in material of inferior quality to the designated source or which would result in an increased cost to the State.

COMPENSATION: All royalty costs and work required by these provisions will not be paid for directly, but shall be considered as subsidiary work pertaining to the various bid items of this contract.

Form 1088

PROGRAM SUPPORTING DATA — FEDERAL-AID ____________ FUNDS

State ____ Texas ____ Proposed Letting Date ____ Date ____
Item No. ____ Project No. ____ County ____
Traffic: Pres. ADT ____ % Comm. ____ Est. Fut. ____

EXISTING FACILITY:

Present Surface Type ____ Pav't Width ____ Base Cr. Width ____
Deficiencies in Alignment and Grade ____

Road Connections at each end of Project:

____ End, Surface Type ____ Surface Width ____ Base Cr. Width ____ Condition ____
____ End, Surface Type ____ Surface Width ____ Base Cr. Width ____ Condition ____

Exist. Bridge Data:

Location (Miles from S. or W. Terminus)	Overall Length	Curb-to-Curb Roadway Width	Overhead Clearance	Type	Condition	Estimated Safe Load

Proposed Treatment of Deficient Bridges ____

Railroad Grade Crossing Data:
Name of Railroad: ____
Number of tracks: Main ____ Passing ____ Industrial ____
Number of trains and maximum speed: Passenger ____
Freight ____ Mixed ____

To determine whether sight distances are restricted, refer to page 308 of Blue Book and comment under Remarks. For quadrant with shortest sight distance show the sight distance along the railroad and the distance from the track in determining this sight distance: ____ feet at ____ feet.

Existing Protection: Gates ☐ Flagman ☐ Bells ☐ Flashing Lights ☐
Other Devices ____
Proposed Protection: ____
(If separation is proposed, state whether principle existing grade crossing will be closed.)

Will new crossing be: at present crossing ____ on essentially a relocation of existing road ____ or on a new highway ____

Is system revision involved ____ (If answer is yes, explain under Remarks)
Is airway-highway clearance involved ____ (If answer is yes, explain under Remarks)
Is water development project involved ____ (If answer is yes, explain under Remarks)
Is public hearing required ____ Has public hearing been held ____
Are incorporated cities involved in location ____
Date of execution of Municipal Maintenance Agreement (Form 1038) ____
Is relocation assistance involved ____ Has it been provided ____

REMARKS: ____

Form 1089R

REQUEST FOR PROGRAMMING OF FEDERAL-AID PROJECT

____
Date

Please program the following project for _______________

_______________ County, Project No. _______________ Route No. _______________

Hwy. _______________ Traffic: Pres. ADT _______________ Future ADT _______________ Year _______________

Limits _______________

____

Proposed Work _______________

____

No. Lanes _______________ Travel Surf : _______________ Base Crown: _______________

Type Pvt: _______________

Front. Roads: No. _______________ Travel Surf : _______________ Base Crown: _______________

Type Pvt: _______________

Bridge: (Drainage Str.) No. _______________ Total Length _______________

No.
_______ Overpasses at _______________ Combined Length _______________

____

_______ Underpasses at _______________ Combined Length _______________

____

Project Length _______________ Miles ROW _______________ Access Control _______________

	Total Funds	Federal Funds	State Funds
Est. Cost:			
P.E.	_______	_______	_______
Construction (Incl. E&C)	_______	_______	_______
Total	_______	_______	_______

Project No.____________________

County_________________________

Additional Data Required for Projects having Urban Characteristics

Furnish large scale project sketch map

Typical proposed cross section should be furnished when available - if not, give following:

Right of way width____

Pavement width____

Number of lanes____

Number of parking lanes____________Parking Control______________

____

Width of median____

Turning lanes____

Frontage roads____

Volume of cross traffic at critical intersections__________________

Grade separations located at______________________________________

Describe plan for control of access________________________________

____

____

Give reference to Preliminary Engineering Report__________________

Explain utility adjustments involved______________________________

____

____

Give breakdown of participating and non-participating portions________

____

____

Explain extra utility work such as storm sewer extensions, etc.________

____

____

6-58-1746
D-8
File P.2

REQUEST FOR CONSTRUCTION SPEED ZONE

1. District____________________
2. County____________________
3. Highway Number____________________
4. Direction____________________(Show direction as Northerly or Southerly, etc., from beginning Station No. to End Station No.)
5. Speed____________________
6. Net Length of each Section outside of Incorporated Cities
   Section 1____________________
   Section 2____________________
   Section 3____________________
   Section 4____________________
7. Control and Section Number at both beginning and end of each Section to be zoned

	Beginning				End			
	Station No.	Cont.	Sec.	Job	Station No.	Cont.	Sec.	Job
Section 1								
Section 2								
Section 3								
Section 4								

8. Project Number____________________

<u>Draw Sketch Below</u>

Indicate North

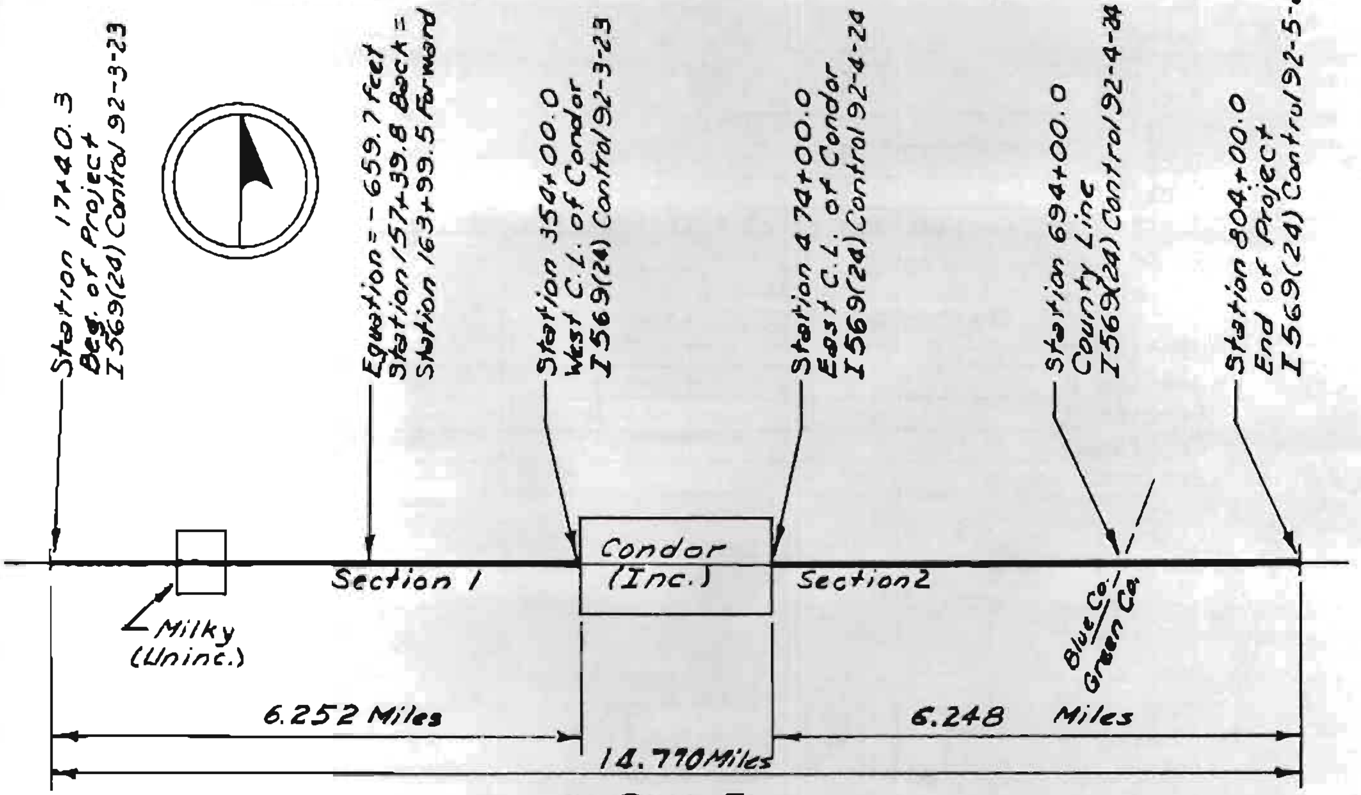
℄ Highway

3-59-768
D-18

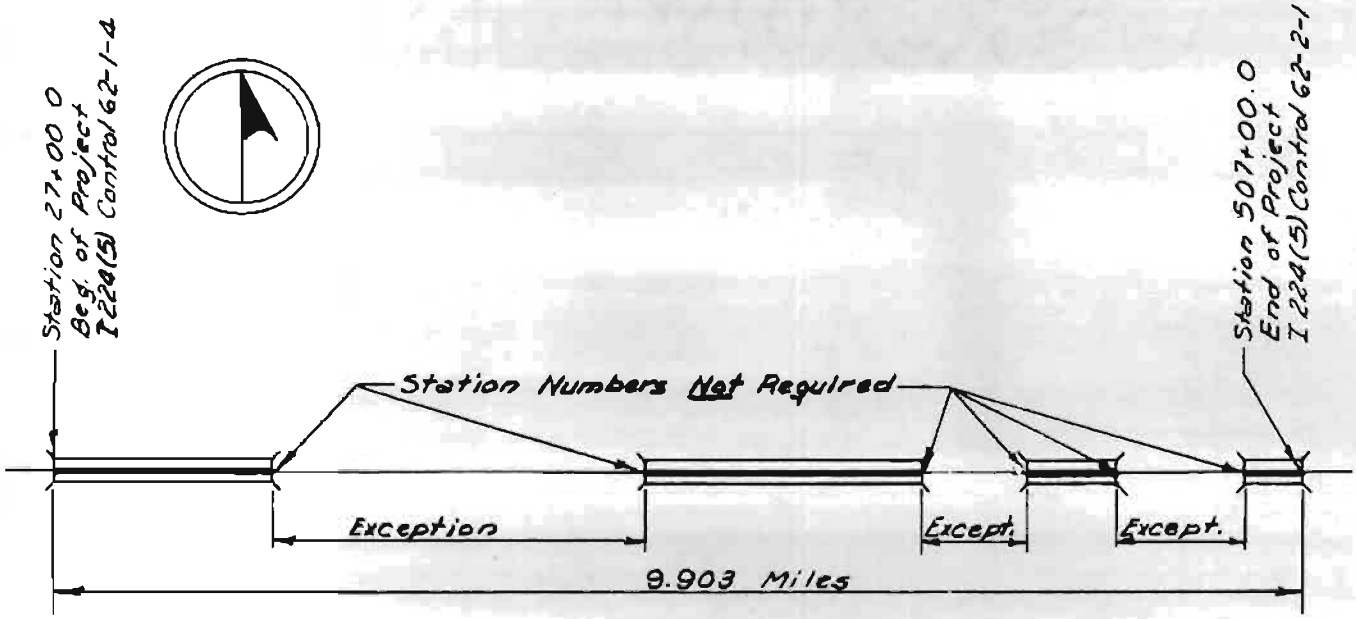
FORM 1204-1

For instructions see reverse side of sheet

Notes: Draw sketch of each project submitted. Show all equations giving forward and back station numbers. Show city limits of all incorporated cities within limits of project giving station numbers. Show the approximate location and name of any unincorporated areas within limits of zone. Show station, project and control numbers of any County Lines that occur within zone limits. Fill out a separate sheet for each zone requested. Give net length of each section within the zone.



Case I
Where there is an Incorporated City within the limits of the Project



Case II
Where there are exceptions within the limits of the Project

FORM 1204-2

UTILITY ADJUSTMENT STATUS

Project:
Control:
Highway:
County:

Utility Adjustment Status as of______________

Owner	Utility	Location	Work Started	Work Completed	Work Remaining	Estimated Completion	Remarks

Project Specific Archaeological Survey Form

1. District ______________________.

2. County ______________________.

3. Associated Highway ______________________________________.

4. I.P.E. or P.D. No. __________.

5. Location (U.S.G.S. Map) ______________________________.

6. Type of locality: ☐ Borrow pit, ☐ Aggregate source, ☐ Sand source, ☐ Top soil, ☐ Waste pit, ☐ Storage area, ☐ Utility area, ☐ Haul Road, other ____.

7. Owner of locality (Name and address) ______________________
____.

8. Size of locality ______________________________________.

9. Presence of Archaeological evidence? ☐ yes ☐ no

10. If yes, what type of evidence? ☐ flint flakes, ☐ pottery, ☐ burned rock, ☐ stone artifacts, ☐ prehistoric architectural remains, ☐ historic artifacts, ☐ historic architectural remains, ☐ man-made earth remains, other ____.

11. Describe the evidence ______________________________________
____
____.

12. Is the locality disturbed? ☐ yes ☐ no

13. If yes, how? ☐ Erosion, ☐ Cultivation, ☐ Vandalism, other ________.

14. Is a professional opinion necessary? ☐ yes ☐ no

15. D-8A notified. ☐ yes ☐ no

16. Recorder ______________________. Date ________________.

17. Signature ______________________.

18. Comments: ____
____
____
____
____
____.

PART VI

SECONDARY ROAD PLAN

PART VI
SECONDARY ROAD PLAN (6-100)

6-101 INTRODUCTION

A. General

The Secondary Road Plan (SRP) described herein sets forth the standards and procedures applicable on Federal-aid construction projects on the Federal-aid Secondary (FAS) System.

B. Certification Acceptance

SRP projects are certified as meeting applicable standards, guidelines, policies, and procedures and subsequently are accepted by the FHWA without submission of P.S.&E. for review and approval. Exceptions to SRP procedures or standards will be submitted to the FHWA for consideration as early as practical in the project development process.

C. Construction Review

The FHWA should be notified when a project is complete and/or ready for construction inspection. An FHWA review is conducted on all completed SRP construction projects.

6-102 ORGANIZATION ADMINISTRATION

The State Department of Highways and Public Transportation (SDHPT) consists of a 3-member Commission appointed by the Governor, an Engineer-Director, 4 Deputy-Directors, 14 Headquarters Divisions, and 24 District Offices. Design, construction, and maintenance of specific highway sections is performed within District Offices. The Headquarters Divisions set operating procedures and policies, review information transmitted from the District Offices, and perform other staff functions for the Administrative (Engineer-Director and Deputy-Directors) level of the SDHPT.

Overall administration of the SRP is within the Highway Design Division (D-8) which is directed by the Chief Engineer, Highway Design. The Geometric Design Section (D8-G) of the Highway Design Division, directed by the Engineer of Geometric Design, develops roadway design guidelines and practices for use on all highways including those developed or improved under the SRP. Three Field Sections (D-8FI, II, and III) each managed by an Engineer of Field Coordination, are responsible for coordinating individual SRP project activities with the Districts and FHWA. The environmental and public involvement phase of the SRP is administered by the Environmental and Community Factors Section, managed by the Director of Environmental Studies, of the Highway Design Division. An organization chart of the entire Division is shown in Part I of this Manual.

6-103 OPERATING PROCEDURES TO BE USED IN ADMINISTERING PLAN PROJECTS

SDHPT will comply with all Federal laws, Executive Orders, and provisions of the Federal-aid regulations in Title 23 CFR applicable to the SRP. In the development of projects under the SRP, SDHPT will follow, as a minimum, the procedures outlined in appropriate federal environmental regulations regarding social, economic and environmental assessments. Public involvement procedures followed will be as prescribed in the SDHPT's "Project Development Procedures for Coordination and Public Involvement". Public hearing transcripts, related data and certifications will be retained in SDHPT's project files.

Projects developed under the SRP will include provision for safety to the traveling public in accordance with acceptable practices for the traffic volumes served. Fiscal responsibility for the State's portion of projects developed under the SRP will be established by action of the SDHPT Commission at the time of project authorization. All cost procedures, accounting, project records, record retention and audit aspects for projects developed under the SRP shall be in accordance with the procedures for Federal-aid projects.

Other specific procedures will be performed as follows:

A. System Revisions: as provided in FHPM 4-6-7 and subsequent revisions.

B. Program Approvals: as provided in FHPM 6-3-2 Subsection 2 and subsequent revisions.

C. Project Authorizations: as provided in FHPM 6-5-3 Paragraph 7b and subsequent revisions.

D. Safety Through Construction Zones: as provided in FHPM 6-4-2 Subsection 12 and subsequent revisions.

E. Equal Employment Opportunity: as provided in FHPM 6-4-1 Subsection 2 and subsequent revisions.

F. Minority Business Enterprises, Disadvantaged Business Enterprises, and Women-owned Business Enterprises: as provided in 49 CFR Part 23, subparts A and D and as supplemented by Federal regulations and procedures.

6-104 STANDARDS APPLICABLE TO PLAN PROJECTS

A. <u>Design Standards</u> (As Revised)

1. <u>Geometric, Hydraulic and Structural</u>

   a. Basic design criteria, including considerations for highway safety, for projects developed under the SRP shall generally be in accordance with applicable portions (Part III, Sections 101, 102, 103, and 104, for resurfacing, restoration, and rehabilitation (R-R-R) projects, and Part IV for new location and major reconstruction projects), of the SDHPT Highway Design Division Operations and Procedures Manual.

b. Hydraulic design shall be in accordance with the applicable sections of the SDHPT Hydraulic Manual.

c. Bridges and culverts shall be designed for HS 20 loading in accordance with Standard Specifications for Highway Bridges by the American Association of State Highway and Transportation Officials.

2. Noise

Noise quality standards for projects under the SRP will be in accordance with the SDHPT publication entitled "Noise Guidelines" dated January, 1985 and future modifications thereto as may be required.

3. Air

Air quality standards for projects under the SRP will be in accordance with the February, 1985 edition of the SDHPT publication entitled "Air Quality Guidelines" and future modifications thereto as may be required.

4. Traffic Control Devices

Standards for traffic control devices for projects under the SRP will be in accordance with "The Texas Manual on Uniform Traffic Control Devices for Streets and Highways".

B. Construction Standards (As Revised)

1. Standard plan sheets as developed by the SDHPT will be used on projects under the SRP.

2. Standard Specifications. Projects under the SRP will utilize the SDHPT "Standard Specifications for Construction of Highways, Streets and Bridges" with Special Provisions and Special Specifications as required to comply with Federal and State laws and assure control of procedures and materials utilized in construction.

3. Construction. Construction procedures for SRP projects shall be in accordance with the SDHPT Construction Manual and pertinent construction bulletins.

4. Testing of Materials. Testing of materials for SRP projects shall be in accordance with the SDHPT Manual of Testing Procedures.

6-105 LOCAL GOVERNMENT KNOWLEDGE OF AND COMPLIANCE WITH STATE AND FEDERAL REQUIREMENTS ON PLAN PROJECTS

Local government involvement requiring knowledge and compliance with State and Federal requirements in projects developed under the SRP will be limited. In such cases, the SDHPT Commission tenders to the local governmental agency or agencies involved a Minute Order establishing responsibility for the various aspects of the project. Acceptance of such tender minutes by the local governmental agency by resolution in writing establishes a contractural agreement. The Department notifies the local governmental agency of State and Federal requirements and/or regulations governing their portion of the project and obtains a certification from the agency involved that all such requirements or regulations have been satisfied prior to advertising for the receipt of bids.

Right of way for SRP projects will be acquired in accordance with applicable procedures provided in the SDHPT Right of Way Manual. The Manual is available and is furnished upon request to local governments when they are the acquiring agency.

6-106 APPROVAL OF PLAN

Recommended for Approval:

M. G. Goode 1-2-86

M. G. Goode Date
Engineer-Director
State Department of Highways
and Public Transportation

Approved:

John Hocmaday 1-2-86

Federal Highway Administration Date

APPENDICES A-H

HIGHWAY DESIGN DIVISION OPERATIONS AND PROCEDURES MANUAL

APPENDICES

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ILLUMINATION (B-100)

B-101 GENERAL INFORMATION

This Manual is designed to benefit individuals in the Field who are responsible for the design, construction and inspection of roadway lighting projects.

B-102 HIGHWAY LIGHTING TERMS

Continuous Lighting - Roadway illumination assemblies installed to provide a minimum initial intensity of 0.4 horizontal footcandles on all main lanes and direct connections, and complete interchange lighting of all interchanges within the project.

Safety Lighting - Highway lighting systems installed at urban, suburban or rural interchanges, highway intersections and points of nighttime hazard to the extent necessary to provide for the safe and orderly movement of nighttime traffic.

Complete Interchange Lighting - The lighting of the main lanes, acceleration and deceleration lanes, all ramp terminals and the crossroad between the outermost ramp terminals. A minimum initial intensity of 0.4 horizontal footcandles should be provided on all main lanes and direct connections within the interchange.

Partial Interchange Lighting - The lighting of acceleration and deceleration lanes, ramp terminals, crossroads at ramp or frontage road intersections, understructure lighting and other areas of nighttime hazard. Lighting of curbed lane dividers is particularly important.

Conventional Lighting - A highway lighting system in which the luminaires are mounted no higher than 50 feet.

High Mast Lighting - Lighting units mounted at heights of 100 feet or more.

Luminaire - A device which directs, controls and modifies the light produced by a lamp. It consists of a light source, reflector, refractor, housing and such support as may be integral with the housing.

Floodlights - Luminaires which are generally employed for spot or wide-area lighting.

Lamp - A light source.

Lumen - Unit quantity of light output.

Footcandle - Luminous intensity of one lumen per square foot.

Photometric Data - Derived from metered measurements of horizontal or vertical footcandles. These metered measurements are obtained by the use of a light meter usually calibrated in footcandles.

Iso-Footcandle Curves - Curves plotted from metered photometric readings for a specific lighting unit, of a particular design and rated wattage, when the unit is mounted at a certain height. These readings are taken on a rectangular grid which is oriented from the center of the light source. From such readings, contour lines are then plotted for identical values in footcandles; and when contours are plotted for equal increments of increase in illumination intensity, the resulting contour lines produce a series of generally concentric semiparabolic curves which are described as iso-footcandle curves. Iso-footcandle curves for the 400-watt and 250-watt HPS roadway luminaires are available from File D-8.

The iso-footcandle curves are indispensable in the location and spacing of lighting units on the layout or plan for a lighting installation.

Uniformity - Uniformity of illumination is the ratio of the average level of illumination to the minimum level of illumination on the roadway.

Mounting Height - Generally the vertical distance between the base of the pole and the luminaire.

Spacing - The distance in feet between successive lighting units measured along the center line of the roadway.

Roadway Illumination Assembly - The luminaire and supporting members (pole, bracket, etc.) with other related lighting equipment attached thereto.

Pole or Lighting Standard - A galvanized steel or aluminum shaft to support the lighting unit.

Mast Arm - An attachment to a lighting pole on the end of which a luminaire is mounted.

Upsweep of a Mast Arm - The difference in elevation between the top of the pole and the outer end of the mast arm.

Regulated Output Ballast - A form of an electrical transformer by which the wattage to the lamp is maintained at a nearly constant value though the line voltage may fluctuate as much as ± 10%. Such ballasts or transformers may be integrally mounted within the luminaire or separately mounted in a ballast enclosure.

Conductor - Electrical wire, bare or insulated.

Transformer Base - A hollow cast aluminum base, the bottom of which is bolted to a concrete foundation and to the top of which the bottom flange of the pole is bolted.

Breakaway Support - A lighting pole designed to shear easily under vehicular impact. The breakaway feature can be an aluminum transformer base, a frangible insert between pole base and foundation, a slip base or other device. The breakaway support must meet current AASHTO and FHWA requirements.

Roadway Illumination Plan Symbols - (See Figure B-3)

B-103 HIGHWAY LIGHTING

A. Construction and Maintenance Responsibility of Highway Lighting Systems

1. Continuous Lighting: Requires a partnership between the State and a municipality.

2. Safety Lighting: State is responsible for all installation, operation and maintenance expense.

B. Types of Highways on Which State Funds May be Spent for Continuous and Safety Lighting

1. Continous Lighting

   a. Freeways which are multilane divided facilities for which full control of access is provided.

   b. Expressways which are defined as multilane highways with partial control of access where access is provided to abutting property; where at-grade crossings are provided at minor streets and roads; and where grade separation structures are provided at the minor crossings of arterial highways, streets and roads.

   c. Certain city streets with a high incidence of nighttime accidents and which are part of the State Highway System.

2. Safety Lighting

   Any designated highway or marked highway route.

C. Highway Lighting Systems Which May be Installed and Financed by Other Governmental Agencies

Local governments, upon approval by the State Department of Highways and Public Transportation, may finance, install and operate lighting systems on those portions of designated and/or marked highway routes in cities and towns where such funds are not available for Departmental financial participation in the cost of such lighting systems. It is the policy of the State Department of Highways and Public Transportation to cooperate with local governments in the consideration of such lighting systems and to prescribe that the design and installation of the systems be in accordance with desirable traffic safety provisions. Personnel of the State Department of Highways and Public Transportation will be permitted to assist and advise in the development of planning and design of such systems when requested to do so by a local governmental agency.

D. Lighting Agreements

There must be an agreement executed between the municipality and the State Department of Highways and Public Transportation covering all lighting projects within the corporate limits of a city or town when State financing is involved. This agreement must be executed before the project may be let to contract and sets out the responsibilities of each party for the construction, maintenance and operation of the lighting system.

For those projects in rural areas where a utility company will perform the maintenance and operation, the agreement will be executed with the utility company. If only electric energy is to be purchased from the utility company, only an agreement on a rate schedule is required. The agreement can be in the form of a letter from the utility company describing the rate schedule and other terms of the agreement (e.g., points of service, voltage, etc.). A copy of the rate schedule should be attached to the letter agreement.

1. Continuous Lighting Systems

a. 50-50 Agreement

The 50-50 agreement provides that the State Department of Highways and Public Transportation and the local government will each share one-half of the cost of the installation, operation and maintenance of a continuous highway lighting system. Under the terms of this agreement, the State Department of Highways and Public Transportation will assume all cost of preliminary engineering incident to the preparation of plans and the contracting of same.

b. 100 Percent Agreement

The State Department of Highways and Public Transportation will assume the total cost of designing and installing continuous lighting systems on those urban highways which are eligible under terms of State Policy, provided the local government will agree to assume all cost of the subsequent operation and maintenance of such a system in accordance with the established terms of a lighting agreement between the State Department of Highways and Public Transportation and the local governmental agency.

2. Safety Lighting Systems

a. The State Department of Highways and Public Transportation will bear the cost of installation, operation and maintenance of safety lighting at interchanges, highway intersections and points of nighttime hazard in both urban and rural areas as the traffic needs may dictate.

b. In those instances where safety lighting systems have been installed by the State Department of Highways and Public Transportation at its expense and such systems are later incorporated within the limits of a continuously-lighted urban freeway or expressway, the cost of operation and maintenance of the safety lighting system shall be shared by the State Department of Highways and Public Transportation and the local government on the same basis as the cost of operation and maintenance of the continuously lighted section is shared.

B-104 HIGHWAY LIGHTING DESIGN PRACTICES

A. Specifications for Highway Lighting

Current highway lighting specifications for the State Department of Highways and Public Transportation are reflected in the *Standard Specifications for Construction of Highways, Streets and Bridges,* and the Roadway Illumination and High Mast Illumination Detail standard sheets which are available from File D-8. The specifications on these sheets reflect the various hardware components of a lighting assembly, together with the photometric and testing requirements of the lighting units and related equipment.

B. Design Criteria for Highway Lighting

1. Recommended Designs for Conventional Lighting Systems

Conventional lighting systems are those in which mounting heights of 50 feet or less are utilized. This description is employed in order to differentiate between the categories of conventional mounting heights and those of 100 feet to 150 feet employed in high mast lighting.

a. Continuous Lighting Systems.

House side lighting and median lighting sketches (Figure B-1 and Figure B-2) illustrate the recommended lighting designs for various roadway sections. The system should be so designed that a minimum initial intensity of 0.4 horizontal footcandle is provided on all main lanes and direct connections.

b. Safety (Partial Interchange) Lighting.

The 250-watt high pressure sodium luminaire at 40-feet MH is recommended for safety lighting.

2. High Mast Lighting

a. Multiple luminaires may be mounted on a pole at a height of 100 feet or greater to effectively light interchange areas and may be utilized in conjunction with a conventional lighting system on the roadway approaches to an interchange. This will permit a driving decision to be made well in advance of the need to execute a driving maneuver, thus contributing to greater safety, comfort and convenience of the driver.

b. Floodlights with aiming capabilities have proven very satisfactory in providing the necessary flexibility and adjustment to fit the irregular geometrics of complex interchanges.

c. High mast lighting provides a panoramic view of the roadway geometrics; thus, a lower minimum design level of illumination is acceptable. The system should be so designed that a minimum initial intensity of 0.3 horizontal footcandle is provided on all main lanes and direct connections.

d. The utilization of high mast lighting is warranted when the needs of the traveling public will be better served through its use than by a conventional illumination system.

3. Safety Lighting

Safety lighting design is based on providing a sufficient number of lighting units to best light the through lanes and speed change lanes at diverging and merging locations, and other points of conflict.

C. Electrical Circuit Design

1. Specifications require HPS ballast to operate satisfactorily at line voltage fluctuations of ± 10 percent of nominal line voltage. Good design practice requires electrical conductor sized to provide no more than approximately 8 percent volt drop to any luminaire on the circuit (38 to 40 volts at a line voltage of 480 volts). Following are recommended design amperes for various luminaires at differing line voltages:

Lamp Watts \ Line Voltage	120 v.	240 v.	480 v.
150	1.8	0.9	0.45
250	3.0	1.5	0.75
400	4.8	2.4	1.2
1000	12.0	6.0	3.0

2. For voltage drop calculations, it is recommended that the resistance of copper conductors at 25 °C (77 °F) be used for buried conductors and resistance at 40 °C (104 °F) be used for conductors installed in conduit above grade (conduit on structures, etc.). Resistance tables are available from the Design Section of Highway Design Division.

D. Economic Considerations in Lighting Design

1. The high pressure sodium vapor lamp is at present the most efficient widely-available light source for roadway lighting. For new construction, the recommendations of

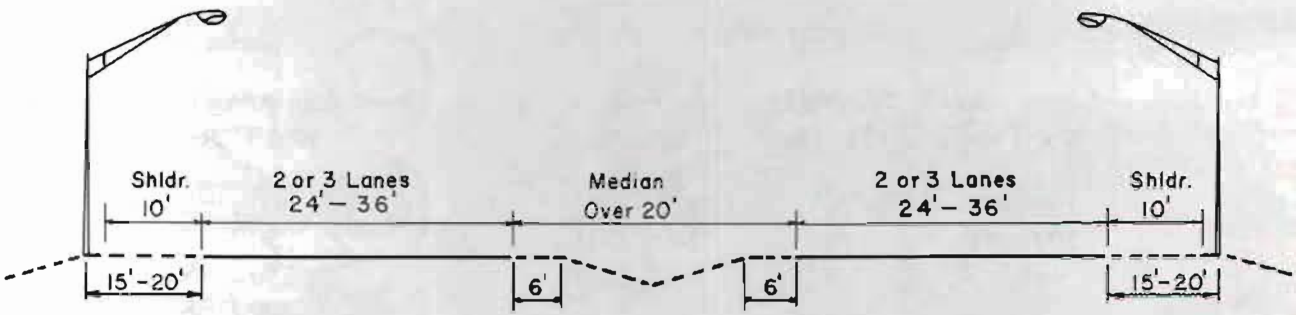
paragraph B-104B1 should be followed. For replacement to conserve energy and reduce operating costs, the following is recommended:

Existing Lighting			Replace with	
Lamp Watts and Type	Mounting Height	Pole Spacing	Lamp Watts and Type	Annual KWH Saved
1000 MV	50′	270′-300′	400 HPS	2356
1000 MV	50′	240′-270′	250 HPS	3084
400 MV	40′	200′-240′	250 HPS	612
			or 200 HPS	812
250 MV	15 ±	U/P	150 HPS	404
			or 100 HPS	648

2. Mast Arm Length. A roadway luminaire meeting State Department of Highways and Public Transportation specification has a light distribution pattern such that the maximum beam candlepower strikes the pavement at a point 18 feet beyond the point directly under the luminaire when mounted 50 feet above the pavement in a level position. Additional lateral coverage may be obtained by tilting the luminaire (an adjustment of 5° - 8° is provided by the slipfitter attachment). In the interest of economy in pole and mast arm costs, it is recommended that 8-foot mast arms be specified.

HOUSE SIDE LIGHTING

DESIGN 1-A

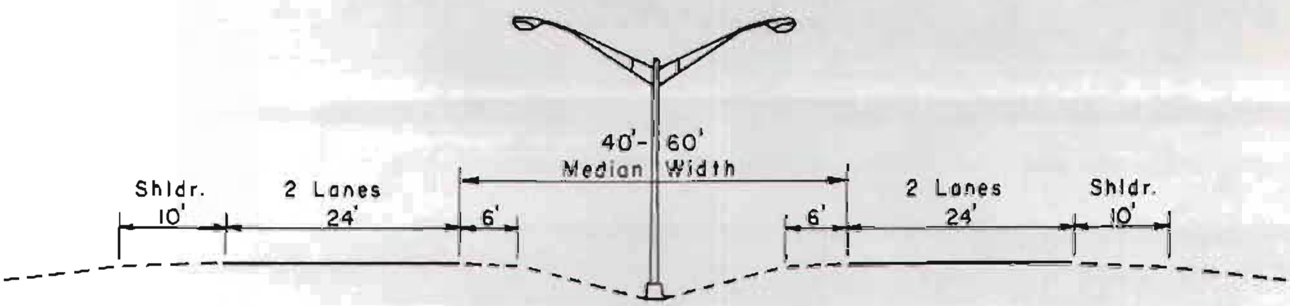


250 Watt High Pressure Sodium
Luminaire - Mounting Height 40' — 240' Spacing
on each side

Poles should be located as far from the shoulder edge as practicable. Generally, 2' should be considered as minimum. Optimum light distribution is obtained when the luminaire is aligned from 5' to 10' outside of lane edge.

MEDIAN LIGHTING

DESIGN 2-A



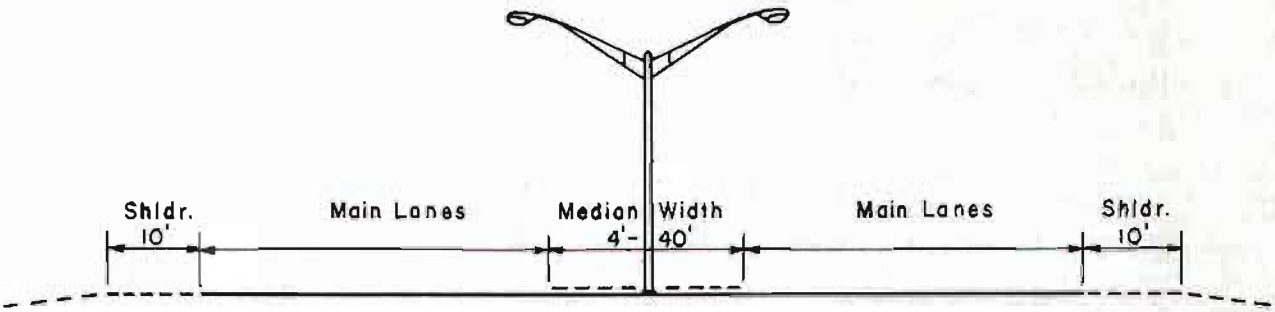
Dual-mounted 250 Watt High Pressure Sodium Luminaires - Mounting Height 40' - 240' Spacing. Where Median Width Exceeds 60' it May Be Necessary To Treat Each Main Lane As A Separate Roadway and Place Poles on House-Side (See Design 1-A).

FIGURE B-1 Refers to Paragraph B-104(B-1)

MEDIAN LIGHTING (Cont.)

DESIGN 2-B

DOUBLE FLEXBEAM MEDIAN BARRIER



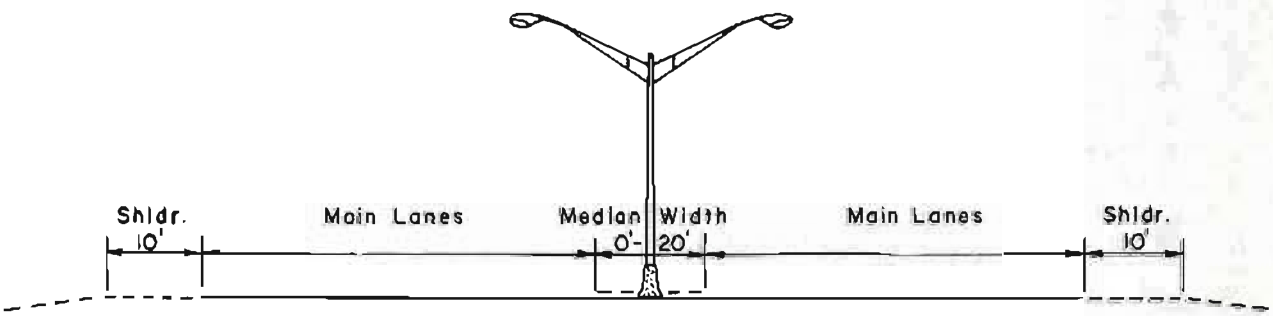
Poles Must Be Protected by Median Barrier.

For 2 or 3 Lanes Each Way, use 250 Watt High Pressure Sodium at 40' MH, Spaced 240'

For 4 or 5 Lanes Each Way, use 400 Watt High Pressure Sodium at 50' MH, Spaced 300'

DESIGN 2-C

CONCRETE MEDIAN BARRIER



Poles mounted on Concrete Median Barrier.

For 2 or 3 Lanes Each Way, use 250 Watt High Pressure Sodium at 40' MH, Spaced 240'

For 4 or 5 Lanes Each Way, use 400 Watt High Pressure Sodium at 50' MH, Spaced 300'.

The 150 Watt High Pressure Sodium Wall Mounted Luminaire is Recommended for Underpass Lighting.

FIGURE B-2 Refers to Paragraph B-104(B-1)

STANDARD ROADWAY ILLUMINATION PLAN SYMBOLS

X	Mast Arm Length - 8' Recommended Length
M	Mercury Vapor
S	Sodium Vapor
■—●	50T-X-1KWM or .4KWS
●—●	50S-X-1KWM or .4KWS
●—■—●	50T-X-X-1KWM or .4KWS
●—●—●	50S-X-X-1KWM or .4KWS
□—○	40T-X-4 KWM or .25 KWS
○—○	40S-X-.4KWM or .25KWS
○—□—○	40T-X-X-.4KWM or .25KWS
○—○—○	40S-X-X-.4KWM or .25KWS
◉	High Mast Pole – 150'
▲	Underpass Luminaire
⬡	Service Pole, Circuit Protector or Transformer Station
■	Ground Box, Below Grade
⊠	Junction Box, above grade
— 8/2 —	Duct Cable - size and number of conductors
— 2–8 / 1"c. —	THW Conductor in conduit
═ ═ ═ 50-2"RMC	Duct Cable under roadway

T - Pole with Breakaway Base

S - Shoe Base Pole

FIGURE B-3 Refers to Paragraph B-102

APPENDIX C-100

ATTENUATION SYSTEM DESIGN GUIDELINES (C-100)

C-101 THE ROADSIDE DESIGN PROBLEM

Accident records indicate that the single vehicle collision with a fixed object is the most frequent cause of injuries and fatalities. Texas accident statistics show that 35% of statewide accidents involve single vehicles striking fixed objects or running off the roadway. Several concepts have been proposed in an effort to reduce this toll. Automobiles, for example, are becoming safer and roadsides are being improved by removing or relocating at a safer distance fixed objects which previously had been located at or near the roadway edge. Objects which cannot be removed or relocated are generally made break-away, encompassed by guardrail, or cushioned by an attenuation device.

Specialized problem areas such as the gores of exit ramps on structures are recognized hazards and generally cannot be handled by techniques other than attenuation. Other problem locations may include a slope or obstacles in the gore area, bridge piers in medians and adjacent to the traveled way, overhead sign supports, and the space between twin structures. Removing or relocating such hazards is often impractical and therefore a feasible alternative is to protect motorists from these hazards with attenuation devices.

The basic purpose of an attenuation device is the dissipation of kinetic energy of the impacting vehicle over enough distance to result in an acceptable deceleration rate. The following are among the several types of attenuation systems in various stages of development:

1. Steel Drum Barrier (Texas Crash Cushion)
2. Sand-Tire Vehicular Impact Attenuator
3. Sand-Filled Plastic Barrels
4. Hi-dri and Hi-dro Cushion Cells
5. Dragnet System

C-102 DESIGN OF THE TEXAS CRASH CUSHION

The Texas Crash Cushion was developed through the cooperative research of the Federal Highway Administration, Texas Transportation Institute, and State Department of Highways and Public Transportation. Utilized in the system are 55-gallon steel drums arranged in rows to control the deceleration of an impacting vehicle. The barrels are welded, bolted or clipped together, top and bottom, to form a cohesive system. Steel cables are incorporated into the system for the purpose of providing lateral stability. The assembly is raised to the optimum height for cushioning vehicles thereby reducing friction at ground level. Redirectional panels may be incorporated into the system design to provide fendering capabilities where site conditions indicate their need.

Experience with the Texas Crash Cushion under controlled testing and in actual field installations has provided a basis for the establishment of design criteria. The size and shape of the system is primarily dependent on three design inputs: vehicle weight, speed and tolerable average g-forces.

In the design of an attenuator system, although the minimum required depth of the system is a fixed distance for a given speed, the energy absorbing capacity (i.e., number of barrels) is related directly to the weight of the vehicle to be attenuated.

Since most passenger cars and some trucks fall within the 2,000- to 4,500-pound range, the procedure presented will result in an attenuation system design capable of restraining a vehicle weighing up to 4,500 pounds. Furthermore, successful attenuation requires tolerable g-forces on the vehicle's occupants. The field of biomechanics is not an exact science and an immense amount of progress is yet to be achieved in order to more fully understand human impact tolerability and insure safety.

In 1961 the Cornell Aeronautical Laboratory suggested tolerable average limits of deceleration as shown in Table 1:

Table 1 - Suggested Tolerable Deceleration Limits

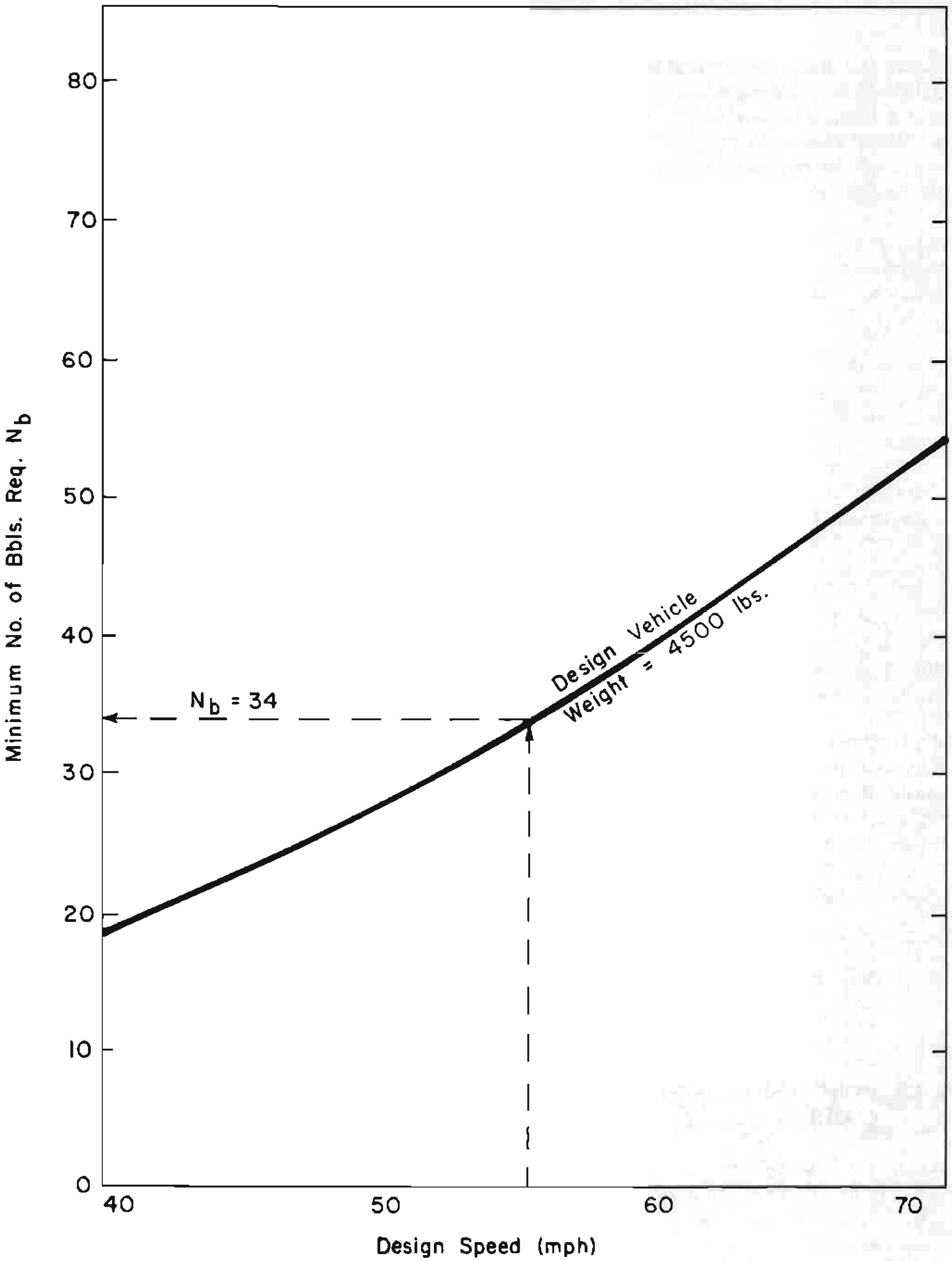
	Average Deceleration (g's)		
Occupant Restraint	Lateral	Longitudinal	Total
Unrestrained	3	5	6
Lap Belt	5	10	12
Lap Belt & Shoulder Harness	15	25	25

Although minimum levels of deceleration are desirable, frequently they can be achieved only at the expense of vehicle maneuvering room. In actual impact experience with attenuators in over 200 in-service impacts, optimum design in terms of overall safety to the motorist can be achieved by a system which is capable of attenuating a 2000-pound vehicle at a speed of 55 mph with approximately 10 g's (i.e., the suggested tolerable g-force level for occupants restrained by seat belts only).

Design Example:

An impact attenuator which will provide an acceptable deceleration level for a 4,500-pound vehicle traveling at 55 mph must be placed at an elevated gore. Fifty-five-gallon steel drums are available for the construction of a Texas Crash Cushion. The problem is to determine the arrangement of barrels that will fulfill these design criteria.

Enter Figure C-1 with the predetermined design speed (55 mph) and design vehicular weight (4,500 pounds) and determine the minimum number of barrels required (N_b = 34) to absorb the vehicle kinetic energy.



Minimum No. of Bbls. Req. N_b
80
70
60
50
40
30
20
10
0
N_b = 34
Design Vehicle
Weight = 4500 lbs.
40
50
60
70
Design Speed (mph)

FIGURE C-1

Figure C-2 illustrates a typical attenuator design. Tolerable g-forces at 55 mph for both heavy and light vehicles require a design which incorporates two barrels in the lead row, 7 rows of 3 barrels, and 3 rows of 4 barrels. Thirty-five barrels are used to produce a symmetrical design. When additional capacity is required, 4-barrel rows may be added to the attenuator rear to achieve the number of barrels determined from Figure C-1. At least one-half barrel should be located outside of the buttress corner but should not infringe on the shoulder area.

Also, it is desirable to construct rigid barriers, such as parapet walls, at a taper rate of 10:1 with the adjacent roadway as shown on Figure C-2. Where roadway geometrics require attenuators with additional redirectional capability (i.e., short radius curves with possible high angles of fixed object impact), the use of plywood redirectional panels should be considered.

Usually there are a number of different designs that will perform satisfactorily, but often a particular design may be much more economical and less complicated to fabricate, install, and maintain. Since attenuators will be installed at hazardous locations, impacts and system repair or replacement are expected.

The modular arrangement of barrels in the Type "R" design allows for a more standardized unit construction. Units may be prefabricated at the maintenance shop, hauled to the field, and placed with medium-weight equipment. The remaining hardware may be installed quickly and easily within non-peak traffic hours.

The Type "T" design is slightly more costly to fabricate and maintain when compared to the Type "R" design; however, often less site modification may be required if the Type "T" arrangement is utilized. Good engineering judgment must be exercised by the designer to determine the best shape of the attenuator system for each design problem.

Replacement should be relatively easy after the Texas Crash Cushion has been struck by a vehicle. In most cases the system will be partially salvageable and one only needs to replace the damaged section of the attenuator with a prefabricated section from the maintenance yard. It may prove feasible to replace the entire system with a spare system which could be stored in the maintenance yard. The system which was struck could then be removed to the maintenance yard and repaired by maintenance personnel if elements of it are reusable. To facilitate maintenance, components should be stocked in the maintenance shop. The major components are listed below:

1. Barrels (55-gallon steel drums)
2. Chair Supports
3. Barrel Connectors (welds, bolts, or clips)
4. Steel Cables and Clips
5. Cable Anchorage Components (nose and rear of attenuator)

C-103 CONCLUSIONS AND RECOMMENDATIONS CONCERNING THE TEXAS CRASH CUSHION

As the result of research and development of the Texas Crash Cushion, the following general conclusions and recommendations can be made:

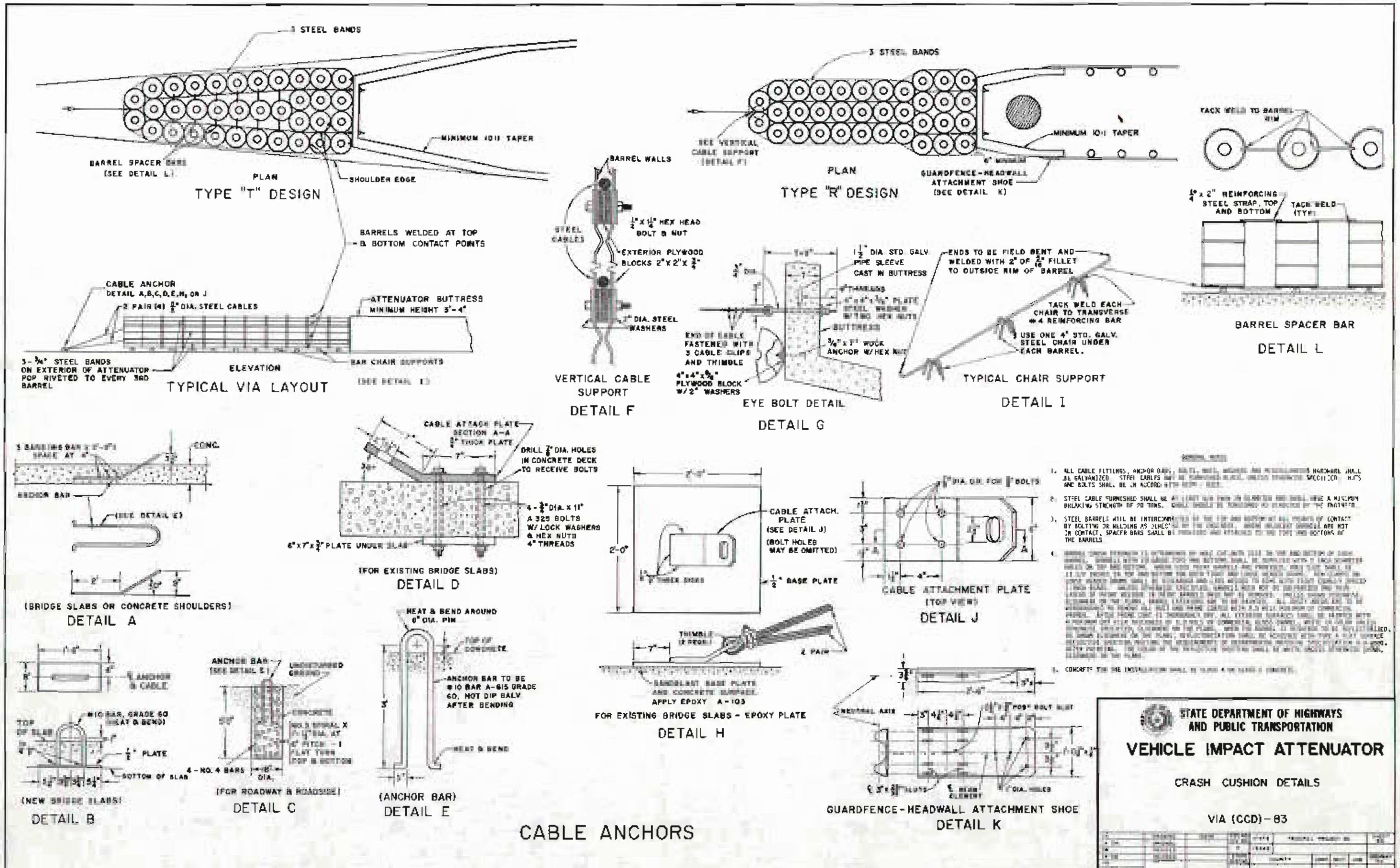

3 STEEL BANDS
MINIMUM 10:1 TAPER
BARREL SPACER BARS (SEE DETAIL L)
PLAN
SHOULDER EDGE
TYPE "T" DESIGN
BARRELS WELDED AT TOP & BOTTOM CONTACT POINTS
CABLE ANCHOR DETAIL A,B,C,D,E,H, OR J
2 PAIR (4) 3/4" DIA. STEEL CABLES
ATTENUATOR BUTTRESS MINIMUM HEIGHT 3'-4"
3-3/4" STEEL BANDS ON EXTERIOR OF ATTENUATOR POP RIVETED TO EVERY 3RD BARREL
ELEVATION
BAR CHAIR SUPPORTS (SEE DETAIL I)
TYPICAL VIA LAYOUT
BARREL WALLS
STEEL CABLES
1/2" x 1 1/4" HEX HEAD BOLT & NUT
EXTERIOR PLYWOOD BLOCKS 2" x 2" x 3/4"
1/2" DIA. STEEL WASHERS
VERTICAL CABLE SUPPORT
DETAIL F
3 STEEL BANDS
SEE VERTICAL CABLE SUPPORT (DETAIL F)
PLAN
MINIMUM 10:1 TAPER
6" MINIMUM
GUARDFENCE-HEADWALL ATTACHMENT SHOE (SEE DETAIL K)
TYPE "R" DESIGN
1 1/2" DIA. STD. GALV. PIPE SLEEVE CAST IN BUTTRESS
BUTTRESS
END OF CABLE FASTENED WITH 3 CABLE CLIPS AND THIMBLE
4"x4"x5/8" PLYWOOD BLOCK W/2" WASHERS
3/4" x 7" HOOK ANCHOR W/HEX NUT
EYE BOLT DETAIL
DETAIL G
ENDS TO BE FIELD BENT AND WELDED WITH 2" OF 3/16" FILLET TO OUTSIDE RIM OF BARREL
TACK WELD EACH CHAIR TO TRANSVERSE #4 REINFORCING BAR
USE ONE 4" STD. GALV. STEEL CHAIR UNDER EACH BARREL.
TYPICAL CHAIR SUPPORT
DETAIL I
TACK WELD TO BARREL RIM
1/4" x 2" REINFORCING STEEL STRAP, TOP AND BOTTOM
TACK WELD (TYP)
BARREL SPACER BAR
DETAIL L
CONC.
ANCHOR BAR
(SEE DETAIL E)
(BRIDGE SLABS OR CONCRETE SHOULDERS)
DETAIL A
CABLE ATTACH PLATE SECTION A-A 3/4" THICK PLATE
DRILL 7/8" DIA. HOLES IN CONCRETE DECK TO RECEIVE BOLTS
4-3/4" DIA. x 11" A 325 BOLTS W/ LOCK WASHERS & HEX NUTS 4" THREADS
6"x7"x3/4" PLATE UNDER SLAB
(FOR EXISTING BRIDGE SLABS)
DETAIL D
CABLE ATTACH. PLATE (SEE DETAIL J)
(BOLT HOLES MAY BE OMITTED)
1/2" BASE PLATE
2'-0"
THIMBLE (2 REQD)
2 PAIR
SANDBLAST BASE PLATE AND CONCRETE SURFACE. APPLY EPOXY A-103
FOR EXISTING BRIDGE SLABS - EPOXY PLATE
DETAIL H
CABLE ATTACHMENT PLATE (TOP VIEW)
DETAIL J
GENERAL NOTES
5. CONCRETE FOR THE INSTALLATION SHALL BE CLASS A OR CLASS C CONCRETE.
ANCHOR & CABLE
TOP OF SLAB
#10 BAR, GRADE 60 (HEAT & BEND)
1/2" PLATE
BOTTOM OF SLAB
(NEW BRIDGE SLABS)
DETAIL B
ANCHOR BAR (SEE DETAIL E)
UNDISTURBED GROUND
CONCRETE
4-NO. 4 BARS
(FOR ROADWAY & ROADSIDE)
DETAIL C
HEAT & BEND AROUND 6" DIA. PIN
TOP OF CONCRETE
ANCHOR BAR TO BE #10 BAR A-615 GRADE 60, HOT DIP GALV. AFTER BENDING
HEAT & BEND
(ANCHOR BAR)
DETAIL E
CABLE ANCHORS
NEUTRAL AXIS
POST BOLT SLOT
GUARDFENCE-HEADWALL ATTACHMENT SHOE
DETAIL K
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
VEHICLE IMPACT ATTENUATOR
CRASH CUSHION DETAILS
VIA (CCD)-83

FIGURE C-2

1. The Texas Crash Cushion is an effective attenuation device for both head-on and angular collisons. It must be realized, however, that the barrel cushion is not a substitute for prudent roadside design, but should be utilized as an interim measure until fixed objects can be removed or relocated to a safer position or should be used as a permanent design feature where removing, relocating, or protecting by other methods is impossible or impractical.

2. Future facilities should be designed free of fixed objects located near the roadway. Where this is impossible or impractical, the highway should be designed so that hazardous areas are receptive to protection by the Texas Crash Cushion.

3. Tentative, approximate locations for attenuators should be noted on the project schematic and bridge layouts where applicable. Barrel layouts, design details, specifications, etc., need not be submitted until the PS&E stage of project development.

4. Maintenance costs are minimal and repair costs are reasonable.

5. Appearance is unobtrusive.

6. If a particular cushion is impacted frequently, additional safety treatments such as providing illumination, additional pavement marking or other delineation, enlarging the maneuver area, improving sight distance, etc., should be considered by the Engineer.

These design methods generally render minimum values and should be considered by the designer as the lowest acceptable limits in design. As research findings permit, refinements to the attenuator design will be made. The barrel layouts shown are merely typical arrangements and are not intended to serve as a standard design and it is expected that the designer will utilize the highest design values commensurate with conditions.

C-104 DESIGN OF THE SAND-TIRE VEHICULAR ATTENUATOR

The Sand-Tire Vehicular Attenuator was developed to provide a low-cost attenuator to complement the steel barrel system so that additional hazard locations may be economically protected.

The sand-tire attenuator is an inertial system which employs Newton's second law of motion.

$$m_1V_1 = m_2V_2$$

In this case m_1 is the mass of the vehicle; V_1 is the velocity of the vehicle immediately prior to impact; m_2 is the combined mass of the vehicle and the attenuator module set in motion by the impact; and V_2 is the velocity of the vehicle and attenuator module after impact. Speed reduction of the vehicle per row of attenuator can be calculated from this equation.

Speed reductions are calculated until the vehicle is within a safe range of approximately ten miles per hour. Also, since occupant loadings upon collision are a very important indication of expected injury severity, g-forces are individually determined for each attenuator row. Design criteria upon which the sand-tire system is based is a 6-g average for a 2000- to 5000-pound vehicle impacting at 60 mph. This loading rate should provide tolerable decelerations to the unrestrained occupant without producing serious injury. Determination of the g-force encountered was computed from the following equations:

$$\text{Average Velocity} = \frac{V_1 + V_2}{2}$$

$$\Delta T = \frac{2.5'}{\text{Average Velocity}}$$

$$g's = \frac{V_2 - V_1}{(\Delta T) \quad (32.2)}$$

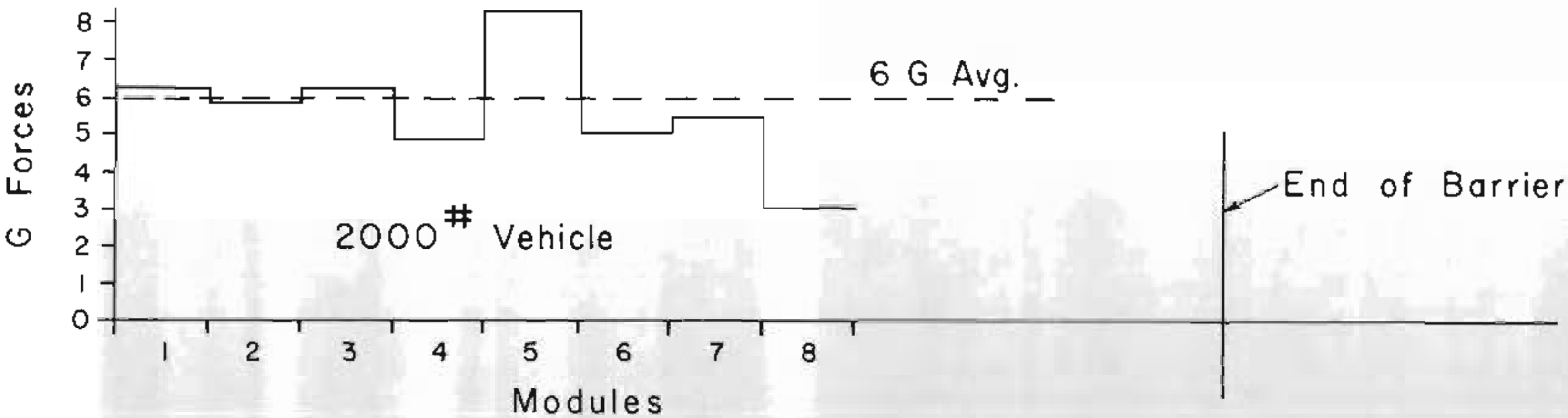
These computations are also continued until vehicle speed has decreased to ten miles per hour. Figure C-3 illustrates performance curves of the sand-tire attenuator for the 2000- and 5000-pound vehicle impacting the system at 60 mph. Deceleration levels are kept in the 6-g range through the use of lightweight front modules. As the heavier weight vehicles penetrate deeper into the system, deceleration remains at a safe level. Completely filled modules at the rear of the attenuator provide a backup for the system to insure containment of the vehicle and to reduce debris scatter. Attenuator buttresses are not needed with sand-tire systems.

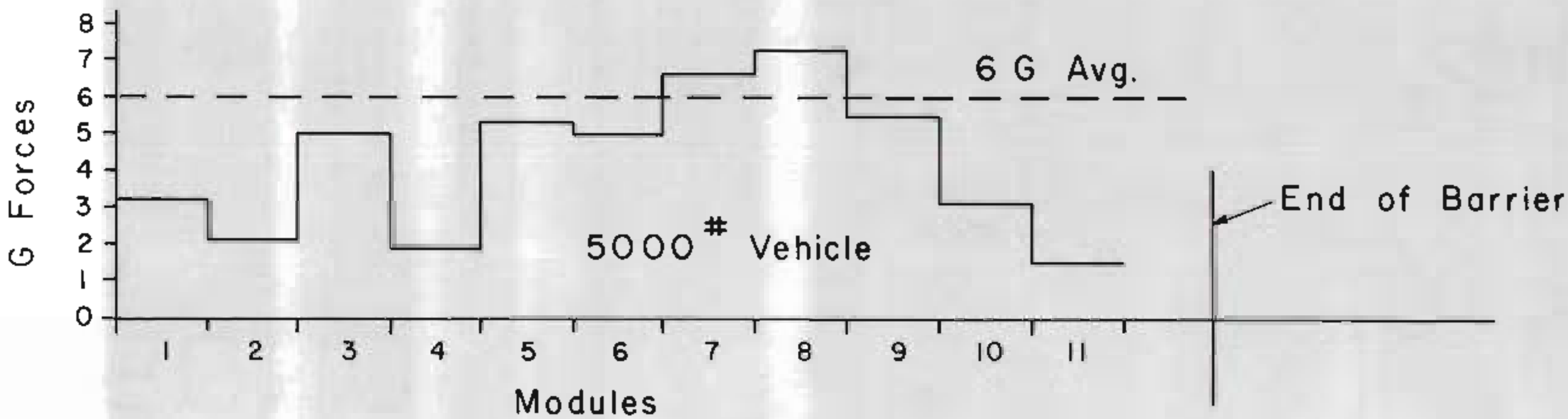
Figure C-4 illustrates details of the sand-tire attenuator which is designed to attenuate 2000- to 5000-pound vehicles impacting at 60 mph with 6 g's average deceleration.

Modules are constructed by loosely filling tire units with pit-run sand in the amounts indicated. When the modules are to be placed on unconsolidated surfaces which may cause support penetration and module instability, it is recommended that treated plywood disks be placed under the bases. Base design is critically important since, to reduce vehicle ramping, tire supports must fully and readily collapse upon vehicle impact. Two types of supports, the modified steel barrel and the wire-mesh support, have been tested and are equally satisfactory for this purpose.

Covering of the sand-tire unit is desirable to prevent moisture from saturating the sand. The material used should be durable, waterproof, present a neat appearance to the finished unit and clearly delineate the presence of a roadside hazard.

Several typical sand-tire installations are illustrated in Figure C-5. Where obstacles need treatment wider than can be accommodated through use of a single attenuator unit, multiples of the basic unit can be combined until the necessary width has been achieved.

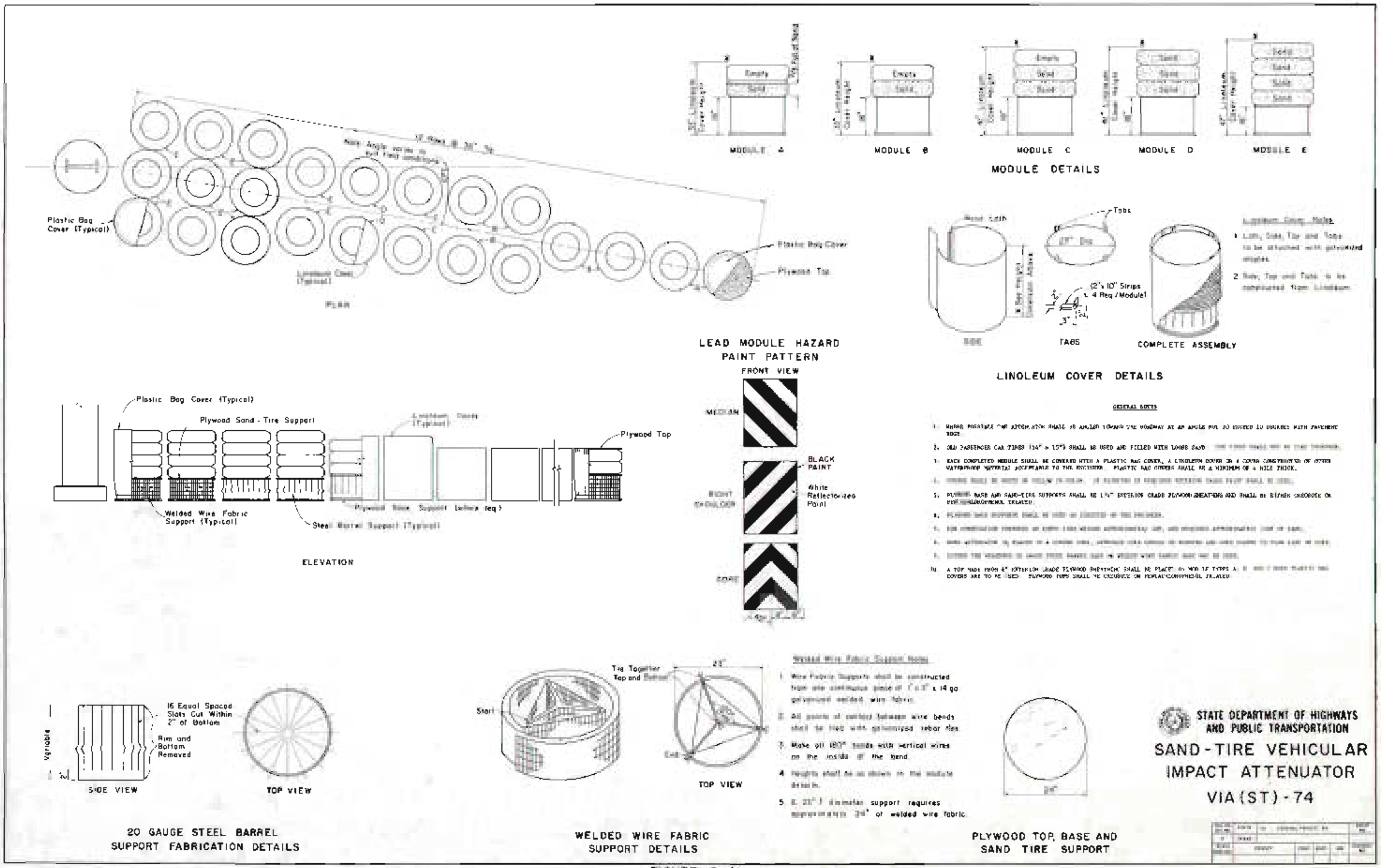




SAND - TIRE VEHICULAR IMPACT ATTENUATOR

AVERAGE COMPUTED G FORCES

FIGURE C-3



MODULE A
MODULE B
MODULE C
MODULE D
MODULE E
MODULE DETAILS
Plastic Bag Cover (Typical)
Plastic Bag Cover
Plywood Top
PLAN
LEAD MODULE HAZARD PAINT PATTERN
FRONT VIEW
MEDIAN
BLACK PAINT
White Reflectorized Paint
Tabs
TABS
(2"x 10" Strips 4 Req./Module)
COMPLETE ASSEMBLY
LINOLEUM COVER DETAILS
Plastic Bag Cover (Typical)
Plywood Sand - Tire Support
Plywood Top
Welded Wire Fabric Support (Typical)
ELEVATION
16 Equal Spaced Slots Cut Within 2" of Bottom
Rim and Bottom Removed
Variable
SIDE VIEW
TOP VIEW
20 GAUGE STEEL BARREL SUPPORT FABRICATION DETAILS
Tie Together Top and Bottom
Start
End
TOP VIEW
WELDED WIRE FABRIC SUPPORT DETAILS
PLYWOOD TOP, BASE AND SAND TIRE SUPPORT
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
SAND-TIRE VEHICULAR IMPACT ATTENUATOR
VIA (ST) - 74

FIGURE C-4

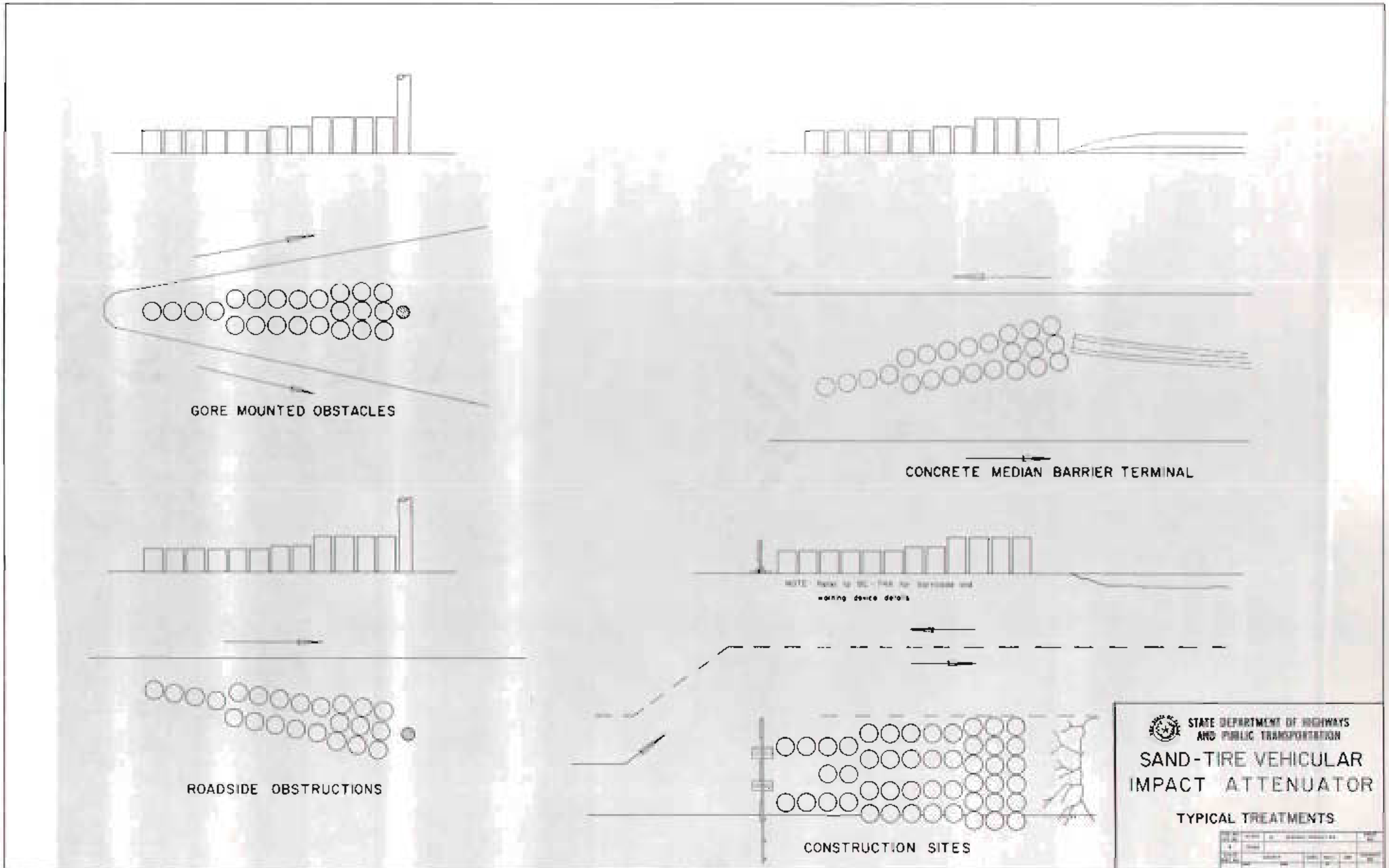

GORE MOUNTED OBSTACLES
CONCRETE MEDIAN BARRIER TERMINAL
ROADSIDE OBSTRUCTIONS
CONSTRUCTION SITES
STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
SAND-TIRE VEHICULAR
IMPACT ATTENUATOR
TYPICAL TREATMENTS

FIGURE C-5

C-105 CONCLUSIONS AND RECOMMENDATIONS CONCERNING THE SAND-TIRE ATTENUATOR

As in any attenuation system the sand-tire attenuator does possess certain limitations which should be fully understood. It is not recommended for the following situations where:

1. Its limited debris scatter can cause operational difficulties when placed in close proximity to the travelled way;

2. Vibration of bridge structures is apt to cause distress of the modules;

3. Redirectional capability is needed; or

4. Where a level cross slope is impractical.

The sand-tire attenuator is a low-cost, effective attenuation unit. Its low cost combined with simplicity of construction and readily available waste material should enable its adaptation to many locations not presently considered for attenuation units.

C-106 DESIGN OF THE SAND-FILLED PLASTIC BARRELS VEHICLE IMPACT ATTENUATOR (VIA)

The sand-filled plastic barrels VIA is an inertial system which includes free-standing, energy-dissipating modules. The individual containers are made of a highly frangible plastic material and are filled with known sand masses as desired. The concept is adaptable to almost any hazardous fixed object site since the free-standing units may be arranged into a variety of configurations.

Design of this inertial barrier at a given location is primarily dependent on expected impact speed, width of the object to be protected, and depth available to accommodate the attenuation system. Each installation should be designed to attenuate impacts at the expected speed with deceleration forces not exceeding 12 g's per row (see Figure C-6) and exit speed desirably 5 mph or less.

Sand-filled plastic barrel VIA's are typically designed in four basic lengths (15 ', 18 ', 21 ', and 24 '). Figure C-6 illustrates typical arrangements of the sand-filled modules to form a VIA system.

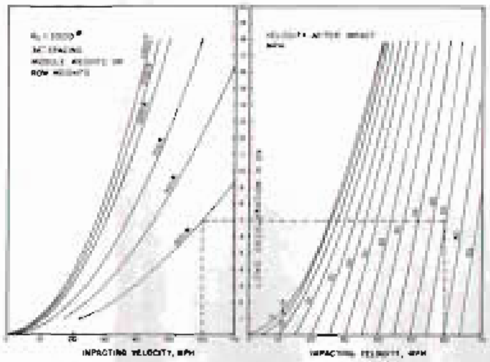
C-107 CONCLUSIONS AND RECOMMENDATIONS CONCERNING THE SAND-FILLED PLASTIC BARRELS VEHICLE IMPACT ATTENUATOR

The following general conclusions and recommendations may be made regarding the sand-filled plastic barrel VIA system.

1. The system is an effective attenuation device for head-on collisions. This system, however, does not include redirectional capability for side impacts.

2. Vibration of bridge structures may cause movement of the sand-filled modules. Other alternative VIA systems should be carefully considered for bridge structures; however, should the sand-filled plastic barrels be used, special design precautions should be taken to minimize module movement.

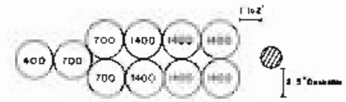
C-12



SAND - FILLED PLASTIC BARREL BARRIER
(36" Row Spacing - 2000 lb. Vehicle)

EXAMPLE PROBLEM

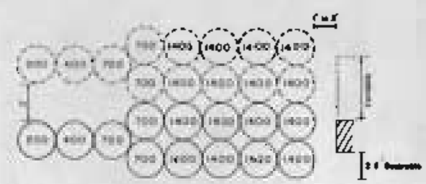
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible] ***
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



40 MPH DESIGN SPEED

50 MPH DESIGN SPEED

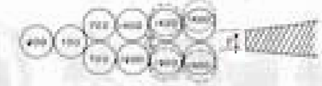
60 MPH DESIGN SPEED



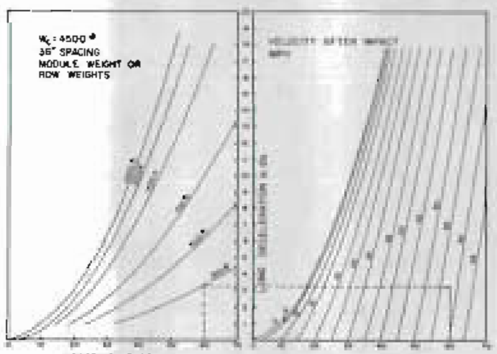
BARRIER ARRAY FOR FIXED OBJECT OF VARIABLE WIDTH

GENERAL NOTES

1. IF SPACE ALLOWS, A 1' TO 2' [illegible]
2. [illegible]
3. MODIFICATION OF ARRAYS: WHEN PROXIMITY OF TRAFFIC LANES EXCLUDE THE USE OF A WIDER BARRIER, THE FRONT OF THE BARRIER MAY RETAIN THE STANDARD WIDTH, BUT THE REAR CAN BE WIDENED BY STAGING AS SHOWN IN THIS DIAGRAM.



4. [illegible]
5. [illegible]
6. [illegible]
7. [illegible]
8. [illegible]



SAND - FILLED PLASTIC BARREL BARRIER
(36" Row Spacing - 4500 lb. Vehicle)

EXAMPLE PROBLEM

[illegible]	[illegible]	[illegible]	G_{avg} **	[illegible]
[illegible] *	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible] ***

* Design Speed
** In design, G's should be less than 12
*** Final Velocity should be a minimum 10 [illegible]

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

DESIGN GUIDELINES AND TYPICAL BARRIER ARRAYS

VIA(SFPB)

FIGURE C-6

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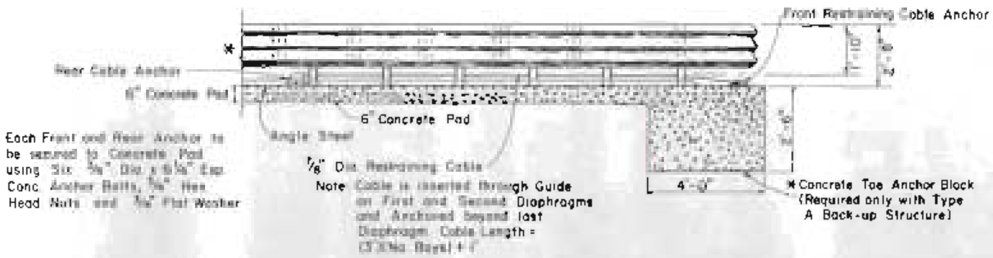


BACK-UP STRUCTURE INFORMATION

Type A — Tension Strut: Consists of [illegible] Struts, Connections, and Accessories, as [illegible] by the Manufacturer, located at rear of G.R.E.A.T. Unit. When used, [illegible] Reinforced Concrete Toe Anchor Block shall be provided beneath the front [illegible] G.R.E.A.T. Unit [illegible] Continuously Reinforced Concrete Pavement.

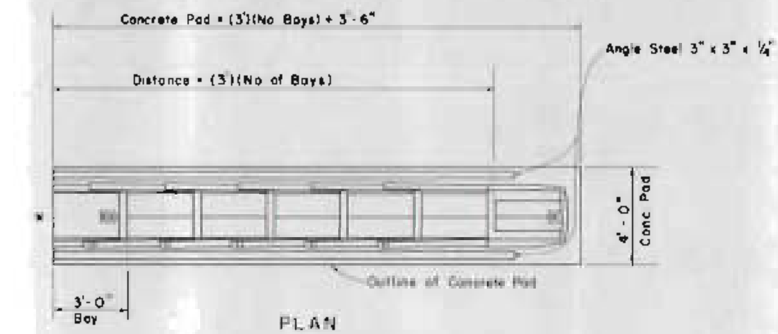
Type B — Cast-In-Place Concrete: Concrete Median Barriers, Bridge [illegible] Cast-In-Place [illegible] G.R.E.A.T. [illegible] and 2' - 0" [illegible] Precast Concrete Median Barrier [illegible] G.R.E.A.T. Unit.

Type C — Wide Flange Back-Up: Consists of [illegible] Steel Post [illegible] G.R.E.A.T. Unit. Posts are set in a Cast-In-Place, Reinforced Concrete Foundation which is [illegible] 2' - 0" x [illegible] Details for connections and accessories for the Wide Flange Back-Up [illegible]

Type D — [illegible] G.R.E.A.T. Unit. Anchorage provided by [illegible] Anchor Pins for placement on other than concrete.

Note: Type of Back-Up Structure for each location specified elsewhere in the Plans.

[illegible]



PLAN

* See Note for Back-up Structure Information

DESIGN SPEED (mph)	NO.* OF BAYS
40 or less	3
45	4
50	5
55	6
60	8
65	10

* Based on maximum deceleration force of 6 G's.

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GUARD RAIL ENERGY ABSORBING TERMINAL

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3. Debris scatter may result in a traffic hazard to lower roadways where used on elevated gores.

4. The system may be quickly restored if replacement materials are readily available.

The sand-filled plastic barrel barrier is a moderate-cost, effective vehicle impact attenuation unit. It is adaptable to most fixed object sites, and can be restored to service through simple and quick maintenance activities.

C-108 CELL SANDWICH ASSEMBLIES

For narrow hazards where available space for occupancy by a crash cushion is restricted, the Guard Rail Energy Absorbing Terminal (G.R.E.A.T.) may be used. This device is available in 2 '0", 2 '6", and 3 '0" widths and consists of vermiculite concrete cells mounted between diaphragms forming bays along the VIA longitudinal axis. The system requires a backup structure and provides redirection for side impacts. Figure C-8 shows design information and plan details for the G.R.E.A.T. system.

Cell sandwich assemblies consist of vermiculite concrete cartridges or water-filled cells forming bays which are "sandwiched" between diaphragms along the VIA longitudinal axis. Backup walls are required for all cell sandwich VIA assembly installations; available standard units require the backup wall to be 3 '0", 5 '2", or 7 '6" in width, and a usual 3 '3" in height. The system includes side panels which provide redirectional capability.

Figure C-9 shows typical features and design data for both types of cell sandwich units. Additional information such as design details, specifications, etc., may be obtained upon request from the Highway Design Division.

C-109 CONCLUSIONS AND RECOMMENDATIONS CONCERNING THE CELL SANDWICH ASSEMBLY VIA

The following general conclusions and recommendations may be made regarding both types of cell sandwich units:

1. Through full testing and field use both types have proven to be effective crash moderation systems.

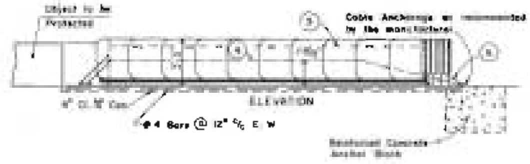
2. The dry system may be favored for use, especially where frequent freezing weather occurs, since the need for antifreeze solution is eliminated.

3. Both systems may be restored to service in a short time if replacement materials are stocked. The dry system may be restored to service at a more rapid rate than the wet system.

4. Both systems have redirectional capability for side impacts.

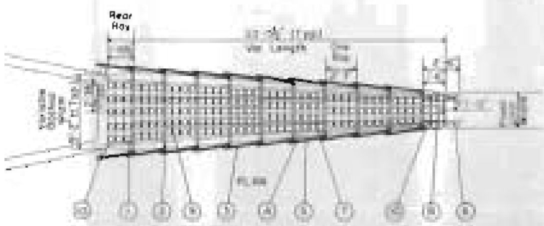
5. Both systems are sensitive to impacting mass and velocity and, substantially, all available deceleration distance is used for all velocities of impacts up to design velocity.

6. The cost of a cell sandwich assembly generally exceeds other alternative VIA systems.



HCC ON ROADWAY

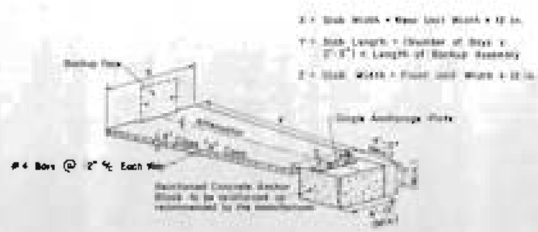
NOTE: Length varied as dictated by design speed and available space; see table for listing of lengths for standard installations.



TYPICAL CELL SANDWICH INSTALLATION (Water Filled Cells)

KEY

1. Water Filled Cells
2. Diaphragms
3. Fender Panels
4. Restraining Cables
5. Pull-Out Cables
6. Secondary Cables
7. Slide Straps
8. Flexible Nose Cover
9. Interior Panels
10. Standard Vinyl Cells



TYPICAL FOUNDATION PAD AND ANCHOR BLOCK ON ROADWAY ONLY

BACKUP FACE, AND SINGLE ANCHOR PLATE ON ROADWAY OR BRIDGE

GENERAL NOTES

1. BACKUP WIDTH SHOULD BE [illegible] TO ACCOMMODATE STANDARD ASSEMBLIES FOR HYDRAULIC CRASH CUSHIONS. [illegible] 3'-3".
2. ANCHOR BLOCKS, [illegible] DIAGONALLY BRACED BACKUP ASSEMBLY [illegible] DETAILS SHOWN HEREON [illegible] BY THE MANUFACTURER SUPPLYING THIS PRODUCT.
3. THE BID ITEM, [illegible] BRIDGE STRUCTURES [illegible] SHOWN HEREON INCLUDING [illegible] ASSEMBLY, [illegible] FOUNDATION PAD OR BRIDGE [illegible] ON ROADWAY, [illegible] BLOCK.
4. A FREE STANDING CUSHION WITH DIAGONALLY BRACED BACKUP WILL [illegible] SPECIFIED AND DETAILED [illegible].
5. WHEN LOCATED ON BRIDGE [illegible] THE SINGLE ANCHORAGE [illegible] SHALL BE LOCATED [illegible] DECK.

TYPICAL SLIDE STRAP ASSEMBLY

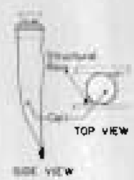
TYPICAL BAY ASSEMBLY

TABLE

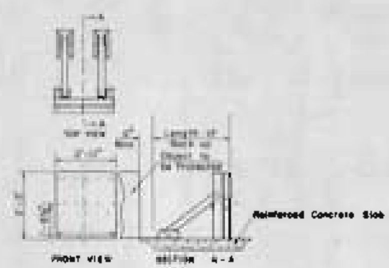
SYSTEM TYPE	LENGTH *	NO. OF BAYS	MAXIMUM DESIGN SPEED	AVERAGE "G" FORCES **
HYDRAULIC CRASH CUSHION	12'-2½"	5	40 MPH	5.8
	14'-5½"	6	40 MPH	4.9
	16'-8½"	7	45 MPH	5.4
	18'-11½"	8	50 MPH	5.9
	21'-2½"	9	50 MPH	5.3
	23'-5½"	10	50 MPH	4.7
	25'-8½"	11	50 MPH	4.3
	27'-11½"	12	60 MPH	5.7

* TOTAL LENGTH OF UNIT AS MEASURED FROM FRONT FACE OF BACKUP TO FORWARD EDGE OF FRONT CELLS

** AVERAGED OVER ENTIRE HCC SYSTEM LENGTH; 50 MILLISECOND PEAK "G" FORCES EXCEED THESE VALUES.



TYPICAL CELL



TYPICAL DIAGONAL BRACED BACKUP ASSEMBLY ON ROADWAY OR BRIDGE

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

HYDRAULIC CRASH CUSHION (HCC) (FREE STANDING)

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TABLE 2: CHARACTERISTICS OF CRASH CUSHIONS

Property	Type of Vehicle Impact Attenuator				
	Steel Drum	Sand Tire	Sand-Filled Plastic Barrels	Water-Filled Cells	Vermiculite Concrete Cartridges
1. Longitudinal Deceleration and Length values for 60 mph design speed:					
(a) Highest average value for a 50-millisecond interval	6 g's @ L = 30'	6 g's @ L = 36'	11 g's @ L = 24'	Unknown	Unknown
(b) Average value over entire barrier length	4 g's @ L = 30'	3 g's @ L = 36'	6 g's @ L - 24'	6 g's @ L = 28'	6 g's @ L = 26'
2. Requirement for backup	Yes	No	No	Yes	Yes
3. Redirectional capability	Yes/No	No	No	Yes	Yes
4. Generation of debris	No	Yes, sand and module fragments	Yes, sand and barrel scatter	No	No
5. Effect of temperature	No	No	No	Yes, freezing in cold climates and evaporation in hot climates	No
6. Penetrable	No	Yes, at impact velocities exceeding design speed	Yes, at impact velocities exceeding design speed	No	No
7. Width					
(a) Minimum	9'-0"	9'-0"	6'-0"	4'-6"±	2'-0"±
(b) Maximum	-	-	-	8'-8"±	8'-8"±
8. Maintenance after crash					
(a) Site cleanup requirements	Minor	Substantial	Substantial	Minor	Minor
(b) Exposure time factor for restoration	4	2	1	1	1
(c) Materials storage requirements	Yes, steel drums, redirectional panels, cables, hardware	Yes, sand, plywood discs, wire cage supports, covers	Yes, sand, plastic barrels, cores, discs, covers	Yes, repair kit, cable, redirectional panels, diaphrams	Yes, vermiculite concrete cartridges, redirectional panels, cable, diaphram hardware
(d) Cost	High	Moderate	Moderate	Low	Low
9. Initial Cost	Moderately High	Low	Moderate	High	High

APPENDIX D-100

CAPACITY AND LEVEL OF SERVICE (D-100)

D-101 INTRODUCTION

Level of service evaluation, mentioned briefly in Part IV, is an important tool in the design of a highway facility. With a reasonably accurate projection of design year traffic volumes in hand the designer can select the physical characteristics of a facility needed to obtain a desired level of service.

The different levels of service are measures of quality of flow as affected by a number of factors including speed, travel time, traffic interruptions, freedom to maneuver, safety, driving comfort, convenience, and operational costs. Specific levels of service range from ideal operation (LOS "A") to complete congestion (LOS "F"). Characteristics of the various levels of service, as defined for different types of highways, are summarized in Figure D-1. In the description of characteristics for levels of service, certain factors are used. The limiting values of these factors are indicative of the various service levels and, therefore, a more particular description of these factors is in order.

A. Load Factors

A ratio of the total number of green signal intervals during the peak hour that are fully utilized by traffic to the total number of green signal intervals available for that approach during the same period. The maximum value obtainable for this ratio would be 1.0; however, the maximum value is seldom obtained and should not be used for design.

B. Peak Hour Factor (PHF)

A ratio of the volume occurring during the peak hour to the maximum rate of flow during a given time period within the peak hour. As with the load factor, the maximum attainable value is 1.0. As a general rule, on controlled access facilities, the following peak hour factors are appropriate: (1) 0.91 for large metropolitan areas of over one million population; (2) 0.83 for areas between 500,000 and one million; and (3) 0.77 for areas under 500,000 population. A PHF of 1.0 is seldom obtained and should not be used for design.

C. Service Volume/Capacity (V/C) Ratio

A ratio of the number of vehicles that can pass over a given section during an hour while operating at a given or selected service level to the maximum number of vehicles that could be accommodated on the same section during the same period under the prevailing roadway and traffic conditions.

D. Factors Affecting Capacity and Service Volumes

Figure D-1 includes the service volumes that can be handled on various types of facilities based on capacities appropriate for ideal conditions; however, many times a highway will not offer ideal conditions. As a result, the capacity and service volumes must be adjusted by application of certain factors before its ability to serve traffic can be determined. The adjustment factors which may need to be applied fall into two broad categories: roadway and traffic.

LEVEL OF SERVICE CHARACTERISTICS BY HIGHWAY TYPE

LEVEL OF SERVICE	TWO-LANE	MULTILANE RURAL w/o ACCESS CONTROL	URBAN AND SUBURBAN ARTERIALS	CONTROLLED ACCESS HIGHWAYS
A	Space mean speeds of 60 mph or higher. 75% of passing maneuvers can be made with little or no delay. Under ideal conditions, a service volume of 400 passenger vehicles/hour, total both directions, can be achieved.	Space mean speed 60 mph or greater. Under ideal conditions, volume is limited to 600 passenger cars per lane per hour or 30% of capacity. Average speeds are likely to be influenced by speed limits.	Average overall travel speed of 30 mph or more. Free flowing with volume/capacity ratio of 0.60. Load factor at intersections near the limit of the 0.0 range. Peak-hour factor at about 0.70.	Free flow. Space mean speeds at or greater than 60 mph. Service volume of 1400 passenger cars per hour on 2 lanes one direction. Each additional lane serves volume of 1000 vph/lane.
B	Space mean speeds of 50 mph or higher. Volumes may reach 45% of capacity with continuous passing sight distance. Volumes of 900 passenger cars per hour, total both directions, can be carried under ideal conditions.	Beginning of stable flow area. Volume at which actions of preceding vehicle will have some influence on following vehicles. Volume will not exceed 50% of capacity or 1000 passenger vehicles per lane per hour at a 55 mph space mean speed under ideal conditions.	Average overall speeds drop due to inter section delay and inter-vehicular conflicts, but remain at 25 mph or above. Delay is not unreasonable. Volumes at 0.70 of capacity and peak-hour factor approximately 0.80. Load factor at intersections approximately 0.1.	Higher speed range of stable flow. Space mean speed at or greater than 55 mph. Service volume on 2-lanes in one direction not greater than 2000 passenger vehicles per hour. Each additional lane above two in one direction can serve 1500 vph.
C	Flow still stable. Space mean speeds of 40 mph or above with total volume under ideal conditions equal to 70% of capacity with continuous passing sight distance, or 1400 passenger vehicles per hour, total both directions.	Stable flow to a volume not exceeding 75% of capacity or 1500 passenger cars per lane per hour, under ideal conditions, maintaining at least a 45 mph space mean speed.	Service volumes about 0.80 of capacity. Average overall travel speeds of 20 mph. Operating conditions at most intersections approximate load factor of 0.3. Peak hour factor approximately 0.85. Traffic flow still stable with acceptable delays.	Operation still stable but becoming more critical. Space mean speed of 50 mph and service flow on 2-lanes in one direction at 75% of capacity or not more than 5 min. flow rate of 3000 passenger cars per hour. Under ideal conditions each additional lane above two in one direction would serve 1800 vph.
D	Approaching unstable flow. Space mean speeds approximately 35 mph. Volumes, two-direction, at 85% of capacity with continuous passing opportunity, or 1700 passenger cars per hour total both directions under ideal conditions.	Approaching unstable flow at volumes up to 90% of capacity or 1800 passenger cars per lane per hour at a space mean speed of about 35 mph under idea conditions.	Beginning to tax capabilities of street section. Approaching unstable flow. Service volumes approach 0.90 of capacity. Average overall speeds down to 15 mph. Delays at intersections may become extensive with some cars waiting two or more cycles. Peak hour factor approximately 0.90; load factor 0.7.	Lower speed range of stable flow. Operation approaches instability and is susceptible to changing conditions. Space mean speeds approximate 40 mph and service flow rates at 90% of capacity. Peak 5 min. flow under ideal conditions cannot exceed 3600 vph for 2-lanes, 1 direction; 1800 vph each added lane. <u>Not used for design of new facilities</u>.
E	Space mean speeds in neighborhood of 30 mph but may vary considerable. Volumes under ideal conditions, total both directions, equal to 2000 passenger vehicles per hour. Level E may never be attained. Operation may go directly from Level D to Level F.	Flow at 100% of capacity or 2000 passenger cars per lane per hour under ideal conditions. Space mean speeds of about 30 mph or less.	Service volumes at capacity. Average overall traffic variable, but in area of 15 mph. Unstable flow. Continuous back-up on approaches to intersections. Load factor at intersections in range between 0.7 and 1.0. Peak hour factor likely to be 0.95.	Unstable flow. Overall space mean speeds of 30-35 mph. Volumes at capacity or about 2000 vph/lane under ideal conditions. Traffic flow metered by design constrictions and bottlenecks, but <u>long</u> back-ups do not normally develop upstream. <u>This level not used for design</u>.
F	Forced, congested flow with unpredictable characteristics. Space mean speeds less than 30 mph. Volumes under 2000 passenger cars per hour, total both directions.	Forced flow, congested condition with widely varying volume characteristics. Space mean speeds of less than 30 mph.	Forced flow. Average overall traffic speed below 15 mph. All intersections handling traffic in excess of capacity with storage distributed throughout the section. Vehicular back-ups extend back from signalized intersections, through unsignalized intersections.	Forced flow. Freeway acts as a storage for vehicles backed up from downstream bottleneck. Space mean speeds range from near 30 mph to stop-and-go operation. This type service is unacceptable and is not used for design.

NOTE: Space mean speed is defined as the average of the speeds of vehicles within a given section of roadway at a given instant, or the average speed of a group of vehicles based on their average travel time over a section of roadway.

FIGURE D-1

1. Roadway Factors

a. Lane Width

Narrower lanes have lower capacity under uninterrrupted conditions than do 12-ft. lanes which have been accepted as the optimum width.

b. Lateral Clearance

Fixed obstructions located less than 6 feet from the edge of the travel lane reduce the capacity and service volumes of a 12-ft. lane by reducing the effective width of the lane. Except in the case of mountable curbs or those of less than 6 inches in height, factors should be applied to adjust the capacities and service volumes or demand volumes of highways which have obstructions within 6 feet of the lane edge.

Continuous obstructions may have less adverse effect on effective pavement width than intermittent, short obstructions, because drivers become accustomed to them. This effect is also true in the case of commuter type highways which have a high percentage of repeat drivers.

Since lane width and lateral clearance are interrelated, there is seldom a need to know the individual effects of each. Therefore, the adjustment factors presented in Figure D-2 are based on their combined effects.

c. Shoulders

Adequate shoulders are essential if the capacity provided by the traffic lanes is to be maintained continuously. Unless a disabled vehicle is provided a refuge area outside the travel lanes, it can reduce the capacity by more than the capacity of one lane. This occurs due to the disabled vehicle blocking one lane and forcing other vehicles to merge into fewer lanes at speeds below those at which capacity can be achieved. No direct adjustment can be applied for inadequate shoulders except when they include obstructions within 6 feet of lane edge. Otherwise, the designer will have to exercise his judgment about the effects of inadequate shoulders.

d. Horizontal Alignment

The horizontal alignment of a highway has a definite effect on its traffic-carrying capability. No specific capacity reduction is required; however, the overall average travel speed within a section will be affected as illustrated in Figure D-24.

e. Vertical Alignment

The vertical alignment of a highway affects the capacity of the highway in the following ways:

(1) For two-lane highways the profile generally determines the restrictions in passing sight distance.

COMBINED EFFECT OF LANE WIDTH AND RESTRICTED LATERAL CLEARANCE ON CAPACITY AND SERVICE VOLUMES

(Uninterrupted Flow Conditions)

DISTANCE TRAFFIC LANE EDGE TO OBSTRUCTION (FT.)	ADJUSTMENT FACTOR, W, FOR LATERAL CLEARANCE & LANE WIDTH			
	OBSTRUCTION ON ONE SIDE ONLY[1]		OBSTRUCTIONS ON BOTH SIDES OF ROADWAY	
	12 Ft. Lanes	11 Ft. Lanes	12 Ft. Lanes	11 Ft. Lanes
a. Two-Lane Highway (Based on Level of Service B which is appropriate for design)				
6	1.00	0.86	1.00	0.86
4	0.96	0.83	0.92	0.79
2	0.91	0.78	0.81	0.70
0	0.85	0.73	0.70	0.60
b. Four-Lane Undivided Highway, Non-controlled Access, One Direction of Travel[2]				
6	1.00	0.95	N.A.	N.A.
4	0.99	0.94	N.A.	N.A.
2	0.97	0.93	0.96	0.92
0	0.94	0.90	0.91	0.87
c. Four-Lane Divided Highway (Conventional or Freeway), One Direction of Travel				
6	1.00	0.97	1.00	0.97
4	0.99	0.96	0.98	0.95
2	0.97	0.94	0.94	0.91
0	0.90	0.87	0.81	0.79
d. Six and Eight-Lane Divided Highway (Conventional or Freeway), One Direction of Travel				
6	1.00	0.96	1.00	0.96
4	0.99	0.95	0.98	0.94
2	0.97	0.93	0.96	0.92
0	0.94	0.91	0.91	0.87

[1] In case of two-lane highways, Table includes allowance for opposing traffic on left.

[2] For six-lane undivided, see Table 10.2, Page 286, Highway Capacity Manual 1965.

Figure D-2

(2) The profile determines the safe headway distance between vehicles. Since braking distances are greater on downgrades and less on upgrades, longer and shorter spaces respectively between vehicles are required for safe operation.

(3) Trucks generally travel at lower speeds on upgrades than do passenger vehicles. The latter can generally negotiate sustained grades of up to 7 percent without adverse effects; however, the effect of sustained grades on trucks results in a capacity restriction that is exemplified by the truck-automobile equivalencies shown in Figures 4-1A and 4-1B. Generally, no adjustment will need to be made for the effect of trucks on grades as this will have been accomplished by the reduction of mixed traffic to equivalent passenger cars (see section 4-201 (E)).

2. Traffic Factors

a. Lane Distribution

On multilane facilities all lanes do not carry the same amount of traffic. For example, on a six-lane freeway section operating at capacity in one direction under ideal conditions (2000 x 3 = 6000 vph), typical lane volumes might be 1700 vph in lane 1 (the outside lane), 2100 vph in lane 2, and 2200 vph in lane 3. No absolute values for lane distribution can be established; however, it can be said that for ideal conditions, greater use is made of the left lanes and less use is made of lane 1 than would be indicated by the average lane volume at each level of service. Although lane distribution is an important variable, no special adjustment is required because where it is of such significance to warrant consideration (as on certain freeways, grades, or at ramp junctions) its effect is included in the basic procedures employed in such evaluations.

b. Traffic Interruptions

Obviously, where features are built into the highway which force some or all traffic to stop, the highway's ability to carry traffic will be impaired. A basic rule to remember in considering traffic interruptions is that passenger vehicles stopped in a line will rarely get underway at a rate greater than 1500 pcph per lane (an average headway of 2.4 sec.). When it is recalled that the capacity of an uninterrupted flow is 2000 pcph per lane, it is easy to understand why back-ups can develop rapidly where traffic is stopped. For the purpose of this discussion, traffic interruptions are divided into two broad categories: at-grade intersections and other interruptions.

(1) At-Grade Intersections

Intersections are the most common type of interruptions and the most difficult to eliminate since they involve the sharing of a common roadway by two or more conflicting traffic flows. Their influence on capacity and service volumes are so great that they often govern the capacity determination rather than being handled as adjustments to uninterrupted flow criteria.

(2) Other Interruptions

This would include such items as drawbridges, at-grade railroad crossings, toll booths, etc. Generally, no adjustment factors can be provided to correct for such influences. Each will be a special case that must be considered individually. To a varying degree even speed limits may be traffic interruptions. If speeds are reduced to approximately 30 mph (or possibly 40 mph on freeways), they do not greatly affect capacity but do affect level of service.

D-102 LEVEL OF SERVICE EVALUATION PROCEDURES

A. General

The procedures outlined herein, unless otherwise noted, were developed after a comprehensive analysis of the information contained in the *Highway Capacity Manual, 1965,* and various research findings. The procedures recommended by these sources are based on actual traffic operations on existing facilities. The methodologies presented here are derived from these publications and experience with traffic operations on the Texas Highway System.

The first step in performing a level-of-service analysis, regardless of the type of facility involved, is the reduction of traffic to adjusted design hourly volumes as detailed in Part IV. Traffic should be adjusted for directional distribution, design hourly volume factor, percent trucks, and grades, whether for the project as a whole or for individual grades. The basic procedure, then, is to compare this traffic with the service volume for the desired level of service adjusted for lane width, lateral clearance, etc.

The general equation for calculating adjusted service volumes is:

$$SV_L = MSV_L \times W$$

Where:

SV_L = Service volume for a given level of service (equivalent passenger cars total for one direction except for two-lane highways which is total both directions).

MSV_L = Maximum service volume, from Figure D-23 for two-lane highways; Figure D-21 for multilane rural highways, or Figure D-3 for freeways.

W = Adjustment factor for obstructions less than 6 feet from the edge of travel lane and/or lane widths less than 12 feet (see Figure D-2).

B. Level of Service Evaluation Procedures for Freeways

1. Main Lanes

The procedure for main lane LOS evaluation involves checking the demand volume across the freeway main lanes against the service volumes shown in Figure D-3 to determine LOS. Figure D-4 is an example that illustrates main lane LOS evaluation.

LEVELS OF SERVICE AND MAXIMUM SERVICE VOLUME FREEWAYS (UNINTERRUPTED FLOW CONDITIONS)

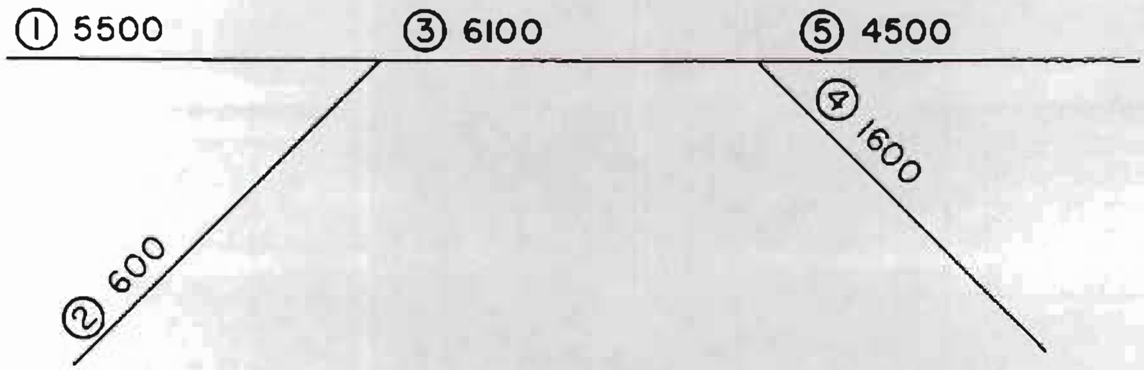
LEVEL OF SERVICE	TRAFFIC FLOW CONDITIONS		SERVICE VOLUME/CAPACITY (v/c) RATIO[a]					MAXIMUM SERVICE VOLUME UNDER IDEAL CONDITIONS, INCLUDING 70-MPH AVERAGE HIGHWAY SPEED (TOTAL PASSENGER CARS PER HOUR, ONE DIRECTION)															
	DESCRIPTION	Space Mean Speed[a] (MPH)	BASIC LIMITING VALUE FOR AVERAGE HIGHWAY SPEED (AHS) OF 70 MPH, FOR:			APPROXIMATE WORKING VALUE FOR ANY NUMBER OF LANES FOR RESTRICTED AVERAGE HIGHWAY SPEED OF		4-LANE FREEWAY (2 LANES ONE DIRECTION)				6-LANE FREEWAY (3 LANES ONE DIRECTION)				8-LANE FREEWAY (4 LANES ONE DIRECTION)				EACH ADDITIONAL LANE ABOVE FOUR IN ONE DIRECTION			
			4-LANE FREEWAY (2 LANES/ DIRECTION)	6-LANE FREEWAY (3 LANES/ DIRECTION	8-LANE FREEWAY (4 LANES/ DIRECTION	60 MPH	50 MPH																
A	Free Flow	$\geq$ 60	$\leq$ 0.35	$\leq$ 0.40	$\leq$ 0.43	b	_b	1400				2400				3400				1000			
B	Stable Flow (Upper Speed Range)	55-60	$\leq$ 0.50	$\leq$ 0.58	$\leq$ 0.63	$\leq$ 0.25	_b	2000				3500				5000				1500			
	Peak-Hour Factor (PHF)[c]							0.77	0.83	0.91	1.00[d]	0.77	0.83	0.91	1.00[d]	0.77	0.83	0.91	1.00[d]	0.77	0.83	0.91	1.00[d]
C	Stable Flow	50-55	$\leq$ 0.75 (PHF)	$\leq$ 0.80 (PHF)	$\leq$ 0.83 (PHF)	$\leq$ 0.45 (PHF)	_b	2300	2500	2750	3000	3700	4000	4350	4800	5100	5500	6000	6600	1400	1500	1650	1800
D	Approaching Unstable Flow	38-50	$\leq$ 0.90 (PHF)			$\leq$ 0.80 (PHF)	$\leq$ 0.45 (PHF)	2800	3000	3300	3600	4150	4500	4900	5400	5600	6000	6600	7200	1400	1500	1650	1800
E[f]	Unstable Flow	30-38	$\leq$ 1.00					4000[e]				6000[e]				8000[e]				2000[e]			
F	Forced Flow	< 30[e]	← Not Meaningful →					← Widely Variable (0 to capacity) →															

[a] Space mean speed and basic v/c ratio are independent measures of level of service; both limits must be satisfied in any determination of level.
[b] Space mean speed required for this level is not attainable even at low volumes.
[c] Peak-hour factor for freeways is the ratio of the whole-hour volume to the highest rate of flow occurring during a 5-minute interval within the peak hour.
[d] A peak-hour factor of 1.00 is seldom attained; the values listed here should be considered as maximum average flow rates likely to be obtained during the peak 5-minute interval within the peak hour.
[e] Approximately.
[f] Capacity.

METROPOLITAN AREA POPULATION (1,000'S)	PEAK HOUR FACTOR (PHF)
Under 500	0.77
500 to 1,000	0.83
Over 1,000	0.91

Figure D-3

MAIN LANE LEVEL OF SERVICE EVALUATION



The line diagram above shows the demand DHV on an existing highway in equivalent passenger cars per hour (epcph) adjusted for percent trucks and grade. This is an 8-lane freeway with 11-foot wide lanes and a 4-foot wide median with a barrier (distance to obstruction = 2 feet). There is adequate clearance on the outside. The freeway is in an area with a population in excess of one million persons.

Determine:

The level of service for each of the main lane sections ("1", "3", and "5").

Solution:

Area of over one million population means PHF = 0.91.
Adjustment for obstructions, from Figure D-2, W = 0.93.

Make a table of adjusted service volumes using the Maximum Service Volumes from Figure D-3 and W. Recall the equation $SV_L = MSV_L \times W$.

LOS	MSV	W	SV
A	3400	0.93	3162
B	5000	0.93	4650
C	6000	0.93	5580
D	6600	0.93	6138
E	8000	0.93	7440

By comparing demand volumes to adjusted service volumes, level of service is determined.

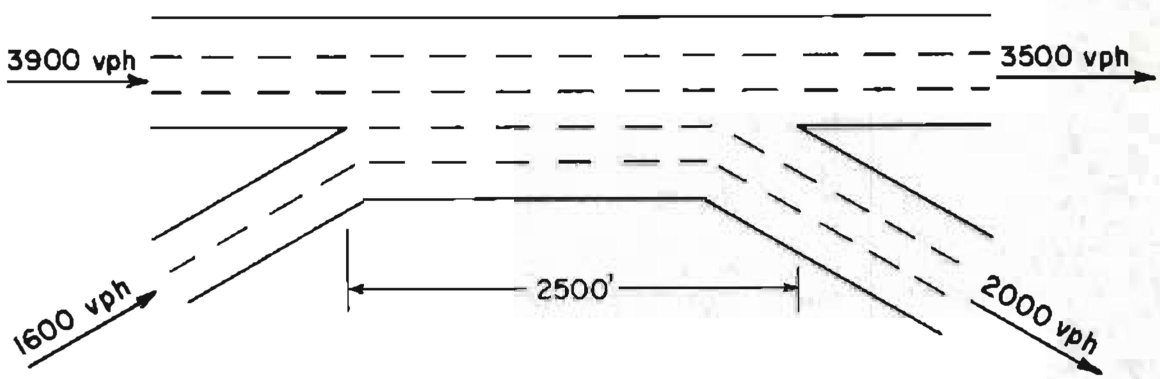
Section 1: $4650 < 5500 < 5580$ LOS "C"
Section 2: $5580 < 6100 < 6138$ LOS "D"
Section 3: $3162 < 4500 < 5640$ LOS "B"

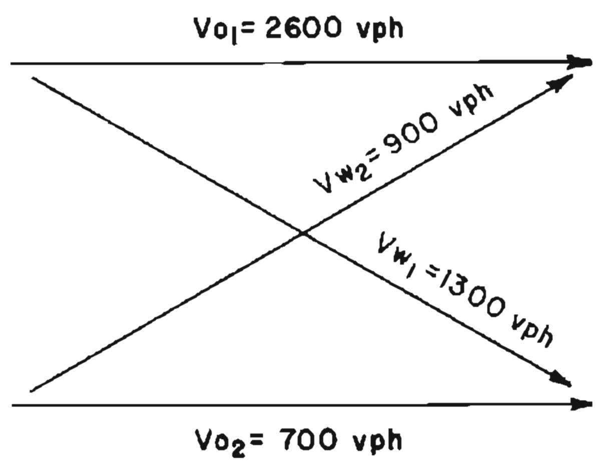
Figure D-4

WEAVING LEVEL OF SERVICE EVALUATION

Given: The proposed weaving section design and the traffic volumes shown (in epcph).
PHF = 0.91

Determine: Is the design adequate to provide level of service "C".





Check: Are all legs of the section adequate to provide LOS "C"? From Figure D-3 the answer is yes. Proceed with weaving analysis.

Total weaving volume = $V_{w1} + V_{w2}$ = 1300 + 900 = 2200

From Figure D-6, using L = 2500', k (weaving influence factor) = 2.9, QF (Quality of Flow) = II - III. From the Table in Figure D-6, LOS = "C"
Therefore, weaving distance is adequate for design.

FIGURE D-5 (Continued)

Check the number of lanes by the equation:

$$N = \frac{V_{w1} + kV_{w2} + V_{o1} + V_{o2}}{SV_L} \text{ or } \frac{V + (k\text{-}1)\,V_{w2}}{SV_L}$$

Where: V_{w1} = larger weaving volume, vph

V_{w2} = smaller weaving volume

V_{o1} & V_{o2} = outer flows

V = total volume

k = weaving influence factor

SV_L = average service volume, per lane, on approaches to the weaving section for given level of service

In this case, use three lanes as the average approach and evaluate the design for level of service "C" operation.

$$SV_C = \frac{4350}{3} = 1450$$

Notes: 4350 is the maximum service volume for LOS "C" on a 6-lane freeway with PHF = 0.91

Hence: $N = \frac{1300 + 2.9 \times 900 + 2600 + 700}{1450} = \frac{7210}{1450} = 4.97$

Therefore, the design is adequate to provide LOS "C".

Figure D-5

2. Weaving

Weaving is the crossing of traffic streams moving in the same general direction, accomplished by successive merging and diverging. While weaving analyses are usually more important for major junctions of multilane urban freeways, a weaving analysis should be performed for the section of highway with an entrance ramp followed by an exit ramp.

The procedure for evaluating the weaving level of service between ramps and/or major freeway legs is illustrated in Figure D-5.

In many cases it may be necessary to obtain information as to the volumes of weaving traffic from File D-10. Weaving volumes for ramp-weave problems will usually be obvious. For other conditions this may not be the case.

3. Ramps (Merge-Diverge Analysis)

Many times the traffic interruptions that occur on freeways are due to the merge and/or diverge conditions near ramp connections with the main lanes. Therefore, it is essential that acceptable merge-diverge conditions be provided in order to reduce traffic congestion on the main lanes.

Figure D-8 is an example problem illustrating some of the techniques used in merge-diverge analyses.

Merge or diverge analyses should be performed even for isolated ramps (greater than 4000 feet from the nearest affecting ramp).

4. Special Cases

There are several special cases that have not been addressed in this discussion. These special cases include multiple ramp systems, multiple weaving sections, two-lane entrance or exit ramps, and lane additions or reductions.

Multiple ramp systems are defined as three or more ramps within 4000 feet which can affect each other. An example would be an on-ramp followed by two downstream off-ramps.

Multiple weave sections are the major highway junction equivalent of multiple ramp systems, i.e., three or more major junctions and/or splits within 4000 feet.

Two-lane ramps should not be confused with major highway junctions or major splits, such as a 4-lane (one way) roadway splitting into two 2-lane roadways. Two-lane ramps are characterized by the merging or diverging maneuvers vehicles must undergo in the vicinity of the ramp. A general rule of thumb is that the capacity of a two-lane ramp will be less than twice the capacity of a one-lane ramp.

Lane additions or deletions occur when a lane is added at an entrance ramp or dropped at an exit ramp.

OPERATING CHARACTERISTICS OF WEAVING SECTIONS

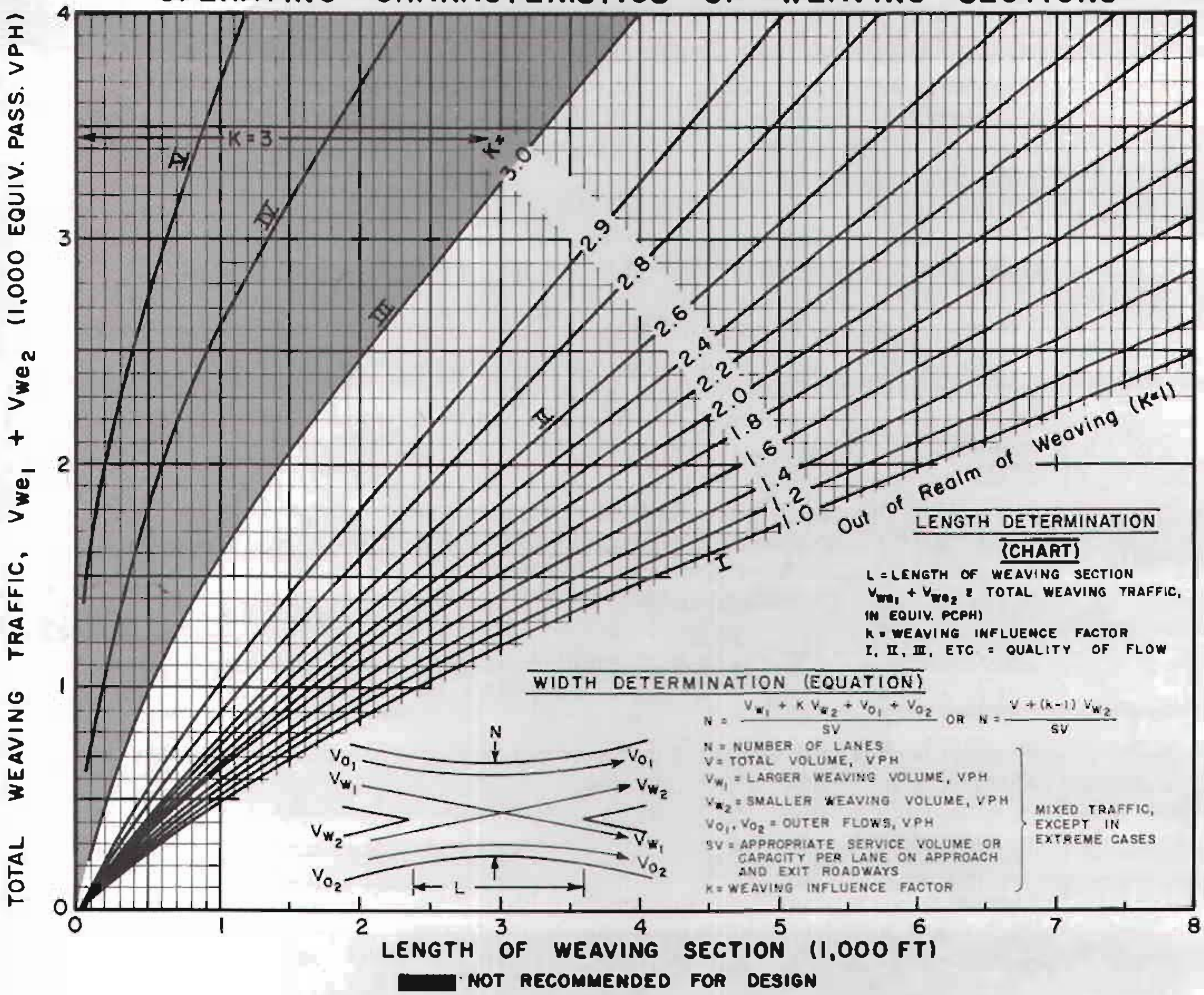
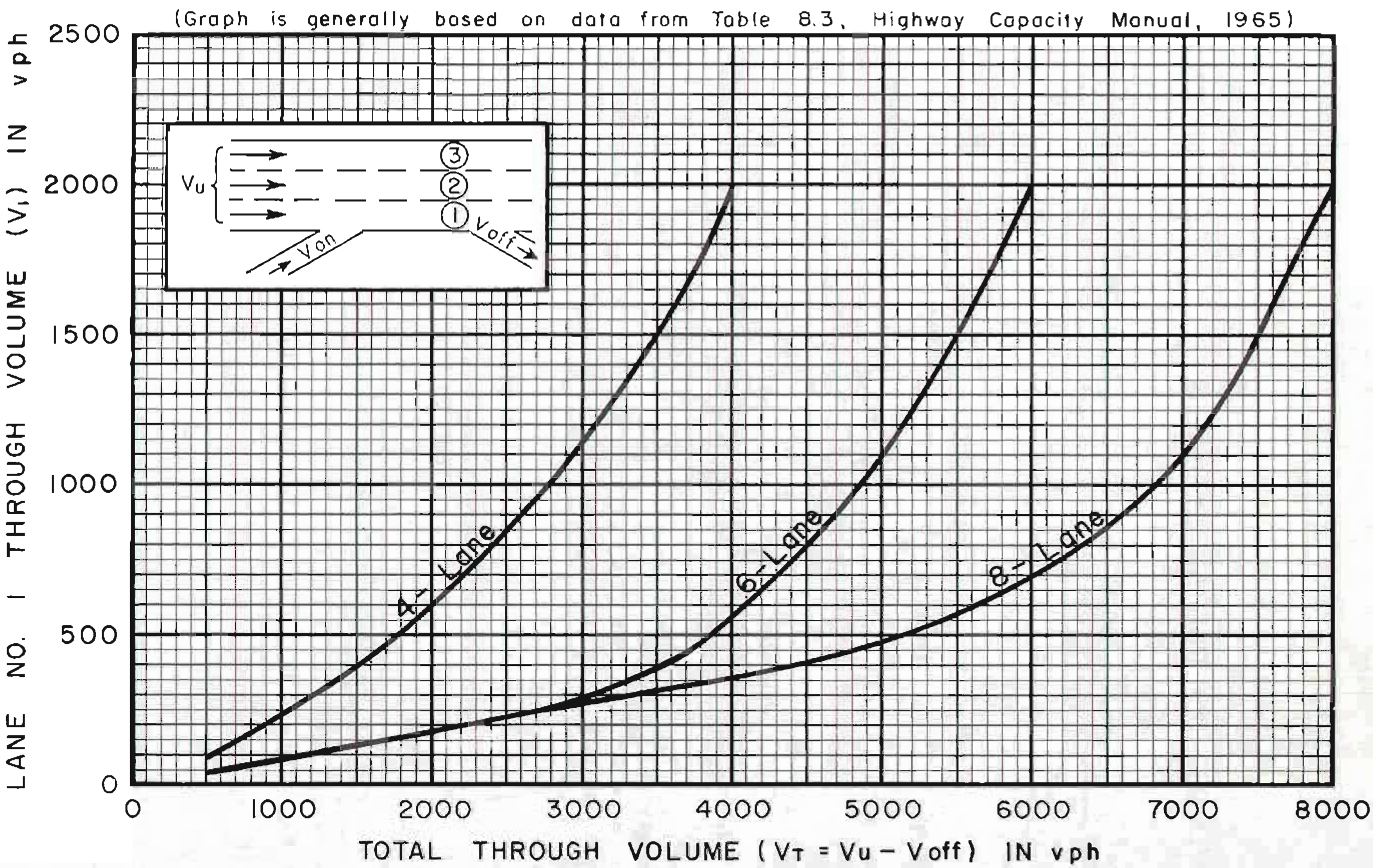


TABLE
ROADWAY LEVELS OF SERVICE AND QUALITY OF FLOW ON WEAVING SECTIONS

LEVEL OF SERVICE	QUALITY OF FLOW			
	FREEWAYS AND MULTILANE RURAL HIGHWAYS		TWO-LANE RURAL HIGHWAYS	URBAN AND SUBURBAN ARTERIALS
	HIGHWAY PROPER	CONNECTING COLLECTOR-DISTRIBUTOR ROADS AND OTHER INTERCHANGE ROADWAYS		
A	I-II	II-III	II	III-IV
B	II	III	II-III	III-IV
C	II-III	III-IV	III	IV
D	III-IV	IV	IV	IV
E	IV-V	V	V	V
F	← UNSATISFACTORY →			

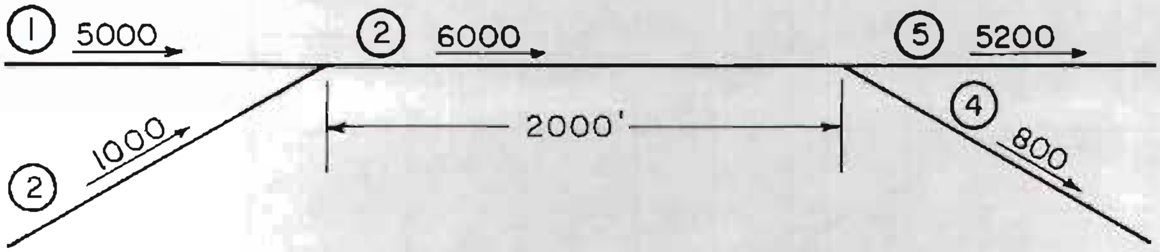
FIGURE D-6



APPROXIMATE VOLUME OF THROUGH TRAFFIC IN LANE NO. 1 IN THE VICINITY OF RAMP GORES

FIGURE D-7

RAMPS (MERGE - DIVERGE ANALYSIS) LEVEL OF SERVICE ANALYSIS



Given: An 8-lane freeway section with a pair of on-off ramps having the demand hourly volumes shown. PHF = 0.91

Determine: The design configuration needed to provide level of service "C" operation or better.

The steps in the analysis are as follow:

1. The through traffic in lane 1 in the vicinity of the ramp needs to be determined. Through traffic can be defined as that traffic which traverses a section of highway without interchanging. In this case, the through traffic would be the 5000 vehicles at point 1 less the 800 vehicles exiting at point 4 or 4200 vehicles. Enter Figure D-7 with 4200 and reflect off the 8-lane curve across to V_1 = 375; V_1 is the hourly volume in lane 1, the outside through lane.

2. The "critical point" for the merge and/or diverge must now be determined. For isolated ramps the critical point will always be at the merge or diverge point where 100% of the on or off-ramp traffic is in lane 1. For this example, the procedure is to determine from Figure D-9 where the sum of on-ramp, off-ramp, and lane 1 traffic is the greatest. In this example, the critical point will be 500 feet from the merge ramp gore at which point 79% of the off-ramp traffic and 100% of the on-ramp traffic will be in lane 1.

3. Calculating the total lane 1 volume at the critical point:

$$0.79 \times 800 + 1.00 \times 1000 + 375 = 2007 \text{ vph}$$

From the Table in Figure D-9, this is LOS "F". Rework the problem with an auxiliary lane between the ramps.

4. Again from Figure D-9, the critical point for the lane 1 merge for this case will be 1000 feet from the merge ramp gore at which point 66% of the on-ramp traffic and 19% of the off-ramp traffic will be in lane 1.

Figure D-8 (continued)

5. Calculating the total lane 1 volume at the critical point:

$$0.66 \times 1000 + 0.19 \times 800 + 375 = 1187 \text{ vph}$$

From the Table in Figure D-9, this is LOS "B".

6. Check the auxiliary lane merge. Again from Figure D-9, the critical point is at the merge ramp gore where 100% of the on-ramp traffic is in this lane.

A volume of 1000 vph is LOS "A" for the auxiliary lane merge.

7. A rudimentary weaving check may be performed. Total weaving volume is 1000 + 800 = 1800 vph over 2000 feet, or 450 vph per 500 feet. Therefore, referring to the weaving portion of Figure D-9, this is LOS "A". Had the weaving level of service thus determined been closer to LOS "C", the necessary level for this example, it would have been necessary to evaluate the weave by the method in Figure D-5.

8. The last necessary check is an evaluation of the level of service of the main lanes, exclusive of the auxiliary lane traffic. The "critical point" for the analysis of the main lanes adjacent to the auxiliary lane is the point where the least traffic is in the auxiliary lane. In this example, this point is 1000 feet from the merge ramp gore.

9. Calculating the auxiliary lane volume at this point:

$$0.76 \times 800 + 0.14 \times 1000 = 748 \text{ vph}$$

Main lane volume at the critical point:

$$6000 - 748 = 5252 \text{ vph}$$

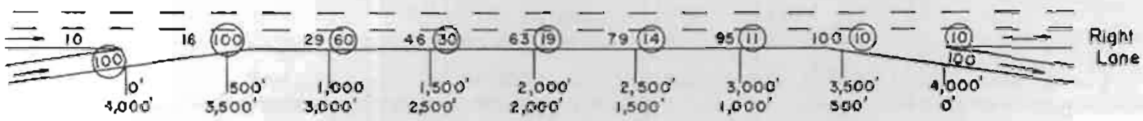
From Figure D-3, this results in LOS "C".

10. Conclusion: This ramp pair will operate at LOS "C" or better under the traffic shown and with the distance between ramps of 2000 feet only if an auxiliary lane is provided.

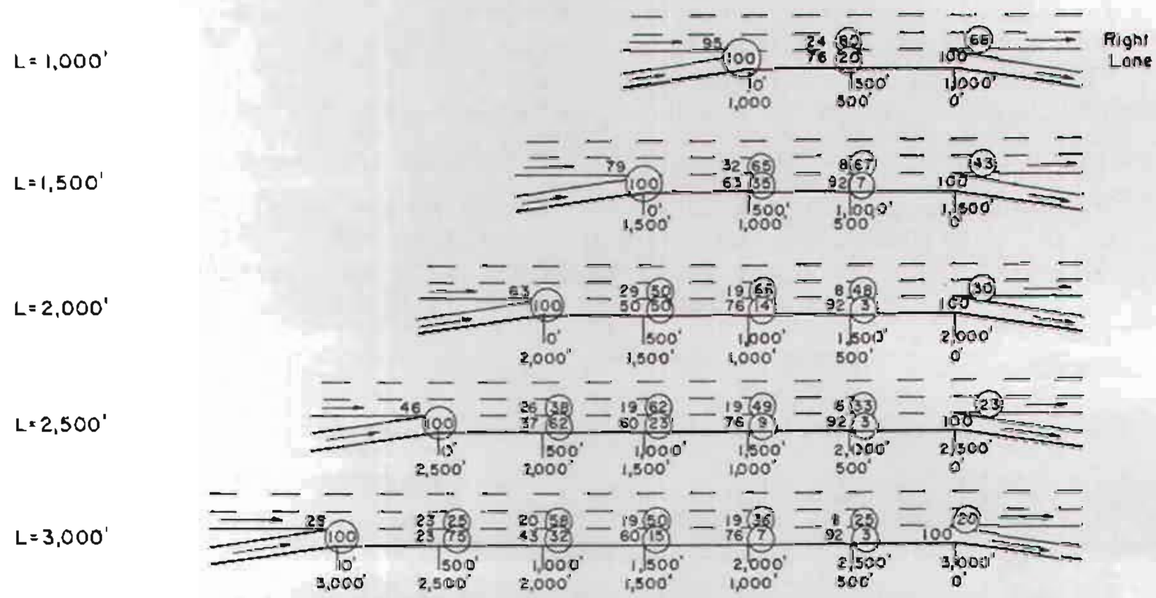
Figure D-8

PERCENTAGE DISTRIBUTION OF ON- AND OFF-RAMP TRAFFIC IN LANE 1 AND AUXILIARY LANE

SINGLE-LANE ON- AND OFF-RAMPS WITHOUT AUXILIARY LANE
(This chart may be used regardless of actual spacing between on- and off-ramps)



SINGLE-LANE ON- AND OFF-RAMPS WITH AUXILIARY LANE



Circled values ⓘ indicate percentage of on-ramp traffic in lane shown. Uncircled values indicate percentage of off-ramp traffic in lane shown. (Remaining portion of ramp traffic is in lane(s) to left of lane 1.)
These percentages are not necessarily the distributions under free flow or light ramp traffic, but under pressure of high volumes in the right lanes at the point being considered and with room available in other lanes.

TABLE
SERVICE VOLUMES AND CAPACITY IN VICINITY OF RAMP TERMINALS

LEVEL OF SERVICE	CHECKPOINT VOLUME (VPH)								WEAVING VOLUME (VPH) PER 500 FT. OF ROADWAY SEGMENT			
	MERGE				DIVERGE							
A B	1000 1200				1100 1300				800 1000			
Peak-Hour Factor	0.77	0.83	0.91	1.00	0.77	0.83	0.91	1.00	0.77	0.83	0.91	1.00
C D E F	1300 1400 ≂ 2000	1400 1500	1550 1650	1700 1800	1400 1500 ≂ 2000	1500 1600	1650 1750	1800 1900	1100 1400 ≂ 2000	1200 1500	1350 1650	1450 1800
	Widely Variable											

Figure D-9

The *Highway Capacity Manual* may be useful in evaluating such special cases. Other publications that may be of interest include: NCHRP Report 159, *Weaving Areas, Design aand Analysis;* Report No.FHWA-RD-74-24, *Capacity Analysis Techniques for Design and Operation of Freeway Facilities,* by Jack E. Leisch; *A Policy on Design of Urban Highways and Arterial Streets, 1973, AASHO;* and Transportation Research Circular No. 212, *Interim Materials on Highway Capacity.*

C. Critical Lane Analysis for Diamond Interchange

Traffic interchange between major arterials and freeways is generally accomplished by the use of conventional-type diamond interchanges. The diamond interchange, like other facilities, cannot operate satisfactorily when traffic demand exceeds the capacity of the interchange. A capacity design procedure for evaluating the diamond interchange was developed by the Texas Transportation Institute and is known as the "critical lane" method. It is based on the assumption that each approach has a critical volume per lane that can be accommodated with basic 4-phase signalization. If the critical volume can be accommodated, then the adjacent lane or lanes on the same approach can accommodate less or equal volumes during the same green phase. Thus, it is necessary to consider only one lane (critical lane) per approach when determining the design of the interchange. For design purposes, a sum of critical lane volumes of 1650 vph is considered to be capacity (LOS = E). The various levels of service are shown in Figure D-10. The procedures for determining the level of service for signalized intersections, as outlined in Paragraph D-102(E), may be employed for the diamond interchange; however, the critical lane volume method is recommended due to its simplicity. The procedures involved in critical lane analysis are illustrated in Figure D-11.

D. Urban and Suburban Arterials

Generally, the capacity and level of service for urban and suburban arterials is controlled by signalized intersections within their lengths. Consequently, no attempt is made here to present material to analyze arterials as such. If such information is required, reference should be made to the *Highway Capacity Manual, 1965.* See Section D-102(E) for a discussion of signalized intersections.

E. Signalized Intersections

1. General

At-grade intersections, like other highway elements, operate at identifiable levels of service under various roadway and traffic conditions. While speeds are used as a measure of level of service for most other highway elements, they are of little use in at-grade intersection level of service analysis.

The procedure outlined herein is based on preliminary results of Research Project 2-18-75-203, "Effects of Design and Operational Performance of Signal Systems," conducted by Texas Transportation Institute.This procedure uses the critical lane analysis technique to determine if a proposed intersection design will provide an acceptable level of service.

The critical lane analysis procedure is based on the fact that for any phase of a signalized intersection one of the movements of the phase will be "critical." As an example,

CRITICAL LANE VOLUME LEVEL OF SERVICE
FOR DIAMOND INTERCHANGES*

Level of Service	Critical Lane Volumes
A	≤ 1250
B	≤ 1300
C	≤ 1350
D	≤ 1480
E	≤ 1650

* Derived from TTI critical lane analysis and extrapolations based on level of service for signalized intersections as contained in Highway Capacity Manual, 1965.

Figure D-10

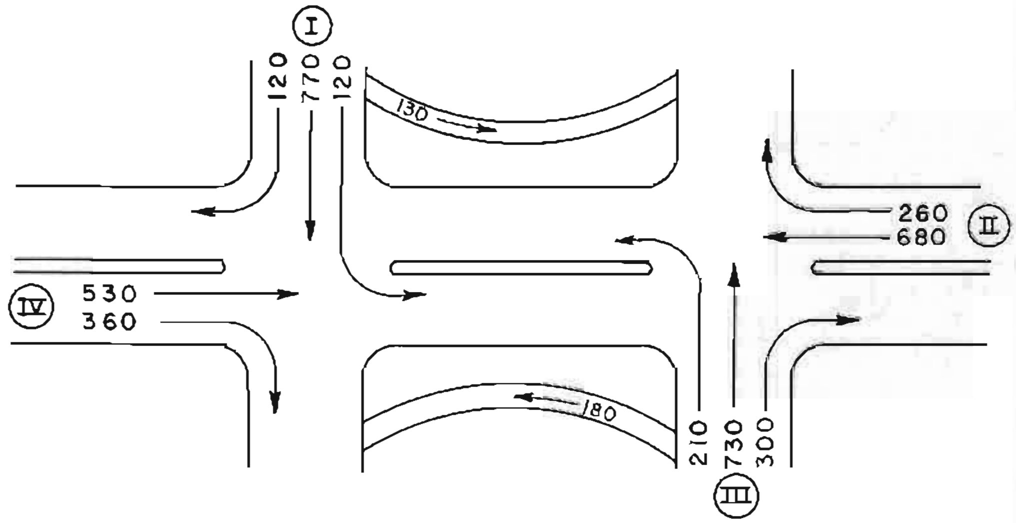
V_c = 280 + 310 + 360 + 300 = 1250

Adjustment for peak period = 1250 x 1.15 = 1440

.˙. 1440 1650 - OK for design

From Figure D-10 (using V_c = 1440) LOS = "D"

The next step would be to check the LOS with turnarounds added. This can be determined by subtracting the turnaround volume from the left-turn movement on Approaches (I) and (III), then recalculate the critical lane volumes. It is advantageous to request turnaround traffic movements from File D-10 on all proposed diamond interchanges. If the turnaround is not required, then this volume can be added to the left-turn movements and the delay in obtaining the turnaround volumes is omitted in cases where their need was not anticipated.



Assume:

4 lanes for Approach (I) and (III)
3 lanes for Approach (II) and (IV)

Turnarounds

Critical Lane Volumes

Approach (I) : $\frac{120 + 770 + 120}{4}$ = 250

Approach (II) : = 310

Approach (III): $\frac{210 + 730 + 300}{4}$ = 310

Approach (IV) : = 300

V_c = 250 + 310 + 310 + 300 = 1170

Adjustment for peak period = 1170 x 1.15 = 1350

.˙. 1350 < 1650 - OK for design

From Figure D-10 (using V_c = 1350) LOS = "C"

Summary: The following is recommended for the intersection:

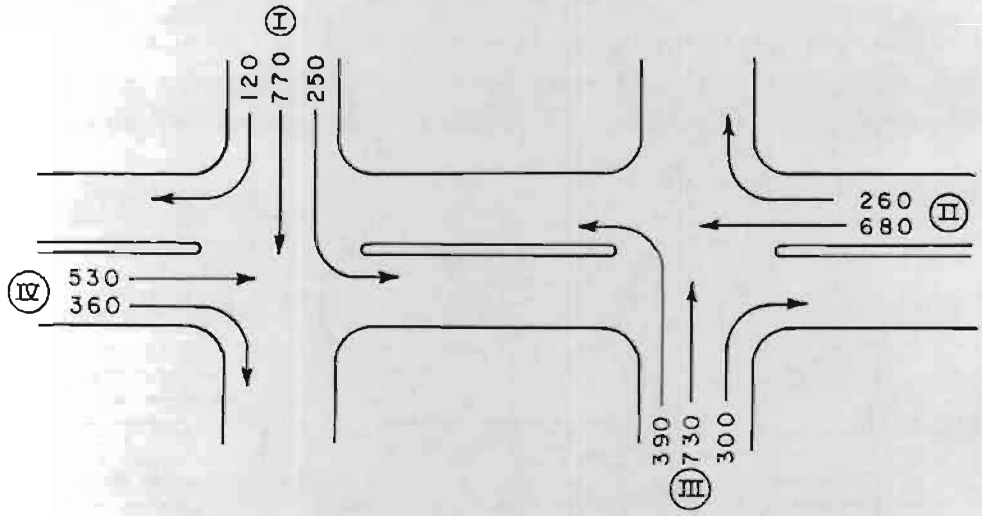
1. 4 lanes for Approaches (I) and (III)
2. 3 lanes for Approaches (II) and (IV)
3. Addition of turnarounds

FIGURE D-11

CRITICAL LANE ANALYSIS
LEVEL OF SERVICE EVALUATION
FOR DIAMOND INTERCHANGES

Given: The diamond interchange with AM design hourly volumes as shown on the sketch below.

Determine: The number of lanes required to accommodate traffic at capacity (LOS = E) and at the level of service "C".



Solution:

Assume 3-lanes for all approaches

Critical Lane Volumes

Approach (I) : $\frac{120 + 770 + 250}{3} = 380$

Approach (II) : $\frac{260 + 680}{3} = 310$

Approach (III): $\frac{390 + 730 + 300}{3} = 470$

Approach (IV) : $\frac{530 + 360}{3} = 300$

Vc = 380 + 310 + 470 + 300 = 1460 vph
Adjustment for peak period: 1460 x 1.15 = 1680 vph
(This adjustment factor of 1.15 is common to all diamond interchanges and should be used accordingly.)
$\therefore$ 1680 > 1650 - not adequate for design.

Assume:

4-lanes for Approach (I) and (III)
3-lanes for Approach (II) and (IV)

Critical Lane Volumes

Approach (I) : $\frac{120 + 770 + 250}{4} = 280$

Approach (II) : = 310

Approach (III): $\frac{390 + 730 + 300}{4} = 300$

Approach (IV) : = 300

FIGURE D-11 (Continued)

take the case of a street phased so that the opposing left-turn bays receive the green indication at the same time. In this example, the "critical" lane for the phase would be the left-turn lane that had the greatest demand volume. For a phase with multilane movements, each of the movement volumes would be divided by the number of lanes provided for the movement and the largest resulting value then would be selected as the critical lane volume.

2. Traffic Volume Preparation

The first step in traffic volume preparation is the reduction of traffic volumes to design hourly volume for each movement on each approach (i.e., left turning, through, and right turning). This is accomplished as detailed in Part IV of this Manual.

The traffic volumes thus obtained should then be adjusted for peaking. The traffic flow rate used to evaluate the level of service at an intersection is the flow rate of the peak 15 minutes of the design hour. The traffic volume flow rates during this 15-minutes period consistently exceed the design hour flow rate by approximately 20-30 percent. For this reason it is necessary to adjust the design hour volume up to account for peaking by the application of a peaking factor. These peaking factors have been found in Texas to vary with the population of the city and are shown in Figure D-12.

The peaking factor should be applied to the design hour volume in accordance with the equation:

$$PPV = DHV \cdot PF \qquad (1)$$

$PPV = DHV/PF$?

where PPV is the peak period volume (flow rate), DHV is the design hour volume previously calculated, and PF is the appropriate peaking factor from Figure D-12. These traffic volume figures can then be arranged on a diagram similar to that shown in Figure D-13 to aid in further analysis.

3. Critical Lane Analysis Procedure

The first step in the critical lane analysis procedure is the selection of an intersection design and signal phasing scheme. Since the design will generally be based on the "twenty-year" design traffic, it is important to analyze the expected ultimate intersection even if it will not be built initially. The reason for this is to ensure that the design year traffic can be accommodated at an acceptable level of service. In addition, this analysis procedure is iterative in nature and it is, therefore, best to select the most reasonable design possible for initial consideration.

The individual peak period volumes shown in Figure D-13 should then be assembled as necessary into traffic movement volumes (MV_m). Eight basic traffic movements are shown in Figure D-14: four for Street A and four for Street B. Depending on intersection configuration and signal phasing, some of these movements may be missing, as at a Tee intersection, or combined with other movements, as for a street with one phase operation. In this case, all movements on each approach would be combined. Normally, thru and right-turning movements are considered as a single thru-right movement

VARIATION OF PEAKING FACTOR, PF, WITH POPULATION OF CITY IN DESIGN YEAR

Population	PF
< 100,000	1.35
100,000 - 300,000	1.30
300,000 - 500,000	1.25
> 500,000	1.18

Figure D-12

unless an adequate free right-turn lane is provided. Then the right-turning volume would be eliminated from the movement volume and neglected in further level of service calculations.

When an approach does not have a left turn bay, the left turn volume is combined with (added to) the thru-right movement volumes, i.e., left plus thru-right (1 + 4 or 2 + 3). Left turns remain separated from the thru-right movement volume when a left turn bay is provided.

All resulting movement volumes, either singles or combinations, are then adjusted to account for design and operational features of the intersection by calculating adjusted traffic volumes:

$$Q_m = U \cdot W \cdot TF \cdot MV_m \qquad (2)$$

where:

Q_m = Adjusted volume for movement(s) m, vph

U = Lane utilization factor (Figure D-15)

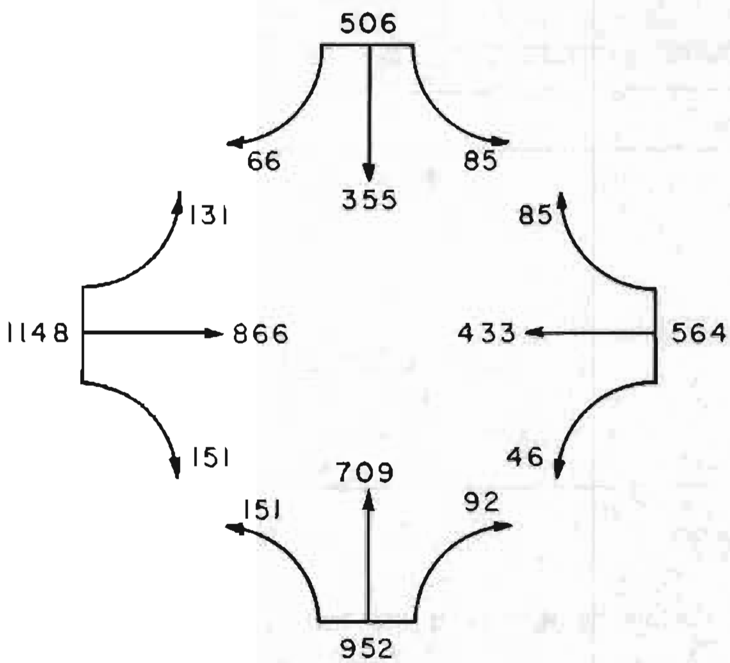
W = Lane width factor (Figure D-15)

TF = Turning movements factor (Equation 3)

MV_m = Volume of appropriate traffic movement(s) m, vph

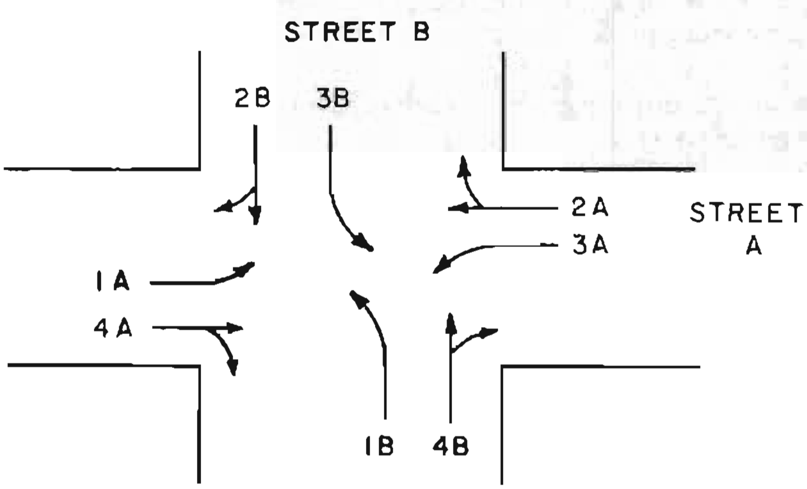
Lane Utilization. As the number of lanes serving a movement increases, there is an increasing tendency for one lane to become more highly utilized than the others. This effect is accounted for by the lane utilization factor, U, presented in Figure D-15.

Lane Width. Lane widths 10 feet or greater have little influence on rush hour traffic flow rates as reflected by the lane width adjustment factor, W, given in Figure D-15. Narrow or meandering lanes may create safety problems, however. Lane width may not include any pavement used for parking.



PPV, PEAK PERIOD VOLUME

Figure D-13



DEFINITION OF MOVEMENTS

Figure D-14

VOLUME ADJUSTMENT FACTORS FOR LANE WIDTH AND UTILIZATION

Factor	Conditions	Value
Lane Utilization, U	Number of Lanes	
	1	1.0
	2	1.1
	3	1.2
Lane Width, W	Average Lane Width, Feet	
	9.0 - 9.9	1.1
	≥10.0	1.0

Figure D-15

Turns. The effects of left and right-turning vehicles on flow are given by the turning factor, TF, as

$$TF = 1.0 + L + R \quad (3)$$

where L adjusts for left turns and R for right turns.

For designs providing no left-turn bay, the left-turn adjustment factor, L, is calculated from

$$L = P_L(E - 1.0) \quad (4)$$

where P_L is the decimal fraction of the total approach volume turning left and E is the appropriate equivalence factor from Figure D-16.

For designs providing a left-turn bay, the left-turn adjustment factor for the left-turn movement only, is

$$L = \frac{1700 \cdot E}{S} - 1.0 \quad (5)$$

where S is the saturation flow of the left-turn bay obtained from Figure D-17 for a given storage length and equivalent left-turning volume from Figure D-13. Left-turn equivalencies have been found to be somewhat dependent on G/C ratios. In this regard, the equivalencies for two-phase intersection operation were derived using an assumed G/C ratio of 0.5 and the equivalencies for three-phase (or more) operation were derived using an assumed G/C ratio of 0.35.

The desired minimum left-turn bay storage length for a given equivalent turning volume is presented at the top of Figure D-17. These desirable storage lengths should be used when possible as shorter bay storage lengths result in saturation flow rates, S, less than 1700 vph. The storage length does not include either the taper section of the left-turn bay or any length of the bay that may be provided beyond a stop line or crosswalk. For normal urban street conditions, a taper length of 70 to 100 feet may be considered appropriate; for high-type urban facilities and rural highways, taper length should be 150 to 300 feet.

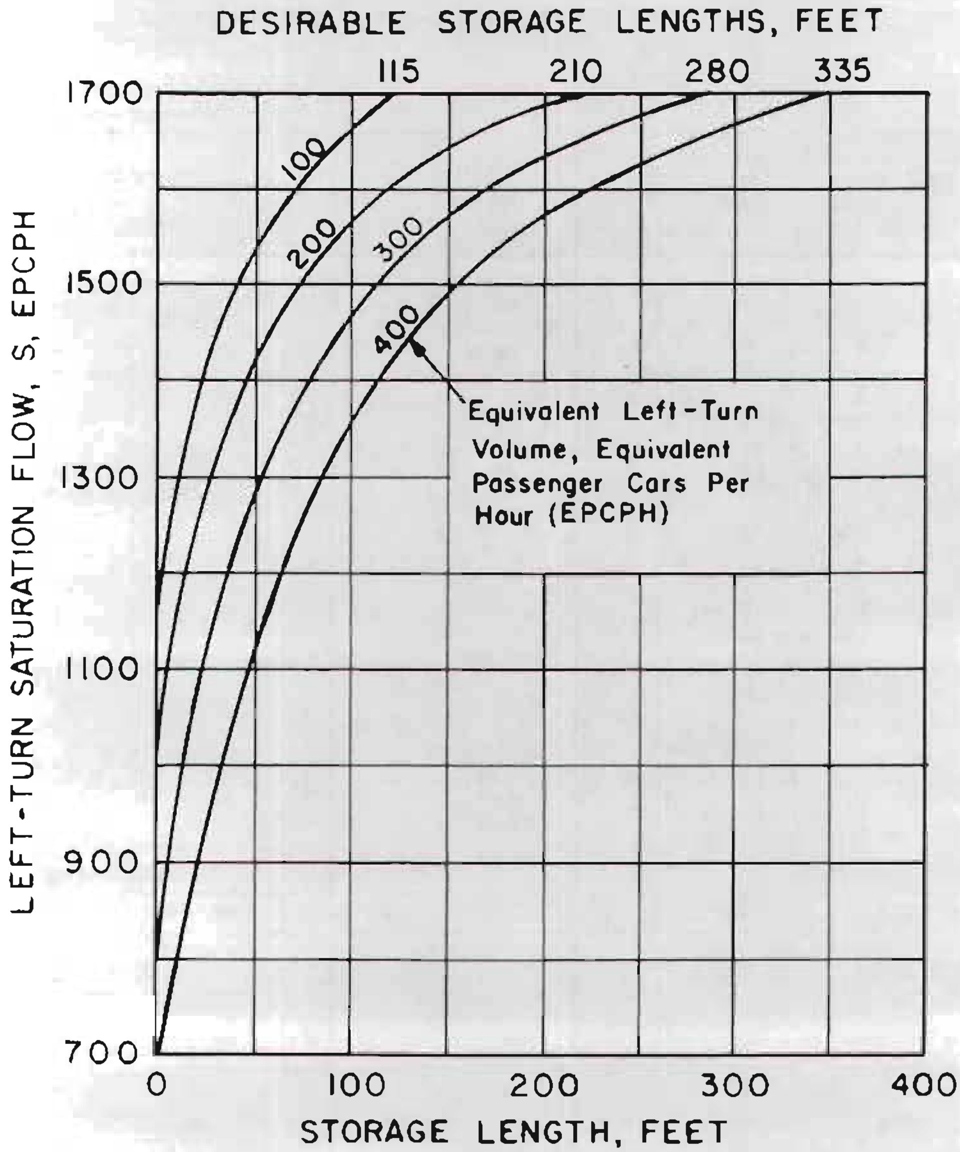
LEFT-TURNING EQUIVALENTS, E

Intersection Signal Phasing	Traffic Movement	Number of Opposing Lanes	Opposing Volume* 200	400	600	800	1000
No Protected Turning							
• Two-Phase							
o No Bay	Left & Thru	1	2.0	3.3	6.5	**	**
	Left & Thru	2	1.9	2.6	3.6	6.0	**
	Left & Thru	3	1.8	2.5	3.4	4.5	6.0
o With Bay	Left	1	1.7	2.6	4.7	**	**
	Left	2	1.6	2.2	2.9	4.1	6.2
	Left	3	1.6	2.1	2.8	3.6	4.8
• Three or More Phases							
o No Bay	Left & Thru	1	2.2	4.5	**	**	**
	Left & Thru	2	2.0	3.1	4.7	**	**
	Left & Thru	3	2.0	2.9	4.2	6.0	**
o With Bay	Left	1	1.8	3.3	**	**	**
	Left	2	1.7	2.4	3.6	5.9	**
	Left	3	1.7	2.4	3.3	4.6	6.8
Protected Turning							
o No Bay	Left	Any	1.2		1.2		1.2
o With Bay	Left	Any	1.03		1.03		1.03

* Total opposing volume (thru, right, and left) from Figure D-13 where no bay is provided. Opposing thru-right volume from Figure D-13 where bays are provided or for narrow one-lane opposing approaches.

** Opposing volume exceeds capacity; not recommended for design.

Figure D-16



SATURATION FLOW OF LEFT-TURN PHASE AS A FUNCTION OF BAY STORAGE LENGTH AND TURNING VOLUME

Figure D-17

When a left-turn bay is provided it is necessary to adjust the thru-right movement to account for any blockage effects that left turns may cause due to inadequate bay lengths. The left-turn adjustment factor to be supplied to the thru-right movement is calculated from

$$L = \frac{1700 - S}{1700\ (N-1)\ + S} \tag{6}$$

where S is the saturation flow from Figure D-17 as in Equation 5, and N is the number of lanes serving the adjacent thru-right movement.

When a separate right-turn lane is provided, the right-turning volume and right-turn lane are not analyzed. Beyond this, the analysis of right turns depends on accuracy requirements. If a detailed analysis is desired, the following approach may be used to estimate the effects of right turns as related to design and operational variables. This approach assumes that

$$R = \frac{5 \cdot P_r}{c} \tag{7}$$

where R = right-turning adjustment factor in Equation 3

P_r = decimal fraction of movement combination turning right

c = related curb return radius, feet.

In addition, the number of vehicles turning right on red are estimated and subtracted from the total movement combination volume. This estimate, which should not exceed 0.5 of the actual right turning volume, is

$$ROR = 50\ \frac{P_e}{1 - P_e} \tag{8}$$

where ROR = estimated right-on-red volume

P_e = estimated decimal fraction of traffic in curb lane turning right.

The usual effect of these right-turn adjustments is that they effectively cancel each other. Therefore, from the viewpoint of practicality and simplicity, the adjustment factor R for most designs can be set to zero, i.e., R = 0 in Equation 3, if right turns on red will be permitted.

Capacity. It is assumed throughout this procedure that the capacity of a normal protected thru lane is 1750 passenger cars per hour. This corresponds to a minimum average headway of 2.06 seconds per car. The type of signalization also affects the capacity of the intersection as will be reflected in the critical lane analysis technique to follow.

The critical lane analysis technique is used to evaluate the acceptability of a proposed design. To begin the analysis, the adjusted traffic volume for each movement Q_m, as calculated in Equation 1, is divided by the number of usable lanes serving the movements to obtain a design volume per lane, V_m of

$$V_m = Q_m/N \qquad (9)$$

where N is the number of lanes provided for the movement. If a left-turn lane is provided on an approach, then N = 1 for the separate left-turning movement and N = 1, 2, or 3 for the thru-right movement, depending on the number of thru lanes provided by the design. If no left turn lane is provided, N will be the total number of approach lanes since Q_m is the total approach movement volumes (the sum of the thru-right traffic and the left-turning traffic).

Figure D-14 defined the movements to be considered at a typical intersection in the critical lane analysis technique. Depending on the signalization scheme used, these movements are combined in different ways as shown in Figure D-18. For a given type of signalization on a street, one movement volume or a sum of two movement volumes will be larger (critical). Different types of signalization result in different sums of critical lane volumes. To evaluate the acceptability of the design, it is necessary to calculate the sum of critical lane volumes for both (all) intersecting streets at the intersection.

METHOD FOR CALCULATING SUM OF CRITICAL LANE VOLUMES AT INTERSECTION

Type of Signal Phasing on Street A or Street B	For Streets A and B Calculate the Maximum Lane Volume Sum of:
"One phase with no left-turn bay"	1 + 4, or 2 + 3
"One phase with left-turn bays"	1, 2, 3, or 4
"Two phases (no overlap) with bays"	
• Dual Lefts Leading	1 or 3, + 2 or 4
• Dual Lefts Lagging	2 or 4, + 1 or 3
• Leading Left	1 or 4, + 2 or 3
• Lagging Left	2 or 3, + 1 or 4
"Multi-Phase (overlap) with bays"	
Overlap Phasings of	
• Dual Lefts Leading	1 + 2, or 3 + 4
• Dual Lefts Lagging	1 + 2, or 3 + 4
• Leading Left	1 + 2, or 3 + 4
• Lagging Left	1 + 2, or 3 + 4

Figure D-18

4. Level of Service Evaluation

The sum of all the critical lane volumes at the intersection is compared against maximum values established for a given level of service as presented in Figure D-19. Level of Service "C" is recommended for design of intersections. The maximum service volumes vary slightly depending on the signalization used. Two-phase signalization has no protected left turning on either street; three-phase has protected turning on only one of the two streets; while multi-phase signalization has protected left turning on both streets. Capacity values are based on practical peak hour cycle lengths.

The purpose of this procedure is to enable the designer to provide an intersection with physical characteristics that will allow it to operate at an acceptable level of service from initial construction thru the design year regardless of the signal timing requirements.

Figure D-20 is an example problem illustrating the procedures involved in the Critical Lane Analysis Procedure and the Level of Service Evaluation. Some assumptions made in the example were selected to illustrate computational procedures of this analysis guide rather than optimum design practice.

No attempt will be made in this Manual to explore optimum signal timing, cycle length, etc. If information or assistance is needed in these areas, contact File D-18.

F. Level of Service Evaluation Procedures for Multilane Rural Highways

The procedure for evaluating the capacity and level of service for a multilane rural highway is similar to that used for freeways. Figure D-21 shows level of service definitions and maximum service volumes for multilane rural facilities. An example problem is worked in Figure D-22.

Fixed traffic interruptions have an adverse effect on multilane rural highways. When signalized intersections are less than a mile apart and/or speed limits or attainable speeds are below 45 mph, the procedures outlined for urban-suburban signalized intersections, Paragraph D-102 (E) should be used. The determination of which procedure to use will require engineering judgment based on anticipated development of the area by the design year.

G. Level of Service Evaluation Procedures for Two-Lane Highways

Two-lane rural highway traffic operations differ from those of multilane facilities by two basic features:

1. Directional distribution of traffic has practically no effect on operating conditions in most cases. Therefore, the capacity and service volumes are expressed in total vehicles per hour in both directions.

2. Overtaking and passing maneuvers must be made in traffic lane normally occupied by opposing traffic. Therefore, whenever service volumes are considered, the corresponding range in average available passing sight distance (1500 feet or greater) must also be considered.

LEVEL OF SERVICE MAXIMUM SUM OF CRITICAL LANE VOLUMES AT SIGNALIZED INTERSECTIONS

Level of Service	Traffic Flow Condition	Volume to Capacity Ratio	Maximum Sum of Critical Lane Volumes, ΣV for Intersection* Two-Phase 2ϕ **	Three-Phase 3ϕ ***	Multi-Phase $\geq 4\phi$ ****
A	Stable	≤ 0.6	900	855	825
B	Stable	≤ 0.7	1050	1000	965
C	Stable	≤ 0.8	1200	1140	1100
D	Unstable	≤ 0.85	1275	1200	1175
E	Capacity	≤ 1.0	1500	1425	1375

* Sum of critical lane volume for Street A and Street B (Figure D-18).
** One-phase operation on Street A and One-phase operation on Street B
*** Two-phase operation on Street A (or B) and One-phase operation on Street B (or A).
**** Two- (or multi-)phase operation on Street A and Street B, or Multi-phase operation on Street A (or B), and One-phase operation on Street B (or A).

Figure D-19

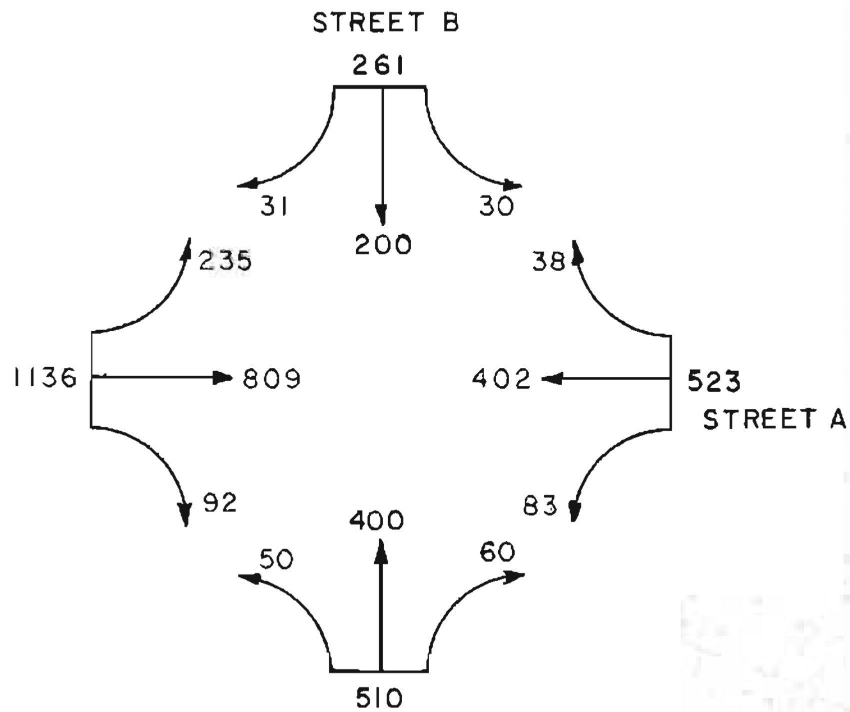
Fixed traffic interruptions have an adverse effect on two-lane rural highway operation and should be considered if present to an appreciable extent. Whenever interruptions and interferences are restrictive enough to result in signalized intersections closer than a mile apart or speed limits or attainable speeds are below 35 mph, then the highway should be analyzed as an urban-suburban arterial street. This is a general rule and engineering judgment must be used to determine the significance of the interruption presented in a particular case. However, when the designer is considering which procedure to employ, he must remember that the basic traffic data is for future traffic; therefore, the decision should be based on what conditions are anticipated to exist by the design year.

It should be noted that an overall level of service of a highway section composed partly of two-lane and four-lane subsections cannot be evaluated. The two-lane and four-lane subsections must be analyzed separately using the appropriate procedures.

Figure D-23 shows the level of service definitions and maximum v/c ratios for two-lane highways. Figure D-24 is an example problem determining the level of service of a two-lane highway.

SIGNALIZED INTERSECTION LEVEL OF SERVICE ANALYSIS

Given: Design hour traffic volume data in equivalent passenger cars per hour as shown
Adequate right-of-way (no restriction on geometrics)
All bay lengths are 100 feet
Right turn adjustment factors assumed equal to zero
Location is in a city of population >500,000



Determine: Intersection configuration and phasing needed to provide a LOS "C"

Figure D-20 (continued)

Step 1: Adjust traffic volumes for peaking, Equation 1, PPV = DHV · PF
City population > 500,000 means PF = 1.18
Make new traffic diagram.

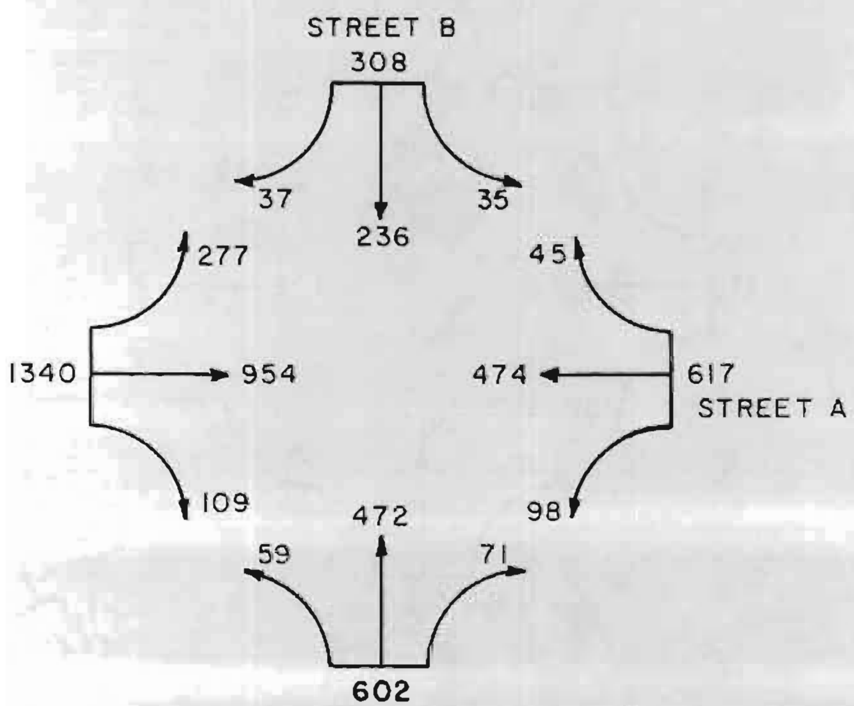


Figure D-20 (continued)

Step 2: Assume a reasonable intersection configuration and phasing, generate movement combination diagram.

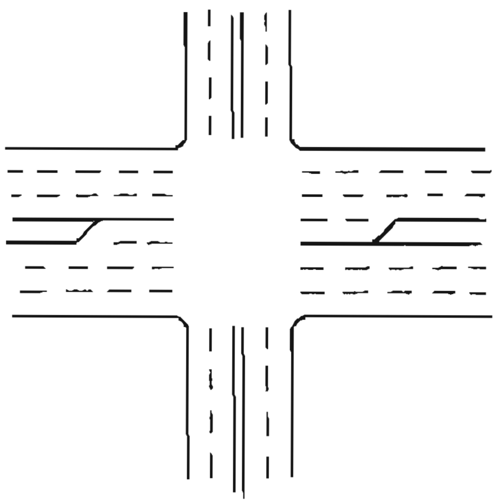
Street A will probably require three-lane approaches plus left-turn bays.

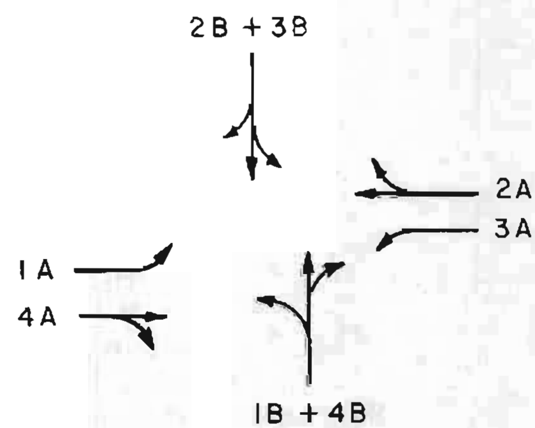
For Street B, two-lane approaches will probably be adequate. See the figure.

For Street A phasing try three phase with dual lefts leading. Try one phase operation on Street B.

Now define movement volumes, MV_m.

$$MV_{1A} = 277$$
$$MV_{2A} = 474 + 45 = 519$$
$$MV_{3A} = 98$$
$$MV_{4A} = 954 + 109 = 1063$$
$$MV_{1B+4B} = 602$$
$$MV_{2B+3B} = 308$$





MOVEMENT COMBINATIONS

Figure D-20 (continued)

Step 3: Calculate left-turn adjustment factors.
For Street A, movements MV_{1A} and MV_{3A}, use

Equation 5: $L = \frac{1700 \cdot E}{S} - 1$; for movements

MV_{2A} and MV_{4A}, use Equation 6: $L = \frac{1700 - S}{1700 \times (N-1) + S}$

$L_{1A} = \frac{1700 \times 1.03}{1520} - 1.0 = 0.15$

$L_{3A} = \frac{1700 \times 1.03}{1700} - 1.0 = 0.03$

L_{2A} = 0 (adequate bay length)

$L_{4A} = \frac{1700 - 1520}{(1700 \times 2) + 1520} = 0.04$

For Street B, use Equation 4: $L = P_L(E-1.0)$

$L_{1B} + 4B = (59/602) \times (2.6 - 1.0) = 0.16$

$L_{2B} + 3B = (35/308) \times (4.7 - 1.0) = 0.42$

Step 4: Calculate adjusted volumes from Equation 2: $Q_m = V \cdot W \cdot TF \cdot MV_m$

$Q_{1A} = 1.0 \times 1.0 \times (1.0 + 0.15 + 0.0) \times 277 = 319$

$Q_{2A} = 1.2 \times 1.0 \times (1.0 + 0.0 + 0.0) \times 519 = 623$

$Q_{3A} = 1.0 \times 1.0 \times (1.0 + 0.03 + 0.0) \times 98 = 101$

$Q_{4A} = 1.2 \times 1.0 \times (1.0 + 0.04 + 0.0) \times 1063 = 1327$

$Q_{1B} + 4B = 1.1 \times 1.0 \times (1.0 + 0.16 + 0.0) \times 602 = 768$

$Q_{2B} + 3B = 1.1 \times 1.0 \times (1.0 + 0.42 + 0.0) \times 308 = 481$

Step 5: Design volume per lane for each movement from Equation 9: $V_m = Q_m/N$

$V_{1A} = 319/1 = 319$

$V_{2A} = 623/3 = 208$

$V_{3A} = 101/1 = 101$

$V_{4A} = 1327/3 = 442$

$V_{1B} + 4B = 768/2 = 384$

$V_{2B} + 3B = 481/2 = 241$

Figure D-20 (continued)

Step 6: Sum of critical lane volumes. From Figure D-18, critical lane volume for Street A will be movements 1 + 2 or 3 + 4. For Street B, critical lane volumes will be movements 1 + 4 or 2 + 3.

V_{1A}	$= 319$	V_{3A}	$= 101$
V_{2A}	$= \underline{208}$	V_{4A}	$= \underline{442}$
$V_{1A + 2A}$	$= 527$	$V_{3A + 4A}$	$= 543$

For Street A, 3 + 4 will be critical.

By observation, movements 1 + 4 on Street B will be critical.

Therefore:

$$V_{3A + 4A} = 543$$

$$V_{1B + 4B} = \underline{384}$$

$$927$$

From Figure D-19, 927 < 1100 (LOS "C") for multi-phase),

Therefore, design is acceptable.

If the level of service had not been acceptable, it would have been necessary to return to Step 2 and make adjustments to the assumed intersection configuration and/or phasing scheme and proceed with the analysis.

Figure D-20

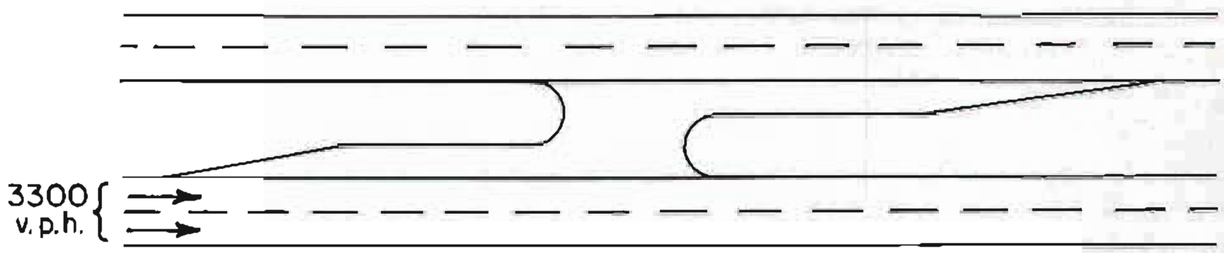
MULTILANE HIGHWAYS
LEVELS OF SERVICE AND MAXIMUM SERVICE VOLUMES
(UNDER UNINTERRUPTED FLOW CONDITIONS - NORMALLY REPRESENTATIVE OF RURAL OPERATION)

LEVEL OF SERVICE	TRAFFIC FLOW CONDITIONS		SERVICE VOLUME/CAPACITY (v/c) RATIO			MAXIMUM SERVICE VOLUME UNDER IDEAL CONDITIONS INCLUDING 70-MPH AHS (TOTAL PASSENGER CARS PER HOUR, ONE DIRECTION)		
	DESCRIPTION	Space Mean Speed[a] (MPH)	BASIC LIMITING VALUE[a] FOR AHS OF 70 MPH	APPROXIMATE WORKING VALUE FOR RESTRICTED AHS OF		4-LANE HWY. (2 LANES ONE DIRECTION)	6-LANE HWY. (3 LANES ONE DIRECTION)	EACH ADDITIONAL LANE
				60 MPH	50 MPH			
A	Free Flow	≥ 60	≤ 0.30	_[b]	_[b]	1200	1800	600
B	Stable Flow (Upper Speed range)	55-60	≤ 0.50	≤ 0.20	_[b]	2000	3000	1000
C	Stable Flow	45-55	≤ 0.75	≤ 0.50	≤ 0.25	3000	4500	1500
D	Approaching Unstable Flow	35-45	≤ 0.90	≤ 0.85	≤ 0.70	3600	5400	1800
E[c]	Unstable Flow	30-35	≤ 1.00			4000	6000	2000
F	Forced Flow	< 30[d]	Not Meaningful[e]			Widely variable (0 to capacity)		

a Space mean speed and basic v/c ratio are independent measures of level of service; both limits must be satisfied in any determination of level.
b Space mean speed required for this level is not attainable even at low volumes.
c Capacity.
d Approximately.
e Demand volume/capacity ratio may well exceed 1.00, indicating overloading.

Figure D-21

MULTILANE RURAL HIGHWAY
LEVEL OF SERVICE EVALUATION



Given: Rural divided section as shown
Demand volume = 3300 epcph in one direction
Average Highway Speed (AHS) = 70 mph
W = 1.0 (12-ft. lanes with adequate clearance)

Determine: Number of lanes required to provide a LOS "C"

Solution: Try 4 lanes
From Figure D-21 (using LOS "C")
MSV_c = 3000 vph (4-lane highway)

No adjustments to service volume are necessary
Compare demand volume to SV_c:

$$3300 > 3000$$

The demand volume is greater than SV_c; therefore, the LOS is lower than "C" and a 4-lane design is not recommended.

Try 6 lanes.
MSV_c = 4500

$$3300 < 4500$$

The section will operate at LOS "C" with 6 lanes.

Figure D-22

H. Climbing Lane Warrants and Design

Climbing lane design is a problem generally associated with two-lane highways, although some of the procedures outlined herein may be useful for multilane highway design or analysis.

Climbing lanes are important on two-lane highways because of the effect of grades on truck performance. On long, steep upgrades there is a large difference between the normal speed of passenger cars and the normal speed of trucks. In effect, trucks on grades take up the space of a larger number of passenger cars (that is, have higher passenger car equivalents) than they do on level sections, particularly on two-lane highways. This situation results in high equivalent traffic volumes and, in effect, lower capacity for uphill sections than for level sections. Climbing lanes can alleviate these problems.

The procedure for warranting and designing climbing lanes follows. Given the design year traffic and the profile of the section of highway under consideration perform the following steps:

Step 1. Does a 15-mph speed reduction occur? Use Figure D-25 to determine this. Figure D-25 is derived from data generated by the research project "Speed of Vehicles on Grades," Project Number 3-8-73-20, conducted by the Center for Highway Research, and from Figure 5.1 of the *Highway Capacity Manual.* The deceleration curves of Figure D-25 are entered with the approach speed of the truck traffic, the percent grade, and the length of grade. If a 15-mph speed reduction does not occur, a climbing lane is not warranted; if it does occur, proceed.

Step 2. Is a climbing lane warranted by capacity analysis? Using a slight modification of the ADT to DHV conversion outlined in Part IV of this Manual, determine the DHV on the grade in question. If this volume is greater than the maximum service volume for the desired level of service, a climbing lane should be provided.

Climbing lanes on multilane facilities can be warranted by a similar procedure.

Step 3. Design the Climbing Lane.

A climbing lane should begin at the point where the 15-mph speed reduction occurs and continue to the point where a speed of 40 mph is expected to be re-attained. A 600-foot transition is added at each end of the climbing lane.

See Figure D-26 for an example problem illustrating the warranting and design of a climbing lane.

In instances where regrading or relocation of an existing highway is proposed, the economics of providing an improved grade line in lieu of providing climbing lanes should be investigated. Attention should be given to the location of ends of climbing lanes. Such lanes should not end in a curve or just prior to obstructions such as culverts, etc. It is preferable to carry the lane beyond these hazards for obvious safety reasons even though theoretical warrants may not indicate a need for the additional length.

In an area of rolling terrain where climbing lanes are warranted almost continuously, it may be preferable to connect these lanes making a four-lane section. This would eliminate the hazard caused by relatively slow-moving traffic entering the through lane at various points and would further alleviate congestion caused by slow-moving traffic.

TWO-LANE HIGHWAYS

LEVELS OF SERVICE AND MAXIMUM SERVICE VOLUMES

(UNDER UNINTERRUPTED FLOW CONDITIONS – NORMALLY REPRESENTATIVE OF RURAL OPERATION)

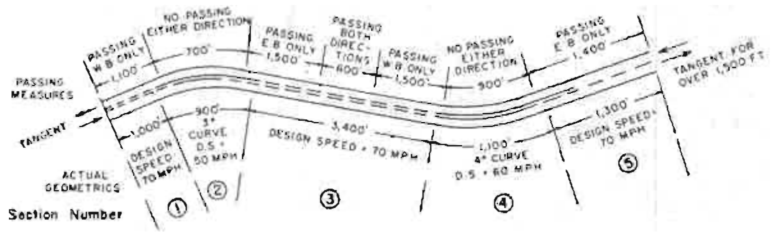
LEVEL OF SERVICE	TRAFFIC FLOW CONDITIONS		PASSING SIGHT DISTANCE > 1,500 FT (%)	SERVICE VOLUME/CAPACITY (v/c) RATIO						MAXIMUM SERVICE VOLUME UNDER IDEAL CONDITIONS INCLUDING 70-MPH AHS (PASSENGER CARS, TOTAL, BOTH DIRECTIONS, PER HOUR)
	DESCRIPTION	Space Mean Speed[a] (MPH)		BASIC LIMITING VALUE[a] FOR AHS OF 70 MPH	WORKING VALUE FOR RESTRICTED AVERAGE HIGHWAY SPEED[b] OF					
					60 MPH	50 MPH	45 MPH	40 MPH	35 MPH	
A	Free Flow	≥ 60	100	≤ 0.20	-	-	-	-	-	400
			80	0.18	-	-	-	-	-	
			60	0.15	-	-	-	-	-	
			40	0.12	-	-	-	-	-	
			20	0.08	-	-	-	-	-	
			0	0.04	-	-	-	-	-	
B	Stable Flow (Upper Speed Range)	50-60	100	≤ 0.45	≤ 0.40	-	-	-	-	900
			80	0.42	0.35	-	-	-	-	
			60	0.38	0.30	-	-	-	-	
			40	0.34	0.24	-	-	-	-	
			20	0.30	0.18	-	-	-	-	
			0	0.24	0.12	-	-	-	-	
C	Stable Flow	40-50	100	≤ 0.70	≤ 0.66	≤ 0.56	≤ 0.51	-	-	1400
			80	0.68	0.61	0.53	0.46	-	-	
			60	0.65	0.56	0.47	0.41	-	-	
			40	0.62	0.51	0.38	0.32	-	-	
			20	0.59	0.45	0.28	0.22	-	-	
			0	0.54	0.38	0.18	0.12	-	-	
D	Approaching Unstable Flow	35-40	100	≤ 0.85	≤ 0.83	≤ 0.75	≤ 0.67	≤ 0.58	-	1700
			80	0.84	0.81	0.72	0.62	0.55	-	
			60	0.83	0.79	0.69	0.57	0.51	-	
			40	0.82	0.76	0.66	0.52	0.45	-	
			20	0.81	0.71	0.61	0.44	0.35	-	
			0	0.80	0.66	0.51	0.30	0.19	-	
E[c]	Unstable Flow	30-35	Not Applicable[e]	≤ 1.00						2000
F	Forced Flow	< 30[d]	Not Applicable[e]	Not Meaningful[f]						Widely Variable (0 to capacity)

a Space mean speed and basic v/c ratio are independent measures of level of service; both limits must be satisfied in any determination of level.
b Where no entry appears, space mean speed required for this level is unattainable even at low volumes.
c Capacity.
d Approximately.
e No passing.
f Demand volume/capacity ratio may well exceed 1.00, indicating overloading.

Figure D-23

TWO-LANE HIGHWAY

LEVEL OF SERVICE EVALUATION



Given: Rural two-lane highway with geometrics as shown in above sketch.

Lane Widths = 12 ft.
Shoulder Widths = 10 ft. paved
Obstructions within 6 ft. of roadway - none
Length of section = 7,700 ft. (1.5 Mile)
Demand Volume = 540 equivalent passenger cars per hour, total both directions

Determine:

Level of Service for the given section.

Solution:

(1) Average Highway Speed

Subsection	Distance		Design Speed		
1	1,000	x	70	=	70,000
2	900	x	50	=	45,000
3	3,400	x	70	=	238,000
4	1,100	x	60	=	66,000
5	1,300	x	70	=	91,000
	7,700				510,000

Average Highway Speed (AHS) = 510,000 ÷ 7,700 = 66 MPH

(2) Passing Sight Distance

The areas of available passing sight distance are those having passing sight distance of 1500 ft. or more. The available passing sight distance is generally the same for both directions; therefore, it will seldom justify separate consideration or averaging. Therefore, we will consider the eastbound conditions for this problem.

Subsection	Available Passing Sight Distance
1	None
2	None
3	2100
4	None
5	1400
	3500 ft.

Available passing sight distance = 3500 ÷ 7700 = 45%

Figure D-24 (continued)

(3) Level of Service

The level of service for two-lane highways can be determined by two methods.

A. Volume/capacity ratio.

Calculate the V/C ratio for the section by dividing the demand volume by the calculated capacity (C = 2000 x W).

Then, enter the percentage of available passing sight distance and average highway speed into Figure D-23 to determine what level of service the calculated V/C will provide.

Example:

As previously determined:

AHS = 66 mph
PSD = 45%

Demand Volume = 540 vph
W = 1.0 (adequate clearance)

C = 2000 x W = 2000 x 1.0 = 2000

V/C = 540 ÷ 2000 = 0.27

From Figure D-3 (using AHS = 66 mph, PSD = 45% and V/C = 0.27) LOS = "B".

B. Maximum service volume formula.

The second method is suitable only where alignment is ideal; that is, average highway speed (AHS) = 70 mph, passing sight distance (PSD) = 100%. This method is similar to the other procedures in computing the service volume of a facility except that the maximum service volume (MSV) from Figure D-23 for the level of service desired is used in place of the basic value adjusted by a V/C ratio.

SV = MSV x W

Using the same problem as before, except assuming ideal alignment, determine the level of service for the given section.

Assume level of service "B".

From Figure D-23 (using LOS "B") MSV = 900

Demand Volume = 540 vph

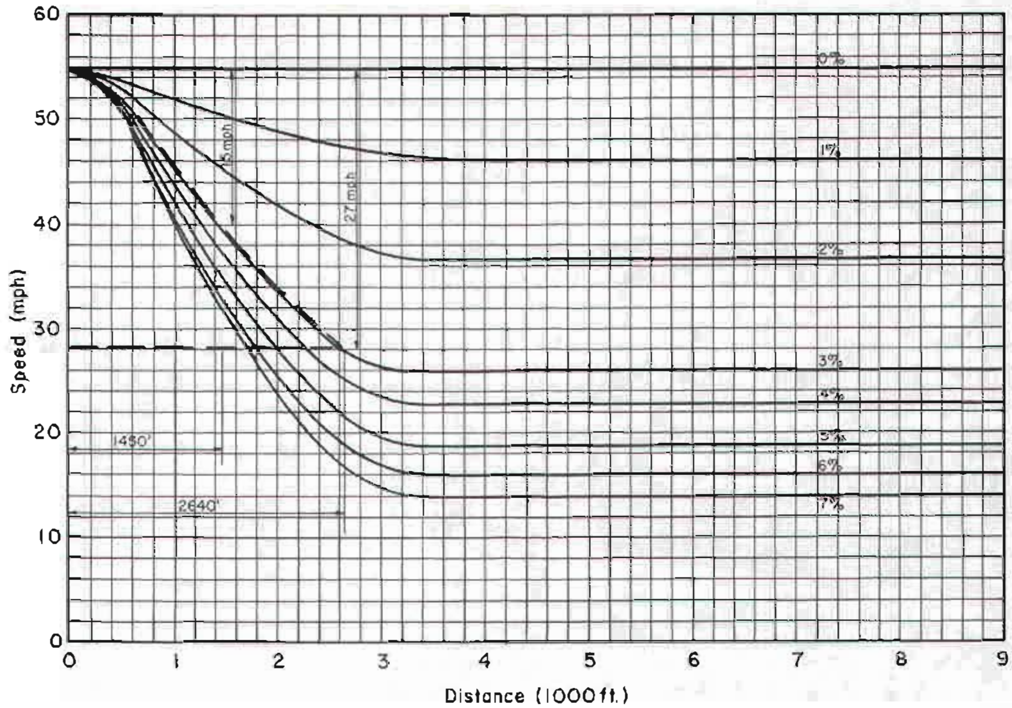
.'. SV = MSV x W = 900 x 1.0 = 900 vph

540 < 900 OK for level of service "B".

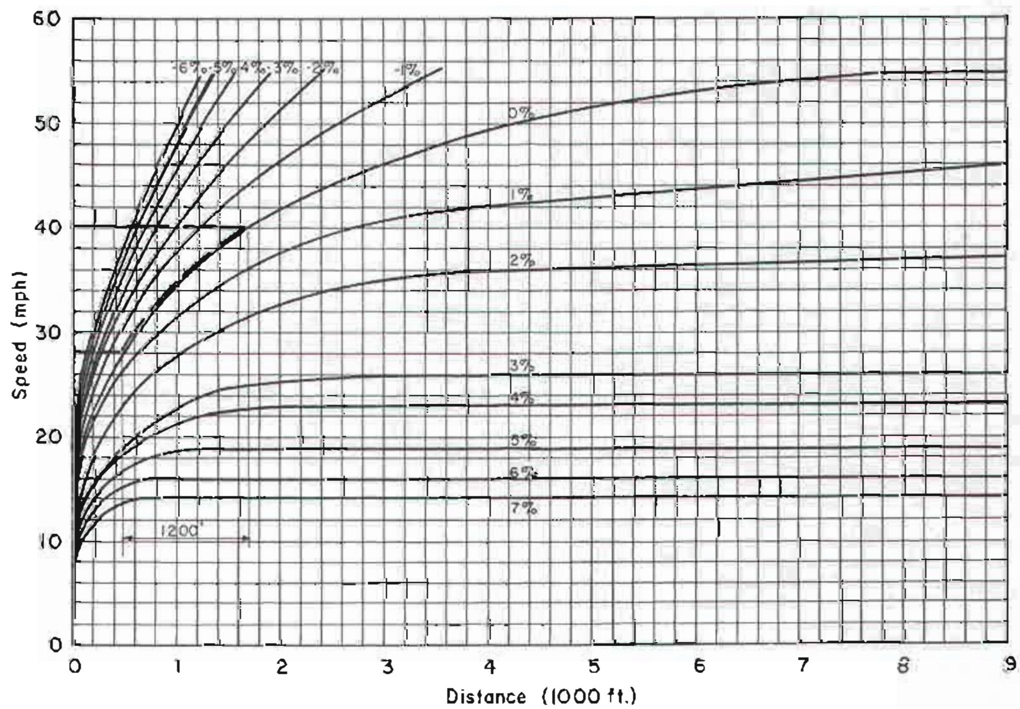
Figure D-24

SPEED-DISTANCE CURVES

FOR TYPICAL HEAVY TRUCKS
OPERATING ON VARIOUS GRADES



DECELERATION ON GRADES SHOWN



ACCELERATION ON GRADES SHOWN

FIGURE D-25

DHV = 4000 [0.15 x 0.6(1 + 0.10(10-1)) + 0.15 x 0.4(1 + 0.10(2-1))]

DHV = 4000 [0.15 x 0.6 x 1.9 + 0.15 x 0.4 x 1.1]

DHV = 948 equivalent passenger cars

Determine maximum service volume for LOS "B" operation.

From Figure D-23, the basic limiting value of the V/C ratio is 0.42 for LOS "B", average highway speed (design speed) = 70 mph, and 80% passing sight distance greater than 1500 feet.

Therefore, maximum service volumes (SV) adjusted for 80% passing sight distance for LOS "B" may be determined as follow:

$$SV_{max} = \text{Capacity} \times V/C$$

$$= 2000 \times 0.42$$

$$SV_{max} = 840 \text{ vph}$$

Compare DHV with SV_{max}:

948 > 840 vph; design traffic exceeds maximum service volume for given conditions. Therefore, climbing lane is warranted.

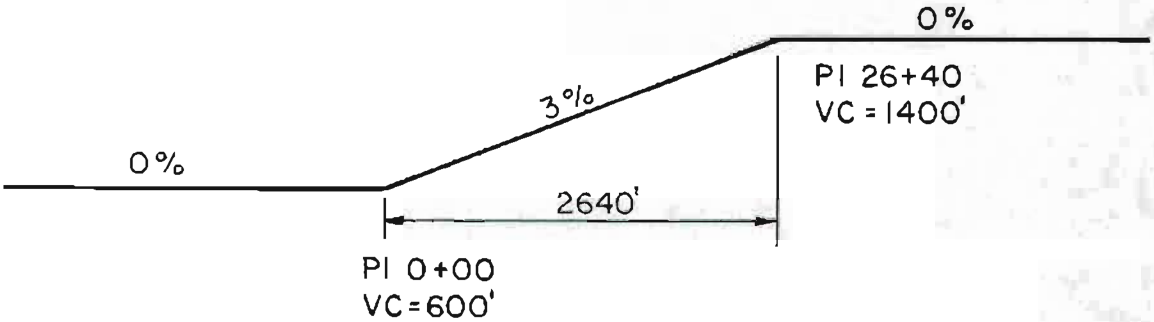
Step 3: Design climbing lane.

Since the approach to the grade is level, assume an initial speed of 55 mph. (In the case of speed zones, adverse geometrics, etc., the appropriate initial speed should be used.) From the deceleration curves of the figure, determine that a 15-mph speed reduction occurs 1450 feet (at Sta. 14+50) from the P.I. at Sta. 0+00. Therefore, begin transition to climbing lane 600 feet in advance of this point (at Sta. 8+50). Minimum speed on the grade is 28 mph and occurs at the P.I. at Sta. 26+40. (The effects of vertical curves on speed are ignored in this analysis.)

From the acceleration curves of Figure D-25, determine that 1200 feet of speed recovery lane is needed (from Sta. 26+40 to Sta. 38+40) to allow re-attainment of a speed of 40 mph. A 600-ft. transition would be added to this distance. The design of the climbing lane would then be as shown.

Figure D-26

CLIMBING LANE
EXAMPLE PROBLEM



Given: Two-lane highway, design speed = 70 mph
Design year ADT = 4000
K factor = 15%
D = 60% - 40%
T = 10%

From the procedure outlined on page 150 of AASHO's 1965 edition of A Policy on Geometric Design of Rural Highways, the percent passing sight distance greater than 1500 feet is 80%.

Determine: Is a climbing lane warranted for LOS "B" operation? If so, design it.

Step 1: Does a 15-mph speed reduction occur? The dashed lines on Figure D-25 indicate the solution to this problem. From the deceleration curves of the Figure, determine the speed reduction = 27 mph $>$15 mph.

Step 2: Is a climbing lane warranted by capacity analysis? Assume the peak traffic is in the upgrade direction and calculate DHV.

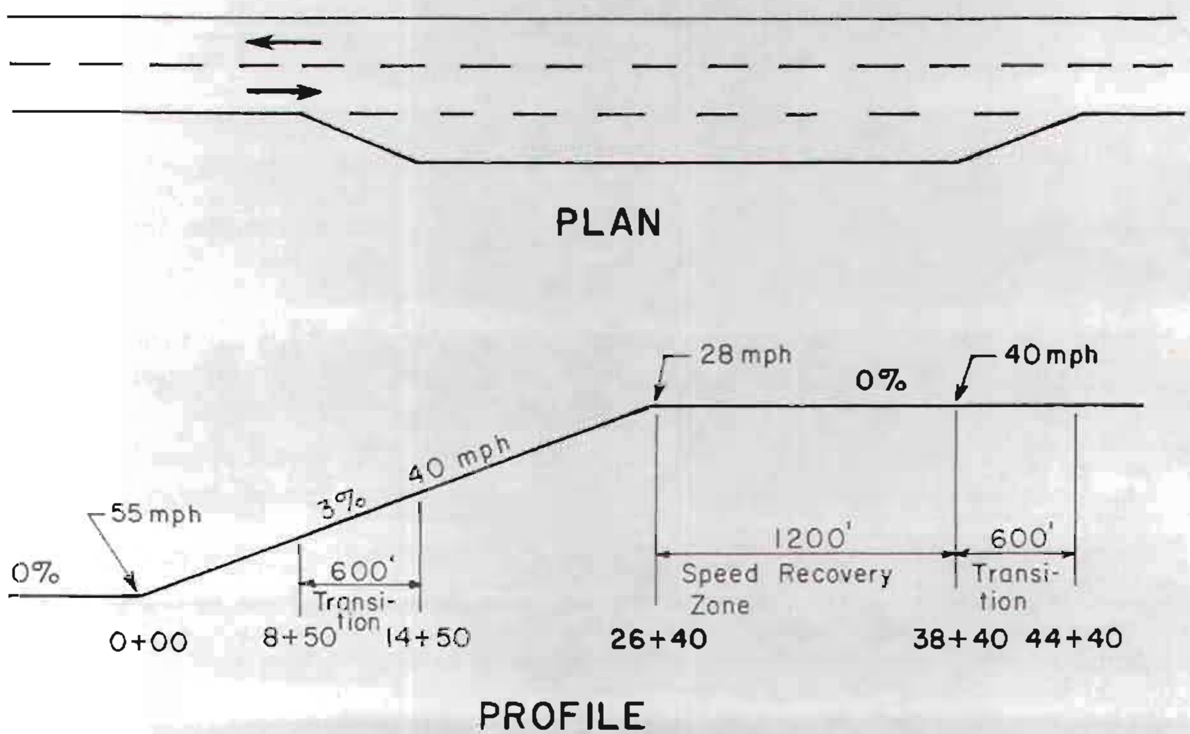
Recalling the ADT to DHV conversion equation and restating it for this example:

$$DHV = ADT \times \left[\underbrace{K \times D_p(1 + T(E_{T_p} - 1))}_{\text{upgrade}} + \underbrace{K \times D_{op}(1 + T(E_{T_{op}} - 1))}_{\text{downgrade}}\right]$$

$E_{T_p} = E_{T_{peak}} = 10$ (Figure 4-1A of this Manual)

$E_{T_{op}} = T_{T_{off\ peak}} = 2$ (ibid)

Figure D-26 (continued)



PLAN
28 mph
40 mph
0%
40 mph
3%
55 mph
0%
1200'
600'
600'
Speed Recovery Zone
Transi- tion
Transi- tion
0+00
8+50
14+50
26+40
38+40
44+40
PROFILE

Figure D-26

APPENDIX E-100

ECONOMIC ANALYSES (E-100)

E-101 INTRODUCTION

Economy in highway construction has been a part of design decision-making from the beginning. The purpose of this Appendix is to provide the Engineer a design tool specifically applicable to evaluating design choices. It is anticipated that the discussion and sample problems contained herein will clarify the objectives of cost evaluation in the design process and promote application of these principles in all areas of design.

The following, from NCHRP Report 122 (Ref. 3), defines engineering economy and provides some insight into the scope and application of this type analysis.

"Engineering economy has to do with the analysis of proposed engineering works, equipment, and processes for the purpose of comparing the worth of the economic gains expected to result from the proposed investment with the economic cost required to produce the gains. Engineering economy is a comparison of the input cost with the net output of revenues, benefits, gains, or profits to determine whether the proposed design or whether the proposed facility is economically feasible. In addition to determining economic feasibility, the process of analysis is also used to determine the most economical design with reference to those factors of design over which the engineer has some choice.

"In much of the application of the principles and procedures of engineering economy to highway transportation there is no dollar cash sales or income involved. However, there are the dollar values of the benefits to the road user, or to the community as a whole, that are the equivalent of income when they can be priced on a dollar basis. It is always possible, of course, to estimate the costs of construction, operation, and maintenance of a specific public works or highway proposal.

"In this particular type of analysis, only those factors that involve the input and output consequences that can be evaluated on a dollar basis are included. Certain other economic and social factors of consequences involved are not included in the analysis for economy because they cannot be priced on a dollar basis. These irreducibles (or nonmarket items, as they may be called) involve a broad scale of consequences, including the effects on business and industry and the community factors that are altered because of the highway improvement. These items are considered separately and given such weight as the decision maker thinks is reasonable.

"As presented, highway engineering economy is not intended to include all costs and all net benefits of highway construction, but only those factors that are affected directly by highway engineering decisions and that can be dollar priced. Therefore, highway engineering economy analysis deals primarily with highway costs, motor vehicle running costs, and other cost or benefit factors pertaining to the road users. This process in no way indicates that the general social and economic consequences are of less importance than are the road-user consequences, but separates them primarily because of necessity in the process of making an economic analysis."

At all times it should be noted that an economic evaluation is a design tool which, when used in conjunction with sound engineering judgment, will aid the designer in making design decisions.

E-102 COST EVALUATION IN HIGHWAY DESIGN AND CONSTRUCTION

The Engineer is faced with many decisions in the process of highway design and construction. Although an actual cost evaluation may not be made, economy is the basis for many of these decisions. As design variables become more complex, cost evaluation becomes a valuable index of cost effectiveness of particular design variables.

In general, there are three types of cost evaluation which will be discussed in this Appendix. These are: (1) overall project design; (2) stage construction application; and (3) design of particular elements. It should also be noted that cost evaluation is useful in project conception. This type analysis, however, involves in-depth study of non-road user consequences, and will not be covered in this Appendix.

A. Overall Project Design

At some point, basic design criteria must be established which will govern in later design decisions involving particular design elements. Such items as whether the facility will be elevated or depressed, controlled access with frontage roads, multilane divided or multilane with continuous left-turn lane, etc., are representative of design decisions which must be made early in design development.

Heretofore, decisions concerning these items have been based on engineering judgment, past experience or community desire. However, it may be worthwhile to evaluate these items from a cost standpoint especially when design alternates are considerably widespread in cost and operational characteristics.

B. Stage Construction Application

In many instances, stage construction is a viable alternate which should be considered since it is often possible to defer large expenditures without undue inconvenience to the public by using stage construction.

Cost evaluation for stage construction is somewhat more complex in that investments, user costs and maintenance expenditures are made at more than one point in time and vary depending on the sequence improvements are made. It is important to keep expenditures relative to the point in time they occur, in order to realistically establish comparative results.

C. Design of Particular Elements

The simplest form of cost evaluation compares two elements of design. In such cases parameters are usually easy to define and the analysis is usually straightforward. It is noted that this case is most prevalent. This Appendix, therefore, will dwell primarily on this aspect of cost analysis. For more complex problems, we refer the reader to *A Manual on User Benefit Analysis of Highway and Bus Transit Improvements, AASHTO, 1977.*

E-103 DEFINITION OF PARAMETERS

There are six basic parameters associated with cost evaluation. General definitions of the parameters are as follow:

A. Investment Cost

Initial right-of-way and construction cost and/or subsequent right-of-way or construction cost associated with a particular improvement or design.

B. Terminal Value

Certain types of highway facilities and appurtenances may have a terminal value at the end of the period used in the analysis. Such value, in effect, is a recovery of invested capital and becomes a factor that reduces the capital cost from the level of the original investment.

In most analyses for economic evaluation and for project formulation the terminal value may be assumed to be zero. Its discounted value is often small, its value is highly uncertain and, as between mutually exclusive alternatives, its value will not vary appreciably. Therefore, its omission will usually not affect the results significantly.

C. Maintenance, Operation and Administrative Costs

Highway maintenance cost is the cost of keeping a highway and its appurtenances in serviceable condition.

Where no better data is available, maintenance costs can be approximated by using maintenance appropriations for the particular type facility being studied.

D. User Costs

1. Road-User Costs and Benefits

The benefits to the road user of highway improvements arise almost wholly from reducing the cost of travel from its present level. Travel cost reductions and benefits include: (1) reductions in motor vehicle running cost, (2) reductions in travel time, and (3) reductions in traffic accident cost. Thus, these travel factors are related to the alternatives of highway design in the normal procedure of calculating the relative economy of the alternative being considered.

2. Vehicle Running Cost

Distance traveled is directly related to vehicle cost such as fuel, lubricants, tire wear, vehicle depreciation and maintenance. The vehicle operator is often willing to sacrifice operating cost by traveling a longer route if a savings in travel time is realized. Estimated vehicle miles are based on projected traffic volumes and distance traveled on the facility. Generally, the unit values per vehicle mile are for passenger cars and trucks; however, specific values for a given highway, based on the operational and physical characteristics of the same, should be determined in each case.

Figures E-2 through E-5 present graphically the relation of geometric features and operational characteristics to vehicle running cost.

3. Travel Time

One of the greatest benefits that can be realized from any roadway improvement is a reduction in travel time. To commercial operators, travel time is directly related to driver's wages, equipment cost and maintenance. The savings in time for passenger vehicles are not as great per unit as for trucks and buses; however, all vehicle operators are attaching an increasing importance to and are willing to pay for travel on facilities that result in a saving of time. Total travel time can be estimated from projected traffic volumes, average running speeds and anticipated delays at intersections. Unit values to be used are $7.50 to $8.00 per hour per truck and $2.50 per hour per passenger car. The relationship between approach speed, standing delay and cost per vehicle stop is illustrated in Figure E-11.

In urban areas, where approximately one-half of the trips are work-oriented, it may be appropriate to raise the value of travel time to reflect the average hourly income of the traffic flow.

4. Accident Cost

The cost of motor vehicle accidents could be a major component of road-user cost and, as such, it would be an important element for inclusion in road-user benefit analysis. However, while there are many types of accident data, the statistics available are general and usually do not provide the desired correlation with highway design and operation necessary for direct application in a road-user benefit analysis. Therefore, inclusion of accident cost in a road-user benefit analysis should be at the District's discretion.

Certain types of hazards associated with highway geometrics and appurtenances can justify spot improvements on existing highways. A procedure has been developed by the Safety Section of File D-18 and accepted by the Federal Highway Administration for use in such cases.

E. Discount Rate

The discount rate for performing present value calculations should represent the opportunity cost to the taxpayer, i.e., the estimated average market rate of return that would be achieved if more public transportation funds were left in private hands rather than being paid to the government in taxes.

A range of 6 to 12 percent is common in current economy studies of public projects; for example, the U.S. Office of Management and Budget recommends a 10 percent discount rate for Federal Government economy studies. The possible effects of uniform future price increases (inflation) should be ignored.

Because the results of the net present value calculations are sensitive to the discount rate, the analyst may wish to perform the economic calculations at two or three alternative discount rates. However, all final comparisons of projects should be made using a consistent value of the discount rate. It is recommended that a discount rate of 10 percent or greater be used.

F. Analysis Period

The period of time over which an analysis is to be made should be based primarily on the ability of the analyst to forecast the future. One of the principles of analysis for economy is that the benefits to be received from the facility should be included in the analysis over the same future time as are the forecasts of highway costs. Because perhaps 20 years is a maximum for a general highway facility for which the traffic volume can be estimated within an acceptable degree of reliability, it is probable then that the analysis for economy should likewise not exceed a period of 20 years. On the other hand, for specific types of facilities, particularly for traffic control devices, a period much shorter than 20 years would be in order. The main thing is to stay on sound ground insofar as estimates of the future are concerned.

In project formulation, the type of materials or particular devices to be used may have different service lives due to variations in physical durability. It is important in such cases to make the analysis over the best estimate of service life that can be achieved.

Variations in the above parameters from the values used to prepare Figures E-1 through E-6 may be appropriate when special conditions warrant. However, for most studies, the following nomographs can be assumed to apply with little error reflected in the results when compared to an in-depth study which would specifically set values for these parameters.

G. Modeling Hourly or Daily Benefits

The nomographs and tables in this Manual provide estimates of hourly traffic costs for those cases where wide traffic variations during the day make separate user benefit calculations advisable for significantly different traffic considerations. In most cases, it will be sufficient to calculate benefits for a typical peak hour and a typical off-peak hour. The daily benefit estimate may then be obtained through weighing these estimates by the number of peak and off-peak hours in the day.

In order to represent or model all daily traffic within peak and off-peak periods, it is suggested that the traffic in minimum traffic hours be added to off-peak traffic and minimum traffic hours be represented as having zero traffic. The total peak and off-peak hours will then add up to less than the total hours in a day. A model day of 18 hours is suggested with traffic in the six hours from 12 midnight to 6 a.m. added to off-peak traffic.

As an example of the above suggestion, if two one-way peak hours per weekday and two per weekend of the same magnitude are assumed together with 16 off-peak hours per weekday and 34 per weekend, then total annual traffic would be represented as follows:

	One-way Hours	Two-way Hours
2 peak hours × 253 weekdays	506	
2 peak hours × 56 weekends (taking 8 holidays as equivalent to 4 weekends)	112	
Total peak hours per year	618	1236
16 off-peak hours × 253 weekdays	4048	
34 off-peak hours × 56 weekends	1904	
Total off-peak hours	5952	5334
Total hours in model (18 × 365)	6570	6570

In cases where AADT is the only traffic estimate available, users of the Manual can derive peak and off-peak traffic levels through K and D factors. To assist in this process for average conditions, Figure 1 provides a nomograph for estimating peak and off-peak traffic levels from AADT per lane and the number of peak hours in the day. The upper lines in Figure E-1 are regressions based on actual hourly vs AADT traffic observations, from the HCM. They show the relationship between *AADT per lane and average 30th and 100th hour traffic volume per lane.* The product of K and D factors implied by these curves is indicated at selected points along the curves.

Use of Figure E-1 is illustrated on the figure itself. Note that the off-peak volume calculation is incorporated in the lower curves of Figure E-1 for cases in which daily one-way peaks occur at the rate of 1, 2, or 3 hours a day for 365 days a year (or less regular peak hours can be converted to an average daily rate). The lower curves are based on an average of the upper curves, and will serve for approximating average off-peak hourly volume within ± 3 percent for an 18-hour model day, as suggested earlier.

An important aspect of this procedure is that Figure E-1 cannot be used for bottleneck sections because it will never result in more peak period hourly traffic than 2,000 vph (which serves in effect as an upper asymptote for the graph). One way of obtaining the correct demand volume for bottleneck sections is to use the estimated peak period hourly demand in the upstream section as derived from Figure E-1.

The capacity for two-lane highways is generally expressed as two-way capacity (e.g., 2,000 vehicles per hour) rather than capacity per lane because capacity in one direction is reduced by traffic in the opposite direction. For one-way analysis during a single typical hour of the day, half the hourly capacity can be used. For more precise analysis, as during a peak hour, peak direction capacity can be estimated by subtracting from two-way capacity the estimated hourly traffic in the non-peak direction during the peak period. For example, if two-way capacity = 2,000 vph (vehicles per hour) and peak period traffic in the off-peak direction = 800 vph, then peak period capacity in the peak direction = 2,000 − 800 or 1200 vph.

In cases where there is no need to analyze peak and off-peak traffic separately, Manual users can estimate average daily highway user benefits through using a single typical hour and multiplying by the number of such hours in the model day.

Conversion of daily highway user benefits to annual benefits is accomplished by multiplying average daily benefits by 365.

E-104 NOMOGRAPHS

The following nomographs (Figures E-1 through E-10) and corresponding discussions are taken from *A Manual on User Benefit Analysis of Highway and Bus Transit Improvements, AASHTO, 1977*. The methodology promoted in this publication is condensed and somewhat simplified in this Appendix for easy application in economic analysis of highway projects. Also presented is a methodology for analyzing spot improvements.

A. Basic Section Costs

The nomographs in Figures E-2 through E-5 enable direct calculation of B, basic section costs, as a function of the level of traffic (v/c ratio) or the average running speed.

Examples illustrating the use of these figures are provided on the passenger car nomographs, Figures E-2 through E-5. The nomographs are entered at the lower left, either with v/c ratios (estimated by the analyst for the representative hour of operation of the analysis section) or with average running speed. The analysis proceeds to determination of travel time, the inverse of running speed, portrayed on the left-hand scale of the lower left-hand graph of Figures E-2 through E-5, tangent running costs, and added running costs due to curves. Then added running costs due to speed change cycles are derived by entering the upper left-hand graph with the v/c ratio from the lower left-hand graph. The indicated costs of speed changes are minor except for level of service F (queuing) conditions.

When a large percentage of the traffic stream consists of trucks, it may be necessary to refer to nomographs in *A Manual on User Benefit Analysis of Highway and Bus Transit Improvements, AASHTO, 1977* to determine more correctly the impact of trucks in the economic analysis. However, when the percentage of trucks in the traffic stream is relatively small, equivalent passenger cars can be found by assuming one truck equals three passenger cars. Then the nomograph included in this Appendix can be used with negligible error.

Examples 1 and 2 are taken from *A Manual on User Benefit Analysis of Highway and Bus Transit Improvements, AASHTO, 1977.*

B. Section Transition Costs (T)

The basic section costs discussed in the previous section represent user costs incurred by vehicles running along a section with uniform physical and traffic characteristics. When a vehicle passes between sections with different physical or traffic characteristics, small but measurable additional running costs may be imposed on highway vehicles to slow down or speed up in accordance with different operating conditions on the adjacent sections. For example, a vehicle on a level tangent section of highway must slow down when entering and traversing a curved section of highway. A vehicle traveling in the opposite direction would be able to speed up in passing from the curved section to a straight section having a higher design speed.

In this Manual, the additional costs imposed by such changes in operating conditions between adjacent sections are termed transition costs, denoted by T, and should be added to vehicle running costs. It is arbitrarily suggested that transition costs be added to the downstream section, except for the last section analyzed which should include transition costs at both ends.

Transition costs are calculated from differences in the average running speeds in the upstream and downstream analysis sections. Estimation of running speeds is a by-product of basic section cost calculations based on the speed-flow relationships noted in the lower left-hand chart of Figures E-2 through E-5 or on any other data providing running speed estimates by section. Where estimated speeds on adjacent sections are different, transition costs will exist and can be calculated using Figure E-6.

The chart on Figure E-6 indicates the additional running cost experienced by passenger cars in changing speeds because of different operating conditions on adjacent sections. Adjustment factors to reflect the existence of trucks in the traffic stream are also provided. The example provided illustrates the use of this figure.

An assumption of equal two-way traffic is embedded in Figure E-6 because the costs indicated are equal to one-half the excess running costs associated with a full speed change cycle*. This is consistent with the usual analysis of traffic for a single direction and later multiplication by two to obtain two-way results. In such cases, transition costs due to decelerations in one direction will be complemented by an equal number of accelerations in the opposite direction, producing complete speed change cycles.

Where separate directional analyses are necessary, e.g., where total traffic over an entire day in one direction is significantly different from that in the other direction, or where running speeds on a given section are always different in different directions, costs derived from Figure E-6 should in theory be modified to show differential effects for each direction of traffic (e.g., higher cost for acceleration phase of the cycle than for the deceleration phase). Speed change cost data is normally expressed in terms of speed change cycles, however, and little empirical evidence as to added costs for the acceleration or deceleration phase only is available. Where the analyst possesses such information, it could be used to modify results from Figure E-6.

C. Choice of Study Years

The most accurate calculation of the present value of a stream of benefits of costs requires an estimate of annual benefits and costs for each year of the analysis period. Since calculation of year-by-year values is laborious, most analysts choose only two years of the study period and extrapolate or interpolate for the other years. Sensitivity checks show that this procedure typically leads to negligible errors. Even if calculations are facilitated by a computer program, the use of only two analysis years may be efficient because it permits more detailed modeling at the same cost as cruder modeling of all years. However, if extreme congestion, with extensive queuing, is anticipated at some point within the study period, it would be best to include an example of such a year as one of those chosen for analysis.

*Speed change cycle costs are usually expressed as excess running cost above that experienced by continuing at a uniform speed and are usually expressed in terms of reducing speed from an initial speed to an intermediate speed and accelerating back to the initial speed.

Figure E-7 enables the analyst to calculate the present value of any stream of annual values using only the estimates of two years' values, an early year and a later year. After calculating the ratio of these two values, the figure provides a present worth factor which, when multiplied times the first year's value, yields a close approximation of present value of the entire stream. An example at the right of the figure illustrates the use of the procedure.

D. Intersection Delay Costs (D)

Intersection delay costs consist of additional time and running costs due to slowing down to and speeding up from a stop caused at an intersection or by a traffic signal, and from idling while stopped. Such costs, symbolized by the letter D, are calculated on a per thousand vehicle basis and should be added to previous estimates of basic section costs and transition costs.

Intersection delay costs depend primarily on the type and configuration of the traffic control devices employed, the level of traffic on the section, and the speed at which the stop or signal is approached. Figures E-8 and E-9 are provided to facilitate the calculation of stopping and idling costs as functions of the above factors. Examples provided on the figures illustrate their use. Approximate adjustment factors are also provided to account for trucks in the traffic stream.

These figures are based on Webster's equations for computing delays at signalized intersections with fixed time signals. The use of these figures (including applications to stop signs) is discussed below.

Figures E-8 and E-9 require data on the following parameters of the signalization and traffic of the intersection under study:

1. Green-to-cycle time ratio (λ): The ratio of effective green time of the signal to the cycle length of the signal, both expressed in the same unit of time (usually seconds). In terms of the HCM, effective green time is the actual green time of the signal. If the HCM is not used, effective green time is defined as the total available for vehicular movement. (If it is assumed that the part of the yellow interval used for vehicular movement and the time lost while the queue gets in motion are equal, then both methods of defining effective green time are equivalent.) The cycle length of a signal is the total time taken for display of all of the several indications provided by the signal.

2. Saturation flow (s): In terms of the HCM, saturation flow is the approach volume in vehicles per hour of green time that is found for the intersection when the load factor is 1.0 and the appropriate adjustment factors are applied. In the absence of HCM solutions, recommended values for saturation flow are 1,700 to 1,800 vehicles per hour times the number of approach lanes.

3. Capacity (c): Where the HCM is used, capacity is the service volume of the approach at a load factor of 1.0. It is also equal to the saturation flow times the green-to-cycle time ratio.

4. Degree of saturation (x): The ratio of the volume of traffic approaching the intersection (usually in vehicles per hour) to the capacity of the intersection (usually in vehicles per hour).

5. Approach speed: Also termed "midblock speed," this is the average running speed at which the signalized intersection is approached by the vehicle stream. Where the distance between signals (signal spacing) is one quarter mile or greater, approach speed can generally be estimated according to the speed flow relationships of Figures E-2 through E-5 or other such relationships. Alternatively, a midblock speed equal to the prevailing speed limit is often a good approximation to approach speed where congestion is not a factor. Where signal spacing is such that one signal affects the traffic at an adjacent upstream or downstream signal or under situations of significant congestion, approach speeds may have to be estimated empirically.

Figure E-8 aids in the estimation of added intersection delay costs due to stopping. The lower left-hand chart is entered with degree of saturation and the green-to-cycle time ratio and determines first the percentage of the traffic stream that is caused to stop at least once at the signal (or, equivalently, the average stops per vehicle per signal). The formula from which the lower left-hand chart of Figure E-9 is derived is given by

$$E = (1-\lambda)/(1-\lambda x)$$

where E is the proportion of traffic required to stop and the other parameters are as defined above. The percentage of vehicles that stop are then transformed in the two lower right-hand charts of Figure E-8 to determine added time and running cost due to stopping which, on a unit or per thousand-vehicle basis, can be associated with the total traffic stream. Time cost adjustment factors are based on assumptions that truck speeds are generally 10% less than equivalent passenger car speeds and that the unit value of time is 2.33 that of passenger cars for single unit trucks and 2.67 times that for 3-S2 combination trucks.

Figure E-9 aids in the estimation of idling costs. Entering with a degree of saturation, intersection capacity, and green-to-cycle-time ratio enables one to determine the intersection idling delay averaged over all vehicles in the traffic stream. Multiplying average delay per vehicle in seconds by 0.2778 converts delay into corresponding hours per thousand vehicles. Passenger car idling costs are then derived using a figure of $0.3126 per hour of idling.

Average delays at stop and yield signs do not normally lend themselves to analytic derivation and are generally influenced by the configuration of such signs, the traffic volumes through the intersection (especially in regard to crossing traffic), and the turning patterns that characterize the intersection. Once an average delay at a stop sign is estimated, however, Figures E-8 and E-9 can be used to estimate associated intersection delay costs. Where all vehicles can be assumed to stop at a stop sign (only a fraction may do so at a yield sign) a green-to-cycle-time ratio of 0.0 can be assumed in Figure E-8 such that the average stops per vehicle is 1.0. Added stopping time and cost at a stop sign can then be determined along the top of the lower charts in Figure E-8 as a function of approach speed.

In addition, once the average delay per vehicle at the stop sign is determined, idling time and costs can then be easily estimated using Figure E-9.

The analysis of intersection delay often requires separate calculations for each direction of approach, especially where opposing and/or crossing approaches have unequal traffic flows or different characteristics (e.g., number and types of lanes, capacity, signalization parameters, etc.). Where, however, intersection characteristics are similar, results of the analysis of one intersection or approach may be multiplied by the appropriate number of similar situations to obtain an overall result. For example, if there are three signalized intersections of approximately the same characteristics included in the overall roadway being analyzed, one intersection might be analyzed and the results multiplied by three. Also, where differing traffic flows in opposing directions during a given time period are offset or reversed according to, say, A.M. and P.M. peaks and all other characteristics are the same, multiplying results of a one-directional analysis by two to obtain two-way results is appropriate.

The condition of intersection congestion or queuing—analogous to level of service F conditions for basic section costs—is implied where potential traffic volume exceeds intersection capacity and therefore the degree of saturation would exceed 1.0. As indicated in Figures E-8 and E-9, a degree of saturation of 1.0 implies that all vehicles in the traffic stream would stop at the signal at least once and that average delay per vehicle would at least equal the signal cycle time. Average delays equal to signal cycle time are generally sufficient to represent conditions of queuing at signalized intersections since additional increments of delay associated with further increments of congestion are small relative to total cycle time, and it can often be assumed that traffic would be diverted to other parts of the network under more extreme conditions of queuing. NCHRP Report 133 should be referred to if assistance is needed in estimating the effect of queues in interrupted flow beyond assuming average delay to be equal to signal cycle time.

The HCM should be consulted for determination of the effects of turning movements at intersections on the capacity of the affected legs.

E. Road Surface

Two types of unpaved roads may be distinguished for practical purposes: those with loose surfaces and those that are completely unsurfaced. A loose surface is one for which a surface of loose stone, rock or gravel has been added to the basic alignment and grading. An unsurfaced or earth road provides only the graded and smoothed right-of-way itself for use by the vehicles.

The data presented in Figures E-2 through E-5 for basic section costs are for paved facilities only. The costs of operating vehicles on an unpaved section can be derived by application of an adjustment factor to the vehicle running costs for paved sections. These factors are greater than one because the motion of a vehicle on an unpaved surface meets with greater rolling resistance and hence requires more fuel than travel at a similar speed on a paved facility. Traction may also be lower because of a lower coefficient of friction for the tire contact with the road, causing power losses when accelerating or negotiating grades or curves. The roughness of the surface contributes to additional tire wear and may influence the maintenance and repair expenses incurred in keeping the vehicle in operation.

While the effect of these influences on costs could be evaluated precisely for a particular type of unpaved facility, the wide variation in actual surface conditions makes such precision useless in application. Nor is the influence of potholes, mud, washboarding, and erosion generalizable in a useful way. Figure E-10, therefore, provides some basic factors for adjusting the vehicle running costs derived for paved roads to approximate the costs on unpaved roads. The effect of such roads on highway speeds will vary with their condition, but in general the design speeds of high-type loose surfaced roads are probably 20% or about 10 mph below similar surfaced roads, and about 15 mph lower for unsurfaced sections.

CONVERSION OF AADT PER LANE TO HOURLY PEAK PERIOD AND OFF-PEAK PERIOD TRAFFIC PER LANE

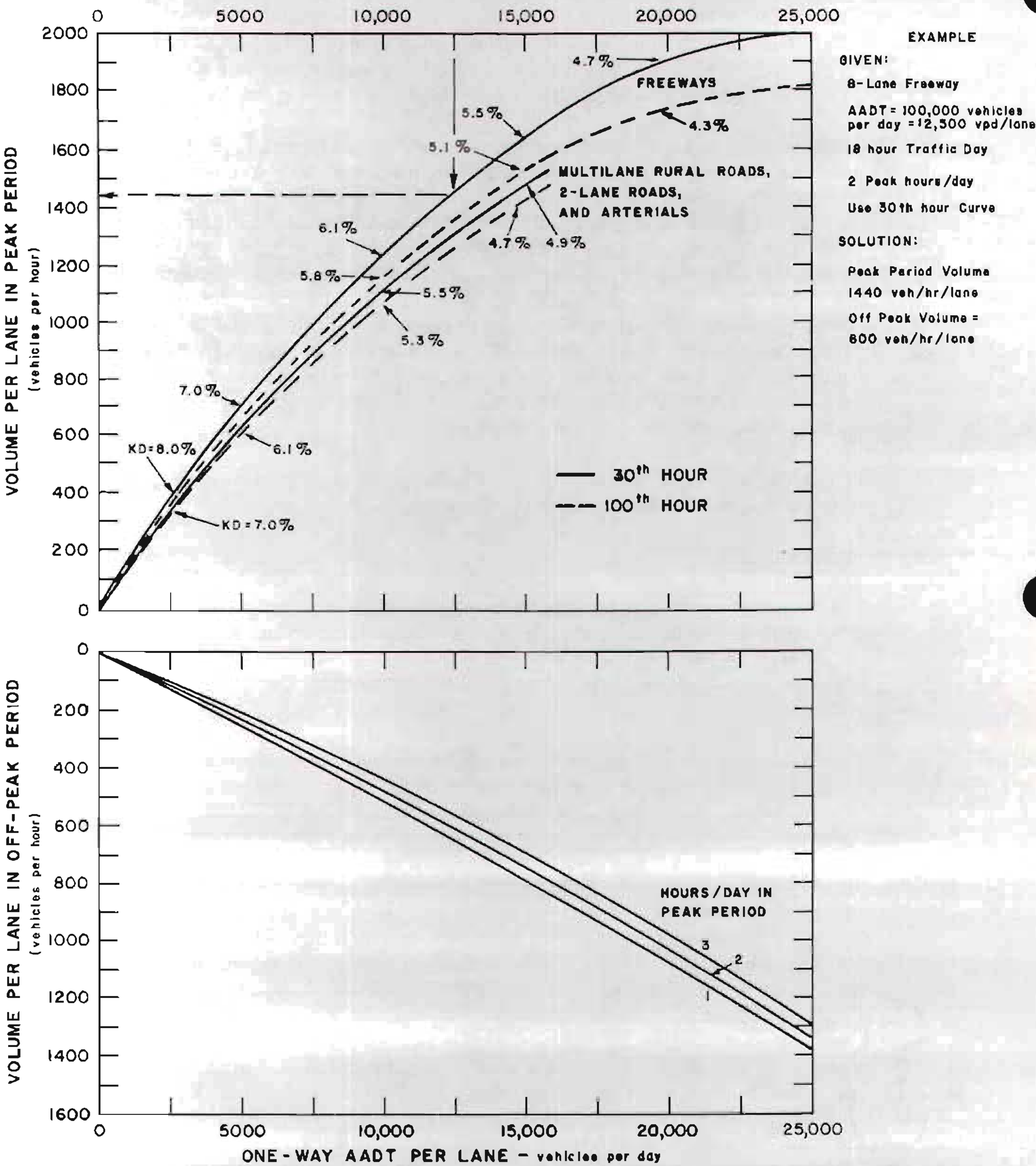
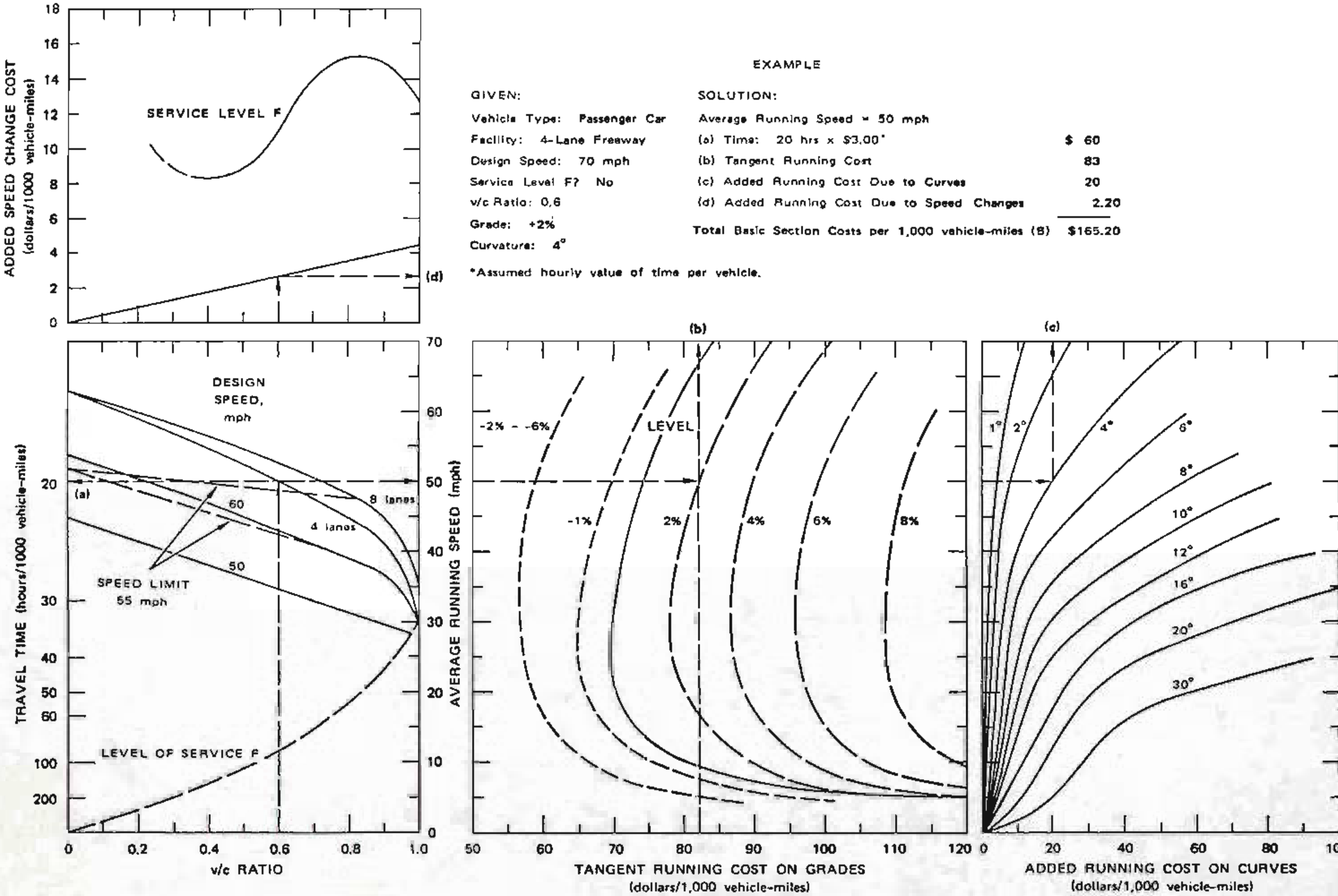


FIGURE E-1



EXAMPLE

GIVEN:

Vehicle Type: Passenger Car
Facility: 4-Lane Freeway
Design Speed: 70 mph
Service Level F? No
v/c Ratio: 0.6
Grade: +2%
Curvature: 4°

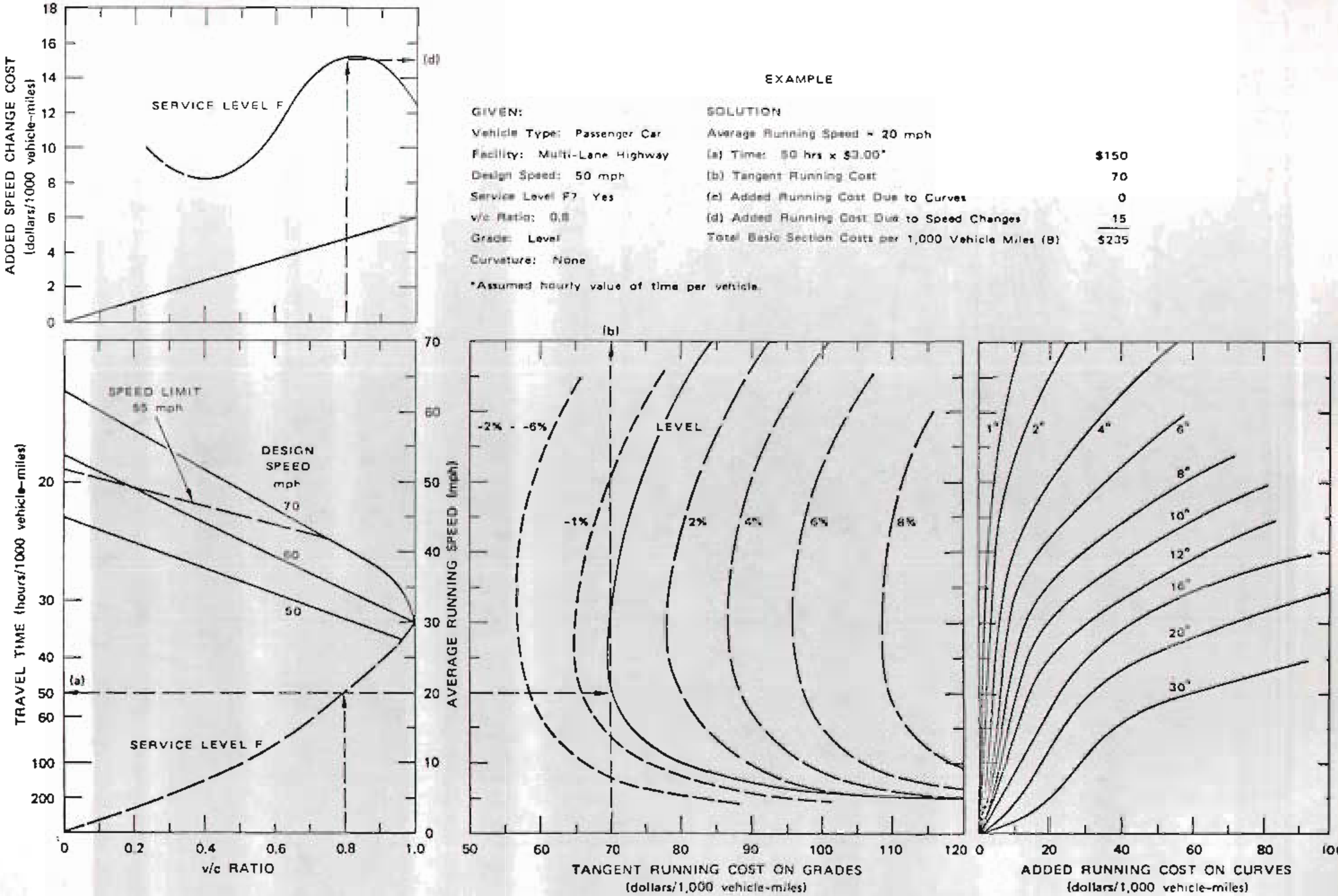
SOLUTION:

Average Running Speed = 50 mph

(a) Time: 20 hrs x $3.00*	$ 60
(b) Tangent Running Cost	83
(c) Added Running Cost Due to Curves	20
(d) Added Running Cost Due to Speed Changes	2.20
Total Basic Section Costs per 1,000 vehicle-miles (B)	$165.20

*Assumed hourly value of time per vehicle.

FIGURE E-2 BASIC SECTION COSTS (B) FOR PASSENGER CARS ON FREEWAYS

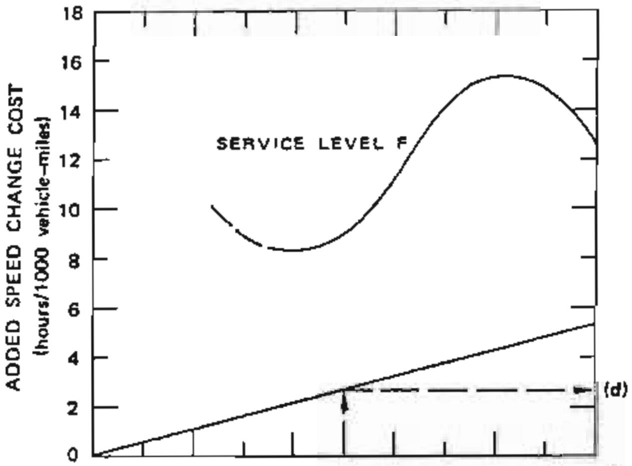


EXAMPLE

GIVEN:	SOLUTION	
Vehicle Type: Passenger Car	Average Running Speed = 20 mph	
Facility: Multi-Lane Highway	(a) Time: 50 hrs x $3.00*	$150
Design Speed: 50 mph	(b) Tangent Running Cost	70
Service Level F? Yes	(c) Added Running Cost Due to Curves	0
v/c Ratio: 0.8	(d) Added Running Cost Due to Speed Changes	15
Grade: Level	Total Basic Section Costs per 1,000 Vehicle Miles (B)	$235
Curvature: None		

*Assumed hourly value of time per vehicle.

FIGURE E-3 BASIC SECTION COSTS (B) FOR PASSENGER CARS ON MULTI-LANE HIGHWAYS



EXAMPLE

GIVEN:

Vehicle Type: Passenger Car
Facility: Two-Lane Highway
Design Speed: 40 mph
Service Level F? No
v/c Ratio: 0.5
Grade: -1%
Curvature: 16°

SOLUTION:

Average Running Speed = 35 mph	
(a) Time: 28.6 hrs x $3.00*	$85.80
(b) Tangent Running Cost:	65
(c) Added Running Cost Due to Curves	60
(d) Added Running Cost Due to Speed Changes:	2.60
Total Basic Section Costs per 1,000 vehicle-miles (B)	$213.40

*Assumed hourly value of time per vehicle.

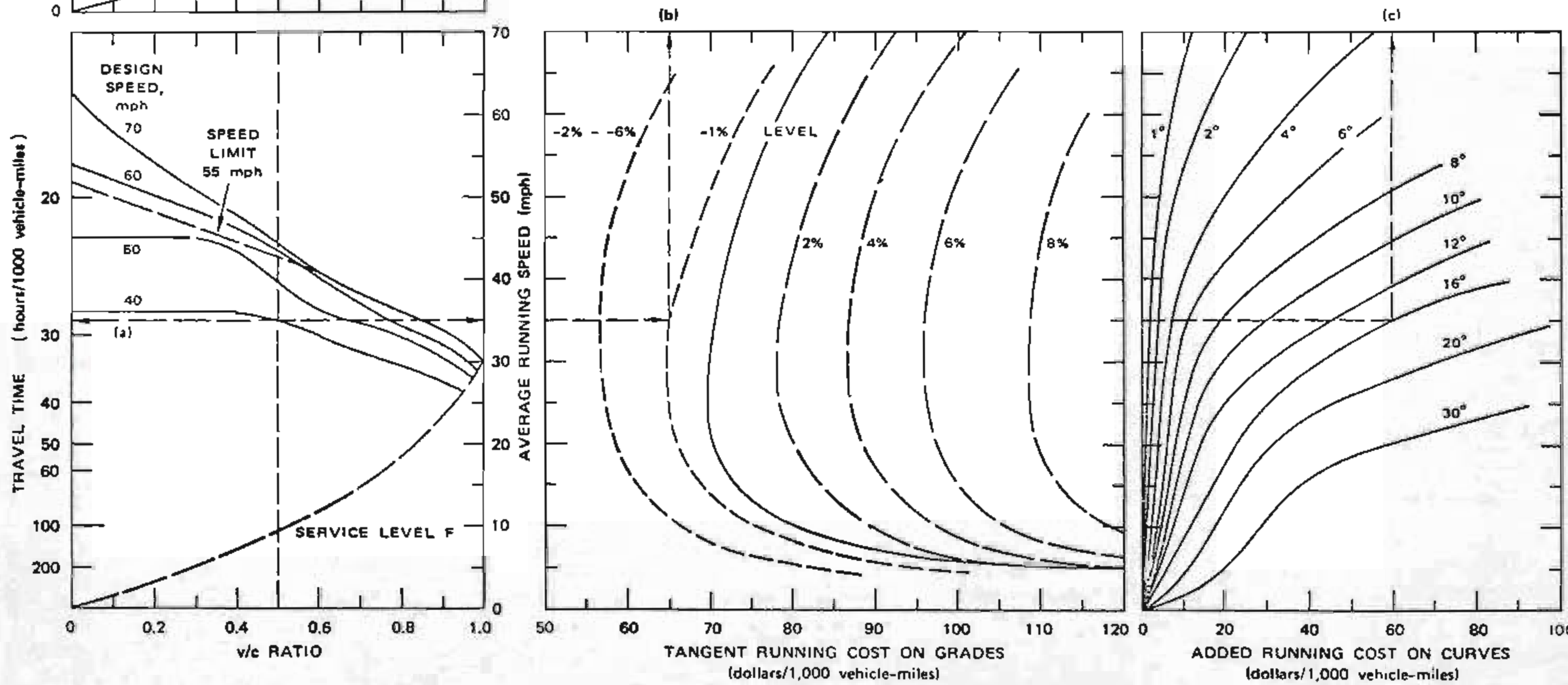
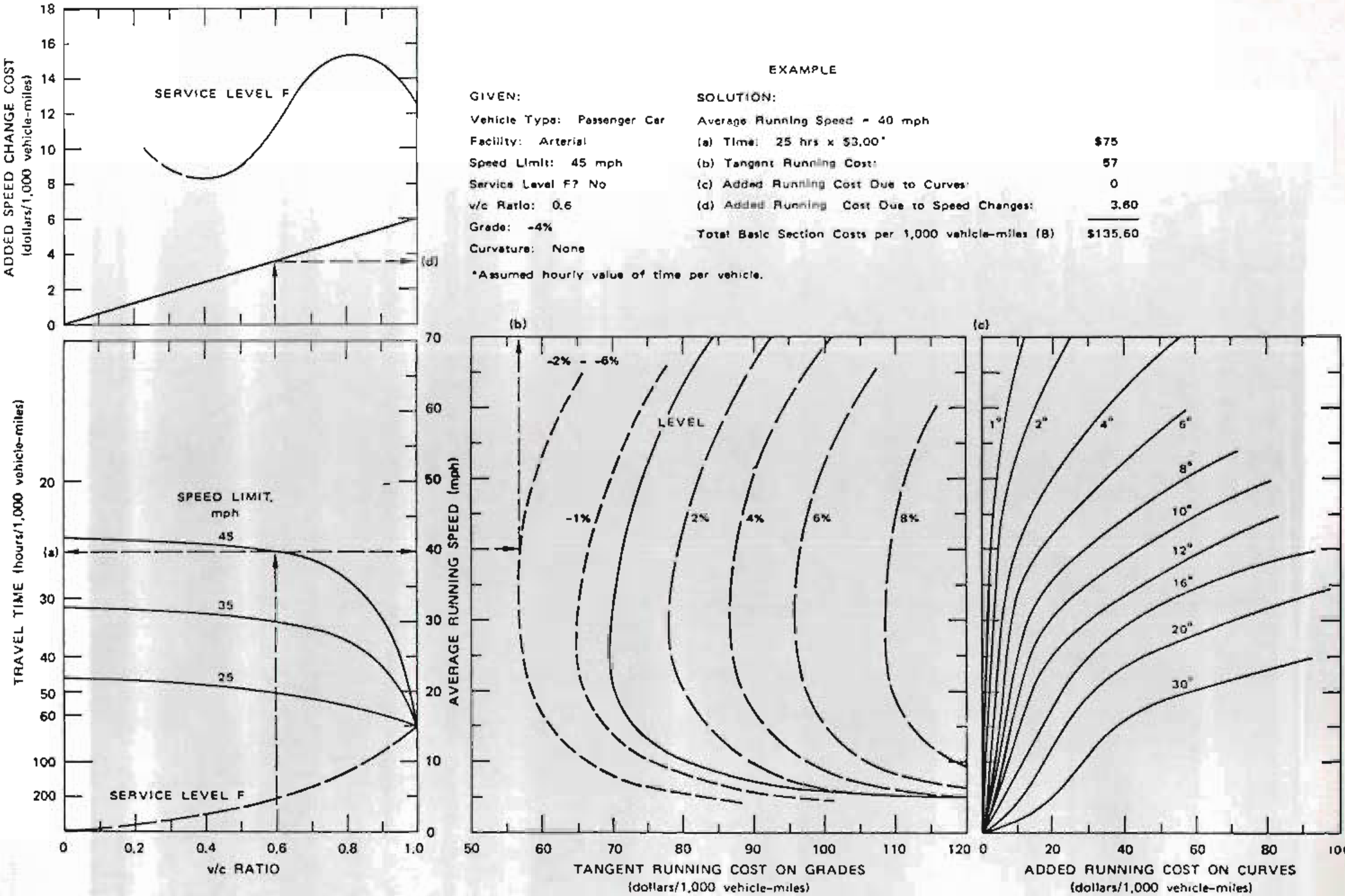


FIGURE E-4 BASIC SECTION COSTS (B) FOR PASSENGER CARS ON TWO-LANE HIGHWAYS



EXAMPLE

GIVEN:

Vehicle Type: Passenger Car
Facility: Arterial
Speed Limit: 45 mph
Service Level F? No
v/c Ratio: 0.6
Grade: -4%
Curvature: None

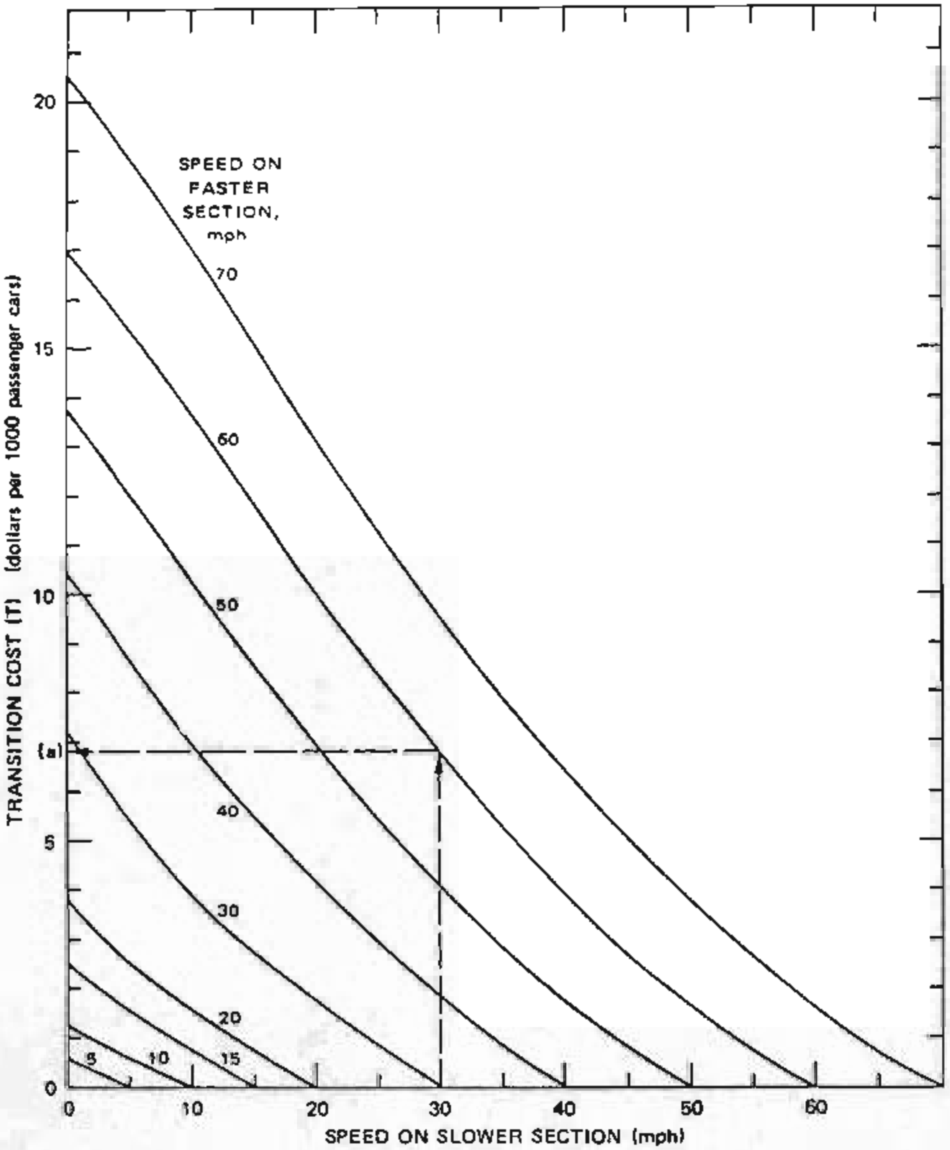
SOLUTION:

Average Running Speed = 40 mph

(a) Time: 25 hrs x $3.00*	$75
(b) Tangent Running Cost:	57
(c) Added Running Cost Due to Curves:	0
(d) Added Running Cost Due to Speed Changes:	3.60
Total Basic Section Costs per 1,000 vehicle-miles (B)	$135.60

*Assumed hourly value of time per vehicle.

FIGURE E-5 BASIC SECTION COSTS (B) FOR PASSENGER CARS ON ARTERIALS



ADJUSTMENT FACTORS FOR TRUCK TRAFFIC

SINGLE UNIT TRUCKS (percent)	3-S2 COMBINATION TRUCKS (percent)											
	0	1	2	3	4	5	6	8	10	20	50	100
0	1,00	1,10	1.19	1,29	1.38	1.48	1.57	1.77	1.96	2,92	5.79	10.58
1	1,02	1.12	1,21	1.31	1.40	1,50	1.59	1.79	1.98	2,94	5.81	–
2	1.04	1.14	1,23	1,33	1.42	1.52	1.61	1.81	2,00	2,96	5.83	–
3	1.06	1.16	1,25	1,35	1.44	1.54	1,63	1.83	2.02	2,98	5.85	–
4	1.08	1.18	1,27	1,37	1.46	1.56	1.65	1,85	2,04	3,00	5.87	–
5	1.10	1,20	1,29	1,39	1.48	1.58	1,67	1.87	$\boxed{2,06}$	3,02	5,89	–
6	1,12	1.22	1,31	1,41	1.50	1.60	1.69	1 89	2 08	3,04	5,91	–
8	1,16	1.26	1,35	1,45	1.54	1.64	1.73	1.93	2.12	3.08	5,93	–
10	1.20	1.30	1,40	1.49	1.59	1.68	1.77	1.97	2 14	3,12	5,97	–
20	1,41	1.50	1,60	1.70	1.78	1.88	1.94	2.17	2.34	3,32	6.17	–
50	2.02	2.12	2.21	2.31	2.39	2.49	2.58	2 78	2.95	3.93	6.78	–
100	3.04	–	–	–	–	–	–	–	–	–	–	–

EXAMPLE

GIVEN:

A stream of traffic consists of 5% single unit trucks and 10% combination trucks. The traffic is travelling at 60 mph and enters a slower section on which the speed is 30 mph.

SOLUTION:

(a) Passenger Car Cost = $6.75

T = $6.75 x 2.06

= $13.91 per 1000 Vehicles

FIGURE E-6 SECTION TRANSITION COSTS

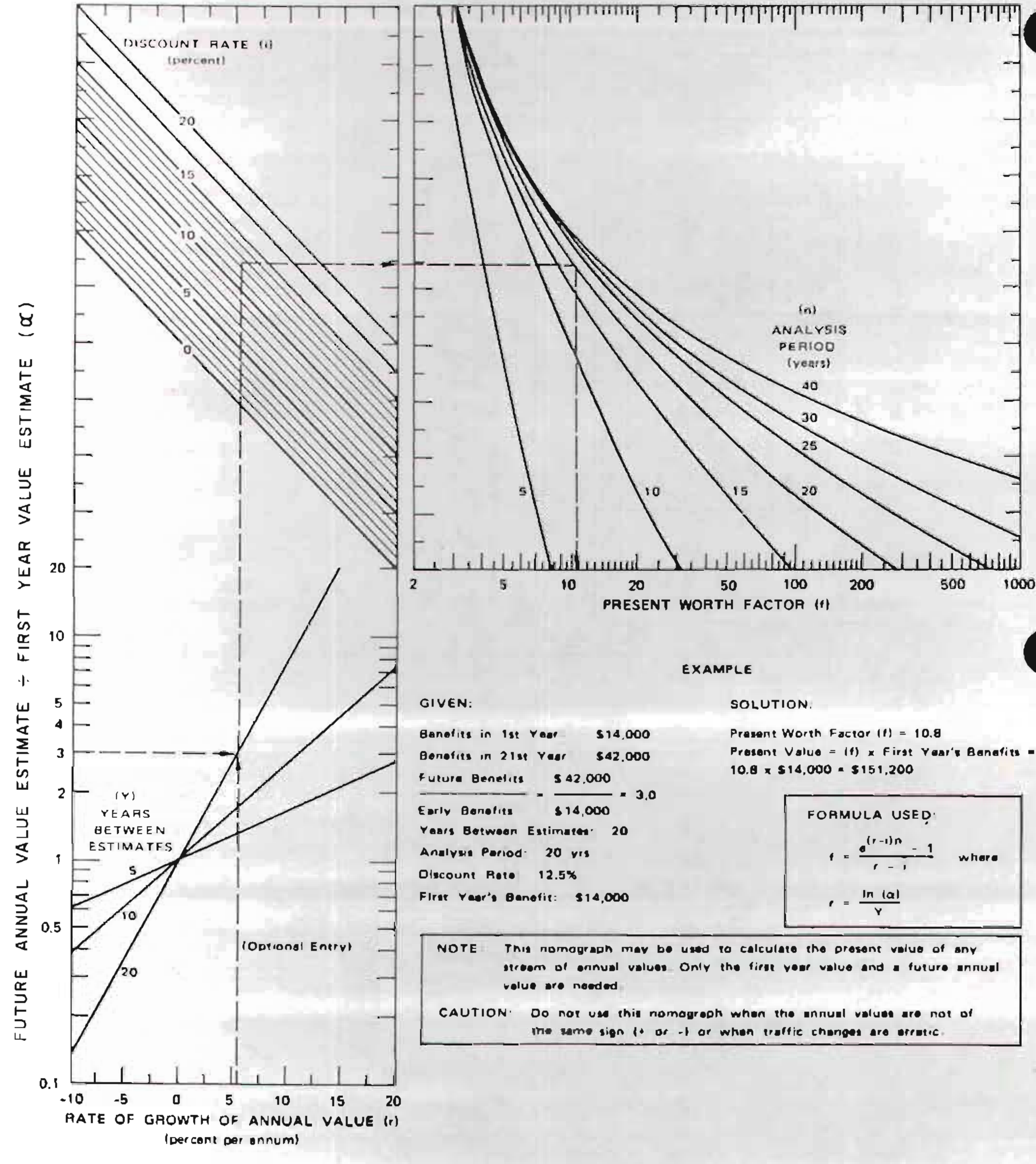


FIGURE E-7 NOMOGRAPH FOR CALCULATING PRESENT VALUE FROM TWO ANNUAL VALUE ESTIMATES

EXAMPLE

GIVEN:

Volume: 480 vehicles/hr
Saturation Flow: 1,600 vehicles/hr
Signal Cycle Time: 60 sec
Effective Green Time: 30 sec
Intersection Approach Speed: 30 mph
5% Single Unit Trucks
5% 3-S2 Combination Trucks

SOLUTION:

λ = 30/60 = 0.5
Capacity of Approach = 0.5 x 1600 = 800
x = 480/800 = 0.6
(a) Average Stops per Vehicle (per Signal): 0.71
(b) Stopping Delay per Signal: 2.5 hrs
(c) Cost of Stopping: $10.30

Time Cost: 2.5 x $3.00* x 1.35†	$10.13
Running Cost: $10.30 x 1.42†	14.63
Total Cost Due to Stopping per 1,000 vehicles per Signal (excludes idling):	$24.76

*Assumed hourly value of time per passenger car.
†Adjustment factors for trucks in traffic stream.

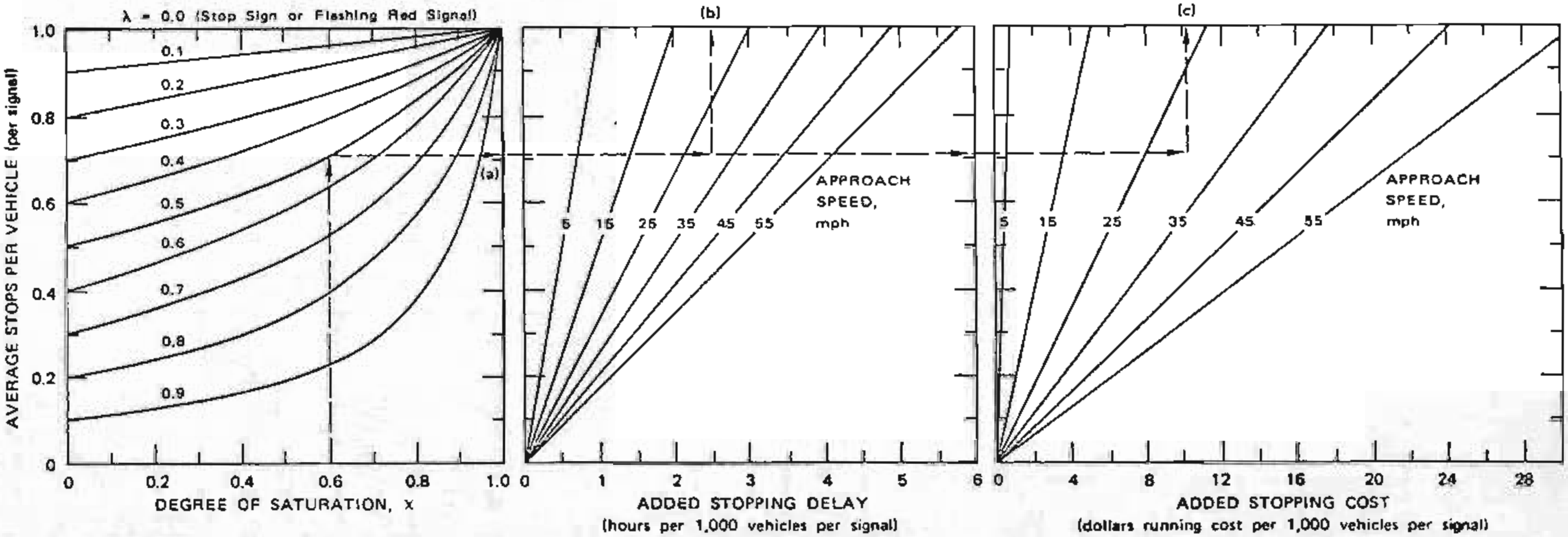
ADJUSTMENT FACTORS FOR PERCENT TRUCKS IN TRAFFIC STREAM

TIME COST

APPROACH SPEED (mph)	SINGLE UNIT TRUCKS (percent)	3 S-2 COMBINATION DIESEL TRUCKS (percent in traffic stream)				
		0	5	10	20	100
5-20	0	1.00	1.15	1.30	1.61	4.03
	5	1.07	1.22	1.37	1.67	–
	10	1.13	1.28	1.43	1.74	–
	20	1.26	1.41	1.57	1.87	–
	100	2.31	–	–	–	–
21-40	0	1.00	1.25	1.51	2.01	6.05
	5	1.10	$\boxed{1.35}$	1.60	2.11	–
	10	1.20	1.45	1.70	2.21	–
	20	1.40	1.65	1.90	2.41	–
	100	2.99	–	–	–	–
41-60	0	1.00	1.41	1.82	2.63	9.17
	5	1.11	1.56	1.93	2.74	–
	10	1.22	1.61	2.04	2.85	–
	20	1.44	1.85	2.26	3.07	–
	100	3.20	–	–	–	–

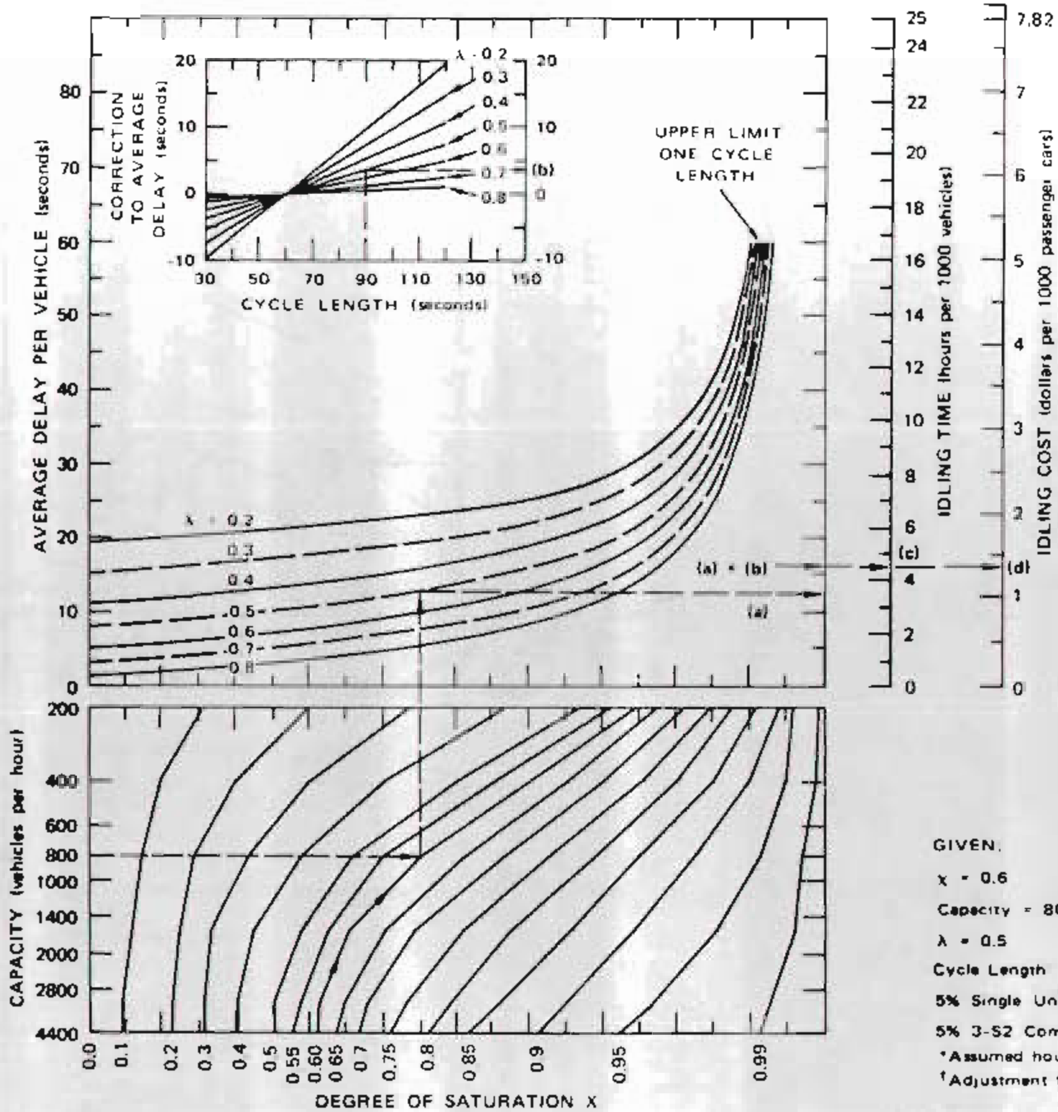
RUNNING COST

APPROACH SPEED (mph)	SINGLE UNIT TRUCKS (percent)	3 S-2 COMBINATION DIESEL TRUCKS (percent in traffic stream)				
		0	5	10	20	100
5-20	0	1.00	1.35	1.70	2.40	8.02
	5	1.08	1.43	1.78	2.49	–
	10	1.18	1.51	1.86	2.57	–
	20	1.32	1.68	2.03	2.73	–
	100	2.62	–	–	–	–
21-40	0	1.00	1.35	1.71	2.41	8.07
	5	1.07	$\boxed{1.42}$	1.78	2.48	–
	10	1.14	1.49	1.84	2.55	–
	20	1.27	1.63	1.98	2.69	–
	100	2.37	–	–	–	–
41-60	0	1.00	1.35	1.70	2.39	7.98
	5	1.06	1.41	1.76	2.45	–
	10	1.12	1.47	1.82	2.51	–
	20	1.24	1.59	1.94	2.63	–
	100	2.21	–	–	–	–



NOTE: Where X = v/λs = v/capacity   s = saturation flow   v = volume   λ = green to cycle time ratio

FIGURE E-8 COSTS DUE TO STOPPING AT INTERSECTIONS (EXCLUDES IDLING)



NOTE Where x = v/λs = v/capacity s = saturation flow v = demand volume λ = green to cycle time ratio

ADJUSTMENT FACTORS FOR PERCENT TRUCKS IN TRAFFIC STREAM

IDLING TIME FACTOR		3-S2 COMBINATION TRUCKS (percent)				
		0	5	10	20	100
SINGLE UNIT TRUCKS (percent)	0	1.00	1.08	1.17	1.33	2.67
	5	1.07	1.15	1.23	1.40	–
	10	1.13	1.22	1.30	1.47	–
	20	1.27	1.35	1.43	1.60	–
	100	2.33	–	–	–	

IDLING COST FACTOR		3-S2 COMBINATION TRUCKS (percent)				
		0	5	10	20	100
SINGLE UNIT TRUCKS (percent)	0	1.00	0.98	0.96	0.92	0.62
	5	0.99	0.98	0.96	0.92	–
	10	0.99	0.97	0.95	0.91	–
	20	0.98	0.96	0.94	0.90	–
	100	0.89	–	–	–	–

EXAMPLE

GIVEN:

x = 0.6
Capacity = 800
λ = 0.5
Cycle Length 90 seconds
5% Single Unit Trucks
5% 3-S2 Combination Trucks

SOLUTION: Average Delay per Vehicle (a) + (b) 16.2 sec
(c) Idling Hours 4.5 hrs
(d) Idling Cost $1.40
Total Delay 4.5 hrs x $3.00* x 1.15† $15.53
Total Idling Cost $1.40 x 0.98† 1.38
Total Cost Due to Idling per 1000 Vehicles (per signal) $16.91

*Assumed hourly value of time per passenger car

†Adjustment factors for percent trucks in traffic stream.

FIGURE E-9 COSTS DUE TO IDLING AT INTERSECTIONS

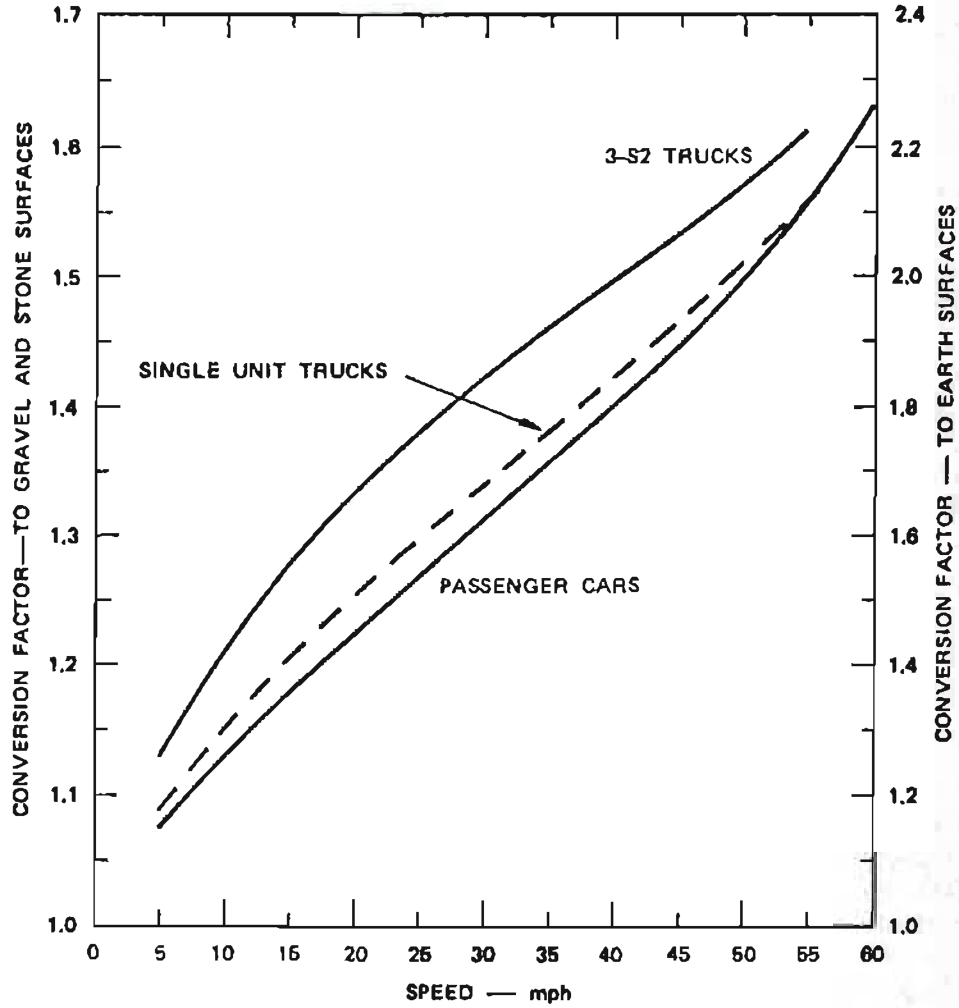


FIG. E-10 MULTIPLICATIVE FACTORS TO CONVERT MOTOR VEHICLE RUNNING COST ON HIGH TYPE PAVEMENTS TO COST ON GRAVEL AND STONE OR TO EARTH ROADWAY SURFACES

E-105 EXAMPLES

Example 1: Curve Elimination

A highway agency is considering eliminating an S-curve on a multilane highway. Because there is only one curve and traffic characteristics are uniform, the analyst may view the improvement as a single section, designated ab. The characteristics of the existing route (alternate 0) and the proposed route (alternate 1) are summarized in Table 1. Note that after the improvement, the design speed of the straightened section will be 60 miles per hour rather than 50 miles per hour.

The analyst has obtained the traffic estimates with and without the proposed improvement for the first and eleventh year of the study period. It is assumed that level of service F conditions will not occur during the analysis period, and that the daily variation of traffic is small enough that explicit consideration of peaking characteristics is unnecessary. Hence the analysis can be performed essentially on an ADT basis. This involves utilizing traffic volume data for a typical hour of the day in each of the analysis years. Such traffic data is summarized in Table 2, where typical one-way hourly volume is defined as ADT divided by 18 (the number of hours assumed, for analysis purposes, in a day). Note that a small increment of traffic is estimated to be induced as a result of the proposed improvement.

There are so few trucks that the traffic stream will be considered to consist entirely of passenger cars; otherwise, the percentage of trucks by type would also be shown in Table 2 or converted to equivalent passenger cars.

Average running speeds (determined from Figure E-3 as a function of v/c) are also noted on Table 2. Since speeds on the analysis section will change as a result of the improvement, transition costs between sections will change, thus speed on the previous and subsequent sections must be specified (as in Table 2).

These traffic and facility data enable calculation of user costs on the existing route and the propsed route, as in Table 3. Unit highway user cost (HU) are calculated from the Formula HU = (B + A) x L + T + D, using basic section costs (B), section length (L), and transition costs (T). Intersection delay costs (D) are not relevant in this example. Accident costs (A) are not considered in this example but, if accident rates were known and changes in accidents were discernible as a result of this improvement, their unit cost would be added to B before multiplication by L. The numbers for B and T are derived from Figures E-3 and E-6 using the facility and traffic data in Tables 1 and 2. A unit value of time of $3 per hour per vehicle is assumed.

Determination B and T for the existing route (alternate 0) in year 1 is further described as follows. Entering the lower left-hand (speed-flow) chart fo Figure 3 with a v/c ratio of 0.50 and design speed of 50 mph yields an average running speed of approximately 36 mph and a corresponding travel time of 27.8 hours per thousand vehicle miles.* Tangent running cost at 36 mph on a level of 0% grade is

*Note that the 36-mph running speed is below the probable minimum road speed on an 8° curve of 45 mph. This is due to the effect of traffic on running speed.

Table 1

FACILITY DATA

Basic Section Data						
Alternate	Section	Length (mi.)	Lanes (one way)	Grade (%)	Curvature (°)	Design speed (mph)
0 1	ab ab	.10 .08	2 2	0 0	8 0	50 60

Table 2

TRAFFIC DATA

Alternate and Section	Analysis Year	Period	One-Way Volume (000)	One-Way Capacity (000)	v/c Ratio	Average Running Speed (mph)	Speed (mph) on: Previous Section	Next Section
0ab	1	typ.hr.	1.900	3.800	.50	36	45	60
1ab	1	typ.hr.	2.000	3.800	.53	41	45	60
0ab	11	typ.hr.	3.000	3.800	.79	31	40	55
1ab	11	typ.hr.	3.100	3.800	.82	34	40	55

Table 3

CALCULATION OF HU

Alternate	Section	Year	Period	(B x L) + T =	HU per KV
0	ab	1	typ.hr.	$177.40 x 0.1 mi +$6.70 =	$24.40
1	ab	1	typ.hr.	147.70 x 0.08 + 4.50 =	16.30
0	ab	11	typ.hr.	$182.90 x 0.1 +$6.80 =	25.10
1	ab	11	typ.hr.	162.20 x 0.08 + 5.50 =	18.50

KV = thousand vehicles

approximately $71** per 1,000 vehicle miles; added running cost due to an 8° curve is approximately $20 per 1,000 vehicle miles; and added running cost due to speed changes at a v/c ratio 0.50 is approximately $3 per 1,000 vehicle miles. Total running cost per thousand vehicle miles on the existing route is thus $94 (71 + 20 + 3). Adding this to a total time value of about $83.40 (27.8 x $3/hr) per thousand vehicle miles yields a total unit basic section cost (B) of $177.40 per thousand vehicle miles for the existing route in year 1.

Entering Figure E-6 with a speed of 45 mph on the "faster" previous section and 36 mph on the section being analyzed yields an added one-way transition cost of approximately $1.70 per thousand vehicles. Similarly, for the transition from the section being analyzed to the next section with an assumed speed of 60 mph, transition cost is from Figure E-6, approximately $5.00. Total one-way section transition cost is thus $6.70 per thousand vehicle miles.

Similar utilization of Figures E-3 and E-6 applied to the proposed route in year 1 and both the existing and proposed route in year 11 yield corresponding values for B and T. Multiplying basic section cost by section length (L) and adding section transition costs then results in the highway user costs (HU) per KV in Table 3.

Benefits in the representative first and eleventh years can be calculated from the above user cost (HU) estimates by applying the formula

$$\text{User benefits} = (U_0 - U_1)\frac{(V_0 + V_1)}{2}$$

as demonstrated below:

> The benefits for the two representative years may be converted into an estimate of the present value of all benefits by use of Figure E-7. Using the ratio of benefits in the eleventh year to those in the first year (132,245/103,773 = 1.27) and using assumptions of a 30-year project life and a 10% discount rate, a present value factor (f) of approximately 12 is obtained. The present value of benefits is then f x first year benefits or
>
> $$12 \times 103{,}773 = \$1{,}245{,}276.$$

Since the improvement affects traffic symmetrically in both directions this one-way benefit estimate can be multiplied by two to yield the total present value of the project's benefits, or $2.49 million.

**The nomographs of this Manual are accurate to probably the nearest $1 per thousand vehicle miles or to the nearest 0.1¢ per vehicle mile. For greater accuracy refer to the running cost tables of Appendix B of *A Manual on User Benefit Analysis of Highway and Bus Transit Improvements, AASHTO, 1977.*

A complete project analysis requires conversion of the costs of the project into present values. The cost of the project includes the cost of construction and the change in maintenance expenses that are incurred on the section as a result of the improvement, with adjustments for any residual or scrap value of the project at the end of the 30-year period. The total construction cost is estimated to be $1,000,000 and will be incurred at the inception of the project. Annual maintenance costs are anticipated to be $2,000 less after the improvement because the elimination of the curve reduces pavement and guard rail damage. The project is likely to have a residual value of roughly $300,000 in the 30th year of the project. Again using a discount rate of 10% the stream of annual maintenance savings is converted to present value. The present value of the residual value in the 30th year is also calculated. The conversion of all costs to present value is summarized in Table 5.

Table 4

USER BENEFIT CALCULATIONS

Section	Year	Period	365 x hours per day in period	x (HU_0-HU_1) x $(V_0+V_1)/2$	= Annual Benefit
ab	1	typ.hr.	365 x 18	x ($24.40-$16.30)x(1.9+2.0)/2	= $103,773
ab	11	typ.hr.	365 x 18	x ($25.10-$18.50)x(3.0+3.1)/2	= $132,254

Table 5

CALCULATION OF PRESENT VALUE

Item			Present Value
1.	Construction costs		$1,000,000
2.	Changes in annual maintenance expenditures	- $ 2,000 x 9.43 =	- 18,854
3.	Residual value in 30 years	- $300,000 x 0.057 =	- 17,193
		Present value of all costs	$ 963,953

The net present value of the project is the difference between the present value of benefits and the present value of costs:

Net present value = present value of benefits - present value of costs

= $2,490,552 - $963,953

= $1,526,599

The net present value of $1,526,599 indicates that the project is economically feasible. The benefit/cost ratio can also be derived as $2.49 million ÷ $96 million or 2.6, for comparison with alternative highway projects. Before a decision is made to implement the project, the decision-maker should also investigate any significant community benefits or costs such as air and noise pollution that may be associated with this project.

Example 2: Intersection Delay and Accident Costs

A four-leg intersection under study has two lanes of traffic in each direction, undivided, on each leg. At present, stop signs exist on the cross street (the street with the lower level of traffic). Due to high traffic levels on the main street (the more heavily traveled street) cross street traffic experiences excessive delays during peak periods. In addition, the intersection is considered dangerous due to its high rate of accidents.

One proposal to alleviate this situation is to install traffic signals at the intersection. Analysis of this proposal involves the calculation and comparison of intersection delay and accident costs for the existing (alternate 0) and the proposed (alternate 1) situation.

Intersection Delay Costs

Under the present situation, it is assumed that traffic on the main street, designated AB, experiences no delay, while traffic on the cross street, designated CD, experiences delay due to the existence of stop signs and interference with traffic on the main street. Since this delay is significantly different from peak to off-peak periods, the analysis will be conducted in terms of representative peak and off-peak hourly traffic.

Table 6 presents estimates of representative peak and off-peak period one-way hourly traffic flow for intersection approaches AB and CD for analysis years 1 and 15. It is assumed that the proposed installation of a traffic signal will not affect these predictions. Trucks are assumed to be a negligible portion of the traffic. The duration of the peak and off-peak periods in each direction is assumed to be 3 and 15 hours, respectively. Symmetric traffic flows are also assumed such that the peak flow in one direction is opposed by the off-peak flow in the opposite direction during the morning peak, and vice versa during the afternoon peak. During the rest of the day, traffic flows at the off-peak level.

Table 6

TRAFFIC DATA

Approach Section	Analysis Year	Period	One-Way Hourly Volume (000)
AB	1	Peak	1.20
AB	1	Off-Peak	0.50
AB	15	Peak	2.40
AB	15	Off-Peak	1.00
CD	1	Peak	0.50
CD	1	Off-Peak	0.10
CD	15	Peak	1.00
CD	15	Off-Peak	0.20

Table 7 summarizes the calculations for intersection delay cost (D) associated with alternate 0, that is, those costs associated with stopping at the stop signs. Note the relatively large estimated per vehicle delays, due mostly to interference with traffic on the main street, during the peak periods. Stopping costs are derived from Figure E-8, under the assumption that all vehicles stop at the stop sign (average stops per vehicle = 1.0 in the lower left-hand chart of Figure E-8). An approach speed of 40 mph is assumed throughout the analysis.

Idling costs are derived by entering the upper left-hand chart of Figure E-9 with average delay per vehicle. Stopping and idling time costs are derived by multiplying stopping and idling times derived from these figures by an assumed value of time of $1.00 per vehicle hour. This value is assumed throughout the analysis.

To illustrate the individual calculations for deriving the above results, consider the peak period in year 1. Entering Figure E-8 along the upper edge of the charts (average stops per vehicle = 1.0) and assuming an approach speed of 40 mph results in an added stopping delay of about 4.4 hours per thousand vehicles and an added stopping cost of about $21 per thousand vehicles. The time delay of 4.4 hours multiplied by a unit time value of $1 results in a time cost of $4.40 per thousand vehicles. This added to stopping costs of $21 results in a total stopping cost of $25.40 per thousand vehicles. Note that since the approach speed is assumed the same for all situations, stopping costs are also the same. Entering Figure E-9 with an average delay of 30 seconds per vehicle results in an idling time of about 8.3 hours per thousand vehicles and added cost of about $2.60 per thousand vehicles. Total idling cost assuming a $1 unit value of time is $10.90.

Table 7

INTERSECTION DELAY COSTS FOR ALTERNATE 0

Year	Period	Average Delay Per Vehicle (Seconds)	Dollars per Thousand Vehicles		
			Stopping Costs + (Figure 8)	Idling Costs = (Figure 9)	Intersection Delay Costs (D)
1	Peak	30	$25.40 +	$10.90 =	$36.30
1	Off-Peak	15	$25.40 +	$ 5.50 =	$30.90
15	Peak	45	$25.40 +	$16.40 =	$41.80
15	Off-Peak	25	$25.40 +	$ 9.20 =	$34.60

Table 8 summarizes the derivation of unit intersection delay costs (D) associated with the proposed installation of a traffic signal. Assumed traffic and signalization parameters are noted in the upper portion of the table while factors derived from Figures E-8 and E-9 are noted in the lower half. Note that approaches AB and CD must be analyzed separately due to different traffic and signalization parameters associated with each of them. It is only necessary, however, to analyze these approaches in one direction of travel due to the simplifying assumption of symmetric traffic flows over the day. Note also that in year 15 traffic on approach AB reaches a saturation degree of 1.0 during the peak period, implying an average delay equal to the signal cycle time and resulting in a relatively large unit intersection delay cost. This condition indicates the beginning of significant congestion at the intersection.

Table 9 summarizes unit user benefit calculations associated with the proposed improvement for each approach, analysis period, and analysis year assuming that intersection delay costs are the only elements of user cost involved. The values used for D in this table are the corresponding values found in Tables 7 and 8. Note that it is not necessary to average traffic volumes in the benefits formula since such volumes are the same for both the existing (alternate 0) and the proposed (alternate 1) situations. Note also that for approach AB, intersection delay costs are assumed to equal zero since the only relevant delay on that approach would be due in the proposed improvement.

From Table 9 it appears that, although positive benefits (intersection delay savings) would accrue to traffic on approach CD as a result of installing a traffic signal, a net increase in costs, or negative benefits, would accrue to all affected highway users taken as a group. In fact, with total "benefits" in year 1 of - $96,688 (twice one-way annual benefits) and -$469,158 in year 15, and assuming a discount rate of 10% and an analysis period of 20 years we find, using Figure E-7, that total net present value related to intersection delay is

-$96,688 × 22.8 (factor from Figure E-7) = -$2,204,486.

It is therefore necessary to determine whether potential accident savings are sufficient to offset the negative benefits of increased overall intersection delay.

Table 8

INTERSECTION DELAY COSTS--ALTERNATE 1

		Approach: AB				Approach: CD			
		Year 1		Year 15		Year 1		Year 15	
		Peak	Off-Peak	Peak	Off-Peak	Peak	Off-Peak	Peak	Off-Peak
1.	Volume, veh/hr	1,200	500	2,400	1,000	500	100	1,000	200
2.	Saturation Flow, veh/hr	3,600	3,600	3,600	3,600	3,600	3,600	3,600	3,600
3.	Effective Signal Green Time, sec	60	30	60	30	30	30	30	30
4.	Signal Cycle Time, sec	90	60	90	60	90	60	90	60
5.	Green/Cycle Time Ratio (line 3/line 4)	0.67	0.50	0.67	0.50	0.33	0.50	0.33	0.50
6.	Capacity of Approach, veh/hr (line 2 x line 5)	2,400	1,800	2,400	1,800	1,200	1,800	1,200	1,800
7.	Degree of Saturation (line 1/line 6)	0.50	0.28	1.00	0.56	0.42	0.06	0.83	0.11
8.	Approach Speed, mph	40	40	40	40	40	40	40	40
9.	Added Stopping Time, hptv (from Fig. 8)	2.2	2.6	4.4	3.0	3.6	2.2	4.0	2.3
10.	Stopping Time Cost, $ptv (unit VOT = $1)	$2.20	$2.60	$4.40	$3.00	$3.60	$2.20	$4.00	$2.30
11.	Added Stopping Cost, $ptv (from Fig. 8)	$10.50	$12.20	$21.00	$14.50	$17.00	$10.50	$18.90	$11.10
12.	Idling Time, hptv (from Fig. 9)	1.8	2.2	25.0	2.5	4.1	2.0	6.1	2.0
13.	Idling Time Cost, $ptv (unit VOT = $1)	$1.80	$2.20	$25.00	$2.50	$4.10	$2.00	$6.10	$2.00
14.	Idling Vehicle Cost, $ptv (Fig. 9)	$0.50	$0.70	$7.82	$0.80	$1.30	$0.60	$1.90	$0.60
15.	Intersection Delay Cost (D), $ptv (lines 10 + 11 + 13 + 14)	$15.00	$17.70	$58.22	$20.80	$26.00	$15.30	$30.90	$16.00

Table 9

USER BENEFIT CALCULATIONS

Approach Section	Year	Period	365 x Per Day x $(D_0 - D_1)$ x V* =	One-Way Annual Benefits
AB	1	Peak	365 x 3 x ($ 0 - $15.00) x 1.2 =	-$ 19,710
AB	1	Off-Peak	365 x 15 x (0 - 17.70) x 0.5 =	- 48,454
CD	1	Peak	365 x 3 x (36.30-26.00) x 0.5 =	11,279
CD	1	Off-Peak	365 x 15 x (30.90-15.30) x 0.1 =	8,541
			Total One-Way Annual Benefits - Yr 1 =	-$ 48,344
AB	15	Peak	365 x 3 x ($ 0 - $58.22) x 2.4 =	-$153,002
AB	15	Off-Peak	365 x 15 x (0 - 20.80) x 1.0 =	- 113,880
CD	15	Peak	365 x 3 x (41.80-30.90) x 1.0 =	11,936
CD	15	Off-Peak	365 x 15 x (34.60-16.00) x 0.2 =	20,367
			Total One-Way Annual Benefits - Yr 15 =	-$234,579

* Instead of $\frac{V_0 + V_1}{2}$, since the level of traffic is not affected by the improvement.

Accident Costs

Over the past several years, an average of twenty accidents occurred at the intersection under study. Included, on the average, have been 1.5 fatal accidents per year (two every three years), 4 injury accidents per year, and 14.5 property damage accidents per year. It is postulated that although the number of accidents will not change with the installation of traffic signals, the number of fatal accidents would be reduced to zero.* Table 10 summarizes the postulated accident distribution for alternates 0 and 1 and calculates the net benefits assumed in year 1 using accident costs for urban areas as follow: $82,000 per fatal accident, $3,400 per injury and $480 per property damage accident. Since intersection accident estimates are expressed annually and are not directly related to vehicle miles, it is not necessary to perform calculations on a per-vehicle-mile basis and annualized calculations can be made directly.

Table 10

ACCIDENT COST CALCULATIONS - YEAR 1

	Number Per Year			Cost/Accident	Net Annual Benefit Per Year
	Alt. 0	Alt. 1	Net Change		
Fatal Accidents	1.5	0	1.5	$82,000	$123,000
Injury Accidents	4.0	5.0	-1.0	3,400	-3,400
P.D.O. Accidents	14.5	15.0	-0.5	480	-240
Total	20.0	20.0	0		$119,360

Based on the assumption that the number and severity of accidents is proportional to the amount of traffic, it is assumed that potential accident savings would double by year 15 to $238,720 per year. Using a discount rate of 10%, an analysis period of 20 years, and a ratio of benefits of 2.0, Figure E-7 indicates a present worth factor of 12.6 which yields a net present value of accident savings of

$$\$119{,}360 \times 12.6 = \$1{,}503{,}936.$$

Comparing net present value of added intersection delay costs with the present value of accident savings results in a net present value of user benefits for the proposal of

$$-\$2{,}204{,}486 + 1{,}503{,}936 = -\$700{,}550.^{**}$$

*Some evidence exists that installation of traffic signals tends, in certain instances, to increase the number of accidents at an intersection, but also to reduce fatalities. In addition, the relative percent of fatal accidents indicated in this example is much larger than most data would indicate. This assumption is included in this example, however, to illustrate concepts rather than to reflect reality.

**Note that Figure E-7 could not have been used to develop this value directly from the ratio of net present values in each analysis year for both intersection delay and accident savings since in year 1 the corresponding value would be positive (−$98,688 + $119,360) while in year 15 the value would be negative (−$469,158 + $238,720).

Taken literally, this implies the project is not economically feasible. The result would be even more negative if, as should be, the costs associated with the traffic signal and its installation were included. The proposed traffic signal installation would have to be justified, where appropriate, based on other factors.

Example Problem 3: Stage Construction

A two-mile section of highway on the perimeter of a rapidly growing urban area is being considered for upgrading to urban freeway standards.

Characteristics of the existing facility (alternate 0) and the proposed facility (alternates 1 & 2) are given in Table 11 below. It should be noted that the proposed facility will have five lanes each direction.

Table 11

BASIC SECTION DATA

Alternate	Section	Length (Miles)	Lanes (One-Way)	Grade (%)	Curvature (°)	Design Speed (MPH)
0	(do nothing)	2	2	0	0	60
1 & 2	a (add main-lanes)	2	3	0	0	70
	b (add front-age road)	2	2	0	0	50

Next, traffic data should be obtained and displayed in tabular form for the particular alternates being considered.

These traffic and facility data enable calculation of user costs on the existing route and the proposed route, as in Table 13. Unit highway user costs (HU) are calculated from the formula:

$$HU = (B + A) \times L + T + D$$

using basic section costs (B), section length (L), and transition costs (T). Intersection delay costs (D) are not relevant in this example. Accident costs (A) are not considered in this example, but if accident rates were known and changes in accidents were discernible as a result of this improvement their unit cost would be added to (B) before multiplication by (L). The numbers for (B) and (T) ar derived from Figures 3 and 6 using the facility and traffic data in Tables 11 and 12. A unit value o time of $3 per hour per vehicle is assumed.

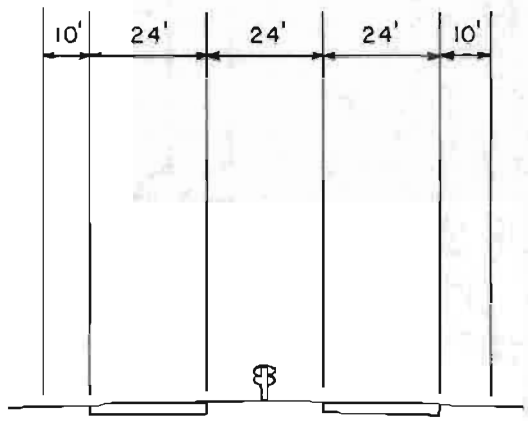
Further discussion of calculating HU may be found in Example Problem 1.

Benefits in the representative first, eleventh and twenty-first years can be calculated for the user co estimates in Table 14 by applying the formula

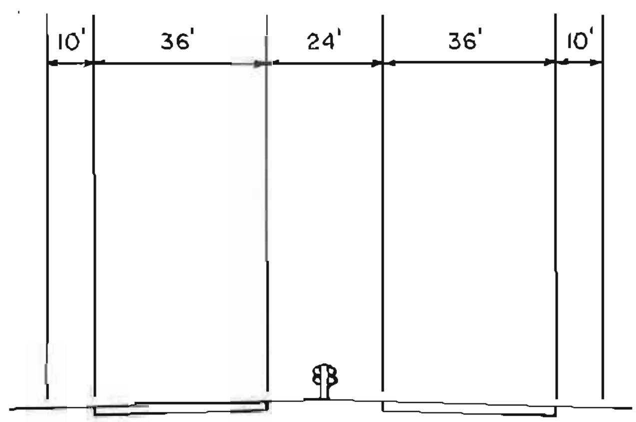
$$\text{User benefits} = (U_0 - U_1)\frac{(V_0 + V_1)}{2}$$

as demonstrated in Table 14.

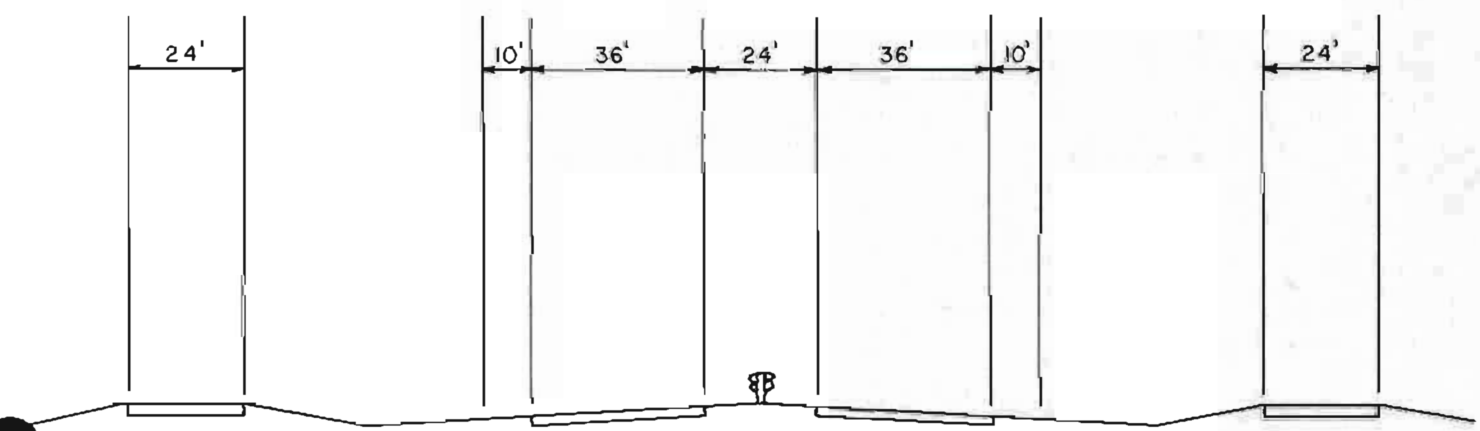
STAGE CONSTRUCTION SEQUENCE



EXISTING



PROPOSED (STAGE 1)



PROPOSED ULTIMATE (STAGE 1 & 2)

FIGURE E-11

Table 12

TRAFFIC DATA

Alternate	Section	Analysis Year	Period	One-Way Volume (1000 Veh)	One-Way Capacity (1000 Veh)	v/c	Speed (MPH)	Speed on Previous Section (MPH)	Speed on Next Section (MPH)
0		1	typ. hr.	2.2	3.4	.65	38	60	50
0		11	typ. hr.	4.4	3.4	(Los F)	20	55	45
0		21	typ. hr.	6.7	3.4	(Los F)	20	50	40
Stage Construction Alternate Stage 1:									
1	a	1	typ. hr.	2.2	5.1	.43	51	60	50
1	a	11	typ. hr.	4.4	5.1	.86	39	55	45
Stage 2:									
1	a'	11	typ. hr.	3.4	5.1	.67	48	55	45
1	b'	11	typ. hr.	1.0	3.4	.30	39	45	--
1	a'	21	typ. hr.	5.0	5.1	.98	34	50	40
1	b	21	typ. hr.	1.7	3.4	.50	36	40	--
Ultimate Facility Alternate									
2	a	1	typ. hr.	1.7	5.1	.33	56	60	50
2	b	1	typ. hr.	.5	3.4	.15	42	45	--
2	a	21	typ. hr.	5.0	5.1	.98	34	50	40
2	b	21	typ. hr.	1.7	3.4	.50	36	40	--
Average running speed is found as a function of v/c ratio using Figure 1 or 2.									

Table 13

CALCULATION OF USER COST (HU)

Alternate - Section	Year	Period	(B x L) + T = HU/1000 Veh.
0	1	typ.hr.	(\$160 x 2) + \$ 6.40 = \$326.40
0	11	typ.hr.	(235 x 2) + 14.00 = 484.00
0	21	typ.hr.	(235 x 2) + 11.10 = 481.10
Stage Construction Alternate Stage 1:			
1_a	1	typ.hr.	(\$134.50 x 2) + \$ 1.50 = \$270.50
1_a	11	typ.hr.	(154.00 x 2) + 3.90 = 311.90
Stage 2:			
$1_a'$	11	typ.hr.	(\$140.00 x 2) + \$ 0.80 = \$280.80
$1_b'$	11	typ.hr.	(151.00 x 2) + 0.90 = 302.90
1_a	21	typ.hr.	(161.10 x 2) + 3.90 = 326.10
1_b	21	typ.hr.	(158.00 x 2) + 0.50 = 316.50
Ultimate Facility Alternate			
2_a	1	typ.hr.	(\$129.50 x 2) + \$ 1.20 = \$260.20
2_b	1	typ.hr.	(145.00 x 2) + 0.40 = 290.40
2_a	21	typ.hr.	(161.10 x 2) + 3.90 = 326.10
2_b	21	typ.hr.	(\$158.00 x 2) + \$ 0.50 = \$316.50

Table 14

ANNUAL USER BENEFIT CALCULATIONS

Section	Year	Period	365 x Hrs. per day in typ. period x $(HU_0 - HU_1)$ x $\frac{V_0 + V_1}{2}$ =	Annual Benefit
Stage Construction Alternate:				
Stage 1:				
a vs 0	1	typ.hr.	365 x 18 x (\$326.40 - \$270.50) x 2.2 =	\$ 807,979
a vs 0	11	typ.hr.	(6570) x (484.00 - 311.90) x 4.4 =	4,975,067
Stage 2:				
a'b vs 0	11	typ.hr.	(6570)x(484.00 x 4.4)-(280.80 x 3.4)-(302.90 x 1.0) =	\$5,613,408
a'b vs 0	21	typ.hr.	(6570)x(481.10 x 6.7)-(326.10 x 5.0)-(316.50 x 1.7) =	6,924,780
Ultimate Construction Alternate:				
ab vs 0	1	typ.hr.	(6570)x(326.40 x 2.2)-(260.20 x 1.7)-(290.40 x 0.5) =	858,042
ab vs 0	21	typ.hr.	(6570)x(481.10 x 6.7)-(326.10 x 5.0)-(316.50 x 1.7) =	\$6,924,780

Having determined the benefits for the representative years, present value can be calculated for all benefits by the use of Figure E-7, as follows in Table 15.

The reader is referred to Example Problem 1 and the text associated with Figure E-7 for detailed discussion of the process involve.

The net present value of the project is the difference between the present value of benefits and the present value of costs.

Observations and Recommendations

It is obvious, from traffic demand within this corridor, that the existing facility will have to be upgraded. From the above economic comparison, it is found that stage construction will provide the most cost-efficient means to provide the necessary additional capacity and would be the recommended alternate.

Table 15
CALCULATION OF PRESENT VALUE (PV)

Alternate 1:

Stage 1: $\frac{\$4,975,067}{\$\ 807,979} = 6.16 = 6.2$ Assume: Discount Rate = 10%
Y = 10
n = 10

Find f: f = 15.5

$PV = (\$807,979)\ (15.5) = \$12,523,675$

Stage 2: $\frac{\$6,924,780}{\$5,613,408} = 1.23 = 1.2$ Assume: Discount Rate = 10%
Y = 10
n = 10

Find f: f = 7

$$PV_{11} = (\$5,613,408)(7) = \$39,293,856$$

$$PV_1 = PV_{11} \frac{1}{(1 + i)^n}$$

$$= \$39,293,856 \frac{1}{(1 + 0.1)^{10}} = \$15,128,135$$

Total PV for Alternate 1 = \$12,523,675 + \$15,128,135 = \$27,651,810

Alternate 2:

$\frac{\$6,924,780}{\$\ 858,042} = 8.07 = 8.1$ Assume: Discount Rate = 10%
Y = 20
n = 20

Find f: f = 19

$PV = (\$858,042)\ (19) = \$16,302,798$

Table 16

DETERMINATION OF NET PRESENT VALUE (NPV)

Alternate 1: Stage Construction

PV (Benefits) = \$27,651,810

Pv (Costs) = \$ 5,000,000 (Initial Construction)

\$ 1,400,000 (In Year 11)

$$\text{PV (Cost in 11th Year)} = \$\ 1{,}400{,}000 \left(\frac{1}{(1+i)^n}\right)$$

$$= \$\ 1{,}400{,}000$$

$$= \$\ 539{,}000$$

PV (Costs) = \$ 5,000,000 + \$ 539,000

\+ \$ 5,539,000

PV (Benefits) - PV (Costs)

NPV (Alt. 1) = \$27,651,810 - \$5,539,000

= \$22,112,810

Alternate 2: Ultimate Construction Initially

PV (Benefits) = \$16,302,798

PV (Costs) = \$ 6,400,000

NPV (Alt. 2) = \$16,302,798 - \$6,400,000

= \$ 9,902,798

In terms of Benefit to Cost Ratio:

$$\text{Alternate 1: B/c} = \frac{\$27{,}651{,}810}{\$\ 5{,}539{,}000} = 4.99 \text{ say, } 5.0$$

$$\text{Alternate 2: B/c} = \frac{\$16{,}302{,}798}{\$\ 6{,}400{,}000} = 2.54 \text{ say, } 2.5$$

E-106 ABBREVIATED PROCEDURE FOR APPLICATION OF ECONOMIC ANALYSIS FOR MINOR IMPROVEMENTS

At times the analyst will be faced with one-to-one design choices which can readily be based on travel of small portion of the total traffic stream. In such cases use of the preceding nomographs may be somewhat cumbersome. It is for this reason the charts in Figures E-11 and E-12 were developed.

This method is based on the format, with some updating, previously used for justification documentation submitted to the Federal Highway Administration.

In Figure E-11, "Extra Cost Per Vehicle Stop Above That for Constant Speed Operation," the cost associated with travel delay to the operator can be found. This chart differs from those in Figures E-8 and E-9 in that operating cost of the vehicle is not included. This feature is shown in Figure E-12 as a constant speed cost.

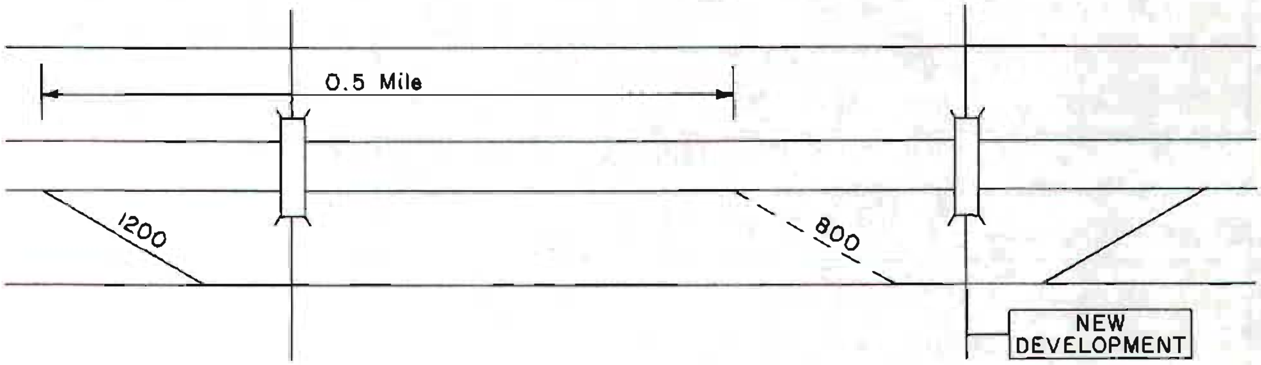
The error involved in such simplification is minor, especially when applied to low volume movements.

Example Problems Using Abbreviated Method

In some cases, user benefits can be reduced to the difference in operating costs associated with traveling alternate types of facilities. Examples of this follow.

Example Problem 4: Ramp Location

A ramp is requested by a city to more directly serve new development as indicated in the sketch.



This problem reduces to simply the difference in operating cost on the main lanes versus the operating cost on the frontage road for the ramp traffic destined for the new development.

Two cases will be shown in this problem: Case 1 for urban application, and Case 2 for rural application. For Case 1, it is assumed that the main lanes will have an average highway speed (AHS) of 50 mph, and the frontage roads will have an AHS of 35 mph. From Figure E-12 it is found that a cost of \$0.158 per vehicle mile to travel the frontage road and cost of \$0.136 per vehicle mile to travel the main lane.

Assuming each vehicle will have to stop once and be delayed twenty seconds, from Figure E-11 it is found that there is an additional cost above that for constant speed operation of \$0.03 per vehicle.

Determination of the benefit-to-cost ratio is shown in Table 18.

For Case 2 the same general conditions are assumed, except AHS for main lanes is assumed to be 55 mph, and 45 mph for the frontage road. Also, no standing delay is assumed at the stop.

Determination of the benefit-to-cost ratio for the proposed revision is shown in Table 17.

Since benefit-to-cost ratio is greater than 1.0, construction of the ramp is justified from an economic standpoint.

Table 17

ROAD USER COSTS											
URBAN APPLICATION											
TRAFFIC	WITHOUT RAMPS					WITH RAMPS					
800	___	Mi. Interstate	@		= $____	0.5	Mi. Interstate	@ 0.136	= $54.40		
VPD	0.5	Mi. Paved	@ 0.158		= $63.20	___	Mi. Paved	@	= $____		
	___	Mi. Non-Paved	@		= $____	___	Mi. Non-Paved	@	= $____		
1	1	Stops	@ 0.03		= $24.00	___	Stops	$ 0.02	= $____		
		(WOR) Total Per Day			= $87.20		(WR) Total Per Day		= $54.40		

NET DAILY ROAD USER BENEFIT (WOR) - (WR) = $32.80

NET ANNUAL ROAD USER BENEFIT $32.80 x 365 = $11,972 = (B)

BENEFIT COST RATIO (1.0 MINIMUM REQUIRED)

$$\frac{\text{NET ANNUAL ROAD USER BENEFITS}}{\text{ADDED ANNUAL COSTS}} = \frac{B}{10\% \quad (R+C)} = \frac{\$11,972}{\$\ 4,000} = \$2.99$$

REMARKS: R = ROW Cost = $0

C = Construction Cost = $40,000

Operating costs are determined from Figure E-12 by entering from bottom with Average Highway Speed (AHS).

Table 18

ROAD USER COSTS									
RURAL APPLICATION									
TRAFFIC	WITHOUT RAMPS				WITH RAMPS				
800	___	Mi. Interstate	@	= $____	0.5	Mi. Interstate	@ 1.35	= $54.00	
VPD	0.5	Mi. Paved	@0.141	= $56.40	___	Mi. Paved	@	= $____	
	___	Mi. Non-Paved	@	= $____	___	Mi. Non-Paved	@	= $____	
1	1	Stops	@0.02	= $16.00	___	Stops	@ 0.02	= $____	
		(WOR) Total Per Day		= $72.40		(WR) Total Per Day		= $54.00	

NET DAILY ROAD USER BENEFIT (WOR) - (WR) = $ 18.40

NET ANNUAL ROAD USER BENEFIT 18.40 x 365 = $6,716 = (B)

BENEFIT COST RATIO (1.0 MINIMUM REQUIRED)

$$\frac{\text{NET ANNUAL ROAD USER BENEFITS}}{\text{ADDED ANNUAL COSTS}} = \frac{B}{10\% \quad (R+C)} = \frac{\$\ 6,716}{\$\ 3,000} = \$2.258$$

REMARKS: R = ROW Cost = $0 for this case

C = Construction Cost = $30,000

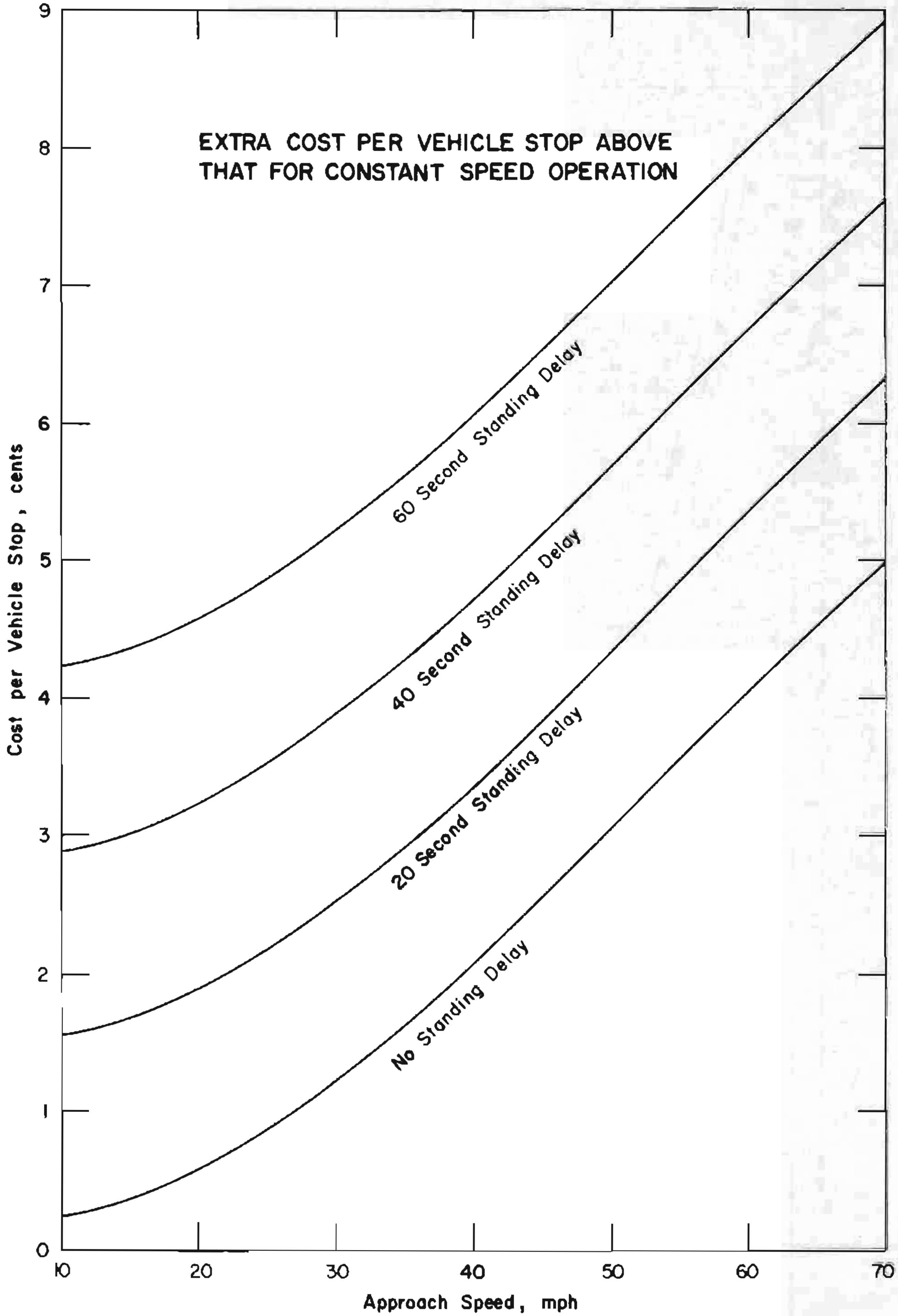

EXTRA COST PER VEHICLE STOP ABOVE
THAT FOR CONSTANT SPEED OPERATION
60 Second Standing Delay
40 Second Standing Delay
20 Second Standing Delay
No Standing Delay
Cost per Vehicle Stop, cents
Approach Speed, mph
0
1
2
3
4
5
6
7
8
9
10
20
30
40
50
60
70

FIGURE E-12

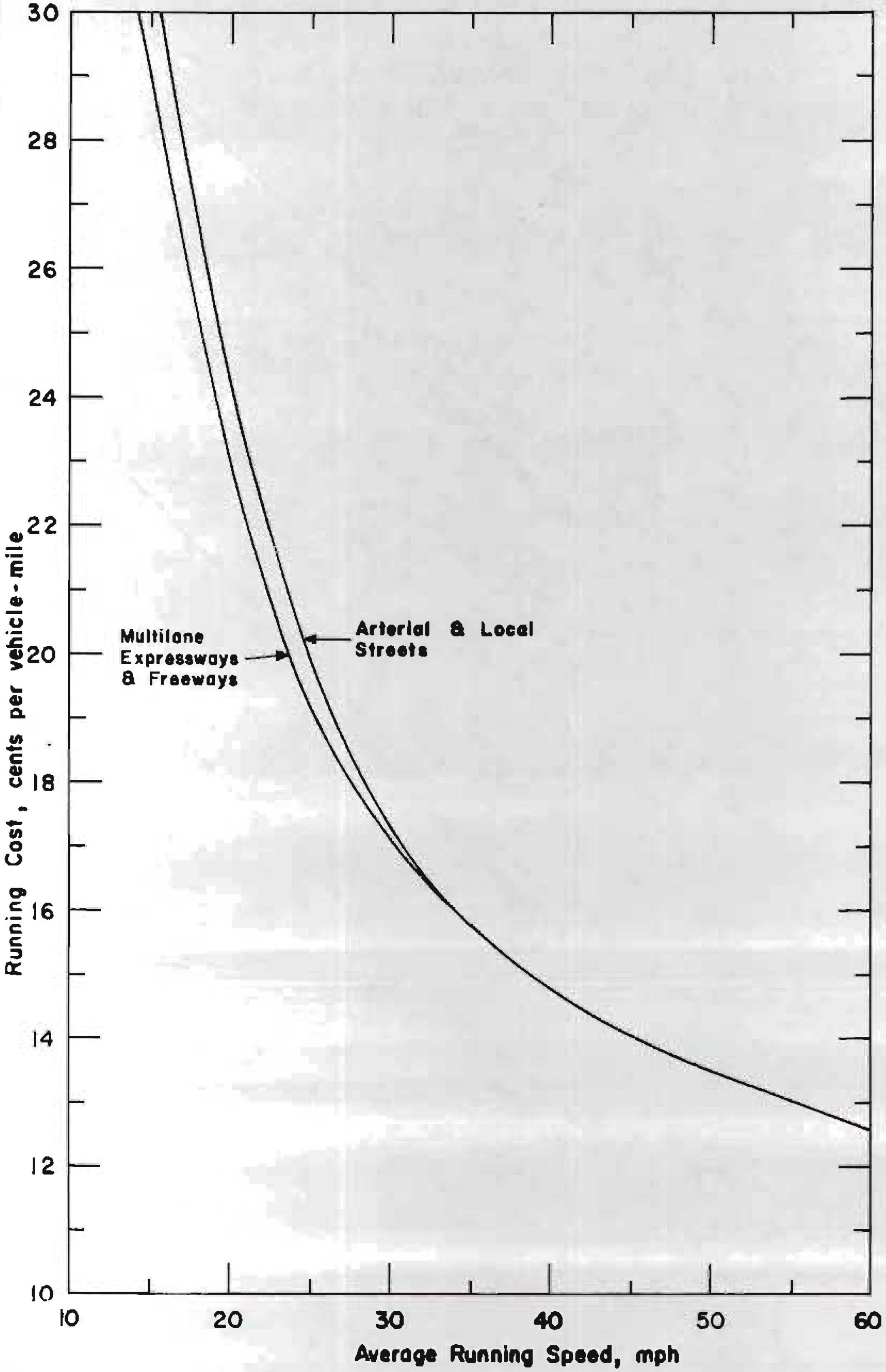
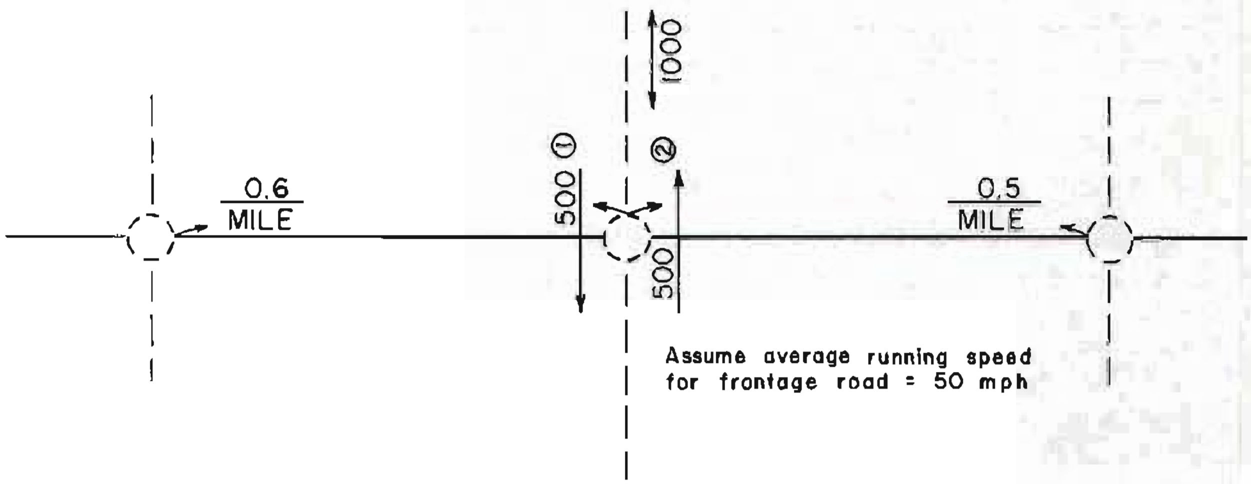

30
28
26
24
22
20
18
16
14
12
10
10
20
30
40
50
60
Running Cost, cents per vehicle-mile
Average Running Speed, mph
Multilane Expressways & Freeways
Arterial & Local Streets

FIGURE E-13

Example Problem 5: Grade Separation

In a rural location considerable demand has been generated to cross a controlled access facility. Without a grade separation, traffic would be forced to travel 0.5 mile one way to the nearest grade separation to cross the facility.



The problem reduces to the cost involved in traveling the additional distance. Average highway speed of 50 mph is assumed for travel on the frontage road and no standing delay is involved in stopping.

Determination of the benefit-to-cost ratio for the proposed improvement is shown in Table 19.

When travel without the grade separation results in traffic traveling on unpaved roads, road user cost factors are increased as indicated in Figure 10. Table 20 shows the determination of the benefit cost ratio for the conditions in above example problem No. 5, except for travel on a gravel, rather than paved, road.

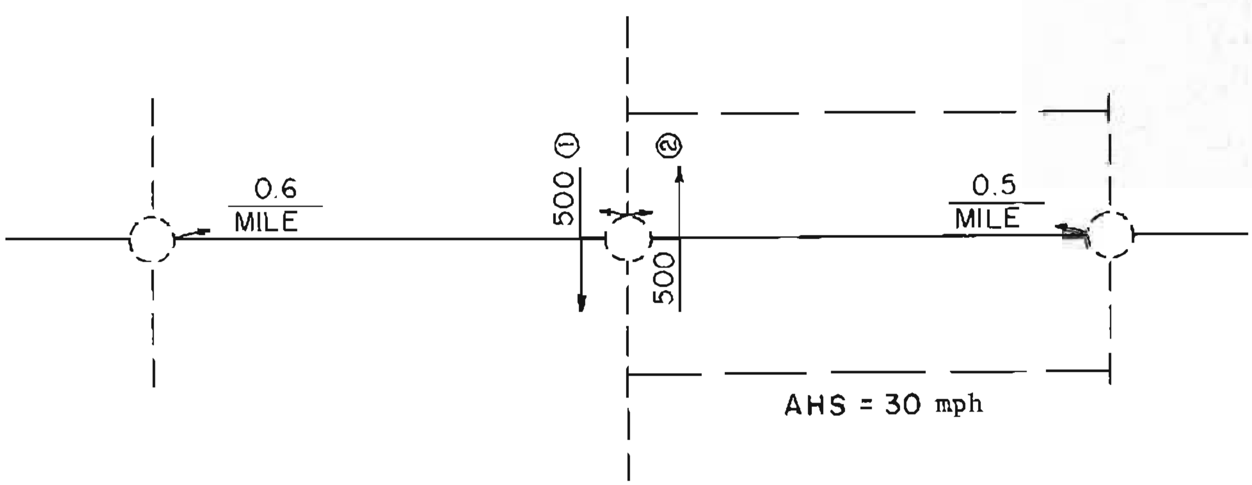


Table 19

ROAD USER COSTS

TRAFFIC	WITHOUT GRADE SEPARATION	WITH GRADE SEPARATION
500 VPD 1	___ Mi. Interstate @ = $___ 1.0 Mi. Paved @ .135 = $67.50 ___ Mi. Non-Paved @ = $___ 2 Stops @ 0.02 = $10.00	___ Mi. Interstate @ = $___ ___ Mi. Paved @ = $___ ___ Mi. Non-Paved @ = $___ ___ Stops @ 0.02 = $___
500 VPD 2	___ Mi. Interstate @ = $___ 1.0 Mi. Paved @ .135 = $67.50 ___ Mi. Non-Paved @ = $___ 2 Stops @ 0.02 = $10.00	___ Mi. Interstate @ = $___ ___ Mi. Paved @ = $___ ___ Mi. Non-Paved @ = $___ ___ Stops @ 0.02 = $___
	(WOGS) Total Per Day = $ 155.00	(WGS) Total Per Day = $___

NET DAILY ROAD USER BENEFIT (WOGS) - (WGS) = $ 155.00

NET ANNUAL ROAD USER BENEFIT $ 155.00 x 365 = $ 56,575.00 = (B)

BENEFIT COST RATIO (1.0 MINIMUM REQUIRED)

$$\frac{\text{NET ANNUAL ROAD USER BENEFITS}}{\text{ADDED ANNUAL COSTS}} = \frac{B}{10\% \quad (R/C)} = \frac{\$56,575.00}{\$\ 25,000} = \$2.26$$

REMARKS: R = ROW Cost = $50,000.

C = Construction Cost = $200,000.

Table 20

ROAD USER COSTS		
TRAFFIC	WITHOUT GRADE SEPARATION	WITH GRADE SEPARATION
500 VPD 1	___ Mi. Interstate @ = $___ ___ Mi. Paved @ = $___ 1.0 Mi. Non-Paved @ .227 = $113.50 2 Stops @ 0.02 = $ 10.00	___ Mi. Interstate @ = $___ ___ Mi. Paved @ = $___ ___ Mi. Non-Paved @ = $___ ___ Stops @ 0.02 = $___
500 VPD 2	___ Mi. Interstate @ = $___ ___ Mi. Paved @ = $___ 1.0 Mi. Non-Paved @ .227 = $113.50 2 Stops @ 0.02 = $ 10.00	___ Mi. Interstate @ = $___ ___ Mi. Paved @ = $___ ___ Mi. Non-Paved @ = $___ ___ Stops @ 0.02 = $___
	(WOGS) Total Per Day = $ 247.00	(WGS) Total Per Day = $___

NET DAILY ROAD USER BENEFIT (WOGS) - (WGS)= $ 247.00

NET ANNUAL ROAD USER BENEFIT $247.00 x 365 = $ 90,155 = (B)

BENEFIT COST RATIO (1.0 MINIMUM REQUIRED)

$$\frac{\text{NET ANNUAL ROAD USER BENEFITS}}{\text{ADDED ANNUAL COSTS}} = \frac{A + B}{10\% \quad (R + C)} = \frac{\$90,155}{\$25,000} = \$3.61$$

REMARKS: Cost to travel on paved road = $0.172/mile

conversion factor to convert to gravel surface = 1.32

Cost to travel gravel road = ($0.172)(1.32) = $0.227

R = ROW Cost = $50,000

C = Construction Cost = $200,000

In both of these cases, the benefit-to-cost ratio is greater than 1.0, thereby indicating that the proposed expenditure would be cost effective.

The above problem could be expanded to consider two or more possible locations for grade separations.

REFERENCES

1. Andersen, D. G., Curry, D. A. and Pozdena, R. J., *User Benefit Analysis for Highway and Bus Transit Improvements,* Stanford Research Institute, Project 3334 (June 1975).

2. American Association of State Highway Officials, *Road User Benefit Analysis for Highway Improvements,* Washington, D. C. (1960), 152 pp (The Red Book).

3. *A Manual on User Benefit Analysis of Highway and Bus Transit Improvements, AASHTO, 1977.*

4. *Winfrey, R. and Zellner, C., Summary and Evaluation of Economic Consequences of Highway Improvements,* NCHRP Report 122 (1971), 324 pp.

5. Winfrey, R., *Economic Analysis for Highways,* International Textbook Company (1969), 923 pp.

6. *Highway Capacity Manual* - 1965 HRB Special Report 87 (1965), 418 pp.

7. Curry, D. A. and Andersen, D. G. *Procedures for Estimating Highway User Costs, Air Pollution, and Noise Effects,* NCHRP Report 133 (1972), 127 pp.

APPENDIX F-100

RIGID PAVEMENT STRUCTURES (F-100)

F-101 INTRODUCTION

"Rigid Pavement" as used in this Appendix includes all pavement structures that contain portland cement concrete. This section discusses design traffic and wheel loads, materials evaluation, selection of thicknesses, subbases, shoulders, reinforcement, joints, and terminal treatment.

F-102 CONSIDERATIONS FOR SELECTION OF CONCRETE PAVEMENT

The selection of the type of pavement to be constructed should be based on economic and safety considerations for the design life of the pavement. Traditionally, portland cement concrete pavement has beeen more expensive initially than bituminous pavements. However, because of its strength, durability and resistance to damage from wheel loads and the environment it requires less maintenance over a longer period of time. The greater increase in the cost of asphalt and the use of greater thickness of asphaltic layers have produced pavements that approach the cost of portland cement concrete pavements. The increased thickness has also improved the reliability of bituminous pavement. The factors that affect economics vary throughout the State and the conditions that influence maintenance strategies are different for different locations. It is, therefore, difficult to establish explicit guidelines for pavement type selection. A general statement can be made that the more expensive and more reliable pavement types should be used on high-volume, high-load carrying arteries where maintenance is difficult and the consequences of failure are severe.

F-103 PORTLAND CEMENT CONCRETE PAVEMENT TYPES

A. Continuously Reinforced

When properly designed and constructed, CRCP provides good riding characteristics with less required maintenance than any other pavement type. Because of a lack of experience, many early CRCP projects were deficient in design thickness, subbase type and construction techniques. The one factor where experience is still lacking is the influence on performance of thickness. The majority of experience has been limited to pavements of 8-inch thickness or less. However, according to theoretical considerations and our experience with jointed concrete pavements and flexible pavements, we should be able to design the thickness of this pavement type based on projected traffic, subgrade and environmental conditions. Experience to date indicates the thickness of CRCP should be approximately the same as jointed concrete pavement for equivalent wheel loads. Because of the amount of steel required, this, generally, will make CRCP the most expensive pavement type. Its selection should be based on the need to provide a high type of pavement with the minimum of maintenance requirements.

B. Jointed Reinforced

The use of light reinforcement in concrete pavement permits a reduction in the number of transverse joints and keeps tightly closed any cracks that form in the pavement. It has been found that joint spacings longer than about 40 feet usually result in excessive joint movement, thus making joint maintenance extremely difficult. Based on experience and theoretical consideration, it is recommended that transverse joint spacings be 30 feet 6 inches for jointed reinforced concrete. The selection of jointed reinforced concrete pavement should be based on the consideration of the number and difficulty of joints to be maintained or it could be set up as an alternate or Contractor's option to one or more of the other concrete pavement types.

C. Contraction Design (Plain Concrete)

1. With Load Transfer Devices

This type of pavement provides for 15-foot transverse joint spacing with load transfer devices at the joints. No reinforcing is necessary for these short slabs. There are twice as many joints to maintain as with the reinforced slab, but joint movement should be less because of the shorter slabs. Load transfer is accomplished by the use of dowels or other approved load transfer devices.

2. Without Load Transfer Devices

Where this type of pavement is used without load transfer devices at transverse joints, it is recommended that the thickness be increased by two inches. Considerable success has been achieved with the contraction designed slabs, both with and without dowels at transverse joints, and it is recommended as an alternate or Contractor's option to other concrete pavement designs where maintenance of the joints can be assured.

D. Skewed Joint

There is limited experience with skewed joint design in Texas, but other states have had extensive experience and excellent results with proper designs. Load transfer at joints is achieved by aggregate interlock which depends on short joint spacing to reduce crack width. Skewed joints reduce the effects of wheel loads at joints and the random spacing of joints prevents the objectionable noise effect and vehicle harmonics that can occur with evenly spaced joints. Two additional inches of thickness are recommended to compensate for the absence of load transfer devices, and it is suggested that a well-stabilized subbase be considered until more experience with this pavement type is obtained. It appears that this design would be an attractive alternate or Contractor's option to other concrete pavement types. A recent survey indicated that 16 states are building skewed transverse joints with nine of these designs calling for random spaced joints and no dowels (Ref. 34).

F-104 SWELLING CLAY

It is recommended that concrete pavement not be used in areas of extensive swelling clay subgrades. The changing profile of the swelling clay area invariably results in the need to level up the surface to restore a suitable riding surface - usually a long time before the structural life of the pavement is expended. In such areas it may be more appropriate to consider a flexible pavement or to use the concrete structure as a base. In this case, serviceability could be restored by overlaying or leveling-up with bituminous surface or by removing the humps.

In locations where minor swelling clay areas intrude on the otherwise suitable subgrade, or where experience has shown that concrete pavement is the most suitable type, extra precautions may be taken to minimize the effects of the swelling clay. Deep lime stabilization, ponding, dry land farming and delaying paving operations have proven helpful but none of these is a positive cure-all.

Experience has indicated that voids under the pavement created by differential movement contribute to early distress in concrete pavement. Increasing design thickness in these areas would help to reduce wheel load stress and prolong pavement life. Properly sealed joints and the use of concrete shoulders would reduce the amount of water available to cause the differential movement. Positive sealing of the subgrade after obtaining moisture equilibrium and construction of an effective drainage system is another technique which might prove helpful.

F-105 DESIGN TRAFFIC

A traffic analysis similar to the one shown in Fig. F-1 should be obtained from D-10. There is a standard form to request the traffic similar to the one shown in Fig. F-2.

The estimate of the 18K-ESAL obtained from D-10 needs to be multiplied by a directional distribution factor and a lane distribution factor to define the design lane traffic:

$$W_D = W_{18\text{-}K}(DD_t)(LD)$$

where W_D = Design Lane Traffic, K-ESAL highway over design period

DD_t = Directional distribution factors (for truck traffic only)

LD = Lane distribution factor (for truck traffic only)

$W_{18\text{-}K}$ = Accumulated 18K-ESAL both directions of the highway over design period. (The traffic obtained from D-10 is for one direction. It should be multiplied by 2.)

Do not confuse DD_t with the directional distribution shown in Column 4, Fig. F-2. This includes passenger cars and is used in geometric design. The directional distribution factor for truck traffic for several CRCP's in the State is shown in Table F-1 which was taken from Ref. 20. In this reference, a relationship between percent of highway defects and the percent of traffic to be assigned to each direction of the highway was developed; this relationship was used to define the DD_t factors. This data may change with time as the direction of heavy loads may shift due to changing conditions.

The lane distribution factor relates the number of trucks moving in the heaviest traveled direction to the number of trucks moving in the heaviest traveled lane in the same direction. For two-lane roadways, this factor is simply 1.00. For highways with more than one lane in each direction, this factor may vary between 0.8 to 1.0 for two lanes in a single direction and 0.6 to 0.8 for three or more lanes in each direction. A conservative value (high) should be used if the lane distribution information is not known.

F-106 SUBBASE DESIGN

A. Subgrade

The modulus of support or reaction K-value must be evaluated for the existing material. This value can be measured with plate load tests or through correlation with other soil tests

TRAFFIC ANALYSIS FOR HIGHWAY DESIGN

Description of Location	Average Daily Traffic		Directional Distribution Factor	Design Hourly Volume	Percent Trucks		Anticipated Annual Rate of Growth	ATHWLD	Percent Tandem Axles in ATHWLD	Total Number of Equivalent 18K Single Axle Load Applications One Direction Expected for a 20-Year Design Period (19 to 19)	
	1975	1995			ADT	DHV				Flexible Pavement	Rigid Pavement
1. West Loop Freeway (IH 610) North of Southwest Freeway (US 59)	168,600	263,000	57-43%	10.9%	8.0	5.0	2.8%	14,500	10	55,619,000	81,655,000
2. South Freeway (SH 288) North of South Loop Freeway (IH 610)	40,000	130,000	65-35%	14.1%	4.7	2.9	11.2%	14,500	10	11,879,000	17,566,000

FIGURE F-1 (REFERS TO PARAGRAPH F-105)

Date ______________

TO :

FROM :

SUBJECT : Traffic Data for Highway Design

District ______________________________

Control and Section ______________________

From Sta.: ____________ To Sta.: ______________

Please furnish this office an estimate of the 18 KSAL for rigid/flexible pavements, ____________ inches thick, from date of construction to present, and from present to 20 years later.

Figure F-2 Request Form to D-10 for Traffic Data

Table F-1. Estimated Directional Distribution Factors for CRCP in Texas (Ref. 20)

Highway Section	District	% Failures		% Traffic	
		EB or NB	WB or SB	EB or NB	WB or SB
IH 10	20	32	69	41	59
	24	34	66	42	68
IH 20	10	57	43	53	47
IH 30	1	49	51	49	51
	19	58	42	54	46
IH 35	9	37	63	43	57
IH 45	17	22	78	36	64

such as presented in Ref. 32; however, the value used in design must be adjusted to a value which is anticipated to exist for the major part of the design life of the pavement.

Evaluations for modulus of subgrade, K, by the plate-load test, are too cumbersome to be repeated often enough to account for variation within any new location project. Generally, the Engineer's experience and knowledge of local material is the best source of information. Soil surveys and laboratory tests will aid the Engineer in his estimate. For evaluation of existing pavements the Dynaflect has given useful data. It has been common practice to lime-stabilize clay subgrades to provide an all-weather working table to promote faster construction. Lime stabilization has also been used to reduce potential swelling problems. In general, a lime-stabilized subgrade does not provide significant structural support for the concrete slab. Asphalt and portland cement stabilization of sandy soils have been used infrequently for special problems; and, because of the lack of performance experience with this type design, it should not be considered as having additional structural value unless experience can be documented.

B. Subbase

A subbase is defined as a foundation course placed between the subgrade and the concrete pavement. The primary function of a subbase is to improve the foundation for the pavement so that the foundation can withstand the effect of large amounts of water that infiltrate the concrete pavement. Secondary functions include providing a working table for construction traffic and strengthening the foundation so that a lesser slab is required. A subbase achieves its primary function by being either erosion-resistant or a drainage layer in an overall drainage system that rapidly carries away the infiltrating water so that high pore pressures under load do not develop. The value of the subbase as a part of the load-carrying structure depends on its strength or modulus of elasticity as compared to the strength or modulus of the pavement slab. A stress analysis should be performed if consideration is to be given to the structural value of the subbase.

The three types of materials that have proven most successful as water-resistant (non-pumping) subbases are: (1) durable, lean concrete; (2) erosion-resistant soil cement; and (3) moisture-resistant (non-stripping) bituminous mixtures.

1. A lean portland cement concrete base of four inches or greater may be used if a bond breaker is provided to prevent cracks in the base from reflecting into the concrete pavement. It appears that the concrete base can have a relatively low cement factor if a good entrained air system can be achieved to provide adequate workability and sufficient durability. The optimum cement and air content for the material to be used should be determined in the laboratory.

2. Enough cement should be used in a soil cement base to assure an erosion-resistant material. The Portland Cement Association recommends an increase in cement content for soil cement base to resist erosion where this material is used as riprap on dams. Bases under concrete pavement should have the same consideration since they are subject to similar or greater erosive action due to pumping. A bond breaker is needed to prevent the cracks in the soil cement base from reflecting through the concrete surface.

3. To provide erosion resistance in bituminous mixtures, relatively high asphalt contents (low air voids) and either non-stripping aggregates or anti-stripping agents are required.

Recent observations have indicated that the benefits of a bituminous subbase may be reduced by the bonding of the concrete pavement to the subbase and the resultant reflection cracking of the pavement joints down through the subbase.

After providing materials that will satisfy the primary function of being non-erosive, the designer must be assured that these materials are of such quality and quantity that will provide an adequate working table for construction equipment and for foundation improvement (if this is a consideration in design).

Stabilized subbases will be required under all concrete pavement except for the following three cases:

1. In areas where other materials have given satisfactory performance for a similar design and traffic.

2. In areas where the cost of subbase approaches the cost of the concrete slabs and where there are concrete curbs, concrete shoulders, or where the concrete slab extends a minimum of three feet beyond the outside shoulder line, the subbase may be deleted by increasing the slab thickness a minimum of three inches. A cost analysis will be necessary to justify the extra slab thickness in lieu of a design with a subbase.

3. Where the Contractor elects to place the subbase with the concrete pavement in one pass, the material specified for the pavement will be used for the entire depth. This would probably be economical in only a few locations and where the design is non-reinforced or lightly reinforced. In this type design the dowel bars remain the same size but reinforcing steel and tie bars will have to be increased in size to keep the area of steel at approximately the same percentage of the slab's cross-sectional area.

There are two important factors to be considered in evaluating the strength of the proposed subbase-on-subgrade combination. These are: (a) improved support strength of the layered system, and (b) the capability of a layered system to maintain its strength and integrity under heavy highway traffic loadings in the presence of moisture or marginal drainage conditions.

The effect of the composite K-value due to the layered effect of the pavement structure may be accounted for as described below in (D). In using this approach, the designer assumes the material does not lose its integrity due to water erosion. Since most unstabilized materials lose part of their integrity during their service life due to pumping, consolidation, erosion, etc., this effect must be considered in design.

C. Drainage of Subbase

A large percentage of the failures in rural concrete pavements in Texas which have required full depth patches have been in the outside wheel path of the outside lane. These failures can be attributed to edge loading in combination with water which collects through the joints and cracks and stands in the subbase on the lower side of the pavement (normally the outside edge). Proper drainage of the subbase, or water-tight pavement joints (Ref. 35) are two possible solutions to the problem.

In some areas, internal drainage has been the most economical solution. The most successful drainage has been where the subgrade was a well-drained sand and the subbase was a fairly permeable material. Where clay subgrade is involved and drainage must be taken horizontally through the subbase and shoulder to the ditch there have been few economical solutions for drainage.

There are two very critical areas in the control of surface water in these designs. The first area is the joint seal between the concrete slab and the shoulder material and of transverse joints in jointed pavements. A good seal here can prevent most of the drainage problems in concrete pavements. To keep a good seal, replacement maintenance must be scheduled for every second or third year. The second problem area is the design and maintenance of the drain. A properly designed drain will need little maintenance except at the outfall, but provision for periodic inspection should be made and maintenance performed if necessary.

Figure F-3 shows typical sections with positive drainage design which could be considered in areas where past performance of concrete pavement has been unsatisfactory and part of the problem is believed to be water in the subbase. Generally, the longitudinal drains will be needed only along the lower edge of the travel lanes. In steep terrain, cross drains may be required periodically to provide proper drainage. For superelevated curves, collector drains should be installed along the lower side of the curve, and cross collector drains should be installed wherever required to prevent the build-up of a hydrostatic head in the drainage layer. Details for design are described in Reference 36.

D. Effect of Layered System

The design chart for evaluating the effect of the layers in a structure is shown in Fig. F-4. The material parameters required in this analysis are the stiffness of the subbase material and the modulus of subgrade reaction. The designer begins with the subbase thickness and projects the corrected K-value at the top of the subbase.

If more than one material is being used for the subbase layer, the designer may take this into account by applying this procedure for each layer. The first time through gives the corrected support value at the top of the first layer. With this value and the thickness and stiffness of the next layer, a new K-value at the top of the next layer is determined. This process is repeated until the K-value immediately below the concrete pavement is obtained. This procedure may be used to determine the structural contribution of a drainage layer if it is provided.

E. Correction for Erodibility and Loss of Support

The influence of material erodibility and loss of support on the long-range characteristics of subbase support may be evaluated by using Fig. F-5. The composite K-value from Fig. F-4 is projected from horizontal axis to the appropriate support loss factor of the subbase material. The design K-value will always be equal to or less than the layered K-value with the reduction depending on the material quality and its ability to resist erosion and movement.

"Support loss factor" (LF) is assigned to subbase materials to account for support loss over the life of the pavement. This factor ranges from 0 to 3, with 0 representing no loss of support and 3 representing a high support loss.

TYPICAL CROSS SECTIONS OF SUBDRAINAGE SYSTEMS

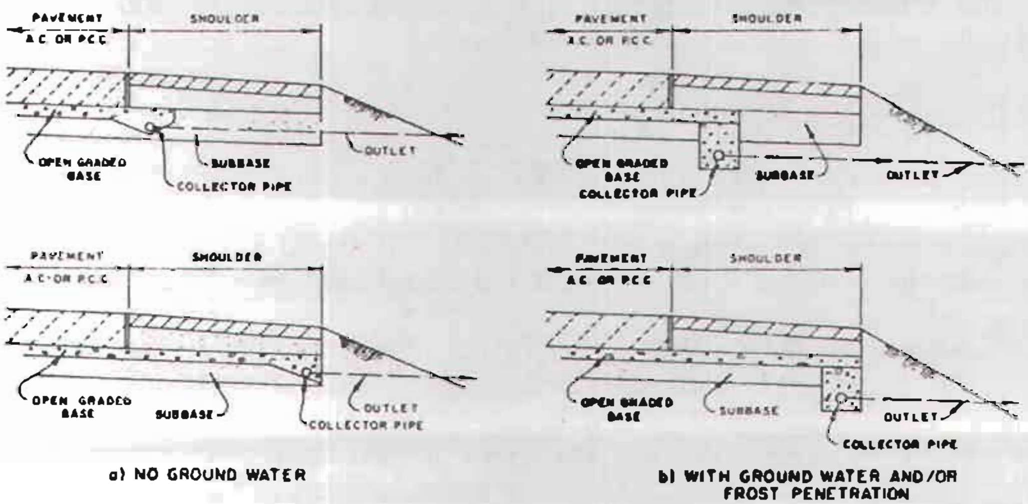


Fig. F-3 Refers to Paragraph F-106(C)

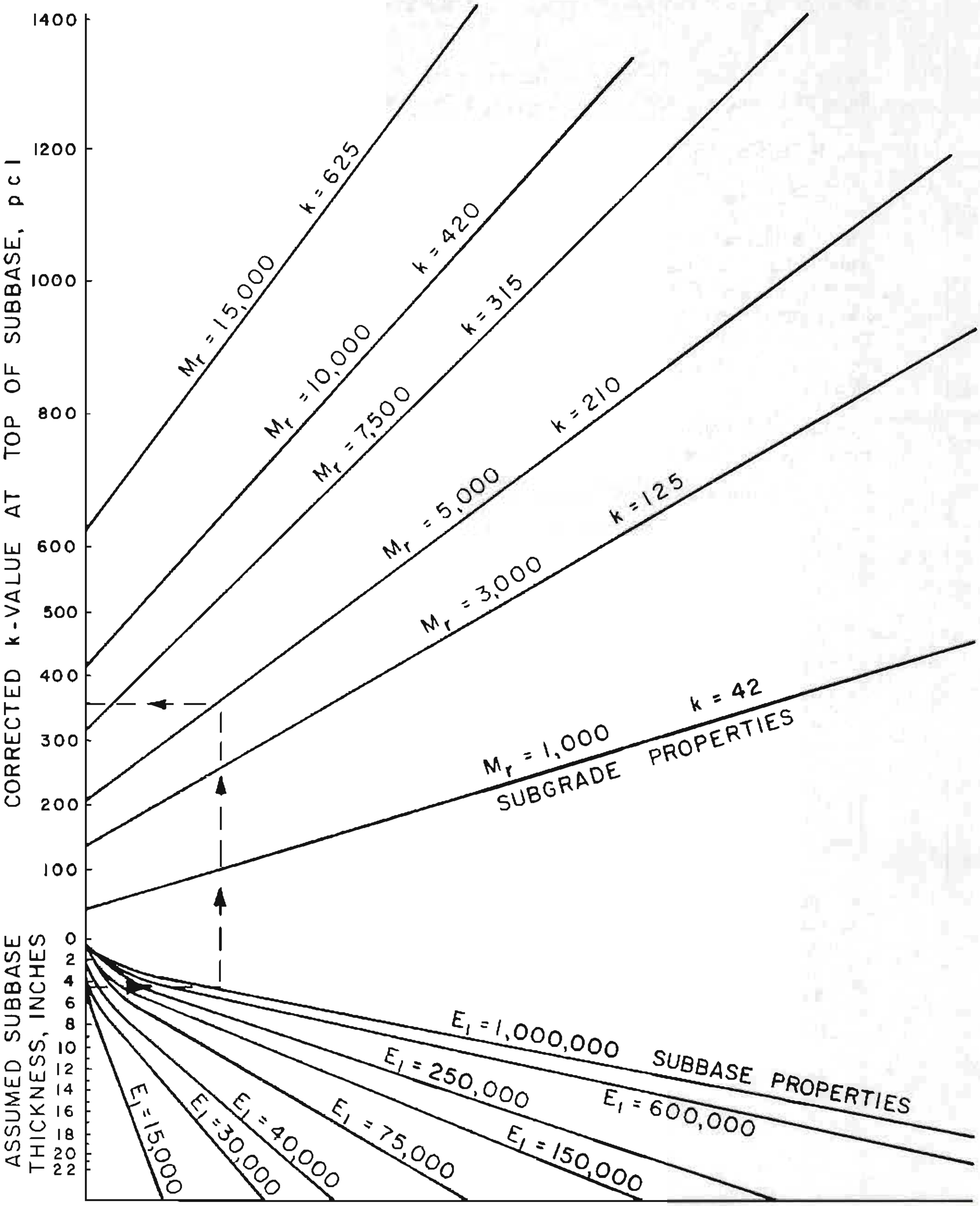


FIGURE F-4 CHART FOR ADJUSTING k-VALUE FOR EFFECT OF SUBBASE LAYERS

At the present time, no tests are available that may be used to directly determine this factor. Suggested values for several categories of subbase systems are presented in Table F-2.

F-107 SLAB THICKNESS DESIGN

A. Thickness Design

The slab thickness design is based on the revised AASHTO rigid pavement design equation which relates the number of 18K-ESAL applications to a selected level of serviceability. A correction is applied to the composite K-value on top of the subbase for materials which have support loss potential. The effects of tied concrete shoulders and adjacent lanes may be incorporated into the design by deducting one inch in thickness from the value given by the nomograph, if experience or judgment indicates that the resulting thickness will be satisfactory.

The following input quantities to the thickness design should be recorded on the input summary sheet in Figure F-6:

1. Number of 18K-ESAL applications expected over the design period in the design lane;
2. The allowable working stress in the concrete*;
3. The concrete modulus of elasticity**; and
4. The design modulus of reaction (K-value) on top of the subbase.

*The working stress should be based on the expected flexural strength of the concrete. Recommended working stress can be calculated by the following equation:

$$f_t = \frac{S_c}{C}$$

Where S_c = 28-day flexural strength of third point loading, psi***

C = constant to determine design working stress.

The C term is a safety factor. The higher the value, the higher the confidence in an adequate design. For freeways and other high volume facilities where closing of a lane for possible rehabilitation will cause the projected traffic to exceed capacity of a probable detour, a higher value for C of up to 2.00 is recommended. Also, for any projected traffic conditions which indicate a relatively low number of total 18 Kip equivalencies during the design life (<1,000,000 for example) but contain above average wheel loads (>10,000#), the factor of safety should be adjusted to prevent damage by one or a few heavy loads. Another case where a different value of C may be required is where local experience has shown that environmental or other factors require that a thicker or thinner pavement be provided. For most conditions a value of 1.33 is recommended. Generally, the safety factor of 2.00 will add between one and two inches to the slab thickness.

** The modulus of elasticity may be determined from static compression tests on cylinders (ASTM C469). An average value is acceptable for use in computations. A value of 4,200,000 psi was used as representative of AASHTO conditions for developing the design equations.

*** Since the Department uses 7-day center point loading for flexural strength, it is necessary to convert to 28-day third point loading flexural strength. This can be accomplished by multiplyng the 7-day center point loading strength by a factor of 1.107. For design purposes the following can be used:

		Design Working Stress			
7-day Center Point	28-day Third Point	Safety Factor 1.33	1.5	1.75	2.0
650 psi	720 psi	540	480	410	360
575 psi	635 psi	475	425	360	320

The nomograph for easy solution of the design equation is shown in Fig. F-7. The design thickness is found by first making the appropriate input values on the various scales. Then starting at the far left on the traffic scale, a line is constructed passing through the values on the traffic scale and working stress and intersecting turning line 1. Next, a similar line is constructed through the design values on the K-value and modulus of elasticity scales and projected to turning line 2. The thickness is then located by constructing a line connecting the intersections of the previously constructed lines and the two turning lines.

B. Shoulder Design

Shoulders built with cement and asphalt stabilized bases which have large shrinkage characteristics have not performed satisfactorily. Many of these shoulders have pulled away from the concrete slab a distance of 1/2" to 1" within three to five years and maintenance funds have not been available to seal the joints. A non-shrinking, good quality flexible base with a surface treatment, in many cases, can reduce the joint problem between concrete slab and shoulder.

Building a concrete shoulder is another solution for consideration. The increasing cost of asphalt combined with the extremely poor performance and required maintenance of asphalt or cement stabilized shoulders makes the consideration of tied concrete shoulders attractive. This would eliminate the joint problem, reduce the amount of water infiltrating the subbase and subgrade and add structural support so that the edge loads would not be so detrimental. In addition to this, in urban areas particularly, the concrete shoulder can be utilized as an added traffic lane to alleviate bottlenecks due to accidents, lane striping operations, joint repair or other maintenance operations. Shoulders have also been converted to permanent traffic lanes through deficient interchanges. Where stage construction is employed and it is contemplated that a future lane will be needed, the full width concrete shoulder would be entirely appropriate.

Where financial conditions for a project preclude the construction of an eight-foot or ten-foot concrete shoulder, consideration should be given to the construction of a partial width concrete shoulder. Investigations have determined that existing slipforming equipment can be economically widened so that a 27-foot width can be placed in one pass. Theoretically, a three-foot widening will reduce stress and deflection caused by edge loads approximately 80 percent as effectively as a ten-foot concrete shoulder. Concrete slabs widened three feet into the shoulder will move the joint farther from expected large wheel loads. To be effective, the concrete in the shoulder must be tied to the main slab or placed in the same pass. The three-foot widened portion should be delineated or treated to discourage the encroachment of vehicles. (Details for 27-foot designs are included in Appendix A.) The remainder of the shoulder may be constructed of a less expensive material. The use of flexible base with a surface treatment has provided as good service as, or better than, stabilized shoulders.

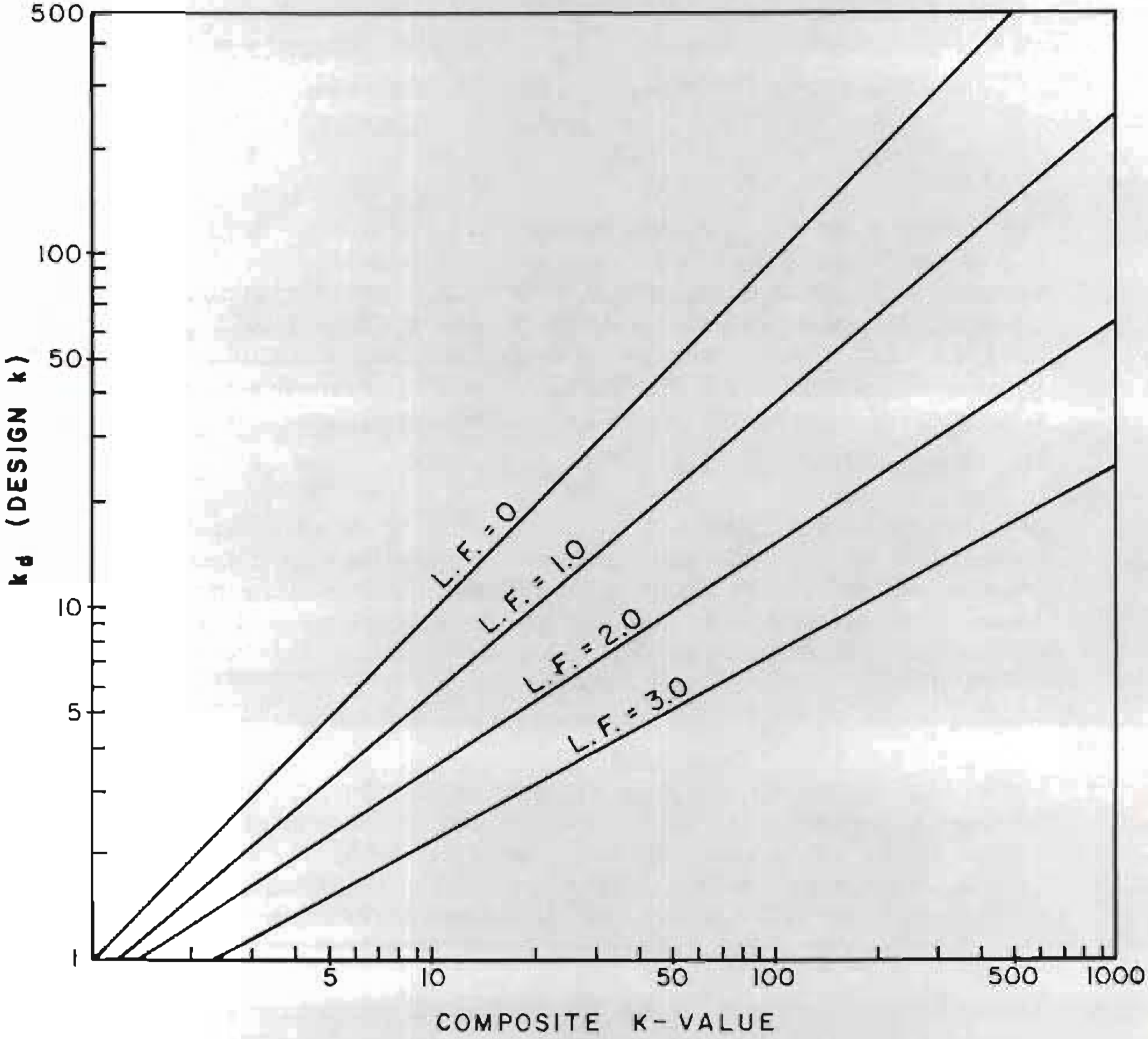


FIGURE F-5 CORRECTION OF k-VALUE FOR SUBBASE LOSS

Table F-2. Typical Support Loss Factors of Subbase Systems

Material	Loss Factor
Lean concrete base on stable subgrade	0
Cement Aggregate Mixtures on Stable Subgrade	1 - 0
Asphalt-Treated Base on Stable Subgrade	1 - 0
Bituminous Stabilized Mixtures on Stable Subgrade	1 - 0
Lean Concrete Base on Unstable Subgrade	2 - 1
Cement Aggregate Mixtures on Unstable Subgrades	2 - 1
Asphalt-Treated Base on Unstable Subgrade	2 - 1
Bituminous Stabilized Mixtures on Unstable Subgrade	2 - 1
Lime Stabilized	2 - 1
Unbound Granular Materials	3 - 1
Fine-Grained Materials	3 - 2

SUBBASE DESIGN

Subbase Materials	Elastic Modulus (psi)	Erodibility Factor	Alternate Trial Thickness

SLAB THICKNESS DESIGN

Subbase Alternatives

Design K-Values on Top of Subbase (pci) 1 2 3 4 5

Design 18K-ESAL Applications ____________

Allowable Working Stress in Concrete ________(psi)

Concrete Modulus of Elasticity ____________ (psi)

LONGITUDINAL REINFORCEMENT DESIGN

Rebar Diameter ____________

Wheel Load Stress ________(psi)

Concrete Shrinkage ____________ (in/in)

Design Temperature Drop ________(°F)

Concrete Tensile Strength ____________ (psi)

Thermal Coefficient Ratio a_s/a_c ________

TRANSVERSE REINFORCEMENT DESIGN

Total Width of Slab ____________ (in)

Subbase Friction Factor ________

Allowable Working Stress in Steel ____________ (psi)

Cross-Sectional Area of Rebar ________(in^2)

Figure F-6 Design Input Summary Sheet

Solves:

$$\log W_{18} = 7.35 \log (D+1) - 0.06 - \frac{0.1761}{1 + \frac{1.624 \times 10^{7}}{(D+1)^{8.46}}} + 3.42 \log \left[\frac{f_t}{690} \left(\frac{D^{0.75} - 1.132}{D^{0.75} - \frac{18.42}{(E/k_g)^{0.25}}} \right) \right]$$

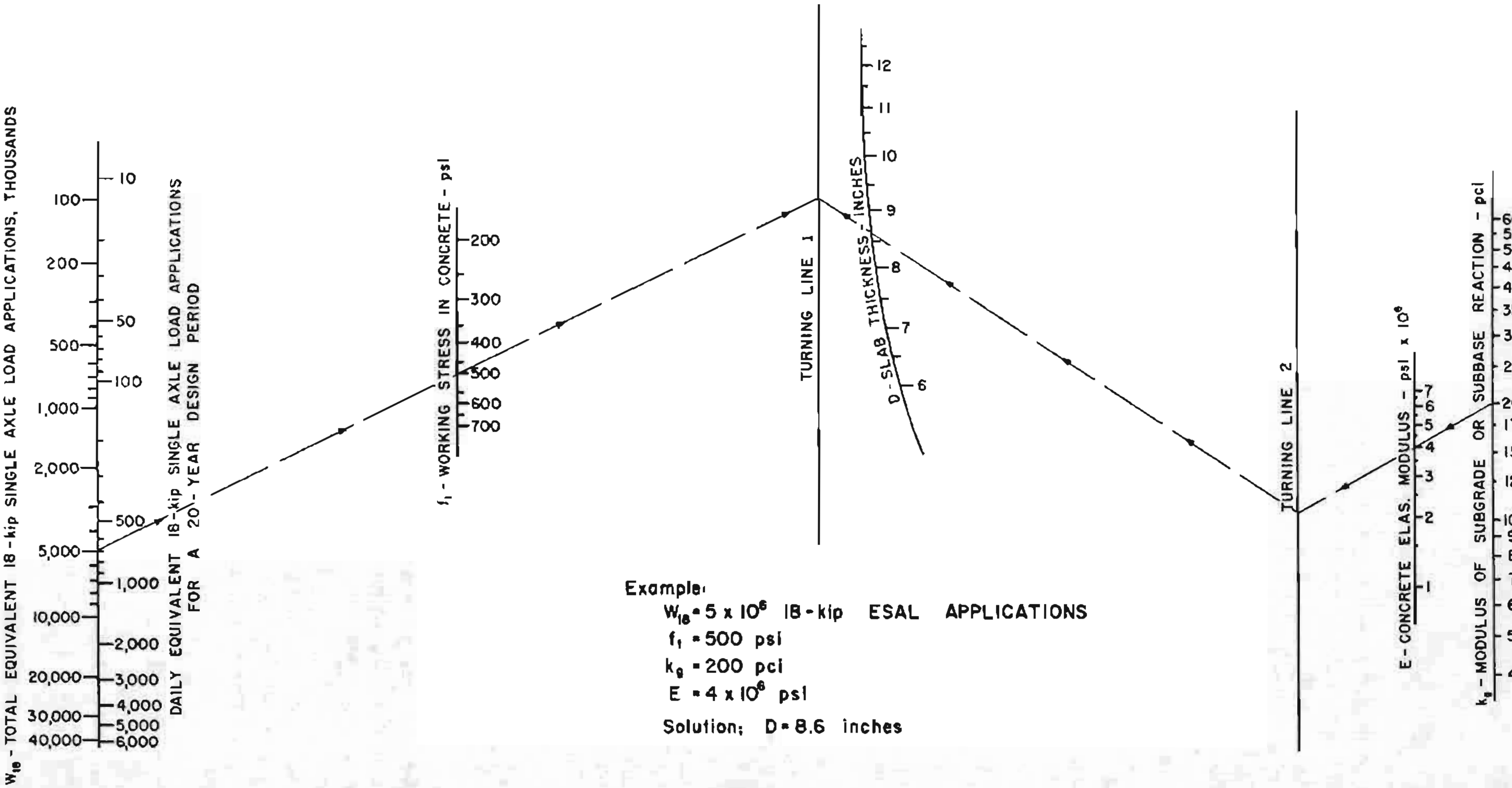


Figure F-7 DESIGN CHART FOR RIGID PAVEMENTS. p_t = 2.5

F-108 JOINT DESIGN

Joints used in portland cement concrete pavement include transverse contraction, transverse expansion, transverse construction, longitudinal grooved, and longitudinal construction joints. These joints should be carefully designed to accommodate the expected environmental and traffic loading conditions. (See Standard Design Details listed in Appendix A.) Load transfer should be developed in all transverse joints either by the use of coated dowels or by other approved load transfer devices or by short joint spacing and thicker slabs. The thicker slabs will reduce deflection and stress under load and reduce the need for load transfer devices. Short joint spacings of less than 15-foot average length will insure load transfer by aggregate interlock. A skew of 6:1 on transverse joints will also reduce the need for load transfer by causing the wheels to go over the joints one at a time (Ref. 37). Random joint spacings are added to reduce possible vehicle harmonics which can cause larger dynamic loads and unsatisfactory riding characteristics. Proper selection and careful installation of load transfer devices are essential to assure the proper function of load transfer. It is mandatory that dowels be correctly positioned and aligned. Improperly functioning load transfer devices are worse than none. Recommended practice for load transfer devices are reflected on the respective design details. Details for recommended joint seals are shown in Standard Design Details. (See Standard Details listed in Appendix A.)

Load transfer in all longitudinal joints and maintenance of a water-tight joint should be accomplished by use of tie bars. Unlike dowel bars, the alignment is not as critical for tie bars. The bar should be kept as nearly parallel as possible to the surface but can be placed up to 45° off perpendicular to the face of the construction joint. In slipforming, this will make bending of the bars easier (if they are to be bent). A detail can be furnished if this option is desired.

The proper design of joints and their required maintenance should be carefully considered when a decision is made to construct jointed concrete pavement. Where future maintenance will be difficult due to any cause such as traffic handling, safety, shortage of funds or maintenance forces, the difficulties of maintenance should be weighed against the added cost of a more reliable pavement. Very few jointed concrete pavements have reached their potential design lives without proper joint design and maintenance.

A. Forming of Weakened Plane Joints

A weakened plane or contraction joint is created simply by weakening the cross section of the pavement (Ref. 34). Generally, one of three methods is used to create the weakness: (1) an insert is placed in the surface of the pavement; (2) a groove is formed in the surface of the wet concrete; or (3) a sawcut is made shortly after the concrete has set.

Regardless of the method used, it is important that the insert or groove be located over the center line of the dowel assembly, if dowels are used for transverse joints. This requires that the position of the dowels be marked clearly on the side form or by stake or flag when a slipform paver is used.

1. When the joint is formed by insertion of a thin plastic strip, or asphalt-impregnated fiber strip, the strip is placed automatically by a machine following the finisher or slipform paver. An alternate is the placement by vibrating a full width or lane width bar into the concrete. The strip is folded over the edge of the bar which is then positioned by

workmen, and the assembly is vibrated into the wet concrete. The bar is then withdrawn, leaving the strip embedded. Great care is needed in this type of installation to prevent the joint from spalling.

2. Grooves in the wet concrete can be made by vibrating a working T-shaped grooving bar into the mix. The bar should have a tapered web to permit easy withdrawal and should be embedded the full depth of the web. The bar should be coated with oil or other appropriate parting materials. After the concrete has hardened sufficiently to prevent flow, the grooving bar is withdrawn and the groove is edged. Even though the joint appears to be well formed, some edging is desirable because of the tendency to disturb the edges when the bar is withdrawn. However, the handwork often produces rougher riding joints.

3. Sawed grooves are made after the concrete has attained sufficient strength to enable the saw to cut through the aggregate with a minimum of aggregate pull-out. The time of sawing is critical and normally should be accomplished within four to eight hours after placing. The selection of this time should be made by experienced personnel who are familiar with local materials. Where hard aggregate requires that sawing be done more than eight hours after placement, strong consideration should be given to inserts or grooving of joints unless experience has shown that longer waiting periods will not result in premature, random cracking.

A majority of weakened plane joints constructed in Texas have been by sawing because of the ability to consistently obtain a more aesthetic and smoother riding joint. However, some projects have experienced cracking near the end of dowel bars and other projects have experienced longitudinal cracking a foot or two either side of the longitudinal saw cut. These cracks usually occurred on projects which could not be sawed within the four to eight-hour period of placement. However, all random cracking should not be attributed to late sawing. If a strong stabilized base is used that has high frictional characteristics or a base that will bond to the hydrating concrete, problems can occur for any type of weakened plane joint. Shrinkage cracks in stabilized subbases act as weakened planes in longitudinal, transverse and diagonal directions when this bonding has occurred. This results in the reflection of these cracks through the concrete pavement. In areas where there is a bond problem, a bond-breaking layer must be placed between the base and the concrete.

B. Sealants

The primary function of joint sealants is to keep foreign solid material out of the joint, and the secondary function is to keep water out to protect the subbase, subgrade, and reinforcing bar or dowels. When solid material enters the joint, spalling occurs very rapidly. Even worse, this can lead to blowups or longitudinal butterfly cracks which usually lead to full depth pavement breakout near the edge of the slab. The entrance of water because of a bad seal weakens the subbase and subgrade but failures usually occur at a much slower rate. Slab thickness and/or proper load transfer design can reduce this rate of failure caused by water-weakened support.

Experience has shown that for the best joint seal, the sealing reservoir should be constructed as narrow as possible, yet wide enough to allow for expected movements (Ref. 37). The narrow joint probably works best because it prevents large material from being pushed into the joint and cutting the sealant. However, contrary to the need for keeping the joint narrow, theoretical calculation shows that the greater the width of the joint, the less the sealer will be strained for a given movement. Theory also shows that the shallower the joint is sealed, the less the sealant will be strained when the joint opens (Ref. 38). The optimum width to depth ratio for elasticity is about 2:1 but from a practical standpoint this makes the reservoir too shallow for bond when short joint spaces are used. Practice has shown that a minimum depth of 1/2-inch should be used for bond (Refs. 39 and 40) and a maximum width of 1/2-inch should be used to prevent intrusion of solids. It is recommended that a maximum joint width of 3/8-inch be used for non-reinforced slab joint spacing of less than 20 feet, and that the joint width of 1/2-inch be used for reinforced slabs with joint spacing greater than 20 feet. Joint spacings longer than 30 feet are not recommended unless a special sealant can be designed to handle movement and prevent intrusion of foreign materials.

Hot poured rubber or cold-applied joint and crack sealer as specified in the Item "Concrete Pavement" of the Standard Specifications (Ref. 41) has not proven satisfactory in transverse joints wider than 3/8-inch. Therefore, this type sealant should be restricted to longitudinal joints and transverse joints with joint spacings of less than 20 feet. For wider joints and joint spacings, as in standard drawing for CPJR, the sealant must be more resilient. The two component synthetic polymers and pre-formed compression seals have given better performance. New specifications and materials should be sought for better performance and longer life.

F-109 REINFORCEMENT

A. Continuous

The selection of continuous longitudinal steel is based on Vetter's analysis of reinforced concrete (Ref. 43). The steel percentage of 0.5 to 0.6 by area has been selected and placed in the standard drawing of Appendix A. A special analysis should be made when non-stabilized subbase or no subbase is used. This situation may reduce friction to the point that additional steel will be required.

The transverse steel requirement in continuously reinforced concrete pavement is based on the subgrade drag theory (Ref. 44) and is defined under "B. Jointed" of this section.

B. Jointed

The amount of longitudinal and transverse steel required for jointed reinforced concrete pavement is calculated by the subgrade drag equation as follows:

$$Ps = \frac{LF}{2fs} \times 100$$

Where: Ps = Percent steel by area
L = Length or width of slab (ft.)
F = Friction factor of subbase or subgrade
fs = Allowable working stress in steel - psi (.75 x yield point)

Example Problem: L = 30'6"
F = 1.75
fs = 45,000 (for grade 60 steel)
Ps = 0.06%

Answer:
Standard details are provided in Appendix A for the case of bar reinforcement of a 30'6" joint spacing and a width of 27 feet. It is anticipated that this will be used only for the rural four-lane divided highway. Designs for wire fabric, barmats, and for the numerous possible combinations of joint spacings and pavement width will be developed upon request. Also, a new design technique is now being developed by research and is expected to be usable in the future (Ref. 12).

F-110 OVERLAY

The design of an overlay is unique to each particular project. The most common practice is the use of asphaltic concrete pavement to restore serviceability. This may also, for a time, reduce joint maintenance and improve drainage characteristics, but it does not provide long-term solutions to most problems. Considerable thickness of asphaltic concrete is needed to provide structural value and to postpone reflection cracking. A detailed study of the existing surface and a thorough analysis of the expected results should be performed in the consideration of an asphaltic concrete pavement overlay.

A limited amount of experience is available with the use of relatively thin ACP overlays on continuously reinforced concrete pavements. A minimum thickness of four inches has given satisfactory performance. For an ACP overlay of four inches or less to perform satisfactorily, it is absolutely necessary to repair all punchouts and potential punchouts in the CRCP before the overlay is placed.

Thinner overlays of two inches or less are not recommended for either jointed pavement or CRCP. When such thin overlays are placed on jointed pavements, the joints reflect through the surface very quickly. This permits the entry of water into the joint, contributing to additional spalling and deterioration of the asphalt in the vicinity of the joint. Thin ACP overlays are also more susceptible to debonding from the concrete surface, because of the entry of water through joints, cracks or through the ACP itself.

Particularly careful attention to the design of an ACP overlay is recommended to assure that the mix is dense and as waterproof as possible, that the aggregate will not strip and that the mix has a sufficiently high stability to prevent shoving and rutting.

The design of a rigid overlay over existing concrete pavement is very complex and there is only a limited amount of experience. Assistance from the Pavement Design Section should be requested when it is desired to consider a rigid pavement overlay over an existing concrete pavement.

F-111 TERMINAL TREATMENT

A. Anchorage Systems

The termini or ends of portland cement concrete pavement may require special treatment in order to reduce the detrimental effects of pavement movement. The use of anchor lug systems is optional, depending upon the District's experience with such pavement movement. For continuously reinforced concrete pavements, the recommended number of anchor lugs can be selected from the tabulation following:

Subbase Type	No. Lugs*
Cement Stabilized	2
Asphalt Stabilized	2

* These recommendations are for a total allowable movement of 0.5 inch. They were derived from Reference 42.

An anchorage system for CRCP containing up to five anchor lugs is shown in Standard Design Details (see Standard Design Details listed in Appendix A).

The recommended anchor lug details for jointed concrete pavement are shown in Standard Design Details (see Standard Design Details listed in Appendix A).

Some Districts use expansion joints in combination with anchor lugs.

B. Bridge Approach Slabs.

The bridge approach slab is a heavily reinforced slab placed between a bridge and pavement end. The approach slab is designed to perform as an unsupported slab over a short length. The use of approach slabs is optional depending upon experience in the locality. Recommended design details are shown in Standard Design Details (see Standard Design Details listed in Appendix A).

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APPENDIX G-100

MULTIPLE USE OF HIGHWAY RIGHT-OF-WAY (G-100)

G-101 POLICY

A. General

In the development of highway projects, the Department usually initially acquires all right-of-way needed for full-scale project development; however, certain areas of this right-of-way may not be used in the initial stage of construction. These areas and areas beneath elevated structures may be made available for other public functions such as parking areas, recreational areas, public parks, immigration control, law enforcement functions, special gas tax inspections or other such legal inspections.

The following general policy provisions on multiple use of right-of-way have been established:

1. The public use of specified areas beneath overhead structures or certain other areas of right-of-way will be considered by the State Department of Highways and Public Transportation when local governmental authorities or other State or Federal agencies indicate a willingness to cooperate in the development of the same. Each proposed instance of joint use will be considered on its individual merits and the respective responsibilities of the State Department of Highways and Public Transportation and other parties involved shall be fixed by agreement.

2. State Department of Highways and Public Transportation approval for the joint use of highway right-of-way may be given only when it is considered to be in the public's interest and it has been determined from engineering and traffic investigations that it would not damage the highway facilities, impair safety, impede highway maintenance, or in any way restrict the operation of the freeway or highway facility.

3. Prior approval by the State Department of Highways and Public Transportation will be required before any permanent improvements are installed or constructed by other governmental units within any joint use area.

4. Where the approved joint use of an area would require increased span length for structures or modifications or variations of structures or highway cross-section to accommodate the public use of land area beneath, above or adjacent to the highway facility and such can be accomplished with reasonable economy without adverse effect upon the operation or maintenance of the highway facility, consideration may be given to the applicability of such modifications. Such considerations shall include evaluating the possible use of structure in lieu of embankment where the former would be more conducive to the public use of land space beneath the structures, improve local traffic circulation, provide for better public services, be more aesthetically pleasing, or better fit the highway into the environment.

5. The governmental agency or unit of local government specified in the agreement shall bear full responsibility for operation of the entire multiple use area. If at any time property is used for any purpose other than that outlined in the agreement, such will constitute grounds for termination of the agreement.

6. If, in the sole judgment of the State Department of Highways and Public Transportation, it is found at any future time that traffic conditions have so changed that the existence or use of the area for other than traffic purposes is impeding maintenance, damaging the highway facility, restricting operation of the freeway or arterial street, impairing safety, or that the facility is not being properly maintained or operated, that it constitutes a public hazard or nuisance or if, for any other reason, it is the Department's judgment that the facility is not in the public interest, the agreement under which the facility was constructed may be: (1) modified if corrective measures acceptable to both parties can be applied to eliminate the objectionable features or practices that exist, or (2) terminated and the use of the area as a joint use facility discontinued.

7. Upon written notification by the State Department of Highways and Public Transportation that the multiple use facility should be discontinued, or if the responsible governmental unit in its own judgment determines that such facility should be discontinued, the responsible agency shall, within the period specified in the agreement and at their entire expense, clear the area of all facilities which had been its financial responsibility which were used in conjunction with the operation and maintenance of the facility, restoring the areas thus cleared to a condition satisfactory to the State Department of Highways and Public Transportation. Any and all construction or appurtenances which had been the responsibility of the Department will remain.

8. Maintenance of the joint use area and facilities thereon will be the responsibility of the operating governmental unit. Such responsibility shall not be transferred, assigned or conveyed to a third party without approval of the State Department of Highways and Public Transportation. Any fees levied for use of the facilities on the area should be nominal and no more than are sufficient to defray the cost of construction, maintenance, and operation thereof. Maintenance of lighting installations will conform with the Department's illumination policy and will be covered under separate agreement.

9. The governmental unit or agency responsible for maintenance and operation of the multiple use facility will indemnify the State Department of Highways and Public Transportation against any and all damages and claims for damages, including those resulting from injury to or death of persons or loss of or damage to property, arising out of, incident to or in any manner connected with the operation or maintenance of the multiple use facility, which indemnification shall extend to and include any and all court costs, attorney's fees and expenses related to or connected with any claims or suits for damages and shall, if requested in writing by the State Department of Highways and Public Transportation to do so, assist or relieve the State Department of Highways and Public Transportation from defending any such suits brought against it.

10. The State Department of Highways and Public Transportation, by execution of an agreement with another local, state or Federal unit of government for the joint use of any area of highway right-of-way, does not impair or relinquish the Department's right to use such land for right-of-way purposes when it is required for construction or reconstruction of the traffic facility for which it was acquired, nor shall use of the land for other than highway purposes under such agreement ever be construed as abandonment by the State Department of Highways and Public Transportation of such land acquired for highway purposes.

B. Offstreet Parking

Where it has been determined that an area within the highway right-of-way would be appropriate for use as a parking facility, the following provisions will apply:

1. **The State Department of Highways and Public Transportation will generally be responsible for the site grading, construction of access driveways, paving, installation of curbs, or other such traffic control devices, lighting, basic landscaping and screening to insure its aesthetic balance with the overall highway design and the environment of the area. The maintenance and operation of the entire joint use facility will be the responsibility of local governmental agencies. The installation of parking meters, gates, attendant's shelters, or other appurtenances necessary to the operation of the facility will generally be the financial responsibility of the local governmental agency.**

2. Regulations shall be enforced by the responsible governmental officials prohibiting the use of any area for the parking of vehicles carrying highly inflammable or explosive loads. Under overhead structures, adequate provision shall be made for protection of piers and the operating agency shall enforce parking regulations limiting parking to motor vehicles of size and capacity as set forth in the agreement, such vehicles to conform in size and use to governing State statutes.

3. This policy pertains only to multiple use of highway right-of-way with controlled points for ingress and egress, and in no way modifies current policies governing parking on or access to freeways, highways and arterial streets, including auxiliary frontage streets, connecting roadways, ramps, or turning lanes.

C. Recreational Areas

1. In the development of parks, mini-parks, hike-and-bike trails, nature trails, bridle paths, etc., within the highway right-of-way the State Department of Highways and Public Transportation will generally be responsible for the site grading, and drainage requirements, walks or other paved areas, fencing, curbing, basic landscaping or other treatment where safety and aesthetic considerations are involved.

2. In the development of recreational facilities, such as basketball or handball courts, play areas, tennis courts, etc., the State Department of Highways and Public Transportation will generally be responsible for the necessary grading and drainage facilities, the provision of minimum hard surfacing, lighting, fencing and basic landscaping as may be warranted by safety and aesthetic considerations. The maintenance and operation of the entire joint use facility will be the responsibility of local governmental agencies. Local governmental agencies will generally be financially responsible for any play equipment, backstops, goals, nets, or other appurtenances necessary for the enjoyment of the recreational functions intended.

3. At highway crossings of streams or reservoirs the State Department of Highways and Public Transportation shall cooperate with the Texas Parks and Wildlife Department or other legally constituted river and reservoir authorities in determining whether the use of highway right-of-way for boat launch facilities, recreational purposes or parking areas would be in the public interest. If it is determined that such facilities should be provided, the State Department of Highways and Public Transportation will provide

and be responsible for the access connection from the highway facility; all other construction necessary to their development will be the financial responsibility of the Texas Parks and Wildlife Department or the appropriate stream or reservoir authority.

D. Inspection Stations

The provision of Inspection Stations will be considered only upon request from the Texas Department of Public Safety, the U.S. Department of Transportation, the U.S. Immigration Service, the Texas Comptroller of Public Accounts, or other responsible governmental agencies. The following will be considered in the design of Inspection Stations:

1. Each inspection station will serve only one direction of travel, regardless of the type of facility. Where two inspection stations are required (one for each direction of travel) their locations will be staggered at a sufficient distance apart to discourage inspectors from crossing the road and creating a hazardous condition.

2. Border Patrol Inspection Stations will generally be located only on the lane(s) departing Mexico.

3. All driveways and ramps will conform to the standards set forth under Paragraph 4-602(J) (Part IV Design) and as shown in Figure G-1.

4. A parking area of 40-ft. width is desirable to provide adequate passing and storage areas for large tractor-trailer combinations.

5. The State Department of Highways and Public Transportation will generally be responsible for the necessary grading and drainage facilities, construction of ramps and driveways, installation of curbs, or other protective devices, and necessary highway signing to direct traffic safely into and out of the inspection station. The installation, maintenance, and operation of the inspector's shelters, scales, or other appurtenances necessary to the operation of the facility will generally be the financial responsibility of the inspecting agency.

Insofar as possible, the various inspection stations should be combined, consistent with proper operation of the highway. The Highway Design Division is responsible for all main office review, coordination with other agencies and further handling of requests for approval of Inspection Stations on the State Department of Highways and Public Transportation System.

E. Passes and Cattle Guards

The provision of grade-separated private passes will be in accordance with the policy and procedures set forth in the *Right-of-Way* and *Appraisal and Appraisal Review Manuals*.

F. Other

In the event that a local governmental unit or State agency should desire to enter into an agreement with the Department for the use of highway right-of-way as sites for law enforce-

TYPICAL INSPECTION STATION

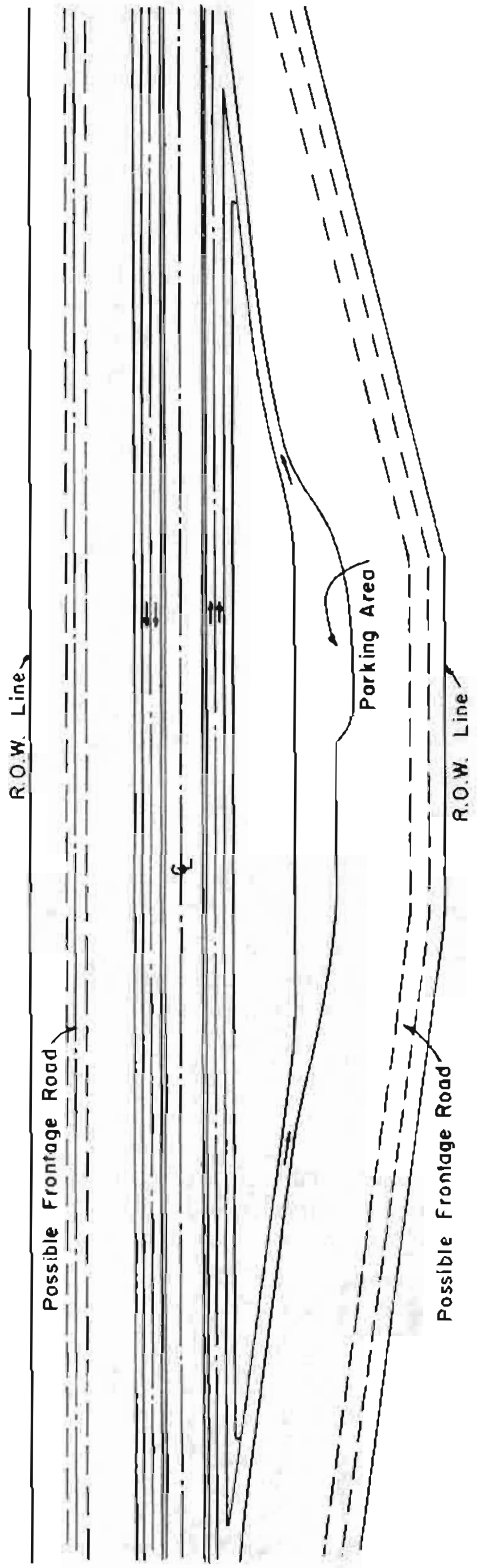


FIGURE G-1 Refers to Paragraph G-101(D)

ment centers, emergency service centers, or any other public functions not specifically described herein, such requests will be independently considered by the State Department of Highways and Public Transportation and each instance judged according to its particular merits, subject to the specific provisions contained herein.

G. Administration of Policy

The responsibility for administering this policy will be shared by File D-8 and File D-18. On projects which are in the design stage or under construction, proposals for multiple use development will be submitted to File D-8 who will then correlate the same with File D-18 and other appropriate Austin Office Divisions. On completed projects, proposals for multiple use will be submitted to File D-18 for further handling with File D-8 and other appropriate Divisions.

G-102 SAFETY REST AREAS

A. Rest Area on Controlled Access Highways and Multilane Highways

Rest areas should be located on the Interstate Highway System in accordance with the proposed plan as approved by the Administration which provides for a spacing of approximately thirty minutes' driving time. Similar criteria for spacing should be used on other controlled access highways. It is desirable to obtain rest area sites at the time right-of-way for highway construction or reconstruction is being acquired.

Figure G-2 shows a typical rest area on a freeway or multilane facility.

Rest areas should have direct access to and from the main lanes and be so located as to provide safe ingress and egress. In selection of a site, consideration should be given to scenic values, such as trees, streams, and views. Generally, the site should be from five to ten acres with the extra width of right-of-way being from 200 to 300 feet. It is desirable to locate rest areas in rural areas, preferably four miles or more from a city.

The necessary grading of the rest area, along with the driveway construction, should be included with the highway construction contract.

The water supply, if obtained from wells, shall be developed prior to letting of a contract for the construction of comfort stations and/or other rest area facilities. It is necessary that separate contracts be let for roadway construction and for rest area facilities with comfort stations, since two different wage scales are involved. Generally, all construction of rest area facilities will utilize desirable fireproof materials in order to reduce vandalism. For certain soil conditions, large areas of right-of-way may be required to dispose of effluent at comfort stations. In the selection, planning and development of rest area sites, the Landscape Section of D-18 will assist the Districts.

B. Rest Areas on Two-Lane Highways

The spacing of rest areas on two-lane highways is dependent upon the volume of through and recreational traffic. Generally, Farm-to-Market Roads having State Highway characteristics with adequate traffic may have rest areas where sites of outstanding qualities can be

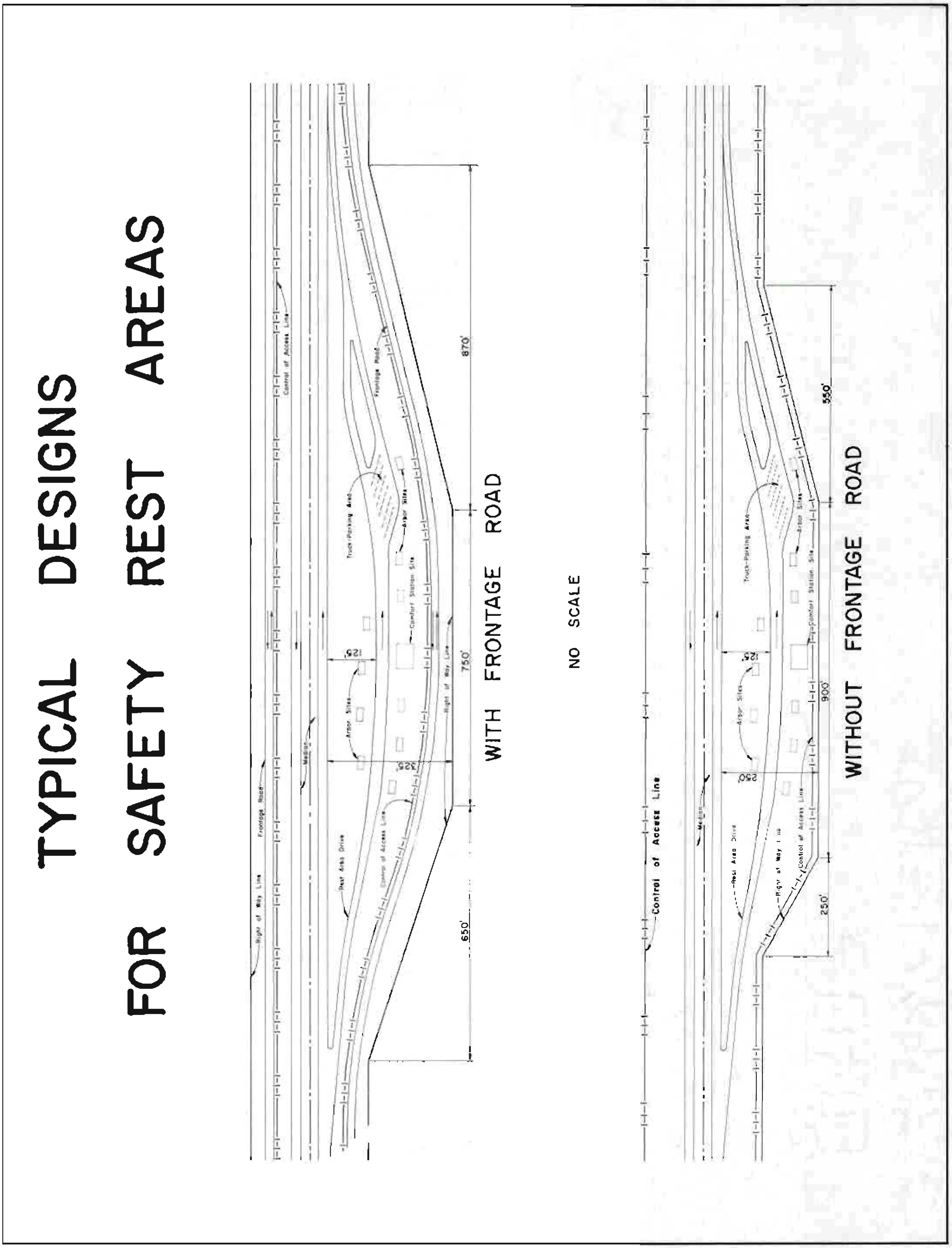


FIGURE G-2 Refers to Paragraph G-102(A)

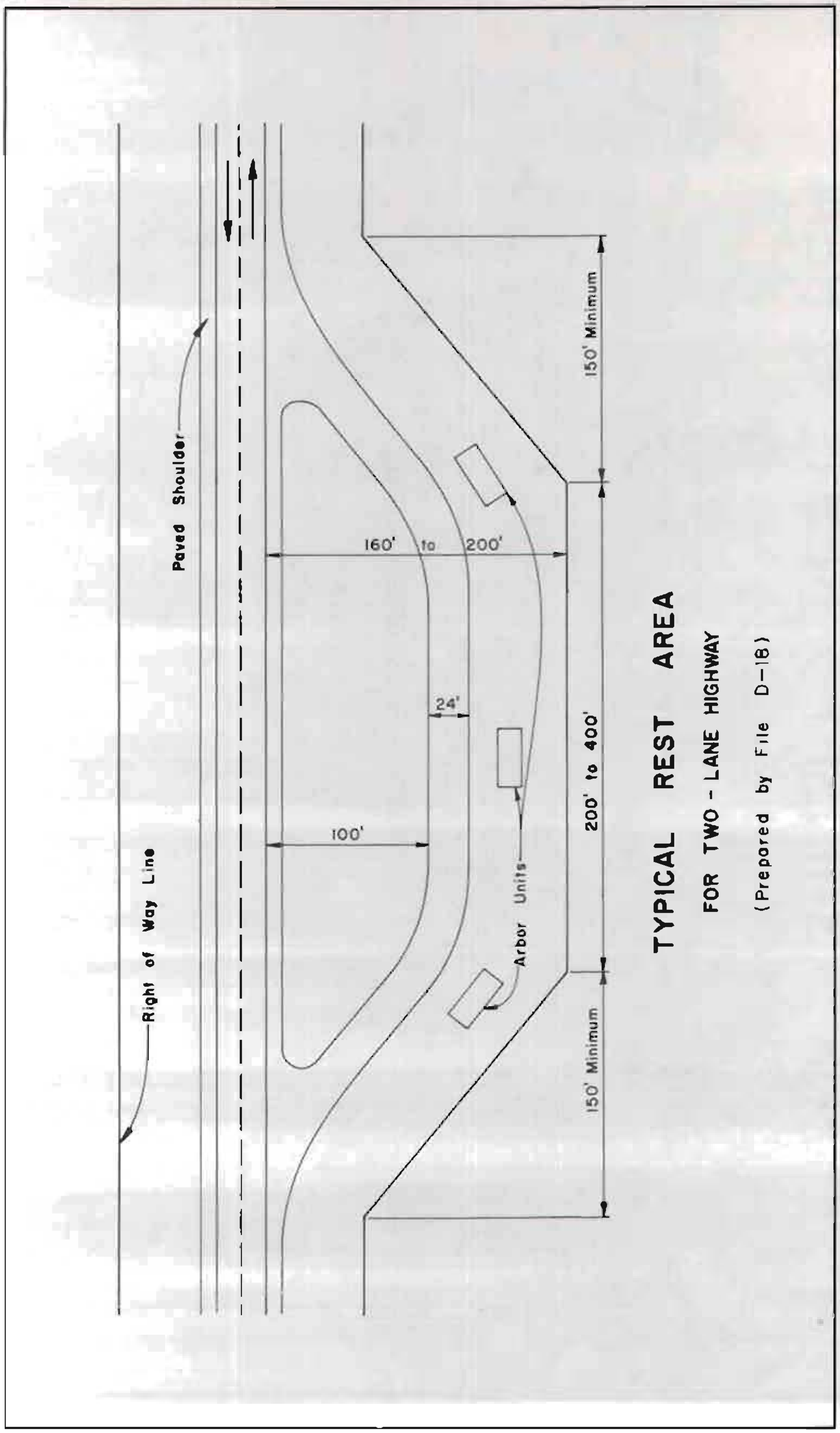


FIGURE G-3 Refers to Paragraph G-102(B)

obtained. On State Highways having a low volume of through or recreational traffic, the installation of rest areas should be only at those locations having outstanding qualities. Generally, rest areas should be provided on the main traveled State Highway System at intervals of thirty to forty-five miles or between county seats.

Figure G-3 shows a typical rest area on a two-lane highway.

It is desirable to obtain rest area sites at the time right-of-way for highway construction or reconstruction is being acquired. Generally, these sites should be located four miles or more from a city.

Safe ingress and egress should be provided for all sites. Consideration should be given those having good scenic values which are not subject to excessive flooding. Generally, the site should have from one to five acres with the extra width of right-of-way being from 100 to 200 feet.

The necessary grading of the rest area, along with driveway construction, should be included with the highway construction contract.

Development of certain rest areas on selected sections of the more heavily traveled highway system may have comfort stations in which case these will be handled as specified for those on controlled access highways. Generally, the rest area facilities will be developed with State Maintenance Forces. In the selection, planning and development of these rest areas, the Landscape Section of D-18 will assist the Districts.

G-103 INFORMATION STATIONS

A. Information stations are located within the right-of-way of a highway for the purpose of furnishing information to the incoming traffic concerning highway routes and conditions, parks, recreational centers, cities and tourists' accommodations.

B. Information stations shall be located along controlled access highways which enter the State. They shall be within the right-of-way of the controlled access highway and between the main incoming lanes and the frontage road, if frontage roads are provided. In no case will information stations be located between the through lanes. They shall be near the point of entrance to the State, preferably adjacent to a town or village for the convenience of the operating personnel, as directed by the District Engineer.

C. The information station shall be directly accessible from the main incoming lanes of travel by way of standard exit and entrance ramps.

The area shall have sufficient parking space to enable passenger vehicles, with or without mobile homes, and truck vehicles to leave the main lanes with ease, thus discouraging parking adjacent to the main lanes.

The size of the area should be governed by the traffic volume of such projections as to preclude the necessity of acquisition of additional area in the foreseeable future.

The building for the facility should be of a construction type that will conform with the local architecture. Figure G-4 shows a typical information station design.

D. **The area for the parking and driveways from the main lanes shall be included in the PS&E as construction items. The building itself will be constructed under a separate contract.**

E. The area of the information station and other facilities shall be maintained by the State Department of Highways and Public Transportation.

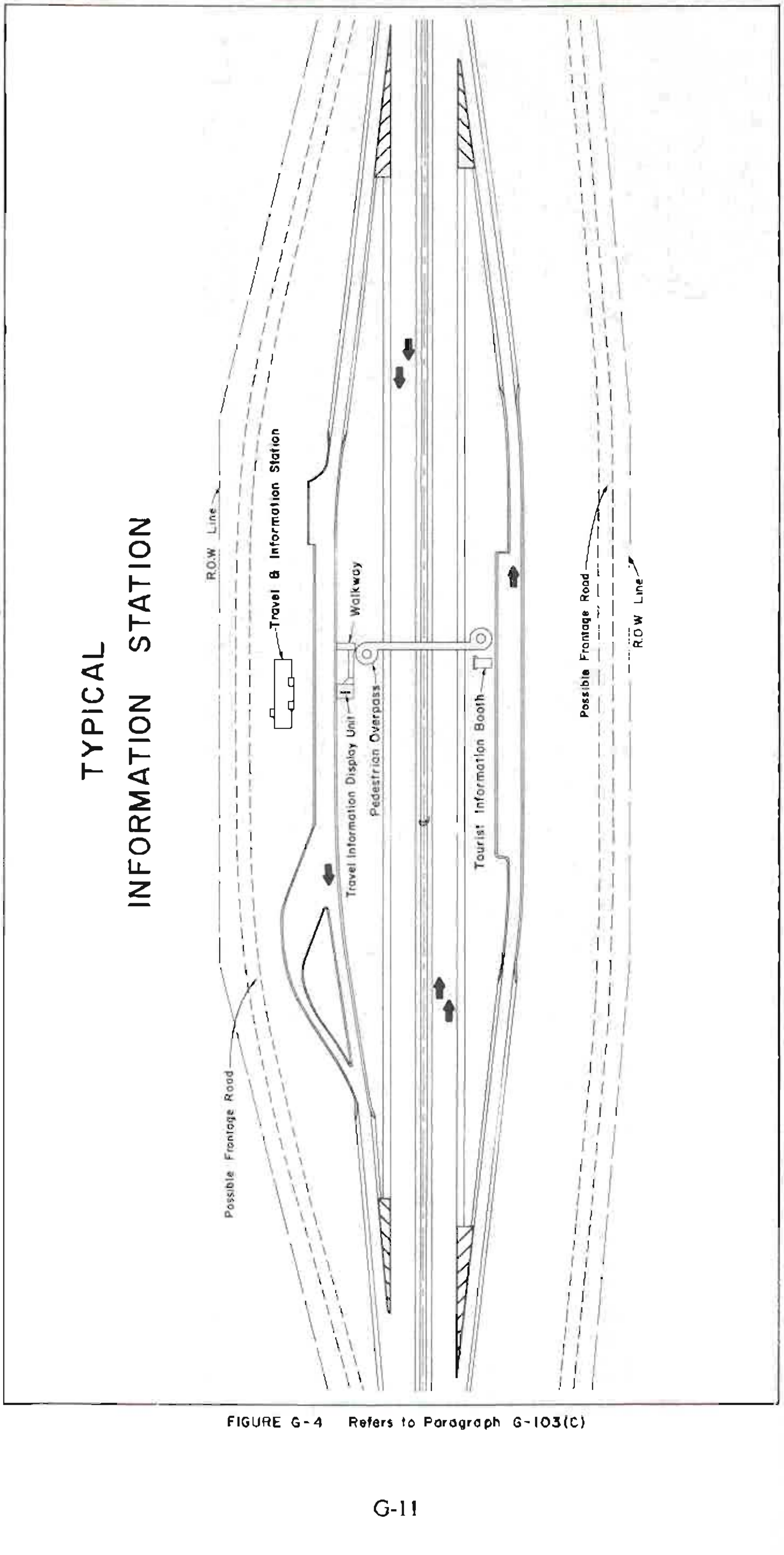


FIGURE G-4 Refers to Paragraph G-103(C)

Referenced on
page 4-55

APPENDIX H-100

Referenced on page 4-55

BIKEWAY DESIGN GUIDELINES (H-100)

H-101 GENERAL

The bicycle is just another mode of transportation and, like automobile transportation, it is necessary to follow a transportation planning process in order to warrant, coordinate, design and produce a facility that will best serve the public for its investment.

H-102 POLICY

Under the 1973 Federal-aid Highway Act, money apportioned for the urban and rural Primary and Secondary Systems and the Urban System can be used to construct separate or preferential facilities for bicycles in conjunction with Federal-aid highway projects. It is the responsibility of local officials to make such proposals to the State for the facilities. Projects proposed for Federal-aid funding on the Urban System are selected by locally elected officials of the jurisdiction involved acting through the metropolitan planning agency designated by the Governor. These projects must have the specific concurrence of the State Department of Highways and Public Transportation. The State will work directly with County or City officials in the development of the project details.

Before a proposal is pursued to any great length, the following conditions must be satisfied:

1. **The facility will not impair the safety of the motorist or bicyclist.**

2. **The facility will be accessible to users or will form a segment located and designed pursuant to an overall plan.**

3. **A public agency has formally agreed to:**

   a. **Operate and maintain the facility.**

   b. **Ban all motorized vehicles other than maintenance vehicles.**

4. It is reasonably expected that the facility will have sufficient use in relation to cost to justify its construction and maintenance.

H-103 FUNDING

State highway construction funds may be spent only within the confines of right-of-way limits. Therefore, for bicycle facilities constructed within the highway right-of-way, highway (State or combination of Federal and State) construction funds, if available, may be used to construct bicycle facilities as an incidental feature of a highway construction project.

State highway funds may not be spent for bicycle facility construction outside of right-of-way limits. However, the Federal-aid Highway Act of 1973 does allow Federal highway funds to be used for these projects subject to Departmental and FHWA concurrence. Where "off" right-of-way bikeway projects are selected by local officials for inclusion in the Federal-aid Urban System, Federal highway funds must be matched with local funds to finance bikeway project preliminary planning and construction.

H-104 WARRANTS

Many considerations should be weighed before developing a bikeway facility. First, it must be determined whether or not the expected bicycle traffic is sufficient to justify the cost involved. Where bicycles are to share facilities designed mainly to accommodate other transportation modes, the safety and capacity of the transportation system must be considered. The warrants for determining a separated facility exist where (a) bicycle volumes will be 200 or more per day in conjunction with motor vehicular volumes of 2000 ADT or more, or (b) where the same bicycle volumes will be in conjunction with motor vehicular speeds of 40 mph or higher. Bicycle travel should be prohibited on the traveled way of freeways and other high speed highways.

H-105 DEFINITIONS

A. **Bicycle - A device having two tandem wheels propelled exclusively by human power upon which a person may ride.**

B. **Bicycle Trail - A separate trail or path which is for the exclusive use of bicycles. Where such a trail or path forms part of a highway, it is separated from the roadways for motor vehicular traffic by an open space or barrier.**

C. **Bicycle Lane - A portion of a roadway which has been designated for preferential or exclusive use by bicycles. It is distinguished from the portion of the roadway for motor vehicular traffic by a paint stripe, curb or other similar device.**

D. **Shared Bike Route - A roadway which is officially designated, signed and marked as a bicycle route but which is open to motor vehicular travel and upon which no bicycle lane is designated.**

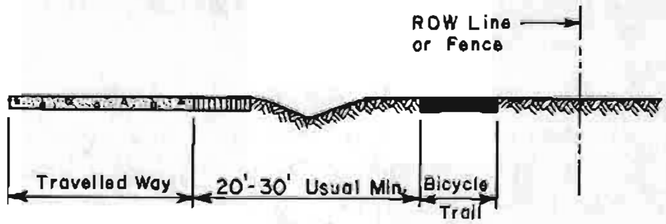
H-106 TYPES OF BIKEWAYS

A. General

The preferred method of providing bicycle travel is the bicycle trail. It can be designed to specifically satisfy the needs and physical characteristics of the bicycle mode of transportation. However, it is not always possible to provide a bicycle trail. In urban areas where availability of right-of-way, associated land use and costs are the governing factors, bicycle lanes and shared bike route are the only feasible alternatives. These two facilities do not always provide the most satisfactory riding environment but they are feasible alternatives. Where possible, bicycle and motor vehicle traffic should be separated in order to decrease bicycle-motor vehicle conflict. The design criteria will be presented separately for each of the three different types of bikeway facilities: (1) Bicycle Trails, (2) Bicycle Lanes, and (3) Shared Bike Routes.

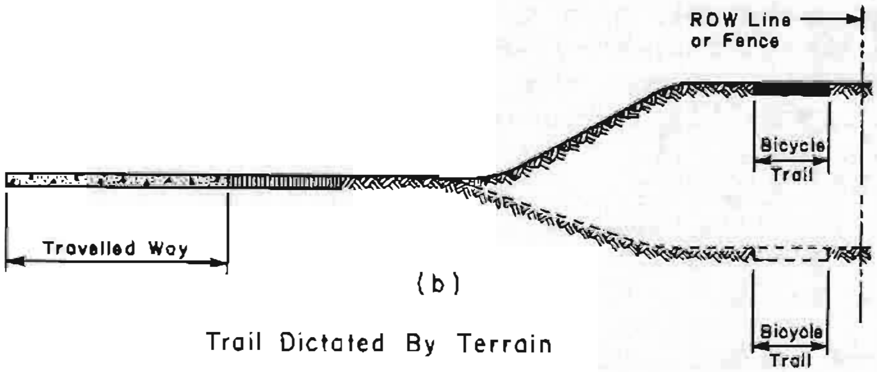
B. Types of Bikeway Facilities

1. Type I Bikeway - Bicycle Trails. The bicycle trail should be located as far from the traveled way as practicable in order to minimize bicycle-motorist conflicts. There should be a usual minimum distance of 20 feet and desirable 30 feet separating the trail from the roadway unless some form of natural barrier is available such as a ditch, earth berm, etc. Figure H-1 shows three typical cross-sections where bicycle trails are located



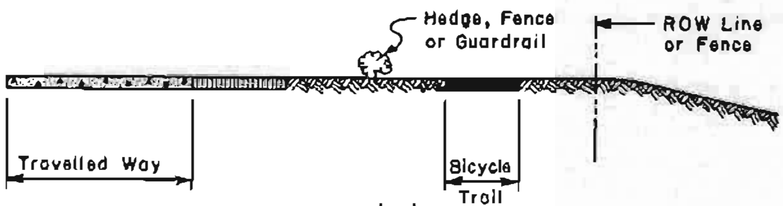
(a)

Trail Outside Ditch Section



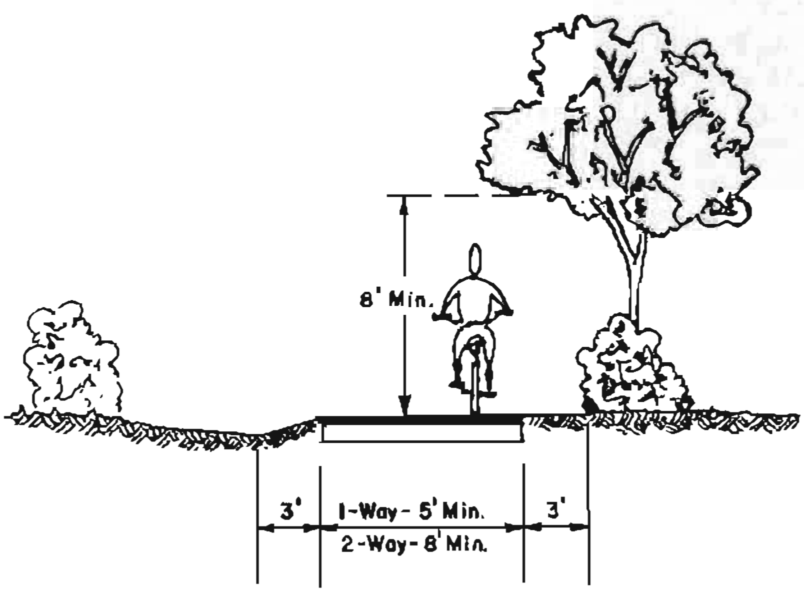
(b)

Trail Dictated By Terrain



(c)

Physical Barrier



(d)

Horizontal and Vertical Clearances

Typical Bicycle Trails
(Type I Bikeway)

FIGURE H-1

within the right-of-way. As an alternate arrangement to the design shown in Figure H-1(c), it may be desirable to place a control-of-access fence along the physical barrier strip a sufficient distance inside the right-of-way line to allow space for a trail outside the fence but still within the right-of-way.

2. Type II Bikeway - Bicycle Lane. The bicycle lane is developed within the cross-section of the vehicular roadway in the outside lane and is intended for the exclusive use of bicycles. The bicycle lane is delineated by means of pavement markings or curbs (see Section H-113). The three general locations for bicycle lanes with respect to the vehicular roadway are shown in Figure H-2.

   Bicycle lanes on roadways are usually one-way because of the limited available width and the potential hazards associated with opposing directions of travel. One-way lanes are preferable where attainable.

3. Type II Bikeway - Shared Bike Route. The shared bike route is specified for bicycle operation by signs and markings but is also shared with motor vehicle traffic. There are no barriers, either symbolic or physical, to delineate a portion of the travelway for bicycles. This type of facility is considered suitable only if motor vehicle volumes are fairly light (less than 2000 ADT) with low speed. Identification of the shared bike route is made by posted signs along the roadway or perhaps by words or symbols painted on the pavement in order to alert the cyclist and motorist.

H-107 GEOMETRICS

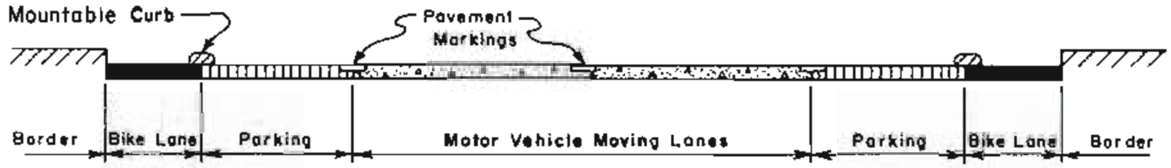
A. Design Speed

The speed that a bicyclist travels is dependent upon geometric features of the traveled way, type of bicycle, weather conditions and physical condition of the rider. In determining the design speed of a bikeway, the geometric features of curvature, superelevation, gradient and width of traveled way are used to produce a traveling speed that is at least as high as the preferred speed of the faster travelers. Nearly all bicyclists travel within a speed range of 7-15 mph with the average speed being between 10-11 mph. On long downgrades, speeds of 20 mph or more should be considered. For Type II and Type III bikeways, the design speed necessary to serve motor vehicle operation will adequately serve bicycle traffic needs.

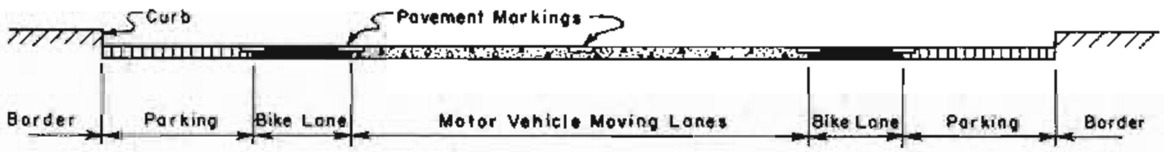
B. Curvature

For a given design speed of a bikeway, consideration must be given to the minimum radius of curvature. Where bicycle lanes and shared bike routes follow the roadway alignment, the curvatures designed to accommodate the motor vehicles will be more than adequate for bicycles. However, care should be taken for bikeways not paralleling roadways to insure that the minimum radius of curvature is provided to permit unbraked turns at the design speed. Figure H-3 shows a family of curves for determining the curvature and superelevation for various bikeway speeds. It should be noted that the superelevation should never exceed 0.12 foot per foot.

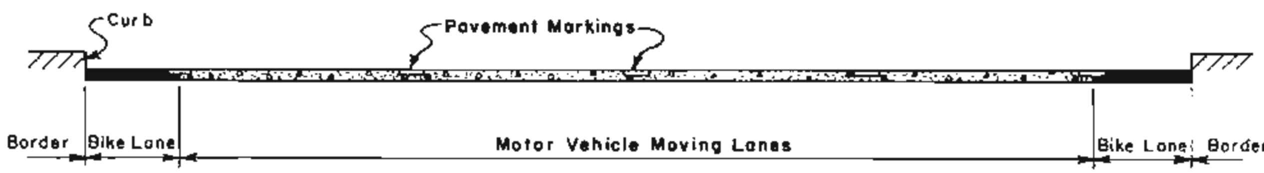
Where the radius of curvature is less than 100 feet, it is advisable to widen the bikeway in order to increase the lateral space required by the cyclist as he leans to the inside of a turn. Figure H-4 shows the methodology used in determining the necessary widening to compensate for lean. The amount of widening should be limited to a maximum of 4 feet.



(a) Parking permitted - Bicycle lane located between sidewalk and parking lane



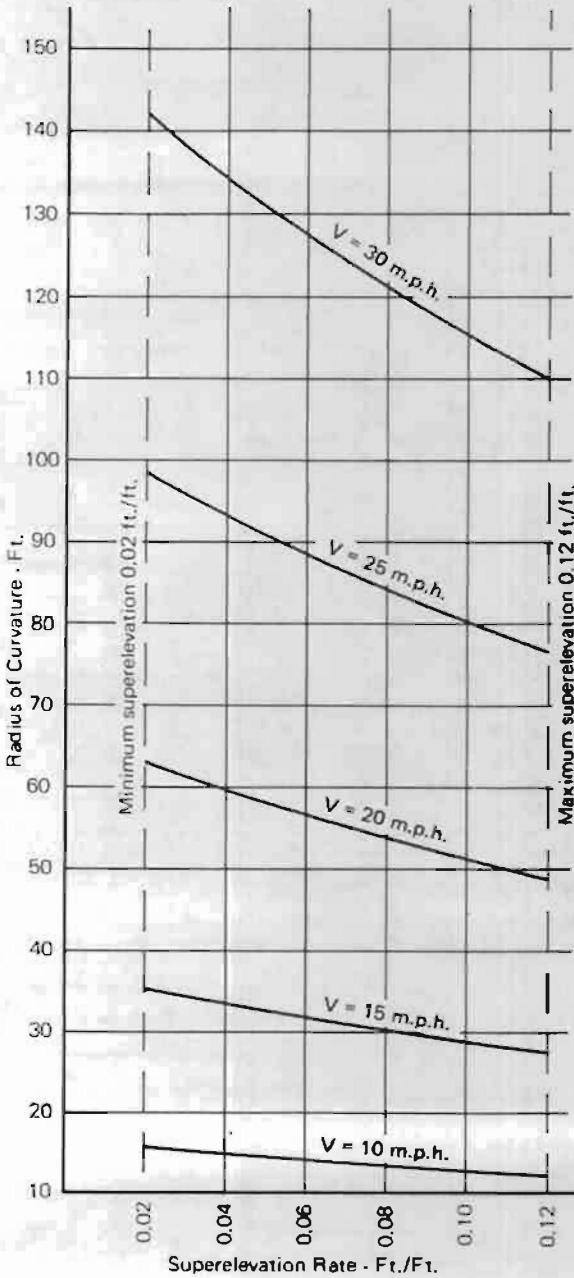
(b) Parking permitted - Bicycle lane located between parking lane and motor vehicle moving lanes



(c) Parking prohibited - Bicycle lane located between sidewalk and motor vehicle moving lanes

ONE-WAY BICYCLE LANES ON ROADWAYS

FIGURE H-2



plot of: $\frac{V^2}{gR} = \frac{\tan\theta + f}{1 - f\tan\theta}$

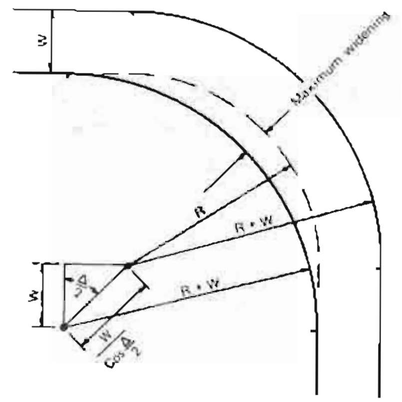
where, V = velocity, ft./sec
g = acceleration due to gravity, ft./sec.^{2}
R = radius of curvature, ft
f = coefficient of friction on dry pavement = 0.4
$\tan\theta$ = superelevation rate, ft./ft.

Curvature shall be based on a normal design speed of 20 m.p.h. Within limits shown, either the radius or the superelevation may be varied to fit individual situations. The dependent variable may be selected from the adjacent chart. Descending grades in excess of 7 percent will have a design speed of 30 m.p.h. Climbing grades in excess of 3 percent may use a 15 m.p.h. design speed. The descending grade determines the design speed on two-way bikeways.

STANDARD SUPERELEVATION FOR BIKEWAYS

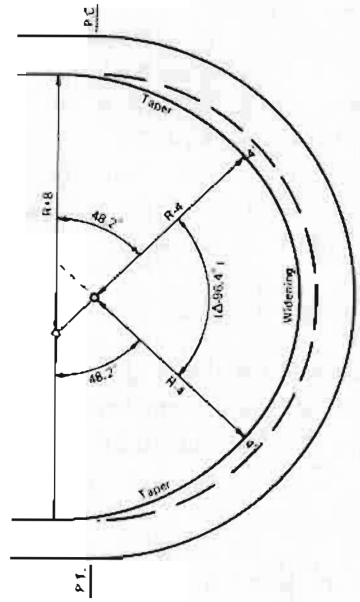
Source: State Of Oregon

FIGURE H - 3



R = Radius of curvature (from Figure 4)
W = Width of bikeway
Δ = Central angle of the curve or the deflection between tangents

Maximum widening shall be limited to 4 feet.

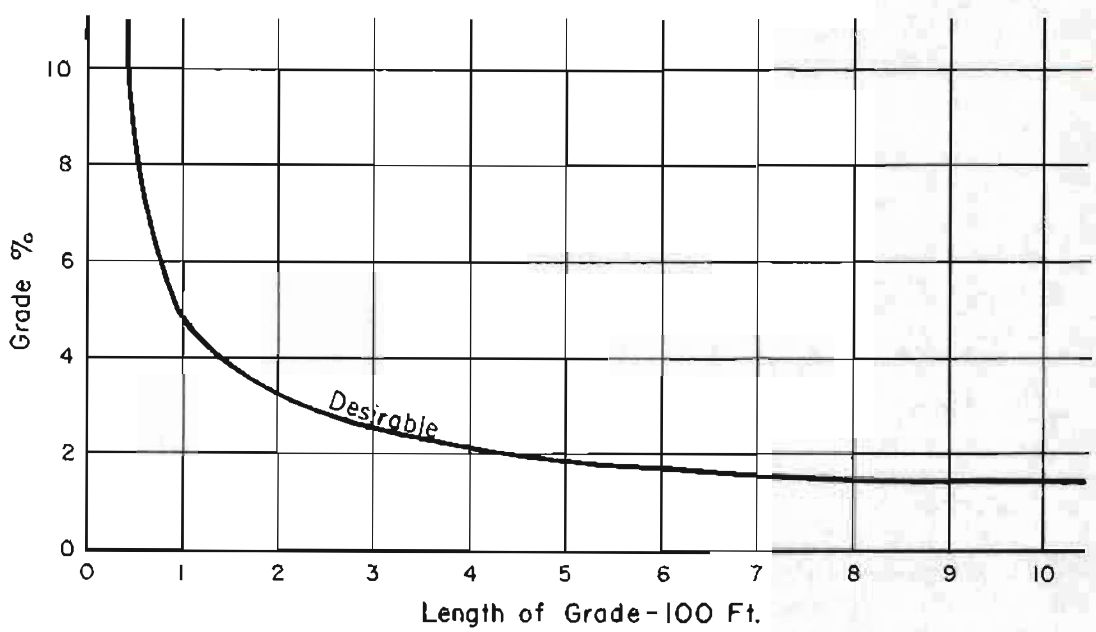


When widening reaches 4 ft. (Δ>96.4°), that width shall be carried on a radius of R-4 through the central portion of the curve (Δ-96.4°) as shown on the right.

CURVE WIDENING

Source: State Of Oregon

FIGURE H-4



DESIRABLE GRADIENT

Figure H-5

C. Grades

Whether or not a bikeway is favorable to cyclists is largely dependent upon the grade and alignment of the bikeway. The amount of energy a cyclist expends in using a bikeway will affect the usage of the bikeway. Therefore, the grades should be kept to a minimum. A bikeway gradient should not exceed 10 percent. Figure H-5 shows the desirable gradients for various lengths of grade.

D. Sight Distance

Also associated with design speed is stopping sight distance. Figure H-6 gives the stopping sight distance for various speeds and related grades. The stopping sight distance for vertical curves can be determined from Figure H-7.

E. Clearance

In order to prevent encroachment conflicts, adequate vertical and horizontal clearances must be provided. The minimum vertical clearance for overhead obstructions is 8.0 feet. The minimum lateral clearance to an obstruction from the edge of the bike trail pavement is 3 feet. These clearances are illustrated in Figure H-1(d).

H-108 CROSS SECTION DESIGN

The cross section design for bikeways will be presented separately for each of the three types of bikeways: bicycle trails, bicycle lanes and shared bike routes.

A. Bicycle Trails

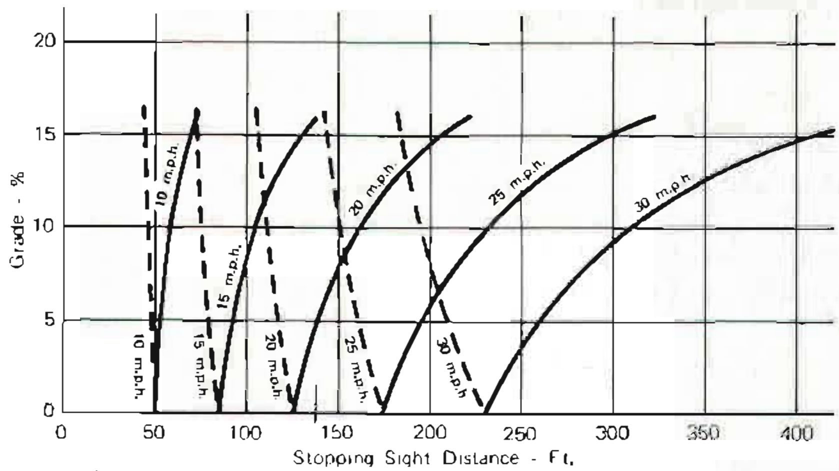
In determining the minimum widths for bicycle trails, the surface widths shown in Table H-1 should be added to the recommended vertical and horizontal clearances. Where maintenance vehicles are expected to utilize the bicycle trail, it may be necessary to adjust these minimum widths in order to accommodate these vehicles.

Number of lanes	Minimum width, feet	Desirable width, feet
1	3.5	4.0
2	7.0	8.0
3	10.5	12.5
4	14.0	17.0

Adjustments to Basic Bikeway Widths

Condition	Additional Width, feet: Minimum	Additional Width, feet: Desirable
Raised curb on one side	0.5	1.0
Raised curb on both sides	1.0	2.0
Parked cars adjacent	2.0	2.0

Table 1. Bikeway Surface Widths



$$S = \frac{V^2}{30(f \pm G)} + 3.67\,V$$

Where S – stopping sight distance, ft
V – velocity, m.p.h.
f – coefficient of friction (use 0.25)
G = grade, ft./ft. (rise/run)

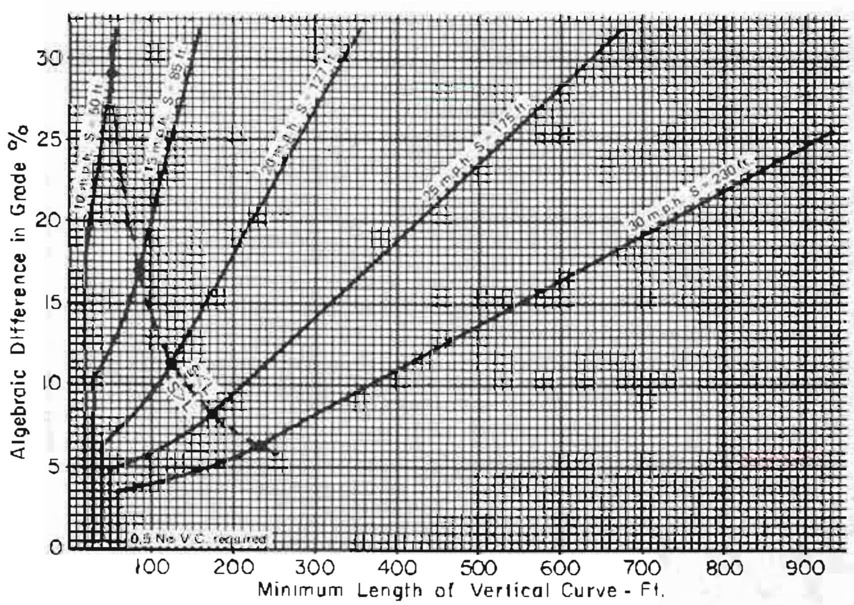
Descend ———

Ascend – – – –

STOPPING SIGHT DISTANCE

Source: State Of Oregon

FIGURE H-6



$$L = 2S - \frac{200(\sqrt{h_1}+\sqrt{h_2})^2}{A} \quad \text{when } S>L$$

$$L = \frac{AS^2}{100(\sqrt{2h_1}+\sqrt{2h_2})^2} \quad \text{when } S<L$$

where: S = Stopping sight distance
A = Algebraic difference in grade
h_1 = 4½ ft.—eye height of cyclist
h_2 = ¼ ft.—height of object
L = Minimum vertical curve length

BIKEWAY SIGHT DISTANCE FOR CREST VERTICAL CURVES

Source: State Of Oregon

FIGURE H-7

B. Bicycle Lanes

It is desirable for bicycle lanes to be restricted to one-way operation. The minimum width of the bicycle lane is dependent on the location of the bicycle lane with respect to the roadway and the parking conditions. Where the bicycle lane is between the curb and the parking lane as shown in Figure H-2(a), the minimum width for one lane should be 3.5 feet plus 0.5 foot clearance to each curb or a total of 4.5 feet. In this case, the 2-foot additional width for clearance to adjacent parked cars as indicated in Table H-1 is not required.

Where the bicycle lane is between the parking lane and traveled lane as in Figure H-2(b), the minimum width should be 3.5 feet (one-lane minimum) plus a 2-foot allowance for car-door openings or a total of 5.5 feet.

Where parking on the roadway is prohibited and the bicycle lane is between the curb and the traveled way, as in Figure H-2(c), the minimum width should be 3.5 feet (one-lane minimum) plus a 0.5-foot clearance to the curb or a total of 4.0 feet.

C. Shared Bike Route

Where a low volume street is designated as a bike route and is to share the roadway with cyclists, the outer lane must have a width of 10 feet or greater. Heavier volume streets would require a width of 12 feet or greater. If parking is to be accommodated, the combined width of the outer lane plus the parking lane should total at least 22 feet.

H-109 BICYCLE TRAIL PAVEMENT STRUCTURES

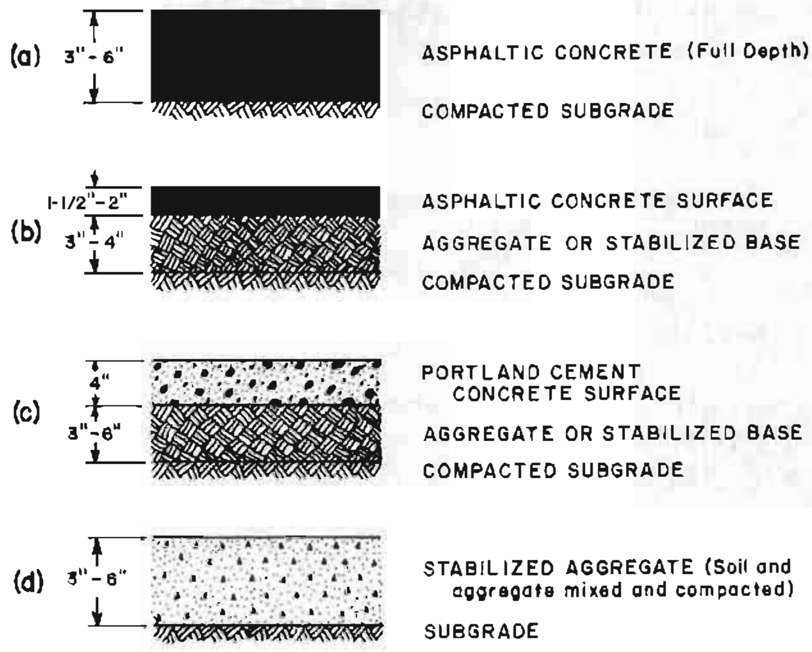
The pavement structural section of a bicycle trail must not only be adequate to support the wheel loads of bicycles and riders but also maintenance vehicles or motorized vehicles which may cross the trail. This structural section will consist of a base course and a riding surface which is stable and traversable even in wet weather. Materials which might be used for a base course include aggregate, stabilized earth, soil cement, asphaltic concrete and portland cement concrete. A desirable riding surface would consist of an asphaltic material or portland cement concrete. For recreational travel, a dense grade surface of crushed aggregate, sand, clay or stabilized soil may be acceptable. Figure H-8 shows several pavement structural sections. Exposed base rock next to the bikeway surface should be avoided and sod or topsoil used instead.

H-110 BRIDGES

Bridges designed exclusively to carry two-way bicycle traffic should have a minimum width of 8 feet. Where it is necessary to carry a bicycle trail across a highway structure on a controlled access highway with high volumes of vehicle traffic, the trail should be carried outside of the normal bridge shoulder and separated from the shoulder by a physical barrier (concrete barrier, railing or fence). On low speed, low volume highways, the bridge shoulder can be utilized for the trail. In this case, the shoulder should be adequately signed and marked. The widths shown in Table H-1 are applicable in determining the bikeway section on a bridge.

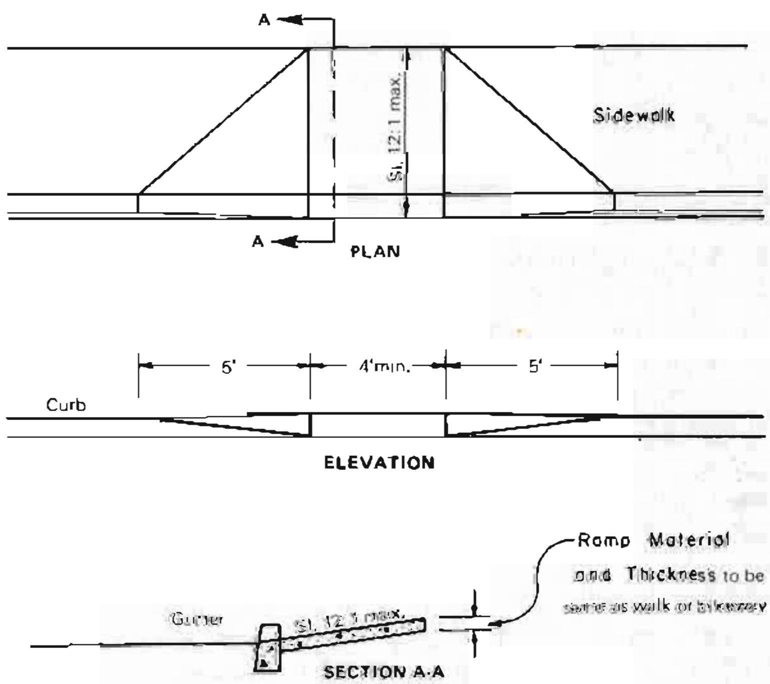
H-111 DRAINAGE GRATES AND BICYCLE RAMPS

For bicycle lanes and shared bicycle routes, the existing street drainage inlet grates may prove to be a hazard. Drainage inlet grates with openings large enough to entrap narrow bicycle wheels should be



Typical Pavement Structural Sections for Bicycle Trails

FIGURE H-8



BICYCLE AND WHEELCHAIR RAMP

Source: State Of Oregon

FIGURE H-9

either replaced with a bicycle-proof grate or modified by welding 1″ × ¼″ steel straps to the grates at a spacing of 6″ to 8″ on centers.

Figure H-9 depicts standard bicycle and wheelchair ramp design.

H-112 INTERSECTIONS AND CROSSINGS

The greatest number of conflicts between motorists, bicyclists and pedestrians occur at intersections and crossings. Elimination of conflicts where bicycle routes cross a roadway can be accomplished by providing a grade separation but this is not always possible or economically feasible. However, some form of channelization with specific routings for bicycles should be provided to minimize these conflicts. Channelization of the bicycle crossing can be accomplished by some form of striping or marking which clearly delineates the path which the bicyclists must take in crossing the intersection. The crossing should be adjacent to but striped separately from the pedestrian crosswalk. Figure H-10 shows some examples of typical channelization arrangements. The arrangement in Figure H-10(a) shows a pair of bicycle lanes which are carried straight through the intersection. Where there is heavy vehicular right-turn movement across the bicycle crossing, the bicycle crossing should be offset from the approach alignment of the bicycle lane approximately 10 to 20 feet as shown in Figure H-10(b). For bicycle lanes which are continued on cross streets, Figure H-10(c) depicts a channelization arrangement to provide for bicyclists turning right or left depending on direction of travel. At unsignalized intersections it may be desirable to stripe the bikeway through the intersection as shown in Figure H-11 to cause the drivers to be more conscious of cyclists present and alert the drivers to right-of-way situations.

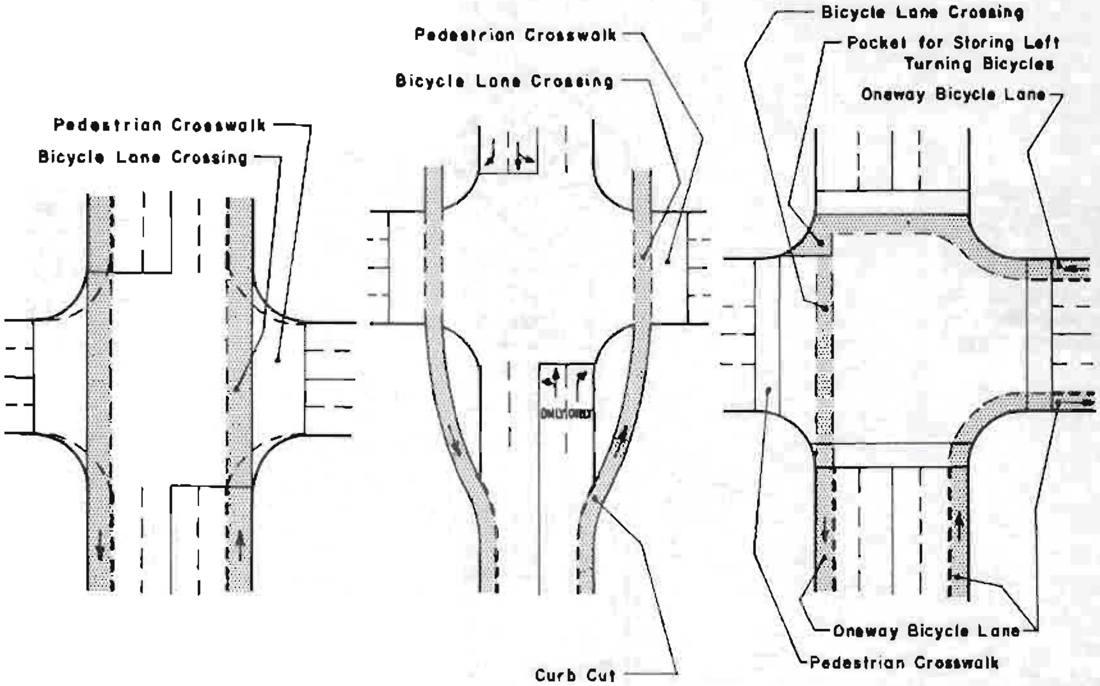
Where bicycle trails cross highways, at-grade intersection should be located where the sight distance along the highway is sufficient to provide time for bicyclists to cross the highway safely. In the case where two highways intersect, it may be desirable to offset the bicycle trail similar to that shown in Figure H-10(b) a distance of 100 feet or more to remove the bikeway crossing from the influence of the highway intersection.

H-113 SIGNS AND PAVEMENT MARKINGS

In order to insure the safe and efficient operation of a bikeway, there must exist adequate signs and markings to warn bicyclists of hazardous conditions or obstacles, to delineate bicycle rights-of-way, to exclude undesired vehicles from the route, and to warn motorists and pedestrians of the presence of bicycle traffic. The standard signs to be used on bikeways can be found in the *Texas Manual on Uniform Traffic Control Devices* (MUTCD). Figure H-12 shows some of the standard signs pertaining to bicycle operation.

A. Sign Placement

The placement of signs is dependent on whether the bikeway is or is not an independent bikeway. The MUTCD prescribes that signs erected on the roadside be mounted with the lower edge of the sign a specified minimum above the pavement edge. Specified minimums include 5 feet on rural highways, 7 feet in business, commercial and residential districts and 7 feet on expressways and freeways. These specifications reflect normal driver vision characteristics. However, because of head inclination, the bicyclist's field of vision appears to be focused lower than that of motor vehicle operators.



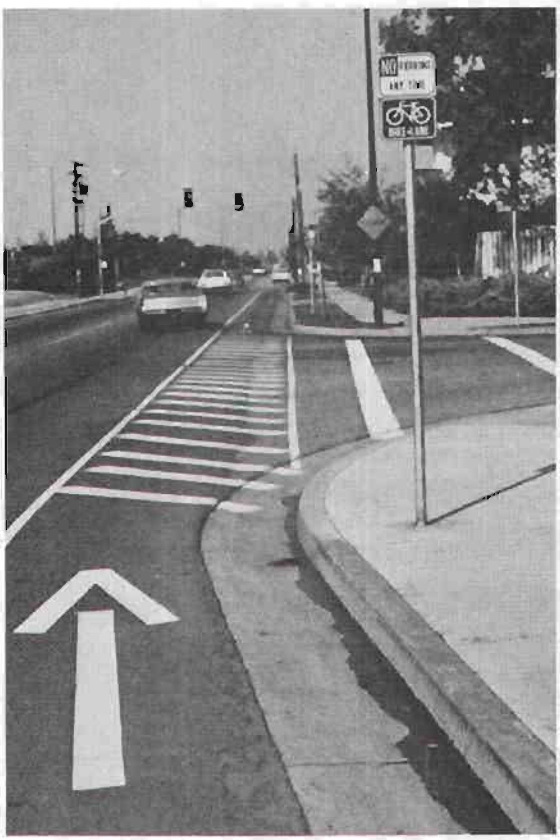
(a) Bicycle Lanes crossing Intersection

(b) Bicycle Lanes offset to cross intersection

(c) Bicycle Lanes continued on cross street

Typical Bicycle Channelization Arrangements At Street Intersections

FIGURE H-10



Bikeway Marked Thru Intersection With Diagonal Lines For Added Visibility And Emphasis

FIGURE H-11

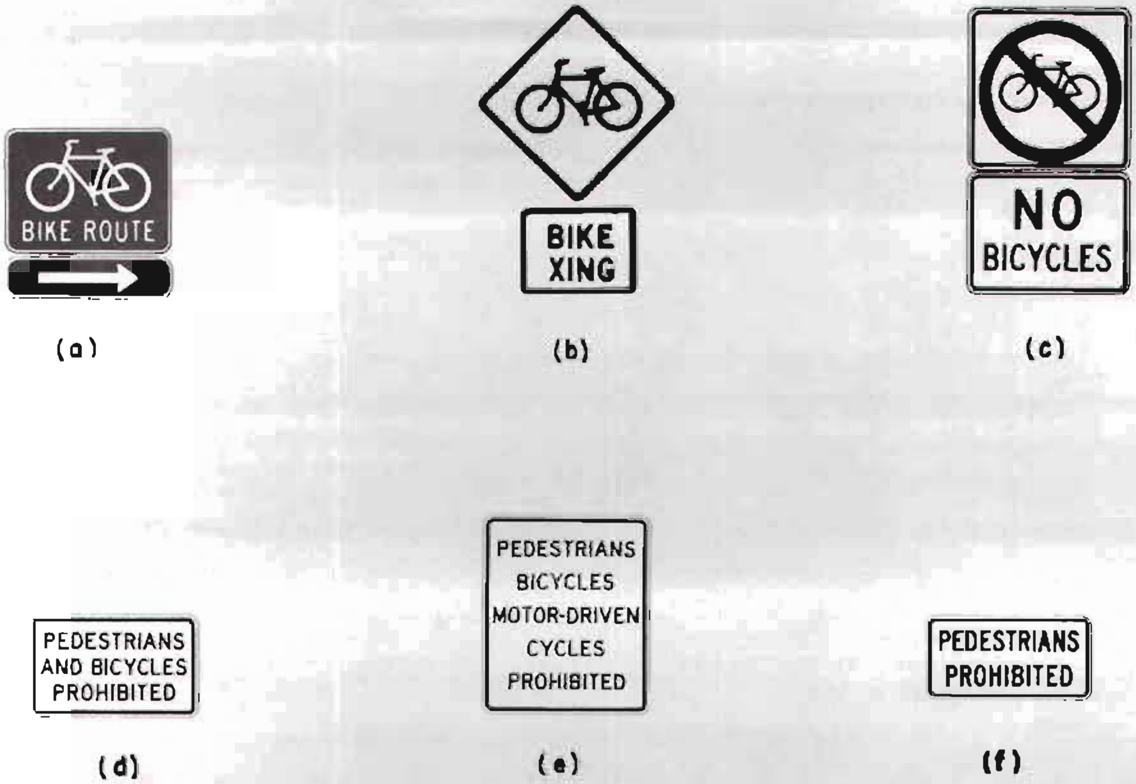


FIGURE H-12

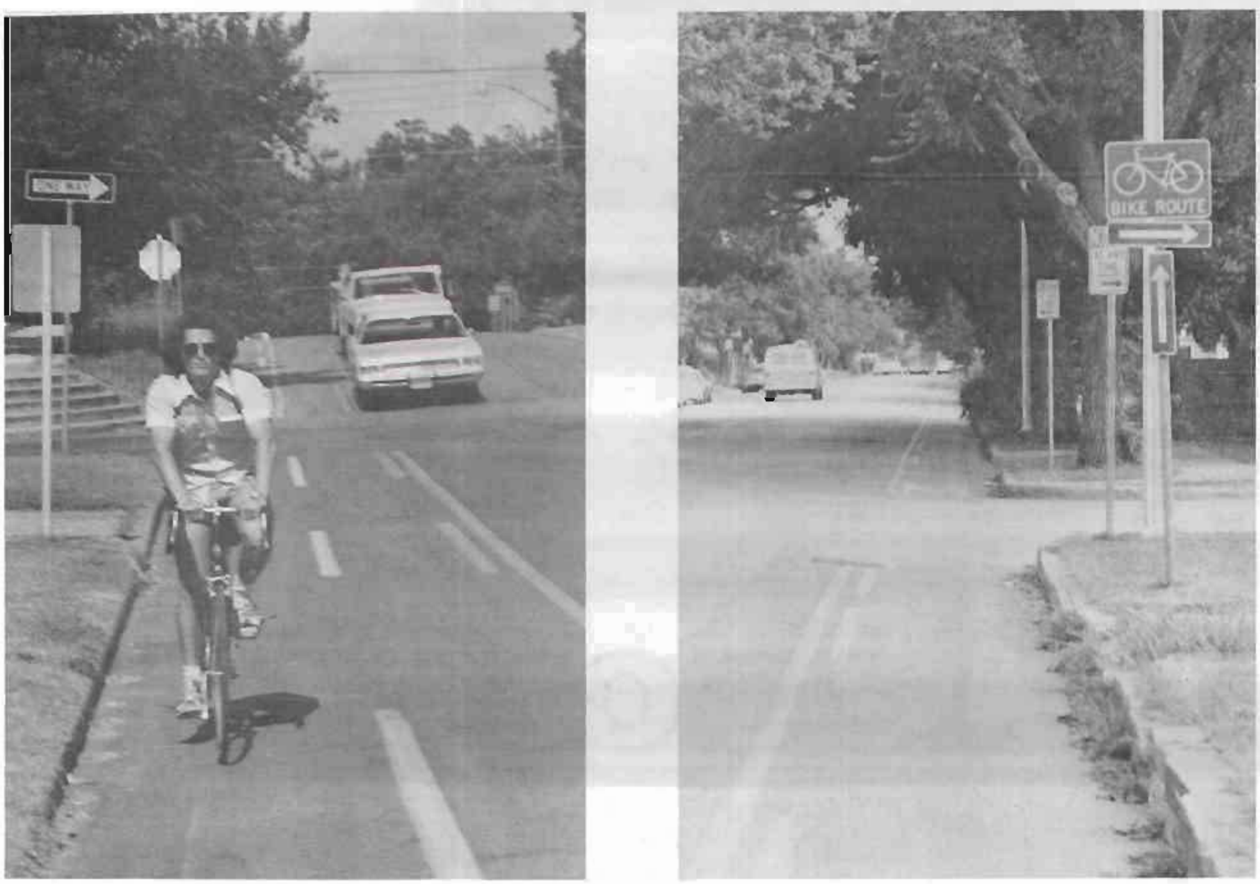


FIGURE H-13

Therefore, on independent bike trails, it may be desirable to mount signs so that the bottom of the sign is 4 to 5 feet above the pavement elevation. Lateral placement should be according to the Texas MUTCD except that signs along curbs should have a minimum clearance of 2 feet from edge of curb to edge of sign. Warning signs informing bicyclists of potential hazards should be positioned not less than 50 feet in advance of the hazardous condition. In urban areas, warning signs directed to motorists should be positioned a minimum of one-half block in advance of any point where bicycles may be encountered.

B. Lane Demarcation

Figure H-13 shows a typical demarcation striping of on-street bike lanes. The MUTCD specifies that solid white line be used to delineate the edge of a travel path where travel in the same direction is permitted on both sides of the line but crossing the line is discouraged. It is very important to maintain bikeway lane lines and other pavement markings in good condition so as not to be confused with an old traffic lane marking which is no longer applicable.

C. Pavement Message Markings

Pavement message markings should be used on all bike lane departures from intersections to insure that turning vehicles do not stray unknowingly into the bikeway. Word messages such as "BIKE LANE" or "BIKE ONLY" painted in at least 5-foot letters appear to be the most effective in informing motorists of lane function. Pavement markings in the form of directional arrows should not be used in bike lanes at intersections to indicate that the bikeway turns at that point.

D. Transition Areas

The termination of any on-street bike lane, the change from a two-way facility to a one-way facility or from one side of the street to the other are some examples of transition areas and the designer should attempt to achieve as smooth a transition as possible rather than an abrupt termination.

H-114 CONTROL, MAINTENANCE AND POLICING

Prior to the construction of the project, an agreement as to the control, maintenance and policing of the bikeway should be established. In most cases, this will be an agency of the municipal government.

REFERENCES

1. American Association of State Highway and Transportation Officials, *Guide for Bicycle Routes*, Washington, D.C., 1974.

2. Oregon State Highway Division, *Bikeway Design*, Salem, Oregon, January, 1974.

3. U.S. Department of Transportation, *Bikeways - State of the Art - 1974*, U.S. Government Printing Office, Washington, D.C., July, 1974.