CONSTRUCTION MANUAL

Prepared and Compiled

by

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION CONSTRUCTION DIVISION

Revised

May, 1986
February, 1986
April, 1984
December, 1980
January, 1977
December, 1974
June, 1972
January, 1971
June, 1970
June, 1969
March, 1969
June, 1968

Issued October, 1966
DEPARTMENTAL USE ONLY

RECORD OF CHANGES

CHANGE NUMBER	REVISED PAGE NUMBER	DATE REVISED
1	Page 1-59	March, 1969
2	Record of Changes, Foreword, Certification, Table of Contents, Page 1-1 through 1-56, 1-65 through 1-80, 3-88	June, 1969
3	Record of Changes, Certification, Table of Contents Page i through iv and Page vii, Page 1-3 and 1-4, Page 1-6, Page 1-10 and 1-11 Page 1-21 through 1-28, Page 1-65 through 1-71	June, 1970
4	Record of Changes, Table of Contents Page viii, and Page 1-76	January, 1971
5	Record of Changes, Certification, Table of Contents Page ii through viii, and xvii, Page 1-14 and 1-15 Page 1-23 through 1-28 A, Page 1-33 through 1-36, Page 1-44, Page 1-47 through 1-61, Page 1-65 through 1-72 A, Page 1-79 and 1-80, Page 3-165 through 3-166 B	June, 1972
6	Record of Changes, Certification, Table of Contents Page i through xix, Page	December, 1974

RECORD OF CHANGES

CHANGE NUMBER	REVISED PAGE NUMBER	DATE REVISED
	1-10 and 1-11, Page 1-12 through 1-12 F, Page 1-21 through 1-28 B, Page 1-30 and 1-37, Page 1-54, Page 1-69 through 1-72 H, Page 1-76 and 1-78, Page 3-15 and 3-16, Page 3-33 and 3-34, Page 3-84 through 3-86	December, 1974
7	Record of Changes, Foreword, Certification, Table of Contents Page i through ix, all Pages of Part I	January, 1977
8	Record of Changes, Certification, Table of Contents Page ii through iv, Page vii, and Page ix, Page 1-21, Page 3-8, Page 3-9, Page 3-11 and 3-12, Page 4-10, Page 6-11 through 6-21, Page 8-1, Page 8-4	December, 1980
9	Record of Changes, Page 6-13, Page 6-15, Page 6-17 Page 6-19, Page 6-21	April, 1984
10	Record of Changes, Page 6-13, Page 6-15, Page 6-17 Page 6-19, Page 6-21	February, 1986
11	Record of Changes Page 6-19	May, 1986

FOREWORD

This manual has been prepared by the Construction Division, with the cooperation of the Districts, in an attempt to present in written form proven practices and methods in the construction of highways which usually have been taught to inexperienced personnel orally. The basic purpose of this manual then is to provide assistance and guidance in training personnel and to promote uniformity in construction and inspection. It is not the intent of this manual to discourage or limit initiative and ingenuity, but instead, it is hoped that it will serve as a foundation upon which better construction practices and procedures will be developed.

It will be essential for the construction personnel to acquire a thorough knowledge of the governing specifications, plans, and the contents of this manual in order to continue the traditional high standard of operation by the Department. This manual should not be considered as a part of any contract, and in the event of a conflict between this manual and the contract documents, the contract documents shall govern.

Part 1 "General Provisions" has been revised to include the administrative instructions which have been previously transmitted by Administrative Orders and Circulars. All personnel connected with the supervision and inspection of construction projects should be thoroughly familiar and should follow the specific instructions and procedures of operation contained in this section.

The contents of this manual will be revised periodically as new requirements and new construction methods are developed. The looseleaf format will facilitate future revisions and expansion, and whenever the need arises, supplemental or revised pages will be distributed by Administrative Circulars. Reference should be made to the "Record of Changes" to determine the current listing of the supplemental or revised pages.

Rev. January, 1977

Wherever reference is made in this manual to "Department" or "Commission", these references shall mean "State Department of Highways and Public Transportation" or "State Highway and Public Transportation Commission", respectively. Similarly, reference to the "Engineer-Director" shall mean "State Engineer-Director for Highways and Public Transportation".

CERTIFICATION

This edition of the Construction Manual, with subsequent revisions, shall be applied on all contract construction projects presently in effect and to all contract construction projects let in the future. This manual cancels and supersedes instructions issued by all previous Construction Manuals.

The following Administrative Circular is cancelled:

74-49

Any portions of Administrative Orders, Administrative Circulars, and Information Circulars issued prior to the date of this revision which are in conflict with this Manual are also cancelled insofar as the conflict exists.

Questions regarding the content of this manual should be directed to File D-6.

M. G. Goode
M.G. Goode
Engineer-Director

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CONSTRUCTION MANUAL

PART I

GENERAL PROVISIONS

PART I
GENERAL PROVISIONS
CHAPTER 1
ORGANIZATION AND RESPONSIBILITIES

101.1 GENERAL ORGANIZATION OF THE DEPARTMENT

The law creating the Texas Highway Department was enacted by the Thirty-Fifth Legislature on April 4, 1917. The 64th Legislature changed the Texas Highway Department's name to State Department of Highways and Public Transportation, effective June 20, 1975. The State Engineer-Director has delegated the authority and responsibility for the actual construction of all construction projects to the District Engineers and the Engineer-Manager. All construction projects are under the direct supervision of the District Engineers acting through their Resident Engineers.

The Construction Division was organized in May, 1923 and has the general supervision of all construction projects from the opening of bids until the projects are completed and accepted by the District Engineers. Specifically, the Field Engineers of the Construction Division will make periodic field inspections on active construction projects and will furnish consultive service when requested.

101.2 PURPOSE AND SCOPE OF THE MANUAL

The Resident Engineer is the key man on every construction project. The successful completion of a project in substantial compliance with the contract documents depends largely upon the Resident Engineer. Therefore, this manual has been developed to provide assistance and guidance primarily for the use of the Resident Engineer and his organization.

This manual is not all inclusive regarding the many technical facets associated with highway engineering and construction. In order to properly discharge their duties and responsibilities, the employees using this manual will find it necessary to refer to other publications issued by the Department, and in some instances, may find it beneficial to consult publications issued by other organizations. The inspecting personnel will find valuable information on the specific types of construction in the inspection manuals published by the Industry and various associations.

It must be recognized that the manual, however complete, must be supplemented by the use of "good judgment" on the part of the employees. For conditions or situations not adequately covered in this manual, personnel should be guided by previous experience or obtain instructions from higher authority.

101.3 ORGANIZATION OF THE RESIDENT ENGINEER

Resident Engineers are direct representatives of the District Engineers and act in the name of their respective District Engineer. The exact organization of the Resident Engineer will be largely determined by the District Engineer.

101.4 RESPONSIBILITIES OF THE RESIDENT ENGINEER

A. **GENERAL.** Even though the Resident Engineer acts in the name of the District Engineer, he is a duly authorized representative of the State Engineer-Director and acts directly in a supervisory capacity in the actual construction and inspection of the work on construction projects. As such, it is his duty to conduct all activities for which he is responsible in a manner that will be in the best interest of the Department and that will reflect credit to his own organization and the Department. The Resident Engineer can best accomplish these objectives by discharging his duties and responsibilities efficiently and impartially. He must correlate the work of his personnel with the Contractor's operations in such manner as to expedite the progress of construction without sacrificing the quality of work or materials.

B. **PLANS, SPECIFICATIONS, AND PROJECT SITE.** The Resident Engineer must study and become thoroughly familiar with the plans, specifications, special provisions, and other contract documents that are applicable to the project. He should carefully compare the actual field conditions with the proposed construction to determine if discrepancies or errors exist, and if necessary, recommend appropriate corrective action.

C. **SHOWING PROJECT TO PROSPECTIVE BIDDERS.** This initial phase of any project presents the Resident Engineer an opportunity to start the project "off right". The Resident Engineer shall afford prospective bidders the opportunity to inspect the project on the ground and furnish pertinent information they might request. He must keep a careful record of all questions asked and his answers, thereto, and exercise utmost caution to avoid any misunderstanding. All prospective bidders must be treated impartially and alike. In no instance shall the Resident Engineer make statements regarding the possibility or probability of changes in plans, specifications, or quantities.

It is a Department procedure that all bidding proposals for highway construction projects be issued to Contractors by the Construction Division (File D-6) at Austin. In addition, all informational proposals requested by material suppliers, subcontractors, etc., will be issued by File D-6. A Contractor should not be given or be allowed to acquire any proposal that has been distributed to a District Office, Urban Project Office or Resident Engineer's Office for informational purposes. The only exception to this procedure will be for those proposals issued for a project where bids are to be received by a District Office or the Urban Project Office. The responsibility for issuance of these proposals rests with the District Engineer or Engineer-Manager.

D. **PRE-CONSTRUCTION CONFERENCE.** The Resident Engineer shall arrange for and conduct a pre-construction meeting prior to the beginning of work, as defined in Section 103.7A of this manual, with members of his organization, members of the Contractor's organization, and when possible, with the members of law enforcement agencies in attendance. Usually, one or more members of the District Headquarters Organization are present at these meetings. An agenda for pre-construction meeting similar to the one at the end of this section will be of great assistance.

These meetings afford key members of the Residency and Contractor's organization the opportunity to become acquainted, lines of authority and communication established, and the responsibilities and duties of the Contractor and Residency personnel determined. Emphasis should be directed toward promoting greater safety to the traveling public and personnel on construction projects.

The Contractor's contractual obligation for complying with State and Federal construction safety standards should be discussed as outlined in Chapter 7 (Section 107.3) of this Manual.

In addition, discussion of the project, plans, specifications, unusual conditions, Contractor's plan and schedule of operation, method of staking the project and other pertinent items will promote better construction operations.

On Federal-Aid Contracts the Equal Employment Opportunity requirements contained in the contract should be brought to the attention of the Contractor. The specific requirements and reporting procedures which must be complied with, prior to beginning of work and throughout duration of the contract, should be discussed in detail at this time. In discussing these requirements the Resident Engineer should refer to the Equal Employment Opportunity Compliance Program issued by File D-6.

If extensive utility adjustments or removals are involved on the project, representatives of the utility firms should be in attendance for that part of the conference pertaining to that phase of the work.

With only Residency and District personnel in attendance, it is highly desirable to review the major phases of work and to make it clear to the project personnel as to their individual responsibilities, duties, hours, frequency of inspections and tests, to whom they are to report, what constitutes proper reporting, if their operation is subject to check; and what action should be taken when unacceptable materials or work are encountered, or when unsatisfactory equipment is proposed for use by the Contractor.

A press release describing location of the project, the proposed construction, the name of the Contractor, the beginning date and the anticipated completion date, the traffic control measures, speed zoning and the name of the Engineer should be distributed to the local newspapers, radio and television stations.

AGENDA FOR PRE-CONSTRUCTION MEETING
Representative of DPS, Department, Contractor
Local Officials and Press

1. Introductions, preliminaries, and statement of purpose of meeting - Representative of the Department.

2. Review of the Project - Representative of the Department.

   a. Location of Project.

   b. Nature of Project (widening, resurfacing, structures).

   c. Size of Project.

   d. Length of time estimated to complete.

   e. Specifications for handling traffic.

   f. Other.

3. Construction Plans - Contractor.

   a. Estimated dates of start and completion and dates of beginning and ending major steps.

   b. Estimate of traffic interference and routing problems to be met.

c. Other.

4. Traffic Control Measures.

   a. Locations, condition, and protection of barricades and lights.

   b. Signs.

   c. Speed Zoning.

   d. Flagging Procedures.

5. Storage of Equipment and Materials.

   a. Review of specifications governing.

   b. Stress importance of keeping traveled parts clear.

6. Review of police supervision available from Highway Patrol - Department of Public Safety representative.

   a. Information on the location and shifts of Patrolmen in the area.

   b. Explain the policy covering assignments to the construction area.

   c. Give Sergeant's name, office location and home address and telephone numbers.

   d. Explain the procedure for the transmission of accident information to Contractor.

   e. Explain the procedure for the transmission of information on routine signing or safety hazards on "Road Hazard Report" to the Resident Engineer.

f. Explain the procedure for the transmission of emergency information to Resident Engineer and Contractor on special hazards by radio and public service.

g. Other.

7. Review of local enforcement assistance in traffic supervision - Local Officer.

8. Plan local public safety education of information activities.

9. Formulate plans for continuous liaison and coordination.

    a. Develop fully the channels of communication to be used.

        1.) Contractor's Representative

            a) Name

            b) Address

            c) Telephone Number

        2.) The Department Resident Engineer or his representative.

            a) Name

            b) Address

            c) Telephone Number

        3.) Department of Public Safety Captain, Sgt., Patrolman

            a) Name

            b) Address

            c) Telephone Number

4.) Local Officials where necessary.

b. Plan any subsequent meetings deemed desirable or necessary.

10. Equal Employment Opportunity Compliance Program (Fed-Aid Contracts).

11. Occupational Safety and Health Regulations and Monitoring Contractor Performance.

12. Other Matters.

E. **TRAFFIC SIGNS AND CONSTRUCTION SPEED ZONES.** Warning signs and speed limit signs shall be erected at the appropriate locations in advance of the date work begins on the project and shall remain in place until the project is completed. Signs should not remain in place longer than necessary and the timing of erection and removal of signs might well be discussed at the Pre-construction Meetings. Standard Traffic signs that are well maintained and properly used will not only promote public safety and convenience but they will command the respect and goodwill of the traveling public.

The following suggestions are offered as a standard practice for signing Construction Speed Zones:

1. Erect Speed Limit signs only for the limits of the section of roadway where speed reduction is necessary for the safe operation of traffic and protection of construction personnel. In most cases this will involve only a short section of roadway where work is in progress, but in some cases it will involve partially completed sections extending for some distance. It should be borne in mind that the reduced speed limits are effective only within the limits where signs are erected, even though the entire length of the project is covered by Commission Minute.

2. Use portable sign stands for posting construction speed zones. If the reduced speed limits are not necessary for the safe operation of traffic during those days and hours the Contractor is not working, they can be made inoperative by turning the signs so that the message will not be visible to either direction of traffic or by moving the signs to the edge of the right of way and facing them away from the roadway. If the use of portable mountings is not practical, then the Speed Limit signs erected on posts should be covered at all times when the reduced speed limits are not necessary.

   Leaving construction Speed Limit signs in place when they are not needed has at least three adverse effects: (a) motorists ignore the signs, and by so doing, they are subject to arrest; (b) respect for all Speed Limit signs is lessened; (c) and the law abiding motorist becomes a traffic hazard by driving at the reduced speed.

3. Give enough engineering supervision to the location and erection of the signs to insure proper use. Safe operation of traffic and keeping the goodwill of the traveling public justify engineering supervision.

4. See that the Contractor does not erect signs of his own design with speed limits of his own choosing. The Contractor has no responsibility whatever for furnishing, erecting, or maintaining the Speed Limit signs.

5. See that the Speed Limit signs are properly maintained and legible at all times.

F. **STAKING THE PROJECT.** The Resident Engineer will furnish and set construction stakes establishing lines and grades in the roadway work and center lines and bench marks for the bridge work and will furnish the Contractor with all the necessary information relating to lines and grades. Construction stakes will be set sufficiently in advance of the work to avoid delay to the Contractor. Additional information on construction staking is contained in Chapter 5, "Control of the Work" and in Part II, "Construction Surveys".

G. **INSPECTION.** Construction of a project in accordance with the contract documents is the direct responsibility of the Resident Engineer. It will be his duty to make periodic inspections of the work for his assurance that the work and materials are in compliance with the contract provisions, and to investigate the activities and performance of his personnel to the extent that he is satisfied that his delegations and assignments are being properly executed.

Inspection is a continuous operation and consists primarily of two phases: visual observation and actual testing. The Resident Engineer should encourage each Inspector to develop a keen sense of observation, for without this attribute the Inspector will fall far below his potential.

Inspection should never develop into persecution. It is the policy of the Department to cooperate with its Contractors in an effort to develop maximum efficiency at the least practicable cost. Reduced costs to the Contractor will be reflected in reduced costs to the Department on subsequent contracts.

Detailed information regarding the inspection of the major phases of work are included in Part III, "Construction Details".

H. **RECORDS AND REPORTS.** The Resident Engineer is responsible for the preparation and maintenance of all notebooks, field books, reports, and other records on the project. Detailed information covering this item is contained in Chapter 3, "Job Records".

I. **CHANGES.** It must be assumed that good and sufficient reasons existed for the preparation of the project plans and specifications, and all items upon which the project was advertised and the contract awarded. Nevertheless, conditions may have existed which were not apparent in the planning stage, or conditions may arise which could not be anticipated. In such cases, the Resident Engineer should determine the necessity for changes as far in advance as possible and advise the District Engineer of his recommendations for such changes. Detailed information regarding Field Changes, Supplemental Agreements, and Extra Work Orders is contained in Chapter 4, "Scope of Work".

J. **MATERIALS FURNISHED THE CONTRACTOR.** In the absence of a specific provision in the contract requiring or permitting the State to furnish materials to the Contractor, the Department will not furnish materials to the Contractor.

K. **MEASUREMENT AND PAYMENT.** The Resident Engineer is responsible for the measurement and computation of quantities on the project and for the preparation of estimates for payments to the Contractor. Prompt submission of the Final Estimate will contribute materially to good Engineer-Contractor relations. Additional information regarding this subject is contained in Chapter 9, "Measurement and Payment".

L. **PERSONNEL.** The Resident Engineer is responsible for all official activities of his employees. Although he is not responsible for their activities while off-duty, he should discourage any off-duty activity which would reflect discredit to the Department. It is the duty of the Resident Engineer to adequately instruct the employees so that they can properly perform their assigned tasks, and encourage them to study and assist in training them for more advanced assignments. Honesty, integrity, efficiency, and EFFORT is a must for all employees. Specific instructions regarding personnel which are issued by the Personnel Division, Insurance Division, other Divisions, and District Headquarters are to be strictly observed.

M. **TRAINING PROGRAM.** It is the District's responsibility to conduct a training program with a goal of providing trained personnel in sufficient numbers to handle inspection of construction within the limitations of the Appropriations Bill and without restriction of the Contractor's operations. The actual working hours of individual employees from day to day and from week to week will necessarily be flexible to fit in with Contractor's operations, weather conditions, etc., and may be controlled to suit the needs of each job with fairness to all employees.

Progress reports on the training programs will be requested from time to time.

N. **EQUIPMENT.** State owned equipment and vehicles which are used on construction projects are the responsibility of the Resident Engineer. They shall be operated and maintained in accordance with the instructions issued by the Equipment and Procurement Division, Insurance Division, and District Headquarters.

O. **PROJECT COSTS.** The Resident Engineer should determine as soon as possible if the project or projects in the contract can be completed within the authorized funds allotted to the contract and if it cannot be done, the District Engineer should be notified immediately in order that additional funds may be requested, and Form No. 470, "Revised Estimate of Quantities" may be prepared and submitted to the Construction Division. The District Engineer should be furnished detailed explanation of the reasons that the contract cannot be completed with the allotted funds, and the same information and Form No. 470 should be submitted to the Construction Division (File D-6). Additional information on this subject is contained in Chapter 3, "Job Records".

State Force Account Work should not be permitted to overrun the Construction Fund Authorization without prior administrative approval. Requests for additional funds for State Force Account Work should be submitted to the Construction Division prior to overrunning the funds authorized on the Fund Authorization for such work. This applies whether or not the overrun of funds authorized for force account will be offset by an underrun of total funds authorized for the project. State Force Account Work which is not included in a

Fund Authorization should not be done on a contract project unless prior approval of such work has been obtained from the Construction Division.

101.5 CONSTRUCTION BULLETINS.

In those contract items where the specifications refer to THD Bulletins, these reference manuals become an integral part of the contract, and as such, must be followed in order for the Department to fulfill its obligations.

1. THD Bulletin C-5 Revised

This construction bulletin is a manual of procedures and requirements for manual welding and submerged arc welding for the fabrication of structural steel.

2. THD Bulletin C-6

This construction bulletin is a manual of testing requirements for the qualification of welders for structural and reinforcing steel.

3. THD Bulletin C-11 and Supplement
   (Issued January, 1964) (Issued November, 1974)

This construction bulletin outlines the procedure to be followed in the design and control of portland cement concrete mixes for structures and pavements.

4. THD Bulletin C-14
   (Issued September, 1964; Revised March, 1968)

This construction bulletin outlines the procedure to be followed in the design and control of asphaltic concrete paving mixtures.

101.6 TITLE VI OF THE CIVIL RIGHTS ACT OF 1964; CONSTRUCTION DIVISION'S RESPONSIBILITIES

GENERAL. The primary purpose of Title VI of the Civil Rights Act of 1964 is to insure that no person shall, on the grounds of race, color or national origin, be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity receiving Federal financial assistance from the Department of Transportation. The following sections outline the Department's policies and procedures on contractor prequalification, advertising for bids, bonding requirements, award of contracts, provisions and procedures for effecting contract compliance which are responsive to effectuation of Title VI provisions for construction.

PREQUALIFICATION OF CONTRACTORS. The Construction Division is responsible for the prequalification of contractors under policies established by the Commission and as outlined in our Standard Specifications for Construction of Highways, Streets and Bridges. Prequalification is based upon requirements that are uniformly applied to all applicants and the selection and retention of contractors for construction is based solely upon said prequalification without regard to race, color or national origin.

As required by Item 2.4 of the Texas Standard Specifications (detailed in the Department's Bulletin No. 2; Contractors Financial Resources), any contractor, before he can be qualified to bid on construction projects requiring financial prequalification, must submit (1) a completed confidential questionnaire containing financial, equipment and experience data and (2) a balance sheet and statement of the contractor's financial resources certified to by either an independent certified public accountant registered and in good standing in any state or an independent public accountant registered under the Texas Public Accountancy Act of 1945. New statements are required each year, and, once submitted, the statements are good for a period of one year from the date of the statement; however, the Department reserves the right to require a new statement at any time. This statement must be on file in Austin ten days prior to the date any bids are to be opened. Prequalification forms do not require any entry that would identify the race, color or national origin of the contractor.

This statement is received and reviewed by the Prequalification Section of the Construction Division. This review involves a thorough examination of the contractor's financial statement including any verification and inquiries deemed necessary. After the review is completed and all needed adjustments have been made, a letter is written to the contractor stating his approved bidding capacity. This capacity is derived by multiplying the adjusted net working capital times a factor set by the Commission. The amount of any and all contracts awarded to him by the Commission is subtracted from the contractor's approved bidding capacity, thereby, allowing him to bid with the remaining available bidding capacity in the next month's letting. As the contractor completes any portion of his work with this Department, the value of that work in dollar amount of capacity is restored monthly to his available bidding capacity for the following month's letting. A list of the qualified contractors is maintained by the Construction Division and published quarterly for distribution. This list does not identify contracting firms by race, color or national origin.

BIDDERS QUESTIONNAIRE CONTRACTORS. Certain projects, consisting primarily of specialty items, do not require the bidders to submit a prequalification statement. These projects on which financial prequalification has been waived may include landscaping, rest areas, junkyard screening, painting, traffic signals, etc. If a contractor desiring to bid on a waived project is not prequalified, he must complete a "Bidders Questionnaire" and return it to the Construction Division in order to submit a bid on any project that has the prequalification requirement waived. A satisfactory "Bidders Questionnaire" must be on file in Austin ten days prior to the date the bids are to be opened. The Bidders Questionnaire is a very simple document to execute. It requires the name of the individual or firm, address, etc. and the name(s) of person(s) authorized to enter into contract in behalf of an Individual Business Entity, a Partnership Business Entity or a Corporation. In addition, if a firm operates under an assumed name or is a firm located outside the State of Texas, they must have an Assumed Name Certificate. Foreign corporations must furnish a Certificate of Authority to transact business in this State. Both of these documents are required by State law. A list of the Bidders Questionnaire Contractors is maintained by the Construction Division and published quarterly for distribution.

IDENTIFICATION OF MINORITY CONTRACTORS

The Construction Division has the responsibility for identifying and for compiling a list of minority contractors and subcontractors qualified to bid or hold subcontracts on construction projects let to contract by this Department.

The procedure that is used to identify minority contractors follows:

1. All files of Prequalified and Bidders Questionnaire contractors are examined to determine ownership. Based upon the ownership, the entity (individually owned, partnership or corporation) is classified as minority or non-minority. A classification of minority ownership is substantiated by (a) personal knowledge on part of Construction Division personnel that ownership is minority or (b) the fact that the contractor or subcontractor has been identified by a minority organization (National Urban League, Operation SER, etc.), A Federal Agency (Federal Office of Minority Business Enterprise, Department of Housing and Urban Development, etc.) and/or the Texas Office of Minority Business Enterprise and is on a published list available from such organizations or (c) verbal confirmation of minority status from such organizations as the National Urban League (through local offices), Alliance for

Minority Enterprise, Inc. (Dallas), Interracial Council for Business Opportunity (Dallas), Texas Office of Minority Business Enterprise, United Organization Coalition (San Antonio) and Mexican-American Contractors' Association (Houston).

2. A card file (separate from all other prequalification information) is maintained on all qualified minority contractors that have been identified.

3. In addition, the names of all potential minority contractors or subcontractors that have been identified through the Department's continuing contact with minority organizations and/or Federal Agencies are kept on file within the Construction Division. A "List of Minority Contractors and Subcontractors" has been published, will be updated periodically, and used by the Department in a program to encourage minority business participation in highway construction activity and to inform contractors of potential minority subcontractors.

ADVERTISING FOR BIDS

A. **Notice to Contractors.** The "Notice to Contractors" is a notice of proposed Texas Highway Construction stating the county, project limits, items of work and approximate quantities involved and other essential information. This notice, prepared by the Highway Design Division and distributed by the Construction Division, goes to all prequalified contractors and bidders questionnaire contractors. Contractors may request and receive additional copies of the notices for their branch offices. The "Notice to Contractors" is furnished gratis to prequalified and bidders questionnaire contractors and to Minority Business Enterprise affiliated offices. Any material suppliers or others who desire a copy for informational purposes may obtain same for a reasonable subscription fee. The "Notice to Contractors" also includes the following statement: "The State Department of Highways and Public Transportation hereby notifies that it will affirmatively insure that in any contract entered into pursuant to this notice, Minority Business Enterprises will be afforded full opportunity to submit bids in response to this invitation and will not be discriminated against on the grounds of race, color or national origin in consideration for an award."

B. **Newspaper Advertisements.** The Highway Design Division, File D-8, maintains a list of newspapers throughout the state with broad circulation. Prior to three weeks in advance of the letting date of a project, File D-8 forwards project information to the classified advertisement department of major area newspapers and a major county newspaper within the immediate vicinity of the project.

An invitation for bids appears in the above newspapers for one day three weeks prior to the letting date and one day two weeks prior to the letting date. Information regarding project type, limits, length, plans, wage rates and non-discrimination is set out in the advertisement.

Under justified emergency conditions, a shorter period of advertising may be approved.

C. **Other Media.** Approximately one week prior to the letting date, the Travel and Information Division, File D-16, provides a press release to the Capitol Newsroom in Austin, Texas. The news release reflects the number of projects scheduled for the letting, the letting dates and indicates some statistics pertaining to miles, dollars and types of highway construction contained therein as well as noting specific projects of interest.

In addition, after the Commission acts on award of the projects, the Travel and Information Division makes a news release to newspapers, radio and television stations in the highway district outlining the commission action, projects let, successful contractors, awarded amounts and any highlights pertaining to specific projects.

PROPOSAL GUARANTY. In compliance with Item 2.7 of the Texas Standard Specifications, the bid proposals shall be accompanied by proposal quaranty of the character and in the amount as indicated in the proposal. Commission Minute Orders set the amount of the proposal guaranty based on the estimated cost of the project. The Minute Order also provides the form of the proposal guaranty which is a certified check, cashier's check, bank money order or bank draft on a State or National Bank.

BONDING REQUIREMENTS. As required by Item 3.4 of the Texas Standard Specifications and in accordance with House Bill 344 of the 56th State Legislature, contractors who are awarded contracts with the Department are required to furnish a performance bond and a payment bond in the full amount of the contract. Surety companies furnishing said bonds are required to be on the list of insurance companies acceptable to the Department and may not exceed their maximum bonding capacity as determined by the Department for any one risk.

A. **Performance Bond.** The performance bond in the full amount of the contract guarantees that the contractor will perform the work in accordance with the terms of the contract.

B. **Payment Bond.** The payment bond in the full amount of the contract is for the protection of claimants who furnish labor and material incorporated into the project.

C. **Qualified Bonding Companies.** Once each year, the Finance Division, File D-3, issues a tabulation showing by companies the maximum contract bonds that will be accepted for any one risk by the Department. This tabulation includes those companies authorized to execute surety bonds as shown by the "List of Insurance Companies under the Supervision of the State Board of Insurance, State of Texas."

AWARD OF CONTRACT. All proposals which are received in accordance with the terms of the advertisement are publicly opened and read item by item. The sum of the products of the approximate quantities shown in the proposal by the unit prices bid is considered to be the amount of the bid. The award of the contract is made to the lowest reasonable bidder, without regard to race, color or national origin, within 30 days after the opening of the proposals. The award of a Federal-Aid contract is subject to the concurrence of the Federal Highway Administration. Contracts not awarded within the prescribed 30 days are readvertised for a future letting.

TITLE VI PROVISIONS - CONTRACTS, SUBCONTRACTS AND MATERIAL PURCHASE ORDERS

A. **Contract Provisions.** Each Federal-Aid construction contract includes Form PR 1273, "Required Contract Provisions All Federal-Aid Construction Contracts". This document includes the Title VI compliance provisions of the Civil Rights Act of 1964.

B. **Subcontracts and Material Purchase Orders.** The provisions of PR 1273 require the contractor of Federal-Aid projects to physically incorporate into each subcontract all of the provisions of Form PR 1273 which, as stated above, include the Title VI compliance provisions of the Civil Rights Act of 1964.

   The provisions of Form PR 1273 require contractors and subcontractors holding contracts or subcontracts valued at $10,000 or more to incorporate the Equal Employment Opportunity provisions of Form PR 1273, including Title VI provisions, into material purchase orders valued at $10,000 or more. Federal Regulations have been interpreted to require that these provisions be physically incorporated into the purchase orders and shall not be incorporated by reference.

The contract requires the contractor to perform with his own organization contract work of a value not less than 50 percent of the original contract amount, except that any items designated by the Department as "Specialty Items" and listed as such in the contract documents, may be performed by subcontract and the amount of any such "Specialty Items" so performed may be deducted from the original total contract amount before computing the amount of work required to be performed by the contractor with his own organization. Each request for approval to sublet any part of the work is required in writing and on Federal-Aid projects must be accompanied by Construction Form 589 Rev. (3) "Contractor's Assurance (Subconstracts— Federal-Aid Projects)". Form 589 is a certification by the contractor that the subcontract agreement contains all pertinent provisions, notices and certificates required in the prime contract and that all labor standard provisions pertaining to the contract are physically incorporated into the subcontract agreement. For projects let after January 1, 1976, Form 589 Rev. (3) requires further certification by the contractor that affirmative action has been taken to seek out, contact, and consider minority business enterprises as potential subcontractors while soliciting their interest, capabilities, and prices for the work to be subcontracted; that the results of the affirmative action have been documented; and that a liaison officer has been designated to administer the contractor's minority business enterprise program.

PROCEDURES FOR EFFECTING CONTRACT COMPLIANCE. The procedures for effecting contractor and subcontractor compliance with the Equal Employment Opportunity provisions of the contract are explained in detail in the Department publication "Equal Employment Opportunity Compliance Program, Federal-Aid Contracts". These procedures provide for (1) continual surveillance by the Project Engineer of the contractor's project site Equal Employment Opportunity compliance posture and (2) project site compliance reviews conducted by the Construction Division in accordance with instructions set forth in the Federal-Aid Highway Program Manual (Vol. 2, Chap. 2, Sec. 3) The Project Engineer must submit quarterly summary reports covering the results of his inspections made on the project site. The guidelines used in conducting both project site and home office compliance reviews require an examination of subcontracts and material purchase orders of $10,000 or more in value for inclusion of applicable Equal Employment Opportunity provisions, including those required by Title VI of the Civil Rights Act of 1964.

CHAPTER 2
RELATIONSHIPS

102.1 RELATIONS WITH THE CONTRACTOR

Every construction project is a joint venture between the Department and the Contractor. Employees of the Department should cooperate with the Contractor to expedite construction of the project without violating the contract documents or sacrificing the quality of work or materials. Employees of the Contractor should cooperate with the Department toward compliance with the contract documents without being forced to do so.

The day to day relations with the Contractor should be amicable without being fraternal or patronal. Instructions to the Contractor should be within the scope of the plans and specifications, clear, precise, and concise without any trace of malice, enmity, or anger. It is important for the Resident Engineer to see that the instructions given to the Contractor are clearly understood and that misunderstandings do not exist between employees of the two organizations.

Important instructions to the Contractor should be given in writing or confirmed in writing and made a part of the project records. The Resident Engineer and his authorized personnel should give instructions only to the authorized personnel of the Contractor and not to the individual workers. Employees of the Department must not act as foreman or in a supervisory capacity for the Contractor. Minor irregularities may be called to the attention of the individual worker provided such a procedure is agreeable with the Contractor.

Differences of opinion between the Contractor's employees and those of the Department regarding the interpretation of the specifications, quality of work, or whether work performed is subsidiary or a pay item are not uncommon. The Resident Engineer shall act as arbitrator in these controversies and an attempt should be made to resolve these differences promptly and fairly, and within the scope of the contract documents. In case disagreements cannot be satisfactorily resolved, the Resident Engineer should refer the matter to his immediate superior.

102.2 RELATIONS WITH THE PUBLIC

The Resident Engineer and his personnel are public employees, employed by the Department, a public service organization. The Public will judge the Department not only by its work, but also by the action and attitude of each individual employee toward each individual citizen. Each employee has a definite responsibility for creating goodwill toward the Department.

Employees of the Department are in daily contact with, and under the surveillance of a large number of citizens. These may be adjacent property owners, local citizens, tourists, public officials, residents of nearby communities, and representatives of news distribution media; therefore, it is essential that all employees conduct themselves in a manner that will command the respect and confidence of the Public.

Courtesy and patience must be extended to the Public at all times. In those instances where it is necessary to inconvenience the traveling public due to construction operations, all precautions must be exercised by providing adequate warning signs, barricades, directional signs, flagmen, etc., in order to move traffic safely and expeditiously through the construction work. Ingress and egress to private property must be maintained during construction unless otherwise provided for in the plans or specifications. A courteous explanation of the reasons for these conditions and courteous answers to questions are essential in creating good public relations.

102.3 RELATIONS WITH THE FEDERAL HIGHWAY ADMINISTRATION

On projects financed wholly or partly with Federal funds, a contract known as a "Project Agreement", which consist primarily of the plans and specifications, is made between the Federal Highway Administration and the Department which binds "the Federal Government to pay its legal pro-rata share of the approved cost of the project when that project has been constructed in accordance with the PS & E as submitted by the State and approved by the Federal Highway Administration".

Representatives of the Federal Highway Administration will make periodic inspections on Federal Aid projects, the frequency depending on whether the projects are Interstate, Primary, Secondary, or any other project on which the Department utilizes federal funds, for the purpose of reviewing the Department's performance in having the projects constructed in accordance with the contract documents.

It is the Department's policy to facilitate inspection and to cooperate with the representative of the Federal Highway Administration in performing his assignment. In order to better assist the Federal Highway Engineer, the Resident Engineer should have a thorough knowledge of those chapters of the Federal-Aid Highway Program Manual on construction and construction materials.

As with any contract, the approved plans and specifications are binding on both the Federal Highway Administration and the Department and should not be changed or modified by either party without the prior concurrence of the other party. This means that the Department should not undertake major changes without first securing the Federal Highway Administration's concurrence. In like manner, after the contract has been awarded, the Federal Highway Administration should not declare work having their prior approval as non-participating in Federal funds, nor should they determine the quality of work based on tests not required in the approved plans and specifications.

As soon as the necessity for field changes or extra work is established on the District level, it would be beneficial to discuss these items with the representative of the Federal Highway Administration on the ground in order that he may become familiar with them and be in a better position to express his concurrence. However, if the representative of the Federal Highway Administration is not available for discussion, the submission of the Field Changes, Supplemental Agreements, or Extra Work Orders should not be delayed.

CHAPTER 3
JOB RECORDS

103.1 GENERAL

Adequate records are essential for the proper administration of all construction projects. Records should be complete, brief, and precise. Summaries are desirable where they will serve a definite purpose, even though a certain amount of duplication may be involved. All important information related to the prosecution of the work and execution of the contract should be kept in written form. Good work without good records is not a good practice.

Records are assumed to be adequate when they fulfill the following conditions: (1) Enable the Resident Engineer to keep current on the progress and quality of work performed, and the quantity and quality of materials used; (2) Allow for a change in personnel on an active project, whether it be the Resident Engineer or Inspector, without creating undue difficulties for the new employee in taking over the assignment; (3) Permit verification by audit of the measurements and calculations of quantities, and the quality of work and materials with a minimum amount of assistance from the project personnel.

This manual does not purport to establish a uniform, statewide system of record keeping; however, it is recommended that the District Engineers establish such a system within their respective districts. An adequate system has proven to be an aid in training the field personnel and in facilitating the transfer of personnel between Residencies.

103.2 CORRESPONDENCE

The Resident Engineer shall handle all correspondence in accordance with the instructions from the District Engineer and the established practice within the District.

103.3 MATERIALS RECEIVED

When feasible, records should be kept of each material received and incorporated into the project in order to document the adequacy of the quantity of materials received, and in some instances, to document the pay quantity of certain materials. Record keeping is quite simple, when each material is delivered directly to and used exclusively on the project. Under certain conditions, however, such as the use of commercial ready-mix plants, it usually will be impossible to keep a record of each separate material used on the project.

It will be satisfactory, but not necessarily recommended, to double check the quantity of the material received and the quantity of the material used by comparing the weights between two different sets of scales. In using this procedure, quite often it has proven to be a fallacy to assume that the foreign sets of scales are as accurate as the project scales, or the material is absolutely moisture free each time it is weighed. Often the difference in the accuracy of the scales or in the moisture content may be greater than twice the allowable tolerance provided in the specifications for the project scales. Naturally, when this occurs, unnecessary confusion is created and the problem may be quite difficult to explain. The proper procedure would be to insure that the project scales comply with the specification requirements.

103.4 TEST RESULTS AND RECORDS

The Resident Engineer should require an orderly record of all tests made in the field, and elsewhere, in order that he may properly administer the project and furnish documentary evidence as to the quality of work done and the quality of materials used.

The record of test results should be kept current, and when required, test results and forms should be promptly submitted to the Austin Office. Copies should also be maintained by the Resident Engineer and become a part of the job records.

All laboratory work sheets containing basic test data must be retained and all test reports must be properly initialed or signed, dated, and be made a part of the permanent records.

Additional information regarding testing of materials is contained in Chapter 6, ''Control and Inspection of Materials''.

103.5 MEASUREMENT AND CALCULATION OF PAY QUANTITIES

The Resident Engineer is responsible for establishing an orderly system of measurement and calculation of pay quantities in order that the Contractor will be paid for work he actually performs on each bid item. Under no circumstances should payment for work performed, but not included in the contract, be made by increasing the quantities of the contract items. Even though this procedure might not involve dishonesty, it would involve falsification of the records, which under the Federal law is subject to certain penalties. A comprehensive cross reference between each pay item and the measurements and calculations of the quantities therefore should be kept in a master index.

It is suggested that all basic measurements and calculations for major items be kept in individual and separate records unless otherwise provided for. Basic measurements and calculations for minor items may be combined into one or more records labeled, "Miscellaneous". Tickets which are issued and used as a basis for payment should be kept in accordance with the applicable instructions. Additional information regarding measurement and payment is contained in Chapter 9, "Measurement and Payment".

103.6 DIARIES

It will be necessary for the Resident Engineer or his authorized representative to keep a "Job Diary". This written record is essentially a brief, day to day report of important events, activities, and discussions which occurred on the project during construction. On some projects, it may be necessary for the employee having direct responsibility for all construction work to keep a general diary which will be supplemented by diaries kept by personnel having direct responsibility for the major phases of work.

Diaries are to be kept daily and in such a manner that new personnel may take over the work at any time. Daily entries should include the following information: date, weather conditions, time charge, work in progress, arrival and departure of equipment, important instructions to the Contractor, names of official visitors and the substance of any discussions with the visitors, unusual construction conditions, the substance of important discussions or controversies with the Contractor, information that may have any connection with a probable claim against the Department (this information should be recorded in detail), and other significant features of the work not recorded in other records, such as labor interviews. The daily entries should be signed by the person making the report.

The job diary, when properly maintained, will provide invaluable information and evidence in the event controversies arise at a later date.

If any type of measurements of quantities are to be recorded in the diary, and no other provisions have been made, it is recommended that ample space for this information be set aside either in the front or the back of the diary with the date and signature of the recorder shown thereon. It is believed, that this procedure would be preferable than to scatter this type of information throughout the records where it would be difficult to find at a later date.

103.7 REQUIRED REPORTS AND FORMS TO BE SUBMITTED TO AUSTIN OFFICE

A. **NOTICE OF BEGINNING WORK.** Immediately after the Contractor begins work, notice shall be given by the Resident Engineer by letter (1 copy) to File D-6 with a copy to the District Engineer, giving the following information: (1) Project number. (2) Date work began. (3) Name, address, and telephone number of the Resident Engineer. (4) Name, address, and telephone number of the Contractor. A copy of the Contractor's letter designating the Superintendent should accompany this notice.

Any work by the contractor that is necessary to complete the contract, including stockpiling materials, material source operations, etc., constitutes beginning of the work.

On State projects, the beginning notice is to be submitted only once without regard to the individual projects within the contract.

For notifying the Federal Highway Administration when their project inspections may begin, an additional notice is to be submitted to File D-6 when construction of the drainage, roadway and/or structure facilities on the right of way begins, if the date is different from that in the beginning notice.

When State and Federal Aid projects are combined in one contract, the beginning notice on State projects is to be submitted only if the work began on the State project prior to the beginning of work on any individual Federal Aid project.

The Resident Engineer should ascertain that the contractor has designated a competent Project Superintendent who is employed by him, who has full authority to direct performance of the work in accordance with the contract requirements, and who will be in charge of all construction operations regardless of who actually performs the work.

B. **TEMPORARY SUSPENSION OF WORK.** When work and time charges are temporarily suspended in accordance with the provisions of the specifications, the Resident Engineer should give written notice to the Contractor indicating the effective date of suspension and reasons thereof, with a copy of such notification sent to File D-6 and to the District Engineer. Additional information on this item is contained in Chapter 8, "Prosecution and Progress".

C. **RESUMPTION OF WORK.** When work and time charges are resumed after having been temporarily suspended, the Resident Engineer should give a written notice to the Contractor of such resumption, with a copy of such notification being sent to File D-6 and to the District Engineer. Additional information on this item is contained in Chapter 8, "Prosecution and Progress".

D. **FORM 314A AND B; RESIDENT ENGINEER'S MONTHLY CONSTRUCTION REPORT.** This form should be prepared for each contract upon completion of work at the end of each month. Additional information on the preparation and submission of this form is included in Chapter 9, "Measurement and Payment".

E. **FORM 112 -- APPROVAL OF CHANGE IN PLANS.** It is the responsibility of the Resident Engineer to prepare and submit this form in accordance with the instructions on the form and according to the information in Chapter 4, "Scope of Work".

F. **CONSTRUCTION FORM 317 REV. -- EXTRA WORK ORDER.** This form is to be prepared and submitted by the Resident Engineer in accordance with the specifications, the instructions on the form, and according to the information furnished in Chapter 4, "Scope of Work".

G. **SUPPLEMENTAL AGREEMENT.** This document is to be prepared and submitted by the Resident Engineer in accordance with the information furnished in Chapter 4, "Scope of Work".

H. **MEMORANDUM AGREEMENT.** The Resident Engineer is to prepare and submit the Memorandum Agreement according to the information furnished in Chapter 4, "Scope of Work".

I. **FORM 470 -- REVISED ESTIMATE OF QUANTITIES.** This form is to be prepared and submitted by the Resident Engineer as soon as it becomes apparent that the contract cannot be completed within the funds authorized for the contract. It should be prepared in accordance with the instructions printed on the form. If any contract, including seal coat contracts, contains more than one control, section and job number, a distribution of the revised costs for the contract items, engineering and contingencies, State force account work, etc., must be furnished for each control, section and job in the contract to facilitate preparation of the Revised Construction Fund Authorization.

J. **CONSTRUCTION FORM 312 REV. -- FIELD LABORATORY REPORT FOR CONCRETE.** On all concrete pavement projects, Form 312 Rev. should be prepared in accordance with the instructions contained in the Bulletin C-11 and submitted weekly to File D-6. One copy of each daily report should be submitted on all types of projects.

K. **CEMENT FACTOR CURVE.** On all concrete pavement projects using the Specification Item Nos. 360 or 366, the Cement Factor Curve should be prepared in accordance with the instructions contained in the Bulletin C-11 and one copy should be submitted to File D-6 upon completion of the test.

L. **PILOT STRENGTH CURVE.** On all concrete pavement projects using the Specification Item Nos. 360 or 366, the Pilot Strength Curve should be prepared in accordance with the instructions contained in the Bulletin C-11 and one copy should be submitted to File D-6 upon completion of the test.

M. **CONSTRUCTION FORM 404 REV. (2) - FIELD LABORATORY REPORT FOR ASPHALTIC CONCRETE.** On all contract projects where asphaltic concrete is used, Form 404 Rev. (2) should be prepared in accordance with the Bulletin C-14 and submitted weekly to File D-6. One copy of each daily report should be submitted on all types of projects.

N. **DENSITY-STABILITY CURVE.** On all contract projects using the asphaltic concrete which is produced under Specification Item Nos. 340 or 350, the Density-Stability Curve should be prepared in accordance with the instructions contained in the Bulletin C-14 and one copy should be submitted to File D-6 upon completion of the test.

O. **FORM 415 -- FINAL CONSTRUCTION INSPECTION REPORT.** Upon notification by the Resident Engineer that the work has been satisfactorily completed in accordance with the contract provisions, it is the responsibility of the District Engineer to make the "Final Inspection" and prepare Form

415 in accordance with the instructions thereon and furnish the original copy to File D-6. After the final inspection and upon acceptance of the work, one copy of the written notice to the Contractor accepting the work should also be forwarded to File D-6.

P. **FEDERAL HIGHWAY ADMINISTRATION FORM PR-47 STATEMENT OF MATERIALS AND LABOR USED BY CONTRACTORS ON HIGHWAY CONSTRUCTION INVOLVING FEDERAL FUNDS.** Form PR-47 should be submitted to File D-6 as soon as possible after the physical completion of the work for each Federal Aid highway construction contract having a cost of $500,000 or more except for projects constructed under the Secondary Road Plan or for installations of protective devices and railroad grade crossings. Instructions for the preparation of this form are shown on the reverse side of Form PR-47. Part A instructions pertain to information to be furnished by the State and Part B outlines specific instructions for the Contractor's guidance in compiling the required information on materials, labor and costs.

Q. **LETTER OF CERTIFICATION OF MATERIALS USED.** Original and two signed copies of the Letter of Certification of Materials Used signed by the District Construction Engineer, Assistant District Engineer, District Engineer or Engineer-Manager shall be submitted for each Federal-Aid project, except Federal-Aid Secondary projects, upon completion of work in the contract.

R. **FORM 168 – PILE RECORD.** Form 168 should be prepared in accordance with the instructions in the "Bridge Division Operations and Planning Manual" and submitted to File D-5. The number of copies to be submitted is noted on Form 168.

S. **FORM 181 – TEST PILE DATA.** Form 181 should be prepared in accordance with the instructions in the "Bridge Division Operations and Planning Manual" and submitted to File D-5.

T. **CONSTRUCTION FORM 589 REV. (3) CONTRACTOR'S ASSURANCE (SUBCONTRACTS—FEDERAL-AID PROJECTS).** The provisions of the contract on Federal-Aid Projects make it necessary that the State be given assurance, as a matter of record, that the subcontract agreement between the prime Contractor and proposed Subcontractor actually contains all pertinent provisions, notices, certificates and labor standard provisions included in the prime contract and for projects let after January 1, 1976 that affirmative action has been taken to seek out, contact, and consider minority business enterprises as potential Subcontrators. To satisfy this requirement each Contractor's written request for permission to subcontract portions of the work must be accompanied by an affidavit (Construction Form 589 Rev. (3)) giving this assurance. A copy of each Contractor's written request for subcontract approval and a single executed copy of the affidavit are to be attached to the District's letter of recommendation to D-6 requesting subcontract approval. Additionally, copies of the Contractor's request and affidavit are to be retained in designated files within the District.

U. **FORM WH-348 OR OPTIONAL FORM WH-347, STATEMENT OF COMPLIANCE AND CONTRACTORSS' PAYROLLS.** Form WH-348 (Rev. 1-68) or optional Form WH-347 (Rev. 1-68) shall be prepared on all Federal-Aid Contracts by the Contractor and Subcontractor(s) and attached to each weekly payroll submission. Optional Form WH-347 provides a transcript with the required certification (Statement of Compliance) appearing on the reverse side. If the employer elects to use this form, the submission of Form WH-348 is not required.

When no work is performed during the week the Statement of Compliance should be submitted with a statement "No work done this week". If no work is anticipated for longer periods, a note on this form should state "No work until further notice", and when work is resumed a letter from the

Resident Engineer should be submitted with the first payroll advising the dates on which no work was performed.

For Interstate Projects only the Statement of Compliance and each weekly payroll shall be submitted to File D-6. Contractor or Subcontractor should not be required to submit more than two copies of this form.

Payrolls and basic records relating thereto should be maintained during the course of the work and preserved for a period of three years thereafter.

V. **DESIGNATION OF PAYROLL SUPERVISOR.** On all Federal-Aid projects, prior to and not later than the preparation of the first payroll, each Contractor and each Subcontractor shall furnish the Resident Engineer three copies of a letter designating his authorized payroll supervisor. The original copy is to be submitted to File D-6. A new letter should be furnished when a change is made in the payroll supervisor by the Contractor or Subcontractor, and the original copy should be submitted to File D-6.

W. **PARTIAL ESTIMATES.** Partial estimates and supporting papers are to be prepared and submitted in accordance with File D-3 Manual of Instructions, Chapter IX, "Construction Estimates".

X. **FINAL ESTIMATES.** Final estimates and supporting papers are to be prepared and submitted in accordance with File D-3 Manual of Instructions, Chapter IX, "Construction Estimates".

Y. **FORM 430 REV. -- CERTIFICATE OF FINAL MEASUREMENT OF QUANTITIES.** This form shall be used in preparation of the final estimate and it shall be signed by the Resident Engineer and the District Engineer or the Engineer-Manager to insure proper measurements, calculations, and documentation of pay quantities on construction projects.

Z. **EQUAL EMPLOYMENT OPPORTUNITY COMPLIANCE PROGRAM FORMS.** Reference should be made to the Federal-Aid contract provisions and to the Equal Employment Opportunity Compliance Program issued by File D-6 for the required reports and forms.

AA. **FORM FHWA-1446 (REV. 2-78) -- FINAL INSPECTION OF FEDERAL-AID PROJECT CONSTRUCTED UNDER 23 U.S.C. 117.** This form shall be submitted to File D-6 upon completion of all Projects Constructed Under the State's Secondary Road Plan. The certification is to be signed by the District Engineer or his assigned representative and is to be submitted with the letter advising that the project has been completed in accordance with plans, specifications and approved changes. Five copies of Form FHWA-1446 (Rev. 2-78) should be submitted to the Austin Office. The original and the District's file copy should be endorsed. The remainder of the copies may be stamped with a facsimile signature.

BB. **FORM 597 -- PLAN QUANTITY ADJUSTMENT.** Form 597 is to be completed by the office of record and distributed in accordance with the instructions on the form to correct an error in the calculation of the quantity contained in the contract for a "Plan Quantity Pay Item". The office of record is that office responsible for the original computations of the quantities for the particular item in question. This form should be completed and submitted for those plan quantity items which are adjusted for inclusions or omissions of quantities for structure elements and to correct errors in excess of the percentages specified in the pertinent specification. Further instructions in the use of this form may be found in the "Bridge Division Operations and Planning Manual".

CC. **FORM 1276 -- DRILLED SHAFT RECORDS.** Form 1276 should be prepared in accordance with instructions in the "Bridge Division Operations and Planning Manual" and submitted to File D-5.

DD. **FORM FHWA-1494 – SEMIANNUAL LABOR COMPLIANCE ENFORCEMENT REPORT.** File D-6 will transmit to the Districts by letter, semiannually, Form FHWA-1494. This form should be prepared and returned to File D-6 in accordance with instructions furnished.

103.8 PROGRESS CHARTS

~~It may be found desirable to~~ maintain progress charts, ~~particularly on projects where progress is unusually slow~~, to show the comparison between the working days used and the total earnings to date. For slow progress projects, such a chart would serve to show the relationship between the actual rate of progress and the Contractor's proposed or anticipated rate of progress, and focus the attention to the necessity for the Contractor to accelerate the work in order to complete the contract within the allotted contract time.

If progress charts are desired by the Resident or the District Engineer, it will be their responsibility to determine the proper method for maintaining such charts.

103.9 CONTRACTOR'S LABOR PAYROLLS

A. **INTERSTATE PROJECTS.** On Interstate projects, the Contractor and Subcontractor(s) must submit weekly the required "Statement of Compliance" Form WH-348 (Rev. 1-68) and a copy of their payroll transcript or the optional Form WH-347 (Rev. 1-68) to the Resident Engineer for his review and check ~~prior~~ to transmittal to File D-6.

When no work is performed during the week the Statement of Compliance should be submitted with a statement "No work done this week". If no work is anticipated for longer periods, a note on this form should state "No work until further notice", and when work is resumed a letter from the Resident Engineer should be submitted with the first payroll advising the dates on which no work was performed.

Contractors weekly payroll transcripts and Statements of Compliance are to be carefully reviewed by District personnel for compliance with Required Provisions Federal-Aid Contracts and predetermined minimum wages and fowarded promptly to File D-6 for review. The weekly payroll submissions will be returned to the District office for filing with other project records upon completion of the review of the individual weekly payroll submissions.

Payrolls and basic records relating thereto should be maintained during the course of the work and preserved for a period of three years thereafter.

B. **PRIMARY, URBAN, SECONDARY, AND OTHER FEDERAL-AID PROJECTS.** Contractors on Federal-Aid Projects are required to submit to the Resident Engineer a copy of their weekly payroll transcript and a statement of compliance Form WH-348 (Rev. 1-68) or the optional Form WH-347 (1-68).

When no work is performed during the week the Statement of Compliance should be submitted with a statement "No work done this week". If no work is anticipated for longer periods, a note on this form should state "No work until further notice", and when work is resumed a letter from the Resident Engineer should be submitted with the first payroll advising the dates on which no work was performed.

The weekly payroll transcripts and Statements of Compliance are to be carefully reviewed by the designated District personnel for compliance with the Required Provisions Federal-Aid Contracts and predetermined minimum wages. The weekly payroll submissions are to be retained and filed with the other project records upon the satisfactory completion of the payroll review.

Payrolls and basic records relating thereto should be maintained during the course of the work and preserved for a period of three years thereafter.

C. **STATE PROJECTS.** On State projects, submission by the Contractor and Subcontractor(s) of payrolls, or copies thereof, to the Resident Engineer is not required. However, each Contractor and Subcontractor is required by the contract to make his weekly payroll records available in the immediate vicinity of the project for inspection by the State personnel or other authorized personnel during the construction period.

In the event the Resident Engineer has accumulated payrolls during the construction period, he should either return all of the payrolls to the Contractor or destroy them on the completion of the project.

103.10 EMPLOYMENT OF TRUCK DRIVER OWNER-OPERATORS AND THEIR DRIVER EMPLOYEES.

The employment by Contractors and Subcontractors of bona fide truck owner-operators on a unit price basis is permissible on all construction projects. This permissible practice applies only to the employment of individual owners of trucks used exclusively for hauling who operate their own equipment. The names of such bona fide owner-operators must be shown on the Contractor's or Subcontractor's payroll with the notation, "Truck Owner-Operator". The hours worked and rates and amounts paid should not be shown.

Payroll data for each driver employee of the truck owner-operators, regardless of the number of trucks owned by one owner-operator, must be shown as for any other laborer or mechanic, on the payroll transcript of the owner-operator employer, or on the payroll transcript of the Subcontractor or Contractor for whom the trucking work is performed.

103.11 EMPLOYMENT OF APPRENTICES

On all construction projects Apprentices will be permitted to work only when they are registered individually under a bona fide apprenticeship program registered with a State apprenticeship council which is recognized by the Bureau of Apprenticeship and Training, U. S.

Department of Labor; or if no such council exists in a State, under a program registered with the Bureau of Apprenticeship and Training, U. S. Department of Labor.

THE RESIDENT ENGINEER IS RESPONSIBLE FOR INSURING THAT:

(1) Contractors who propose to employ apprentices are participating in an approved and registered training program:

(2) Only bona fide apprentices are employed on the project:

(3) The Contractor or Subcontractor furnishes the Department written evidence of the registration of his program and apprentices as well as the appropriate ratios and wage rates, prior to using any apprentices on the contract work. A copy of this written evidence is to be forwarded to File D-6.

(4) Unless the written evidence described in (3) above is in the Department's possession, the employee must be paid not less than the minimum Journeyman's wage rate as prescribed in the contract for the work performed.

103.12 FINAL PLANS

As soon as possible after the work has been completed and accepted by the District Engineer (and preferably at the time of final estimates), the completed plan tracings including all supplemental plan sheets which were prepared during construction showing the work as actually constructed and a reproduction order, should be submitted directly to File D-19 for reproduction. A letter of transmittal should be sent to File D-6 documenting the submission of the plan tracings to File D-19 with copies to Files D-4, D-5, D-8, D-14 and D-19. Upon receipt of copies of this letter, File D-5 will immediately forward shop plans to File D-19 for incorporation in the final plans before reproduction. Final detailed cross section tracings are not to be submitted to the Austin Office.

Under this procedure, when the final estimate is submitted to File D-3, a reproduction order should be submitted to File D-19 by the District for three sets of final as-built plans. This reproduction order should specify the total number of sheets to be reproduced and should cover the number of plan sheets, shop plans, etc. File D-3 will accept the charge from File D-19 and the cost of the three sets of final as-built plans will be charged to the project. If the District Engineer determines that additional copies of final as-built plans are required, a separate reproduction order should be submitted to File D-19 and the cost of the copies charged to the District's overhead account.

The words "FINAL PLANS" should be placed in a conspicuous place on the title sheet followed by the letting date, date of beginning of work and the date of completion and acceptance. Additionally, a summary of all field changes, supplemental agreements and extra work orders should be shown on the title sheet if space permits. Otherwise, this summary should be prepared on a separate supplementary sheet and inserted in the plans immediately following the title sheet.

CHAPTER 4
SCOPE OF WORK

104.1 GENERAL

It is the intent of the plans and specifications to provide for the construction of a complete project; however, it is recognized that there are certain inherent conditions in highway planning and construction which may require deviations from the plans and specifications under which the contract was let. The contract documents make ample provisions for making of such changes and alterations under Item 4, "Scope of Work", of the Standard Specifications.

104.2 FIELD CHANGES

Form 112, "Approval of Change in Plans", is an administrative document prepared by the Resident Engineer to secure approval of a change or an alteration of the plans or specifications. When it becomes apparent that revision of the plans or specifications or additions are necessary to care for unanticipated or changed conditions, the Resident Engineer should discuss the problem with his immediate superior and prepare a Field Change Request as soon as a proper course of action has been determined.

It will be necessary to submit Form 112 to the Construction Division for approval of changes in plans and/or specifications, when:

(1) Unforeseen conditions require disproportionate deviation from the plans and specifications.

(2) It is necessary to correct errors in the plans or specifications.

(3) It is necessary to alter the design of the roadway, structures, or to modify the drainage pattern.

(4) It is found impossible or impractical to produce or to use the specified materials.

(5) It is necessary to modify the limits of the contract.

(6) Unforeseen conditions require deletion of, addition to or modification of fixed features specified by the plans or specifications.

Work on such field changes is not to be initiated until approved by the Construction Engineer. The District Engineer may authorize appropriate minor changes during construction of the project, provided they are within the scope of the contract and are not of the category listed above. The District Engineer's approval of a minor change will constitute full authority to proceed with construction. It is assumed that such changes would be of minor nature and would not involve disproportionate variation of quantities for the particular items of work. Following are some examples of changes which ordinarily would not require the preparation of Form 112:

(1) Change in the flow line grade of a culvert not in excess of one foot provided, in the case of a box culvert, the grade change does not affect the length of the structure.

(2) Change in the skew angle of pipe culverts up to 20 degrees.

(3) Minor additions, deletions, or minor changes in location or length of side road or access culverts conforming with the Commission policy except on controlled or limited access facilities.

(4) Minor adjustments in grade line of the roadbed consistent with sound engineering design principles.

(5) Adjustments or changes of drainage channels within the limits of easements shown in the plans.

Form 112, "Approval of Change in Plans" should be carefully prepared to concisely and factually present all of the information and quantities pertaining to the proposed change. The following guide lines for preparation of field change requests should be followed except in unusual situations:

(1) Field Change Requests are to be consecutively numbered and referenced to the Federal-aid project having the lowest control or to the State project having the lowest control if the contract contains no Federal-aid project. The identity of the individual project(s) on which the change is proposed, if not on all projects in the contract, is to be stated in the transmittal letter.

(2) The limits of the proposed change are to be shown.

(3) The proposed work is to be described briefly and accurately.

(4) The necessity or reason for making the change is to be carefully and concisely stated.

(5) The items of work to be shown are only those involved in the change. This would include Extra Work added either by force account or by supplemental agreement provided the Extra Work is in connection with the proposed change.

Field Change Requests are to be signed by the District Engineer or in his name by his authorized representative and promptly forwarded to File D-6, and

(a) The letter of transmittal should furnish sufficient detailed information to properly explain conditions requiring the change and fully describe the work to be performed to rectify this condition.

(b) Also, the letter of transmittal should advise whether the proposed change can be financed out of the funds allocated to the project.

(c) Two full size blue-line prints of each supporting drawing which adequately detail the revision in design of the work should be submitted to support Field Change Requests when necessary. If blue-line prints cannot be furnished the original drawings should be submitted so that the necessary prints can be made.

All original drawings will be returned and three half-scale copies of all plan-sheet size drawings or blue-line prints will be returned for District use. For letter-size or similar sketches, three actual-size copies will be returned for District use.

104.3 EXTRA WORK

The Standard Specifications provide means to perform necessary work for which no item or price is included in the contract. This work is defined as "Extra Work" and shall be performed by the Contractor in accordance with the governing specifications and as directed. Extra Work may be performed either by Force Account or by Supplemental Agreement. The contract clauses which pertain to Extra Work are:

Item 4.3 - Changes and Alterations (Par.6)
Item 4.4 - Extra Work
Item 5.9 - Inspection
Item 7.5 - Restoration of Surfaces Opened by Permit
Item 7.7 - Public Safety and Convenience (Par.5)
Item 9.4 - Payment for Extra Work
Item 9.5 - Force Account
Item 9.6 - Partial Payments
Item 9.7 - Acceptance and Final Payment

A. **FORCE ACCOUNT WORK.** Extra Work on a Force Account basis shall be authorized and performed in accordance with the following regulations:

1) Extra Work Orders (Form 317 Rev.) involving expenditures estimated to cost $2,500 or less are to receive final approval at the District Engineer or Engineer-Manager level and no work is to be undertaken until authorized by signature of the District Engineer or Engineer-Manager.

2) Extra Work authorized under (1), above, shall be limited to that necessary to complete a project substantially as planned or to produce the usable facility con-

templated by the plans. Extra Work for the purpose of expanding the scope of a project is not to be authorized.

3) Extra Work Orders not covered by (1) & (2), above, shall be submitted to File D-6 for approval and no work is to be undertaken until approved by the Construction Engineer.

4) All authorized or proposed Extra Work Orders are to be forwarded to File D-6 immediately after being approved by the District Engineer or Engineer-Manager. State and Secondary projects require the original and one copy, Primary and Interstate projects require the original and four copies.

Form 317 Rev., "Extra Work Order", is to be prepared in accordance with Item 9.5, Force Account, and signed by the Resident Engineer and the Contractor or his authorized representative after an agreement has been reached on the scope of the proposed work, the classification and hourly wage rate for all labor, and the hourly rental rate on all equipment required to perform the Extra Work.

The following guide lines for preparation of Form 317 Rev. should be followed except in unusual situations:

1) Extra Work Orders are to be consecutively numbered and referenced to the Federal-aid project having the lowest control or to the State project having the lowest control if the contract contains no Federal-aid project. The identity of the individual project(s) on which the change is proposed, if not on all projects in the contract, is to be stated in the transmittal letter.

2) The limits of the work area are to be shown.

3) All equipment should be listed by type and actual size, H. P. or other rating which definitely establishes the equipment to be used.

4) All labor and equipment operators required should be listed using the same nomenclature as shown in the contract labor provisions.

5) Any increase from the agreed rates should be covered by a Supplemental Extra Work Order. Any decrease from the agreed rates complying with the wage rates in the contract will not require submission of a Supplemental Extra Work Order.

6) A listing of materials and their unit cost are not to be shown on Form 317 Rev. Any detail information on the type, quantity, or unit cost of materials incorporated in the work should be included in the transmittal letter.

7) The Contractor's overhead expenses are not to be shown on Form 317 Rev. To facilitate the preparation of the contingency statement the Contractor should furnish in writing his premium rate on public liability insurance, workmen's compensation insurance, unemployment insurance taxes (federal and state), and Contractor's bonds.

8) Item 9.5 of the Standard Specifications provides that materials furnished on a force account basis will be paid for at the actual cost including freight charges. Material charges are not subject to the retail sales tax; consequently, this tax should not be included as a part of force account cost.

Form 317 Rev. when completed should be promptly forwarded to File D-6, and

(a) The letter of transmittal should give all information necessary to establish the reasons and propriety of the Extra Work and any other information considered pertinent.

(b) Also, the transmittal letter should advise whether the Extra Work can be financed out of the funds allocated to the project.

(c) Two full size blue-line prints of each supporting drawing should be submitted when necessary. If blue-line prints cannot be furnished the original drawings should be submitted so that the necessary prints can be made.

All original drawings and copies will be returned in the same manner as for Field Change Requests.

The Contractor should not be permitted to begin Force Account Work until the Extra Work Order has been approved by the District Engineer, Engineer-Manager or the Construction Engineer (File D-6) in accordance with the regulations 1 through 4 at the beginning of the section on "Force Account Work".

Form 316 Rev., "Daily Report on Extra Work", is to be prepared each day by the Inspector assigned to the work. All items of equipment and labor used must correspond to those shown on approved Form 317 Rev., Extra Work Order except for a decrease from the agreed rates.

It is required that the Inspector and the Contractor's Superintendent or Foreman compare records on the Force Account work at the end of each day. All copies of Form 316 Rev. are to be signed by the Inspector, the Contractor's Superintendent or Foreman, and approved by the Resident Engineer.

B. **SUPPLEMENTAL AGREEMENTS.** A supplemental agreement is a formal agreement between the contracting parties to amend the contract in some manner, or to accomplish and pay for necessary Extra Work on a unit basis. The executed agreement represents the considered thinking of both parties to the contract in mutually determining the most satisfactory method for performing the proposed work and in reaching an agreement on fair and equitable unit prices for the added construction items. If an agreement cannot be reached on unit prices for the required items of work then the Extra Work should be performed on a Force Account basis.

A supplemental agreement will be required when any of the following conditions are encountered:

1) When new items of work are added to the contract.

2) When the demand of either party to the contract for revised consideration is justified on a major item of work to be done or materials to be furnished which vary in excess of the specification tolerances.

3) When revised consideration is justified due to Extra Work made necessary in a contract item which results in a substantial change in the character of the work which materially increases or decreases the cost of the work and which is not included in the prices bid for other items in the contract.

4) When specifically described in construction specifications included in the contract.

5) When it is to the best interest of the State to modify the method of measurement or change the basis of payment on contract items.

6) When it is necessary to omit or add work by altering the project limits described in the contract.

Supplemental agreements are to be prepared and submitted as soon as the need becomes apparent, and, in most cases, submission of a Field Change Request may also be required. The agreement should be carefully prepared in accordance with the current practice and will normally consist of the following paragraphs:

The contract number and project identification should be placed upper left on the first page: Contract Number, Project

Number, State Control Number, Project Designator Number and County. Each page shall be numbered and identified by Project Number and County.

The text should contain:

1) An introduction which states the date of the contract and the factual information identifying the contracting parties and the work contemplated in the contract.

2) A brief statement describing the necessity for the agreement and a clear definition of the work to be performed under the agreement.

3) An enumeration of the items of work and the agreed unit price on each added item of work.

4) The usual witness statement closing the agreement.

5) The signature portion of the agreement should be prepared as shown on the next page. The signature requirements for the Contractor are the same as those required in the original contract.

On State and Secondary projects original and four copies should be submitted and on Primary and Interstate projects the original and seven copies should be submitted.

The Contractor cannot be authorized to proceed with the work under the changed conditions contained in the supplemental agreement until approved by the Construction Engineer (File D-6).

RECOMMENDED FOR APPROVAL BY:

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION	CONTRACTOR
______________________ Resident Engineer Date	______________________ (Firm)
______________________ District Engineer Date or Engineer-Manager	By: ______________________ Date
______________________ Bridge Engineer Date Chief Engineer of Highway Design Chief Engineer, Safety and Maintenance Operations	SURETY APPROVAL ______________________ (Firm)
______________________ Construction Engineer Date	By: ______________________ Date

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

____

Engineer-Director Date

Executed and approved for State Highway and Public Transportation Commission under authority of Commission Minute ~~77446~~

104.4 MEMORANDUM AGREEMENTS

A memorandum agreement is a semiformal written agreement between the Resident Engineer and the Contractor's authorized representative which establishes the fact that a "Major Item" of work or materials furnished will vary in excess of the tolerances set forth in the contract and records the mutual agreement that the cost of doing the work has not been affected to the extent to require revised consideration by either party to the contract.

A memorandum agreement may be used when a change in the character of work is indicated and the cost of performing the work will not be materially affected. Memorandum agreements should also be prepared by the Resident Engineer on affected items of work when it is apparent that it is provident to the State to have such a document on file.

Memorandum agreements are not described in the contract but are State management documents and as such are not classified as the required project documents.

The Contractor or his authorized representative, or the Resident Engineer cannot be forced into signing a memorandum agreement; therefore, the Contractor's payment estimates cannot be withheld pending his agreement to such documents.

CHAPTER 5
CONTROL OF THE WORK

105.1 AUTHORITY OF THE ENGINEER

The specifications provide that workmanship performed, and materials used on the project shall comply with the plans and specifications as interpreted by the Engineer. They also provide the Engineer with authority to determine if the rate of progress is satisfactory and if other phases of the contract are being fulfilled. The Engineer's decisions are final to the extent that the Contractor must carry out instructions issued to him by the Engineer, even though he may not be in agreement with the decision. This does not preclude the Contractor from seeking relief through the proper channels.

Usually, the methods or procedures employed by the Contractor in accomplishing the work are his responsibility. If the specifications or plans specify the methods or procedures to be followed in performing the work, the Engineer has the authority not to accept work done by other methods, even though the Contractor may contend that he can secure equally good or better results.

If the contract does not specify the methods, and the Engineer believes the methods selected by the Contractor may result in faulty work, it is proper to so advise the Contractor with the understanding that the Engineer is not dictating the procedures to use.

Where the governing specifications state: "or as directed by the Engineer in writing", this usually refers to the construction procedures, and such instructions should be issued to the Contractor in writing. Likewise, where the specifications state: "or as directed by the Engineer", and the instructions are issued orally, an appropriate notation to this effect should be made in the diary.

105.2 PLANS

A. **QUANTITIES.** The bid quantities are part of the plans. Item 5.3 of the Standard Specifications, states in part the following: "It is the responsibility of the Contractor to verify all quantities of materials shown on the plans before ordering same, as payment is provided for acceptable materials complete in place, and materials rejected due to improper fabrication or excess quantity, or for other reasons within control of the Contractor will not be paid for regardless of the quantities or dimensions shown on the plans. The Engineer, when requested, will check any and all material orders prepared by the Contractor, but such check will not relieve the Contractor of responsibility." Under these provisions, the Contractor is responsible for the accuracy of plan quantities and plan dimensions if it is within his control to check them. If it is determined by the Engineer that it is not within the control of the Contractor to check the accuracy of the plan dimensions, the Contractor is entitled to any additional cost incurred by him in making corrections or changes necessitated by the plan dimensions being in error. Likewise, if it is determined by the Engineer that it is not within the control of the Contractor to check the accuracy of the plan quantities, the Contractor is entitled to his cost on that quantity of material not used when that quantity is the difference between the quantity of material actually used and the plan quantity of material ordered and delivered for use on the project.

Under these circumstances the cost of material delivered to the project but not used, can be paid to the Contractor on the project estimates by Extra Work Order or Supplemental Agreement.

Any materials acquired by the State under these procedures should be handled under the following conditions:

1. They are suitably stored or stockpiled and are in a first-class condition at the time they are turned over to the State by the Contractor.

2. The acquisition shall be covered by a duly executed agreement between the State and the Contractor.

3. Payment to the Contractor will be made by including the agreement purchase price in the final estimate after the agreement has

been fully executed. A copy of the executed agreement is to be attached to the final estimate.

4. If the materials are not to be used on the contract involved then the cost will be charged to the District Stock Account.

B. **WORKING DRAWINGS.** The specifications and/or construction plans for construction contracts involving bridge structure components, sign supports and illumination facilities require the Contractor to furnish certain construction shop drawings, supplementary bridge plans or working drawings. The review and approval of these drawings and other required information should be handled by the offices indicated below or in accordance with instructions found in the responsible Division's manual.

Bridge Structure Components	In accordance with instructions found in the "Bridge Division Operations and Planning Manual"
Overhead Sign Supports	Bridge Division (File D-5)
Signal Poles	Maintenance Operations Division (File D-18T)
All Lighting Poles except High Mast	Resident Engineer or District Office
High Mast Poles	Bridge Division (File D-5)
High Mast Assemblies	Bridge Division (File D-5)
Roadside Sign Supports	Resident Engineer or District Office
Brochures - Electrical Matters, etc.	Highway Design Division (File D-8)

If Department fabrication inspection is required, two copies of shop drawings should be furnished the Materials and Tests Division (File D-9) immediately after the drawings have been approved by the reviewing office. One copy of the approved drawings should be furnished the Contractor.

105.3 COORDINATION OF PLANS, SPECIFICATIONS, AND SPECIAL PROVISIONS.

Although considerable care is excercised in the preparation of the contract documents, disagreements will occasionally occur. In such cases, figured dimensions shall govern over scaled dimensions, plans shall govern over specifications, and special provisions shall govern over both plans and specifications.

It is the responsibility of the Resident Engineer to base his decisions on the above established priorities.

105.4 CONSTRUCTION STAKES

One of the principal elements in staking a project is for the Resident Engineer to be certain that the staking operations are performed at such time so as not to delay the Contractor's progress of the work. Futhermore, the Resident Engineer must be certain that the Contractor and his supervisory personnel clearly understand the information or meaning shown on construction stakes.

It is the responsibility of the Contractor to build the project as staked; however, unless otherwise provided for in the plans or specifications, it is the responsibility of the Resident Engineer to stake the basic controls of the project. This responsibility includes the staking necessary to establish lines and grades in the roadway work, and center lines and bench marks for bridge work. Roadway work includes such items of construction as earthwork, base courses, and surface courses or pavements. Additional discussion of the construction staking is contained in Part II, "Construction Surveys".

105.5 INSPECTION

All work should be inspected to determine if it is performed in accordance with the requirements of the contract. The Contractor shall furnish the Engineer with every reasonable facility to expedite the inspection operations. The Contractor shall advise the Engineer sufficiently in advance of the proposed construction work in order that inspection of the work can be made. No work shall be done by the Contractor without suitable inspection or supervision. Where practical, it is the responsibility of the Resident Engineer to provide suitable inspection as the work is being done. Item 5.8 of the Standard Specifications provides that such inspection will not relieve the Contractor from any obligation to perform the work in accordance with the requirements of the specifications; however, this part of the specifications should not be considered as justification for inadequate, unsuitable, or negligent inspection.

Detailed information regarding the inspection of the various types of construction work is covered in Part III, "Construction Details".

105.6 AUTHORITY AND DUTIES OF INSPECTORS

Inspectors will be authorized to inspect all work done, all materials furnished, and all equipment used on the project. An Inspector will be stationed on the work to report to the Engineer as to the progress of the work and the manner in which it is being performed; also, to report whenever it appears that the materials furnished and the work performed by the Contractor fail to fulfill the requirements of the specifications and contract, and to call the attention of the Contractor to any such failure or infringement. Such inspection will not relieve the Contractor from any obligation to perform the work in accordance with the requirements of the specifications. In case of any dispute arising between the Contractor and the Inspector as to materials furnished or the manner of performing the work, the Inspector will have authority to reject materials or suspend work until the question at issue can be referred to and decided by the Engineer. The Inspector does not have authority to revoke, alter, enlarge, or release any requirement of the specifications, nor to approve or accept any portion of the work, nor to issue instructions contrary to the plans and specifications. He will in no case act as foreman or perform other duties for the Contractor nor interfere with the management of the work. It is sometimes necessary, that the specifications specify the manner and sequence of performing the work in order to insure the desired end result. The Inspector, however, should not tell the Contractor how to perform the work where the specifications do not specify the methods but merely the end result.

105.7 DEFECTIVE AND UNAUTHORIZED WORK

All work which has been rejected shall be remedied or removed and replaced with acceptable work. Work done beyond the lines and grades given or shown on the plans, except as provided, or any extra work done without written authority will be considered as unauthorized work and done at the expense of the Contractor. The Engineer has the authority to cause the defective work to be remedied, or removed and replaced, and unauthorized work to be removed, and the cost may be deducted from any money due to the Contractor.

105.8 FEDERAL INSPECTION

Projects financed in part or wholly with Federal funds will be inspected periodically by representatives of the Federal Highway Administration in accordance with the Federal-Aid Highway Program Manual issued by their Washington Office. Such inspection does not make the Federal Highway Administration a party to the contract existing between the Department and the Contractor.

Arrangements should be made, when feasible, with the Federal Highway Administration's representative to observe progress and final record sampling and testing at the time they report to the District for their usual inspection of construction projects; however, the Contractor's normal operations are not to be delayed due to securing either type of samples. In addition a complete file of the test results shall be maintained by the Resident Engineer and be made available for inspection by representatives of the Federal Highway Administration.

CHAPTER 6
CONTROL AND INSPECTION OF MATERIALS

106.1 GENERAL

Inspection and control of materials is an essential and important part of every construction project. Many organizations are involved in this work, namely: the Resident Engineer's Field Laboratories and his personnel, the District Laboratory and District personnel, the Materials and Tests Division Laboratory, and the commercial and manufacturer's laboratories. The Materials and Tests Division (File D-9) is charged with the responsibility of correlating the work of these various organizations. In order to properly discharge this responsibility, it is essential that the Resident Engineer prepare Form 1005, "Material Inspection Notice", at the earliest possible time and promptly forward this form to File D-9 so that proper arrangements can be made for sampling and testing of the various materials. The Resident Engineer should encourage the Contractor to order materials sufficiently in advance to allow adequate time for sampling and testing without any delay to the Contractor in their use. The Contractor should identify the project and the specification item number on all his material orders.

It is the responsibility of the Resident Engineer to accept only those materials substantially complying with the specification requirements and to keep records of the test results as evidence to substantiate his acceptance.

The specifications state which method of testing should be used for each material. The general practices for the sampling and control of materials are contained in the "Manual of Testing Procedures" prepared by the Materials and Tests Division, the Departmental Bulletins, and the "Guide Schedule of Sampling and Testing (Per Contract)" included in this chapter, Section 106.11.

Sampling and testing of materials to be used on the project can be divided into the following three groups of tests:

1. Job Control

2. Record

3. Referee or Split Sample

106.2 JOB CONTROL TESTS

Job control tests are the acceptance tests, which are made on a day-to-day basis to ascertain whether the quality of the materials and the quality of the construction work being produced, conforms to the plans and specifications. In most instances, the job control tests will be made on the project under supervision of the Resident Engineer.

Since the specifications and the test methods ordinarily do not specify the exact point of sampling the materials, whenever feasible, materials should be sampled for testing at the source; otherwise, they should be sampled as soon as possible after delivery to the project. It is the responsibility of the District Engineer to establish the point of sampling for the materials which are to be tested under the supervision of the Resident Engineer, where such points have not been established by the specifications, plans, Departmental Bulletins, Guide Schedule, or the test methods.

It is in the Department's interest that the point of sampling be established as soon as possible, keeping in mind the necessity for securing representative samples. Without any sacrifice in quality, this procedure will afford the Contractor a better opportunity to make corrections in the event the material does not meet the specification requirements.

The statements made in the Standard Specification Item No. 6.1 to the effect that "All materials being used are subject to inspection or tests at any time during their preparation or use. Any material which has been tested and accepted at the source of supply may be subjected to a check test after delivery and all materials which, when retested, do not meet the requirements of the specifications, will be rejected", are not included to allow the Engineer to indiscriminately establish variable points of sampling the same material, or give him authority to recheck and retest accepted material merely on a routine basis. It is anticipated that the Contractor and the producer will exercise due caution in maintaining the quality of the material after it has been accepted; however, if they do not, then the material must be retested.

Any change occurring in the material after acceptance, which results from the normal and usual construction operations is not sufficient justification for resampling and retesting.

106.3 RECORD TESTS

Record tests consist of random samples and test made as an independent spot check on the results shown by the job control tests. These tests are made by the District Laboratory personnel, and are required on all construction projects. The principle to be observed in such sampling is that the record samples be selected and tested by personnel other than those normally doing these operations at the project.

It is recommended that the Resident Engineer examine and compare all the results of record tests with the results of the job control tests on similar materials.

On Federal-Aid Projects it is recommended that the procedure outlined below be followed on all record sampling whereby the Federal Highway Administration personnel in reviewing test reports may be able to identify the personnel responsible for the sampling.

1) Where Federal Highway Administration personnel selects the sample, the name and title of the individual taking the sample be shown on the sample identification slip and test report.

2) Where the sample is obtained by Department personnel in the presence of Federal Highway Administration personnel, this information be shown on the sample identification slip and test report.

3) Where the sample is obtained by District personnel, independent of Project personnel and Federal Highway Administration personnel, this information be shown on the sample identification slip and test report.

Since the primary objective of the record tests is to check the technique of the actual sampling and testing made by the project personnel, it is necessary that the point of sampling for the record tests be from the same stage of production as that for the job control tests.

Personnel performing the test should be the only variable, and if any other variable is introduced, then the record tests cannot be considered as check tests within the purpose and scope of such tests.

With some materials it is not possible nor practical to perform record testing without introducing variable factors not associated with the job control testing. These variable factors could affect the test results appreciably. In such instances, the District personnel should periodically observe the actual job control sampling and testing, and identify such observed tests as record tests.

It is very important that the initial record tests on each item of work be taken at the beginning of such work. Should variations greater than normal develop between the job control and the record test results, immediate steps must be taken to determine which one is correct in order that the other one may be correlated with it.

A copy of the test report should be forwarded to the Resident Engineer in charge of the work and also kept on file in the District Office or District Laboratory. The close cooperation and scheduling required between the Resident Engineer and District Laboratory in obtaining these samples will be the responsibility of the District Engineer or his delegated representative.

106.4 REFEREE OR SPLIT SAMPLE TESTS

In the early stages of flexible base construction on each project of any magnitude, where liquid limit and plasticity index values have been established by the specifications, referee or split samples shall be taken for the liquid limit and plasticity index tests as an additional procedure, other than normal record testing, to conform the correlation between the Project and District Laboratories. This procedure also serves as a check on the techniques of the personnel at the Project Laboratory and is an excellent method in promoting the reliability of job control testing. Additional split samples should be taken for changes in laboratory personnel or for too great a variation between the job control tests and record tests. Split sample tests may serve as job control tests and record tests.

106.5 LOCAL MATERIAL SOURCES

A. **GENERAL.** The Department is currently securing options on three types of local material sources, which are identified as "Required", "Designated", or "Listed" sources.

1. **Required Sources.** Local material sources are classified as "Required" when the Contractor is required by the specifications to secure material from State optioned sources. When this type of material source is used by the Contractor, the Department assumes full responsibility for the quantity of acceptable material available in the source and will provide another source if it develops that a sufficient quantity of acceptable material cannot be produced from the required pit.

   The Contractor is to be compensated for all additional cost incurred in producing material from a new source upon failure of the required source. This additional compensation may include the cost of dismantling, moving, and reassembling equipment, additional haul, and additional cost in producing the material if such cost is determined. This does not imply that the Department assumes responsibility for the Contractor's operations in the required source. Whether the Contractor fulfills his responsibility will have to be determined on the circumstances and conditions involved in each case.

2. **Designated Sources.** Local material sources are classified as "Designated" when the State guarantees the quantity of acceptable material in the optioned source. The Contractor is usually permitted by the specifications to secure material from sources obtained by him. In no case will approval of the Contractor's 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. When the designated source is used by the Contractor, the Department assumes full responsibility for the quantity of acceptable material available in the source and will secure another source if it develops that a sufficient quantity of acceptable material cannot be produced from the designated pit. It must be understood, that the provisions in the specifications permitting the Contractor, under certain specified conditions, to use a source obtained by him, does not relieve the Department of its responsibility when the Contractor uses the designated source. However, the Department does not assume any responsibility for the quantity of acceptable material in any source obtained by the Contractor and approved by the Department.

The Contractor is to be compensated for all additional cost incurred in producing material from a new source upon failure of the designated source. This additional compensation may include the cost of dismantling, moving, and reassembling equipment, additional haul, and additional cost in producing the material if such cost is determined. This does not imply that the Department assumes responsibility for the Contractor's operations in the designated source. Whether the Contractor fulfills his responsibility will have to be determined on the circumstances and conditions involved in each case.

In most instances, the Contractor will be responsible for the specified gradation, liquid limit, and plasticity index of the material; however, the Contractor cannot make large size aggregate out of smaller sizes, and on occasions he might not be able to control the liquid limit and plasticity index of the material by a reasonable amount of selective quarrying and scalping operations.

Certain inherent characteristics of the material such as soundness, resistance to abrasion and degradation, and also the quantity of material in the pit, usually are not dependent upon the method of the Contractor's operation. The Contractor is expected to exercise a reasonable amount of selective quarrying if such a procedure is practical and will improve the above mentioned characteristics. Here again, the responsibility of each party to the contract can only be determined after due consideration of the circumstances and conditions involved in each case.

3. **Listed Sources.** Local material sources are classified as "Listed" when the Department assumes no responsibility whatever as to the quantity of acceptable material in the source. This classification will apply in those instances where the Department has secured options or easements on sources which are made available for use by the Contractor. The practice of securing options on listed sources is used to promote competition between the various bidders by preventing any firm from obtaining exclusive rights to the use of a potential source.

   The Department does not assume any responsibility as to the quantity of acceptable material in a listed source. It is the Contractor's sole responsibility to make any and all investigations to be satisfied as to the quantity of acceptable material available in the listed source. If preliminary tests have been made, 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 nor any requirements of the specification item. The Department secures options on listed sources not only to promote competition, but also to provide for the right of ingress and egress to the bidders for making preliminary investigations, and to provide the right to the successful bidder for removing material from the source. Should the quantity of acceptable material prove inadequate in a listed source, the Contractor must provide material meeting the specification requirements from another source, obtained by him, at no additional cost to the Department regardless of the cost to the Contractor in producing and furnishing acceptable material out of the new source.

B. **ROYALTY PAYMENTS.** The method of handling royalty payments is the same for the required, designated, and listed sources, except in unusual and specific cases for the listed sources. When the Contractor is required to negotiate regarding royalty payments with the owner of a listed source, provision for such is included in the plans and specifications.

106.6 STORAGE OF MATERIALS

Stored materials are usually sampled, tested, and accepted prior to storage, and proper storage facilities shall be provided to insure the preservation of their quality and fitness for the work. The Resident Engineer will determine the adequacy of the storage facilities, and if necessary, he may require covers, wooden platforms, hard clean surfaces other than the ground, or any combination of these facilities. Any material that becomes unfit due to improper storage shall be rejected.

106.7 STOCKPILING OF MINERAL AGGREGATES

Mineral aggregates are stockpiled for various purposes. Mineral aggregates proposed for use in surface treatments, portland cement concrete, and asphaltic concrete usually are stockpiled to insure a ready supply and to insure an orderly prosecution of the work. These materials are usually sampled for testing as they arrive at the stockpile site, and it is expected that all the test results will be in compliance, or occasionally, in substantial compliance with the specification requirements. In this event, the material is accepted. Then, it is the Contractor's responsibility to maintain the quality of the stockpiled material. Excessive, improper, or careless handling of accepted and stockpiled material which results in excessive degradation, excessive segregation or contamination will be sufficient justification for resampling and retesting, and if tests so indicate, rejection of the material.

Mineral aggregates for use in subbases and bases are ordinarily stockpiled to insure a more uniform product. The gradation requirements for these materials usually cover a wide band, and under the specifications, gradation anywhere within this band is acceptable. Other requirements may also vary from the low toward the higher value allowed, and any material within the prescribed limits is acceptable. Material is acceptable even though it may vary from the upper to the lower limits of the specification requirements; however, it would be impossible to construct a uniformly good subbase or base under such conditions. Stockpiling of these materials has eliminated wide variations within the specification requirements.

106.8 TEST METHODS AND TESTING EQUIPMENT

When specifications refer to the THD Bulletins or the Test Methods, these reference manuals become an integral part of the contract, and as such, must be followed in order for the Department to fulfill its obligations. In all cases the provisions and sampling and testing procedures of the THD Bulletins and Test Methods shall be fulfilled.

All of the testing equipment used in making tests on materials and in making tests on the products made from the materials, shall be in good working order and as specified in the applicable test method. In addition, an independent check or calibration on each piece of testing equipment such as beam breakers, air meters, volumeters, scales, etc. used on job control testing shall be made by a qualified laboratory technician at least once each year and by one who is not associated with the project. Evidence that such checks or calibrations have been made shall be in the form of a proper notice placed on each piece of testing equipment or a proper document shall accompany each piece of testing equipment.

The District Laboratory must establish a definite procedure that may be documented for reviewing the Project Laboratory testing procedures. This assignment may well be executed in performing the progress record testing.

106.9 MATERIALS REQUIRING CERTIFICATION FROM THE CONTRACTOR

1. **Cement.** A certificate indicating the specific surface area for each shipment of cement shall be submitted to the Resident Engineer.

2. **Concrete Admixtures.** For each admixture, the Contractor shall furnish the Resident Engineer three (3) copies of the invoice for the admixture to be used on the project.

106.10 TEST REPORTS

A. **FORMS AND REPORTS TO BE SUBMITTED TO THE AUSTIN OFFICE.** It is the responsibility of the Resident Engineer to prepare the following forms and reports for submission to the appropriate Divisions of the Austin Office. The information in parenthesis following each listing identifies the appropriate Division and the publication containing instructions for the preparation, distribution, and submission of the respective form.

1. Form 168 - Pile Record
   (D-5, Bridge Division Operations and Planning Manual)
2. Form 181 - Test Pile Data
   (D-5, Bridge Division Operations and Planning Manual)
3. Form 1276 - Drilled Shaft Records
   (D-5, Bridge Division Operations and Planning Manual)
4. Constr. Form 312 Rev. - Field Laboratory Report for Concrete
   (D-6, THD Bulletin C-11)
5. Cement Factor Curve
   (D-6, THD Bulletin C-11)
6. Pilot Strength Curve
   (D-6, THD Bulletin C-11)
7. Constr. Form 404 Rev. - Field Laboratory Report for Asphaltic Concrete
   (D-6, THD Bulletin C-14)
8. Density - Stability Curve
   (D-6, THD Bulletin C-14)
9. Form CX101 - Identification Slip for Asphaltic Concrete
   (D-9, Manual of Procedures)
10. Form 202 - Identification Slip for Material Samples
    (D-9, Manual of Procedures)
11. Form 342 - Compressive Strength Specimens
    (D-9, Manual of Procedures)
12. Form 517 - Tag Envelope
    (D-9, Manual of Procedures)

B. **FORMS NOT TO BE SUBMITTED TO THE AUSTIN OFFICE.** It will be the responsibility of the Resident Engineer to prepare the following forms or equivalent substitutions, in accordance with the established practice within the District or in accordance with instructions issued by the District Engineer. The information in parenthesis following each listing identifies the responsible Division, and if applicable, the publication containing instructions for the preparation and distribution of the respective form.

1. Form 187 - Daily Road Report - Asphalt (D-6, Part II, Chapter 8 of this manual)
2. Constr. Form 309 - Concrete Design Work Sheet - Natural Aggregates (D-6, Bulletin C-11)
3. Constr. Form 310 - Field Laboratory Aggregate Sieve Analysis Report (D-6, THD Bulletin C-11)
4. Constr. Form 311 Rev. - Daily Road Report - Concrete Pavement (D-6, THD Bulletin C-11)
5. Constr. Form 356 Rev. - Concrete Design Report (D-6, THD Bulletin C-11)
6. Form 360 - Soil Laboratory Mechanical Analysis of Soil and Base Course Aggregate (D-9, See Test Method Tex-110-E)
7. Form 476-A-Soils and Base Materials Test Report (D-9, Manual of Procedures)
8. Form 481 - Cumulative Mechanical Analysis (D-9, See Test Method Tex-110-E)
9. Form 491 - Field Soil Work Card (D-9, See Test Method Tex-104-E, 105-E, and 110-E)
10. Constr. Form 544 Rev. - Asphaltic Concrete Sieve Analysis Work Sheet (D-6, THD Bulletin C-14)
11. Constr. Form 545 Rev. - Asphaltic Concrete Data Sheet on Molded Specimens and Road Samples (D-6, THD Bulletin C-14)
12. Form 546 Rev. - Asphaltic Concrete Extraction Test Work Sheet (D-6, THD Bulletin C-14)
13. Form 1062 - Triaxial Test Data Sheet (D-9, Test Method Tex-117-E)
14. Various work sheets as shown in the Manual of Testing Procedures issued by File D-9.
15. Constr. Form 590 - Weekly Summary of Embankment Subbase or Base Material Tests Results (D-6)
16. Form 596 - Concrete Batch Tickets (D-5, Supplement to Bulletin C-11)

106.11 GUIDE SCHEDULE OF SAMPLING AND TESTING PER CONTRACT

The "Guide Schedule of Sampling and Testing Per Contract", Tables I, IA, II, III, IV and V dated December, 1980, establishes the sampling and testing requirements per contract and shall be applied on all projects under construction.

It must be realized that the guide schedule of sampling and testing, has been developed for the average operation. When borderline materials are involved, it probably will be necessary to increase the amount of sampling and testing in order to insure that specification materials are used in the work.

In case of conflict between the guide schedule and the plans and specifications, the plans and specifications shall govern.

GUIDE SCHEDULE OF SAMPLING AND TESTING
(Per Contract)

THIS IS A GUIDE FOR MINIMUM SAMPLING AND TESTING. WHEN NECESSARY FOR QUALITY CONTROL, ADDITIONAL SAMPLING AND TESTING WILL BE REQUIRED.

EMBANKMENTS, SUBBASES, AND BASE COURSES

MATERIAL or PRODUCT		TEST FOR	TEST NUMBER	JOB CONTROL TESTS: LOCATION or TIME of SAMPLING	JOB CONTROL TESTS: FREQUENCY of SAMPLING	RECORD TESTS: LOCATION or TIME of SAMPLING	RECORD TESTS: FREQUENCY of SAMPLING	REMARKS
EMBANK-MENT		Compaction	Tex-115-E	As Designated by The Engineer	Each 5,000 C.Y. (F)	Same as Job Control	Each 100,000 C.Y. or Fraction Thereof (B)	115E Or Other Approved Method
UNTREATED SUBBASE AND BASE COURSES		Gradation	Tex-110-E	During Stockpiling Oprs., from Stockpile, or from Windrow *	Each 4,000 C.Y. or 6,000 Tons	Same as Job Control	1 Out of 20 Job Control Tests or Fraction Thereof (C)	* Engineer Will Select Any One of These Three (3) Locations or Any Combinations Thereof With the Provision That a Minimum of 10% of Tests Will Be Sampled from the Windrow for Gradation, Plasticity Index, and Liquid Limit Only
		Liquid Limit	Tex-104-E	During Stockpiling Oprs., from Stockpile, or from Windrow *	Each 4,000 C.Y. or 6,000 Tons	Same as Job Control	1 Out of 20 Job Control Tests or Fraction Thereof (C)	
		Plasticity Index	Tex-106-E	During Stockpiling Oprs., from Stockpile, or from Windrow *	Each 4,000 C.Y. or 6,000 Tons	Same as Job Control	1 Out of 20 Job Control Tests or Fraction Thereof (C)	
		Wet Ball Mill	Tex-116-E	During Stockpiling Oprs., from Stockpile, or from Windrow	Each 20,000 C.Y. or 25,000 Tons*			* When a stockpile is to be sampled that has not been built in horizontal layers, sampling will be 1 test for each 4,500 C.Y. or 6,000 tons.
		Triaxial	Tex-117-E	During Stockpiling Oprs., from Stockpile, or from Windrow	Each 20,000 C.Y. or 25,000 Tons (D)**			Triaxial tests are not a field laboratory function. **When a stockpile is to be sampled that was not built in horizontal layers, sampling will be 1 test for each 12,000 C.Y. or 16,000 tons.
		Compaction	Tex-115-E	As Designated by The Engineer	Each 3,000 Lin. Ft. Per Course Per Travel-Way (A)	Same as Job Control	1 Out of 20 Job Control Tests of Fraction Thereof (C)	115E Or Other Approved Method
		Thickness		As Designated by The Engineer	1 Depth Per 3,000 Lin. Ft. Per Travel-Way(A) (E)		1 Total Depth Per Travel-Way Per 2 Miles or Fraction Thereof (A)	If payment is by the S.Y., frequency shall be as per specification requirement for J.C. testing.
TREATED SUBBASE AND BASE COURSES	BASE MATERIAL	As Shown Above For Untreated Base		As Designated by The Engineer Prior to the Addition of a Stabilizer	As Shown Above For Untreated Base	Same as Job Control	As shown above	When central mix site or plant is used, windrow sampling may not be required.
	LIME	Compliance With Item 264 "Hydr. Lime & Lime Slurry"	Tex-600-J	During Delivery to Project	Ty A, Ea. 200 Tons Ty B, Ea. 200 Tons Ty C, Ea. 150 Tons or Fraction Thereof*			*On projects requiring less than 50 tons, material from D-9 approved sources may be accepted on the basis of Producer's Certification without sampling.
	CEMENT	Compliance With The Std. Specifications & Spl. Provisions	ASTM C-150	Railroad Car, Truck, or Cement Bins	Each 2,000 Bbls. for Each Type or Brand			Each Brand and Each Type To Be Sampled and Tested Separately
	ASPHALT	Compliance With Item 300 "Asphalts, Oils and Emulsions"	Tex-500-C, Etc.	Sampled, Tested, and Approved by D-9				
	FLY ASH	Compliance With Std. Spec. Spl. Specs. D-9-8900	Tex-733-I	During Delivery to Project	Each 150 Tons or Fraction Thereof			Each Source To Be Sampled And Tested Separately
	COMPLETE MIXTURE	Pulverization	Tex-101-E Part III	Roadway; After Pulverization	Each 4,000 C.Y. or 6,000 Tons***	Same as Job Control	1 Out of 20 Job Control Tests or Fraction Thereof (C)	Where required to control degree of pulverization. ***Minimum of 1 per land.
		Compaction	Tex-115-E	As Designated by The Engineer	Each 3,000 Lin. Ft. Per Course Per Travel-Way (A)	Same as Job Control	1 Out of 20 Job Control Tests or Fraction Thereof (C)	115E Or Other Approved Method
		Thickness		As Designated by The Engineer	Each 3,000 Lin. Ft. Per Course Per Travel-Way (A)		1 Total Depth Per Travel-Way Per 2 Miles or Fraction Thereof (A)	

(A) Travel-way is defined as total width of a travel facility that is not separated from other parallel travel facilities by a median, ditch, etc.

(B) Record tests are not required for a contract quantity of less than 25,000 C.Y.

(C) Record tests are not required for a contract quantity resulting in less than 6 job control tests.

(D) When base material is from a source where the district has a record of satisfactory triaxial results, the frequency of testing may be reduced to one per 30,000 C.Y. (40,000 Tons). If any one test falls below the minimum value required, the frequency of testing will return to that required by this guide.

(E) Not required where survey grade control documents compliance.

(F) Or approximately one foot compacted depth lift as approved and directed by the Engineer.

TABLE I

Rev. Feb. 1986

THIS IS A GUIDE FOR MINIMUM SAMPLING AND TESTING. WHEN NECESSARY FOR QUALITY CONTROL, ADDITIONAL SAMPLING AND TESTING WILL BE REQUIRED.

ASPHALT STABILIZED BASE
(Plant Mix)

			JOB CONTROL TESTS		RECORD TESTS		
MATERIAL or PRODUCT	TEST FOR	TEST NUMBER	LOCATION or TIME of SAMPLING	FREQUENCY of SAMPLING	LOCATION or TIME of SAMPLING	FREQUENCY of SAMPLING	REMARKS
AGGREGATE	Gradation	Tex-110-E	During Stockpiling Oprs., from Stockpile, or Prior to Mixing	Each 4,000 C.Y. or 6,000 Tons	Same as Job Control	1 Out of 20 Job Control Tests or Fraction Thereof (A) (D)	
	Liquid Limit	Tex-104-E	During Stockpiling Oprs., from Stockpile, or Prior to Mixing	Each 4,000 C.Y. or 6,000 Tons	Same as Job Control	1 Out of 20 Job Control Tests or Fraction Thereof (A) (D)	
	Plasticity Index	Tex-106-E	During Stockpiling Oprs., from Stockpile, or Prior to Mixing	Each 4,000 C.Y. or 6,000 Tons	Same as Job Control	1 Out of 20 Job Control Tests or Fraction Thereof (A) (D)	
	Wet Ball Mill or L.A. Abrasion	Tex-116-E or 410-A	During Stockpiling Oprs., from Stockpile, or Prior to Mixing	Each 20,000 C.Y. or 25,000 Tons*			When L.A. Abrasion is specified, tests are not required if aggregate is on D-9 Quality Monitoring Program *When a Stockpile is to be sampled that was not built in horizontal layers, sampling will be one test for each 4,500 C.Y. or 6,000 Tons.
	Sand Equivalent	Tex-203-F	Hot Bins or Feeder Belt	1 Each 10 Days' Production			
LIME	Compliance With Item 264-"Hydrated Lime and Slurry"	Tex-600-J	During Delivery	Ty A, Ea. 200 Tons Ty B, Ea. 200 Tons Ty C, Ea. 150 Tons or Fraction Thereof*			*On projects requiring less than 50 tons, material from D-9 approved sources may be accepted on the basis of Producer's Certification without sampling
ASPHALT	Compliance With Item 300 "Asphalts, Oils and Emulsions"	Tex-500-C, Etc.	Sampled, Tested, and Approved by D-9				
COMPLETE MIXTURE	Laboratory Density	Tex-126-E or Tex-204-F	Plant or Road	Each 12,000 C.Y. or 16,000 Tons			
	Percent Asphalt	Tex-126-E or 210-F	Plant or Road	1 For Each Day's Production (C)	Same as Job Control	1 For Each 10 Days' Production (A)	
	In-Place Density	Tex-207-F	As Designated by The Engineer	Each 3,000 Lin. Ft. Per Course Per Travel-Way (B)	Same as Job Control	1 Out of 20 Job Control Tests or Fraction Thereof (D)	
	Dimensions		As Designated by The Engineer	1 Depth Per 3,000 Lin. Ft. Per Travel-Way (B) (E)	Same as Job Control	1 Total Depth Per Travel-Way Per 2 Miles or Fraction Thereof (B)	

(A) Not required when D-9 provides inspection at plant.

(B) Travel-way is defined as total width of a travel facility that is not separated from other parallel travel facilities by a median, ditch, etc.

TABLE 1A

(C) Not required where plant produces less than 1/2 day due to weather, breakdown, etc.

(D) Record tests are not required for a contract quantity resulting in less than 10 job control tests.

(E) Not required for level-up courses over existing pavement surfaces.

SURFACE TREATMENTS

AGGREGATE	Gradation	Tex-200-F (Dry)	At Source or At Point of Delivery	1 Each 300 C.Y.	Same as Job Control	1 Out of 20 Job Control Tests or Fraction Thereof (A)	Record Testing Not Required When D-9 Provides Job Control Testing
ASPHALT	Compliance With Item 300 "Asphalts, Oils and Emulsions"	Tex-500-C, Etc.	Sampled, Tested, and Approved by D-9				

(A) Record tests are not required for a contract quantity resulting in less than 6 job control tests.

TABLE II

THIS IS A GUIDE FOR MINIMUM SAMPLING AND TESTING. WHEN NECESSARY FOR QUALITY CONTROL, ADDITIONAL SAMPLING AND TESTING WILL BE REQUIRED.

PORTLAND CEMENT CONCRETE; STRUCTURAL & MISCELLANEOUS

MATERIAL or PRODUCT		TEST FOR	TEST NUMBER	JOB CONTROL TESTS: LOCATION or TIME of SAMPLING	JOB CONTROL TESTS: FREQUENCY of SAMPLING	RECORD TESTS: LOCATION or TIME of SAMPLING	RECORD TESTS: FREQUENCY of SAMPLING (B)	REMARKS
MINERAL AGGREGATES	COARSE AGGREGATE	Decantation (A) (C)	Tex-406-A	During Delivery to Plant, from Stockpile, or from Batch Bin	2 Each Source	Same as Job Control	1 Each Source	
MINERAL AGGREGATES	COARSE AGGREGATE	Sieve Analysis (A) (C)	Tex-401-A	During Delivery to Plant, from Stockpile, or from Batch Bin	1 Each 500 C.Y. or Fraction Thereof	Same as Job Control	1 Each 5,000 C.Y. or Fraction Thereof	Test Combined Aggregates When Used
MINERAL AGGREGATES	FINE AGGREGATE	Sand Equivalent (A) (C)	Tex-203-F	During Delivery to Plant, from Stockpile, or from Batch Bin	1 Per Week (F) (Each Source or Combination of Sources)*	Same as Job Control	1 Per Project (Each Source or Each Combination of Sources)	Test Combined Aggregates When Used
MINERAL AGGREGATES	FINE AGGREGATE	Organic Impurities (A) (C)	Tex-408-A	During Delivery to Plant, from Stockpile, or from Batch Bin	2 Each Source	Same as Job Control	1 Each Source	
MINERAL AGGREGATES	FINE AGGREGATE	Sieve Analysis (A) (C)	Tex-401-A	During Delivery to Plant, from Stockpile, or from Batch Bin	1 Each 500 C.Y. or Fraction Thereof	Same as Job Control	1 Each 5,000 C.Y. or Fraction Thereof	Test Combined Aggregates When Used
MINERAL AGGREGATES	FINE AGGREGATE	Fineness Modulus (A) (C)	Tex-402-A	During Delivery to Plant, from Stockpile, or from Batch Bin	1 Each 500 C.Y. or Fraction Thereof	Same as Job Control	1 Each 5,000 C.Y. or Fraction Thereof	Test Combined Aggregates When Used
CEMENT		Compliance With The Std. Specifications & Spl. Provisions (A) (C)	ASTM C-150	Railroad Car, Truck, or Cement Bins	Each 1,000 Bbls. (For Each Type or Brand)			Each Brand and Each Type To Be Sampled and Tested Separately
FLY ASH		Compliance With The Std. Spec. Spl. Spec. D-9 8900	Tex-733-I	During Delivery to Project	Each 150 Tons or Fraction Thereof			Each Source to be Sampled and Tested Separately
WATER		Compliance With The (A) Std. Specifications (C)	AASHTO T-26	At Source (If Not Approved)	1 Test (Each Source)			Municipal Supply Approved By State Health Department Will Not Require Testing
CONCRETE		Flexural (K) Strength (H)	Tex-420-A	At Point of Concrete Placement	1 Test (2 Beams) For Each 60 C.Y. or Fraction Thereof (E)	Same as Job Control	Witness Fabrication and Testing of 1 Test (2 Beams)	
CONCRETE		or Compressive (K) Stength (H)	Tex-418-A	At Point of Concrete Placement	1 Test (2 Cylinders) for Each 60 C.Y. or Fraction Thereof (E)	Same as Job Control	Witness Fabrication for 1 Test (2 Cylinders)	Record Testing Not Required Where D-9 Provides Inspection at Source
CONCRETE		Slump (C) (H) (J)	Tex-415-A	At Point of Concrete Placement	1 Test Per Set of Strength Specimens (D)	Same as Job Control	Witness 1 Test	
CONCRETE		Entrained (C) Air (H)	Tex-416-A	At Point of Concrete Placement	1Test Per Set of Strength Specimens (D)	Same as Job Control	Witness 1 Test	Required When Used
CONCRETE		Average Texture Depth	Tex-436-A	After Concrete Has Hardened	1 Per Placement (G)			For Bridge Decks and Top Slab of Direct Traffic Culverts
CONCRETE		Temperature of Slab Concrete		At Point of Concrete Placement	1 Per Truckload			
ADMIX-TURE		Compliance With The Specification Item 437: "Concrete Admixtures"	As Specified	Sampled, Tested, and Approved by D-9				Contractor Shall Furnish Res. Engr. 1 Copy of Invoice for the Admixture to be Used on the Project
JOINT MATERIAL		Compliance With The Std. Specifications & Spl. Provisions	As Specified	Sampled At Jobsite If Not Sampled At Source by D-9; Tested by D-9	1 Per Batch or Shipment			
CURING COM-POUND		Compliance With The Std. Specifications & Spl. Provisions	As Specified	Sampled At Jobsite If Not Sampled At Source by D-9; Tested by D-9	1 Per Batch or Shipment			
REINFORCING STEEL		Compliance With The Std. Specifications & Spl. Provisions	As Specified	Sampled, Tested, and Approved by D-9				
REINFORCING STEEL		Depth of Reinforcement		During Finishing	1 Per 50 S.Y.;** Min. 4-Max. 20 Per Placement			** Record Locations & Dimensions For Bridge Slab and Top Slab of Direct Traffic Culverts

(A) Coordination of inspection should be utilized to avoid duplication of sampling and testing. These job control tests may be used for one or more projects being furnished concrete from the same plant during the same period. Also applicable to record tests.

(B) Record tests are not necessary when the amount of concrete placed is less than 500 C.Y.

(C) Miscellaneous concrete is defined as concrete with less critical structural use such as culverts (except top slabs of direct traffic structures), pipe headwalls, inlets, manholes, riprap, concrete in compaction wings and thrust beams, curb, curb and gutter, and other concrete so designated in the plans. Concrete used in bridges (including foundations), top slabs of direct traffic structures, retaining walls, pump stations, paving, and other concrete that may

(C) Con't.
be designated on the plans is not included in this category of miscellaneous concrete. Normally, the tests marked (C), (E) will not be required for "miscellaneous concrete" which may be accepted on the basis of strength tests (2 cylinders for each 50 C.Y. or 2 beams for each 50 C.Y.). Where deemed necessary by the Engineer, plant inspection and the tests marked (C), (E) may be required and used to determine specification compliance.

(D) For Class S, F and H ready mix concrete for bridge slab only both air and slump will be checked on the first few loads of concrete as necessary to obtain a desired consistency. Thereafter each third load will be tested for both slump and air content. Slump and air content should also be performed on the same load from which strength tests specimens are made.

(E) Not less than one set of beams or cylinders will be required for each day's placement except as specified in note "C".

(F) Where the fine aggregate is from a source with a history of sand equivalent values greater than 85*, the frequency of testing may be reduced to 1 per month during production. If any individual test falls below 85*, the test frequency should be 1 per week during production until the value is 85* or higher for four consecutive weeks.

* or the specified sand equivalent value +5.

(G) Omit texture depth test on bridge deck and direct traffic culverts which are to receive subsequent surface treatments as a part of the same project.

(H) Sampling shall be in accordance with Test Method Tex-407-A.

(J) Not required for extruded or slip form items.

(K) Not required for extruded curb.

TABLE III

Rev. Feb. 1986

THIS IS A GUIDE FOR MINIMUM SAMPLING AND TESTING. WHEN NECESSARY FOR QUALITY CONTROL, ADDITIONAL SAMPLING AND TESTING WILL BE REQUIRED.

PORTLAND CEMENT CONCRETE PAVEMENTS

MATERIAL or PRODUCT		TEST FOR	TEST NUMBER	JOB CONTROL TESTS: LOCATION or TIME of SAMPLING	JOB CONTROL TESTS: FREQUENCY of SAMPLING	RECORD TESTS: LOCATION or TIME of SAMPLING	RECORD TESTS: FREQUENCY of SAMPLING (A)	REMARKS
MINERAL AGGREGATES	COARSE AGGREGATE	Decantation	Tex-406-A	During Delivery to Plant, from Stockpile, or from Batch Bin	2 Each Source	Same as Job Control	1 Each Source	
		Sieve Analysis	Tex-401-A	During Delivery to Plant, from Stockpile, or from Batch Bin	Each 3,000 C.Y.	Same as Job Control	Each 9,000 C.Y. or Fraction Thereof	Test Combined Aggregates When Used
	FINE AGGREGATE	Sand Equivalent	Tex-203-F	During Delivery to Plant, from Stockpile, or from Batch Bin	1 Each Week During Production (Each Source or Combination of Sources) (D)	Same as Job Control	1 Each Source or Combination of Sources	Test Combined Aggregates When Used
		Organic Impurities	Tex-408-A	During Delivery to Plant, from Stockpile, or from Batch Bin	2 Each Source	Same as Job Control	1 Each Source	
		Sieve Analysis	Tex-401-A	During Delivery to Plant, from Stockpile, or from Batch Bin	Each 1,500 C.Y.	Same as Job Control	Each 4,500 C.Y. or Fraction Thereof	Test Combined Aggregates When Used
MINERAL FILLER		Sieve Analysis	Tex-401-A	During Delivery to Plant, from Stockpile, or from Batch Bin	Each 1,500 C.Y.	Same as Job Control	Each 4,500 C.Y. or Fraction Thereof	
CEMENT		Compliance With The Std. Specifications & Spl. Provisions	ASTM C-150	Railroad Car, Truck, or Cement Bins	Each 1000 Bbls. (For Each Type or Brand)			Each Brand and Each Type To Be Sampled and Tested Separately
FLY ASH		Compliance with the Std. Spec. Spl. Spec. D-9 8900	Tex-733-I	During Delivery to Project	Each 150 Tons or Fraction Thereof			Each Source To Be Sampled and Tested Separately
WATER		Compliance With The Std. Specifications	AASHTO T-26	At Source (If Not Approved)	1 Test (Each Source)			Municipal Supply Approved By State Health Department Will Not Require Testing
CONCRETE		Strength (B)	Tex-420-A or Tex 418-A	At Point of Concrete Placement	1 Test (2 Beams) or (2 Cylinders) For Each 3,000 S.Y.		Witness Testing and Fabrication of 1 Test	Witness Testing of Beams Only
		Slump (C) (B)	Tex-415-A	At Time & Location Strength Specimens Are Made	1 Test Per Set of Strength Specimens		Witness 1 Test	
		Entrained Air (B)	Tex-416-A	At Time & Location Strength Specimens Are Made	1 Test Per Set of Strength Specimens		Witness 1 Test	When Entrained Air is Required by Specifications
		Average Texture Depth (E)	Tex-436-A	After Concrete Has Hardened	3 For Each Days' Production			Number of Tests may be Reduced to 1 Each Day After a Satisfactory Finishing Procedure has been Established and Approved by the Engineer
		Thickness	Tex-424-A			After 14 Days' Placement	1 Core Per 1,000 L.F. Per Traffic Lane When Payment is by the S.Y., or 1 Core Per 2,000 L.F. Per Traffic Lane When Payment is by the C.Y.	
ADMIXTURE		Compliance With The Specification Item 437; "Concrete Admixtures"	As Specified	Sampled, Tested, and Approved by D-9				Contractor Shall Furnish Res. Engr. 3 Copies of Invoice for the Admixture to be Used on the Project
JOINT MATERIAL		Compliance With The Std. Specifications & Spl. Provisions	As Specified	Sampled At Jobsite If Not Sampled At Source by D-9; Tested by D-9	1 Per Batch or Shipment			
CURING COMPOUND		Compliance With The Std. Specifications & Spl. Provisions	As Specified	Sampled At Jobsite If Not Sampled At Source by D-9; Tested by D-9	1 Per Batch or Shipment			
REINF. STEEL		Compliance With The Std. Specifications & Spl. Provisions	As Specified	Sampled, Tested, and Approved by D-9				

(A) Except for coring of concrete for thickness, no record tests will be required if the contract quantity is less than 500 C.Y.

(B) Sampling shall be in accordance with Test Method Tex-407A.
(C) Not required for slip-formed pavement.
(D) Or one per approved Stockpile.
(E) Not required when a Carpet Drag and Transverse Metal Tine Finish Device is called for in the Specifications.)

TABLE IV

Rev. May, 1986

THIS IS A GUIDE FOR MINIMUM SAMPLING AND TESTING. WHEN NECESSARY FOR QUALITY CONTROL, ADDITIONAL SAMPLING AND TESTING WILL BE REQUIRED.

ASPHALTIC CONCRETE PAVEMENTS

MATERIAL or PRODUCT	TEST FOR	TEST NUMBER	JOB CONTROL TESTS: LOCATION or TIME of SAMPLING	JOB CONTROL TESTS: FREQUENCY of SAMPLING	RECORD TESTS: LOCATION or TIME of SAMPLING	RECORD TESTS: FREQUENCY of SAMPLING (E)	REMARKS
COARSE AGGREGATE	Gradation	Tex-200-F (Dry)	During Delivery to Plant or From Stockpile	Each 6,000 Tons (D) or Fraction Thereof (G)	Same as Job Control	Each 60,000 Tons (A) or Fraction Thereof (D)	Tests To Be Made for Each Coarse Aggregate
COARSE AGGREGATE	Deleterious Material and Decantation	Tex-217-F	As Designated by District Engineer or as Specified	Each 12,000 Tons or Fraction Thereof (D)	Same as Job Control	Each 60,000 Tons (A) or Fraction Thereof (D)	When the Fine Aggregate in a Coarse Aggregate Stock Pile Exceeds 15%, It Shall Be Tested for Plasticity Index
FINE AGGREGATE	Gradation	Tex-200-F (Dry)	During Delivery to Plant or From Stockpile	Each 6,000 Tons (D) or Fraction Thereof (G)	Same as Job Control	Each 60,000 Tons (A) or Fraction Thereof	Tests To Be Made for Each Fine Aggregate
FINE AGGREGATE	Plasticity Index	Tex-106-E	During Delivery to Plant or From Stockpile	Each 6,000 Tons or Fraction Thereof	Same as Job Control	One Per Project (A)	Test To Be Made for Each Fine Aggregate
MINERAL FILLER	Gradation	Tex-200-F (Dry)	During Delivery to Plant or From Stockpile	Each 6,000 Tons or Fraction Thereof	Same as Job Control	Each 60,000 Tons or Fraction Thereof (A)	
COMBINED AGGREGATES	Gradation	Tex-200-F (Dry)	Hot Bins	4 For Each Day's Production	Same as Job Control	Each 30,000 Tons (A) or Fraction Thereof (D)	For Weigh Batch Plants Only. Reduce the Required Number of Tests Proportionately When Plant Produces Fractional Part of Day
COMBINED AGGREGATES	Sand Equivalent	Tex-203-F	Hot Bins or Feeder Belt	1 Per 10 Days of Production			Sample Prior to Addition of Additives to Materials, i.e., Lime, Mineral Filler, etc.
LIME	Compliance with Item 264—"Hydrated Lime and Slurry"	Tex-600-J	During Delivery	Ty A, Each 200 Tons Ty B, Each 200 Tons Ty C, Each 150 Tons or Fraction Thereof*			*On projects requiring less than 50 tons, material from D-9 approved sources may be accepted on the basis of Producers Certification without sampling.
ASPHALTS, OILS & EMULSIONS	Compliance with Item 300 "Asphalts, Oils and Emulsions"	Tex-500-C Etc.	Sampled, Tested, and Approved by D-9				
COMPLETE MIXTURE — HOT MIX ACP & HOT MIX-COLD LAID ACP	Laboratory Density	Tex-207-F	Plant or Road	1 For Each Day's Production (H)	Same as Job Control	1 For Each 10 Days' Production or Fraction Thereof (A)	
COMPLETE MIXTURE — HOT MIX ACP & HOT MIX-COLD LAID ACP	Stability	Tex-208-F	Plant or Road	1 For Each Day's Production (H)	Same as Job Control	1 For Each 10 Days' Production (A) or Fraction Thereof	
COMPLETE MIXTURE — HOT MIX ACP & HOT MIX-COLD LAID ACP	Extraction	Tex-210-F	Plant or Road	1 For Each Day's Production (F) (H)	Same as Job Control	1 For Each 10 Days' Production (A) or Fraction Thereof	
COMPLETE MIXTURE — HOT MIX ACP & HOT MIX-COLD LAID ACP	In Place Density	Tex-207-F	Per Course	1 For Each Day's Production (H)	Same as Job Control	1 For Each 10 Days' Production or Fraction Thereof	When Required
COMPLETE MIXTURE — HOT MIX ACP & HOT MIX-COLD LAID ACP	Cohesiometer	Tex-214-F	Plant or Road	1 For Each Day's Production (H)	Same as Job Control	1 For Each 10 Days' Production (A) or Fraction Thereof	When Required
COMPLETE MIXTURE — HOT MIX ACP & HOT MIX-COLD LAID ACP	Moisture Content	Tex-212-F	Plant or Road	1 For Each Day's Production (H)	Same as Job Control	1 For Each 10 Days' Production (A) or Fraction Thereof	When Required
COMPLETE MIXTURE — HOT MIX ACP & HOT MIX-COLD LAID ACP	Hydrocarbon Volatile Content	Tex-213-F	Plant or Road	1 For Each Day's Production (H)	Same as Job Control	1 For Each 10 Days' Production (A) or Fraction Thereof	Required for Hot Mix-Cold Laid ACP Only
COMPLETE MIXTURE — COLD MIX LRA PAVEMENT	Compliance With Item 330 or 332—"Cold-Mix Limestone Rock Asphalt"	As Specified	Sampled, Tested, and Approved by D-9				
COMPLETE MIXTURE — COLD MIX LRA PAVEMENT	Moisture Content	Tex-212-F	When Weighing for Payment	Each 200 Tons or Fraction Thereof Per Day			
COMPLETE MIXTURE	Dimensions		Completed Pavement	As Necessary For Control		1 Total Depth Per Travel-Way Per 2 Miles (B) or Fraction Thereof (C)	

(A) Not required when D-9 provides inspection at plant.

(B) Travel-way is defined as total width of a travel facility that is not separated from other parallel travel facilities by a median, ditch, etc.

(C) Not required for level-ups and overlays.

(D) When synthetic aggregate is used in lieu of natural aggregate reduce the quantity under "Frequency of Sampling" by 50%.

Example: Natural Aggregate 6,000 Tons = Synthetic Aggregate 3,000 Tons

(E) Record tests are not required for a contract quantity resulting in less than 3,000 Tons.

(F) When producing from drum mixer or continuous mix plants one extraction test per 1,000 tons or fraction there of not to exceed three (3) per day.

(G) When production is by drum mixer, frequency shall be 3,000 tons or fraction thereof.

(H) Not required when production falls below 200 tons per day.

TABLE V

Rev. Feb. 1986

CHAPTER 7
LEGAL RELATIONS
AND RESPONSIBILITIES TO THE PUBLIC

107.1 LAWS TO BE OBSERVED - GENERAL

The Standard Specifications require the Contractor to be familiar with, and at all times to observe and comply with all laws, ordinances, and regulations which affect the work. The Department is not a law enforcing agency in the usual sense. However, the Resident Engineer is responsible for the Contractor's compliance with certain laws which are specifically made a part of the contract.

107.2 LABOR LAWS

Unless other instructions are issued by the District Engineer, it will be the responsibility of the Resident Engineer to make periodic interviews with the Contractor's employees in order to determine compliance by the Contractor on those labor laws where the Department is the enforcing agency. The Resident Engineer shall notify the Contractor of any discrepancy, error, etc., that may be disclosed in checking the labor payrolls or by personal interviews of the Contractor's employees, and if the Contractor fails to correct such discrepancy, error, etc., the Resident Engineer shall report such failure to the District Engineer for submission to the Construction Division (File D-6).

The Labor Compliance Manual, Direct Federal and Federal-Aid Construction, furnished by the U. S. Department of Transportation, Federal Highway Administration should be used as a guide and reference in matters pertaining to the enforcement of Labor Standards Provisions on all Federal-Aid Construction Contracts.

As an aid to the Resident Engineer in fulfilling his responsibility, a brief outline of contract labor laws and requirements follows:

1. **COPELAND ANTI-KICKBACK ACT (FEDERAL STATUTE)**
   a. Applies to all Federal-Aid Highway construction contracts.

   b. The Department has the primary responsibility for obtaining compliance with the requirements of this Act.

c. Each Contractor or Subcontractor shall furnish each week a statement to the Resident Engineer with respect to the wages paid and any deduction made from the wages of each laborer, workman or mechanic engaged on work covered by the Copeland Regulations during the preceding weekly payroll period. The statement shall be executed by the Contractor or Subcontractor or by an authorized officer or employee of the Contractor or Subcontractor who supervises the payment of wages.

d. Grants outright permission to make certain payroll deductions from the wages of laborers and mechanics. Examples:
   1. Bonafide Prepayment of Wages
   2. Any deduction made in compliance with the requirements of Federal, State of local law, such as Federal withholding income taxes and Federal Social Security taxes, etc.

e. Grants permission to make certain payroll deductions from the wages of laborers and mechanics (with the employees' written consent).
   Examples:
   Life Insurance, Hospitalization and Medical Insurance, Retirement Plan, Vacation Plan, Safety Shoes and Safety Hats

f. Deductions requiring written application to and prior approval of the Secretary of Labor.
   Examples:
   Gasoline, Uniforms where required by the employer as a condition of employment.

g. Does not apply to -
   1. Contractor's supervisory and office employees.
   2. Contracts or subcontracts for furnishing supplies, materials and equipment.
   3. Contracts with a political subdivision.
   4. Contracts or work agreements for construction work

or services with railroads or public utilities when the work or services are performed by railroad employees covered by the Railroad Labor Act or by personnel employed directly by the public utility firm.

h. The statement to be submitted with the Contractor's or Subcontractor's payroll transcript within seven days after the regular payment date of the payroll period.

2. **DAVIS-BACON AND RELATED ACTS (FEDERAL STATUTES)**

a. Applies to all Federal-Aid Highway construction contracts.

b. The Department has the primary responsibility for obtaining compliance with the requirements of this Act.

c. Sets a minimum wage rate for various labor classifications, predetermined by the Secretary of Labor, to be paid to laborers and mechanics.

d. Requires that laborers and mechanics be paid at least once a week for all hours worked at rates not less than that prescribed for the classification or work which they actually perform.

e. Fringe Benefits: To be paid laborers and mechanics when included in the Secretary of Labor's minimum wage rate decision.

f. Requires that the predetermined minimum wage rates shall be posted by the Contractor on the job site.

g. Does not apply to -
   1. Contractor's supervisory and office employees.
   2. Contracts or subcontracts for furnishing supplies and equipment.
   3. Contracts with a political subdivision.

4. Contracts or work agreements for construction work or services with railroads or public utilities when the work or services are performed by railroad employees covered by the Railroad Labor Act or by personnel employed directly by the public utility firm.

3. **CONTRACT WORK HOURS AND SAFETY STANDARDS ACT (FEDERAL STATUTE)**

a. Applies to all Federal-Aid Highway construction contracts.

b. The Department has the primary responsibility for obtaining compliance with the requirements of this Act.

c. The calendar day is the standard unit for determining compliance with the requirements of this Act.

d. Provides that any laborer, workman, mechanic, watchman or guard shall be paid on the basis of eight hours constituting a day's work, and all such labor so employed shall be paid at the rate of one and one half times the regular rate for every hour worked in excess of eight hours per day and/or forty hours per week whichever is the greater number of overtime hours.

e. Does not apply to -
   1. Contractor's supervisory and office employees.
   2. Contracts or subcontracts for furnishing supplies and equipment.
   3. Contracts with a political subdivision.
   4. Contracts or work agreements for construction work or services with railroads or public utilities when the work or services are performed by railroad employees covered by the Railway Labor Act or personnel employed directly by the public utility firm.

4. **FAIR LABOR STANDARDS ACT (FEDERAL STATUTE)**

a. The act applies to all Federal-Aid and State projects.

b. The Act does not constitute a part of the labor standard provisions of our contracts.

c. The Department is not responsible for the enforcement of this Federal Statute. The Contractor is required by Federal Statute to be in compliance with the regulations established by the Department of Labor.

5. **EQUAL EMPLOYMENT OPPORTUNITY COMPLIANCE PROGRAM (FEDERAL AID CONTRACTS)**

a. The authority for the Equal Employment Opportunity requirements found in the contract provisions is derived from the Civil Rights Act of 1964, from the Executive Orders and the Federal Aid Highway Acts.

b. The implementation of the preceding as pertains to the Federal-Aid highway construction contracts is found in the Department's Assurances relative to the Civil Rights Act of 1964 and to the Federal Aid Highway Acts and in the FHWA Orders.

Applicable portions of the above documents are a part of the contract labor provisions on all Federal-Aid construction contracts of $10,000 or more.

c. The Department is primarily responsible for compliance with the requirements of the provisions of the Federal-Aid Highway Acts. The Construction Division (File D-6) has been charged with the responsibility for the overall implementation of this program with the assistance of the District Offices and the Resident Engineers. The "Equal Employment Opportunity Compliance Program" issued by File D-6 provides guidelines and should be referred to for uniform enforcement of the EEO Special Provision and the reports that are to be submitted by the Contractor, District Offices, and Resident Engineers.

d. The Federal Highway Administration has a responsibility for obtaining compliance with the requirements of these provisions.

6. **MINIMUM WAGE RATES (STATE STATUTE)**

a. Applies to projects financed entirely with State funds.

b. The contractor is required to pay laborers and mechanics at least once a week for all regular hours worked and all overtime hours worked at rates not less than that prescribed for the classification or work which they actually perform.

c. Job classifications and minimum wage rates, as established, are included in each contract.

d. The Department has the responsibility for obtaining compliance with the above requirements.

107.3 FEDERAL SAFETY AND HEALTH LEGISLATION

Subsequent to the passage of the Federal Construction Safety Act of 1969 and the Occupational Safety and Health Act of 1970, the Department of Labor published in the Federal Register rules and regulations which affect contractors holding highway construction contracts with the Department. These regulations have been published in the Federal Register under Title 29 of the Code of Federal Regulations: Part 1926, "Safety and Health Regulations for Construction" and Part 1910, "Occupational Safety and Health Standards".

Resident Engineers have the responsibility for monitoring the contractor's performance under these regulations as to providing safe working conditions for his employees and employees of the Department and protection to the public traveling through the construction site. The following paragraphs identify those agencies that have responsibilities in effecting safe and healthful working conditions on construction projects and indicate steps to be taken in preparation for the work and during the construction process.

A. GENERAL

1. **STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION.** As the owner-contracting agency, the State Department of Highways and Public Transportation has the responsibility for enforcement of the provisions of the contract; however, provisions and regulations which are by law the fundamental responsibility of other agencies (both Federal and State), both from the standpoint of interpretation and enforcement, should not be monitored by this Department without giving proper recognition to the responsibilities and authorities of other agencies involved. Recognizing such provisions and regulations, this Department will cooperate fully with the responsible agency; alert said agency of any noted serious violations; and utilize such sanctions as are consistent with the contract terms in assisting the responsible agency in enforcing applicable laws, rules, and regulations.

2. **U. S. DEPARTMENT OF LABOR.** Federal law has placed the basic responsibility for administration of the national program for occupational safety and health in the U. S. Department of Labor. This responsibility includes the issuance of mandatory safety and health regulations and standards and the enforcement of these standards in the nation's construction industry as well as other industries. In addition to other functions, the Occupational Safety and Health Administration (OSHA) of the Department of Labor will investigate complaints, make safety inspections, issue citations for violations, assess penalties and handle appeals.

3. **TEXAS OCCUPATIONAL SAFETY BOARD.** In this State the contractor is obligated by law to comply with State and Federal safety and health regulations. The Occupational Safety Board of the Texas Department of Health administers this program in Texas and has adopted the Federal standards. This does not mean the Occupational Safety Board now has autonomy to administer the OSHA program at this time, but it is anticipated on their part that legislation will be enacted to give them sufficient authority to act, in all aspects, in lieu of the Department of Labor.

4. **FEDERAL HIGHWAY ADMINISTRATION.** Since Federal law requires all Federal-Aid construction contracts to contain provisions that the work of contractors and subcontractors will be performed in accordance with the Federal construction safety standards, the Federal Highway Administration has a responsibility to see that this contractual requirement is observed. Under existing relationships with State highway departments, FHWA field engineers will monitor adherence to construction safety provisions in the same manner as other contract provisions. Their personnel will be primarily concerned with reviewing the adequacy of Department procedures for determining that the safety provisions referred to in the contract are observed. FHWA personnel may also review actual project conditions from the safety standpoint on a selective or sampling basis.

B. MONITORING CONTRACTOR PERFORMANCE

1. Federal Highway Administration Notice; "Highway Construction Safety", dated August 20, 1971 established the principles of monitoring, by State personnel, of the contractor's response to and performance under the safety and health regulations.

2. To fulfill the Department's obligation to monitor contract operations in accordance with the safety and health regulations, the following procedures shall be followed on both Federal-Aid and State contracts. This listing indicates the steps to be taken in preparation for the work and during the construction process. Detailed requirements are contained in the construction safety regulations and standards published by the Occupational Safety and Health Administration. Further, guidance and information of a general nature can be found in the AASHO "Informational Guide on Occupational Safety on Highway Construction Projects".

Preconstruction Preparation

(1) The Project Engineer should avail himself of the Occupational Safety and Health regulations and review same with

his key field inspectors to insure reasonable familiarity to the extent that he and his key people can recognize important requirements.

(2) The contract plans and specifications should be reviewed to identify those aspects of the work meriting special attention from the standpoint of potentially dangerous types of work and hazard eliminations.

Preconstruction Conference

As part of the required preconstruction conference, the following points should be covered.

(1) The contractual obligation of the contractor for complying with State and Federal construction safety standards.

(2) Availability on the contractor's part of the safety standards that apply to the contract.

(3) The accident prevention program of the contractor--organization, staff, names of responsible individuals, meetings, training, reports, etc. The following checklist questions should be answered specifically.

a. Does the contractor have a definite Safety program?

b. Does the program have the active and continued support of company management?

c. Has responsibility for safety been assigned to a specific top company official?

d. Does the contractor make frequent safety inspections of operations on the project? Does this include subcontractor operations?

e. Does the contractor discuss with his employees how to recognize and avoid unsafe conditions and practices related to their individual work assignments? Are periodic safety meetings held with employees?

f. Are all occupational injuries and illnesses investigated by the contractor, recorded and reported?

g. Does the Contractor keep currently informed on governmental safety regulations and standards?

(4) Contractor responsibility for seeing that subcontractors comply with safety regulations.

(5) The Contractor's plans for meeting specific safety requirements and for eliminating potentially critical hazards on the project.

(6) A written record of safety measures discussed should be placed in the project files.

Construction Surveillance

When construction starts, and throughout the construction period, project personnel in their observation of operations should be alert to note any violations of the applicable safety requirements. The following listing, based on the Federal construction safety standards and regulations, indicates some of the principal requirements that must be met.

(1) **First aid and medical services.** The Contractor must provide readily accessible first aid kits; and telephone numbers of doctors, hospitals and ambulances must be conspicuously posted.

(2) **Housekeeping.** Scrap and used materials- -scattered debris and combustible scrap- -that would constitute hazards to workmen must be cleared from work areas.

(3) **Noise exposure.** If effective means cannot be provided to lower noise level exposures to permissible levels, personal

protective equipment must be provided.

(4) **Head protection.** Employees subject to danger of head injury from impact of falling objects or from electrical shocks or burns must wear protective helmets.

(5) **Eye and face protection.** Must be provided when employees are subject to hazards created by machines or operations presenting potential eye or face injury from physical, chemical or radiation agents.

(6) **Safety nets.** Required when work places are more than 25 feet above ground or water surface, or other surfaces where use of ladders, scaffolds or safety lines are not practicable. Nets must extend 8 feet beyond work area and may not be more than 25 feet below the work area.

(7) **Power-operated hand tools.** Hand-held powered tools, such as circular saws, chain saws, and percussion tools without positive accessory holding means, must be equipped with a constant pressure switch that will shut off the power when the pressure is released. Electrically powered hand tools must be of the double insulated type or grounded. Pneumatic power tools must be secured to the hose or whip by some positive means to prevent the tool from becoming accidentally disconnected. Power actuated tools must be operated by employees trained in the operation of the particular tool.

(8) **Ladders.** Must be free of defects and adequately supported or anchored; and must not be more than 24 feet in length (double cleat) or 30 feet in length (single cleat).

(9) **Scaffolds.** Guard rails and toeboards are required on all open sides and ends of platforms more than 10 feet above the ground or floor, except needlebeam scaffolds and floats.

(10) **Cranes, derricks, etc.** Rated load capacities must be posted on the equipment. Frequent inspections of the equipment and a thorough annual inspection of the hoisting machinery must be made by a competent person. Electrical distribution lines near operating equipment should be de-energized and grounded, or insulating barriers erected to prevent contact with the lines. Otherwise operation must allow at least 10 feet clearance from live electrical power lines.

(11) **Earth moving equipment.** Equipment must have brakes capable of stopping and holding the equipment fully loaded. All bidirectional machines (rollers, compactors, front-end loaders, bulldozers, and similar equipment) must be equipped with an operable horn. Audible backup warning devices must be in place and in good operating condition on equipment which has an obstructed view to the rear unless assistance is provided by an observer during the backing operations.

(12) **Excavation.** Trees, boulders and other surface encumbrances located so as to create a hazard to employees involved in excavation work or in the vicinity thereof must be removed or made safe before excavation is begun.

(13) **Trenching.** Banks more than 5 feet high must be shored, laid back to a stable slope, or some other equivalent means of protection provided against cave-ins. Sides of trenches in unstable or soft material 5 feet or more in depth must be shored, sheeted, braced, or sloped, or otherwise supported by means of sufficient strength to protect employees working within them.

(14) **Concrete forms.** Forms must be erected and braced so as to withstand safely all vertical and horizontal loads that may be imposed on them during concrete placement. Stripped forms must be removed and stockpiled promptly

after stripping. Protruding nails, wire ties, etc. must be removed to eliminate hazard.

(15) **Structural steel assembly.** During the erection of structural steel members, the load must not be released from the hoisting line until the members are secured with at least 2 bolts at each connection, or at least 2 erection clamps at each welded connection and drawn up wrench tight.

(16) **Cofferdams.** If overtopping of the cofferdam is possible by high water, means must be provided for controlled flooding. At least 2 means of rapid egress from the work area must be provided.

(17) **Explosives.** Smoking, firearms, matches, etc. are prohibited near explosives or while explosives are being handled, transported, or used.

(18) **Handling traffic through and around construction.** Temporary roadways and detours must be properly maintained, and satisfactory traffic control measures must be used--signs, barricades, and flagmen in accordance with the Manual of Uniform Traffic Control Devices.

Violations of the Regulations

Violations of the safety and health regulations may be minor in nature; or, they may be serious and a threat to human life. Oral or written notice to a Contractor should inform him of the specific safety regulation(s) which he is considered to not be fulfilling. Department personnel should not instruct a Contractor as to how to correct a deficiency.

When an apparent violation is noted it should be immediately brought to the attention of the Contractor's project supervisor. If adequate correction is initiated by the Contractor, a notation should be made in the project record and no further action need be taken.

If the project supervisor fails to take corrective action, written notice of the apparent violation should then be given the Contractor with request for prompt correction or explanation. Also indicate that lack of response will result in notification being given to the Department of Labor and/or the Occupational Safety Board of the apparent violation requesting their review.

In the case of a serious hazard which presents an imminent danger to the Contractor's employees, Department personnel and/or the public, the Contractor's project supervisor shall be informed at once so that immediate corrective action may be taken. The project Engineer or Inspector should also immediately suspend the work in the area of the hazard and refer the matter of work suspension and reasons therefor to the Resident Engineer so that written notification can follow as required by Item 8.4 of the Standard Specifications. After a determination has been made that adequate safeguards are installed or other corrective measures taken, the work may be allowed to proceed. Here again, prompt corrective action should negate further action on the part of the Department; however, failure to correct should be handled as previously outlined.

Investigations by Other Agencies

When investigations or inspections are conducted by the U. S. Department of Labor, the Occupational Safety Board of the Texas Department of Health or the Federal Highway Administration, full cooperation will be extended to them by Department personnel.

Construction Division

The Construction Division has overall responsibility for handling all matters relating to the Federal Safety and Health regulations as they affect highway construction contracts. This division should be notified of all work suspensions due to serious violations or if a Contractor refuses to take corrective action which may require notification being given to the Department of

Labor or the Texas Occupational Safety Board requesting their review.

107.4 ANTIQUITIES CODE OF TEXAS

The Antiquities Code of Texas of 1970 (Article 6145-9, Vernon's Texas Civil Statutes) states that historical sites and Archaeological Landmarks on land belonging to the State may not be altered, destroyed or excavated without a permit from the Texas Antiquities Committee. A Memorandum of Understanding between the Texas Antiquities Committee and the Department has been executed to assure that unwarranted destruction of sites, buildings and locations of historical, archaeological, educational or scientific interest located within the right of way of either existing or future highways in the State of Texas would not take place. This Memorandum places specific obligations upon the Department to: (1) make an investigation including the excavation of historical or archaeological sites within the right of way and (2) provide for appropriate specifications in highway construction contracts that will provide for delay in construction occasioned by sites discovered after award of contract.

If an archaeological site is discovered within the highway right of way or material source under option to the State during any phase of project development or construction, it shall be immediately reported to the Construction Division and the Highway Design Division. Further activity at the site shall cease and not be resumed until such time as an investigation is conducted and evaluation made concerning each individual site.

107.5 ADDITIONAL LABOR CLASSIFICATIONS AND TRAINEE LABOR CLASSIFICATIONS

On all Federal-Aid contracts, requests for additional labor classifications and rates not included in the contract wage rate decisions and trainee labor classifications under the Manpower Development and Training Program established by the Texas Highway - Heavy Branch Associated General Contractors should be submitted to File D-13 in accordance with File D-13 instructions.

On State Projects, requests for additional labor classifications and rates not included in the contract wage rate decisions should be approved by the Resident Engineer and retained in the project records. Such agreements should not be submitted to File D-13.

107.6 REQUIRED POSTERS (FEDERAL-AID PROJECTS)

The following posters are to be displayed at the project site on Federal-Aid projects:

a. Form PR-809 Wage Rate Information.

b. Form PR-1022 False Statements.

c. Equal Employment Opportunity Poster.

d. Equal Employment Opportunity Policy. (Furnished by Contractor and approved Subcontractor).

With exception of the EEO Policy, supply of the above listed posters should be obtained from File D-4.

107.7 SANITARY PROVISIONS

It is the responsibility of the Resident Engineer to cooperate with the State Health Department, or other authorities having jurisdiction, in requiring the Contractor to provide neat and sanitary accommodations for the use of his employees.

107.8 PUBLIC SAFETY AND CONVENIENCE

Item 7.7 of the Standard Specifications provides ample authority for the Resident Engineer to require proper safeguard and convenient facilities to the public traveling through a construction project.

When traffic is carried through construction work, the project is usually speed zoned at a relatively low maximum rate of speed. It is quite important for the Resident Engineer to make every reasonable attempt toward requiring the Contractor to maintain the surface of the traveled-way in such condition that will permit the public to travel at the maximum allowable rate of speed in relative comfort and safety. The Resident Engineer should give particular attention to the speed of construction trucks operating within the limits of a speed zone. Extremely bad public relations result when the haul trucks are permitted to operate at a substantially greater speed than that which is posted.

It is the responsibility of the Resident Engineer to make constant checks to see that flagmen are posted at the proper places, that their attire and flagging procedure are in accordance with the specifications, and that they are competent, courteous, and discharging their duties and responsibilities in a commendable manner.

On seal coat projects every effort should be exerted to reduce car damage to automobile windshields, headlights, paint, etc. from flying stone. Loose gravel signs, advisory speed signs, flagmen and pilot cars have been used to good advantage in handling traffic through seal coat projects. The principal advantage of the "Loose Gravel" signs will be found at night and on Sundays when flagmen will ordinarily be off duty.

107.9 BARRICADES AND DANGER, WARNING AND DETOUR SIGNS

It is the responsibility of the Resident Engineer to see that all barricades and the various signs are erected and maintained as required by the plans and specifications. Barricades and signs shall be kept in good condition by the Contractor and properly illuminated between sunset and sunrise.

The Resident Engineer may approve special signs proposed by the Contractor to protect the traveling public against special conditions or hazards.

107.10 PROTECTION OF ADJOINING PROPERTY

The Contractor shall take proper precautions to protect and preserve adjacent or adjoining property which might be damaged by any process of construction operations. In case of damages resulting from any act or omission on the part of the Contractor, he shall restore at his own expense the damaged property to a condition similar or equal to that existing before such injury or damage was done, or he shall make good such injury or damage in an acceptable manner. In the event the Contractor fails or refuses to restore or make good damaged property, the Resident Engineer should notify the Contractor of such damages in writing and notify the District Engineer.

107.11 USE OF EXPLOSIVES

Item 7.9 of the Standard Specifications places the responsibility for storage and use of explosives on the Contractor. However, for the protection of the public and the adjacent or adjoining property, the Resident Engineer should carefully observe and check the Contractor's operations. Additional precautions are required when using electric blasting caps in proximity to any railroad track.

107.12 CONTRACTOR'S RESPONSIBILITY FOR WORK

It is recommended that the Resident Engineer become thoroughly familiar with Items 7.10, 7.11, 7.12 and 9.2 of the Standard Specifications and be guided accordingly. Item 9.2 relieves the Contractor of any damages when conclusive evidence shows that such damages were due to inadequate design and not to other reasons.

On earthwork operations the Contractor is permitted, within certain limitations, to use equipment of any size or weight in the excavation, hauling, or compaction of earth materials unless specific provisions to the contrary are included in the specifications. The Contractor is required under the specifications to rebuild and make good at his own expense all injuries and damages to the work occurring before its completion and acceptance.

CHAPTER 8
PROSECUTION AND PROGRESS

108.1 SUBCONTRACTING

All requests by the Contractor for permission to sublet any part of the work shall be made in writing and on Federal projects they shall be accompanied by Construction Form 589 Rev. (3) "Contractor's Assurance (Subcontracts-Federal Aid Projects)". The Resident Engineer will forward each request with his recommendation to the District Engineer, who in turn will transmit each request with his recommendation to File D-6 for consideration. Each request shall clearly indicate the work to be sublet; the geographic area in which the subcontract work is to be performed; the name, address, telephone number and employer identification number of the proposed subcontractor; the estimated starting and completion dates of the subcontract work; and the amount and percentage of the total contract represented. In addition, the District Engineer's letter transmitting the request to File D-6 should include a statement indicating whether the Subcontractor's firm is or is not a small business as defined in the Small Business Assistance Act of 1975, enacted by the 64th Legislature. The Act defines a small business as "A corporation, partnership, sole proprietorship, or other legal entity formed for the purpose of making a profit, which is independently owned and operated and has either fewer than 100 employees or less than $1,000,000.00 in annual gross receipts". This determination is to be based on the complete organizational structure of the company and not the local branch unless the branch is owned by other than the parent company.

In the event the Subcontractor desires to sublet a portion of his work, he should be advised to secure the concurrence of, and submit his request to the prime Contractor, who in turn will submit the request in the same manner as required for the initial subcontract.

The contract requires the Contractor to perform with his own organization contract work of a value not less than 50 percent of the original total contract price, except that any items designated by the Department as "Speciality Items" and listed as such in the contract documents, may be performed by subcontract and the amount of any such "Speciality Items" so performed may be deducted from the original total contract price before computing the amount of work required to be performed by the Contractor with his own organization.

"His own organization" shall be construed to include only the workmen employed and paid directly by the prime Contractor and the equipment owned or rented by him, with or without operators. The contract amount upon which the 50 percent requirement of the Contractor is computed includes the cost of materials and manufactured products which are to be purchased or produced by the Contractor under the contract provisions.

The Contractor shall furnish a satisfactory and competent Superintendent on the work who has full authority to receive orders and direct the work regardless of the amount of work sublet. The Superintendent shall be employed by the Contractor and shall be in charge of all construction operations regardless of who performs the work.

108.2 PROSECUTION AND PROGRESS OF WORK

The Contractor shall not begin work until authorized by the Engineer (File D-3) in writing, and he shall begin work under the contract within 30 days after the date of such authorization.

The Standard Specifications require the Contractor to furnish a chart or brief outlining the manner of prosecution proposed to complete the work. It is necessary for the Resident Engineer to be familiar with the Contractor's plan of operation in order to arrange for proper and timely inspection and to stake the project in accordance with the needs of the Contractor. It has been previously suggested that the Contractor furnish this information at the pre-construction conference.

Should it develop during construction that there is a continuing lag between the Contractor's progress and the elapsed contract time, the Resident or District Engineer should notify the Contractor in writing that his progress is unsatisfactory and request the Contractor to furnish evidence that would enable him to complete the work within the allotted time.

108.3 WORKMAN AND EQUIPMENT

According to the Specifications, the Contractor will employ workmen having adequate skill and experience to enable them to properly perform their assigned duties and will furnish suitable and adequate machinery and equipment in a good state of repair. Failure to do so will be sufficient cause for the Resident Engineer to suspend the work without suspending the time charges, and to withhold all estimates which have or may become due until his requests are complied with.

108.4 TEMPORARY SUSPENSION OF WORK

A. **GENERAL.** The Resident or the District Engineer will have authority to suspend the work, wholly or in part, for such period as he may consider necessary, and the "Time Charge" will be suspended during such period. Notice of suspension of the work and time charges with the reasons therefore shall be given to the Contractor in writing with a copy to File D-6. The Engineer should clearly indicate in such notice whether the work is suspended wholly or in part. Notice to resume work shall be given to the Contractor in writing with a copy to File D-6.

It is quite important for the Resident Engineer to recognize the necessity for the suspension of work, wholly or in part, with the corresponding time suspension, at the time the need arises. However, if it should develop at some later date that time charges should have been suspended, but were not, the contract time may be increased in an amount equal to the amount of time the Contractor was delayed in the completion of the project.

B. REASONS FOR SUSPENSION

1. To comply with the provisions of the specifications, special provisions, and plans.

2. Weather or soil conditions unsuitable for the prosecution of the work.

3. Delays in the prosecution of the work due to conditions beyond the control of the Contractor, such as failure to adjust utilities on

time, inability on the part of the Contractor to secure needed materials through the normal suppliers, etc. Equipment breakdowns, or failure to provide adequate equipment, etc., would not fall into this category.

4. As provided in Section 108.3, "Workmen and Equipment", of this chapter.

5. Unusual conditions which delay the work and are not usually associated with the highway construction.

108.5 CONTRACT TIME

Contract time will be computed beginning 15 days after the date the Contractor was authorized in writing to begin work by the Engineer, and the date for beginning of the time charges will be specified in the letter. Each working day shall be charged as defined in the Standard Specification Item 1.38.

The dates shown in the list below are the legal holidays authorized by State Statutes for computing contractors' time on work handled under contract. These dates are the only dates for which the Contractor can be allowed time credit as legal holidays.

January 1	New Year's Day
January 19	Confederate Heroes Day
Third Monday in February	G. Washington's Birthday
March 2	Texas Independence Day
April 21	San Jacinto Day
Last Monday in May	Memorial Day
June 19	Emancipation Day In Texas
July 4	Independence Day
August 27	Lyndon B. Johnson's Birthday
First Monday in September	Labor Day
2nd Monday in October	Columbus Day
November 11	Veteran's Day
Fourth Thursday in November	Thanksgiving Day
December 25	Christmas Day

Every day on which an election is held throughout the State.

These holidays are not necessarily the same as bank holidays nor do they coincide in all cases with holidays provided for State offices and employees under the appropriation bill. A Monday which follows a legal holiday falling on Sunday is not to be credited as a holiday in computing Contractor's time charges.

The Contractor shall complete the work within the number of working days stated in the contract and any additional working days that may be authorized by the Engineer. Additional working days may be authorized to compensate for the time that work as a whole was delayed due to the following conditions:

1. When Extra Work is authorized.

2. As provided in Section 108.4(A), "Temporary Suspension of work", of this chapter.

3. An increase in an item of work which would control the time of completion of the contract.

4. An increase in the total contract amount.

Notice authorizing additional working days on State Projects shall be given to the Contractor in writing with a copy to File D-6.

On Federal-aid projects, the following procedure for contract time administration shall be followed:

1. The authority to make decisions regarding contract time charges, time extensions and time suspensions rests with the Resident Engineer and/or the District Engineer. Such decisions will be made within the framework of the governing specifications and plans for a project.

2. When contract time is extended because of unforeseen work or work and materials in greater amounts than those set forth in the contract, the reasons for and the basis of such action must be documented. As soon thereafter as is practicable, the Federal Highway Administration field representative should be

advised of the action taken or being considered and his concurrence requested. The Construction Division should be furnished a letter outlining the action taken and reasons therefor with any necessary supporting documentation attached. Additional working days justified by Field Change Requests or other types of extensions will require such a submission to File D-6 immediately after the amount of adjustment in contract time can be determined.

3. The entries in the "Job Diary" regarding daily contract time charges should be sufficient in detail to justify the time charged or not charged. The daily time charge, once made, should remain unchanged. If it should develop at a later date that a charged day or days should have been credited, a time extension should be used to compensate for the number of days previously charged that are justified under contract provisions as an extension of the contract time. Such action should be documented and submitted to File D-6 as outlined above.

CHAPTER 9
MEASUREMENT AND PAYMENT

109.1 GENERAL

Item 9.1 of the Standard Specifications defines, in general, the various dimensions and describes the measurement of quantities, but it does not specify the units of measurement to be used for the particular bid item. Under Part II, "Construction Details" of the Standard Specifications the unit or units of measurement are defined for each bid item, or they are included in the applicable Special Specification or Special Provision. Ordinarily, the specifications provide for a choice in the units of measurement for payment, and in those instances, it will be necessary to refer to the contract item in order to determine the required unit of measurement.

For each item, the "Payment" section of the specification defines what work is covered for payment, and when appropriate, also defines what work is to be done without direct payment and is considered subsidiary to the work for which payment is made. Some items provide for payment by the "Plan Quantity", with additional provisions for revision of the "Plan Quantity". It is the responsibility of the Resident Engineer to become thoroughly familiar with the "Measurement" and "Payment" sections of each item in order that proper payment will be made to the Contractor.

It will be the responsibility of the District Engineer to select the proper method of calculations to determine the pay quantities. All of the methods shall be within the framework of the contract documents.

All approved vehicles used for hauling materials measured by the cubic yard in vehicles shall be properly identified by a permanent and plainly legible number. Only one number should be assigned to a vehicle and any identification number used on the project should not be transferred to another vehicle or repeated. Each equipment number should be identified with the year, model, and make of the truck, and the license plate number, and all identifying data should be recorded in the project records. With this data, future reference to a particular truck can be made through the assigned equipment number.

The truck bed should be measured, the volume calculated, and the measurements and volume recorded along with the respective truck identification data. It is recommended that the depth used in calculating the volume be permanently marked on the inside of the bed with paint, welds, etc. This will be of aid later in determining whether the depth of the truck bed has been altered, especially on trucks with built-up beds.

109.2 HAUL TICKETS

1. Form No. 124 Rev. HAUL RECORD

   Haul Tickets Form 124 Rev. may be issued in accordance with instructions on the cover of the Haul Record Book or in conjunction with other measurement methods as set forth in pertinent Chapters of Part III of this Manual and in the publication "Construction Records to Support Pay Quantities of Work Done on Contract Construction Projects".

2. Form No. 124W HAUL TICKET
   Form No. 124WS HAUL TICKET SUMMARY

   Haul tickets Form No. 124W are to be issued in accordance with the instructions on the back of the Materials and Haul Ticket Summary for each load of material where the amount is based on weight and the material is weighed at a central location in the presence of the Department's Weight Inspector but is placed at another location on the project. This will include flexible bases, asphaltic concrete mixtures, centrally mixed stabilized materials, etc.

   A full-time Weight Inspector shall be stationed at either the platform truck scales or batching scales who can verify the weight of each batch and issue or validate a weight ticket for each load leaving the plant.

109.3 SCOPE OF PAYMENT

The Scope of Payment is covered in detail under Item 9.2 of the Standard Specifications, and the Resident Engineer shall be thoroughly familiar with this item in order that he can properly advise the Contractor of his responsibility.

Probably the most controversial part of this item is that of damages. In the event damages have occurred to the work under contract, it will be the responsibility of the Resident Engineer to determine the causes as soon as possible, or to refer the case to a higher authority for such determination. Unless there is conclusive evidence that damages occurred due to inadequate design, and not to other causes, the Department will not assume any responsibility for the damages.

On earthwork operations the Contractor is permitted, within certain limitations, to use equipment of any size or weight in the excavation, hauling, or compaction of earth materials unless specific provisions to the contrary are included in the specifications. The Contractor is required under the specifications to rebuild and make good at his own expense all injuries and damages to the work occurring before its completion and acceptance.

109.4 EXTRA WORK

Extra Work authorized, performed, and accepted will be paid for according to the terms of the "Supplemental Agreement" or on the "Force Account" basis, and is to be included in all estimates subsequent to the performance of acceptable work.

109.5 PARTIAL PAYMENTS

Item 9.6 of the Standard Specifications provides that "the Engineer once each month will make an approximate estimate in writing of the materials in place and the amount of work performed and the value thereof at the contract unit prices".

In addition to the above, this item provides for a partial material estimate for certain non-perishable materials which are manufactured and stored under specified conditions. Partial estimate will be allowed for non-perishable materials that have not been incorporated in the work and have been delivered to the project or placed in acceptable storage places upon presentation of a copy of invoices and freight bills which represent the material under consideration. Records of materials received should correspond to the invoices and freight bills. Materials stored at a commercial source are not considered to be placed in an acceptable storage place, except when allowed by the specifications.

Partial payment will be allowed for specified structural members or units not delivered to the project, if they meet the criteria established in the specifications.

Partial estimates and supporting papers are to be prepared and submitted in accordance with File D-3 Manual of Instructions, Chapter IX "Construction Estimates". Partial estimates should not be prepared until the Contractor has completed all of the work for which he will be paid in any given month, and should not include quantities of work which were anticipated to be performed between the time the estimate was made and the end of the month.

No partial payment is to be made until notice of beginning work has been sent to File D-6.

In preparing partial estimates, the Resident Engineer must exercise good judgement on those contract items, where due to the nature of the work, the quantities allowed will only be approximate. On other contract items, the Resident Engineer will be able to determine reasonably accurate quantities (subject to recheck) to be allowed on partial estimates. However, regardless of whether the quantities are approximate or reasonably accurate, a record must be kept of the method, procedure, and basis for determining any quantity which is allowed on partial estimates.

109.6 FORM 314A AND B; RESIDENT ENGINEER'S MONTHLY CONSTRUCTION REPORT

This form is divided into Parts A and B and should be prepared for each contract upon completion of work at the end of each month. Part A is produced in the computerized monthly construction estimate process and is printed on the remote terminals with the monthly estimates. Part B should be prepared by the Resident Engineer and accompany his work sheets for the monthly estimates to the District Office. When the monthly estimate has been printed on the remote terminal and proven correct, Form 314 A and B should be stapled together and forwarded directly to File D-6 in accordance with the instructions printed on Form 314B. A brief reference should be made on Form 314B to the following items:

1. "Work Done to Date" - Report the percentage complete of the major divisions of construction, i.e., earthwork, subbase and base courses, surface courses and pavements, small structures, large structures, and incidentals.

2. "Work in Progress" - Report the principal items of work in progress.

3. "Adequacy of the Contractor's Labor Force, Equipment, and Supervision" - Under this heading, report if sufficient workmen are used and if they are properly skilled and experienced; whether adequate equipment is used and the equipment is in excellent, good, or fair operating condition; and if the supervision is excellent, good, or fair.

4. "Quality of the Work" - Under this heading, indicate if the tested materials are border-line or well within the specifications; if the workmanship is excellent, good, or fair.

5. "General Rate of Progress" - Briefly describe the general rate of progress of the work and explain if the percent complete compared to the percent time used, is a true reflection on the progress of the work.

6. "Work Done By" - Indicate if worked performed during the month is the result of (1) a prime Contractor (2) an approved Subcontractor, or both. If work is performed by an approved Subcontractor, whose subcontract is $10,000 or more, please indicate by name.

109.7 FINAL ESTIMATES

Final estimates and supporting papers are to be prepared and submitted in accordance with File D-3 Manual of Instructions, Chapter IX "Construction Estimates".

The publication, "Construction Records to Support Pay Quantities of Work Done on Contract Construction Projects" has been issued as an aid to the field personnel in the preparation of Final Estimates. This publication presents an orderly method of documentation to substantiate all pay quantities on the Final Estimate, and its use or equivalent, is a necessity.

PART II
CONSTRUCTION SURVEYS

PART II
CONSTRUCTION SURVEYS
CHAPTER 1
CONSTRUCTION SURVEYS

201.1 GENERAL

Construction surveying may well be considered as an extension, and in some instances, a repetition of the preliminary surveys. Its cost will be governed by: (1) Efficiency of the construction survey party, (2) Complexity of the work, (3) The extent of the preliminary survey and the degree of destruction thereto.

With the advent of complex travel facilities, the initial staking on many projects has become a major engineering task. Extensive planning, careful attention to details, and timely staking are necessary to insure economy, expedite the work, and to construct a project according to the plans. This is a District responsibility.

The degree of accuracy to be maintained in the various phases of construction surveying will be determined by its use and location. This is also a District responsibility.

It is the responsibility of the Resident or the District Engineer to establish the method to use for construction surveying and staking. The method selected should provide for certain routine checks, it should avoid unnecessary duplication, and it should permit replacement of stakes which have been destroyed with a minimum cost and loss of time.

201.2 NOTES AND RECORDS

The extent and method of keeping notes and records should be adequate to establish lines, grades, and sections of the proposed work, and to determine pay quantities when applicable.

Each day's work should be dated with the names and duties of each field party member shown thereon. A brief description of the weather conditions may be shown if such information is considered to be significant to the work.

201.3 QUANTITY CONTROL

The District or the Resident Engineer will determine the need for replacing the original cross sections and measurements made during preliminary surveys with those taken by the construction surveyors. Final cross sections and measurements are to be made in accordance with the established District policy and the accepted engineering practice. On pay items such as borrow, channel excavation, stripping, etc., where the quantities are calculated by the method of average end areas, original cross sections are usually taken by the construction survey parties.

In taking all final cross sections, it is essential that they be made in the same location as the original cross sections, otherwise the calculated quantities will not reflect the actual quantities.

201.4 HORIZONTAL CONTROL

Horizontal control is accomplished by the use of simple traverses or by the use of coordinates. In any event, if sufficient control points were not established and referenced during the preliminary survey, such points should be established and referenced as soon as possible after award of the contract in order to make them readily available for use during the life of the construction project.

201.5 VERTICAL CONTROL

In order to establish vertical control, permanent type bench marks are used. Bench marks should be placed at intervals not to exceed 1,000 feet, in the immediate vicinity of structures, and particularly in rough terrain, it has been found convenient to place them in the area of grade points.

201.6 CONSTRUCTION STAKES

A. <u>RIGHT OF WAY, PREPARING RIGHT OF WAY, AND CLEARING AND GRUBBING.</u> Ordinarily, one set of stakes will suffice for establishing the limits of the right of way, preparing right of way, and clearing and grubbing. In most instances, right of way stakes will have been set during the preliminary survey and only those that have been destroyed will need to be reset.

Trees that are to be preserved should be designated with temporary markers, such as colored flags, paper posters, etc. Such markers should be removed prior to final acceptance of the project. Markers that cannot be removed, such as paint, blazes, etc., should not be used.

B. STAKES FOR EARTHWORK

1. Master Grade Stakes. For many years it has been standard practice for the Department to set what are commonly called the " Master Grade Stakes " . These stakes should be set at intervals of not less than 100 feet and at the beginning and ending of the horizontal and vertical curves. They should be set on each side of the road, preferably on the right of way line, or on some other convenient line where they will not be destroyed by the construction operations.

   Master stakes usually consist of hub stakes driven approximately flush with the ground and the elevation of the top determined to the nearest hundredth of a foot. Guard stakes, identification stakes, and cross section data stakes are placed slightly behind the hub stakes. In lieu of the cross section data stakes, some Resident Engineers furnish the cross section data to the Contractor in the form of notes. Suffice it to say, the cross section data must show every break in the section to be constructed. All pertinent data are correlated with the hub stakes. Vertical measurements, either cut or fill, are always calculated from elevations and are shown from the top of the hub stakes. Horizontal measurements may be calculated or taken from the cross section sheets and are shown from the center of the hub stakes.

   From the information furnished by either the cross section data stakes or the cross section data notes, the Contractor will set auxiliary stakes by which to do the work. Even though the auxiliary stakes may accidently be destroyed, they can easily be replaced by the Contractor from the information furnished by the cross section data.

2. Check Stakes. When grading of the roadbed has been substantially completed, check stakes (blue tops) should

be set to the nearest hundredth of a foot and at the same interval as for the master grade stakes, and at such points on the graded section that will enable the Resident Engineer to determine if the work has been constructed to line, grade, and section. Check stakes will also guide the Contractor in doing the finishing work.

3. Balance Point Stakes. On some projects, it may be desirable to set stakes designating the locations of the balance points.

C. STAKES FOR SUBBASE AND BASE COURSES. Stakes for this type of construction usually consist of setting blue tops at each station for subgrade and the completed courses of the various classes of subbases and bases. Additional stakes will be set as needed. The blue tops usually will serve for grade control and alignment control.

D. STAKES FOR SURFACE COURSES AND PAVEMENTS

1. Surface Treatments. Horizontal or alignment control stakes, are the only type of stakes set for this type of work. Tack points are set at 100-foot intervals on tangents and at 100 or 50-foot intervals on horizontal curves on one side of the work only, and usually on a two-foot offset outside the limits of the work.

2. Asphaltic Concrete Pavements. Stakes for horizontal control on this type of construction consist of setting tack points at 100-foot intervals on tangents and at 100 or 50-foot intervals on horizontal curves on one side of the work only, and usually on a two-foot offset outside the limits of the work. When vertical control is desired, blue tops are set to the nearest hundredth of a foot for elevation and at 50-foot intervals.

3. Concrete Pavements. On this type of construction, tack points are set at 50-foot intervals on one side of the work and usually on a two-foot offset outside the limits of the work. Blue tops are set to the nearest hundredth of a foot in elevation and at 50-foot intervals for each line of forms, and are offset to the extent that they are not destroyed by the paving operations.

E. STAKES FOR STRUCTURES. Structures should be staked in accordance with the recommendations of the Bridge Division or as directed by the District or the Resident Engineer.

F. STAKES FOR MISCELLANEOUS ITEMS. Curb, curb and gutter, sidewalks, utilities, fences, dykes, terraces, guard rail, right of way markers, and other miscellaneous items are to be staked in such manner and with such accuracy that will permit the orderly construction of the items in accordance with the lines, grades, and sections shown on the plans.

201.7 PERPETUATING SURVEY

It is standard practice that permanent ground controls be established on construction projects and adequate records thereof be made for future reference. Horizontal control is achieved by the placement of permanent right of way markers at the appropriate locations and records made thereof. Vertical control is maintained by establishing permanent bench marks on selected structures or monuments and records made thereof.

PART III

CONSTRUCTION DETAILS

PART III
CONSTRUCTION DETAILS
CHAPTER 1
PREPARING RIGHT OF WAY

301.1 GENERAL

The item of "Preparing Right of Way" provides for preparing the right of way for the construction operations, and is generally used in the urban areas. It provides for the removal and disposal of all debris and obstructions from the right of way where such removal and disposal is not otherwise provided for in the plans and specifications.

301.2 INSPECTION

The Standard Specifications describe the work in detail; however, special attention should be given to the following:

a. The Contractor should exercise a reasonable amount of caution in protecting the existing utilities and other improvements within or near the right of way. Even though the Department is not responsible for any damages, the Department receives much of the criticism when services are disrupted.

b. Unless otherwise provided, all debris and materials removed from the right of way become the property of the Contractor. Such disposal may be of interest to the Inspector or Resident Engineer to the extent that the creation of unsightly conditions or health hazards may be prevented.

c. As the work progresses, inspections should be made for soft or spongy areas, for deposits of unsatisfactory material , and for evidence of seeps or other conditions which may require correction before the earthwork operations are started.

d. Special consideration should be given to designating trees and shrubs for preservation in accordance with recommendations of File D-18. Trees and shrubs designated to be preserved should be plainly marked by temporary markings and should be protected from damage.

e. As the work progresses, the Contractor should be required to keep holes, ruts, etc., backfilled and compacted, and the right of way drained in order to prevent the accumulation of water producing unstable areas, and to provide a more uniform foundation and moisture content of the soil for the earthwork operations.

301.3 MEASUREMENT

When the item of "Preparing Right of Way" is included in the contract, it applies to the entire right of way area for the project and additional areas of public or corporate lands that are made available for the construction of the project. Measurement for payment will be made only on areas indicated and classified on the plans as "Preparing Right of Way", and additional areas not indicated but classified as follows:

a. If during construction it was found necessary to perform work on additional areas which were not made available on the plans for the construction of the project, and the work comes within the purview of "Preparing Right of Way", such additional areas will be measured for payment. Specifically, such additional areas would include additional right of way and additional public or corporate lands which were not originally made available for the construction of the project.

b. If during construction it was found necessary to perform work, other than the work required under this item, outside the work limits originally proposed by the plans but within the areas which were made available on the plans for the construction of the project, and the work comes within the purview of "Preparing Right of Way", such areas will be measured for payment. Specifically, such additional areas would include additional cut or embankment areas.

c. If the "Measurement" section of the specifications is modified by the plans or special provisions, such modification shall govern.

301.4 RECORDS AND REPORTS

Daily entries should be made in the diary book describing location of the work, instructions received from the Project Engineer, instructions given to the Contractor, unusual conditions, and other items of interest.

CHAPTER 2
CLEARING AND GRUBBING

302.1 GENERAL

The item of "Clearing and Grubbing" provides for the removal and disposal of trees, stumps, brush, roots, vegetation, logs, rubbish, and other objectionable matter.

302.2 INSPECTION

The Standard Specifications describe the work in detail; however, it is considered good practice to give special attention to the following:

a. The Contractor should exercise a reasonable amount of caution in protecting the existing utilities and other improvements within or near the right of way, particularly during the blasting, grubbing, and ripping operations. Even though the Department is not responsible for any damages, the Department receives much of the criticism when services are disrupted.

b. All cleared and grubbed material shall be disposed of in a manner satisfactory to the Engineer. If the Resident Engineer is to permit the Contractor to dispose of material on private property, such permission should not be granted until the Resident Engineer is furnished a copy of an agreement between the property owner and the Contractor providing for such an arrangement, and stipulating that the disposed material will be sufficiently removed from the highway to be completely out of sight. Where the Department has the authority, it should not permit the creation of unsightly conditions within the view of the highway.

c. Unless otherwise provided, all merchantable timber removed under this item of work shall become the property of the Contractor.

d. As the work progresses, inspections should be made for soft or spongy areas, for deposits of unsatisfactory material, and for evidence of seeps and other conditions which may require correction before the earthwork operations are started.

e. Special consideration should be given to the selection of trees and shrubs for preservation in accordance with the recommendations of File D-18. Trees and shrubs designated to be preserved should be plainly marked by temporary markings and protected from damage.

f. As the work progresses, the Contractor should be required to keep all holes, ruts, etc., backfilled and compacted and the area drained in order to prevent the accumulation of water producing unstable areas, and to provide a more uniform foundation and moisture content of the soil for the earthwork operations. The Resident Engineer has the authority to eliminate the backfilling of holes in areas to be immediately excavated. On sections where the actual clearing and grubbing has been completed, but the holes have not been backfilled and proper drainage has not been provided as required, the Resident Engineer would be justified in excluding these areas from the partial estimates until conditions are corrected.

302.3 MEASUREMENT

When the item of "Clearing and Grubbing" is included in the contract, it applies to the entire right of way area and areas used for borrow sources, material sources, and channels. Measurement for payment will be made only on areas indicated and classified on the plans as "Clearing and Grubbing", and additional areas not indicated but classified as follows:

a. If during construction it was found necessary to perform work on additional areas not originally proposed by the plans, and the work comes within the purview of "Clearing and Grubbing", such additional areas will be measured for payment. Under this condition, the additional areas would include additional right of way, additional borrow and material sources, and additional channels.

b. If during construction it was found necessary to require work, other than clearing and grubbing, on additional areas not originally proposed by the plans, and the work comes within the purview of "Clearing and Grubbing", such areas will be measured for payment. Under this condition, the additional areas would include additional excavation areas and additional embankment areas.

c. If the "Measurement" section of the specifications is modified by the plans or by special provisions, such modification shall govern.

302.4 RECORDS AND REPORTS

Daily entries should be made in the diary book describing location of the work, instructions received from the Project Engineer, instructions given to the Contractor, unusual conditions, and other items of interest.

CHAPTER 3
EXCAVATION AND EMBANKMENT

303.1 GENERAL

This section consists of a general discussion of the methods used in excavation and construction of embankments in accordance with the specifications for the roadway and channel, borrow materials, and embankment items.

The Department personnel assigned to this phase of operation should be thoroughly familiar with the meaning of all the construction stakes and should discuss this item with the Contractor's personnel to insure that they understand the meaning of all of the information furnished for their use. Any unusual conditions or anticipated problems should be discussed with the Contractor in advance. All grading operations should be kept within the limits of the grade stakes until such time that conclusive evidence indicates a change will be necessary in order to construct the improvement as required by the plans, or as provided by approved changes in the plans. This does not preclude making of minor changes to improve the section or to correct errors.

303.2 DRAINAGE

The Contractor is required by the Standard Specifications to maintain drainage of the roadbed and ditches during construction. Usually, he can do this without hindrance to his operations by opening ditches, beginning excavation at the low points and working toward the highpoints, and maintaining cross drainage. Before leaving the project at the end of each day, the Contractor's attention should be directed to any condition that might hinder the proper runoff, particularly if rain is anticipated. Adequate drainage will expedite the Contractor's operation, facilitate prosecution of the work, and will aid in securing a roadbed having a uniform moisture content and bearing capacity.

303.3 EXCAVATION

Excavation, within the scope of this section, will include the excavation, removal , utilization or disposal of material from roadway, channels, and borrow sources.

A. CLASSIFICATION. If no classification is indicated on the plans, excavated materials will be designated as, "Unclassified Excavation". If classification is made on the plans, excavated material will be designated as, "Common Excavation" or "Rock Excavation", and the Inspector must be alert for any errors which may have been made in classifying the materials. When discrepancies are found, proper classification should be made during the progress of the work, and adequate cross sections taken to determine the pay quantities. The Standard Specifications describe in detail the materials that are classified as rock excavation, but should the Contractor question the material classification, a detailed record of his operations should be kept by the Resident Engineer or Inspector for future reference in the event he submits a claim.

When blasting is involved in rock excavation, all precautions should be exercised with respect to the safety of personnel and the public, and to prevent overblasting. Limited experience with the preshearing or presplitting method of blasting indicates this method to be exceedingly satisfactory.

B. WASTE. Unsuitable roadway excavation and excavation in excess of that needed for construction is considered "Waste". The Resident Engineer has the authority to order the Contractor to waste material when considered necessary or desirable. Waste is not to be permitted unless specifically indicated on the plans or required by written order of the Engineer and it shall become the property of the Contractor to be disposed by him outside the limits of the right of way.

Excavation in excess of the amount needed for construction is a form of waste that seldom presents any problem. Unsuitable material encountered in a cut or fill section is a form of waste that frequently causes problems or controversies. Unsuitable material may be defined as any material which, by its very nature, is not satisfactory for use in the construction of a highway facility. Material that is unsatisfactory for use, solely because of its condition, is usually considered as suitable material.

C. UNDERCUTTING. Undercutting may be defined as the authorized removal of material below the natural ground or below the subgrade elevation for the purpose of making permanent improvements to the roadbed. For example, undercutting could be authorized to correct unstable conditions which are caused by water pockets occurring in the low places of an undulating substrata of clay. The overlaying material would be removed and water pockets eliminated by filling the low places with clay obtained from the higher places or from other locations, and the removed material replaced in accordance with the requirements for embankment. In another example, undercutting may be desirable at grade points in order to provide a more gradual change from cut to fill. Observation of unsatisfactory pavement performance on many completed projects, seems to indicate a need for undercutting at these locations.

Authorized undercutting is to be measured and paid for in accordance with the applicable specification or as provided by the plans. The Resident Engineer has the authority to require undercutting when considered desirable or necessary. Undercutting performed by the Contractor for his convenience, such as removal of material to expedite drying, is not eligible for measurement and payment.

D. SELECTION OF MATERIALS. When required by the plans, selected material shall be utilized to improve the roadbed. Unless the required sequence and manner of prosecuting the work is specified in the plans or specifications, this will be the Contractor's responsibility.

E. USE OF MATERIALS FOUND ON THE RIGHT OF WAY. Item 4.7 of the Standard Specifications allows the Contractor, with the approval of the Engineer, to use in the work any suitable stone, gravel, or sand found within the "Excavation", and the Contractor will be paid for the excavation of such materials at the contract price bid. The removed materials which were intended for use in embankments, backfills, approaches, or elsewhere shall be replaced with other suitable materials at his own expense.

303.4 EMBANKMENT

A. GENERAL. It is anticipated that the Contractor will provide a balanced construction operation. Prime earth movers must be supplemented with adequate blading equipment, mixing and pulverizing equipment, water trucks, and rollers. Where rolling is a pay item, it will be necessary for the Inspector to check such equipment for compliance with the specification requirements and to record the results thereof.

B. PREPARATION OF THE GROUND SURFACE. "Preparing Right of Way" or "Clearing and Grubbing" shall have been completed on excavation and embankment areas prior to the placement of any embankment. Stump holes or other small excavations present within the embankment areas, shall be backfilled with suitable material and compacted prior to placing embankment. If the surface of the ground to receive embankment is irregular due to cultivation, small washes, etc., it shall be restored to approximately its original slope by blading or other methods. When required by the plans or directed by the Resident Engineer, the corrected ground shall be compacted by sprinkling and rolling.

Unless otherwise indicated on the plans, the surfaces of the embankment areas, other than rock or paved, shall be loosened by scarifying to the minimum prescribed depth and recompacted with the new embankment material. Hillside locations are potentially more troublesome than the regular cut or fill sections. When directed by the Engineer or indicated on the plans, the hillside surfaces shall be stepped or terraced before placing the embankment material.

Particular attention should be given to the required construction procedure as specified by the Standard Specifications where embankment is to be placed over or adjacent to the existing roadbeds.

C. EARTH EMBANKMENTS

1. Placing. All earth embankments shall be constructed in successive horizontal layers, and the depth of the layers

will be governed by the specified method of compaction. Roots, stumps, trees, vegetation, or other unsuitable material shall be removed. Layers of embankment on hillsides shall be placed part width, beginning at the low side and increasing in width as the embankment is raised. Layers of embankment adjacent to an existing roadbed shall be placed in part width, and the new embankment must be brought up to the level of the old roadbed before it is permissible to increase its height.

Layers of embankment are usually formed by equipment that will spread the material as it is dumped, and may be formed by dumping the material into piles or windrows and spreading by blading or other acceptable methods.

2. Mixing, Watering, and Drying. The Standard Specifications require that each layer of embankment be uniform as to material, density, and moisture content prior to beginning of compaction. When different types of materials are encountered in a layer, it will be necessary to mix them by disking, scarifying, blading, or any other effective method that will produce a uniform material. The extent of mixing can only be determined by previous experience in this phase of operation. Usually, mixing should proceed to the point where visual inspection will not detect any distinct streaks, areas, or spots of different types of materials within a layer. The phrase, "different types of materials" denotes materials having pronounced differences in the optimum moisture content and having significantly different capacities for volumetric changes.

   Insofar as practicable, each layer of embankment must be of uniform moisture content prior to compaction. This condition may be attained by sprinkling or drying. Ordinarily, a certain amount of mixing is necessary to incorporate the water uniformly throughout the layer or to promote uniform drying.

3. Compaction. The Standard Specifications provide for two methods of compaction, the "Ordinary Compaction" method and the "Density Control" method. The required method to be followed on a particular project will be indicated on the plans. The preparation of each layer of

embankment, prior to compaction, will be substantially the same for either method.

a. Ordinary Compaction Method. Under the Ordinary Compaction method, the specifications usually contain the following provisions:

1. The maximum layer thickness (loose) shall not exceed 8 inches.

2. Compaction will be obtained by using specified rollers meeting certain specification requirements.

3. The amounts of rolling and water used will be paid for directly under the appropriate bid item.

4. Rolling shall continue until satisfactory compaction has been obtained.

Fulfilling of the requirements under the Ordinary Compaction method, depends to great extent upon the experience and qualifications of the Inspector. Good judgement must be exercised in determining the proper compaction moisture, and in determining when satisfactory compaction has been obtained.

Before the actual construction of embankment begins, the Inspector should accomplish the following:

1. Determine the capacity of each water truck. This is usually done by accurately measuring the tank dimensions and computing the volume, or by weight determinations whereby the truck is weighed empty and fully loaded, thus providing the water capacity in pounds which can be converted to gallons. A record of measurements or weights, and calculations should be made for future reference. Use of leaking water trucks should not be permitted.

2. Check all rollers for compliance with the Specifications.

(a) Make the necessary measurements and checks to ascertain that the rollers meet the applicable specifications for the effective rolling width, tire width, number of wheels or drums, etc.

(b) Weigh the rollers and verify that the specified and desired total load and ground pressures can be attained.

(c) For pneumatic tire rollers, secure the necessary data for use in determining the contact areas and the contact pressures. Information on this subject is also contained in the "Pneumatic Tire Pressure Table", in the Appendix.

(d) A record of measurements, weights, and calculations should be made for future reference.

3. Require each water truck and roller to be identified by a prominent number or other satisfactory identification.

4. Consult with the Contractor's personnel regarding grade stakes, construction procedures, proposed methods, equipment, etc.

Since sprinkling and rolling are pay items, it will be necessary to keep a record of the quantity of water used and the number of hours each roller worked. Form 124 Rev. may be used for this purpose. If one ticket is to be used for the amount of water placed by each truck in a day, a tally should be kept on the ticket, or in a field book if the loose-leaf record system is not used, for each load of water delivered. Ordinarily, one ticket per day per roller is used to record the number of hours each roller has worked for payment. The start and stop times for each roller used each day should be recorded on the ticket or in the field book. Another acceptable record of measurement for these pay items utilizes Form 1257, "Report Showing Work Performed", or its equivalent. A tally should be kept on the form for each load of water delivered by each truck. Start and Stop times should be recorded on Form 1257, or its equivalent, for each roller that worked during the day. Examples of completed Form 1257 for these items may be found in the publication, "Construction Records to Support Pay Quantities of Work Done on Contract Construction Projects".

b. Density Control Method. When the Density Control method of compaction is specified for embankments, any method, type, and size of equipment may be used to obtain the required densities. The desired density or degree of compaction will be predetermined in the soils laboratory by performing the appropriate tests in accordance with the approved and designated methods. It must be assumed that adequate preliminary investigations have been made during the design stages of the project to indicate that embankment materials are sufficiently uniform, and local conditions are of such nature that it is both possible and practical to construct the embankment substantially within the values established under the density control method of compaction.

The depth of layers will depend upon the efficiency of the construction equipment, upon the space available for mixing, and other conditions which affect compaction of soils. Construction methods employed under the Density Control method normally are similar to those used under the Ordinary Compaction.

Since only a small portion of embankment can actually be tested, it is important that special attention be directed toward obtaining the specified compaction uniformly throughout each layer of embankment. The methods and construction equipment used must provide for uniformity of compaction. Tests made on a layer of embankment which lacks uniformity will be of little value.

The following three separate phases of work must be carried out on controlled density projects in order to adequately inspect and control compaction, and to prevent delaying the Contractor's operations:

(1) Samples of different soils to be used in the embankment must be obtained for laboratory tests.

(2) Compaction Ratio tests must be made in the laboratory to establish moisture - density relationships and the Compaction Ratio density values (D_A) to use in the field to check compaction. Unless otherwise specified, tests should be made in accordance with the Test Method Tex-114-E.

(3) Field density tests in accordance with the Test Method Tex-115-E must be made during the progress of the work to verify that the specified percent of Compaction Ratio is being obtained.

Phases (1) and (2) should be completed before embankment construction operations are started. The laboratory tests require considerable time and the Contractor's operation may be delayed if bulk of the sampling and testing is attempted during construction. Although additional laboratory tests may be necessary after construction starts, the preliminary sampling and testing under Phases (1) and (2) should be sufficiently thorough to require a minimum of additional testing. Phase (3) tests (field density tests) are made as required as the work of constructing the embankment progresses.

In carrying out Phase (1), large pilot samples should be obtained from the major soil deposits which will be used in the embankment. A sample should be taken from each deposit having different color and texture. Ordinarily it is not good practice to take pilot samples composed of a mixture of two or more distinctly different soils. Mixing of soils makes identification more difficult, and the mixed samples may not be representative of the embankment placed during construction. Pilot samples for the Compaction Ratio tests should be secured sufficiently in advance to permit completion of the tests before embankment construction begins. Soil Surveys, made during the design stages, will be especially helpful in determining the required number of samples to properly check compaction. The Inspector assigned to inspect the earthwork and to make the density tests should, whenever possible, sample or assist in sampling the soils for the pilot tests. This will give him the opportunity to become familiar with their location and limits in the excavation, and will be of great benefit later in identifying the soils as density tests are made and in selecting the correct laboratory density for checking compaction.

Phase (2) consists of performing the required tests in the soils laboratory to determine the Compaction Ratio density for each soil sampled under Phase (1). Tests must be performed by experienced and well-trained personnel in accordance with the Test Method Tex-114-E. The results representing the Compaction Ratio density value (D_A) and the estimated compaction moisture content for each soil sampled under Phase (1) will be used as reference by the inspecting field personnel to determine when the required compaction of the embankment has been obtained. The Earthwork Inspector can gain valuable experience in judging the proper compaction moisture content of the soil by assisting the soils laboratory personnel in performing the laboratory tests. For each soil, the test report sent to the field by the soils laboratory should include the following information:

(1) Compaction Ratio density value (D_A)

(2) Estimated compaction moisture content

(3) Soil constants and gradation

(4) Location and depth from which the sample was taken

(5) Description of the soil, and possibly a small sample for use in identification

Phase (3) involves the actual checking of compaction, using the laboratory test data from Phase (2) and the field density test results, to determine that the compaction being obtained substantially meets the specification requirements. In checking compaction, the Inspector should be careful to select locations for making density tests that will reflect a true appraisal of the compaction method being used by the Contractor. It must be remembered that every square yard of the embankment layer cannot be tested, and the tests must provide reliable information on the effectiveness of the pulverizing and mixing equipment, the uniformity of moisture, and the effectiveness of the compacting equipment. When the embankment is ready for testing, the Laboratory Technician or Inspector should make the density tests and the Contractor should be advised immediately of the results.

Difficulties which often develop in connection with the density control projects may be greatly simplified by observing the following recommendations:

(1) Efficient pulverizing and mixing equipment, and good moisture distribution system should be used to obtain the correct and uniform moisture content

in the embankment layer prior to rolling. Control of the moisture content is probably the most important factor in earthwork compaction operations. The required density can be obtained with the least amount of effort if the moisture content is at or near the optimum. The importance of obtaining the correct moisture content in the embankment layer and securing uniform distribution throughout the layer cannot be overemphasized. It can be readily verified in the laboratory that the same soil, under the same compactive effort, will have a different density using a different moisture content. The same soil placed in an embankment layer and given the same amount of rolling, will more than likely, have a different density at every location where the moisture content is different. Uniform moisture distribution can only be obtained when proper methods and equipment are used.

(2) Considerably more than the minimum required testing should be made at the beginning of the compaction operation to enable the Contractor to make adjustments in his procedure, and to determine if his methods and equipment are adequate. Close inspection at the beginning to insure operation that will produce adequate and uniform results will make it possible to reduce the amount of testing later. This is also the appropriate time for representatives of the District Laboratory to work with the field personnel in checking the testing equipment and correlating the test procedures.

(3) When possible, mixing of soils having vastly different compaction characteristics should be avoided. Often it may be possible to arrange, without undue hindrance to the Contractor, to haul the "hard-to-mix" materials to different locations in the embankment. Study and discussion of the soil profile prior to construction will often lead to solutions of this problem without inconvenience and expense to the Contractor, and may even result in savings because of the simplication of the density control procedures. When mixing

the "hard-to-mix" soils in the same layer of embankment, the Contractor may find it necessary to use additional disc plows and possibly employ some type of mechanical road mixers to properly blend the materials.

(4) It should be made certain that the soil being tested for density has been correctly identified, and that the appropriate Compaction Ratio density value is being used to determine the required degree of compaction. Knowledge of the original location from which the embankment material came will narrow the selection considerably. The soil characteristics such as color, texture, plasticity, gradation, etc., offer other valuable means of identification. In making the identification, it is important to ascertain that the laboratory density selected is the correct one.

(5) Periodic investigations of cuts, borrow pits, and other sources of material should be made for soils which may have been overlooked when pilot samples were taken. Such soils should be sampled and tested in the laboratory, and the Compaction Ratio density (D_A) determined immediately. If it appears that two different soils are to be mixed together in fairly uniform proportions, a sample of this mixture should also be tested to determine the D_A value. An energetic Inspector will be continually alert to these possibilities and will be able to anticipate the need for additional tests. Although this procedure may sometimes result in some tests not being utilized, the overall benefit will be a considerable savings in time and inconvenience.

(6) When compacting swelling-type soils (Plasticity Index of 20 or more), it is recommended that the compaction moisture be kept at not less than the optimum. Usually it is not difficult to obtain the specified density of the swelling-type soils, and overcompaction may result if they are compacted on the dry side of the optimum moisture. Even if overcompaction is avoided during rolling of the

layer, density will more than likely, increase under construction traffic and as the succeeding lifts are placed. Construction haul routes over the swelling-type soils should not be confined to the same path.

Test Method Tex-115-E, or any other methods which correlate satisfactorily with this method, should be followed closely in making the field density tests. A smooth surface is required for the field density test. Any marks and holes left by the rollers at the selected location should be bladed off, and loose material on the surface removed. The test hole for the volumeter test should have vertical walls, and care should be taken not to loosen the material in the walls of the hole. The density obtained by the volumeter method will be the average density giving equal weight to both the top and the bottom portions only if the walls of the test hole are vertical. If the test hole is larger at the top and is "cone-shaped", the upper portion will contribute more soil to the total sample than will the bottom portion, and in addition if the layer is denser at the top than at the bottom, the resulting density will be higher than the average density. This is often the case when heavy rollers are used on relatively thick layers of material, or when the material being compacted is too dry. Particular care must be taken in performing the field density tests in accordance with the Test Method Tex-115-E, since a relatively small error made in measuring the volume of the hole and in weighing the material will be magnified when the results are expressed in pounds per cubic foot. Past experience indicates that inaccurate test results were caused by the following:

(1) Poor maintenance and care of the volumeter.

(2) Failure to excavate large enough test hole.

(3) Scales used for weighing excavated material not sufficiently sensitive and inaccurate.

(4) Excessive heat used to determine moisture content of soils containing an appreciable amount of combustible material.

(5) Water level in the volumeter too low for the high-range reading or too high for the low-range reading, resulting in zero setting or tape reading being made in the "no-read" zone of the bulged upper chamber.

(6) Volumeter not held solidly against the digging tray, permitting it to float while pressure is being applied to the balloon.

(7) Failure to be consistent in adjusting eye level to the level of the meniscus when determining the zero setting and again when reading the tape.

Assuming that all volumeter measurements are subject to some error, satisfactory accuracy can be secured by giving special attention to the size of the test hole. For heavy or coarse grained materials (125 - 150 p.c.f.), test holes should always be at least 0.08 cu. ft. and preferably should be approximately 0.10 cu. ft. Test holes in lighter or fine grained materials can be smaller; however, the minimum size should be at least 0.05 cu. ft. For any material, density errors due to the volume measurement errors can be held to a minimum by excavating test holes as large as practicable.

Test Method Tex-103-E is the standard procedure for determining the moisture content of the field density samples, and the use of accelerated methods should be confined to those methods which correlate satisfactorily with the standard method for the purpose of computing the dry densities from the wet densities. Some soils contain appreciable amounts of combustible materials which burn off at high drying temperatures. The weight of material lost by burning will appear as moisture loss in the moisture test and will result in the computed dry density being low. Sufficient checks should be made to insure that such errors will not occur if an accelerated drying method is used.

D. ROCK EMBANKMENTS. The Standard Specifications describe in detail the procedure to be followed in construction of rock embankments, and the Inspector should emphasize the importance of the proper placement of the fill material. Material should never be deposited in piles which are leveled off on the top. A more uniform arrangement of the different rock sizes can be maintained in the fill layer by dumping the material on top of the layer being built and shoving it ahead with a bulldozer. Particular care should be taken in constructing the top layer of rock embankments, as the top of this layer will usually serve as subgrade. The intent of the specifications is to provide a layer which can be graded and finished satisfactorily, and care should be taken to exclude or reduce in size by sledging any oversize rock exposed on the surface of the layer. The amount of sprinkling and rolling required in constructing rock embankments will depend upon the type of material being placed. Very seldom will the density tests be of any value in controlling the compaction of rock embankments.

303.5 RECORDS AND REPORTS

Daily entries should be made in the diary book describing location of the work, instructions received from the Project Engineer, instructions given to the Contractor, unusual conditions, and other items of interest.

For density control projects, a tabulation should be kept of all the density tests made. This tabulation should include the following information: date of test, location of the test hole, (D_A) density, estimated moisture content, actual field density, actual moisture content, and percent of (D_A) density obtained. Failing test results should be referenced to subsequent tests and notations made as required to explain the action taken.

Construction Form 590, "Weekly Summary of Embankment, Subbase or Base Materials Test Results" should be submitted in accordance with the instructions on the form.

CHAPTER 4
UNTREATED FLEXIBLE BASES

304.1 GENERAL

The versatility in the use of untreated flexible bases is almost unlimited. Untreated base materials are used in building the most modern interstate highways as well as the most remote farm to market roads. Proper construction and competent inspection are essential in this type of work.

304.2 PRELIMINARY INVESTIGATIONS OF SOURCES

Some type of preliminary investigation of the proposed sources of base materials should always be made prior to beginning production. The extent of the investigation will depend upon the type and quality of the material to be produced and the availability of reliable information.

For sources shown on the project plans, records might be available from investigations made during the design stages of the project. These records will usually consist of test hole logs, material test results, and possibly a pit layout, showing test hole locations and other features which may affect the pit operations. The Inspector should obtain all the available records and make a study of the pit site. If a study is made before the Contractor begins any work at the pit, it is probable that most of the test holes can be located and an examination made of the exposed materials. This will do much to acquaint the Inspector with the different materials that will be encountered during the processing and production operations. Special note should be made of all materials which appear to be of questionable quality.

If the Contractor elects to use sources other than those shown on the plans, sufficient evidence should be obtained prior to the delivery of any base material to the project, to indicate that base material meeting the specifications can be produced from the proposed sources. It is very important that the steps taken provide assurance that the delivered and placed base material will meet all the requirements of the specifications.

Particular attention should be given to sources which will be used to produce the base material meeting physical requirements determined through the use of the Triaxial Compression Test.

Preliminary Triaxial Tests should always be made on material from pits expected to produce this type of base material.

304.3 OPERATIONS AT THE PIT

Special attention should be given to the excavating and mining operations at the pit or quarry. The preliminary investigation made prior to the beginning of operations at the pit should have provided the necessary assurance that base material meeting the specifications could be produced from the materials available in the source.

Before beginning the actual mining operations, the pit or quarry must be cleared and stripped of all unsuitable materials. Material should be disposed of in accordance with the agreement made with the property owner and deposited at locations which will not hinder the subsequent operations. If the plans or specifications require payment for clearing and grubbing, stripping of overburden, etc., measurements must be made in accordance with the specified methods.

The methods employed by the inspecting and testing personnel should be designed to provide maximum assistance to the Contractor in making full use of all the acceptable materials in the pit and in excluding all the undesirable materials. Although various methods may be used for accomplishing this objective, the following example will illustrate the procedure. As soon as the Contractor opens the pit, the exposed vertical faces should be carefully examined for evidence of unsound rock, gravel, or other coarse materials which may have been overlooked in the preliminary investigation. The amount and location of detrimental clay should be noted and considered to determine if any changes are indicated in the excavating and mining methods. As the work progresses and new areas are exposed, close observation should be maintained and selected samples taken from ledges, layers, and pockets. Information obtained in this manner will enable the Inspector to recognize the different materials as they occur during all stages of production and to know the probable effect they will have on the final product. Also, close examination should be made of the holes drilled in rock formations for blasting purposes. Changes in color, texture, and moisture content of the material removed from these holes can be very helpful in determining the good and bad portions of the pit, and when to expect changes which may affect the production operations.

The Inspector's duties at the processing plant can usually be coordinated with his efforts at the material pit. As has been pointed out, the primary concern at the pit is to make use of all acceptable materials and to exclude all materials which will be harmful to the finished product. The duties at the plant will consist mostly of checking the produced material to determine if it meets the specified requirements. The Contractor should be advised immediately when the test results indicate a trend toward unsatisfactory quality in order that necessary adjustments can be made in the operations at the pit or in the processing methods. The processed base material should be sampled using procedures which are applicable to the production methods and equipment.

Except for base materials produced to meet requirements of the Triaxial Compression Test, the testing of flexible base materials during production will involve the use of all or most of the following standard laboratory tests:

Preparation for Soil Constants and Sieve Analysis	Test Method Tex-101-E
Liquid Limit	Test Method Tex-104-E
Plastic Limit	Test Method Tex-105-E
Plasticity Index	Test Method Tex-106-E
Sieve Analysis	Test Method Tex-110-E
Wet Ball Mill	Test Method Tex-116-E

On some projects, base material must be furnished which will meet the minimum requirements for a specified Triaxial Class or specified minimum Triaxial compressive strengths. In addition to making the sieve analysis, soil constants, and possibly the wet ball mill tests, the procedure described in Test Method Tex-117-E is used to determine the quality of the material. Generally, it is intended that Part II of this test (the accelerated method) be used for quality control during construction. When required, pilot grading tests must be made prior to beginning production of this type of base material. The procedure used in making these tests will be taken up in paragraphs to follow.

As soon as production of the base material has leveled off, several samples of the processed material should be obtained for testing in the Project Laboratory. All specified tests should be carefully made and the Contractor advised of the test results. Failing or borderline test results should be noted, and any changes in production methods which are indicated by these tests should be made.

At the beginning of production operations, samples should also be sent to the District Laboratory and representative portions of the same samples should be retained in the Project Laboratory for similar testing. As soon as the test results from both laboratories are available, comparison should be made and the causes for any significant differences determined and corrected. This type of testing will provide a good check on the testing equipment and procedures.

A. PILOT GRADING TESTS. Triaxial compressive strength of a base material is mostly influenced by the following factors:

(1) Shape and frictional characteristics of the aggregate.
(2) Cementation provided by the fine particles.
(3) Density provided by the arrangement and the amounts of the different size particles.

A study of the above factors reveals that sieve analysis tests for gradation, soil constants tests for plasticity of the soil binder, and wet ball mill tests to determine the aggregates resistance to disintegration are not always sufficient to measure the quality of a base material in terms of the Triaxial strength. The particle shape, which influences frictional resistance, and gradation, which influences density must also be considered. For these reasons, pilot grading tests should be made prior to beginning large scale production for the following purposes:

(1) To determine if the crushing, processing equipment, and methods are adequate.
(2) To determine the gradation and grading tolerances to use during production.

In order to make the pilot grading tests, the Contractor should be requested to begin crushing and process only enough base material to form a 400 to 500 cubic yard stockpile. While awaiting the test results material should not be hauled to the road, and production of large amounts for stockpiling is not recommended. The time required to produce this stockpile of material should permit the Contractor to adjust his operations and furnish representative material for testing. On projects where stockpiling is specified, small quantities of failing material which may result from the pilot grading test, can usually be spread thinly over the area to be used for stockpiling and later blended with the other material in the stockpile. On other projects, the material needed for the pilot grading tests may be obtained during production of the subbase material if the same source and the same processing facilities are used. Only in cases where pilot grading tests are not specified and the Engineer has the necessary grading information from recent production at the source in question, should base material of this type and grade be hauled directly to the road prior to the time passing test results are available.

The grading limits required by the specifications usually will be the controlling factor in selecting the trial gradation for the pilot grading tests. The band formed by the grading limits usually is very narrow and will not permit experimentation over a wide range of gradations. For this reason, gradations representing the fine side, midpoint, and coarse side of the specified grading limits should be molded and tested. To be more specific, the trial gradations for the pilot grading tests for Type A, Grade 1 base material under the Standard Specification Item 248 would be as follows:

		Specified Grading Limits	Trial Gradations 1	2	3
% Retained	1 3/4"	0	0	0	0
"	7/8"	8-30	8	20	30
"	3/8"	30-50	30	40	50
"	No. 4	45-65	45	55	65
"	No. 40	70-80	70	75	80

Having established the trial gradations for the specified base in a manner similar to that illustrated above, the procedures described in Test Method Tex-101-E and Test Method Tex-117-E should be carefully followed to determine the Triaxial Class or the Triaxial compressive strength for each gradation. It is very important that the trial mixtures used for the pilot grading tests are proportioned to fit, as nearly as possible, the desired trial gradations and that the desired percent of soil binder is incorporated into each mixture. Test Method Tex-101-E should be supplemented to the extent necessary to provide mixtures conforming as nearly to the grading desired as possible. If the specified class or strengths are not obtained using these gradations, the Contractor should be requested to make adjustments in his processing methods as may be indicated by the first series of tests and the procedure repeated. Some indications that the inspecting and testing personnel should watch for during sampling and testing of the material are as follows:

(1) The presence of significant amounts of coarse particles which are elongated, shattered, brittle, or unduly soft. Evidence of brittleness or softness usually can be detected during molding of the test specimens, particularly during molding of the first layer, and by observing the results obtained from the wet ball mill tests.
(2) Indications of too much clay in the fines as indicated by a plasticity index near the maximum permitted by the specifications.
(3) Indications of fines in the material lacking sufficient cohesive properties as indicated by low compressive strengths at low lateral pressures and a low plasticity index.
(4) Need for denser gradation, as indicated by large voids in the sides of the molded test specimens.

B. <u>PRODUCTION FROM CENTRAL MIXING PLANTS</u>. When more than one material, or materials from more than one source are used to produce the base material, central mixing plants equipped with approved mixers are sometimes specified for use in proportioning and mixing the different materials. When weigh-batch type plants are used, the scales and metering devices which are used to proportion the materials should be checked to determine that the equipment meets the requirements of Item 500, "Weighing and Measuring Equipment". When continuous-flow type plants are used, the plant facilities should be carefully calibrated to insure that materials are properly proportioned to produce the required mixture. For best accuracy, calibration of the plant should be made under normal working conditions. It should also be remembered that flow of the fine aggregate through a gate is influenced by its moisture content. For this reason, fine materials having a variable moisture content should be stockpiled for sufficient length of time to permit moisture to become uniformly distributed. This will do much to provide for uniform proportioning of the materials to be blended and for the desired gradation of the mixture.

304.4 STOCKPILING

Stockpiling of base material will be required when provided for by the plans or specifications. Normally, the plans will also indicate the maximum depth for the stockpile layers and the height to which the stockpile may be built.

The primary objective of stockpiling is to achieve a more uniform base material. Since material deposits in most sources vary vertically as well as laterally, the methods used in working these sources must be designed to overcome as much of this lack of uniformity as possible. The usual practice of working the vertical faces in successive vertical cuts extending through all of the exposed strata will provide a satisfactory blend of materials from top to bottom, but will not overcome the variations from one area of the source to another. Proper stockpiling procedure will do much to overcome the lateral variation in the materials. Materials should be deposited in layers covering the full area of the stockpile, and the stockpile should not be built to a height that will make it impossible for the loading equipment to load from the entire face. Many of the benefits to be gained from stockpiling can often be lost by not being able to work the stockpile by making vertical cuts through the entire depth.

The area for the stockpile should be leveled and cleared of all vegetation and debris. The extent of the preparation for the stockpile will determine the amount of base material that must be wasted later due to contamination; therefore, this work should be done carefully. The width and length of the first layer should be based on the height to which the stockpile will be built. The stockpile should be constructed from a broad base at the bottom and decreasing in width as the height increases in order to prevent excessive spilling of aggregates over the side. Side-dumping or shoving of the material over the sides of the stockpile should not be permitted. For best results layers should be constructed by dumping the material in a systematic pattern over the preceding layer with just enough leveling after dumping to provide a level surface for the next layer. The use of bulldozers on a stockpile should depend upon the gradation of the material and its susceptibility to degradation.

304.5 OPERATIONS ON THE ROAD

A. PREPARATION OF SUBGRADE. Subgrade on which the base material is to be placed must be thoroughly compacted and conform to the proper cross section and grade. Density tests, if required, should have been completed and should indicate that the specified compaction has been substantially secured. The subgrade should be free of holes, ruts, and other depressions which may be detrimental to proper drainage. Any unstable or soft areas should undergo additional rolling or be aerated, rolled, and restored to the proper section prior to the placement of base material. Areas which appear to be excessively wet should be investigated for seeps or other sources of water. If such conditions are found, the Project Engineer should be advised without delay in order that appropriate action can be initiated.

Inspectors should check at each blue top to insure that subgrade conforms to the established grade, and in addition, should take steps to eliminate sags and humps which often occur between the blue tops. These sags or humps may not be readily visible to the eye, but can cause a rough riding finished base or a base of improper thickness. The subgrade preparation should proceed sufficiently ahead of the base operations to permit orderly and satisfactory placement of the base.

B. PLACING OPERATIONS. Equipment which will be used in hauling, placing, and compacting of the base material should be checked prior to the time of delivery or during the first stages of the placing operations. These checks usually will involve the following:

(1) When the specifications provide for the base material to be measured by the cubic yard in vehicles as delivered to the road or to the stockpile, all vehicles used for this purpose must be measured and their capacities computed in cubic yards in accordance with the recommended procedure in Part I, Chapter 9, "Measurement and Payment".

When it is specified that material will be measured by the ton, all hauling vehicles must be weighed in the empty condition using a procedure which will take into account the changing fuel load and establish an average tare weight for the vehicle. The tare weights should be recorded and used for determining the net weights. Enough spot checks should be made throughout the continuance of the placing operations to indicate that the average tare weights being used are sufficiently accurate. Vehicles should be numbered in order that each truck can be easily identified.

(2) When sprinkling water is to be measured for payment, water trucks used for this purpose must be checked for capacity. This is usually done by accurately measuring the tank dimensions and computing the volume, or by weight determinations whereby the truck is weighed empty and fully loaded, thus providing the water capacity in pounds which can be converted to gallons. A record of measurements or weights, and calculations must be made for future reference. Use of leaking water trucks should not be permitted.

(3) When the types of rollers to be used in compacting the base material are specified, they will usually require checking as follows:

(a) Making the necessary measurements and checks to ascertain that rollers meet the applicable specifications for the effective rolling width, tire width, number of wheels or drums, etc.

(b) Weighing the rollers and verifying that the specified and desired total load and ground pressures can be attained.

(c) For pneumatic tire rollers, securing the necessary data for use in determining the contact areas and contact pressures.

Information on this subject is also contained in the "Pneumatic Tire Pressure Table", in the Appendix.

(d) A record of measurements, weights, and calculations should be made for future reference.

(4) Platform scales that may be required for weighing the base material for payment should be checked by the Contractor and should comply with Item 500, "Weighing and Measuring Equipment".

If sprinkling and rolling are pay items, it will be necessary to keep a record of the quantity of water used and the number of hours each roller worked. Form 124 Rev. may be used for this purpose. If one ticket is to be used for the amount of water placed by each truck in a day, a tally should be kept on the ticket, or in a field book if the loose-leaf record system is not used, for each load of water delivered. Ordinarily, one ticket per day per roller is used to record the number of hours each roller has worked for payment. The start and stop times for each roller used each day should be recorded on the ticket or in the field book. Another acceptable record of measurement for these pay items utilizes Form 1257, "Report Showing Work Performed", or its equivalent. A tally should be kept on the form for each load of water delivered by each truck. Start and Stop times should be recorded on Form 1257, or its equivalent, for each roller that worked during the day. Examples of completed Form 1257 for these items may be found in the publication, "Construction Records to Support Pay Quantities of Work Done on Contract Construction Projects".

Flexible base materials are placed and compacted under the "Ordinary Compaction" method or the "Density Control" method. The method to be used on a particular project will be indicated on the project plans. Under the Ordinary Compaction method, base material will be placed and compacted using construction methods specified and approved by the Engineer. The type of roller to be used in compaction will be specified and the amounts of sprinkling and rolling used in obtaining compaction will be measured and paid for. Compaction must be uniform and adequate as judged by the Engineer. The Density Control method normally permits the Contractor to obtain the specified compaction using construction methods and equipment of his own selection. Under this method, a specified percent of laboratory density must be obtained and field density tests are used to determine when the specified compaction has been accomplished. Sprinkling water and rolling are not paid for directly under this method. Regardless of the compaction method specified, each method will normally involve the same fundamental principles, the main difference being the thickness of material compacted in each layer and the methods used for ascertaining that the required compaction has been obtained.

Base materials should be delivered to the road in vehicles of uniform capacity. When this is done, a pattern of dumping can be established which will provide for satisfactory distribution of the required quantity of material throughout each 100 foot station. The base material is usually dumped in one or two rows near the center of the road. Rows should be kept straight and the correct spacing maintained between loads. Spacing of the loads should be carefully worked out before hauling of the base material begins. This will permit the hauling operation to be carrried out systematically and without unnecessary delay due to the lack of proper planning. The quantity of material dumped in each station depends upon the mixing space available, the capacity of equipment, and the methods used to secure thorough and uniform distribution of moisture. When a sufficient amount of material has been delivered and properly dumped, the mixing operation can begin. In general, the base material in the piles should be leveled, sprinkled, and bladed back and forth across the road in a thick layer until it is thoroughly mixed. All material should be moved in this operation, and if necessary, sufficient water should be added at the beginning to prevent the soil binder from sifting through and being lost on the subgrade or the base course underneath. As the mixing continues, water should be added in light applications until the material is thoroughly mixed and the "optimum" moisture content has been reached. It is better to add water in several light applications in order to provide for a more uniform mixture, allow for saturation of the aggregates, and to prevent overwetting of the subgrade. The final mixing will usually leave the material in two windrows, one along each side of the road. The material is then bladed into place in relatively thin layers. Generally, the thickness of the layers will depend upon the type of roller being used for compaction. When pneumatic tire rollers are used, the layer thickness may just exceed the maximum size aggregate in the material. When tamping rollers are used, layers must be thick enough to prevent mixing of the subgrade material with the base material due to penetration of the tamping feet into the subgrade. Rolling should be continued as each layer is placed, until all of the material in the windrow has been spread and compacted. Throughout the placing operation special care should be taken to maintain the proper section and to provide a finished surface meeting the specified requirements for alignment and grade. Material compacted with tamping rollers will usually require finishing out with pneumatic tire rollers in order to provide a finished surface free of depressions and holes caused by the tamping feet. For some bases flat wheel rolling may be required to provide the desired finished surface. After completion of compaction, the Inspector should again check at each blue top to see that the finished base course conforms to the established grade. Sags and humps between blue tops should be corrected as necessary by scarifying, wetting, shaping, and re-compacting. Following these precautions will aid in securing the proper thickness of the base course having the desired riding qualities.

The success of the compaction methods will depend mostly on good control of moisture. Mixing and blending of water with the base material must be thorough. Usually it is better to be slightly on the wet side of optimum when rolling starts, than to be on the dry side. This is particularly true in dry, windy climates or when the base material will absorb water. The chances of obtaining more density through additional rolling are better when the base material is slightly wet, than when it is dry.

Under the Density Control method of compaction, the use of special equipment for introducing moisture and mixing materials will often make it possible to place the base material in greater thicknesses than could be handled using the ordinary compaction equipment. When special equipment is used, the Inspector should make certain that the methods will provide for uniformity and that the results of field density tests clearly show that compaction is being obtained in the bottom of the layers as well as in the top.

C. CONTROL OF DENSITY. Field density tests are required when the density control method of compaction is specified for the base material. As in earthwork operations, proper control of compaction involves:

(1) Laboratory testing of representative samples of the base material to be compacted on the road.

(2) Field testing of the base material after compaction to determine if the specified compaction has been obtained.

Laboratory testing should preferably be made well in advance of the actual road compaction. At least three samples should be obtained and delivered to the laboratory for the Compaction Ratio tests. Unless otherwise specified, the procedures described in Test Method Tex-114-E should be followed carefully to provide the Compaction Ratio density value (D_A) for each sample. Before using the laboratory densities to check the field compaction, gradations and soil constants should be checked to insure that the samples are representative of the base materials to be compacted. Any significant differences in the densities of the samples should be carefully investigated by rechecking the computations or retesting. The test report issued to the field should include all the test results and other information which will be of assistance to the Inspector in selecting the proper Compaction Ratio density to use in checking compaction.

Field density tests should be made by following the procedures described in the Test Method Tex-115-E. This method provides for using the volumeter as a means for determining the field density. If other methods are used, the test results must correlate satisfactorily with those obtained with the volumeter.

In checking compaction, the Inspector should be careful to select locations for making density tests that will reflect a true appraisal of the compaction method being used by the Contractor. Good judgment must be applied in selecting the Compaction Ratio density to use from the data furnished by the laboratory. For very uniform base materials there should be very little variation in the Compaction Ratio densities of the several laboratory samples, and it usually will be satisfactory to use an average of these tests for checking the field compaction. Base materials containing mixtures of variable proportions of more than one type of aggregate, and those base materials which vary considerably in gradation will present a more complicated problem. This type of problem can be illustrated by the following example:

COMPACTION RECORD

Laboratory Data	
% Moist.	D_A Density
8.2	131.6
7.8	134.8
7.6	136.2
8.1	132.1
7.6	136.0
Avg.	134.1

Location of Field Test	Field Density % Moist.	Density	% Compaction
129+40	8.3	132.0	98.4
135+00	7.7	135.8	101.3
142+50	7.9	133.2	99.3
151+00	7.8	134.8	100.5
160+00	7.5	136.0	101.4

A study of the above data indicates that, in some instances, less than the specified 100 percent compaction has been obtained; however, it is also evident that all of the field densities are above the lowest controlling laboratory density. Since ordinarily it is not possible to perfectly identify the correct laboratory density, this data should be considered as evidence that the compaction being obtained substantially meets the specification requirements. As shown in the above example, tests indicating less than 100 percent compaction in many cases do not indicate inadequate compaction. Due to the limitations of the procedures being used, reworking of compacted base materials should be ordered only after careful consideration of all of the variables involved.

304.6 CONTROL SAMPLES AND TESTS

Control sampling and testing is done primarily for two purposes:

(1) To obtain information during production which will enable the Contractor to make the necessary corrections and changes to keep the base material within the limits for quality established by the specifications.

(2) To provide test data on the finished base material which will serve as a basis for acceptance.

The sampling and testing required to serve the above purposes can often be done simultaneously. The minimum number of tests to be performed will be found in the "Guide Schedule of Minimum Sampling and Testing", Section 106.11. All specifications currently being used provide for the base material to meet certain specified physical requirements prior to compaction on the road. These provisions, together with other factors, normally will present the following conditions for sampling and testing required for control of production and for providing a basis for acceptance of the base material:

(1) Unless otherwise provided by the specifications, the following procedures may be used when the base materials are stockpiled prior to delivery to the road:

(a) If representative samples of the material are taken as it is being stockpiled, and practically all of the test results meet, with a few tests substantially meeting the specification requirements, it will be permissible for the Engineer to accept the material in the stockpile, provided of course, that the Contractor properly handles the material for delivery to the road and that the minimum of 25% of tests will be sampled from the windrow for gradation, plasticity index, and liquid limit only.

(b) If representative samples of the material are taken as it is being stockpiled and some of the test results do not substantially meet the specification requirements, it will not be permissible for the Engineer to accept the material in the stockpile. Under these conditions, the mathematical average of all the test results, even though within the specification requirements, does not justify acceptance.

(2) When stockpiling is not required and the Contractor elects to haul directly to the road, samples for sieve analysis, soil constants, and wet ball mill tests may be taken from production, or from the road prior to compaction. When material is sampled from production, a minimum of 25% of tests will be sampled from the windrow for gradation, plasticity index, and liquid limit only.

(3) Samples for Triaxial tests preferably should be taken from production or from the completed stockpile.

Variations in sampling and testing and the fact that nearly all base materials change to some extent through handling, make it very important that all samples which are to be used for accepting the base material be taken at the same stages of construction. To be inconsistent in this respect would often lead to acceptable tests at one stage and unacceptable tests at some succeeding stage. The District Engineer should designate the actual points where samples for acceptance or rejection of the base material will be taken.

The methods used in sampling base materials should be carefully selected. The value of a test is almost entirely dependent upon the adequacy of sampling. When samples are taken from production, the arrangement of the processing plant will be the determining factor. Samples are usually obtained from the conveyor belts, loading bins, or from individual loads that are dumped on the stockpile. The uniformity of the pit supplying the raw material should be the determining factor in deciding whether composite samples are necessary. If a single conveyor belt brings the material to the loading bin, this usually will be the best point for sampling. Preferably, the belt should be stopped and the material covering the entire width of the belt and several feet in length removed to make up the sample. Methods used in sampling from the loading bins should provide for a large sampling of the entire cross section of the flow of the material from the bin. Individual loads dumped on the stockpile are best sampled by cutting away the top and digging deep to remove the sample, or by cutting away at one side and shaving the sample from the remaining vertical face. In either case, sufficient depth should be sampled to provide an average sampling of the materials in the load. Loads which appear to be segregated should not be sampled. Completed or partially completed stockpiles of crushed limestone and other similar base materials may be sampled satisfactorily using power-driven earth augers or drills capable of drilling through the entire depth of the stockpile. This method yields large samples which usually are carefully reduced to laboratory size at the drilling site. Use of augers or specially built core barrels reduces degradation of the sample to a minimum. Samples are obtained in this manner from several locations in the stockpile and are used to supplement tests made on the various layers during construction of the stockpile. This method provides composite samples consisting of all layers of the stockpile and the test results obtained from them should represent the base material that eventually will be loaded and delivered to the road. Samples taken from the road should be taken from the windrow after mixing and prior to rolling. Samples are usually obtained by removing a portion of the windrow, a full cross section in width and approximately one foot in length.

All acceptance testing should be performed in accordance with the applicable Texas Highway Department standard laboratory testing procedures. Any sieve analysis or soil constants tests which are made using abbreviated or accelerated methods should be regarded as tests for informational purposes only. Such tests, if used, should be made on representative portions of samples and followed up with tests being made on the remaining portions of the samples using the standard methods. Special attention must be given to samples suspected of containing clay. Materials containing clay are often difficult to prepare and Test Method Tex-101-E should be carefully followed in preparing such samples for test.

304.7 RECORDS AND REPORTS

Daily entries should be made in the diary book describing location of the work, instructions received from the Project Engineer, instructions given to the Contractor, unusual conditions, and other items of interest.

For density control projects, a tabulation should be kept of all the density tests made. This tabulation should include the following information: date of test, location of the test hole, (D_A) density, estimated moisture content, actual field density, actual moisture content, and percent of (D_A) density obtained. Failing test results should be referenced to subsequent tests and notations made as required to explain the action taken.

Construction Form 590, "Weekly Summary of Embankment, Subbase or Base Materials Test Results" should be submitted in accordance with the instructions on the form.

CHAPTER 5
LIME TREATMENT

305.1 INTRODUCTION

It is generally recognized that the addition and mixing of hydrated lime with plastic soil binder produces beneficial changes in the physical characteristics of the material. The following summarizes the most significant changes, which are of primary interest in highway construction:

1. The plasticity index is substantially reduced.
2. The plastic limit is substantially increased.
3. The liquid limit is usually decreased; however, for some soils the liquid limit may increase, particularly when the liquid limit of the untreated soil is approximately 45 or less.
4. The small soil particles are bonded together to form larger particles.
5. The density is reduced and the optimum moisture content is usually increased with any given compactive effort.
6. The Triaxial compressive strength is increased.

Extensive study and research has been directed toward determining the causes of these beneficial changes. Without being too scientific, it is believed that a brief review of these phenomena will be of value to the construction personnel associated with this type of work. The beneficial effects are generally attributed to complex chemical reactions that occur within the soil-lime-water mixture. These changes are usually grouped under the two main categories:

1. Ion Exchange and Flocculation

   When lime, plastic soil, and water are mixed together and allowed to cure in a loose-moist condition, there is a noticeable reduction in the plasticity of the soil, and the soil becomes friable and more workable. The chemical reactions responsible for this change are identified as "Ion Exchange" and "Flocculation". Undesirable monovalent sodium cations are replaced by desirable bivalent calcium cations on the surface of the clay particle. When available, additional calcium cations will also be crowded onto the surface of the clay particle. These processes of replacement and crowding substantially increase the electrical charge at the surface of the clay particle. Because of this increase, clay size particles are bonded together to form silt size or small sand size particles. The increase in the grain size is referred to as flocculation or coagulation or other terms of similar meaning, and under favorable conditions, this process for highly plastic soils is usually completed within several days.

2. Cementation

Two chemical reactions which produce a cementing effect have been identified. The first and faster of the two, involves calcium reaction with the available silica and alumina to form a gel of monocalcium silicates and aluminates which tends to cement the soil particles together in a manner similar to that produced by the hydration of portland cement, but occurring at a much slower rate. The second and slower cementing process, involves the absorption of carbon dioxide from the air which reacts with calcium hydroxide to form calcium carbonate (limestone). However, in order to derive any benefit from these reactions, the soil-lime mixture must be in a compacted condition.

305.2 GENERAL

Lime treatment is specified either for materials in place or for base courses. Materials in place may be subgrade, existing subbase, or existing base. Base courses will be new materials which may be used as subbases or bases. For both types, the construction methods may vary slightly due to different types of equipment being used and different types of material designated for treatment. Regardless of the variations encountered in construction, proper inspection must be concerned with the following basic operations.

305.3 PREPARATION OF MATERIALS

Standard Specification Item No. 260 (Lime Treatment for Materials in Place) and Item No. 262 (Lime Treatment for Base Courses) explain in detail the required manipulations for the "in-place" or the "new" materials prior to beginning of the lime treatment. It is essential that these instructions be followed in order to secure a firm subgrade for the treated material, to insure a uniform lime content in the mixture, and to control the depth of the treated course. If the material is of the type that will bulk substantially with the addition of lime, allowance may be made for the anticipated gain in volume. This could be an important consideration where fixed features will not permit slight adjustments in the grade and section.

305.4 APPLICATION OF LIME

Lime is usually delivered to the project in self-unloading truck transports. Each truck shipment must have the weight of lime certified on public scales, or the weight of lime must be determined on a set of platform or hopper scales furnished by the Contractor. It is essential that the weight of lime be known prior to its use.

Unless otherwise specified on the plans or in the specifications, the Contractor has the option of placing lime on the road either by the "Dry" or the "Slurry" method. Either method will produce satisfactory results, provided good operational procedures are used.

Good operational procedures dictate that lime be distributed with a reasonable degree of uniformity, and that proper care be exercised to avoid undue loss of lime. Dry lime shall not be spread when the wind conditions are such as to cause an excessive loss, or when blowing lime becomes objectionable to the traffic and adjacent property owners. In distributing lime, a uniform forward motion must be maintained and care must be exercised to secure proper laps of the longitudinal strips.

Frequent checks on the rate of application must be made. The actual distance or area of spread for each shipment should be compared with the desired distance or area of spread, as determined by the specified rate, and such information is to be made a part of the job records.

When the slurry method of application is used, lime and water are mixed into a slurry and applied through spray bars from tank trucks equipped with agitating equipment to keep the lime in suspension until it is spread. The procedure used for mixing the slurry should provide for accurate proportioning of lime and water. The proportion of the lime-water slurry usually depends upon the required percent of lime, the optimum moisture content of the soil or base material, and the field moisture content in the soil or base material at the time of application. When the specified percentage of lime is low, a slurry of low lime content will usually be desirable. High lime concentrations are necessary when the field moisture is near the optimum moisture content. During cool weather care should be exercised to prevent excessive application of lime slurry greatly exceeding the optimum moisture content of the soil as drying back to compaction moisture content often is a very slow and time consuming process. Overwatering of the soil or base material during hot weather presents no serious difficulties as the addition of lime to the soil or base material usually increases the capacity of the material for water. A minimum amount of mixing and aeration will be required to reduce the moisture content to the proper compaction moisture. Slurry consisting of 1 ton of lime and approximately 400 gallons of water (approximately 37% solution) is ordinarily the heaviest concentration which can be pumped and spread efficiently. Typical mixtures contain 1 ton of lime and about 500 gallons of water, or 1 pound lime and 2.1 pounds of water (approximately 32% solution). Lime slurries may be varied from the heaviest concentration down to a concentration which best fits the conditions for the specified rate of application, field moisture content, and optimum moisture content for compaction. When average lime contents are used, the usual conditions will permit an even distribution of the required percentage of lime without having to be too concerned about getting the treated mixture too wet. Two or more passes with the tank truck are usually required to spread the lime. After the lime is spread, the procedure will be to add moisture or dry back to near optimum moisture to provide a mixture having the proper moisture content for compaction. This can be done during the final blending and mixing operations.

The Standard Specifications do not permit application of lime to more area than can be satisfactorily mixed during the same working day, and also require that lime be mixed initially with the soil or base material within 6 hours after application. These requirements are necessary to prevent loss of lime due to wind and rain, and to prevent the use of lime which has been made less effective by exposure to the open air. Even though these requirements are met, the spreading operation should be well coordinated with the mixing and compaction operations. When application of lime is extended too far in advance of the other operations, moisture and density control procedures are often complicated by the gradual change in physical properties of the lime treated mixture.

305.5 MIXING OPERATIONS

Specifications generally require the same mixing procedure to be used for both the dry method and the slurry method of application, but with the following exceptions: When the materials contain plastic clays or other materials which will not readily mix with lime, lime usually must be mixed with the soil or base material, brought to the proper moisture content and left to cure or "rot" for a period of from 1 to 4 days before the final mixing is accomplished. Care should be taken during the initial mixing to distribute lime to the proper depth and width in order that the moist clay lumps, etc., will be in contact with the lime during the curing period. Again, it is good practice to establish a work schedule which will result in compaction being started on the mixed materials which have been cured about the same length of time. Proper work schedule will often simplify the compaction control procedures.

Final mixing should produce a uniform blend of lime, soil or base material, and water. Moisture contents slightly above the optimum will probably provide for a more uniform compaction due to the usual loss of moisture by evaporation. Pulverization tests, when required to check the degree of pulverization, should be made after the final mixing process.

305.6 COMPACTION, FINISHING, AND CURING

Compaction of the lime treated material should begin soon after mixing has been completed, using the specified or designated rollers.

Although this may depend on the type of roller being used, ordinarily it is advisable to blade the material into windrows on either side of the road in order to permit rollers to begin compaction at the bottom of the stabilized section. When other methods involving thicker lifts are permitted by the specifications, the Inspector should check to insure that the specified compaction is being obtained in the bottom of the section, as well as in the upper portions. Project plans will indicate whether the Ordinary Compaction or Density Control methods are to be used in securing the required compaction. When Density Control methods are specified, the Inspector should be very careful to select samples for making the required laboratory compaction tests which will be representative of the material to be compacted. As discussed previously, the chemical reaction which usually occurs when hydrated lime comes into contact with moistened clay materials results in a change in the physical characteristics of the soil or the fine portion of the base material. This physical change makes it advisable to make the laboratory compaction tests on the road samples taken just prior to the time when compaction will start. The laboratory density to be used in the field to check compaction should be determined in accordance with the Test Method Tex-114-E. Procedure similar to that described under "Compaction and Finishing" for the Portland Cement Treatment is recommended.

Finishing of the lime treated base course is very similar to the methods used for other flexible type base courses. If final finishing of the lime treated base courses involves rewetting and reworking of the material in order that it can be brought to the proper line and grade, additional lime (1/2 to 1%) should be added to the reworked material in order to maintain adequate strength in the reworked layer. This should be done at the Contractor's expense. Also, care should be taken to use the limed-sprinkling water sparingly for curing the treated materials which will receive thin asphalt wearing surfaces. Lime dust coating on the surface sometimes causes difficulty in obtaining good adherence of the asphaltic material to the compacted base course.

The Standard Specifications provide for a 7-day period of moist curing after the lime-treated base course has been brought to the required cross section and grade. During this period, sprinkling should be done as necessary to maintain the base in a moist condition and to control hair-cracking.

305.7 CRACKING AND FLUFFING

Cracking and fluffing are two objectionable features that frequently occur in lime treated base courses, and any construction procedure that would minimize or eliminate these problems would be of benefit.

Where extensive or excessive cracks have developed, usually their cause cannot be attributed to the construction procedures. However, it is generally conceded that if compaction of lime treated materials occurs prior to the chemical changes which lower the plasticity index and change the soil characteristics from plastic to friable, such a procedure may contribute to excessive hair-cracking. This would indicate that compaction should not start until it has been determined by visual inspection that the soil particles have reached a friable condition.

Fluffing is usually associated with the lack of curing, particularly during hot weather. The surface should be kept moist for seven days after compaction, but repeated flooding of the surface should be avoided. The loss of stability in the top 1/4" to 3/4" of the base course is usually attributed to the migration of lime from repeated flooding or excessive working, or reworking of the surface.

305.8 RECORDS AND REPORTS

Daily entries should be made in the diary book describing location of the work, instructions received from the Project Engineer, instructions given to the Contractor, unusual conditions, and other items of interest.

For density control projects, a tabulation should be kept of all the density tests made. This tabulation should include the following information: date of test, location of the test hole, (D_A) density, estimated moisture content, actual field density, actual moisture content, and percent of (D_A) density obtained. Failing test results should be referenced to subsequent tests and notations made as required to explain the action taken.

When density control is specified, Construction Form 590, "Weekly Summary of Embankment, Subbase or Base Materials Test Results" should be submitted in accordance with the instructions on the form.

CHAPTER 6
PORTLAND CEMENT TREATMENT

306.1 GENERAL

Portland cement treatment may be specified for materials already in place or for newly processed materials. Mixing and processing of the cement treated in-place materials normally involves road mixing with either multiple-pass or single-pass traveling mixing plants. For new processed materials, mixing may be accomplished on the road using either the multiple-pass or the single-pass traveling plant, or a central mixing plant may be specified.

On some projects, the cement content to be used in the materials will be established by the plans or specifications. On others, the desired minimum strength will be specified, and laboratory tests in accordance with the Test Method Tex-120-E must be made in order to determine the proper cement content. This test method is intended primarily for the design of the cement treated mixtures. When strength tests are specified for checking the design strength during construction, provisions should be made for testing the mixture at the site of the work.

The Standard Specifications describe the construction methods in detail and it will serve no useful purpose to repeat them here. For this reason, this discussion will be concerned mostly with those operations which should be emphasized and inspection procedures which are normally not included in the construction specifications.

Cement treated materials can be constructed properly only if the equipment and methods used in the work provide for the following:

(1) Completion of cement treatment of a length of treated section within the specified time limitations.
(2) Uniform distribution of cement throughout the base material.
(3) Good pulverization and moisture control.
(4) Proper densification.
(5) Adequate curing.

The Inspector assigned to this type of construction should devote his efforts mainly to the accomplishment of these objectives. The work involved in treating base materials with cement should be started by laying out several short sections rather than one long section. Preferably, these sections should be short enough to leave no doubt that the work can be properly completed during the time available. As the work progresses, length of the sections can be adjusted to fit the maximum capabilities of the equipment and personnel.

306.2 ROAD-MIX

When using the road mixing methods, it is necessary that the material to be treated is properly distributed on the road. When new materials are used, this can be accomplished by uniformly distributing the required amount of material in each 100-foot station. For in-place construction, the material to be treated usually should be shaped to the approximate desired section and grade, and compacted prior to the application of cement. This procedure will make it possible to secure the proper proportions of cement, base material, and water, and will make it easier to obtain the specified final cross section, grade, and desired depth.

There should be sufficient moisture in the material at the time cement is applied to prevent the loss of cement to the subgrade, but moisture should not be present in such amount that it will prevent proper blending of the materials, and it should never exceed the optimum moisture content. If a satisfactory blend of materials is not obtained during the mixing process, cement balls may form in the mixture when water is applied to bring it to the optimum moisture content. Water added to reach the optimum moisture content should be applied in small increments using pressurized equipment as specified. The specifications indicate that moisture checks should be made just prior to applying cement and just prior to beginning compaction. It may also be desirable to make a moisture check after the dry-mixing of the cement and base material in order to know the amount of water that needs to be added to reach the optimum moisture content. Oven-dried procedures for determining the moisture content will usually serve best until the Inspector has learned to satisfactorily estimate the moisture content in the material by visual means.

Bulk cement spreaders which are used in the work should be operated at a constant slow speed in order to obtain a uniform spread of cement. The spreader should be carefully positioned and guided through each spread to insure a uniform distribution of cement over the area to be covered. Cement spread checks should be made at the beginning of the spreading operations to check the initial adjustments of the spreader, and frequently thereafter, to make sure that the specified quantity is being spread. Spread checks generally are made in two ways:

(1) By making a square yard spot check. A 3 ft. x 3 ft. piece of canvas cloth is placed in the path of the spreader. After the spreader passes over it, the cloth is carefully picked up and the collected cement is weighed. Better accuracy can be obtained using larger canvas cloth in sizes up to 6 ft. x 9 ft.
(2) By comparing the desired linear distance of spread (based on the specified cement content), with the distance of spread actually obtained with a known quantity of cement.

By using these checks throughout the period of construction, the specified rate of application will be maintained and proper amount of cement will be used in the work.

When road mixing plants are used which require the raw material to be windrowed prior to mixing, provisions must be made for constructing windrows of uniform section and quantity. The quantity of material per linear foot of windrow should be known in order to correctly proportion the raw material and cement. A method for checking the cement distribution should be used to insure that proper distribution is maintained for each cement shipment and throughout the continuance of the stabilization work.

306.3 CENTRAL-MIX

On some projects, central mixing plants will be required. The proportioning of the base material, cement, and water will normally be done using a batching type or a continuous-flow type plant. Usually, all mixing of the proportioned materials will be done in a pugmill. Prior to beginning of the base haul operations, plant facilities should be checked to insure that satisfactory proportioning and mixing can be accomplished. Scales used for batching materials and for weighing the cement treated mixture for payment should be checked by the Contractor and should comply with Item 500, "Weighing and Measuring Equipment". Continuous-flow type plants should be carefully calibrated in order that all materials will be proportioned accurately. The mixer should be checked to determine that it is in good condition and will mix the materials satisfactorily. If water is measured by volume, water meters should be checked for accuracy. Cement storage facilities should be checked to insure that protection is provided against moisture and weather. The storage facilities for all materials should be adequate to insure that materials will be available and production can be accomplished within the specified time limitations.

In calculating batch weights or material proportions for the cement treated base material mixture, the Inspector should use the same basis for determining the cement requirements as was used in determining the plan quantities or in making the design test specimens, when required. On some projects, cement content may be based on the dry weight of the base material, while on others, it may be based on the dry weight of the combined cement-base material mixture. The difference in cement requirement is small on projects where average cement contents are used; however, the difference becomes larger as the specified percentage of cement increases, and for this reason the batching or proportioning designs should be carefully verified.

Specifications usually require that trucks used for hauling the cement treated mixture to the road be equipped with protective covers to minimize the loss of moisture. Ordinarily, dumping in piles or windrows on the subgrade is not permitted. Under the Standard Specification, approved spreaders must be used in laying the mixture.

306.4 COMPACTION AND FINISHING

Compaction should begin immediately after the required cement and moisture have been evenly incorporated into the mixture by the road-mixing method, or after the spreader has placed a sufficient amount of properly shaped plant mixed material on the subgrade. As discussed previously, the length of the treated sections should be adjusted to the capabilities of the equipment and personnel, and it will depend on the weather conditions. The density of the compacted cement treated mixture has a definite bearing upon the ultimate strength of the completed base. For this reason, the specifications include density requirements for controlling the compaction operations. Due to the effects of partial hydration of the cement during the mixing and placing operations, the plans or specifications usually require that the field density be not less than 95 percent of the Compaction Ratio density as determined from the road mixture tested in accordance with the Test Method Tex-114-E. After sampling, the road mixture should be placed in a sealed container and transported to the laboratory for testing. Molding of the test specimens should be correlated with the road operations in order that the elapsed time between sampling and completion of molding will correspond to the elapsed time between sampling and completion of compaction on the road. Due to the effects of the cement, it is usually best not to dry-back and screen the mixture, but to run the moisture-density curve on the moist material as taken from the road just prior to compaction. This can be done by splitting the road sample, which should be near optimum moisture content, into four parts. One portion should be molded immediately, and after testing, it should result in a point located near the peak of the moisture-density curve. Two portions should be wetted and molded to result in points on the wet side of the optimum. The remaining portion should be allowed to dry-back slightly and then molded to result in a point on the dry side of the optimum. The compaction process can then be checked using the maximum density determined in this manner.

The Standard Specifications describe in detail the finishing process that is to be used on the cement treated bases and the finishing requirements should be followed carefully. When transverse construction joints are formed by cutting back to a vertical face, all roughness and ungraded material should be cut away, leaving only a smooth section free from loose and shattered material. Special care should be taken to secure good compaction when placing fresh mixture next to a previously finished base. Sometimes it is better to finish the fresh mixture at the joint slightly higher and trim it to grade during the "tight-blading" finishing operation. Joints finished low usually cannot be corrected because it is not possible to satisfactorily add thin layers of material to the base surface.

Most of the cement treated courses are shaped and finished by blading. Probably due to the time limitations and the nature of the work, smooth riding surfaces built to line, grade, and section are difficult to secure. If a treated course is not properly constructed from the start, it is next to impossible to correct the errors or faults without tearing everything out and starting over - something that no one likes to do. Too frequently, this is the only solution.

A wavy surface and non-uniform sections are caused when proper grade is not followed in finishing between blue tops. If the blade operator is not skilled to the extent that he can maintain proper grade and section between blue tops, he should be replaced with one that can. Also if blue tops are set too far apart, the spacing should be reduced. Joints between the adjoining sections always need double or even triple checking.

Too much emphasis cannot be placed on checking the grade and section at and between the blue tops as the treated course is being finished, and both the inspecting and the Contractor's personnel should check this operation.

306.5 CURING

The cement treated course should be kept wet for the period of time specified. This is usually accomplished using one of the three methods:

(1) Sprinkling as necessary throughout the specified curing period to maintain the moist condition.
(2) Application of an asphalt membrane.
(3) Application of a 2-inch earth layer and sprinkling as necessary to maintain the base course in a moist condition.

Regardless of the curing method used, the proper moisture condition of the treated course should be maintained throughout the specified curing period. If it is not possible to apply a moist soil layer or an asphalt membrane immediately after finishing the course, sprinkling should be continued until such time as the moist earth layer or asphalt membrane can be applied.

306.6 RECORDS AND REPORTS

Daily entries should be made in the diary book describing location of the work, instructions received from the Project Engineer, instructions given to the Contractor, unusual conditions, and other items of interest.

For density control projects, a tabulation should be kept of all the density tests made. This tabulation should include the following information: date of test, location of the test hole, (D_A) density, estimated moisture content, actual field density, actual moisture content, and percent of (D_A) density obtained. Failing test results should be referenced to subsequent tests and notations made as required to explain the action taken.

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CHAPTER 7
SOIL ASPHALT BASES

307.1 GENERAL

Soil asphalt bases are constructed using either the plant-mixed or the road-mixed materials. At this time, the use of the plant-mixed materials far exceeds the use of the road-mixed materials principally because of the better control offered by this type of operation and the simplification of traffic problems which are common in the present day highway construction. The control required for the production and placement of plant-mixed soil asphalt base material is normally very similar to that of regular hot mix asphaltic concrete and is covered by the Construction Bulletin C-14. For this reason, only the fundamental steps involved in the road-mix operations will be discussed in the following paragraphs.

The type of asphalt to be used normally will be indicated on the project plans, and usually will be based on the results of laboratory tests made during the design stages for the project. If minimum design strength is specified, the procedures described in the Test Method Tex-119-E should be followed in making the preliminary design tests to determine the percent of asphalt to use in the soil asphalt base.

307.2 CONSTRUCTION METHODS

The equipment used in the work should be in good condition and should meet all the requirements of the specifications. Equipment checks should be made prior to beginning of the work to ascertain the following:

(1) That the equipment to be used for applying asphalt is properly calibrated and is capable of applying the material at the specified rate and at the proper temperature.
(2) That the equipment to be used for mixing is capable of uniformly blending the materials to the required depths.
(3) That water truck capacities have been determined if required.
(4) That the required type of rollers will be used for compaction and that they are of the specified dimensions and weights.

(5) That asphalt storage facilities are adequate and equipped with the necessary facilities for maintaining proper control of the heating temperatures.

The procedures used in constructing soil asphalt base courses will vary to some extent depending upon the type of soil and the type of equipment used in the work. Soil may be one of the following: an existing soil in the roadbed, a mixture of new material and existing soil in the roadbed, or entirely new material hauled in from local pits. Asphalt materials generally mix well with sandy soils. Coarse sands also mix very well; however, much of the stability exhibited by the mixture is normally due to the fine portion of the soil. Consequently, it is desirable to use soils that are well graded and contain a good balance of the coarse and fine grained particles. This type of soil, when properly blended with the asphaltic material, usually results in a base course meeting both the structural and economic requirements. Because of the variables involved, it is not possible to establish a construction procedure that would be adaptable under all conditions. For this reason, a general procedure will be discussed and it is expected that certain changes will be necessary to fit the conditions on a particular project. Specifications for the project will be designed to fit these special conditions and must be followed in all instances.

On the usual soil asphalt project, the existing roadbed material should be shaped to a uniform section and grade, pulverized, mixed with new material if required, and moved to the shoulder areas. This will expose the subgrade which usually must be shaped, sprinkled, and compacted to provide a firm and stable foundation for the soil asphalt base. Additional or new base material that must be hauled in should be delivered in approved vehicles of uniform capacity and the required amount placed in each 100-foot station by dumping in accordance with the predetermined load spacings.

Mixing of the soil and asphalt is usually accomplished with pulvi-mixers and disk-harrows working in conjunction with maintainers. Asphalt is applied to the evenly spread material by approved distributors in increments usually at a rate not exceeding 1 gallon per square yard. Thorough mixing is required after each application until a proper amount of asphalt has been uniformly mixed with the soil. Water, as necessary, is added during this operation to disperse the asphalt evenly through the soil and to provide water for compaction. Generally, it is considered best to add only enough water to provide for the proper dispersion of the asphalt throughout the soil. If this amount of moisture does not provide sufficient lubrication of the mixture to obtain the specified compaction, then additional moisture should be added.

When travel plants have been approved for mixing asphalt and soil and the method of mixing requires the use of windrows, these windrows should be accurately sized and of uniform section to insure the proper proportioning of the materials in the mixture. Regardless of the method of mixing, the overall operation must produce a mixture of uniform color and texture, free from fat or lean spots and lumps of soil. Aeration of the mixture to release volatiles or asphalt solvent is vital. Volatiles remaining in the mixture when compaction begins often result in a base course lacking the required stability. Experienced judgment and laboratory tests are necessary to determine that the volatile content has been reduced to a point where compaction can be started. Moisture content should also be reduced during this operation to the lowest percentage that will permit compaction to the required density. Excessive moisture in the base course after the completion of compaction may result in lack of stability under construction traffic and future failures due to inability to cure the base properly prior to placement of the surface.

After mixing of the soil, asphalt, and water has been completed and the volatiles released, rolling can be started. Compaction is accomplished by blading and rolling at the proper moisture content until the specified density has been obtained. The laboratory density to use in the field to check compaction should be determined from the road mixed samples in accordance with the Test Method Tex-119-E. Under this test method, moist samples taken from the roadway during construction should be quartered to approximate specimen size batches, and molded to establish the peak of the moisture-density curve for use in controlling field compaction.

The application and mixing of the asphalt with the soil should not be allowed to proceed too far ahead of the compaction operations. The length of the treated section should be controlled in order that rolling will start as soon as mixing and aeration have been completed. During compaction, the shape of the soil asphalt base should be maintained by blading, if necessary, and the methods used should not result in the formation of laminations and cleavage planes. Finished bases that are slightly high, usually can be honed to a smooth grade by blading. The finished base must be allowed to dry before it is covered by another layer or a surface course.

307.3 RECORDS AND REPORTS

Daily entries should be made in the diary book describing location of the work, instructions received from the Project Engineer, instructions given to the Contractor, unusual conditions, and other items of interest.

For density control projects, a tabulation should be kept of all the density tests made. This tabulation should include the following information: date of test, location of the test hole, (D_A) density, estimated moisture content, actual field density, actual moisture content, and percent of (D_A) density obtained. Failing test results should be referenced to subsequent tests and notations made as required to explain the action taken.

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CHAPTER 8
PRIME COATS, SEAL COATS, AND SURFACE TREATMENTS

308.1 GENERAL

This chapter is primarily concerned with the operations involved in the actual construction of prime coats, seal coats, and surface treatments. The design procedure is not discussed in this chapter, as is assumed that the design of the surface application has been made prior to construction. If additional information concerning the design is desired, reference may be made to Manual Series No. 13, "Asphalt Surface Treatments and Asphalt Penetration Macadam", published by the Asphalt Institute, and to "Supplement to Volume 29 of the Proceedings of The Association of Asphalt Paving Technologists".

308.2 DESCRIPTION

Several types of surface applications are included in the specifications. These range from a prime coat to a three course surface treatment. The descriptions and purposes of the various types of surface applications discussed in this chapter are given below.

A. PRIME COATS. The two types of prime coats in the Standard Specifications are the penetrating type and the non-penetrating type.

Penetrating Type Prime Coat. This type of prime coat consists of an application of asphaltic material on a completed base course or other approved area.

Non-Penetrating Type Prime Coat. This type of prime coat consists of an application of asphaltic material on a completed base course or other approved area covered with sweepings from the base and/or with native sand.

Even though the two types are slightly different, they serve the same purposes. The primary purposes of a prime coat are to prevent absorption by the base of the asphaltic material contained in the subsequent surfacing material, to promote adhesion between the base and the surfacing, and to provide a dust free surface upon which to apply the asphalt of the wearing surface.

The penetrating type prime coat prevents absorption by penetrating the base surface and plugging the capillary voids. The non-penetrating type prime coat prevents absorption by sealing over the base surface and results in a thicker surface mat using approximately the same quantities of asphalt as for the penetrating type prime coat.

B. SEAL COAT. A seal coat consists of a single application of asphaltic material covered with aggregate. Seal coats are used to resurface the existing surfaces. Surface defects such as cracks, raveling, bleeding, and lack of skid resistance can be corrected by a properly placed seal coat.

C. SURFACE TREATMENTS

One Course Surface Treatment. A one course surface treatment consists of a single application of asphaltic material covered with aggregate. It is usually placed on a completed base to provide an economical, all-weather wearing surface.

Two Course Surface Treatment. A two course surface treatment consists of two separate applications of asphaltic material, each covered with aggregate. It is used when it is necessary to provide an economical and dense waterproofing and wearing surface in order to accommodate a moderately high volume of traffic.

Three Course Surface Treatment. A three course surface treatment consists of three separate applications of asphaltic material, each covered with aggregate. It is used when it is necessary to provide a dense waterproofing and wearing surface in order to accommodate a high volume of traffic.

308.3 OPERATIONS PRIOR TO CONSTRUCTION

Extensive preparatory work is necessary prior to the actual construction operations for a prime coat, seal coat, or a surface treatment. The quality of the end product depends considerably on the manner in which the preparatory work is done, and it is important that this work be performed as conscientiously as possible.

A. TESTING AND STOCKPILING OF MATERIALS. Prior to use, all materials must be tested for compliance with the requirements of the governing specifications. Asphaltic materials and cover aggregates are usually tested and approved at their respective sources; however, if any material has not been tested prior to its arrival on the project site, it will be necessary for the Engineer or his authorized representative to sample the material and have the samples tested.

1. Asphaltic Material. All asphaltic materials used on highway construction projects are tested and approved at the refinery by the personnel of the Materials and Tests Division. Three copies of Form 537, Asphalt Loading Certificate, usually accompany each shipment. This certificate is issued to inform the Engineer that the material in the respective shipment was drawn from an approved tank.

   Occasionally, a loading certificate is not issued or is lost while the shipment is en route to the project. If this happens, permission to use the material should be withheld until the Materials and Tests Division has been notified and clearance, either verbal or written, for the material has been received.

2. Aggregate. The general types of cover aggregate used are: gravel, crushed gravel, crushed limestone, crushed slag, crushed natural limestone rock asphalt, and lightweight aggregate which may be burned clay or burned shale. When precoated aggregates are specified, these aggregates, with the exception of lightweight aggregate, are coated or fluxed with 0.5 to 1.5 percent by weight of light asphaltic material. Cover aggregate obtained from a commercial plant is sampled and tested at the plant site by the personnel of the Materials and Tests Division. Cover aggregates obtained from a source other than a commercial source must be sampled by the Engineer or his authorized representative and tested as required by the governing specifications.

3. Native Sand. Native sand and its source are subject to the approval of the Resident Engineer.

4. Stockpiling of Aggregate. In this type of work, the aggregate is usually stockpiled in a neat and orderly manner along the right-of-way at a location or locations convenient to the project. The proposed stockpile site should be examined prior to the arrival of the aggregate to make certain that the stockpile will not interfere with the roadway drainage or obstruct traffic; and that the site has been leveled and cleaned of all trash, weeds, grass, or other debris in order to prevent contamination of the stockpiled aggregate.

B. INSPECTION, CALIBRATION, AND ADJUSTMENT OF EQUIPMENT. As each piece of equipment arrives on the project, it should be inspected for compliance with the requirements of the governing specifications, and to make certain that it is properly adjusted prior to its use. Each piece of equipment which is used to measure materials must also be calibrated to determine its capacity.

1. Asphalt Distributor. The Standard Specifications governing these types of work require an approved, self-propelled, pressure distributor for applying the asphaltic material. The asphalt distributor consists of several components, and it is considered necessary to inspect each one, and perform calibration and adjustments as required.

a. Tank. The tank is an insulated shell equipped with flues, thermometer, baffle plates, manhole, and an overflow pipe. Prior to using the distributor, the tank must be in a clean condition. It will be necessary to look inside the tank to see that it has been properly cleaned.

If the distributor has been used previously on State highway work, it will have been calibrated. Copy of the notarized calibration data which was prepared by the person who calibrated the distributor and which identifies and describes the distributor, and relates the depth of material in the tank to the volume of material, should be secured from the Contractor. A statement of this calibration must be placed in the job records.

When the calibration data has been secured, it should be verified that it applies to the distributor on the project. If no changes have been made, it will be satisfactory to begin construction basing the measurement of asphaltic material on the calibration data. Should the measurement of materials by the calibration data obviously be erroneous, it will be necessary to recalibrate the distributor tank.

If the distributor has not been previously used on State highway work, if the volume of the tank has been changed, or if calibration data cannot be provided by the Contractor, it will be necessary to calibrate the distributor prior to its use. The best time to perform the calibration is immediately after the tank is inspected and found to be clean.

For the distributor to be calibrated, the tank must first be leveled, both longitudinally and transversely, with a spirit level. When it is leveled, enough water should be added to completely fill all pipe connections and to stand approximately one-sixteenth of an inch deep on the bottom of the tank. This amount of water, in gallons, should be recorded and then enough water added to bring the total amount in the tank to the nearest multiple of ten gallons, and this amount and the corresponding depth recorded. Next, water should be added in increments of ten gallons until the tank is filled. After each ten gallons has been added, the water surface must be allowed to become completely still in order that the depth can be determined. When the depth is being measured, the rod must be held vertically in the center of the tank.

Calibration of the distributor should be done in the presence or under the authority of the Resident Engineer. When the calibration is completed, the data should be carefully prepared along with the identification, description, and the measurements of the tank and an adequate description of the rod used for measuring the depth of material inside the tank. This must be signed by the Resident Engineer under affidavit. A copy must be retained for the contract file and the original should be given to the Contractor.

b. Heating System. The heating system is composed of one or more burners, each of which directs a flame into a flue. The asphaltic material is heated by coming in contact with the flue, and it must be circulated while it is being heated.

c. Circulation System. The circulating system consists of a pump with lines passing from the tank to the spray bar and hand spray, and back to the tank. The proper operating pump pressure or the proper pump speed, depending on the type of pump control, should be determined in the field. This determination can be made by the following procedure. The spray bar should be set in the highest operating position. Then, with the asphaltic material at the application temperature selected by the Engineer, the pump pressure should be increased in increments of five pounds from ten to thirty pounds per square inch. If the pump speed is the controlling factor over the rate of discharge, the pump speed should be increased in increments so that the discharge rate per linear foot of spray bar length is increased by two and one-half gallon increments from five gallons to fifteen gallons per minute. The highest possible pump pressure or speed that does not cause distortion or atomization of the spray is the proper one to use during construction operations.

This determination is extremely important because the pump speed or pressure has considerable effect on the uniformity of the transverse distribution of the asphaltic material. If the pump speed or pressure is too low, there will be unequal amounts of material discharged from the individual nozzles and the application will be streaked and non-uniform. If the pump speed or pressure is too high, the spray fans will be distorted, the asphaltic material may be atomized, and as a result, the application will be streaked and non-uniform. The ideal spray fan which can be secured at the highest possible pump speed or pressure, should appear as a solid sheet of asphaltic material extending from the nozzle opening to the surface.

d. Tachometer. The tachometer is a device used for measuring the traveling speed of the distributor. It consists of an independent wheel equipped with a rubber tire which is so designed and mounted that it may be raised from the operating position when the distributor is not applying the asphaltic material. When the wheel is lowered to the road surface, there must be sufficient pressure exerted to keep it in contact with the surface while the distributor is being operated. This wheel is connected to an indicating instrument mounted in clear view of the driver of the truck. Since projects are staked in feet, it is necessary for the instrument to indicate the speed in feet per minute.

e. <u>Volume Gauge</u>. The volume gauge should be reasonably accurate. It is used for the convenience of the distributor operator and in no instance should it be used to measure volume for payment.

f. <u>Spray Bar</u>. Proper inspection and adjustment of the spray bar is essential to securing a uniform application of the asphaltic material. There must not be <u>any</u> slack in the linkage from the control to each nozzle so that <u>all</u> of the nozzles will be <u>completely</u> opened or <u>completely</u> closed when the control is operated. There must be <u>no</u> leakage of asphaltic material <u>at any time</u>.

(1) <u>Nozzles</u>. The condition of the nozzles has considerable effect on the shape and uniformity of the fan of the sprayed material. Prior to use, all nozzles should be removed from the spray bar and cleaned in kerosene or other suitable solvent. The nozzle slots should be inspected to see that they are of proper size and that the edges are not damaged. A nozzle with a damaged slot will produce a distorted fan. All nozzles which are damaged or are of irregular size must be replaced with acceptable nozzles. <u>Generally, the smallest size nozzle available for a distributor will provide the most uniform application of material</u>.

All nozzles should be positioned so that the longitudinal axis of each slot makes the exact angle recommended by the manufacturer with the longitudinal axis of the spray bar. See Figure 1. This angle of setting will prevent interference between the fans of material sprayed from the adjacent interior nozzles. All distributors are equipped by the manufacturer with a special wrench for setting nozzles at the required angle. If this wrench is not available, it is recommended that one be made or otherwise acquired. <u>The angle setting should not be estimated</u>. It is recommended that a "cur-

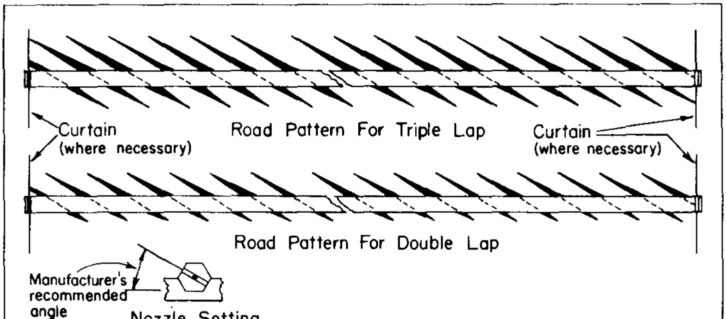


Figure 1

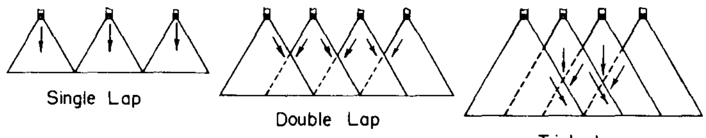
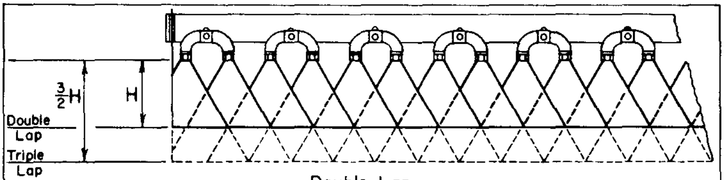
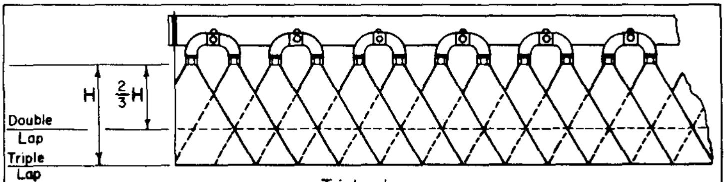


Figure 2



Double Lap
Figure 3



Triple Lap
Figure 4

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tain" or shield be attached to the outside end or ends of the spray bar, in areas where it is necessary for the asphaltic material to be placed to a neat edge line.

(2) Spray Bar Height. After all nozzles have been set at the proper angle, the spray bar must be set at the proper height to secure either double-lap or triple-lap coverage. See Figure 2. This operation is extremely important because the spray bar height has considerable effect on the uniformity of the transverse distribution of the asphaltic material. If the spray bar is either too high or too low, the application will be streaked and composed of heavy bands or light bands alternating with the desired application rate. The heavy streaks will probably flush to the surface and the light streaks will not hold the cover aggregate.

The spray bar height must be determined in the field under normal shooting operations. The height of the spray bar should not materially increase due to the action of the truck springs as the distributor tank is emptied. The difference in the spray bar height when the distributor is loaded and when it is empty should not be more than one-quarter of an inch. If the difference is greater than one-quarter of an inch, corrective action must be required of the Contractor or the applications of asphaltic material will be streaked.

The proper spray bar height can be determined by one of the following procedures:

Double-Lap Coverage. Only the center portion of the spray bar is used to set the height of the bar. Alternate nozzles are closed and the distributor is operated for short intervals at the proper pump speed or pressure determined as described under the "Circulation System". After each interval, the spray bar is raised or lowered, as required, in increments of not more than one-half of an inch until it is determined by visual inspection that an exact single-lap of material is being applied.

When the closed nozzles are opened, an exact double-lap of material will be applied. To change from a double-lap coverage to a triple-lap coverage, the spray bar height is increased by fifty percent. See Figure 3.

Triple-Lap Coverage. Again, only the center portion of the spray bar is used. Beginning at one end, close the second and third, the fifth and sixth, the eight and ninth, etc., nozzles. The distributor is operated for short intervals at the proper pump speed or pressure determined as described under the "Circulation System". After each interval, the spray bar is raised or lowered, as required, in increments of not more than one-half of an inch until it is determined by visual inspection that an exact single-lap of material is being applied. When the closed nozzles are opened, an exact triple-lap of material will be applied. To change from triple-lap coverage to double-lap coverage, the spray bar height is reduced by 33 1/3 percent. See Figure 4.

g. Traveling Speed. The proper traveling speed for any distributor is determined by the following formula:

$$S = \frac{9D}{WR}$$

Where: S = traveling speed in feet per minute
D = discharge rate in gallons per minute
W = width of roadway surface to be treated in feet
R = desired rate of application in gallons per square yard

h. Transverse Spread. The transverse spread of the asphaltic material will be uniform if the proper size nozzles have been selected, if all of the nozzle slots have been set at the correct angle, if the spray bar has been set at the correct height, and if the proper pump speed or pressure is used. The following procedure may be used to check the transverse spread. It is preferable to make this determination at the end of a "shot" or application.

For this test, strips of thin, foil-backed insulation twelve inches wide and fifteen inches long should be prepared. Each of these strips must be as near the same width and length as practically possible. Each individual strip must be marked for identification and weighed, and this information must be recorded. Strips should be placed side by side on the ending paper with the leading edges of the strips flush with the leading edge of the ending paper. It may be necessary to use an additional width of building paper in connection with this determination. The strips should be placed to the full length of the spray bar and the position of each strip should be recorded. The distributor is passed over the positioned strips as the "shot" is completed. The fibers of the insulation will prevent the asphaltic material from flowing. Each strip is then weighed again. The increase in the weight of each strip is the amount of asphaltic material sprayed on each strip. The amount of material received by each strip should not deviate from the arithmetic average by more than plus or minus ten percent. If the amount is outside of this tolerance, corrective action should be required of the Contractor.

i. Longitudinal Spread. If the distributor is in good working condition, has been properly inspected and adjusted, and is operated at the proper speed, the longitudinal spread will be sufficiently uniform.

2. Aggregate Spreader. The Standard Specifications require the aggregate spreader to be an approved, self-propelled, continuous-feed type, unless otherwise shown on the plans or authorized in writing by the Engineer. The self-propelled continuous-feed type spreader is preferred because it permits close control of the traveling speed and it can apply the cover aggregate continuously and uniformly. It can also keep up with the distributor better since its operation is not totally dependent on the aggregate trucks. This permits the aggregate to be applied immediately while the asphalt is still able to bond the particles to the surface.

a. Inspection, Calibration, and Adjustments. The aggregate spreader must be inspected to see that it is in good operating condition. It should be calibrated and adjusted in accordance with the manufacturer's recommendations and operating manual.

b. Traveling Speed. The speed at which the spreader is to be operated must be correlated with the discharge opening and should be based on the manufacturer's recommendations. If the individual truck loads of aggregate do not satisfactorily cover the length of roadway calculated, based on the desired rate of application, the speed or opening must be adjusted until satisfactory coverage is being obtained. Spreader must travel in a smooth manner and the operating speed must always be less than the speed at which the spreader will lope or undulate.

c. Spread. If the spreader is in good working condition, is properly adjusted, and is operated at the proper speed, both the transverse spread and the longitudinal spread will be sufficiently uniform.

d. Connecting Hitch. The hitch by which the spreader is connected to the aggregate trucks must be checked to make certain that it will furnish positive connection while the truck is dumping the aggregate, and to make certain that it can be released quickly by the spreader operator when the truck is empty. If it does not meet these requirements, it must be repaired or replaced.

3. Aggregate Trucks. The trucks proposed for use in hauling the cover aggregate and native sand, if required, must be inspected to make certain that they are in good operating condition and that the truck beds are free of leaks. Each truck should be identified by a permanent and plainly legible number.

a. Calibration. The Standard Specifications provide for cover aggregate to be measured by the cubic yard. It is necessary, therefore, to determine the volume of the truck beds in accordance with the recommended procedure in Part I, Chapter 9, "Measurement and Payment".

b. Connecting Hitch. The hitch by which the truck is connected to the aggregate spreader must be checked to see that it will furnish positive connection. If it does not, it must be repaired or replaced.

4. Rollers. It is recommended that seal coats and surface treatments be rolled primarily with self-propelled, pneumatic tire rollers, because experience has shown that flat wheel rollers may do more harm than good. The flat wheel roller tends to reduce the size of the aggregate which was determined in the design as being correct and thus violates a fundamental principle of construction procedure, which is to avoid using any practice or equipment that will appreciably change the design characteristics of the material being used. Furthermore, in areas of depressions it will come in contact with only the high spots, and as a result, the aggregate particles will not be pressed into the asphaltic material in surface depressions. The same will also occur in areas where the roller is carried by a relatively few large particles.

   The pneumatic tire roller will provide a uniform pressure over the entire area if all tires are of the same size and ply, and are inflated to the same pressure. The necessary data for use in determining the contact areas and contact pressure should be secured. Information on this subject is also contained in the "Pneumatic Tire Pressure Table", in the Appendix. By using the roller charts which relate the tire inflation pressure and the amount of ballast or load to the ground contact pressure, the desired ground contact pressure can be obtained by varying the amount of ballast on the roller and the tire inflation pressure.

a. Pneumatic Tire Rollers. All pneumatic tire rollers must be inspected for compliance with the requirements of the governing specifications. In addition, the king pin on each roller should be inspected for excess slack and the roller should be observed in operation to make certain that the front wheel assembly does not wobble or vibrate excessively. The operation of the roller should be observed and corrective action should be required of the Contractor for any wheel that vibrates or wobbles on its axle. The use of any roller which cannot be started, operated, stopped, or turned around without excessive vibration or displacement of the aggregate shall not be permitted.

b. Flat Wheel Rollers. If flat wheel rolling is used, each roller must be inspected for compliance with the requirements of the governing specifications. Each wheel should be examined to make certain that it is not pitted, and that the wheel rims are not worn excessively. The king pin on each roller should be inspected for excess slack and each roller should be observed in operation to make certain that the front wheel assembly or either of the rear wheels does not wobble or vibrate excessively. Just as for the pneumatic tire rollers, the use of any roller which cannot be started, operated, stopped, or turned around without excessive vibration or displacement of the aggregate shall not be permitted.

5. Power Broom. Power brooms are often used to remove dust just prior to construction operations from the surface which will receive a prime coat, a seal coat, or a single or multiple course surface treatment. They are also used to remove loose aggregate from new seal coats or surface treatments after the asphaltic material has set or hardened. Any broom proposed for use must be inspected to make certain that it is in good operating condition. If the bristles of the broom are worn excessively, the broom should be replaced.

6. Secondary Aggregate Distribution Equipment. The self-propelled, continuous-feed type aggregate spreader will provide sufficiently uniform distribution of the cover aggregate if it has been adjusted and is operated properly. The use of secondary distribution equipment, such as brooms, blades, and rakes, or utility crews as a supplement to the aggregate spreader is convincing testimony to the fact that the aggregate spreader was not adjusted or operated properly.

7. Miscellaneous Equipment. All storage tanks, piping, and booster tanks which may be used in the operation should be clean and in good operating condition. If any of this equipment is proposed for use, it must be inspected for compliance with these requirements, and also to make certain that its operation will not permit contamination of the asphaltic material.

308.4 PREPARATION OF THE ROADWAY

Since the quality of the actual construction depends to great extent on the condition of the roadway, the need for proper preparation of the roadway prior to construction cannot be overemphasized. The preparation of new work, such as base or a foundation course, and the preparation of existing surfaces are slightly different and will be discussed separately.

A. EXISTING ASPHALTIC SURFACES. The riding quality of the new seal coat or surface treatment cannot be better than the surface on which it is placed.

Existing asphaltic surfaces will generally require repair for surface defects. The most common surface defects are raveling, cracks (including transverse, longitudinal, alligator, slippage, and shrinkage cracks), broken edges, potholes, corrugations, depressions, bumps, foreign material (such as mud) adhered to the surface, absorbent areas, and flushed or bleeding areas. All of these types of defects should be properly repaired well in advance of the construction operations.

The existing surface must be cleaned just prior to the application of the bituminous material. All foreign materials such as paper and mud must be removed. The entire surface should then be thoroughly broomed to remove dirt and dust. If the Contractor elects to remove the dirt and dust by flushing the surface with water, the surface must be allowed to completely dry before any asphaltic material is applied.

The edge of the existing pavement is used as a guide in placing the new surface; therefore, it will not be necessary for the Contractor to set a string line guide.

B. NEW BASE OR FOUNDATION COURSES. It should seldom be necessary to repair new surfaces, since the base course should have a smooth riding surface when finished and have been under traffic long enough for defective areas to have been detected and corrected.

1. Preparation for Penetrating Type Prime Coat. In order to obtain a satisfactory prime coat, the base or foundation course must be smooth, properly compacted, properly cured, uniformly dry, and clean before the asphaltic material is applied.

Asphaltic material will not penetrate a damp surface; therefore, it will be necessary to suspend sprinkling for several days prior to placing the prime coat in order to obtain a uniformly dry base course. The drying time will depend on the type of material. A prime coat placed on a base course that is damp or wet, or has damp or wet areas, will usually bleed through the finished wearing surface and cause unsightly areas with little or no skid resistance.

After the base course has been dried, all traffic should be removed, and the entire surface should be broomed to remove all loose material and as much dust as possible. Generally, there will be a small amount of dust remaining on the surface after cleaning, which may cause the asphaltic material to "ball up" and leave small areas not covered with prime. This problem can be remedied in one of two ways: by sprinkling the base very lightly prior to placing the prime, or by rolling the prime with pneumatic tire rollers immediately after its application.

It is recommended that the method which uses the pneumatic tire rollers be employed because it will give a more uniform distribution of the prime, and if the base is unusually dense, rolling with pneumatic tire rollers will cause better penetration by the prime.

If the sprinkling method is used, sprinkling should be carefully controlled so that a very light, uniform application of water will be obtained. As previously stated, asphaltic material will not penetrate a damp or wet surface; therefore, sufficient drying time must be allowed after sprinkling in order that the base can be penetrated by the prime.

After the surface has been cleaned and otherwise prepared for the prime coat, a string line must be set by the Contractor along one side and about two feet outside of the surface area which is to receive the prime coat. The nail line set by the Engineer may be used as a reference for setting the string line. This string line will be used to guide the distributor as the prime coat is being applied.

The base and the string line should be inspected "on foot" before each application of the asphaltic material to see that the surface is still properly prepared and that the alignment of the string line is correct.

2. Preparation for Non-Penetrating Type Prime Coat. With one exception, the preparation of the base for this type of prime coat follows the same procedure as the preparation for a penetrating type prime coat. This one exception, however, is very essential to securing the desired results and consists of placing the prime on a damp surface instead of a dry surface in order to prevent penetration by the prime and to eliminate any tendency for the asphaltic material to "ball up"

   After the base has been dried and cleaned, it should be sprinkled just enough to insure that it is uniformly moist. This procedure should be followed, since any other procedure will more than likely result in some areas being too wet, which will cause bleeding through the finished wearing surface at the excessively wet areas and loss of skid resistance.

   The base sweepings are usually swept into a windrow along each shoulder so that the material is readily available to cover the surface after the asphaltic material has been applied. Native sand, as required to cover the surface, should be used promptly.

3. Preparation of Primed Surface for Surface Treatment. The first step in the preparation of a primed surface for a surface treatment is to make certain that the prime coat has properly cured. A properly cured prime coat is one in which there are no volatiles or free asphalt present. If a surface treatment is placed on an improperly cured prime coat, it will be too rich in the areas of the volatiles and the free asphalt, and bleeding or flushing will probably result.

   After it has been determined that the prime coat has properly cured, all loose material such as dirt, dust, and other foreign material should be broomed off the primed surface.

The string line set as a guide for placing the prime coat may be straightened and repaired, or a new string line may be set for use in placing the surface treatment.

The surface and the string line should be inspected "on foot" to see that the surface is properly prepared and that the alignment of the string line is correct.

308.5 CONSTRUCTION

The actual construction operations have a direct bearing on the quality of the end product; therefore, it is essential that the construction operations receive careful attention of both the Contractor's and the Department's personnel.

A. WEATHER. The most ideal weather conditions for placing prime coats, seal coats, and surface treatments can be described as hot, calm, and dry. The Standard Specifications specify the minimum air temperature at which these types of construction can be placed.

None of these types of construction have ever been satisfactorily constructed during wet weather. Construction operations must never be allowed to proceed in foggy or rainy weather, whenever rain is threatening, or whenever the surface which is to receive the surface application is damp or wet.

B. CONTROL OF TRAFFIC. Item 7, "Legal Relations and Responsibilities to the Public", requires that adequate provisions be made for the safe and convenient passage of the traveling public through all areas of construction. Traffic must be controlled in order to have orderly traffic movement, to avoid interruption and damage to the work, to protect the construction personnel, and to protect the traffic itself from the hazards created by the operation of the construction equipment. Traffic can best be controlled by using a combination of barricades, warning signs, detours, flagmen, and in some instances, pilot cars. The required traffic control to be used should be determined by the Resident Engineer or his authorized representative.

Whenever traffic is to be detoured onto the shoulders, the shoulders should be kept reasonably dust free but not sloppy wet. Whenever flagmen are used to direct traffic, they shall use the standard attire, flags, and signals, and follow the procedures set forth in the booklet, "Instructions to Flagmen", which is issued by the Department.

C. APPLICATION OF ASPHALTIC MATERIAL. Each "shot" or application of asphaltic material should be begun and completed on one or two widths of building paper. Two widths of paper should be slightly overlapped. The paper at the joint should be placed so that each successive application overlaps the end of the preceding one by approximately one-half of an inch in order to avoid a gap in the surface and to prevent the joint from being rough and unsightly. By properly placing the paper and careful operation of the distributor, neat, smooth, and square transverse joints and uniform distribution of the asphaltic material at the joints will be obtained. The length of each application should be determined in order that the paper may be properly located.

The length of an application is usually controlled by the quantity of the asphaltic material in the distributor. For seal coats and surface treatments, however, the length of an application may be controlled by the quantity of aggregate that can be delivered, spread, and rolled before the applied asphaltic material becomes too cool to bond the aggregate. The length of an application of either the asphaltic material or the aggregate can be calculated by the following formula:

$$L = \frac{9Q}{RW}$$

Where: L = length of application in feet

Q = quantity of material available in gallons for prime coats, and in cubic yards for seal coats and surface treatments

R = rate of application specified in gallons per square yard for prime coats, and in cubic yard per square yards for seal coats and surface treatments

W = width of application in feet

When calculating the length of an application, regardless of whether it is a prime coat, seal coat, or surface treatment, always make provision so that there will be approximately one hundred gallons of asphaltic material remaining in the distributor tank at the end of any application. This amount is required to insure that there will be sufficient material in the tank to complete the application, and to provide an accurate measurement of the amount of material remaining after completion of the application.

Prior to applying any asphaltic material, the aggregate lands or the length of roadway surface to be covered by each truckload of aggregate should be calculated and marked in some manner to assist the operator in controlling the rate of application of the cover aggregate. The length of coverage by any truckload of aggregate can be calculated by the following formula:

$$L = \frac{9Q}{RW}$$

Where: L = length of coverage in feet
Q = volume of aggregate in cubic yards in the truckload
R = desired rate of coverage in cubic yard per square yards
W = width of application in feet

When the surface has been properly prepared, the string line has been properly set, the starting and ending paper has been placed, the land for each truckload of aggregate, if required, has been staked, and the weather is permissible, asphaltic material may be applied. The procedures for applying the asphaltic material for prime coats, seal coats, and surface treatments are basically the same.

After the distributor arrives at the location where the asphaltic material is to be used, it should be parked off the roadway and the temperature of the material should be checked. If the material is not at the application temperature selected by the Engineer, it must be heated to that temperature. The material must be circulated while it is being heated. If the material is at the application temperature, it should be circulated through the spray bar until the spray bar is heated to the temperature of the material. This will melt the cold asphaltic material in the nozzles; however, if it does not, the spray bar is usually heated by one of the two methods: (1) using a coil burner, (2) sprinkling kerosene on the spray bar and then setting the kerosene on fire. In all cases, heating must be done with the distributor parked off the roadway.

It is recommended that, while the distributor is parked off the roadway and while the pump is operating at the correct pump speed or pressure, the distributor operator be required to open all of the nozzles at once for a short period of time before <u>every</u> application to see that the nozzles are not clogged.

Immediately prior to applying the asphalt, the tank must be strapped with the distributor in a level position. The distributor is then backed up past the beginning paper a sufficient distance so that, by the time it passes over the paper in its forward motion, it will have attained the traveling speed necessary to provide the desired rate of application. This speed must be maintained throughout the length of the application. If possible, application should always be made with the wind in order to minimize wind interference with the spray pattern. As the spray bar passes over the beginning paper the nozzles are opened, and as the spray bar passes over the ending paper the nozzles are closed, and the distributor is again strapped while in a level position. Immediately after the distributor has passed over the paper at the beginning and ending of the application, the paper must be dragged off the roadway and disposed of as directed by the Resident Engineer so that the material on the paper does not run onto the roadway surface. This is usually accomplished by burning the paper on the following day, if no fire hazards are present.

When cover aggregate is to be placed on the asphaltic material, application of the asphaltic material should not begin until sufficient aggregate required to cover the entire length of the application has arrived at the location where the work is to be performed unless the aggregate stockpile is relatively close and enough trucks are provided to insure continuity of the work. This will permit immediate coverage of the distributed asphaltic material which is necessary in order for the aggregate to be properly embedded and bonded.

The amount of asphaltic material used for any application is the difference between the quantity of material in the tank at the beginning and at the ending of the application. This quantity, the beginning and ending station numbers of the application, and the temperature of the asphaltic material should be recorded in the field book.

After the distributor has been emptied, except for the remaining amount of approximately one hundred gallons, the appropriate copy of the haul ticket, Form No. 124 Rev., may be issued to the driver. It will be permissible to issue one ticket for the total amount of asphaltic material used in any one day as recorded in the field book, on Form 187, "Daily Road Report-Asphalt" or its equivalent. In lieu of issuing Form 124 Rev., a copy of Form 187 or its equivalent may be furnished the Contractor at the end of the day as evidence of the pay quantity for asphalt on a particular day.

As each application is being made, the operation of the distributor must be observed to see that all of the nozzles are open, that the proper overlap of adjacent fans is being obtained thereby providing a uniform rate of application and preventing streaking, that the spray fans are not distorted, and that there is no interference between adjacent fans. If any of these are observed, work should be suspended and the necessary corrective action should be required of the Contractor.

Typical problems that may be encountered are: improper overlap, distorted spray fans, and interference between the adjacent spray fans. Improper overlap is the result of the spray bar height being incorrect. Distorted spray fans are generally caused by incorrect pump speed or pressure, the nozzles being too large, the distributor being driven too fast, or too much wind interference. Interference between adjacent spray fans is the result of the nozzle slots not being set at the proper angle with the spray bar.

There is no known procedure which is satisfactory for patching areas of seal coats or surface treatments left uncovered after passage of the distributor. It is recommended, therefore, that every precaution be taken in order to prevent the occurrence of this condition.

Occasionally seal coats or surface treatments may be placed in such manner that a longitudinal joint is necessary. Longitudinal joints should be controlled as carefully as the transverse joints; however, since it is not practical to use building paper on these joints, it is considered better to have a slight build-up due to overlapping of the adjacent passes than to have a gap in the application. It is recommended that the succeeding passes of the equipment slightly overlap the previous pass.

For the two course and three course surface treatments, the procedure for applying the asphaltic material for each course is identical and the same precautions should be observed on all the succeeding applications.

D. <u>APPLICATION OF COVER AGGREGATE.</u> As stated under "Application of Asphaltic Material", when aggregate is to be placed, the aggregate required to cover the entire length of the application should be available at the location of the work, or delivery of enough aggregate before the asphaltic material cools too much should be certain before any of the asphaltic material is applied. Spreading of the cover aggregate should be begun immediately after the beginning of the distribution of the asphaltic material. The sprayed material will cool rapidly, and if the aggregate is not spread immediately, it will not be properly embedded and bonded.

In the beginning, the self-propelled, continuous-feed spreader should be operated at the traveling speed estimated to be correct as determined during the initial inspection and adjustment of the spreader. The length of coverage by each truckload of aggregate should be checked to determine if it is being spread to cover the length calculated and marked. If the length is not satisfactorily covered, the aggregate spreader's speed of operation or the discharge opening must be changed.

As the spreader applies the aggregate, it tows an aggregate truck which is dumping aggregate into the spreader. Each truck should be examined before work on any particular application is begun to see that it is properly loaded. Any truckload which is not loaded as determined by the calibration procedure should be rejected. After a truckload of aggregate has been dumped into the spreader, the truck driver may be issued the appropriate copy of the haul ticket Form 124 Rev. for the load, or a tally may be kept for each load of aggregate delivered to the spreader for each asphalt application and one ticket issued at the end of the day for the total pay quantity of aggregate for that particular day. In lieu of issuing Form 124 Rev., a copy of Form 187, "Daily Road Report - Asphalt", or its equivalent, may be furnished the Contractor at the end of the day as evidence of the pay quantity for aggregate for that particular day. A tally should be kept on the form for each load of aggregate delivered to the road for each particular asphalt application made during the day.

It is recommended that the use of secondary aggregate distributing equipment, such as brooms, rakes, etc., be held to a minimum. If the spreader is in proper adjustment and working condition and is operated properly, a far more uniform application, than is possible with the use of brooms, rakes, etc., will be obtained.

For the two course and three course surface treatments, each of the successive courses of aggregate is placed in the same manner as the first, and the same precautions should be observed on each course.

l. Rolling. Rolling is often used on prime coats and is required to properly seat the aggregate for seal coats and surface treatments.

If the asphaltic material placed for a prime coat "balls up" into small globules due to dust particles on the surface or if the asphaltic material does not penetrate the surface of the base course, immediate rolling with a light pneumatic tire roller will usually be beneficial. This should not be interpreted to mean that the prime can be forced to penetrate a damp or wet surface. Rolling operations should be discontinued when the globules of asphalt have been broken and uniform coverage has been obtained, when most of the material has penetrated the surface, or when the asphaltic material becomes tacky. Traffic or construction equipment should not be allowed on the prime coat until permitted by the Engineer, and permission should not be given until the prime coat can no longer be picked up by the traffic or the construction equipment.

Rolling operations should be begun immediately after the beginning of the spreading of the aggregate for seal coats and surface treatments. It is recommended that pneumatic tire rollers be used for this work. Rollers should be operated at such speed that the tires do not pick up or shove the aggregate particles. Rolling should begin at the outside edges of the surface and progress toward the center. Each pass of the roller should overlap the preceding pass by approximately one-half of the effective rolling width and should be slightly different in length. Rolling should continue until the asphaltic material has hardened, the aggregate is firmly held in place, and additional rolling will not further embed the aggregate particles. Rolling should not continue after the asphaltic material has hardened because the bond on the aggregate particles may be damaged or broken.

For the two course and three course surface treatments, the rolling operation for each of the successive courses is performed in the same manner as for the first, and the same precautions should be observed on each succeeding course.

If flat wheel rolling is specified, extreme caution must be exercised in this operation. It is recommended that no more than one coverage of the surface by flat wheel rollers be permitted, since this type of rolling quite frequently seriously degrades the aggregate particles.

2. Removing Excess Cover Aggregate. Usually, there will be some loose aggregate particles on a new seal coat or surface treatment after the rolling operation has been completed. It is important that these particles be removed because they will be scattered by the traffic and will quite often cause damage to automobile windshields and finishes. The loose aggregate particles will also serve as a tool by which traffic will loosen bonded aggregate particles.

   The loose aggregate particles are removed most satisfactorily by lightly brooming the entire surface with a rotary broom. Extreme care must be exercised in this operation not to loosen the aggregate particles that are bonded. The preferable time for removing these loose particles is in the early part of the morning when the bituminous material is quite firm and the bonded aggregate particles will least likely be disturbed.

308.6 DAILY CHECK LIST

The following is a list of some of the more important items which should be checked before construction operations for any sepparate application of a prime coat, seal coat, or surface treatment are begun:

1. See that the provisions for traffic control are adequate.
2. See that all required equipment is present and in operating condition.
3. Inspect the surface to see that it is properly prepared.
4. Check the string line for proper alignment.
5. Make certain that the building paper is properly placed at the beginning and ending of each application.
6. Make certain that cover aggregate, if required, is of the proper gradation and is at the work site or can be hauled to the work site before the asphaltic material has cooled excessively.
7. Make certain that the aggregate lands are properly marked.
8. Make certain that the tachometer wheel is clean.
9. Make certain that the asphaltic material is at the proper temperature.
10. Make certain that the spray bar is at the proper height.
11. Make certain that all nozzles are set at the proper angle.
12. Make certain that all nozzles are open.

308.7 RECORDS AND REPORTS

Daily entries should be made in the diary book describing location of the work, instructions received from the Project Engineer, instructions given to the Contractor, unusual conditions, and other items of interest.

All data necessary for preparing Form 187, Daily Road Report-Asphalt, should be recorded. Form 187 should be prepared promptly for each day's operations as directed by the Resident Engineer and copies should be maintained in proper files at the District Headquarters.

CHAPTER 9
LIMESTONE ROCK ASPHALT PAVEMENT

309.1 GENERAL

Natural limestone rock asphalt deposits are found in several locations in the state; however, the use of this type of material in construction will necessarily be limited to areas within the economical hauling distance from the producing plants. Rock asphalt is commonly used as a surfacing or resurfacing course placed on an existing base or surface, and may be used as a base course in conjunction with the same type of wearing surface.

309.2 MATERIALS

The natural rock asphalt material consists of limestone impregnated with asphalt in percentages normally ranging from 2 to 15 percent. This range in asphalt content may be found in different areas of the same quarry. Generally, before quarrying operations begin, the average asphalt content of the various ledges and locations in the quarry are predetermined by core drilling, so that the materials may be regulated to produce a specific asphalt content. The rock asphalt is quarried, crushed, and sized to meet the type and grading required by the specification.

The rock asphalt mixture is obtained by mixing the rock asphalt with an approved flux oil and water. The flux oil is needed to soften the impregnated asphalt, and along with the water, it performs other functions necessary to keep the mixture in a workable condition.

309.3 PLANT OPERATIONS

After the rock asphalt is crushed, it is screened to give the various size fractions which can be blended to result in the grading required by the specifications. The blended aggregate is then introduced by a controlled feed into a pugmill-type mixer where it is mixed with the specified percentages of flux oil and water. When the mixing operations are completed, the mixture may be loaded directly into railroad cars or trucks for shipment to the project or stockpiled for future shipment.

The design, plant control, and testing of the rock asphalt mixtures are performed by the Materials and Tests Division. The Engineer will be furnished test reports indicating that the mixture meets the specification requirements for the project.

309.4 ROAD OPERATIONS

From the quarry, the rock asphalt mixture is hauled directly to the road in trucks or is received at the nearest railroad siding. Mixture should be weighed in accordance with the governing specifications, and samples should be taken from the railroad cars or trucks to determine the average moisture content. Water in the mixture above the specified percentage must be deducted from the pay quantities.

When the rock asphalt paving mixture is open graded, aeration of the mixture is not critical. This type may be placed with an asphalt paver. To give proper workability to the mixture when placing with an asphalt paver, the moisture content should be slightly higher than when a motor grader is used. The placing and finishing operations are essentially the same as for the hot-mix construction. Dense or fine graded mixes must be placed with a motor grader. When placing the mixture with a motor grader, the placing and finishing operations are essentially the same as for the cold-mix construction.

309.5 RECORDS AND REPORTS

Daily entries should be made in the diary book describing location of the work, instructions received from the Project Engineer, instructions given to the Contractor, unusual conditions, and other items of interest.

Work sheets, forms, and reports should be maintained and submitted in accordance with the instructions in this manual and Construction Bulletin C-14.

CHAPTER 10
HOT MIX
ASPHALTIC CONCRETE PAVEMENT

310.1 GENERAL

This chapter describes the various operations involved in the construction of the hot mix asphaltic concrete pavement.

Construction Bulletin C-14, which is a part of the Standard Specifications, describes the necessary preliminary testing of the aggregates, the method of combining the aggregates in order to meet the combined grading requirements, the design, mixing, and testing of the preliminary mixes, the use of these test results in establishing the initial batch design at the hot mix plant, the tests required for job control, and the instructions for preparing reports and maintaining records.

Construction of the hot mix asphaltic concrete pavement can be divided in two principal parts:

1. Operations at the hot mix plant
2. Operations on the road

The "Plant Operations" section describes the operations involved in placing a hot mix plant in production and maintaining the quality control of production throughout the life of the project. It includes a procedure for stockpiling the aggregates, description of the physical parts of the hot mix plant, the function of each part in production of the mixture, inspection considered necessary to produce a quality product, and a recommended procedure for detecting trouble spots.

The "Road Operations" section describes construction procedures recommended for laying the hot mix asphaltic concrete. It includes a discussion of the preparation of the base or surface, description of the paving equipment, the recommended procedure for checking each piece of equipment, the inspection procedure that should be followed in order to secure quality pavement, a discussion of the possible causes of defective construction, and the control of traffic through the project.

310.2 PLANT OPERATIONS

A. GENERAL. In the construction of the plant mixed asphaltic concrete pavement, it is important that the produced material meets all the requirements of the specifications. The responsibility for obtaining a mixture meeting the specification requirements rests initially with the Plant Inspector. Since the best possible construction at the lowest cost to the State cannot be obtained unless the mixture produced at the plant is of uniformly good quality, the importance of his work cannot be overemphasized.

The proper method of obtaining the best possible asphalt mixture can be stated very simply--careful inspection and control of the component materials and of the mixing process, in accordance with the specifications and instructions. Various tests are provided for the use of the Inspector to insure that the component materials and the completed mixture meet the requirements of the specifications. However, since only relatively small samples of each day's production can be tested, the Inspector's duties and responsibilities involve a great deal more than merely performing the required tests. He must know all the features of the asphalt plant and be especially familiar with the various controls which are under his general supervision. He is responsible for the uniform application of these controls, so that the end product is of uniform quality. Only when the product is uniform, can the samples be considered representative of the produced material.

In fact, if there is one key word to describe the quality production of asphalt mixtures, it is this: UNIFORMITY. The aggregate in the stockpiles must be of UNIFORM quality and gradation; they must be fed into the plant in a UNIFORM, controlled manner; the heating and drying of the aggregate must be UNIFORM; the separation of the aggregate in the bins must be UNIFORMLY controlled, and the aggregates and asphalt must be combined and mixed in a UNIFORM, consistent manner.

In order to achieve this uniformity in quality, each phase of the production operation must be in balance with all the other phases. For instance, the production of the pugmill cannot exceed that of the dryer or screens. The productive capacity of the plant is, of necessity, limited by the capacity of the least productive unit in the production cycle, whether it be dryer, screens, pugmill or any other unit. For these reasons, it is imperative that the Inspector be thoroughly familiar with all the phases of the mixing operation.

B. TESTING EQUIPMENT. Before production commences, the equipment listed in the Construction Bulletin C-14 should be requisitioned from the District Office and installed in the field laboratory generally specified to be furnished by the Contractor.

The Inspector is responsible for the care and safekeeping of all testing equipment issued for his use. Equipment must be maintained in a clean and proper operating condition to insure accuracy of the test results. Special care must be exercised in the use and maintenance of the sieves to insure that they do not become clogged. Thermometers must be handled carefully to avoid breakage.

The torsion balance is a delicate and expensive instrument, requiring care in handling. The locking blocks and bolts should be retained in order that the balance can be locked again for shipping. Balance should be checked before weighing any item because the accuracy of all the test results depends almost entirely on the accuracy of the weighing procedure.

The gyratory molding press and the extractor should be installed and checked for any malfunctions. If this equipment should malfunction at any time, it should be returned to the Equipment and Procurement Division (File D-4) for repair or replacement.

Given reasonable care and maintenance, the testing equipment will give long and satisfactory service.

C. STOCKPILING OF AGGREGATES. Essentially, the following types of hot mix plants, involving different stockpiling operations are used:

1. Portable plant setup for one construction project.
2. Semi-permanent plant set up for an extended period of time.
3. Permanent type commercial plant with multiple production operations.

The Plant Inspector should familiarize himself with the types of plants that will be used on construction projects in his area. Upon assignment to the project, the Plant Inspector should meet with the Contractor and discuss the plans for handling and stockpiling aggregates that will be used on the project.

When a portable plant is set up for production of the hot mix for one project, the required number of the aggregate stockpiles usually are four or less. Stockpiles should be spaced to prevent intermingling of aggregates, and prior to the stockpiling operations, the Contractor should carefully clear and level the stockpile area. It is recommended that stockpiles be constructed from a broad base at the bottom and decreasing in width as the height increases.

The semi-permanent plant is usually set up to produce a number of mixes for several projects in the area and may require a number of stockpiles of different sizes and types of aggregates. To prevent intermingling of the stockpiles in the congested area near the cold feeder, it may be necessary to construct bulkheads of timber or concrete. The Plant Inspector should thoroughly investigate all stockpiles proposed for use on the project that were stockpiled previous to his assignment to the plant and be sure that they comply with the specifications; otherwise, this aggregate must be removed and replaced by the specification materials.

At a large permanent plant, the stockpile areas are generally separated by concrete bulkheads which serve as the cold feed bins. An opening under each stockpile feeds the aggregate to a tunnel belt conveyor system, which in turn feeds it directly into the dryer. The aggregates may be delivered to these stockpile areas by trucks, by a clamshell directly from the railroad cars, or by a belt conveyor system. With this type of operation, it is very important that segregation of the aggregates be held to an absolute minimum in order that a uniform material may be produced.

Stockpiling is essentially the Contractor's responsibility; however, when the Plant Inspector and his assistants check this operation carefully the usual result will be a uniform product, a smoothly operating plant, and the feeling of a job well done by both parties to the contract.

D. ASPHALT STORAGE. The average hot mix job in the State is supplied with asphalt by truck shipment directly from the asphalt refinery. It is therefore necessary that the Contractor provides adequate storage tanks to keep the plant operating. These tanks are generally in the 10,000 to 20,000 gallon class and are equipped with coils which may carry steam, hot oil, or electric coils to heat the asphalt to the desired temperature. Each tank and the asphalt line carrying asphalt to the plant is provided with a return line, in order that asphalt may be continuously circulated while it is being heated. The asphalt lines, to and from the plant, should also be jacketed to heat from the same element that heats the storage tank in order to maintain the asphalt at the required temperature. A recording thermometer with a 24-hour chart should be located in the asphalt line that will record the temperature of the asphaltic material where it is at the highest temperature. This instrument should be located near the outlet end of the asphalt line from the storage tank. The Plant Inspector should check the recorded temperature periodically throughout the day, to assure himself that asphalt is maintained within the required temperature range. Each morning upon arrival at the plant, he should collect the chart for the previous twenty-four hours, date it, and file it in the laboratory files.

E. PLANT

1. General. Immediately upon assignment to the project, the Plant Inspector shall discuss the schedule of the work with the Project Engineer, the Road Inspector, and the Contractor. He should familiarize himself thoroughly with the plans and specifications applicable to the work and be especially familiar with the Construction Bulletin

C-14. As soon as possible, he should inspect the field laboratory available for his use at the plant site, and insure that all the necessary testing equipment is on hand. In addition, he should have a copy of the trial mix design and curves, the proposal issued for the project, the Standard Specifications, Construction Bulletin C-14, and sufficient forms to record the different tests that are to be performed each day.

As soon as the plant is set up and ready to operate, the Plant Inspector should make a thorough examination of the equipment for compliance with the specification requirements. He should become familiar with the plant features and the mechanical condition of each component part. Particular attention should be directed to the examination of the gates, feeders, dryer and dust collector, screens and bins, pugmill, recording thermometers, weighing scales, and the automatic time lock and batch counter on the batch-type plants. A check list similar to the example in the Appendix may be of assistance. Deficiencies should be called to the attention of the Contractor, and the required corrections must be made before commencing production of the mixture.

The asphalt plants in operation at the present time, vary from the old type plants that are manually operated and controlled, to the new type plants which are semi-automatic with very few manual operations. It is anticipated that the asphalt plant of the future will be fully automatic with practically all operations controlled by one man. However, regardless of the type of plant, the principal operations and component parts of the plant will not change, and the duties and responsibilities of the Plant Inspector will remain essentially the same in the fully automated era.

2. Plant Safety. During the preliminary inspection of the asphalt mixing plant, the Engineer should note any violation of the safety rules concerning machinery safeguards, such as lack of guards on belts, sprockets, etc. He should call to the attention of the Contractor any such violations and request that corrections be made. If the violations directly affect the functions of the Engineers or Inspectors, the Project Engineer should refuse to allow mixing to begin until conditions are safe for sam-

pling, inspecting, etc. The Plant Inspector should continually warn his men to be alert when working around moving parts and moving equipment at the plant site.

3. Cold Aggregate Feeder. The cold aggregate feeder is one of the critical control points in the production flowline. The Standard Specifications require the use of a cold aggregate feeder with at least four compartments, and further state that each aggregate will be fed from a separate compartment. The cold feeder on most asphalt plants consists of an open-top aggregate bin with four compartments. It is usually charged by a crane with a clamshell bucket. The asphalt plant at a permanent location may be fed from the stockpiles through a tunnel and conveyor system. This system must have at least four separate adjustable feeder gates. On any project that the Contractor elects to use more than four materials, the Engineer should require the blending of materials prior to stockpiling or the use of sufficient bins to feed each aggregate separately.

   It is important that separation of each aggregate be maintained in the stockpile and at the cold aggregate feeders. If the coarse and fine aggregates intermingle in the stockpiles or in the aggregate bins, or over the tunnel, control of the cold aggregate gradation will be lost.

   The Plant Inspector should check the cold feeder for compliance with the specifications, and then direct the Contractor to set the gate openings to deliver the percentage of sizes required by the trial mix design and the volume of material desired by the Contractor for his plant production. For the convenience of the Contractor, a reasonably accurate calibration of the rate of feed of each of the cold aggregate feeders may be made in order that the proper proportion of each size fraction will be fed into the plant. Although proportioning of the aggregate in the mix is actually accomplished from the hot aggregate bins, the cold aggregates should be fed in the proper proportions if a smooth balanced operation is to be achieved.

4. Dryer. After passing through the cold feeders onto a belt or elevator, the aggregates are fed into the dryer.

In this unit the aggregates are heated to the required temperature and moisture is removed from the materials.

The component parts of the dryer are: a revolving cylinder, usually from three to ten feet in diameter and from twenty to forty feet long, a burner which is either gas or oil fired, and a fan which may be considered part of the dust collector system, but its primary function is to provide the draft air for combustion in the cylinder.

The cylinder is equipped with longitudinal cups, or channels, called "lifting flights", which lift the aggregate and drop it in a veil through the burner flame and hot gases. The slope of the cylinder, its speed, diameter, and the arrangement and number of flights control the length of time required for the aggregate to pass through the dryer.

The fan is in the dust collector system which is attached to the upper end of the dryer. It is generally of a size designed by the manufacturer for the particular dryer and is equipped with a variable speed motor. Its primary functions are to draw the draft air through the dryer to complete the combustion of the fuel, to draw the heat throughout the dryer, and to pass the exhaust into the dust collector system.

The burner along with a non-revolving combustion chamber is installed at the lower end of the dryer. The dryer can be fitted with a burner that can use natural gas, liquid gas, or fuel oil. Some types of burners are designed to use any of these fuels.

Most dryers are designed for the average or usual aggregate moisture content. Very wet aggregate will reduce the dryer capacity and require corrective measures, two of which are: the amount of heat can be increased by burning more fuel while the flow of aggregate remains constant, or the aggregate flow can be reduced. There is a limit to the increase in the heat that is possible, and beyond that limit, the rate of aggregate flow must be reduced. Highly absorptive aggregates usually require longer drying periods. This can be accomplished by reducing the incline of the dryer drum or by rearranging the dryer flights. Increasing the dryer time, incidentally, will remove more moisture than increasing the heat. In very humid areas, or when the aggregates are exceptionally wet or highly absorptive, two dryers may be linked by a long, open belt and operated in tandem.

Most problems in the operation of the dryer are caused by crowding more material through the dryer than it can handle properly. However, there are other factors which will affect the efficient operation. Several of these factors involve the proper operation of the burner. If the dryer is equipped with an oil burner, it is important to use the proper grade of the fuel oil. It is also important that the fuel oil be uncontaminated. The oil burner must be properly adjusted in order that the air (or steam) furnished by the burner-blower properly atomizes the oil. In addition, the draft air which combines with the atomized fuel oil for combustion, must be in balance with the blower air and the amount of fuel oil being fed into the burner. This adjustment is largely governed by the draft which is supplied by suction of the exhaust fan and the opening around the burner.

If the blower air, draft air, and amount of the fuel oil are not in balanced adjustment, incomplete combustion of the fuel may be caused, leaving an oily coating on the aggregate particles which will be harmful to the finished mixture. Black smoke from the exhaust stack indicates that the oil being introduced into the burner is not being burned completely. This may be corrected by decreasing the amount of the fuel oil, or by increasing the blower or the draft air. If a wet wash system is in operation with the dust collector, it may be necessary to shut it off while observing the exhaust smoke.

Lack of balance between the blower air and the draft air can create back pressure within the dryer drum, causing "puff back" at the burner end of the dryer. "Puff back" indicates that the draft is not sufficient to accomodate the air pressure being introduced by the burner blower. The solution is to increase the draft or to reduce the pressure of the blower air.

Dryers burning natural gas or liquid petroleum gas rarely develop combustion problems. However, unbalance between the gas pressure, combustion air, and draft can still occur. The gas burner must be the correct type for the available gas pressure.

The heated aggregate is discharged from the low end of the dryer into a chute that delivers the aggregate to the hot elevator. A recording thermometer sensing unit is installed in this chute to record the temperature of the heated aggregate, and the recording instrument should be mounted in full view of the burner operator. The Plant Inspector should periodically check this instrument to insure that proper temperature is maintained and every morning collect the temperature chart for the previous day's run, date it, and file it in the laboratory files.

5. Dust Collector. The dryer or the dust collector fan exhausts the draft air from the dryer into the dust collector system. This draft air contains dust particles, vapor, and gases. Dust particles from the dryer and other parts of the plant are carried in the current of the draft air which enters the dust collector at the upper periphery and goes into a vortical motion. The heavier dust particles in the air stream are separated by centrifugal force into the collector shell and fall to the bottom. The finer dust remains in suspension and is carried out of the exhaust stack with the air. The heavier dust that falls to the bottom of the dust collector is reclaimed and reintroduced into the flow of the aggregate, generally at the hot elevator, through an auger conveyor. Means should be provided for wasting a portion or all of the reclaimed fines, if required to maintain the grading limits.

When the exhaust from the dust collector creates a public nuisance, or a health hazard, the Contractor is usually compelled by public officials to add a wet wash system to the dust collector. There are several types of wet wash systems, but they usually consist of a short tower, with or without baffles. Exhaust from the dust collector enters the tower at the bottom and passes upward through a series of water sprays that remove the dust. Use of a wet wash system usually will increase the fan requirements by 10 to 15 percent because of the pressure loss in the tower.

6. <u>Screening Unit</u>. The heated aggregate is usually elevated by a bucket elevator to a screening unit, which separates the aggregate into the required number of size fractions and deposits the various sizes into the separate compartments or hot bins.

   The screening unit on most asphalt plants is of the horizontal vibrating type , and may be equipped with as many as four decks. The sizes of the screens on the decks depend on the type of hot mix to be produced. The top deck is covered with a scalping screen which removes all the oversize material that has been delivered by the hot elevator, and this material is discharged into the reject chute. It is very important that the first two or three feet of this deck be covered with an intermediate size screen to prevent a deluge of material dropping straight through to the finer screens; thus blinding out portions of that deck and inducing "carry over". Carry over refers to depositing of finer material in a bin that should contain the next larger size aggregate. Carry over may also occur when the screens become plugged with aggregate particles being stuck in the screen openings . When a screen becomes loose and slips, or a hole is worn in the screen cloth, the larger size aggregate is deposited in the next finer bin. When any of these situations occur, the uniformity of grading is impaired and corrective measures should be taken as soon as possible. The Plant Inspector should insist that the screening unit be checked and cleaned by the Contractor every morning before work begins.

   The specifications usually require that a hot mix plant be equipped with four hot bins or compartments, and when mineral filler is used an additional compartment will be needed to feed that material. These hot bins hold the heated, screened aggregates in various size fractions required for the type of hot mix to be produced. The bin partitions should be tight, free from holes, and of sufficient height to prevent intermingling of the aggregates. Each hot bin should be equipped with an overflow pipe to prevent aggregate from backing up into the other bins, and to prevent overfilling to the point where the vibrating screen will ride on the aggregate. The overflow pipes should be checked frequently to make sure that they are free-flowing and thus prevent contamination by intermingling materials from the adjacent bins. When bin shortages or excesses occur, they are corrected by adjusting the cold feed. The bottom of each bin is fitted with gates through which the aggregate is discharged into the weigh box. The Plant Inspector should examine these gates before production begins to make sure that they operate properly and the closure is positive enough to insure that no leakage into the weigh box will occur.

Most modern hot mix plants are equipped with special devices for sampling the hot aggregate in the bins. These vary from sampling "gates" or "windows" in the sides of the bins, to devices for diverting the flow of the aggregate from the bins into the sampling containers. Ordinarily the best place to obtain a sample from any plant is from the bin gates as the material falls into the weigh hopper. It is essential that sampling facilities be constructed and located so that the samples will be representative of the material in the bins. In the flow of material over the plant screens, finer particles fall to the near side of the bins and coarser particles fall to the far side. When material is drawn from the bin by opening a gate at the bottom, the stream consists predominantly of fine material at one edge and coarse material at the other. This condition is critical in the No. 1, or the fine bin, since the asphalt demand is influenced heavily by the material from this bin. Therefore, the relative position of the sampling device in the stream determines whether the sample will be composed of the fine portion, the coarse portion, or will be an accurate representation of the material in the bin. The Contractor is equally concerned that a representative sample be secured, because a non-representative sample may cause him to discontinue production, draw down the hot bins, and go through a useless check of the screening unit. A shovel or scoop is a very poor sampling device. A very good sampling device can be constructed from a piece of sheet metal, two 3/8 inch steel rods, and a piece of 3/4 inch pipe five or six feet long. The sheet metal should be formed into a box approximately twelve inches square or wide enough to catch the full flow of the material as it falls through the hot bin gate. The metal box should be about three inches deep. The 3/8 inch steel rods should be welded to each side of the box and brought together at the rear to be attached to the 3/4 inch pipe. A representative sample can be secured by inserting this box under the hot bin as the material is being drawn to charge the weigh box. This sampling device can only be used on plants where it is possible to gain access to the hot bin gates. Some plants are equipped with a sampling pan as part of the plant or may have an automatic sampling device. It is anticipated that all new plants will be equipped with automatic sampling devices.

7. Scales (Batch Type Mixing Plants). With a batch type mixing plant, the separate sizes of aggregates and asphalt are proportioned by weight before mixing. The weigh hopper for the aggregate is located directly under the hot bins. The weigh hopper is suspended on the weighing mechanism generally equipped with a springless dial scale on which the Plant Inspector sets the weight of the aggregate from each hot bin. The scale reading is cumulative and the last mark on the scale must read the total weight of the aggregate in each batch. Since it is not necessary to charge the weigh hopper in any consecutive sequence from the hot bins, the Contractor or the Plant Inspector may set any sequence they choose, but once the sequence is chosen and the cumulative weights are marked on the scale this sequence of weighing must be strictly adhered to. To prevent the seepage of fines through the discharge gate and to prevent possible damage to the discharge gate it is suggested that the weigh hopper be charged from the hot bins with the medium size aggregate, the large size aggregate, and then the fine aggregate.

   Scales should comply with Item 500, "Weighing and Measuring Equipment", and should be checked by the Contractor before beginning of production and periodically during the life of the job. If any question develops concerning accuracy and adjustment of the scales, the Contractor must have them checked and adjusted.

   The asphalt scales are checked in the same manner as the aggregate scales except that they should be checked more frequently; because a small error in the weight of asphalt in each batch can result in serious pavement failures. Every morning and periodically throughout the day the asphalt scale should be checked for adjustment to zero to compensate for accumulations of asphalt and dust on the asphalt weigh bucket.

8. Hot Bin Control Gates (Continuous Mix Plants). Up to the point of discharge of the aggregates from the hot bins, the functions of the continuous mix plants and the batch type plants are essentially the same. In continuous mix plants, the proportioning of the separate sizes of aggregates is accomplished through the adjustable gates on the hot bins, which deposit the aggregates into the elevator to be delivered directly to the pugmill. The asphalt is discharged through a calibrated metering pump. The aggregate feeder and the asphalt pump are geared to a common power source in order to maintain constant proportions of aggregate and asphalt regardless of the variations in the power supply. Material delivered during a revolution of the driving mechanism, or in any chosen time interval, is considered a batch, and the proportion of each ingredient is calculated just as for a batch type plant.

   The Project Engineer should request the Contractor to procure a copy of the manufacturer's plant specifications and operating instructions, which will indicate the operating speed of the feeder and the asphalt pump delivery rate for the various sprocket sizes.

   Before production begins, a careful calibration of the flow of aggregates from each feeder gate must be made in accordance with the manufacturer's instructions. The rate of flow of the aggregate from each bin is determined by weighing the amount discharged at various gate openings, and computing the quantity delivered per revolution of the feeder drive shaft. A curve is then plotted for each gate, showing the pounds of aggregate per revolution against the gate opening in inches. This aggregate flow chart is used in determining the gate openings when establishing the mix proportions. The percentage of each bin required in the final mix should be determined by drawing several samples of aggregate from each bin during the calibrating process, running the screen analysis on each sample, and securing an average screen analysis of each bin. If the screens transmit vibration to the hot bins and feeder gates, they should be in operation during the calibration process.

Usually, it is necessary to check the quantity of asphalt delivered by weighing the amount pumped into a suitable container during a carefully timed interval. This will check the manufacturer's recommended sprocket size; however, to complete calibration of the asphalt pump, a similar check must be made after the selected sprocket is operating on the plant. For constant asphalt proportioning, the temperature of the asphalt going through the pump must be known at all times. The Plant Inspector should take frequent readings of the thermometer installed in the circulating line just ahead of the pump in order that necessary adjustments can be made to compensate for the volumetric changes in the asphalt caused by the temperature changes. Pump adjustments are not necessary for minor temperature variations.

It should be possible to control the feeder gates and the asphalt pump so that no change in setting can be made without the knowledge of the Plant Inspector.

9. Pugmill Mixer. After proportioning, the aggregate and asphalt are introduced into the pugmill for mixing. All modern hot mix asphalt plants are equipped with pugmill mixers, which consist of twin shafts equipped with paddles for mixing the ingredients into a homogeneous mass. Main parts of the mixer are: the paddle tips, paddle shanks, liners, shafts, discharge gate, and heated jacket. For efficient operation, all mixer parts must be in good mechanical condition and in proper adjustment. The mixers for the batch type plants and the continuous mix plants are essentially of the same design, except for the variations in the arrangement of the paddle tips. In the batch plant mixer, materials are dumped into the center of the mixer and the paddle tips are arranged to give an end-to-center mixing or a run-around (figure eight) mixing pattern. The material is held in the mixer for the required mixing time and then discharged through the discharge gates into the transporting vehicle. In a continuous mix pugmill, materials are introduced in one end of the mixer and the paddle tips are set to transport the materials to the discharge end as the mixing is accomplished. The mixing pressure varies with the height or weight of the material in the pugmill and can be controlled by adjusting the dam gate at the discharge end.

In any case, efficient mixing depends upon the number and shape of the paddle tips, clearance between the paddle tips and liner plates, speed of the mixing shafts, length of the mixing time, temperature of the materials, and quantity of materials in the mixer. Paddle tips should be full-sized, without excessive wear of corners and edges. The clearance between the paddle tips and the liner plates should be about 5/8 inch. If clearance exceeds this distance, the paddle tips will not pick up the materials efficiently and "dead spots" will be created in the mixer. It may be necessary to replace the paddle tips and the liner plates to obtain the correct clearance. To improve mixing efficiency of the continuous mix pugmill, it may be desirable to make one or both of the following adjustments:

(1) Raise the dam on the discharge end of the mixer to hold the material in the mixing unit for a longer period of time at a depth that will further intensify the mixing action.

(2) Adjust or reverse the pitch of the paddles to retard movement of material through the pugmill and increase the degree of mixing action within the unit.

The mixing period for a batch type mixer is defined as beginning at the time the hot aggregate is introduced in the mixer and ending when the mixer discharge gate is opened. The specifications require a "dry" mixing period and a "wet" mixing period for a combined total of not less than thirty seconds. It must be remembered that the asphalt film on the aggregate is hardened by exposure to air and heat; therefore, the mixing time should be the shortest time required to obtain a uniform distribution of aggregate sizes and a uniform coating of asphalt on all the aggregate particles. The specifications also require an automatic time lock on the discharge gates which should be set to open the gates at the end of the mixing period selected, for frequently the time required for the weighing operation exceeds the mixing period and holding the mixture in the pugmill will be detrimental to the finished product.

The weight of any batch must not exceed the rated capacity of the mixer as shown on the mixer name plate, and the production rate of a continuous mix plant must not exceed the manufacturer's rated capacity of the plant.

F. ESTABLISHING MIX PROPORTIONS. The Plant Inspector shall obtain from the Project Engineer the mix design, that has been recommended by the Resident Engineer after careful review of all the test results obtained from the trial mix design. He shall make the sieve analysis of the aggregates from each bin of the gradation unit and calculate the batch weights (or gate openings and pump sprockets for a continuous mix plant) required to produce a mixture that will conform as closely as possible with the recommended mix design. It is important to draw several dry batches through the plant to give the screening unit a chance to operate at normal operating speed, before securing samples used in making the sieve analysis. The mix design secured from this sieve analysis will be used to start production of the mixture and should be reported as No. 1 on the daily report sheet. The procedure for establishing the batch weights, the schedule of minimum requirements for the job control tests, and possible causes of low stability are explained in the Construction Bulletin C-14.

It must be recognized that the trial mix design is to be used as a guide since it is based on the information obtained from supposedly representative samples. It may be necessary to make small adjustments in the proportions of the various sized aggregates and in the asphalt content in order to balance the plant operation consistent with the specification requirements.

The Contractor should be advised of the proportions of the coarse and fine aggregates to be used in order that the proper gate settings may be established at the cold aggregate feeders. Each mineral aggregate generally contains one dominant size and the Plant Inspector, by studying the combined grading analysis, will be able to determine if the various aggregates are being proportioned according to instructions. It may be necessary to require the Contractor to make additional small adjustments in the gate openings on the cold bins.

G. INSPECTION DURING MIXING OPERATIONS. Each day prior to beginning of the work, the Plant Inspector should check to insure that the various gates, scales, timers, etc., are properly set before mixing begins. He must see that markers are properly and firmly set on the scale dials to indicate the proper weight for each component of the batch. Screens and bins should be inspected to determine their condition, and particular attention should be given to the bins to determine that no aggregate remains from the preceding day's work. The overflow vents should be checked to insure that they are not plugged.

After mixing begins, and throughout the day, the Inspector shall make the required sieve analysis tests of the aggregate and perform the extraction tests of the mixture. It is very important, however, that the Inspector spends most of his time observing the mixture being produced. If possible, an assistant should be assigned to perform the routine tests under the supervision of the Plant Inspector.

During the day, the Inspector should make periodic checks of the operation of the cold aggregate feeders and the screens and bins. He should watch for evidence of improper proportioning at the cold feeders, as indicated by overflow from any of the bins. If one bin overflows constantly, and the trouble cannot be attributed to the cold aggregate feeder, he should investigate the possibility of a slight change in the batch weights to produce a more uniform operation. However, batch weights should not be adjusted continually to compensate for the overflow of the bins as it is more likely that the trouble is caused by the segregation of the aggregates in the stockpile. The Inspector may advise and assist the Plant Foreman in correcting the segregation.

Periodic checks of the temperature of the aggregate and asphalt, as well as of the mixture produced, must be made. The Inspector will be advised by the Project Engineer as to the desired temperature of the mixture. The desired temperature will depend on the weather conditions, length of haul, and other factors. Generally, the temperature of the mixture should be as low as possible, consistent with the requirements for mixing and placing. The Plant Inspector shall watch for excessive variations in temperature and shall notify the Contractor of any variation that occurs. He shall insist that the temperature be kept as uniform as possible, particularly when highly absorptive aggregates are used.

When stockpiled aggregates contain a high percentage of moisture, difficulty may be encountered in heating the material to the proper temperature. Usually, the Plant Fireman will try to correct this condition by increasing the amount of the fuel oil fed to the burner. This can be done satisfactorily until incomplete combustion of the fuel oil occurs. Black smoke from the exhaust stack is an indication that incomplete combustion is occurring. The Inspector should watch for this condition, as the unburned fuel will deposit a sooty, oily film on the aggregate particles which is detrimental to proper coating of the material with the asphalt film. A reduction in the amount of cold aggregate fed to the dryer will usually correct the situation and allow proper heating and drying of the material.

The Weight Inspector must check the batching and mixing operations to make sure that the proper batch weights are being obtained, and that the aggregate hopper and asphalt weigh bucket are completely emptied into the pugmill.

If one bin tends to overflow and another bin runs empty, some operators are prone to try to correct this situation by drawing some material from the overflowing bin and less from the bin that is running low. This practice must not be allowed, and <u>the Inspector should be very firm in insisting that the correct batch weights be measured</u>. He should especially watch the asphalt scale to determine if it is correctly adjusted to allow for increase in the tare weight of the bucket caused by the asphalt clinging to its sides.

Frequent inspections of the condition of the mixture leaving the plant should be made, noting the consistency of the mix, the distribution of asphalt and aggregate throughout the mixture, and the temperature of the mixture. If the quality of the mixture varies from batch to batch, an immediate check should be made to locate the source of trouble. Uniform distribution of the asphalt throughout the mix is extremely important. If portions of each batch vary from rich to lean, the Inspector should look for uneven distribution of the asphalt across the mixer as it is introduced. It may be necessary to increase the mixing time to correct this situation. By examining the mixture in bright light, an experienced inspector can quickly detect non-uniformity in the mixture.

While maintaining an attitude of cooperation with the Contractor, the Plant Inspector must insist that the requirements of the specifications are met. If tests indicate that the mixture consistently fails to meet these requirements, it shall be his duty to reject the product and immediately contact the Project Engineer for further instructions.

H. MISCELLANEOUS DUTIES OF THE PLANT INSPECTOR. If truck platform scales are used at the plant, the Plant Inspector shall supervise the work of the scale man and shall insure that the required tests of the scales are performed. He must see that the material haul tickets are properly made out and issued for each truckload of the mixture delivered, and that daily totals are promptly obtained and entered on the daily report as outlined in the Construction Bulletin C-14.

Before trucks are allowed to be loaded at the plant, a check should be made to determine that the truck beds are in satisfactory condition, and if required, that the canvas covers are in satisfactory condition and the truck beds are properly insulated. The specifications allow the truck beds to be lightly coated with oil to prevent the mixture from adhering to the surface; however, no pools of oil shall be allowed to remain in the truck bed after this operation. In all cases the truck bed must be raised after each oiling to insure that excess oil is drained before placing mixture in the truck.

It is important to emphasize at this point that the presence of an experienced Plant Inspector at the plant will contribute much to the production of a uniform mixture. He should train his assistant(s) to perform the routine laboratory work and devote a large portion of his time to the observations of the various operations around the plant. No testing method or device is as quick and convenient as the human eye and visual inspection certainly has an important place in controlling the production of the hot-mix; however, it should never be relied upon as the sole factor in evaluating the quality of the mixture.

I. PLANT INSPECTOR'S CHECK LIST. For the convenience of the Engineer and the Inspector, some of the more important details of inspection in production of the hotmix asphaltic concrete are listed below:

1. Determine that the testing tools and equipment are on hand and in good condition. Make sure you understand all the tests.

2. Inspect all components of the mixing plant, and make sure that all deficiencies are corrected before mixing is begun.

3. Check all scales for accuracy periodically, and determine correct adjustment to zero daily.

4. See that the stockpiled aggregates are kept separate, and that no intermingling occurs at the cold feeders.

5. Check the temperature of the heated aggregate frequently.

6. Watch for evidence of incomplete combustion of the burner fuel, as evidenced by dark smoke from the plant exhaust and coating on the aggregate.

7. Check the temperature of the asphalt frequently.

8. Establish the scale settings for the batch weights, and station the Weight Inspector at or near the batching scales so that he can observe the weighing of the aggregates and asphalt.

9. Daily check the screens, bins, and overflow chutes for proper operation.

10. Check an occasional batch to see that it is mixed the required length of time.

11. Make frequent visual inspections of the mix leaving the plant for evidence of non-uniformity or incomplete mixing.

12. Check the temperature of the mix frequently.

13. Inspect the truck beds before loading; see that the truck beds are free of congealed chunks of mix and excess diesel oil.

14. Check occasionally with the Road Inspector concerning workability and uniformity of the mix at the paving machine.

15. Take samples of the mixture for extraction test and for molding the Hveem stability specimens. Sample the aggregates from the hot bins and perform the combined sieve analysis.

16. Maintain an accurate and complete record of all the test results, the number of batches mixed, the quantity of the asphalt used, and other pertinent data.

J. MEASUREMENT AND PAYMENT. The specifications require that records are kept of the number of batches, the batch designs, and weights of the asphalt and aggregate. It is the Plant Inspector's responsibility to insure that these records are kept. If the specifications require separate payment for asphalt and aggregate, the percent of asphalt in the mixture should be recorded on each material haul ticket. When a batch type plant is used, the Contractor ordinarily elects to be paid on the basis of batch weights, but the mixture produced by a continuous mix plant must be weighed on the truck scales. In either case, the haul ticket issued to the truck driver should show the net weight of the load in the truck and the design percent of asphalt in the mixture. The net weight and the design percent of asphalt in the mixture will be used in calculating the pay quantities of the asphalt and aggregate. These pay quantities will generally be calculated to the nearest one hundreth (.01) of a ton, unless closer calculations are directed by the Engineer.

310.3 ROAD OPERATIONS

A. GENERAL. In construction of the asphaltic concrete pavements, it is the responsibility of the Road Inspector to insure that construction methods and equipment used, as well as the finished pavement, meet the requirements of the specifications. In order that he may properly discharge this responsibility, it is necessary that he thoroughly understands the project plans, the Standard Specifications, and the special provisions of the contract. He must also have a good working knowledge of the methods and equipment involved in this type of construction.

The Road Inspector should adopt an attitude of cooperation with the Contractor. He must so conduct his inspection duties that no unnecessary delays will occur to the paving operation. A smoothly organized, continuous paving operation will generally produce the best results both in quality and economy.

A means of communication between the Road Inspector and the Plant Inspector must be established, and the Road Inspector shall keep the Plant Inspector informed of any difficulties encountered in the laying of the mixture or of any faulty mixture received at the paving site.

B. DUTIES BEFORE PAVING BEGINS. Immediately following his assignment to the project, the Road Inspector should contact the Project Engineer, the Plant Inspector, and the Contractor's representative for a discussion of a plan of the paving operation. An understanding should be reached as to the point of beginning of the work, the direction in which paving will proceed, the methods of performing any unusual features of work peculiar to the project, the proposed traffic control methods, etc. Once a plan of operation is agreed upon, it should be followed faithfully whenever possible.

Prior to construction of the pavement, an inspection of the surface upon which the pavement is to be placed shall be made, noting all the soft or weak areas, small depressions or potholes, and any areas which require extensive pre-leveling.

The Contractor shall be required to remove and repair all soft areas, and to clean and prepare any existing pavement to be resurfaced, as required by the specifications.

The Engineer should give careful consideration to the use of a pre-leveling course over areas of unusual roughness or sags in the profile of the pavement base. The Contractor should be given as much advance notice as possible of the intention to place a pre-leveling course in order that he can plan his operations in an efficient manner.

C. TRAFFIC CONTROL. The Project Engineer should discuss with the Road Inspector and the Contractor the proposed plan for controlling traffic, and should arrange a meeting with the District personnel for the purpose of discussing this important phase of the work. Before paving begins, all signs required by the plans shall be properly installed on the job. Due to the relatively fast movement of the paving operations, additional portable signs and flagmen will be required in and around the areas where construction is in progress. If traffic is to be carried on an unpaved shoulder during the paving operations, adequate measures should be taken to prevent the blowing dust from becoming a traffic hazard. On an asphalt widening job the open trench is an unusually dangerous traffic hazard and this edge of the pavement should be properly signed and marked by flares as required.

D. INSPECTION OF PAVING EQUIPMENT. It is the duty of the Road Inspector to make a personal inspection of the Contractor's paving equipment, checking the condition and adjustments of the component parts of the paving machines and rollers. In order that the best possible surface finish will be obtained, it is essential that all equipment is in good condition and all parts are in proper adjustment. A check list similar to the example in the Appendix may be of assistance. By making this inspection prior to the beginning of the paving operations, obvious deficiencies in the condition of the equipment may be discovered and corrected; thus avoiding delays once the work is under way. The Contractor must not be allowed to begin work until the Inspector is satisfied that the equipment is in a good operating condition.

Listed below are some of the more important details the Inspector should check during the inspection of the paving equipment:

1. Paving Machines. Several types and makes of pavers are used in the State, and all of them are capable of producing satisfactory surface finishes. The various types of the paving machines primarily differ in the methods used in striking off, compacting, and smoothing the mixture. The Inspector should be familiar with the mechanical features of the type of paver to be used on the job in order that an intelligent appraisal of the condition and adjustment of the machine can be made. Handbooks containing the various details and the operating instructions are available from the manufacturers. The Inspector should obtain copies of these instructions from the Contractor or the manufacturer. Other manuals prepared by the allied industries may also prove to be very useful.

   Paving machines using the tamping bar and fixed screed principle require rather precise adjustments of clearances and movements. The size, shape, length of the stroke and extension of the stroke of the tamper bar below the screed are critical factors in obtaining proper compaction. The condition of the screed plate and its adjustment for crown are very important in achieving a smooth, uniform surface. The clearance between the tamper bar and the leading edge of the screed must be checked for proper adjustment. The speed of the engine, which drives the tamper bar must be checked to determine if the tamper bar is operated at the correct number of strokes per minute. With the paving machines using a transverse oscillating screed to strike off the mix, followed by a vibrating screed plate which compacts and smoothes the mix, it is essential that the oscillating screed is free of excessive play and is correctly adjusted for crown and tilt. For best results, the vibrator on the screed plate must be operating at the correct frequency.

   Machines using an electrically vibrated screed to strike off, compact, and smooth the mix must be checked to insure that all vibrators are set to deliver vibrations of equal amplitude. The screed plate should be checked for signs of excessive wear, and the engine speed determined to insure correct adjustment of the governor. The immobile foot in front of the screed, which serves to push the mixture under the screed and assists the screed in striking off, should be checked for proper height.

On all track-laying machines, correct adjustment of the track linkage is essential for a smooth operation. A poorly adjusted track, or a badly worn one, can produce an uneven, lurching movement in the travel of the machine which will be reflected in an uneven, "choppy" pavement surface. Observation of the machine in motion will usually detect any defects in the track or the drive mechanism.

Some pavers are suspended on rubber tire wheels. With these machines, all pneumatic tires must be inflated to the correct pressure, and the chain drives must be examined to insure that chains are adjusted properly, without excessive slack.

2. Rollers. Flat wheel rollers must be inspected to determine that the wheels are capable of rolling in a true plane, and that the wheels are in good condition. The Inspector should be especially watchful for flat spots on the wheels. The steering and the driving mechanisms must be free of excessive play or backlash, and the motor or the driving transmission should not leak oil on the pavement. Observation of the roller in motion and reversing direction will disclose any deficiencies in the drive and clutch mechanisms. Each roller will be fitted with a water tank connected to spray bars and mats on each wheel. The wetting mats should be checked for excessive wear and the spray bars checked for proper operation.

   The self-propelled pneumatic tire rollers, to function properly, must have equal size tires which are in good condition. All tires must be inflated equally, in order to provide uniform compression of the pavement under all wheels. Tire pressure and the loading of the roller may be varied to suit the conditions on the project and to result in the ground contact pressure that is desirable for the particular mixture. The necessary data for use in determining the contact areas and contact pressures should be secured. Information on this subject is also contained in the "Pneumatic Tire Pressure Table", in the Appendix. The Inspector should observe the roller in motion, to see that all wheels are rolling true, without wobble or creep.

3. Miscellaneous Tools. A check must be made to insure that the Contractor has available on the job an adequate supply of rakes, lutes, shovels, brooms, and other small tools. The Inspector should satisfy himself that the Contractor is properly equipped with portable barricades, cones, or other means of protecting the freshly laid pavement from damage by the traffic.

   Upon completion of the check, the Road Inspector should call any deficiencies or maladjustments of the equipment to the attention of the Contractor, in order that corrections can be made before the work begins.

E. JOINTS. At the beginning of the day's work, special care must be exercised in the construction of the transverse joint between the freshly laid mixture and the previous day's work. The paver should proceed only a short distance from the joint, and should not be allowed to proceed until hand finishing of the joint is completed. The Inspector should check this work closely, using a straightedge to determine that the requirement for surface smoothness is met.

   The standard transverse joint constructed in the State is the butt joint. The use of heavy paper or top soil is recommended to form the butt joint at the end of the day's work, with a temporary ramp laid beyond the joint to assist traffic over the change in elevation and to facilitate completion of the rolling operation. The paper or soil is placed under the ramp to prevent the mixture from adhering to the surface. When the ramp is removed prior to beginning the succeeding day's paving a well-constructed joint will require a minimum of cutting back to full cross section of the pavement to form the butt joint. The face of the joint and ramp area shall be lightly tacked with a cut-back asphalt. When hand raking is performed on a joint, all segregated coarse aggregate shall be removed to avoid a coarse, porous surface.

F. SPREADING AND FINISHING. In general, nearly all of the hot mix pavements constructed in the State are placed with a paving machine; therefore, this section is essentially a study of this type of operation. The pertinent duties of the Road Inspector relative to the construction of a level-up course with a motor grader and the widening of an existing pavement with asphaltic concrete will be discussed in the latter portion of this section.

In recent years the manufacturers have developed an electronic grade control sensing device which automatically controls the operation of the screed unit. When the Contractor elects to operate a paving machine equipped with an electronic grade control, it will be necessary to secure instructions from the manufacturer regarding the proper use of their device. The devices used at the present time, have a grade sensor which travels along a wire that is set at the desired grade line. Some devices may be equipped with a shoe or a ski, which is attached to the grade sensor and which can follow the grade of the pavement, curb, base, or a previously laid mat. If wire is used, it is important that the grade be staked at least every twenty-five feet. The Contractor's forces will follow the staked grade line in erecting a reference string line, which consists of a stiff wire (similar to piano wire) strung along the top of the supports so tight that it does not sag. The Inspector should be especially alert for possible malfunctions, as the device tends to compound its errors, and unless the machine is stopped immediately, the pavement surface will require extensive repairs. It should also be remembered that there is no paving machine that will eliminate the need for securing good lines and grades of the base.

In the construction of asphaltic concrete pavements, it is extremely important that the paving machine be in good adjustment, and that the machine and screed operators be experienced and capable. The Inspector should be quick to note operational practices which have an adverse effect on the work, and request the Contractor to make immediate corrections.

Before beginning of the paving work for the day, or before resumption of the paving following a lengthy shutdown, the Inspector must see that the machine is cleaned of all congealed pieces of mix and that the screeds are heated to the operating temperature. If a delay occurs during the day which allows the mix to cool below the temperature required for proper compaction, the Contractor must be required to construct a transverse butt joint before resuming work.

During the paving operation, constant inspection must be maintained to insure that the machine is producing a smooth pavement having the required texture and uniformity. The Inspector must require immediate action to correct any trouble that may develop and should attempt to assist the Contractor in locating the source of the trouble.

Listed below are some of the common difficulties encountered in the asphalt paving work, together with the most likely causes of the difficulty:

1 - Wavy surface (short choppy waves):

> Worn or poorly adjusted tracks or drive chains; truck driver setting brakes too tight; excessive speed of the paving machine.

2 - Wavy surface (long waves):

> Excessive variation in the amount of mix carried in the auger box ahead of the tamper or screed; rolling too early; rollers operated too fast; overcontrolling the screed.

3 - Excessively open surface texture:

> Improper adjustment of the tamper bar; improper speed of the tamper bar; screed plate rough or galled; excessive speed of the paving machine.

4 - Varying surface texture:

> Insufficient mixing; segregation of mix in the trucks; poor gradation control at the mixer.

5 - Streaked surface texture:

Insufficient mixing; overmixing; overheating the mixture; segregation of mix in the trucks; worn or damaged screed plate

6 - Bleeding patches on the surface:

Asphalt not distributed uniformly in the mix; excessive moisture in the mix.

7 - Irregular rough spots on the surface:

Roller standing on the fresh surface; abrupt reversing of the roller; truck backing into the paver; poor workmanship at the transverse joints.

In addition to the difficulties listed above, there are two variables that should be emphasized. The first one is the thickness of the mat being laid by the paving machine. If the thickness of the mat is somewhat less than 1 1/2 times the maximum size of the aggregate for the type of hot mix being laid, the result may be tearing of the mat and crushing of the aggregate by the rollers. If the thickness is somewhat more than twice the maximum size of the aggregate for the type of hot mix being laid, it may be difficult to roll it to the desired density, or to roll it without leaving blemishes on the surface, or some "starved out" areas that will show up later under the wheels of the traffic as minor depressions producing a rough riding pavement. The second difficulty is the hazard of laying the hot mix asphaltic concrete in cold weather. This does not become a real problem if the specification requirements on the temperature limitations are observed, unless it is necessary to haul the mixture some distance or production is intermittent and the paver is stopped for a long period between loads. The mixture that remains too long in the truck during cool weather may congeal into a mat of two or three inches thick on the top, in front and along the sides of the truck. The hard crust dumped into the paver may or may not break up when it comes in contact with the rest of the mixture. If the hard balls pass through the machine, they must be dug out of the mat and the mat repaired. The temperature of the mixture may also fall so low that it is impossible to properly compact the mix. Placing the hot mix in cool weather is one of the more common causes of "shelling" of the hot mix pavements; therefore, the Road Inspector should be especially alert during the cool weather and when the trucks begin arriving with congealed mixture, the production should be suspended.

Some paving machine operators have a tendency to operate the paver at speeds in excess of that required to handle the quantity being produced at the plant, resulting in a jerky stop-and-go operation. This should not be allowed. Generally, the slower the paver is operated, consistent with the plant production, the smoother will be the finished surface. The ideal speed of the paver will be that which will result in a smooth, nearly continuous process of laying with a minimum of stops required in waiting for the trucks. If the production rate of the mixing plant is very high, requiring excessive speed of the paver, the Contractor should be required to correct the situation by slowing the production or using additional paving machines.

The Inspector should periodically check for difficulties during dumping of the mixture into the hopper of the paving machine. Trucks must not be allowed to back into the paver in such a manner that they bump the paver, nor shall the trucks which bear against any part of the machine other than the pushing rollers be permitted to dump into the paver. Any mix spilled onto the pavement in front of the paving machine must be shoveled into the hopper of the machine or back into the truck before paving is resumed. The Inspector should be especially watchful to see that mixture spilled in the paths of the tracks or wheels of the machine is removed.

<u>The crown adjustment of the screed should be checked to insure that the finished surface will conform to the required section</u>.

Particular attention must be given to the construction of the longitudinal joint when paving adjacent to a previously completed lane. The screed of the paving machine should overlap the previously laid lane from one to two inches to insure sufficient material to completely fill the joint. The Inspector must insist that handraking be held to a minimum, by adjusting the screed so that the freshly laid pavement is of the proper depth, allowing for compaction, to meet the grade of the previously laid lane. The uncompacted mixture immediately adjacent to the joint should be left slightly high in order that the roller can thoroughly compact the mixture in this area. The rakers should not be permitted to cast excess mixture over the uncompacted, freshly spread lane. The Inspector should insist that segregated coarse particles of the mix remaining after making of the joint be removed and wasted, to avoid construction of a coarse, porous joint.

In constructing a level-up course with a motor grader, the Inspector should insure that the surface is tacked and the pavement edges are marked by a string line. He should calculate the truck spacing to produce the desired yield. The asphaltic concrete should be dumped in piles, or in a windrow box which discharges the load in the center of the road within the required spacing. The material should be uniformly windrowed before spreading operations begin. A space should be provided between the first load of the fresh material and that of the previously laid pavement, and the last load should be placed in this area in order that a relatively hot joint may be constructed.

The most important principle in the level-up work with a motor grader, is to spread and finish the mixture before it cools off. The Inspector should work closely with the operator of the motor grader to insure that all areas are leveled and that the proper pavement crown is achieved.

In widening of the concrete pavement with hot mix, the Inspector should check to insure that the edge of the old concrete pavement is clean and that the subgrade is properly compacted. The widening paving machine and the trench roller should be checked for proper operating condition.

The widened section is generally constructed using three 2 1/2 inch to 3 inch courses of the asphaltic concrete. The succeeding course should not be placed until the previous course is thoroughly compacted and allowed to cool; however, the job conditions will control this feature of construction. Heavy rolling should be applied to the top course, because the widened section will generally carry one wheel lane of the traffic.

During construction of a leveling course, an attempt must be made to remove all depressions and sags in the grade line by adjusting the depth of the course. The Inspector should work closely with the screed operator to accomplish this result by pointing out irregularities in the surface far enough ahead of the machine to allow proper adjustment of the screed to eliminate the irregularity. The objective to be attained in the construction of a leveling course, placed by a paving machine or a motor grader, is the complete elimination of all irregularities in order that the placing of the wearing course can be accomplished with a minimum of screed adjustments. If the old pavement is excessively rough, preleveling should be performed prior to the construction of the leveling course.

Smooth surface and good riding quality of the pavement are secured only by hard work and strict attention to small details on the part of an alert Inspector. The Inspector should continually study the special conditions peculiar to the job, and strive to obtain the smoothest surface possible. A smooth riding pavement does not cost any more than an unsightly, poor surface, but it does require a constant and careful inspection of all the construction details.

G. COMPACTION. Periodic checks of the rolling operation must be made, with particular attention for violations of the proper rolling methods. The rolling procedures outlined in the specifications should be followed; however, special circumstances may warrant minor changes in these procedures.

Roller wheels must be kept moistened by mats fastened to the wipers on each wheel, without using an excessive amount of water which might harm the surface of the pavement. Considerable judgment must be used in the timing of the various phases of compaction, taking into account the weather conditions, temperature of the mixture, and the characteristics of the pavement. Under certain circumstances, rolling may be completed an hour after the mix is laid, while during the hottest part of the season several hours may elapse before the pavement is ready for the finish rolling. By being observant, the Inspector will be able to determine the proper compaction procedure for the particular conditions.

Under normal conditions, the initial or the "breakdown" rolling should be applied as soon as possible after the mixture is placed. The initial rolling is generally performed by the three wheel rollers. The roller wheels should be checked for water ballast and should be loaded or unloaded as the job conditions warrant. The Inspector should insist that the drive wheels should compress the mixture first, which means that the roller should be traveling backward toward the rear end of the spreader. This will help to eliminate waves in the mat that may be caused by pushing a wave of the fresh mixture in front of the small tiller wheel. During periods of hot weather, or if the temperature of the mixture is high, it may be necessary to delay the initial rolling to avoid hairchecking of the mat, or to avoid picking up of the mix on the wheels of the roller. Excessive rolling of the mix, particularly during the initial rolling, may damage the pavement more than insufficient rolling. Generally, for thin mats, one complete coverage of the mat by the breakdown roller is sufficient; however, for the thicker mats, it may be necessary to make two complete coverages. When the rolling of one section is completed and there is a waiting period, the roller should be moved back to the previously rolled section and parked at approximately a 45° angle with the center line of the pavement. The subsequent rolling operations will remove any depressions that may be caused by the standing roller.

The self-propelled pneumatic tire roller specified for the project should begin compaction as soon as the mixture cools sufficiently to prevent picking up of the mixture on the tires. The pneumatic tire roller is equipped with a water tank, spray bars, and mats; however, watering of the tires does not completely prevent the mixture from adhering to the tires. The use of a small amount of a non-foaming detergent on the wetting mats at the beginning of the rolling operation will be helpful in preventing the mixture from sticking to the tires. If the mixture has high stability, the roller may be operated in the medium to high range of the ground contact pressures. If the mixture has low stability, it may be necessary to operate the roller in the medium to low range of contact pressures. The Standard Specifications define the range of the ground contact pressures each type of roller must be capable of producing; however, the Engineer should select the desirable ground contact pressure for the particular mixture. In general, rollers should be operated at as high ground contact pressures as practicable without rutting, shoving, or otherwise displacing the mixture.

When compacting a level-up mixture spread by a motor grader, the pneumatic tire roller should be loaded to produce high contact pressure, and should begin rolling the mixture when the motor grader begins the spreading operation. Pneumatic tire rolling should be continued right behind the motor grader until the final pass of the grader, and the finish rolling should be applied as on other asphaltic pavements.

When the mix has cooled sufficiently, a flat wheel tandem roller should make the finishing coverage, rolling out all the roller marks and leaving the pavement surface smooth and true to profile and crown. The Inspector should check the roller wheels for proper loading to produce the desired compression.

H. COMPUTING YIELD. During the paving operation, a careful record shall be kept of the truck loads, the weight of the material in each truck, and other pertinent data. Periodically, the Inspector shall compute the quantity of the mixture placed per square yard and compare the yield against the proposed quantities. Frequent checks of the yield will prevent any large overrun or underrun of quantities. The yield should be computed for the day's work and entered on the daily report form.

I. MISCELLANEOUS DUTIES OF THE ROAD INSPECTOR. Before placing of the asphaltic concrete pavement adjoining gutters, curbs, etc., the Inspector shall see that all contact surfaces are painted with an approved asphaltic material.

The Inspector should frequently check the traffic control operation to insure that traffic is moving smoothly, with a minimum of delay. Attention to this detail may save the embarrassment of public criticism.

At the end of the day's work, a check of the traffic control and construction signs should be made to insure that all signs not required during the non-working hours are removed or are covered. As soon as possible after completion of the project, all temporary signs shall be removed.

J. <u>ROAD INSPECTOR'S CHECK LIST</u>. For the convenience of the Engineer and the Road Inspector, some of the more important details of inspection of the asphaltic concrete pavement construction are listed below:

1. Check condition and adjustment of the paving machines and rollers. Check crown in the screed.

2. See that the traffic control is organized and functioning properly and that the required signs are in place.

3. Determine if the required patching and pre-leveling has been completed and the surface is ready for paving. Verify the proposed depth of surfacing.

4. Check application of the tack coat.

5. See that the paver guide lines are set.

6. Check the transverse joint for smoothness and appearance.

7. Watch the trucks dumping into the hopper of the paver for adverse effect on the operation of the paver.

8. Check the temperature of the mixture occasionally.

9. Maintain constant inspection of the mat behind the paver for signs of roughness or non-uniformity of the mixture.

10. Inspect the longitudinal joint for proper raking and compaction.

11. Make frequent checks of the yield.

12. Watch the rolling operation and see that the best rolling sequence fitting the job conditions is used. Watch for excessive speed of the rollers.

13. Keep record of the truckloads of material used each day, and compare the recorded weight of material with the Plant Inspector.

14. Make sure that the job is in good shape before you leave it at the end of the day; see that all lights, barricades, etc., are placed properly and all signs not required during the non-working hours are removed or covered.

310.4 RECORDS AND REPORTS

Daily entries should be made in the diary book describing location of the work, instructions received from the Project Engineer, instructions given to the Contractor, unusual conditions, and other items of interest.

Worksheets, forms, and reports should be maintained and submitted in accordance with the instructions in this manual and Construction Bulletin C-14.

CHAPTER 11
HOT MIX - COLD LAID
ASPHALTIC CONCRETE PAVEMENT

311.1 GENERAL

The hot mix-cold laid asphaltic concrete is a mixture similar to the hot asphaltic concrete except that the asphaltic material and additives, when required, are of such a nature that the mixture may be transported, stockpiled, and laid cold. This type of mixture may be used as a base course, a level-up course, a surface course, or a resurfacing course over an existing pavement. Ordinarily, when the quantities are sufficient to warrant setting up a plant on the project, it is more economical to mix and lay the asphaltic mixture hot. This change can be made in accordance with the Construction Bulletin C-14.

311.2 MATERIALS

A. MINERAL AGGREGATE. The mineral aggregates should be handled and stockpiled in the same manner as the hot mix aggregates.

B. ASPHALTIC MATERIAL. The liquid asphaltic material should be of the type that will remain fluid at air temperature sufficiently long enough to permit completion of the construction operations. Asphalt cements used with a primer and water should be of the high penetration, low viscosity type.

311.3 DESIGN

Since most of the mixtures are produced by commercial plants set up at permanent locations, the design, plant control, and testing are usually performed by the Materials and Tests Division personnel. Where File D-9 does not furnish the plant inspection, trial mixes should be made in the same manner as for the hot mixtures and the results of these trial mixes should indicate the design mix formula that will produce a mixture with the density and stability specified for the project. The gradation of the aggregate and the percent asphalt shall conform to the requirements of the governing specifications.

311.4 PLANT OPERATIONS

The plant operations for the cold asphaltic concrete are the same as for the hot asphaltic concrete except for the drying and mixing operations.

The temperature of the mineral aggregate at the mixer must be considerably lower for the cold mix. The mixing temperature limits are usually set forth in the governing specifications. These temperature limits must be strictly observed to insure a mixture that will remain in a workable condition from the time it is mixed until it is incorporated in the pavement. The temperature may be controlled by heating and drying the aggregate, and then cooling back to the required temperature; or by controlling the heat and rate of flow of the aggregate through the plant so that the aggregate will arrive at the mixer properly dried and at the specified temperature.

The graded aggregates should be proportioned according to the mix design formula and dry mixed until they are uniformly distributed. The asphaltic material and moisture should then be added and mixed with the aggregate for the specified wet mixing period.

The sequence of introducing the aggregate, asphalt cement, approved primer, and water into the mixer, and the length of the mixing period should be such that a uniform and workable mixture conforming to the specification requirements is produced.

311.5 ROAD OPERATIONS

The road operations for the cold laid mixtures are the same as for the hot asphaltic concrete except as discussed below.

The cold mix, after being uniformly windrowed on the paving surface in the amount required, must be thoroughly aerated to reduce the hydrocarbon volatiles and moisture content to less than 0.5 percent before the spreading operations begin. As this type of mixture ordinarily produces a dense pavement, there is practically no loss in the hydrocarbon volatiles and moisture content after compaction; therefore, if the volatiles and moisture are not removed to the level specified prior to compaction they will tend to overfill the voids which in turn may cause the pavement to become unstable. This feature precludes laying of the cold mix with an asphalt paver. Since the aerating process is largely controlled by the weather, the weather limitations set forth in the governing specifications should be strictly observed.

When the mixture is ready for spreading, it shall be uniformly windrowed, spread, finished, and compacted in the same manner as the hot mix asphaltic concrete. No succeeding course shall be applied until the mixture has cured sufficiently as required by the plans and specifications.

311.6 RECORDS AND REPORTS

Daily entries should be made in the diary book describing location of the work, instructions received from the Project Engineer, instructions given to the Contractor, unusual conditions, and other items of interest.

Work sheets, forms, and reports should be maintained and submitted in accordance with the instructions in this manual and Construction Bulletin C-14.

CHAPTER 12
PORTLAND CEMENT CONCRETE PAVEMENTS

312.1 GENERAL

This chapter consists of a general discussion of the procedures involved in construction and inspection of the various types of portland cement concrete pavements.

Construction of portland cement concrete pavements is similar to any other manufacturing process in that certain raw materials are assembled at one location, combined in controlled amounts, and the mixture is subjected to mechanical and manual processing to form the finished product. Coordinated and conscientious efforts are required on the part of all concerned with this process to make the finished pavement a quality product. It must be realized that the many steps in this manufacturing process are interdependent and that additional effort at one stage cannot compensate for inefficiency at some other stage. This process may be grouped under two main headings: "Operations at the Plant" and "Operations on the Road".

312.2 OPERATIONS AT THE PLANT

A. GENERAL. In the construction of the portland cement concrete pavements, it is important that the produced material meets all the requirements of the specifications. The responsibility for obtaining a mixture meeting the specification requirements rests initially with the Plant Inspector. The Plant Inspector, in a common effort with the Contractor, is responsible for the initial phases of this process, all of which require a conscientious and continual effort to insure that the specified materials are handled, combined, and delivered to the paving site in the proper manner. The Plant Inspector must organize his work in a logical sequence in order to fulfill these responsibilities. His primary duties consist of the following: preliminary inspection, operational control, and reports. In meeting this responsibility, the importance of a thorough knowledge of the plans, specifications, testing procedures pertaining to this work, and the contents of Construction Bulletin C-11 cannot be overemphasized.

B. PRELIMINARY INSPECTION - MATERIALS AND PLANT SITE. After the contract has been awarded, the Contractor shall make available to the Plant Inspector sufficient amounts of all materials proposed for use in the concrete pavement, for quality and other preliminary testing. The Inspector should send representative samples of the coarse aggregate (or aggregates), the fine aggregate (or aggregates), cement, and water to the Materials and Tests Laboratory for quality testing. Water from a known potable source need not be submitted. It is important that the above samples be truly representative of the materials to be shipped for job production. Information as to the proper sampling procedure, the size of samples required for the various tests, and the manner of submission can be found in the "Manual of Procedures" issued by File D-9. Tests as described in the Construction Bulletin C-11 should then be made in the District or the Residency Laboratory to determine the physical characteristics of the aggregates required to be known in the design of the concrete mixture.

The Preliminary Inspection phase of the plant operation will, normally, consist of duties on the Plant Inspector's part that must be performed prior to the arrival of materials at the plant site and prior to the actual production of the concrete. Although the plant site and size is the Contractor's choice, the Plant Inspector has a responsibility to see that provision is made for a workable layout of bins, etc., and stockpile areas. This is the proper time for the Inspector to have an understanding with the Contractor as to the site layout, equipment, and material handling methods. If any of these items are not in accordance with the specifications, the Contractor is entitled to a warning that enforcement can be expected. Also, if the proposed plan should result in obvious inefficiency without the actual violation of the specifications, a constructive suggestion to the Contractor is in order, and can be of advantage both to the Department and the Contractor alike in effecting harmonious job conditions.

C. MIX DESIGN. The Standard Specifications contain the following three concrete pavement items: Item 360 (Water Cement Ratio), Item 364 (Class "A" Concrete), and

Item 366 (Continuously Reinforced). These specifications require that the concrete be designed by the Absolute Volume Method (Specified Cement Content) in accordance with the instructions contained in Construction Bulletin C-11. Items 360 and 366 require pilot tests prior to beginning of the paving operations to be made in accordance with the procedure in the Concrete Pavement Section. Item 364 requires pilot tests if concrete admixtures are used. Pilot tests for this item should be made in accordance with the section Concrete For Structures (Natural Aggregates).

As soon as the laboratory building is available, the laboratory equipment required for job control sampling and testing should be installed. Construction Bulletin C-11 contains a check list of the equipment and materials, and should be used to inventory equipment and materials on hand and for ordering of the needed items. A curing tank (complete with a device for automatically controlling the water temperature between 70° and 90° F.), and an enclosure for the Department's beam testing equipment should be installed by the Contractor. The Plant Inspector should see that the curing tank and the beam testing equipment are conveniently located near the laboratory building.

If not previously performed in the Residency or in the District Laboratory, the mix design must be determined, and small trial batches and pilot tests for strength must be made in accordance with the procedure in the Construction Bulletin C-11. Based on the information secured from these preliminary tests, the design factors should be selected in compliance with the specification requirements and the initial batch design determined for the beginning of the paving operations.

D. STOCKPILING AND STORAGE. Materials, either all or in part, are usually shipped to the plant site in trucks. This type of operation will normally result in large quantities of materials arriving in short periods of time, and will require more diligence in record keeping and in maintaining proper sequence of the job control testing. Many materials, other than aggregates and cement, received during this period must be checked for specification compliance and put into proper storage. Storage of this latter group, which may include such items as the air entraining agent, joint sealing and curing compounds, wire mesh, reinforcing steel, etc., will be handled by the Contractor, but the manner of storage should be of interest to the Plant Inspector. If required, labels on some containers will give instructions as to protection of the contents against extremes in temperature. Materials should be stored in such a way that their condition is acceptable at the time of use. The timing of inspection and the job control sampling of materials, particularly the aggregates, must be such that the samples are representative of the entire lot, batch, or stockpile. Sampling and testing in conjunction with the arrival of materials will allow ample time for securing the test results prior to use and will ordinarily be more representative of the total quantity of material. The area occupied by the stockpile should be clean and smooth prior to placing the first load of the aggregate, and throughout construction the stockpile should be constantly watched for contamination by mud, grass, etc. Lack of room at the plant site does not justify intermingled stockpiles. If the Contractor insists on using such a site it becomes his responsibility, regardless of the extra expense involved, to separate the aggregates (with bulkheads, etc.) and to restrict the stockpile size to one that will fit the available area.

Regardless of the size of the stockpile area, contamination by foreign substances must be avoided, degradation held to a minimum, and uniformity of moisture in the aggregates must be maintained as closely as practical. It is recommended that the stockpile be built in successive layers, not exceeding three feet in thickness, with a distinct berm maintained between layers. This will minimize spilling of the larger particles and subsequent segregation. During the early stages of the operation enforcement may not be too difficult, but as the work progresses and the stockpile is replenished it becomes more difficult to prevent segregation. Only by constant observation and changes in the handling methods, when necesary, can detrimental segregation be prevented.

In addition to segregation and contamination by foreign substances, degradation of materials under a certain handling sequence could be a deterrent to quality concrete production. Repeated passes of the tracklaying equipment, for example, can degrade an otherwise satisfactory material. There may be occasions, where additional gradation and decantation tests may be in order to encourage revision of the material handling methods and to prevent this condition. Closer observation and possibly additional tests may be required on the lower portion of a stockpile that has had quantities of material moved over it or has been in place for a long period of time.

Stockpiling of aggregates for an adequate length of time prior to use is probably the most effective method of securing uniform moisture content. The Standard Specifications require that the coarse aggregate containing more than 0.5 percent free moisture and all the fine aggregate be stockpiled twenty-four hours prior to use. During the course of construction, a stockpiling system must be developed that will prevent the newly received aggregates from going directly into the batch bins.

E. EQUIPMENT INSPECTION. Although the Inspection of Equipment will be a continuing duty during the entire operation, an early and thorough inspection of the scales, batching equipment, and batch trucks is necessary for proper quality control and to reduce the possibility of delays in production. A check list similar to the example in the Appendix may be of assistance.

Scales should comply with Item 500, "Weighing and Measuring Equipment" and should be checked by the Contractor before beginning of production, and periodically during the life of the job. All bins should be loaded at least 24 hours prior to the scale check in order to allow for any settlement that may take place in the footings. Wind protection should also be considered at this time for all indicators, lever systems, and lower load receiving elements. The effect of the wind on the weighing accuracy may be small, but the error is never compensating. If any question develops concerning accuracy and adjustment of the scales, the Contractor must have them checked and adjusted.

All scales should be subject to continuous visual checks and periodic weight checks to be assured of reliable day-to-day performance. Each day prior to use, all beam scales should be checked for balance and the dial equipped scales checked for return to zero. This is the time to see that all batch weights are properly set and that no material has accumulated on the lever arms or around the knife edges.

The proposed cement storage equipment should be examined by the Plant Inspector at the time of its installation at the plant site. Cement must be stored in a suitable weathertight building or bin which will protect it from dampness. The cement storage facilities should be arranged and equipped so as to provide for easy access to the cement for identification, measurement, and inspection of each shipment. When a closed-type cement weigh box is used it should be properly vented, be equipped with a springless dial to indicate the empty condition, and have a tightly covered inspection opening.

F. <u>BATCHING OPERATIONS</u>. The Plant Inspector is not directly responsible for the manner in which the plant is set up and equipped, but it is his duty to insist on the proper operation of the component parts.

Batch bins for the aggregates and cement should be checked for adequate clearance above the truck beds and for adequate means of conveying material from the weigh box to the proper truck compartment. When the truck beds are not uniform in height, the discharge chute on the cement weigh hopper must be adjustable to prevent excessive material loss by blowing or diversion into the adjacent compartments. Batch truck compartments should be measured to determine if batches will be retained without spillage, even when the bed is raised to its maximum dump position. The compartment dividers should be tight-fitting and equipped with a positive latching device that will prevent leakage and multiple dumping of batches into the mixer skip. It would serve no useful purpose to weigh the aggregates and cement and then allow spillage or faulty dumping at the mixer. Trucks should be equipped with covers or tarps which should be used to control the loss of materials (primarily cement) by blowing, or the loss of moisture by evaporation. The length of haul, sequence of loading the batch ingredients, and weather must be considered in requiring or not requiring their use.

During the batching operations the Plant Inspector is responsible for several individual operations which can materially affect the quality of the finished pavement. Batches must be composed of properly proportioned, accurately weighed materials complying with the specification requirements, and be accompanied by information as to the amount of water to be added at the mixer that will produce concrete of the desired workability. Uniformity of the concrete is essential, and depends mostly on the accuracy of the information as to the amount of water to be added at the mixer. Since moisture in the aggregates must be considered as a part of the total water, a continuous program of moisture testing must be initiated and followed. After the aggregate sample has been taken from the batch bin it should be tested without delay, and the results transmitted as soon as possible to the Mixer Inspector. Communication between the Plant and the Mixer Inspector is important, because each of them must be constantly informed on changes in the moisture and the mix conditions. Construction Form 356 Rev., sent on a selected batch truck, should be used to transmit this information to and from the Mixer Inspector.

The initial moisture test, made at the beginning of the day's operation, will usually be very misleading unless the aggregate bins are emptied at the end of the previous day's work. Rain on the stockpile will also cause similar problems and will require special attention in procuring moisture test samples and in the selection of material to be loaded into the bins. After production is well underway on the day's operation and the successive moisture reports reveal that water added at the mixer varies from the design water content by more than two gallons per cubic yard of concrete, another moisture check on aggregates should be made immediately. If this check does not change the amount of water to be added, the batch design should be investigated for mathematical accuracy, the plant operation examined (for example: one aggregate bin overflowing into another bin), a scale check made, etc. Normally, the reason for this variation can be determined if the Plant and the Mixer Inspector will carefully examine the operations and equipment under their control.

Check on the theoretical amount of cement used daily compared with the amount of cement computed from the batch count including the known wasted cement, should not be considered as satisfactory evidence that all is well. A supplementary cement check should be made periodically by comparing the total volume of concrete placed in a selected interval with the weight of cement actually used during the same interval. The beginning and ending point for this check is not easily predetermined, but the Inspector at the cement scale usually has an opportunity to make the check when the cement bin can be conveniently emptied between delivery of loads. The Mixer Inspector can then be notified to record the station marking the point of delivery of the last batch (that is practical to get out of the bin) on the road. If possible, three or four truckloads of cement should be run through the bins and the station recorded when the last batch has been used and the bin is again practically empty. This information should be compared with the number of batches used in the same area.

312.3 OPERATIONS ON THE ROAD

A. GRADE INSPECTION

1. General. The Inspector on the grade is usually responsible for the proper performance of all operations on the road that precede the actual placement of concrete. The Grade Inspector should be thoroughly familiar with the plans and specifications applicable to the work, and be especially familiar with the equipment and procedures that will be used on the project.

2. Grade Line. Contracts that include concrete pavement with the grading, structures, subbase, etc., usually will not require adjustment of the planned paving grade as the grade should fit the supporting elements in the

roadbed. Where concrete pavement is to be constructed under a separate contract, it may be necessary to take cross sections of the roadbed to establish the grade line for the pavement or to check the proposed plan grade line. The grade line selected as a result of such investigation is then used for the top of the pavement grade at the profile location indicated on the plans, and all subsidiary grades will be calculated from this established grade.

3. Compaction. Subgrade shall be prepared in accordance with the plans and specifications. Regardless of the method of compaction used on the project, it is extremely important that subgrade be compacted as uniformly as possible. When the areas of the subgrade or subbase to be paved have been accepted, it is the Grade Inspector's duty to see that any areas disturbed during preparation of the form line or in fine grading be restored to its previous grade and density.

4. Forms and Form Grade. The primary criterion by which the traveling public judges the quality of a pavement is the riding surface. Therefore, it is good construction practice to direct the maximum effort toward attainment of this goal---a smooth riding pavement. In order to secure the desired quality of the finished surface, this effort must begin with the subgrading and the form setting operations and must be applied continuously through all the subsequent operations including curing.

   When side forms are used, they must be "set" to the established line and grade, securely locked together, and pinned in place. The side forms serve the following main purposes: (1) provide the grade line for finishing of the subgrade; (2) contain the plastic concrete in place until it "sets-up" sufficiently to maintain its shape; (3) provide the grade line to which the riding surface is built; and (4) provide the "track" that guides and supports the spreading and finishing equipment. Checking of the forms prior to use should not be performed hurriedly. Metal forms should be at least ten feet long and be of the approved depth and base width as required by the specifications. Each section should be constructed so that it can be staked in position with not less than three pins. Wedges used for locking of the pins should be inspected, and worn, bent wedges should be replaced. The top of the rail and inside face of each form should be straight and any defective forms should be clearly marked to prevent their use. Forms should be clean and lightly oiled. During construction, additional examination of the re-used forms should be made to eliminate those that may become damaged.

Preparation of the subgrade that will support the paving forms is very important. Settlement of forms under the weight of the spreading and finishing equipment is very often the cause of poor riding quality. The subgrade should be cut to grade with a form-line grading machine, or by other approved methods, in accordance with the string line set from the grade stakes. Subgrade under the forms should be firm and shaped at the proper grade so as to support the form along its entire length, and for the full width of its base. Any areas below the established grade should be corrected with approved material, compacted, and graded to the proper elevation. Where a surface treatment is used under the concrete pavement, low areas under the form line must be corrected with approved material, such as cement-stabilized sand, premix, etc., without substantial disturbance of the seal. If the seal is destroyed during the form setting operation, the subgrade shall be restored as directed by the Engineer, or the surface resealed. The increasing use of soil-cement or other stabilized materials under the concrete pavements has created new problems in effecting full contact between the form bases and the supporting material. The limited time available for spreading, finishing, and compacting of the stabilized materials makes it more difficult to produce a finished surface that meets the required grade at all points. After curing, the stabilized materials are difficult to trim and fine grade. It is important, that stabilized materials be properly finished during the initial construction period. Motor graders and electronically controlled mechanical subgrade finishers are presently being used for this purpose. When motor graders are used in combination with the automatic finishers to uniform the material during the compaction phase, the surface should be finished approximately one-quarter inch or more above the "blue-top" grade.

The final trimming is then made by the mechanical subgrader, as close to the required grade as the capabilities of the machine will permit. Both methods can produce a good finish, but may leave small irregularities that must be smoothed out to produce a satisfactory base for the form line. As a result, some contractors leave the subbase in the vicinity of the form line somewhat higher than the desired grade in order to allow the mechanical equipment to "cut" this area down to the final grade. When supplemented by manual trimming a smooth, stable base is produced for the form line.

After the forms have been set in place and all the pins driven, forms should be aligned and graded to a string line, and the wedges and form locks driven tight. During driving of the pins, pins should also be checked to see that the length gives sufficient lateral stability to the forms; if not, longer pins should be required. Wedges should tighten securely on the pins and if they do not, the pin size should be changed, or the form sections removed and replaced with forms containing the proper wedges. The Grade Inspector should then check the vertical and horizontal alignment by eye. Large adjustments in elevation of the forms required to meet a satisfactory grade should be made by removing the form sections, filling or excavating, and compacting the disturbed area before replacement of the forms. Minor adjustments can be made by hand-tamping material under the form along its entire length. A rolling straightedge may be used as a supplemental check on the vertical alignment. At this time, a final check should be made of the distances between the form line and the tack point, and across the subgrade between forms.

When the "slip-form" type paver is permitted, the "track-grade" performs the same function as a line of forms and determines the smoothness of the concrete surface. For this reason, the same characteristics (stable, smooth, to grade, etc.) peculiar to a good form line grade are required in the preparation of the subgrade.

5. Preparation of Subgrade. If a sealed surface has not been previously constructed, a subgrade planer or a mechanical subgrader may be used to fine grade the subgrade surface after the forms have been set and approved

by the Grade Inspector. The subgrade planer is a heavy machine which is operated on the side forms, and is equipped with adjustable blades capable of cutting the subgrade to the proper cross section and elevation.

The subgrade must be checked for elevation prior to placing of the concrete. At this time the Grade Inspector should recheck the forms for line and grade. Flags or other identification marks should be used to mark the forms and subgrade which are found to be acceptable.

6. Reinforcing Steel and Joint Assemblies. Concrete pavements may be classified as "plain" concrete pavements (no reinforcement), "lightly reinforced" with wire mesh or reinforcing bars, and "continuously reinforced" with deformed wire mats or reinforcing bars. When reinforcement is used, it must be clean, free of loose rust, and placed as closely as possible to the position required by the plans. Unless otherwise specified, reinforcing bars should be securely wired together at all intersections, at the splices, and at each dowel bar intersected. The method of supporting the steel reinforcement should have the approval of the Resident Engineer. The supporting chairs should accurately locate the reinforcing steel and provide resistance to any lateral forces (such as concrete batches being deposited on the grade). When stamped steel chairs are used, it is recommended that every other one be faced in the opposite direction. This will provide added resistance to any lateral forces. Normally, the chair spacing should not exceed 48 inches longitudinally and 30 inches transversely. If the proposed type of chairs will not substantially support the steel at these spacings, additional chair supports should be used, or the type of chair should be changed.

   Wire mesh reinforcement normally requires the placement of concrete in two layers, with the mesh placed on top of the lower layer. Two mixers are usually required for this operation. The lower layer will normally be spread to the proper depth by a special spreader. In using this method it is imperative that a minimum of time elapses before the top layer is placed in order to avoid any possibility of developing a plane of weakness between the two layers. The depth of placement of the wire mesh should be controlled from the top of the forms and in its final position (after the finishing equipment has passed over it) it should be within the limits established by the plans and specifications. The wire mesh has a tendency to move downward during the finishing operations and it is important to maintain uniform surface of the lower layer of concrete and to avoid any low areas. The wire mesh fabric should be checked constantly to insure that bent, or otherwise damaged mats are not used. After the wire mesh has been installed on top of the bottom course, the top course is placed using the "bucket" and the boom on the mixer and machine spreading or hand leveling in front of the finishing machine. In hand leveling far more than just shoveling is involved. The concrete must be placed in such a manner that the forward transverse screed of the finishing machine carries a fairly large, uniform roll in front of it. By the nature of the work, walking in the concrete and on the reinforcing steel mats cannot be avoided. However, filling of these "tracks" must be done properly; not with mortar, but with well-graded concrete. Some contractors use two spreaders on this type of work, but even this additional equipment does not eliminate the hand-placement of the mesh and "tracking" in the concrete that is a part of this operation.

When a mechanical "mesh-placer" machine is used, concrete is placed full depth in one course and the wire mesh is placed manually on the surface. The "mesh-placer" uses a combination of pressure and vibration to force the wire mesh from the surface to the required position in the slab. Although these machines have not been used extensively in the State, the results have been highly satisfactory.

Where dowels or other joint assemblies are required by the plans, it becomes necessary to securely position all or part of the assembly at the plan location and elevation prior to concrete placement. Devices indicated by the plans, or other approved methods, must be used to hold the assembly firmly in place during concrete placement and finishing. Usually, these devices are anchored or nailed directly to the subgrade. Regardless of the anchor method used, it is recommended that concrete from the mixer be deposited adjacent to the assembly, and that this concrete be hand-shoveled on and around it. Hand placing will be advantageous in two respects: (1) proper vibration of the concrete in and around the joint assembly will be obtained, and (2) the joint assembly will be protected against displacement.

When a trapezoidal key joint (tongue and groove) is used to form the longitudinal construction joint it shall be made of the proper material and conform to the plan requirements. The shape and tight attachment of the keyway to the forms is important, because improper shape or improper removal of the forms will cause edge spalling. In removing the keyway forms, force should be applied perpendicular to the edge of the concrete slab. To insure against displacement during placing of the concrete, the steel tie bars should be bent, if permitted, to fit snugly in the keyway groove, and be adequately supported by chairs or by an alternate method approved by the Engineer.

B. <u>EQUIPMENT INSPECTION</u>

1. <u>General</u>. The Mixer Inspector is responsible for the on-site mixing and placement of the concrete. He is normally assisted by an Inspector who is responsible for the finishing of the surface. Construction of a sound pavement with the desired surface characteristics will depend to great extent upon their supervision, familiarity with the plans and specifications, and constant attention to details.

Before any concrete is placed in the forms, all equipment should be checked for compliance with the specifications. A check list similar to the example in the Appendix may be of assistance. At this time adjustments and repairs should be made in order to put the equipment in a good operating condition.

2. <u>Mixer Inspection</u>

a. <u>General</u>. The concrete mixer (sometimes referred to as a paver) must be in a good mechanical condition to produce uniform and well-mixed concrete. This discussion will be confined to the "conventional" type mixers presently in use. The mixer size (such as 27-E, 34-E, etc.) designates in cubic feet the rated size of the drum, or the mixing compartment. Therefore, a 34-E mixer is rated by the manufacturer to mix 34 cubic feet of concrete per batch. Specifications currently allow a 20 percent increase in the maximum size of the concrete batch, which would permit mixing of a maximum of 40.8 cubic feet per batch in the 34-E rated mixer.

A multiple-drum type mixer is divided into two or more mixing compartments. Although these compartments are effectively separated from each other, provision is made for rapid and complete transfer of batches from one compartment to the next. The "dual-drum" 34-E mixer is the most common type found on paving projects at this time.

Paving mixers are equipped with a boom and bucket, which are used to deposit concrete on the subgrade so as to require as little rehandling as possible. The boom on the mixer should be positioned as low as possible to reduce the free fall of the concrete when it is discharged from the bucket, but it must be positioned at such a height that will allow the discharge gates, when open, to clear the side forms. When one mixer is used to place the concrete in a twenty-four foot section, the boom must be of sufficient length to allow uniform placement of concrete between the forms.

b. Water Measuring Device. According to the specifications, mixer shall be equipped with a suitable water measuring device which will consistently regulate the amount of water within plus or minus one percent of the specified amount. All valves used with this device should cut off promptly and should not leak.

The water measuring device should be checked by at least ten successive trials on each regulator "setting" used in the check series. Dependable, accurate measurement of water, batch after batch, is essential in production of uniform concrete. A series of trial measurements can be started with the regulator setting at that point where it was when last used and should cover a range between 25 and 45 gallons using 5 gallon increments. The dispensed amount of water can be checked for accuracy by volume measurement or by weighing. Platform scales positioned adjacent to the mixer and checked for accuracy prior to use, and a 55 gallon drum can be used for the weight check.

During the paving operations rust, scale, sand grains, or other foreign particles in the water system can interfere with the proper metering of the mixing water. When undue variations occur in the batch as indicated by the slump (too wet - too dry) this system should be immediately inspected, for many times valve malfunction is the source of trouble. During the progress of the job, the main discharge should be occasionally inspected for leakage. Even small amounts of leakage can affect control over the slump of the mix.

c. Mixing Compartment. Prior to use, and routinely during the course of the job, the mixing compartments should be examined. Accumulations of hardened concrete or excessive blade wear can result in a poorly mixed concrete. Blades should be replaced when worn down 3/4 inch or more.

d. Timer. A timing device, equipped with a sounding device to signal the completion of the mixing cycle, is required. This automatic device must also prevent the discharging of the batch before the minimum required mixing cycle is completed. When multiple drum mixer is used, mixing time should not include the time required to transfer concrete from one mixing compartment to the next. The time cycle should be checked for elapsed time between signals (with a stop watch) when the mixing drum is operating between 16 and 22 revolutions per minute.

e. Admixture Dispenser. When admixtures are used, a mechanical admixture dispenser is usually required. It is recommended that the admixture be discharged into the stream of the mixing water and the outlet be securely fixed in that position. At intervals during the course of the job it is urgently recommended that the metering device be cleaned to prevent partial or complete clogging by accumulation of the thickened admixture. A suitable container, graduated in ounces, should be used to check the amount dispensed. The dispenser should be checked immediately when repeated abrupt changes occur in the slump of the mix.

3. Finishing Equipment

a. General. The mechanical equipment generally used for finishing of concrete pavements consists of power-driven vibrators, transverse strike-off and screed, and a longitudinal float. Each piece of equipment should be in a good operating condition and each screed must be adjusted to the proper crown by the Contractor and checked by the Mixer Inspector.

b. Transverse Finishing Machine. The transverse finishing machine consolidates the plastic concrete and gives it the proper shape by transverse screeding or "striking off" of the surface. To fulfill this function, the machine must be in proper adjustment. Each transverse finishing machine is equipped with two transverse screeds which have an opposing, laterally reciprocating motion as the machine propels itself forward over the forms. Screeds are equipped with the following types of adjusting devices: (1) a single row of adjusting studs, uniformly spaced along the middle of, and for the length of the screed; (2) two rows of adjusting studs, one row uniformly spaced parallel to the leading edge of the screed and another row parallel to the rear edge and opposite each other in pairs, for the length of the screed; and (3) later model machines equipped with the "quick-crown-change" type adjustment. The quick type adjustment consists of a double row of adjusting studs that are positioned simultaneously to change the screed shape by a single adjusting mechanism from one end of the screed. This quick change feature is advantageous in transitions from a crowned section to a flat or straight-slope, and vice versa. Some screeds have an additional pair of studs located over the end shoes, which afford better control in the screed end adjustment. It is recommended that a second pair of adjusting studs be added to a screed not so equipped.

The position of the screed bottom, relative to the direction of its longitudinal travel, governs its performance. A flat screed "cuts" whereas a tilted screed tends to "float over" and "iron out" the concrete surface. In addition, greater consolidation of the concrete is secured with a tilted screed. Keeping this in mind, the necessary adjustments can be made to accomplish the desired finishing effect.

Before paving operations begin and many times during the progress of the job when changes, adjustments, or checks are required, the shape of the screed must be "set" or changed to conform to the specified shape or crown-section of the pavement, and the tilt and height of the screeds may need changing to provide the desired surface finish.

In adjusting the screeds it should be first determined that the screeds are clean and that the wheels of the machine and the top of the forms supporting it are free of all accumulations of hardened concrete or other foreign material. The section of the forms supporting the machine must be properly lined, graded, latched, and keyed. Screed should be centered in its lateral motion and wheels should not be positioned over a joint in the forms. With the screed in a raised position, the end wear plates (or "shoes") should be examined for excessive wear. If the rubbing contact between the shoes and the forms, has worn them down (or "hollowed-out") as much as one-eighth of an inch, they should be reversed (turned over and installed on the opposite end of the screed). If both sides are worn one-eighth of an inch or more, shoes must be replaced. Shoes should then be adjusted to set flat against the form rail when the screed is lowered, and allowed to rest freely on the rails. By means of the adjusting studs previously mentioned, shoes should be set flat against the rail and aligned to conform to the required section or crown. Using some sort of lever (such as a grade stake) each corner of the screed should be raised to determine if approximately the same resistance is encountered at each point. If not, the "lighter feeling" corner should be adjusted downward until the load is equalized at all corners.

Next, the screed should be raised off the forms and that area of the forms should be cleaned. Two lines (one just under the front edge and one just under the rear edge of the screed) of fine fishing cord should be tightly stretched from form to form and secured in any convenient manner outside the forms. A stake (1" x 2" x 15") should be placed on top of the forms over these cords under each end of the screed and the screed gently lowered to rest on the stakes, making certain that the screed is fully supported on them. By means of the adjusting screws, the screed bottom is then positioned to the specified shape using the two cords as reference lines from which measurements are made.

In making the adjustment, all the intermediate studs should be adjusted in pairs by setting both the back and the front edges of the screed at each adjusting point before proceeding to the next point. As mentioned previously, to assist in consolidation and finishing of the concrete, the front of the screed should be slightly tilted upward. One-sixteenth of an inch tilt is recommended as the usual initial setting for both screeds, keeping in mind that only the intermediate points are tilted. The end shoes should be set flat so as to ride flat on the forms.

During concrete placement, a set of spacers on the top of the forms, a taut cord drawn over them, and a ruler will enable the Inspector to quickly determine if the surface of the slab is being finished at the desired height and to the proper crown.

If the concrete is being finished satisfactorily, but the surface of the concrete needs to be raised slightly, the entire screed should be raised by adjusting only the end shoe studs. Adjustment of the end shoes downward will raise the screed, but will not change the tilt.

If the elevation is satisfactory, but the surface of the concrete has a "pulled or ragged" appearance, a little more tilt in the screeds is necessary. Tilt in the rear screed can be increased by lowering the rear edge of that screed. This adjustment will tend to force the aggregate below the concrete surface and leave a surge of mortar behind the screed for the subsequent finishing operations.

When paving downhill the natural tendency of the plastic concrete is to move downhill ahead of the screeds. This condition may be compensated for to a degree by raising the front screed height and increasing its tilt; however, under this condition, additional "passes" will probably be required to insure a satisfactory surface finish. Normally, in this type of operation the rear edge of the rear screed should be set at the same height as the top of the forms.

When paving uphill the natural tendency of the plastic concrete is to surge under the screed and cause an excessive bulge behind it. This effect can be offset by positioning both screeds flat and at the same height as the top of the forms. This position enables the screeds to cut off the bulge and carry it forward. Again, additional passes of the finishing machine will probably be required under this condition.

When the elevation of the form lines differs sufficiently to cause slumping of the plastic concrete to the low side, an adjustment can be made by intentional warping of the end two or three feet of the screed. The amount of adjustment will vary considerably depending on the consistency of the batch and the difference in the side form elevations. The lower end of the screed should be adjusted to produce a slightly concave surface and the upper end should be adjusted to produce a slightly convex surface. The exact amount of adjustment to offset slumping of the plastic concrete must be determined at the job site. Particular emphasis must still be placed on uniformity of the concrete and under these paving conditions the minimum slump, consistent with proper workability, should be used. Even with this type of screed setting some concrete may have to be added to the high side during finishing.

Specific instructions for screed settings required to cope with all the various situations are not practical; however, it must be remembered that a "tilted" screed has an "ironing" effect on the concrete surface and a "flat" screed produces a "cutting" action. When adjustments are made to provide a certain finishing effect under the existing or anticipated paving conditions, it should be a standard practice to check the results using a string line and making depth tests.

c. Longitudinal Finishing Machine. The longitudinal finishing operation is normally the last mechanically controlled operation in the finishing process. The finishing machine should be in proper adjustment and it should leave the concrete surface in such a condition that a minimum of "manual" straightedging is required. The manual straightedging should consist of removal of the screed marks and minor surface irregularities. In this respect, operations preceding the longitudinal float can appreciably reduce the amount of work this machine is required to do. Improper adjustment and poor operation of the longitudinal float can also ruin a well-prepared surface. When irregular form lines, non-uniform batches, changes in the horizontal or vertical alignment, or changes in the surface conditions are encountered, a properly adjusted longitudinal finishing machine is essential in correcting these irregularities.

Adjustments vary for different types of equipment, but in general, adjustments are made to maintain the screed or the "float", parallel to the top of the forms and at the proper elevation at all points in its travel. The longitudinal float is suspended from the transverse tracks at the front and rear of the machine. To maintain proper adjustment, tracks must be sufficiently stiff to support the weight of the float and the operator, and to resist deflection as the float is moved across the pavement surface.

Several adjustments should be checked in order to maintain the correct operating performance: (1) the height of the crown-rail above the top of forms for a basic determination of the plane of the pavement surface; (2) alignment of the crown-rail and the track to control the transverse plane of the pavement surface; (3) alignment of the screed "pan" so that it performs as a "straightedge"; and (4) screed adjustments required to avoid "twist" in the contact surface and to control the height of the strike-off.

The height of the crown-rails (or tracks), upon which the screed assembly is conveyed from one side of the pavement to the other, should be checked and adjusted so that they are exactly the same distance above the plane of the wheel bottoms at all four points above the form rails. Prior to making this check the forms supporting the machine should be clean, aligned, graded, and preferably on a section of a flat gradient. A fine cord should be stretched across the top of the crown-rails at a point over the form lines, and the distance measured from the top of the crown-rails (as established by the cord) to the top of the forms at or near the crown track. This dimension must be exactly the same at all four points. Since it may vary for different machines, this dimension should be set in accordance with the manufacturer's operating instructions.

The crown-rail alignment, to conform with the specified shape or crown of the pavement surface, is checked by means of a fine cord stretched from end to end of the rail and offset up from the rail surface by blocks (of equal thickness) at each end. By means of the adjusting studs, spaced uniformly along the length of the track, the track should be adjusted to conform to the required surface shape. Measurements should be made between the tightly stretched cord line and the top of the rail considering the thickness of the end blocks. Some machines have a double track to convey the screed assembly across the slab. One of the tracks is always set flat and the other controls the cross section shape of the pavement. When circular or parabolic crowns are encountered, the ordinates used to set the crown in this track are measured from the flat track. Transitions from the flat to the crowned section (or vice versa) are made by increment adjustments in quadrants located at both ends of the screed carriage. Some machines have only one track. This track can be changed from a flat position to a full crown by means of cams. The cam action is controlled by a wheel and connecting linkage. Using a string line, the track is checked in the flat position, the cams are rotated 90°, and the lengths of the cam arms are adjusted to produce the required crown.

The screed bottom resembles a "pan" with turned-up edges, which can be adjusted vertically to provide a "straightedge" alignment. The screed is connected to a beam with adjustable studs uniformly spaced along each edge. Prior to making the adjustments, the pan and the studs should be cleaned of the hardened concrete and a fine cord should be stretched tightly along and near both edges of the pan bottom. Spacers should then be placed under these string lines (pennies may be used) at or near the ends of the pans. Each pair of studs should be adjusted (except those pairs on each end of the screed) by forcing the pan away from the beam slightly, but uniformly, by 1/3 to 1/2 of the thickness of the coin. This slight upturn in the ends of the screed should break the vacuum between the plastic concrete and the screed, permit the screed to operate in a smooth manner, and prevent the ends from "digging into" the concrete surface.

The entire contact surface of the screed must operate in a plane parallel to that of the longitudinal concrete surface, and if the screed is twisted it will not finish properly. Before beginning adjustment, the screed should be centered between the forms in its lowered operating position with all the operational load on it (including the operator). If necessary, the corresponding points at each corner should be adjusted the same distance above the cords tightly stretched across the top of the forms.

d. Concrete Spreader. Concrete spreading devices are sometimes required by the specifications (mandatory when central mixed concrete is used), or are used by the Contractor at his option. At least three different types of mechanical concrete spreaders are used. One type receives the mixed batch in the hopper and distributes the concrete laterally between the forms in a fairly uniform manner. An adjustable strike-off plate attached to the machine levels the distributed concrete to the required depth. The other two types, use an "auger" or a "paddle" to distribute the concrete.

The auger type is the most versatile of the latter pair. It can spread concrete towards the forms or away from them, or from one side to the other. It can be set to "strike-off" at one level on the initial pass and at a higher level on the final pass. It produces very little abrupt "thrust" against the forms; instead, there is a steady push outward or inward depending upon the direction the concrete is being moved. When wire mesh is used, this spreader can strike off the concrete at the proper elevation for mesh placement and make another pass over the same area, leaving the top layer at the proper elevation for the finishing equipment.

The "paddle" type spreader can duplicate the work of the "auger" type, but it exerts a great amount of side thrust against the forms. Additional attention must be given to the maintenance of the form lines when this type spreader is used.

Just behind the auger or paddle is an adjustable "strike-off" plate. The height of the distributor (auger or paddle) and the strike-off plate are adjustable. Before use, the height of the strike-off should be set at the top of the form elevation and the gauge reading checked. If the plate is not set at zero it should be adjusted to this reading. The auger or the paddle distributor is normally set one inch above the strike-off elevation, but this distance should be checked on the project, as it depends on the skill of the operator and the mix characteristics.

If the mixer operator will strive to distribute the concrete across the grade uniformly ahead of the spreader, consolidation of the concrete mass will be more uniform and will contribute substantially to attaining good riding qualities. Spreader should not be used as a substitute for this operation, as a minimum of re-distribution of the concrete is desirable.

e. New Types of Finishers. If other types of finishing equipment are permitted, their adjustment should be covered by special instructions supplemented with observation of their performance on the project.

Two general types of machines have been developed to replace the conventional spreading and finishing equipment. One type combines two transverse screeds with a pan (or drag) float. This combination is mounted on a long wheel base frame, and it has been used successfully to replace the transverse finishing machine and the longitudinal float. The pan (or drag) float is adjusted to the required pavement crown and extends from form to form, but does not rest upon them. As the machine moves along the forms, the pan float adjusted vertically to barely contact the concrete surface, produces the final transverse shape and removes the longitudinal irregularities as a result of its suspension on a long wheel base carrier. Adjustments of the transverse screeds are made in the manner previously described. The "drag" float is adjusted to the required surface section of the concrete and to the elevation of the top of forms. As with other types of finishing equipment, minor adjustments will be required to produce the desired surface and finish.

To achieve a good riding surface, this machine must be supported by a stable form line, in good alignment and to grade, and the concrete batches must be as uniform as possible. Continuous forward movement is preferred, as stopping and starting of the machine can cause surface flaws. Since it is not practical to reverse this machine and rework a section of pavement, great care must be exercised in securing a satisfactory surface with one pass.

The second type of machine that has been developed is the slip-form (or formless) type paver. This machine eliminates the use of the side forms and performs all the functions of a conventional paving train. Concrete is spread with a dozer-type blade, it is vibrated, consolidated and shaped with an extrusion plate, and finished with a V-type float. All of these operations are controlled by one operator and are completed in a single pass of the machine at a speed of five to ten feet per minute.

Several items may require particular attention when this type of machine is used. As this machine is supported by a crawler type track and passes over the concrete only one time, the preparation of its "track grade" is very important. The "track grade" must be prepared very carefully to provide stability and accuracy of grade equal to or exceeding the grade prepared with a line of steel forms. When concrete is being placed, this area must be kept free of concrete and other obstructions. Uniformity of the concrete is essential in producing a satisfactory pavement with this machine. Entrained air content should be maintained as constant as possible, and frequent checks of the dispenser operation are advisable. Proper vibration of all the concrete is important, for it must produce sufficient consolidation to prevent honey-combing without bringing excess mortar to the surface. However, some excess mortar should be developed in front of the extrusion plate in order to form a workable surface behind the plate. The internal type vibrators must be positioned, in relation to the extrusion plate, so as to satisfy the following: (1) clear any reinforcement in the slab, and (2) prevent excessive air bubbles on the surface behind the plate (vibrators too close to the plate), or tearing of the surface (vibrators too far from the plate or mix too harsh). During this adjustment, the slump of the concrete should be maintained as constant as possible.

Usually, forty-eight feet of trailing forms are attached to the slip-form paver, and a sixteen foot bay adjacent to the paver is occupied by a V-type finisher. This finisher can be adjusted to the pavement cross section and can be moved vertically by cables attached to the paver. When properly adjusted it should be in full contact with the pavement surface and it should carry a small roll of mortar along its leading edge. Initial straightedging and placement of the transverse joints, if required, is usually accomplished between the trailing forms. If additional straightedging is necessary to improve the surface, it can be done outside the trailing forms. Straightedging outside of the forms must be stopped before reaching the unsupported edge, and any mortar left near the edge should be smoothed out by an edger. Edging must be done with a tool of the proper radius, and only enough pressure should be applied to form the radius and not to depress the tender concrete. If the unsupported edge should slump for any reason, it should be repaired immediately. This can be done by removing the slumped material, supporting the edge with a board or steel form of proper depth, and replacing the removed material with fresh concrete. This area should be finished and edged to fit the original surface. Excessive slumping can be corrected by appropriate changes in the mix design that will maintain workability at a lower slump. Belting of the surface is performed in the same manner as if the steel forms were in place, although the belt cannot be pulled down on the unsupported edge without causing some damage, and as a result, a narrow band of surface along each edge must be textured by hand brushing.

The slip-form paver can produce a satisfactory concrete pavement. However, to accomplish this it must be supported by a good track grade and be supplied with consecutive uniform batches of concrete.

C. PLACING AND FINISHING CONCRETE. Although the actual paving operations are the particular responsibility of the Mixer Inspector, certain preliminary work should also be checked by him prior to the beginning of the work and during construction. Items that should be checked are: alignment, proper setting and oiling of the forms, dowel and steel reinforcement alignment (if used), and condition of the subgrade. Required corrections should be brought to the attention of the Grade Inspector and the Contractor. Normally, corrections should be made prior to the beginning of the concrete placement.

The Mixer Inspector is responsible for the workability of the concrete mix. The initial concrete batches produced in accordance with the preliminary tests, should be closely observed by the Mixer Inspector to see that they are workable in all respects. At this time, it should be determined if the coarse aggregate factor, normally the same as used in the preliminary tests, is the proper one to use. If the mix is harsh and difficult to finish, the coarse aggregate factor should be reduced and the mix observed to determine how it responds to the finishing equipment. Observations may sometimes indicate that the reverse is true. The coarse aggregate factor may then be increased. In any event, the Mixer Inspector should advise the Plant Inspector to make such changes in the mix design as his observations indicate.

Uniformity of the concrete batches is one of the basic requirements of good pavement construction. Durable, good-riding pavements can be built using different mix designs as long as the concrete is uniform from batch to batch, and the finishing operations are properly performed. Any batch that is non-uniform, such as being too wet or too dry, oversanded, undersanded, or lacking the proper amount of cement shall be rejected. Based upon observations of the mix and the slump tests, the Mixer Inspector should adjust the quantity of water (being added at the mixer) to maintain uniform consistency of the batches. Should the amount of water added at the mixer vary consistently from the design water content by more than two gallons per cubic yard of concrete, a new moisture check or a change in the mix design should be requested immediately.

Variation in the moisture content of the aggregates is sometimes caused by improper handling of materials at the plant. Loading of the bins from different parts of the stockpile, without any pattern on the part of the crane operator, can result in the bins being filled with material containing varying amounts of moisture. These sudden changes in the moisture content of the individual batches make it very difficult, if not impossible, to maintain consistency of the concrete. Gradual changes are to be expected, but erratic moisture content should be called to the attention of the Plant Inspector and corrective action should be initiated by him.

Batch trucks, although correctly loaded at the plant, can cause difficulty in maintaining uniformity in concrete batches at the mixer. It is recommended that the Mixer Inspector observe this operation initially and during construction. The following problems, if noted, should be immediately corrected: (1) batches spilling from one compartment to another when the dump bed is elevated; (2) dumper not requiring truck drivers to back the trucks far enough onto the skip apron with resultant spillage of a portion of the batch on the ground; (3) a short apron on the paver that does not hold the complete batch and leaves part of it on the ground when the skip is raised; and (4) truck pulls off the skip apron before the complete batch is emptied out of the truck bed. Some of these conditions can be corrected by mechanical alteration of the equipment, while others will require constant attention during construction.

All plastic concrete, sooner or later, loses some of the moisture. When this rate of moisture loss exceeds the rate of evaporation from the pavement, free water will appear on the slab behind the finishing operations. This is called bleeding. Bleeding will most likely occur when humidity is high or the fine aggregate used contains a relatively high percentage of voids. Bleeding is objectionable for several reasons. It will leave a thin film or laitance on the pavement surface which will readily wear or scale off under traffic. This produces an unsightly as well as an open, weak surface which will deteriorate much faster than a tight, strong, low void surface. In addition, bleeding will unduly delay the finishing operations.

There are several methods by which bleeding can be stopped or materially reduced. The addition of entrained air or an increased amount of entrained air will generally allow a reduction in the amount of mixing water required to maintain the same slump. This will reduce the amount of water available for bleeding. Addition of fine sand or mineral filler up to a certain amount will usually result in a decrease in the percent voids in the fine aggregate. This reduction in voids will allow a reduction in the amount of the mixing water required to maintain the same slump. Addition of fine sand or mineral filler also increases the surface area of the fine aggregate which tends to hold the moisture within the concrete for a longer period of time, thereby decreasing the rate of moisture loss.

Hair cracking is the opposite of bleeding. This condition is caused by the rate of evaporation being much greater than the rate of moisture loss from the concrete surface. An increase in the percentage of voids in the fine aggregate should give some relief. Thorough wetting of the subgrade will also be of some help. The primary remedial action, however, consists of accelerated curing operations.

Prior to the placement of concrete within the forms, the grade should be in a moist and acceptable surface condition. This condition should be maintained at all times ahead of the concrete placement. Concrete should be placed fairly uniformly across the subgrade in front of the spreader. A certain amount of excess concrete allows the spreader to carry the material ahead of it for filling any voids in the concrete mass. Observation of concrete at this point, will indicate if the mixer is producing uniform, well-mixed batches.

The specifications require that concrete be consolidated by an approved mechanical vibratory unit operated ahead of the transverse finishing machine and designed to vibrate the concrete internally or from the surface. There are two types of mechanical vibratory units in general use at the present time. One of these is the "pan" type vibrator, which operates along and over the concrete surface. The other type referred to as the "spud" type vibrator, consists of a single tube or a group of individual short tubes known as "spuds". These spuds are held at the proper elevation as they pass through the concrete mass. Both types can produce satisfactory vibration of the concrete, if the units are checked and adjusted as required by the specifications or as directed by the Engineer. Satisfactory vibration may be described as that which consolidates the concrete mass so that honeycomb is eliminated and excess mortar is not produced on the concrete surface. Vibrators should be operated when the machine transporting the vibrators is in motion and should be stopped whenever the machine stops. One uniform pass over the surface or through the concrete mass is usually sufficient, and overvibration should be avoided. Overvibration segregates the materials and brings excess mortar to the surface which is difficult to finish and which produces uneven surface when all the shrinkage has occurred during the curing process.

The transverse finishing screed smoothes, consolidates, and shapes the surface to the required cross section. The front screed should carry a small roll of concrete at all times and should be operated at a forward speed that is related to the workability of the mix. The height of the roll should be maintained at about four inches with a maximum height of eight to ten inches. The important characteristics of this roll are its uniformity of height, and its continuity for the full width of the pavement. This "head" of concrete has a direct effect on the amount of surge behind the screed. Finishing machines are equipped with variable speed transmissions and with variable stroke length of the transverse screed which can be adjusted if condition of the mix warrants a change. Workable mixes respond to shorter, slower screed strokes combined with a rather fast forward motion of the machine. Harsh mixtures require more transverse screed movement per foot of the forward travel in order to work up sufficient mortar to cover the larger aggregate. Loss of all or a part of this roll in front of the screed indicates a low area in the surface. When this occurs, the machine should be backed up, concrete from the mixer and not that wasted over the forms, should be used to fill the low area and the screeding process repeated. Normally, at least two passes should be made over the pavement surface and the last trip over any given area should be a continuous run of at least forty feet. The longer run results in more continuity in the finished surface. Overmanipulation with the transverse finisher tends to work the larger aggregate down from the concrete surface. This excess thickness of mortar at the surface should be avoided for the same reasons as discussed previously under vibration.

The longitudinal finishing operation is the last mechanically controlled finishing operation applied to the concrete surface. The manner in which it is performed can improve the surface or it can increase the amount of work to be done by the straightedge operators. If the transverse finishing machine has performed its function properly and the forms were correctly set, the longitudinal floating operation will be needed to merely float and smooth the surface. The need for cutting and filling of areas is an indication that the preceding operations have been performed poorly and the surface alignment is unsatisfactory. Unless the longitudinal float leaves the surface substantially free of irregularities, the hand finishers will have great difficulty in securing a satisfactory surface. The longitudinal screed should carry a plastic roll of mortar, not slurry, in front of it and be operated so that the low areas will be detected by a loss of the roll. These areas should be filled with concrete, not mortar, and reworked with the longitudinal float. Each successive pass of the screed should overlap the previous one by at least one-fourth of the screed length.

The top of the forms should be continually cleaned, to prevent build-up of mortar, during operation of both the finishing machines. Mortar build-up should also be removed from the wheels of the finishing machines . It would be a very poor procedure to insist on good form alignment and then allow the finishing equipment to operate over the irregular profile created by this build-up. The longitudinal float should be held back as far as possible , depending on the weather and the concrete mix, so as to allow most of the initial settlement of the concrete to take place. This is particularly important when operating on steep grades. On the downgrade, operation of this machine too close to the mixer will cause concrete to move ahead of it. On the upgrade, concrete will tend to flow under and up behind the screed. Both conditions can produce a surface that is hard to shape and which will probably result in a choppy riding quality. It is recommended that the following conditions be avoided in the use of the longitudinal float: operation too close to the mixer especially on grades, irregular progress along the pavement surface, and insufficient overlap between successive passes across the surface. Excessive finishing with either the transverse or the longitudinal finishing machine is no substitute for a good form line, and as has been discussed before, can be detrimental to the completed surface.

The timing sequence of the "finishing train" varies and will probably require frequent revisions. Timing sequence can be affected by a number of circumstances: condition of the mix, production rate, weather, etc. The proper timing of the finishing operations cannot be established by the specifications or regulated in advance of the work, but must be continually adjusted to produce the best results.

Generally, the initial screeding and compacting operation should follow the "placement" of concrete as closely as possible. All subsequent operation should be delayed as long as feasible, allowing sufficient time for completion of all operations before the concrete becomes unworkable. Intentional delay will allow time for the normal consolidation of concrete which takes place during the working and finishing operations. Shrinkage cracks and surface irregularities caused by subsidence of the concrete mass will be minimized. A finishing time-sequence based upon this principle will materially aid in producing a durable slab and a good riding surface.

When the placement of concrete is stopped, whether intentionally or not, a "header" must be set to form a neat end on the preceding placement. Although the minimum distance is not specified, it is considered good practice to place a header at least ten feet away from the last contraction joint. Using a tight string line as a guide, the header should be installed perpendicular to the center line of the pavement, vertical to the subgrade, and slightly below the surface of the pavement. The latter is necessary to prevent displacement of the header by the screeds. The transverse finishing machine should be stopped short of the header and the final finishing should be accomplished by the longitudinal float and straightedges. The transverse finishing machine should not be allowed to fill the void adjacent to the header with the roll of mortar carried by the front screed. Void at the header should be filled with well-graded concrete, the longitudinal float should proceed toward the header, its forward motion should be stopped and the screed should be operated on the slab just short of the header. This operation should be repeated with about one-fourth of the screed extending beyond the header. Final finishing and checking of the surface should be done with straightedges.

D. JOINTS. Improper construction of any type of transverse joints (expansion, contraction or construction) can cause difficulties that will continue throughout the entire service life of the concrete pavement. Adequate inspection during construction and installation phase can do much to insure that joints will perform as designed. Joints should be placed as near the planned location as possible, and maintained in that position until the concrete has attained its initial set. To function properly, all joints should be vertical, straight, and at the depth specified. Joint assemblies installed prior to concrete placement, must be attached firmly to the grade in order to resist displacement by the concrete and to prevent movement during the finishing operations. A tilted or bent assembly can contribute toward future joint failure and can become a source of costly maintenance. Careful operation of the finishing equipment at the joint will prevent displacement of the assembly and will eliminate possibility of faulty operation at a later date.

Terminal sections of the transverse construction joints may not be accessible to the mechanical finishing equipment and considerable handwork may be required to secure good riding quality. The quality of concrete and quality of workmanship are especially important at the beginning and end of each day's paving operation and at any time that an unintended stoppage requires a construction joint. Both are necessary to insure durability of concrete pavement in the area adjacent to a transverse construction joint.

It is recommended that the first several batches of concrete in the morning be dumped away from the construction joint. The area adjacent to the joint should be filled with subsequent loads of concrete after the plant operations have stabilized. Every effort should be made to secure proper consolidation of the entire depth of concrete using the hand manipulated mechanical vibrators. A procedure should be established to insure complete consolidation of the entire mass of concrete not accessible to the mechanical finishing equipment. The hand type vibrators should be inserted vertically for the full depth of concrete at points 18 to 24 inches apart, and slowly withdrawn. Concrete along the construction joint should be consolidated by operating the vibrator along and close to but not against the vertical surface of the joint. Vibration of concrete should be continued until thorough consolidation is obtained but not to the extent that would cause segregation. Surface should be screeded and straightedged to the required section. After finishing is complete and the concrete is still workable, it should be carefully tested with a 10 ft. straightedge to insure a smooth joint and good riding quality. The surface texture and curing should be applied as soon as possible.

Joints that are grooved in the plastic concrete require special attention in order to prevent spalling and to produce a smooth surface. The flat plate used to form the groove must be straight and inserted vertically with minimum vibration. Overvibration produces segregation and excess mortar is formed adjacent to the joint. Excess mortar at the joint can result in spalling. Any wood floating required to smooth the disturbed concrete surface should move the concrete, not just the mortar, back against the grooving plate. Bent or twisted plates should not be used as they can cause spalled joints. Special care must be exercised in edging the transverse joint and in removal of the grooving plate. The edging tool should have the smallest radius available in order to keep the top of the joint as narrow as possible. To avoid creating a sloping surface adjacent to the joint the edging tool should be kept flat against the concrete surface. Plates used to form the groove should be carefully removed in order not to pull the loose concrete as the plane of weakness is formed. Even though efforts may be made to recompact the loose concrete, spalling will probably occur. After the joint is edged and the plate extracted, the smooth troweled surface texture adjacent to the joint should be removed using a brush or burlap drag to produce a texture matching the remainder of the surface. All joints should be carefully straightedged when the concrete is plastic and the required surface tolerance should be maintained across and adjacent to the joint..

If sawed joints are used, the sawing operation must be started early enough after concrete placement is completed to prevent random cracking, but late enough to prevent damage to the surface of the slab and to the concrete adjacent to the joint. The proper time for sawing must often be determined by observations of the trial saw cuts. Hard aggregates will probably present most difficulty in deciding when to saw. A slight ravelling of the fine aggregate along the edge may not be too objectionable, but when the concrete strength is not sufficient to retain the larger aggregate particles and spalling occurs, sawing should be delayed or the sawing method modified. It must always be kept in mind, however, that any extended delay increases the chance of random cracking. Multiple gang sawing will help to a great extent, but the lead saw can still cause spalling if sawing is started too early. The Standard Specifications require that transverse contraction joints spaced at approximately 60 foot intervals be sawed as soon as sawing can be accomplished without damage to the pavement, and before 24 hours after the concrete has been placed. The exact time of sawing should be approved by the Engineer. The longitudinal joint should be sawed as soon as possible after the placement of concrete, but at such a time that it will not cause damage to the pavement. Timing of the longitudinal joint sawing is not as critical as for the transverse joints, but it must be accomplished before any traffic is allowed on the slab. At intervals the depth, width, and alignment of the sawed joint should be checked for compliance with the plan requirements.

E. FINAL FINISHING AND CURING. After the mechanical finishing is completed, the entire surface should be checked for compliance with the surface tolerances by the straightedge operators. Straightedging should eliminate all small surface irregularities and indicate if the transverse screed and longitudinal float are performing properly. Straightedging will produce the greatest benefit when concrete is rather firm but the surface is still pliable. The straightedge must be checked for alignment, before and several times daily during use, by holding the straightedge horizontally with the contact face down and approximately at the eye level. A second person performing the check should then sight along the edges of the "contact surface". The blade is considered in proper adjustment if it has a slight droop (when supported only by the handle) toward each end of approximately 1/16 inch or more below the middle. If adjustment is necessary, one end of the blade should be supported on the forms and sufficient pressure should be applied to "re-align" the contact surface at the point of deviation.

The straightedge operator should begin finishing by placing the straightedge at a convenient working angle to the form line (for example approximately 30°) with the outside end of the blade extending outside the form line approximately one foot. Blade should then be pushed ahead a convenient working distance to expose the form rail and to provide preliminary smoothing of the surface adjacent to the form. This operation will reveal any low spots adjacent to the form line. It will also move any surplus mortar toward the center of the slab where it can be used for filling the minor surface depressions. If this accumulation is "sloppy" wet, its use should not be permitted, but it should be wasted over the forms. Straightedging should continue perpendicularly to the form line, cutting mortar from the high areas and depositing it in low areas. If a low area cannot be filled with the available mortar, additional concrete should be brought from the placement area. Long-handled floats are sometimes used to work this added concrete into the low area; however, the final finishing should always be done with a steel straightedge. If this condition prevails or occurs repeatedly, it means that one or more of the mechanical finishing operations is not being done properly. The source of the trouble should be located and corrected. If an appreciable amount of time will be required to correct the problem, the placing operation should be suspended until the proper corrections are made. Straightedging is not intended to be, nor should it be used to accomplish work that should be done by the mechanical finishing equipment. If open-textured spots continually appear, and the long-handled floats and mechanical finishing equipment are in proper adjustment, this must be called to the attention of the Mixer Inspector for possible mix design change. A properly proportioned mix should not require hand floating behind the properly adjusted mechanical finishing equipment. The successive and final passes of the straightedge should be perpendicular to the centerline of the slab and overlap each other by one half length of the straightedge. Observation of the pavement surface at this time should indicate if excessive bleeding is present. If excess surface moisture is noticed, this condition should be brought to the Mixer Inspector's attention and design adjustments should be made to correct it.

When the straightedge testing has revealed that the surface is satisfactory, and before the concrete becomes non-plastic, the surface texture should be applied. A rubber hose, approximately one inch in diameter and of sufficient length to form a "lagging" loop when pulled over the slab surface, is used to distribute and smooth the mortar. This provides a uniform amount of mortar for the belting or the burlap-drag operation that follows. When thin, watery accumulation is encountered, it should be wasted over the forms and "hosing" repeated in that area. Normally, each area is covered by at least three passes of the hose. The actual number required depends on the mix design, the finishing equipment, and the weather conditions; in other words, the surface should be "belted" only the number of times necessary to produce uniformity in the surface mortar. The belt should be operated with short strokes at right angles to the form line, maintaining a fairly rapid, yet uniform movement along the slab. This operation should produce a gritty uniform texture on the concrete surface. The Inspector may have to insist that belting be done on short stretches as the surface reaches, but does not lose, the proper firmness to accept and retain this texture. Usually, the proper time is reached when the water sheen is leaving the surface. The belting procedure will be controlled, to great extent, by observation of the results. When belting lifts the surface mortar into ridges, it is being done too quickly. If the herringbone pattern is irregular and spotted with undisturbed patches or streaks, the belting is not being completed soon enough. A new belt may need temporary wiring to bow the belt and to prevent the edges from digging into the surface. Both new and old belts should be kept free of hardened mortar and soaked in water prior to use.

A burlap drag finish is sometimes allowed or required in lieu of a belted finish. The width, weight, and the time of application will require experimentation in developing a drag that will produce the desired surface texture. To some degree, the burlap drag operation will depend on the mix design and the weather conditions. Usually a double thickness of burlap, approximately three feet in width and of a length equal to the pavement width, is sufficient to produce the desired surface. The width and the number of layers should be varied, if necessary, to produce the contact area and weight required to yield a uniform, gritty texture. On new burlap the trailing edge may need to be raveled for two or three inches to aid in producing the desired texture. In general, application of the drag should be delayed until such time that the surface of the concrete is sufficiently dry to permit removal of the float marks and a uniformly roughened surface is produced. Hardened mortar collected on the drag should be removed periodically, in order not to produce deep groves in the surface and not to mar the uniformity of the texture.

The initial edging of the pavement slab is usually done just behind the straightedge operation, when the concrete is soft enough to allow the protruding coarse aggregate to be pushed down from the surface. The finish edging must be delayed until the concrete has hardened enough to retain a neat radius. The edging tool must be held flat on the surface in order not to create a sloping edge on the slab. A brush or a burlap drag should be used to secure uniform surface texture after edging.

Curing of the concrete pavements is intended primarily to protect the slab against excessively rapid drying and should follow as soon as possible after the belting operation. Membrane curing compounds can be applied closely behind the belt finishers, while other acceptable curing methods must be delayed until the concrete has hardened sufficiently to allow placement without marring the surface. Improper application of a curing compound can also mar the surface. The nozzle on the spray machine must be adjusted to produce a fine spray and not an erratic stream of drops, and be operated at a distance from the concrete surface that will eliminate marking of the surface. Application of the compound to a tender surface, usually too close behind the belting operation, can cause streaking from the force of the spray, and can force some of the spray into the mortar and result in deterioration of the surface under traffic. Each day the operation of the spray machine should be inspected during its initial use. Curing compounds require agitation, before and during use, and the compound should be thoroughly mixed before the machine begins application. When forms are removed during the curing period the sides of the slab should receive the same curing as the surface.

During removal of the forms, the sides of the slab should be examined for honeycombing and bridging (of mortar) across the ends of the transverse joints. Honeycombs should be immediately "pointed-up" with approved mortar and the required curing should be applied to these areas. Mortar bridged across the end of a formed transverse joint should be carefully removed to prevent spalling at a later date. It may be advisable to inspect the form line to determine how complete was the contact between the form bases and the supporting material. Excessive intrusion of mortar under the form bases indicates improper compaction or improper contact under the forms. Repeated intrusion of mortar under the forms should be brought to the attention of the Mixer Inspector.

In hot, dry, windy weather the concrete surface must be constantly observed for evidence of checking or hair cracking. Normally, these fine hairline cracks begin to develop as soon as the surface begins to dry just prior to the initial set. If this condition is observed, application of the curing treatment should be accelerated. If some method of curing other than the membrane curing is used, it may become necessary to use an interim application of the membrane curing compound. In any event, the Mixer Inspector should be informed of this condition and adjustments in the mix that might possibly eliminate or reduce this condition should be made.

As soon as possible, the surface of the concrete should be thoroughly straightedged by the Inspector. All areas not within the specified surface tolerance should be clearly marked. A rolling straightedge, such as a "Hi-Lo Detector", may be used on the hardened concrete to supplement the straightedge check. A machine of this type can be used for rapid checking of the surface and can be as accurate as a straightedge in detection of surface irregularities. For proper operation, this machine must be adjusted prior to each checking operation using the manufacturer's recommendations. Repeated occurrence of surface irregularities should be brought to the attention of the Contractor and steps should be taken to determine the cause and initiate corrective measures.

F. SAMPLING AND TESTING. An important part in the control of the paving operation consists of making, transporting, curing, and testing of the flexural strength test specimens. As required by the Construction Bulletin C-11, two test beams shall be made for a certain area of concrete pavement placed to determine if the design requirements of the concrete mix are being satisfied. The two test beams should be made from the same batch of concrete in accordance with the Test Method Tex-420-A.

The beam molds must be carefully cleaned, inspected for damage, and lightly oiled. Molds should not be used, if they are twisted or have suffered damage that would appreciably alter the cross-sectional area.

Beams should be made very carefully in accordance with the prescribed procedure. The initial twenty-four hours of curing of these test specimens is very important, and particular attention should be given to their care during this period and to the manner in which they are transported and deposited in the curing tank. Rough treatment during this stage will probably result in erratic beam strengths and lack of reliable results. If at all possible, the severity of the weather, both hot and cold, to be expected during the initial curing period should be anticipated and the Contractor should be urged to provide additional protection for the beams. Normal protection will be provided by a double thickness of burlap or cotton mats if they are kept saturated with water for the entire period preceding the placing of beams in the curing tank. Additional protection will be required to prevent freezing in cold weather or excessively rapid loss of moisture in hot, dry weather. The purpose of the test specimens is to determine the adequacy of the design to produce the desired strength, and not to test the strength of concrete in the pavement. This purpose cannot be accomplished, unless the test specimens are prepared, transported, and cured in a manner that will produce reliable information on the concrete design they represent.

Slump tests, as required by the specifications and the Construction Bulletin C-11, are made to check the uniformity of the consecutive batches of concrete. The slump test should be made in accordance with the procedure outlined in Test Method Tex-415-A. This test should be made and recorded each time a set of test beams is made, and more frequently if necessary to insure that the slump of the concrete complies with the specifications. Erratic slump results may indicate faulty operation of the water meter, uneven distribution of free moisture in the aggregates, improper handling of the material being fed into the aggregate bins, overloaded batch truck compartments, spillage out of the mixer skip, etc.

When air entrainment is used, air content of the freshly placed concrete should be determined in accordance with the Test Method Tex-416-A. This test should be made each time a set of test beams is made and at such other intervals as may be required to insure that the designed air content is being obtained. When erratic results are noted, the Mixer Inspector should be notified and immediate steps should be taken to correct this condition. It is recommended that this test be made in conjunction with the preparation of the test beams and be recorded with the data pertaining to the test beams.

Depth tests at prescribed intervals are required in accordance with the procedure in the Construction Bulletin C-11 to test the depth of the slab during placing. Normally, three or four plates are placed across the subgrade and a method is used to mark their position in order that they may be readily located after the concrete is placed. The station number, position of the plates relative to one edge of the pavement or the centerline of the slab, and the depth test results (to the nearest one-eighth inch) should be recorded.

312.4 RECORDS AND REPORTS

Daily entries should be made in the diary book describing location of the work, instructions received from the Project Engineer, instructions given to the Contractor, unusual conditions, and other items of interest.

Work sheets, forms, and reports should be maintained and submitted in accordance with the instructions in this manual and Construction Bulletin C-11.

APPENDIX

APPENDIX
1. PNEUMATIC TIRE PRESSURE TABLE

The Pneumatic Tire Pressure Table has been compiled to display the range of ground contact pressures that may be obtained from a roller equipped with tires of a given size and ply when varying the wheel load and the tire inflation pressure. The values shown for the ground contact pressures and areas have been rounded off to the nearest whole number. The ground contact area values were obtained by dividing the wheel loads by the respective ground contact pressures.

Intermediate values which do not appear in the tables can be approximated by interpolation on a straight line basis in accordance with the following example:

Example:

It is desired to determine the ground contact pressure for a 13.00 x 24,.22 Ply tire at a 5,000 lb. wheel load and an inflation pressure of 90 p.s.i.

From table on Page A-8:

Ground contact pressure at 100 p.s.i. = 89 p.s.i.

Ground contact pressure at 80 p.s.i. = 79 p.s.i.

Difference in inflation pressure = 100 p.s.i. - 80 p.s.i. = 20 p.s.i.

Difference in ground contact pressure = 89 p.s.i. - 79 p.s.i. = 10 p.s.i.

Increase in the inflation pressure from 80 to 90 p.s.i. = 10 p.s.i.

$$\text{Increase in ground contact pressure} = \frac{\text{Desired increase in inflation pressure}}{\text{Difference between nearest inflation pressure above and below the desired pressure}} \times \text{Difference between ground contact pressures for nearest inflation pressures above and below the desired pressure}$$

$$\text{Increase in the ground contact pressure} = \frac{10 \text{ p.s.i.}}{20 \text{ p.s.i.}} \times 10 \text{ p.s.i.}$$

$$= .5 \times 10 \text{ p.s.i.}$$

$$= 5 \text{ p.s.i.}$$

$$\text{Ground contact pressure at } 90 \text{ p.s.i.} = 79 \text{ p.s.i.} + 5 \text{ p.s.i.}$$

$$= 84 \text{ p.s.i.}$$

Values for the ground contact pressure obtained by this method will be slightly high. If greater accuracy is desired, a curve may be plotted for the given tire size and ply and wheel loads, and the ground contact pressure determined from the curve.

PNEUMATIC TIRE PRESSURE TABLE

TIRE SIZE AND PLY	WHEEL LOAD Lbs	INFLATION PRESSURE P.S.I.	CONTACT PRESSURE P.S.I.	CONTACT AREA Sq.In.
7.50 X 15 4 PLY	750	30	33	23
		35	35	21
	1,000	30	35	29
		35	37	27
	1,250	30	36	35
		35	39	32
	1,500	30	37	41
		35	40	38
	1,750	30	39	45
		35	42	42
	2,000	30	40	50
		35	43	47
	2,250	30	41	55
		35	44	51
	2,500	30	42	60
		35	45	56
	2,750	30	43	64
		35	46	60
7.50 X 15 6 PLY	750	35	35	21
		40	37	20
		45	39	19
		50	40	19
		55	43	17
	1,000	35	37	27
		40	39	26
		45	41	24
		50	43	23
		55	45	22
	1,250	35	39	32
		40	41	30
		45	43	29
		50	45	28
		55	47	27
	1,500	35	40	38
		40	43	35
		45	45	33
		50	47	32
		55	49	31
	1,750	35	42	42
		40	44	40
		45	46	38
		50	48	36
		55	51	34
	2,000	35	43	47
		40	46	44
		45	48	42
		50	50	40
		55	53	38
	2,250	35	44	51
		40	47	48
		45	49	46
		50	52	43
		55	55	41
	2,500	35	45	56
		40	48	52
		45	51	49

TIRE SIZE AND PLY	WHEEL LOAD Lbs	INFLATION PRESSURE P.S.I.	CONTACT PRESSURE P.S.I.	CONTACT AREA Sq.In.
7.50 X 15 6 PLY	2,500	50	53	47
		55	56	45
	2,750	35	46	60
		40	49	56
		45	52	53
		50	55	50
		55	57	48
	3,000	35	47	64
		40	50	60
		45	53	57
		50	56	54
		55	59	51
	3,250	35	48	68
		40	51	64
		45	54	60
		50	57	57
		55	60	54
	3,500	35	49	71
		40	52	67
		45	55	64
		50	58	60
		55	61	57
7.50 X 15 10 PLY	750	50	41	18
		60	44	17
		70	48	16
		80	50	15
		90	52	14
	1,000	50	43	23
		60	47	21
		70	51	20
		80	53	19
		90	55	18
	1,250	50	46	27
		60	49	26
		70	53	24
		80	56	22
		90	59	21
	1,500	50	48	31
		60	52	29
		70	55	27
		80	58	26
		90	62	24
	1,750	50	50	35
		60	54	32
		70	58	30
		80	61	29
		90	64	27
	2,000	50	53	38
		60	56	36
		70	60	33
		80	64	31
		90	67	30
	2,250	50	54	42
		60	58	39
		70	62	36
		80	66	34

TIRE SIZE AND PLY	WHEEL LOAD Lbs	INFLATION PRESSURE P.S.I.	CONTACT PRESSURE P.S.I.	CONTACT AREA Sq.In.
7.50 X 15 10 PLY	2,250	90	69	33
	2,500	50	56	45
		60	60	42
		70	64	39
		80	68	37
		90	72	35
	2,750	50	58	47
		60	62	44
		70	66	42
		80	70	39
		90	74	37
	3,000	50	59	51
		60	63	48
		70	68	44
		80	72	42
		90	77	39
	3,250	50	61	53
		60	65	50
		70	69	47
		80	74	44
		90	78	42
	3,500	50	62	56
		60	66	53
		70	71	49
		80	75	47
		90	80	44
	3,750	50	64	59
		60	68	55
		70	72	52
		80	77	49
		90	82	46
	4,000	50	65	62
		60	69	58
		70	73	55
		80	78	51
		90	83	48
	4,250	50	66	64
		60	71	60
		70	75	57
		80	79	54
		90	84	51
	4,500	50	67	67
		60	72	63
		70	76	59
		80	81	56
		90	85	53
	4,750	50	68	70
		60	73	65
		70	78	61
		80	82	58
		90	86	55
	5,000	50	69	72
		60	74	68
		70	79	63
		80	83	60
		90	87	57

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TIRE SIZE AND PLY	WHEEL LOAD (Lbs)	INFLATION PRESSURE (P.S.I.)	CONTACT PRESSURE (P.S.I.)	CONTACT AREA (Sq.In.)
7.50 X 15 12 PLY	750	50	42	18
		60	45	17
		70	49	15
		80	53	14
		90	58	13
		100	60	13
		110	62	12
	1,000	50	44	23
		60	48	21
		70	51	20
		80	56	18
		90	60	17
		100	63	16
		110	65	15
	1,250	50	47	27
		60	50	25
		70	54	23
		80	58	22
		90	63	20
		100	65	19
		110	67	19
	1,500	50	49	31
		60	52	29
		70	56	27
		80	61	25
		90	65	23
		100	67	22
		110	69	22
	1,750	50	51	34
		60	55	32
		70	58	30
		80	63	28
		90	68	26
		100	70	25
		110	71	25
	2,000	50	53	38
		60	57	35
		70	61	33
		80	65	31
		90	70	29
		100	72	28
		110	74	27
	2,250	50	54	42
		60	59	38
		70	63	36
		80	67	34
		90	72	31
		100	74	30
		110	76	30
	2,500	50	56	45
		60	61	41
		70	64	39
		80	69	36
		90	74	34
7.50 X 15 12 PLY	2,500	100	76	33
		110	78	32
	2,750	50	58	47
		60	62	44
		70	66	42
		80	71	39
		90	76	36
		100	78	35
		110	80	34
	3,000	50	59	51
		60	64	47
		70	68	44
		80	73	41
		90	78	38
		100	80	38
		110	82	37
	3,250	50	61	53
		60	65	50
		70	70	46
		80	75	43
		90	79	41
		100	81	40
		110	84	39
	3,500	50	63	56
		60	67	52
		70	71	49
		80	76	46
		90	81	43
		100	83	42
		110	86	41
	3,750	50	64	59
		60	69	54
		70	73	51
		80	78	48
		90	82	46
		100	85	44
		110	87	43
	4,000	50	66	61
		60	70	57
		70	75	53
		80	79	51
		90	84	48
		100	86	47
		110	89	45
	4,250	50	68	63
		60	72	59
		70	76	56
		80	81	52
		90	85	50
		100	88	48
		110	91	47
	4,500	50	69	65
		60	73	62
		70	78	58
7.50 X 15 12 PLY	4,500	80	82	55
		90	86	52
		100	89	51
		110	92	49
	4,750	50	70	68
		60	74	64
		70	79	60
		80	84	57
		90	88	54
		100	91	52
		110	93	51
	5,000	50	71	70
		60	76	66
		70	80	63
		80	84	60
		90	89	56
		100	92	54
		110	94	53
	5,250	50	72	73
		60	76	69
		70	81	65
		80	86	61
		90	90	58
		100	93	56
		110	95	55
	5,500	50	72	76
		60	78	71
		70	82	67
		80	87	63
		90	91	60
		100	94	59
		110	96	57
	5,750	50	73	79
		60	78	74
		70	84	68
		80	88	65
		90	92	63
		100	95	61
		110	98	59
7.50 X 15 14 PLY	750	50	48	16
		60	51	15
		70	54	14
		80	57	13
		90	59	13
		100	63	12
		110	66	11
		120	69	11
		130	72	10
	1,000	50	51	20
		60	54	19
		70	57	18
		80	60	17
		90	62	16
		100	66	15

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TIRE SIZE AND PLY	WHEEL LOAD (Lbs)	INFLATION PRESSURE (P.S.I.)	CONTACT PRESSURE (P.S.I.)	CONTACT AREA (Sq.In.)
7.50 X 15 14 PLY	1,000	110	69	14
		120	72	14
		130	75	13
	1,250	50	53	24
		60	57	22
		70	60	21
		80	63	20
		90	66	19
		100	69	18
		110	72	17
		120	76	16
		130	78	16
	1,500	50	56	27
		60	59	25
		70	62	24
		80	65	23
		90	68	22
		100	71	21
		110	75	20
		120	78	19
		130	81	19
	1,750	50	57	31
		60	61	29
		70	64	27
		80	67	26
		90	70	25
		100	74	24
		110	77	23
		120	81	22
		130	83	21
	2,000	50	59	34
		60	63	32
		70	66	30
		80	69	29
		90	73	27
		100	76	26
		110	79	25
		120	83	24
		130	86	23
	2,250	50	61	37
		60	65	35
		70	68	33
		80	71	32
		90	75	30
		100	78	29
		110	82	27
		120	85	26
		130	88	26
	2,500	50	63	40
		60	66	38
		70	70	36
		80	73	34
		90	77	32
		100	80	31

TIRE SIZE AND PLY	WHEEL LOAD (Lbs)	INFLATION PRESSURE (P.S.I.)	CONTACT PRESSURE (P.S.I.)	CONTACT AREA (Sq.In.)
7.50 X 15 14 PLY	2,500	110	84	30
		120	87	29
		130	90	28
	2,750	50	64	43
		60	68	40
		70	71	39
		80	75	37
		90	78	35
		100	82	34
		110	86	32
		120	89	31
		130	92	30
	3,000	50	66	45
		60	69	43
		70	73	41
		80	77	39
		90	80	38
		100	84	36
		110	87	34
		120	91	33
		130	94	32
	3,250	50	67	49
		60	71	46
		70	75	43
		80	78	42
		90	82	40
		100	85	38
		110	89	37
		120	93	35
		130	96	34
	3,500	50	68	51
		60	72	49
		70	76	46
		80	80	44
		90	83	42
		100	87	40
		110	91	38
		120	94	37
		130	98	36
	3,750	50	70	54
		60	74	51
		70	78	48
		80	81	46
		90	85	44
		100	89	42
		110	92	41
		120	96	39
		130	99	38
	4,000	50	71	56
		60	75	53
		70	79	51
		80	83	48
		90	87	46
		100	90	44

TIRE SIZE AND PLY	WHEEL LOAD (Lbs)	INFLATION PRESSURE (P.S.I.)	CONTACT PRESSURE (P.S.I.)	CONTACT AREA (Sq.In.)
7.50 X 15 14 PLY	4,000	110	94	43
		120	98	41
		130	101	40
	4,250	50	72	59
		60	76	56
		70	80	53
		80	84	51
		90	88	48
		100	91	47
		110	95	45
		120	99	43
		130	103	41
	4,500	50	73	62
		60	77	58
		70	82	55
		80	86	52
		90	89	51
		100	93	48
		110	96	47
		120	101	45
		130	104	43
	4,750	50	74	64
		60	78	61
		70	83	57
		80	86	55
		90	90	53
		100	94	51
		110	98	48
		120	102	47
		130	106	45
	5,000	50	75	67
		60	79	63
		70	84	60
		80	87	57
		90	91	55
		100	95	53
		110	99	51
		120	103	49
		130	107	47
	5,250	50	76	69
		60	81	65
		70	85	62
		80	89	59
		90	92	57
		100	96	55
		110	100	53
		120	104	50
		130	108	49
	5,500	50	77	71
		60	81	68
		70	86	64
		80	90	61
		90	94	59
		100	97	57

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TIRE SIZE AND PLY	WHEEL LOAD (Lbs)	INFLATION PRESSURE (P.S.I.)	CONTACT PRESSURE (P.S.I.)	CONTACT AREA (Sq.In.)
7.50 X 15 14 PLY	5,500	110	101	54
		120	105	52
		130	109	50
	5,750	50	78	74
		60	83	69
		70	87	66
		80	91	63
		90	94	61
		100	98	59
		110	102	56
		120	106	54
		130	111	52
	6,000	50	78	77
		60	84	71
		70	88	68
		80	92	65
		90	95	63
		100	99	61
		110	103	58
		120	107	56
		130	112	54
9.00 X 20. 10 PLY	2,000	50	53	38
		60	57	35
		75	64	31
		85	67	30
	3,000	50	58	52
		60	63	48
		75	71	42
		85	74	41
	4,000	50	61	66
		60	67	60
		75	75	53
		85	80	50
	5,000	50	64	78
		60	70	71
		75	78	64
		85	83	60
	6,000	50	66	91
		60	72	83
		75	81	74
		85	86	70
	7,000	50	68	103
		60	74	95
		75	83	84
		85	88	80
9.00 X 20 12 PLY	2,000	50	53	38
		60	57	35
		75	64	31
		90	68	29
	3,000	50	58	52
		60	63	48
		75	71	42
		90	76	39
	4,000	50	61	66

TIRE SIZE AND PLY	WHEEL LOAD (Lbs)	INFLATION PRESSURE (P.S.I.)	CONTACT PRESSURE (P.S.I.)	CONTACT AREA (Sq.In.)
9.00 X 20 12 PLY	4,000	60	67	60
		75	75	53
		90	82	49
	5,000	50	64	78
		60	70	71
		75	78	64
		90	85	59
	6,000	50	66	91
		60	72	83
		75	81	74
		90	88	68
	7,000	50	68	103
		60	74	95
		75	83	84
		90	91	77
	8,000	50	69	116
		60	75	107
		75	84	95
		90	93	86
9.00 X 20 14 PLY	2,000	50	50	40
		60	53	38
		75	57	35
		90	62	32
		105	67	30
	3,000	50	54	56
		60	58	52
		75	63	48
		90	68	44
		105	75	40
	4,000	50	58	69
		60	62	65
		75	68	59
		90	74	54
		105	81	49
	5,000	50	61	82
		60	65	77
		75	71	70
		90	78	64
		105	85	59
	6,000	50	62	97
		60	67	90
		75	74	81
		90	81	74
		105	89	67
	7,000	50	64	109
		60	69	101
		75	76	92
		90	84	83
		105	92	76
	8,000	50	66	121
		60	71	113
		75	78	103
		90	86	93
		105	94	85

TIRE SIZE AND PLY	WHEEL LOAD (Lbs)	INFLATION PRESSURE (P.S.I.)	CONTACT PRESSURE (P.S.I.)	CONTACT AREA (Sq.In.)
9.00 X 20 16 PLY	2,000	50	50	40
		60	53	38
		75	57	35
		90	64	31
		105	69	29
		120	75	27
	3,000	50	54	56
		60	58	52
		75	63	48
		90	70	43
		105	76	39
		120	82	37
	4,000	50	58	69
		60	62	65
		75	68	59
		90	75	53
		105	81	49
		120	88	45
	5,000	50	62	81
		60	66	76
		75	72	69
		90	78	64
		105	85	59
		120	93	54
	6,000	50	63	95
		60	68	88
		75	75	80
		90	82	73
		105	89	67
		120	96	63
	7,000	50	66	106
		60	71	99
		75	78	90
		90	84	83
		105	92	76
		120	99	71
	8,000	50	68	118
		60	73	110
		75	80	100
		90	87	92
		105	94	85
		120	101	79
10.00 X 20 14 PLY	2,000	70	51	39
		85	56	36
		100	61	33
	3,000	70	57	53
		85	62	48
		100	68	44
	4,000	70	60	67
		85	66	61
		100	72	56
	5,000	70	63	79
		85	69	72
		100	75	67

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TIRE SIZE AND PLY	WHEEL LOAD (Lbs)	INFLATION PRESSURE (P.S.I.)	CONTACT PRESSURE (P.S.I.)	CONTACT AREA (Sq.In.)
10.00 X 20 14 PLY	6,000	70	66	91
		85	71	85
		100	77	78
	7,000	70	68	103
		85	74	95
		100	80	88
	8,000	70	71	113
		85	76	105
		100	82	98
	9,000	70	72	125
		85	78	115
		100	85	106
	10,000	70	75	133
		85	80	125
		100	87	115
	11,000	70	77	143
		85	83	133
		100	90	122
	12,000	70	79	152
		85	85	141
		100	93	129
10.00 X 20 18 PLY	2,000	85	57	35
		100	61	33
		110	64	31
		125	67	30
	3,000	85	63	48
		100	68	44
		110	71	42
		125	75	40
	4,000	85	67	60
		100	72	56
		110	75	53
		125	80	50
	5,000	85	70	71
		100	75	67
		110	79	63
		125	83	60
	6,000	85	72	83
		100	78	77
		110	81	74
		125	87	69
	7,000	85	75	93
		100	81	86
		110	84	83
		125	89	79
	8,000	85	77	104
		100	83	96
		110	87	92
		125	92	87
	9,000	85	80	113
		100	86	105
		110	89	101
		125	95	95
	10,000	85	82	122
		100	88	114

TIRE SIZE AND PLY	WHEEL LOAD (Lbs)	INFLATION PRESSURE (P.S.I.)	CONTACT PRESSURE (P.S.I.)	CONTACT AREA (Sq.In.)
10.00 X 20 18 PLY	10,000	110	92	109
		125	97	103
	11,000	85	84	131
		100	90	122
		110	94	117
		125	100	110
	12,000	85	87	138
		100	93	129
		110	97	124
		125	103	117
11.00 X 20 14 PLY	2,000	80	63	32
		90	67	30
	3,000	80	67	45
		90	71	42
	4,000	80	71	56
		90	75	53
	5,000	80	74	68
		90	79	63
	6,000	80	77	78
		90	82	73
	7,000	80	79	89
		90	84	83
	8,000	80	82	98
		90	86	93
	9,000	80	83	108
		90	88	102
	10,000	80	85	118
		90	89	112
	11,000	80	86	128
		90	90	122
	12,000	80	87	138
		90	91	132
11.00 X 20 16 PLY	2,000	80	63	32
		90	67	30
		105	77	26
	3,000	80	67	45
		90	71	42
		105	80	38
	4,000	80	71	56
		90	75	53
		105	83	48
	5,000	80	74	68
		90	79	63
		105	86	58
	6,000	80	77	78
		90	82	73
		105	88	68
	7,000	80	79	89
		90	84	83
		105	91	77
	8,000	80	82	98
		90	86	93
		105	92	87
	9,000	80	83	108
		90	88	102

TIRE SIZE AND PLY	WHEEL LOAD (Lbs)	INFLATION PRESSURE (P.S.I.)	CONTACT PRESSURE (P.S.I.)	CONTACT AREA (Sq.In.)
11.00 X 20 16 PLY	9,000	105	93	97
	10,000	80	85	118
		90	89	112
		105	95	105
	11,000	80	86	128
		90	90	122
		105	96	115
	12,000	80	87	138
		90	91	132
		105	97	124
11.00 X 20 18 PLY	2,000	80	63	32
		90	67	30
		105	77	26
		120	83	24
	3,000	80	67	45
		90	71	42
		105	80	38
		120	86	35
	4,000	80	71	56
		90	75	53
		105	83	48
		120	90	44
	5,000	80	74	68
		90	79	63
		105	86	58
		120	93	54
	6,000	80	77	78
		90	82	73
		105	88	68
		120	95	63
	7,000	80	79	89
		90	84	83
		105	91	77
		120	97	72
	8,000	80	82	98
		90	86	93
		105	92	87
		120	99	81
	9,000	80	83	108
		90	88	102
		105	93	97
		120	100	90
	10,000	80	85	118
		90	89	112
		105	95	105
		120	101	99
	11,000	80	86	128
		90	90	122
		105	96	115
		120	102	108
	12,000	80	87	138
		90	91	132
		105	97	124
		120	103	117

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TIRE SIZE AND PLY	WHEEL LOAD (Lbs)	INFLATION PRESSURE (P.S.I.)	CONTACT PRESSURE (P.S.I.)	CONTACT AREA (Sq.In.)
13.00 X 24 18 PLY	2,000	60	56	36
		80	63	32
		100	70	29
	3,000	60	59	51
		80	67	45
		100	75	40
	4,000	60	62	65
		80	70	57
		100	79	51
	5,000	60	64	78
		80	73	68
		100	82	61
	6,000	60	67	90
		80	75	80
		100	85	71
	7,000	60	68	103
		80	77	91
		100	87	80
	8,000	60	70	114
		80	79	101
		100	89	90
	9,000	60	72	125
		80	81	111
		100	91	99
	10,000	60	73	137
		80	83	120
		100	93	108
	11,000	60	74	149
		80	84	131
		100	94	117
	12,000	60	76	158
		80	86	140
		100	95	126
	13,000	60	77	169
		80	87	149
		100	97	134
	14,000	60	78	179
		80	88	159
		100	98	143
	15,000	60	79	190
		80	89	169
		100	99	152
	16,000	60	80	200
		80	90	178
		100	99	162
	17,000	60	81	210
		80	91	187
		100	100	170
	18,000	60	81	222
		80	92	196
		100	101	178
	19,000	60	82	232
		80	93	204
		100	101	188
	20,000	60	82	244
		80	94	213
		100	102	196

TIRE SIZE AND PLY	WHEEL LOAD (Lbs)	INFLATION PRESSURE (P.S.I.)	CONTACT PRESSURE (P.S.I.)	CONTACT AREA (Sq.In.)
13.00 X 24 22 PLY	2,000	60	62	32
		80	72	28
		100	83	24
		125	94	21
	3,000	60	64	47
		80	75	40
		100	85	35
		125	97	31
	4,000	60	66	61
		80	77	52
		100	88	45
		125	99	40
	5,000	60	68	74
		80	79	63
		100	89	56
		125	101	50
	6,000	60	69	87
		80	81	74
		100	92	65
		125	103	58
	7,000	60	71	99
		80	82	85
		100	94	74
		125	105	67
	8,000	60	72	111
		80	84	95
		100	95	84
		125	107	75
	9,000	60	74	122
		80	85	106
		100	97	93
		125	109	83
	10,000	60	75	133
		80	87	115
		100	98	102
		125	110	91
	11,000	60	76	145
		80	88	125
		100	99	111
		125	112	98
	12,000	60	77	156
		80	89	135
		100	101	119
		125	113	106
	13,000	60	78	167
		80	90	144
		100	102	127
		125	114	114
	14,000	60	79	177
		80	91	154
		100	103	136
		125	116	121
	15,000	60	81	185
		80	92	163
		100	104	144
		125	116	129

TIRE SIZE AND PLY	WHEEL LOAD (Lbs)	INFLATION PRESSURE (P.S.I.)	CONTACT PRESSURE (P.S.I.)	CONTACT AREA (Sq.In.)
13.00 X 24 22 PLY	16,000	60	82	195
		80	93	172
		100	105	152
		125	118	136
	17,000	60	83	205
		80	94	181
		100	106	160
		125	118	144
	18,000	60	84	214
		80	94	191
		100	107	168
		125	119	151
	19,000	60	85	224
		80	95	200
		100	107	178
		125	120	158
	20,000	60	86	233
		80	96	208
		100	108	185
		125	121	165
13.00 X 24 26 PLY	4,000	60	69	58
		80	81	49
		100	91	44
		125	103	39
		150	112	36
	6,000	60	73	82
		80	85	71
		100	96	63
		125	108	56
		150	117	51
	8,000	60	76	105
		80	89	90
		100	100	80
		125	113	71
		150	121	66
	10,000	60	79	127
		80	92	109
		100	103	97
		125	116	86
		150	124	81
	12,000	60	82	146
		80	94	128
		100	106	113
		125	119	101
		150	127	94
	14,000	60	83	169
		80	95	147
		100	108	130
		125	121	116
		150	129	109
	16,000	60	85	188
		80	97	165
		100	110	145
		125	123	130
		150	131	122

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TIRE SIZE AND PLY	WHEEL LOAD Lbs	INFLATION PRESSURE P.S.I.	CONTACT PRESSURE P.S.I.	CONTACT AREA Sq.In.
13.00 X 24 26 PLY	18,000	60	85	212
		80	98	184
		100	111	162
		125	124	145
		150	133	135
	20,000	60	86	233
		80	99	202
		100	112	179
		125	125	160
		150	134	149
18.00 X 24 24 PLY	10,000	80	73	137
		90	75	133
	12,500	80	76	164
		90	79	158
	15,000	80	79	190
		90	82	183
	17,500	80	81	216
		90	85	206
	20,000	80	83	241
		90	87	230
	22,500	80	85	265
		90	89	253
	25,000	80	87	287
		90	90	278
	27,500	80	88	313
		90	91	302
	30,000	80	90	333
		90	93	323
18.00 X 24 32 PLY	10,000	80	73	137
		90	75	133
		100	77	130
		110	79	127
		120	82	122
	12,500	80	76	164
		90	79	158
		100	82	152
		110	84	149
		120	88	142
	15,000	80	79	190
		90	82	183
		100	85	176
		110	88	170
		120	93	161
	17,500	80	81	216
		90	85	206
		100	88	199
		110	92	190
		120	97	180
	20,000	80	83	241
		90	87	230
		100	90	222
		110	94	213
		120	100	200

TIRE SIZE AND PLY	WHEEL LOAD Lbs	INFLATION PRESSURE P.S.I.	CONTACT PRESSURE P.S.I.	CONTACT AREA Sq.In.
18.00 X 24 32 PLY	22,500	80	85	265
		90	89	253
		100	92	245
		110	96	234
		120	102	221
	25,000	80	87	287
		90	90	278
		100	94	266
		110	97	258
		120	104	240
	27,500	80	88	313
		90	91	302
		100	95	289
		110	98	281
		120	106	259
	30,000	80	90	333
		90	93	323
		100	96	313
		110	98	306
		120	108	278
18.00 X 24 40 PLY	10,000	80	73	137
		90	75	133
		100	77	130
		110	79	127
		120	82	122
		130	85	118
		150	86	116
	12,500	80	76	164
		90	79	158
		100	82	152
		110	84	149
		120	88	142
		130	92	136
		150	95	132
	15,000	80	79	190
		90	82	183
		100	85	176
		110	88	170
		120	93	161
		130	98	153
		150	102	147
	17,500	80	81	216
		90	85	206
		100	88	199
		110	92	190
		120	97	180
		130	103	170
		150	107	164
	20,000	80	83	241
		90	87	230
		100	90	222
		110	94	213
		120	100	200

TIRE SIZE AND PLY	WHEEL LOAD Lbs	INFLATION PRESSURE P.S.I.	CONTACT PRESSURE P.S.I.	CONTACT AREA Sq.In.
18.00 X 24 40 PLY	20,000	130	107	187
		150	112	179
	22,500	80	85	265
		90	89	253
		100	92	245
		110	96	234
		120	102	221
		130	110	205
		150	117	192
	25,000	80	87	287
		90	90	278
		100	94	266
		110	97	258
		120	104	240
		130	112	223
		150	120	208
	27,500	80	88	313
		90	91	302
		100	95	289
		110	98	281
		120	106	259
		130	114	241
		150	122	225
	30,000	80	90	333
		90	93	323
		100	96	313
		110	98	306
		120	108	278
		130	115	261
		150	124	242
21.00 X 25 44 PLY	10,000	85	56	179
		150	67	149
	15,000	85	66	227
		150	77	195
	20,000	85	72	278
		150	85	235
	25,000	85	76	329
		150	91	275
	30,000	85	80	375
		150	97	309
	35,000	85	84	417
		150	102	343
	40,000	85	88	455
		150	108	370
	45,000	85	92	489
		150	112	402
	50,000	85	96	521
		150	116	431

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APPENDIX
2. CHECK LISTS (EXAMPLES)

A. ASPHALTIC CONCRETE PLANT CHECK LIST
(Example)

County:__________ Project:__________ Control:__________ Hwy:__________

Contractor:____________________ Producer:____________________

I. GENERAL PLANT INFORMATION:

1. Type of plant: Batch____ Continuous____ Permanent____ Portable____
2. Make____________________
3. Model or Serial No.__________ General condition__________
4. Rated capacity____________________
5. Plant location____________________
6. Controls: Automatic______ Semi-automatic______ Manual______
7. Are specified test weights available?____________________

II. COLD AGGREGATE BIN AND PROPORTIONING DEVICE:

1. Make____________________ Model No.____________________
2. Compartments: No. provided_____ No. required_____ Condition_____
3. Are compartment dividers leak-proof?____________________
4. Is overflow from one compartment into another prevented?__________
5. Equipment used to load the bins:____________________
6. Can gates on cold bins be a adjusted and secured at proper opening?____________________
7. How are aggregates fed from cold bins to the dryer?____________________

III. DRYER:

1. Make____________________ Model No.____________________
2. Size: Diameter________________ft. Length________________ft.
3. Type of burner________________Type of fuel________________
4. Type of burner control for dryer ____________________
5. Condition of dryer flights____________________
6. Is dryer equipped with recording thermometer on discharge end?____________________
7. Make__________ Range(°F): Minimum________ Maximum________
8. Location of sensing element____________________

IV. DUST COLLECTOR:

1. Make____________________
2. Model No.____________________ Type____________________
3. Condition____________________
4. Disposal of collected "fines": Wasted__________ Used__________
5. If used, can the fines be fed back into the aggregate mixture uniformly in the desired amount?____________________

V. SCREENING AND PROPORTIONING:

1. Are the screens clean?____________ Worn or broken?____________ Properly arranged?____________
2. Are the screen frames in good condition?____________
3. Number of screen decks____________
4. Condition of hot bins____________
5. Number of hot bins: Provided____________ Required____________
6. Are compartment dividers leak-proof?____________
7. Is overflow from one compartment into another prevented?____________
8. Are discharge gates on hot bins leak-proof?____________
9. Are safe and satisfactory provisions made for sampling hot bins?____________
10. Explain sampling methods and device.____________

    ____
11. Are reject chute and overflow pipes open?____________

VI. AGGREGATE WEIGH BOX AND BATCHING SCALES:

1. Aggregate weigh box:
   A. Is weigh box of sufficient size to hold a complete batch of aggregate without wasting or leveling by hand?____________
   B. Is weigh box sufficiently tight to prevent leakage?____________
   C. Is weigh box discharge gate quick-operating, close-fitting, and leak-proof?____________
   D. Is weigh box designed so that the entire batch of aggregate will discharge quickly into the mixer?____________
   E. Is weigh box satisfactorily attached to the batching scales?____________
2. Aggregate batching scales:
   A. Make____________
   B. Type: Beam____________ Dial____________
   C. Smallest division____________lbs. Capacity____________lbs.
   D. Are scales of sufficient capacity to weigh a complete batch of aggregate?____________
   E. Are the scales satisfactorily insulated against shock, vibration, and movement of other operating equipment in the plant?____________
   F. Have scales been checked to the satisfaction of the Engineer?____________
   G. Who checked the scales?____________ Date____________
   H. Can scales be adjusted quickly at zero to provide for any tare change?____________
   I. Are scales equipped with a pointer or a "tell-tale" indicator of the springless dial type to indicate full load?____________
   J. Is pointer or indicator in full view of operator while charging weigh box?____________
   K. Are scales easily viewed by the Inspector at all times?____________

VII. ASPHALTIC MATERIAL BUCKET AND SCALES:

1. If measurement of asphaltic material is by weight, complete the following:
   A. Asphaltic material bucket:
      (1) Is the plant equipped with an asphaltic material bucket?____________

(2) Is the bucket of sufficient size to hold the total amount of asphalt required for one full batch?________
(3) Is the bucket sufficiently tight to prevent leakage?________
(4) Is the bucket designed so that the entire batch of asphalt will discharge quickly into the mixer?________
(5) Is the bucket satisfactorily attached to the batching scales?________

B. Scales
(1) Make________
(2) Type: Beam________ Dial________
(3) Smallest division________lbs. Capacity________lbs.
(4) Are scales of sufficient capacity to weigh the amount of asphalt required for one full batch?________
(5) Are the scales satisfactorily insulated against shock, vibration, and movement of other operating equipment in the plant?________
(6) Have scales been checked to the satisfaction of the Engineer?________
(7) Who checked the scales?________ Date________
(8) Can scales be adjusted quickly at zero to provide for any tare change?________
(9) Are scales equipped with a pointer to indicate the full load?________
(10) Is the pointer in full view of the operator while charging the bucket?________
(11) Are scales easily viewed by the Inspector at all times?________

C. Are the asphalt valves of the quick cut-off type?________
D. Are the valves in good working condition?________
E. Are the valves free of leaks?________
F. Is drainage of the asphalt line below the cut-off valve after each weighing prevented?________

2. If measurement of asphaltic material is by volume based on weight, complete the following:
A. Is the measuring bucket of the overflow type?________
B. Is the bucket of sufficient size to hold the total amount of asphalt required for one full batch?________
C. Is the bucket sufficiently tight to prevent leakage?________
D. Is the bucket designed so that the entire batch of asphalt will discharge quickly into the mixer?________
E. Are the asphalt valves of the quick cut-off type?________
F. Are the valves in good working condition?________
G. Are the valves free of leaks?________
H. Is drainage of the asphalt line below the cut-off valve after each measuring prevented?________

3. If the asphaltic material is measured by a pressure-type flow meter, complete the following:
A. Can the meter be locked on any setting?________
B. Does the meter reset itself to the desired setting after addition of asphalt to each batch?________
C. Are provisions made for checking the accuracy of the meter output?________
D. Can the metered amount of asphalt for a full size batch be diverted into one container for a weighing check?________
E. Are scales provided for this purpose?________

VIII. MIXER:

1. Make:______________________________
2. Manufacturer's rated capacity______________________________
3. Manufacturer's recommended mixing R. P. M.'s______________________________
4. Is the mixer of the pugmill type?______________________________
5. How many mixing blades?______________________________
6. What is the spacing between the paddle tips and the liner?______________________________in.
7. What is this spacing at or near the point of discharge? ______________________________in.
8. Are paddles in good condition?______________________________.
9. Is pugmill liner in good condition?______________________________
10. Are dump doors tight enough to prevent spillage of aggregate or mixture?______________________________
11. Are shaft seals tight enough to prevent spillage of aggregate or mixture?______________________________
12. Is mixer equipped with a spray bar that will distribute the asphalt quickly and uniformly throughout the mixer?______________
13. Is mixer equipped with an automatic time lock for locking the discharge doors for the prescribed mixing time?______________
14. Make of pugmill timing device______________________________
15. Type of signal______________________________
16. Selected mixing period: Dry____________secs. Wet____________secs.
17. Is the mixer equipped with a batch counter?______________________________
18. Is the counter in good operating condition?______________________________
19. Does the mixer produce a uniform batch?______________________________

IX. TRUCK SCALES:

1. Make:______________________________
2. Type: Beam______________________ Dial______________________
3. Smallest division________________lbs. Capacity______________lbs.
4. Are scales capable of weighing the entire load as a single draft?______________________________
5. Have scales been checked to the satisfaction of the Engineer?______________________________
6. Who checked the scales?________________ Date________________
7. Can scales be adjusted quickly at zero to provide for any tare change?______________________________
8. Is a weather-tight building of sufficient size to house the Contractor's weigher and the State's checker provided?____________

X. ASPHALTIC MATERIAL HEATING EQUIPMENT:

1. Type of asphalt heating system: Steam______________________ Circulating oil________________ Other (describe)______________
2. Type of heater controls: Manual__________ Automatic____________
3. Is asphalt heated by use of direct fire?______________________________
4. If so, who is the manufacturer of the heater?______________________________
5. Model No.______________________________
6. Is there positive circulation of the asphalt throughout the heater?______________________________
7. Are return lines discharging into the storage tanks submerged below the asphalt level at all times?______________________________

8. Is heating apparatus equipped with a recording thermometer with a 24-hour chart that will record the temperature of the asphaltic material at the hottest point in the circulation system?____________________
9. Make__________ Range (^{o}F): Minimum__________ Maximum__________

XI. AGGREGATE STOCKPILES:

1. Are aggregates stockpiled in such a manner as to prevent mixing of one aggregate with another aggregate?____________________
2. Are bulkheads used to prevent stockpile mixing?____________________
3. Is suitable equipment of acceptable size furnished to work the stockpiles?____________________

XII. ASPHALT STORAGE EQUIPMENT:

1. Number of storage tanks____________________
2. Give capacity of each tank.____________________
3. Is all equipment for storing and handling asphaltic material clean?____________________
4. Is all equipment for storing and handling asphaltic material operated in such manner that there will be no contamination with foreign matter?____________________

XIII. ADDITIONAL INFORMATION AND REMARKS:

____

____

Inspected by:

____________________ ____________

Signature and Title Date

Approved by:

____________________ ____________

Signature and Title Date

APPENDIX

B. ASPHALTIC CONCRETE
PAVING EQUIPMENT CHECK LIST
(Example)

County:__________ Project:__________ Control:__________ Hwy:__________

Contractor:____________________ Producer:____________________

I. ASPHALT PAVER:

1. Make__________ Model__________ Manufactured (Year)__________
2. Crawler Tractor__________ Pneumatic Tractor__________
   (Note: In this section complete the blanks that pertain to the paver on the project.)
3. Is the governor on the engine operating properly?__________
4. Are the slat feeders in good condition and adjustment?__________
5. Are the hopper gates in good condition and adjustment?__________
6. Are the spreader screws in good condition and adjustment?__________
7. Are the crawlers adjusted properly?__________
8. Do the pneumatic tires contain correct and uniform air pressure?__________
9. Is the screed heater working properly?__________
10. Are tamper bars free from excessive wear?__________
11. Are tamper bars correctly adjusted for stroke?__________
12. Are tamper bars correctly adjusted for clearance between the back of the bar and the nose of the screed plate?__________
13. Are the surfaces of the screed plate true and in good condition?__________
14. Are mat thickness and crown controls in good condition and correct adjustment?__________
15. Is the oscillating screed in proper position with respect to the vibrating compactor?__________
16. Does paver drip oil or grease on pavement?__________
17. Remarks:____________________

II. MOTOR GRADER:

1. Make____________________ Model____________________
2. Is the motor functioning properly?__________
3. Cutting edge of blade straight and sharp?__________
4. Are all joints and linkages of the suspension system snug and free from excessive wear?__________
5. Do all controls respond quickly and accurately when actuated, and hold the position set?__________
6. If grader is equipped with automatic controls, are controls properly adjusted?__________
7. Does grader drip oil or grease on pavement?__________

III. STEEL WHEEL ROLLERS:

1. Make	Model	Type	Weight	Number of Wheels	Width of Wheels

2. Can each roller start, stop, and reverse smoothly?__________
3. Are king pins free of slack?__________
4. Are wheel bearings free of excessive wear?__________
5. Is the rolling surface of each wheel flat, not excessively worn on edges, and free of grooves and pits?__________
6. Are scrapers and wetting pads in good condition?__________
7. Is the sprinkling system on each roller in good operating condition?__________
8. Does roller drip oil or grease on pavement?__________

IV. PNEUMATIC TIRE ROLLERS:

1. Make	Model	Type	Weight Empty	Weight Loaded	Type of Ballast

2. Can roller start, stop, and reverse smoothly?__________
3. Number of tires: Front__________ Rear__________
4. Size of tires:__________ Ply rating__________ Condition__________
5. Are all tires inflated to the desired pressure?__________
6. Are all wheels free from wobble and vibration?__________
7. Are wetting pads in good condition?__________
8. Is the sprinkler system in good operating condition?__________
9. Does roller drip grease or oil on pavement?__________

V. INCIDENTAL TOOLS:

1. Rakes__________ Lutes__________
2. Brooms__________ Shovels__________
3. Hand Tampers__________ Cleaning Equipment__________
4. String line and setting equipment__________
5. Blocks and shims to support screed of paver when beginning paving operations__________
6. Joint cutting and paving tools__________ Straightedge__________
7. Remarks:__________

VI. ADDITIONAL INFORMATION AND REMARKS:

Inspected by__________ __________
Signature and Title Date

Approved by__________ __________
Signature and Title Date

APPENDIX

C. PORTLAND CEMENT CONCRETE PAVEMENT
BATCH PLANT CHECK LIST
(Example)

County:___________ Project:___________ Control:___________ Hwy:___________

Contractor:____

I. GENERAL PLANT INFORMATION:

1. Plant location______________________________
2. General condition______________________________
3. Are specified test weights available?______________________________

II. AGGREGATE STOCKPILING AND STORAGE:

1. Are stockpile areas free of grass and other foreign material, and smooth?______________________________
2. Are separate stockpiles or bins provided for each size or type of aggregate delivered?______________________________
3. Are provisions made for all aggregates to be handled and stored in a manner to prevent contamination?______________________________
   Degradation?______________ Segregation?______________
   Explain.______________________________
4. Is equipment available for reworking the stockpiles to correct segregation of the aggregates?______________________________
5. Are aggregates scheduled for delivery so that they will be stockpiled long enough to attain uniform moisture content?______________

III. AGGREGATE BATCHING EQUIPMENT:

1. Aggregate Bins

   a. Make______________________ Model______________________
   b. Condition of bins______________________________
   c. Number of compartments provided______________________________
   d. Number of aggregates provided______________________________
   e. Are compartment dividers leak-proof?______________________________
   f. Is overflow from one compartment into another prevented?__________
   g. Are discharge gates on bins leak-proof?______________________________
   h. Equipment used to load the bins______________________________
   i. Do the bins have adequate clearance to clear all of the truck beds?______________________________
   j. Are provisions made for conducting aggregates into the proper truck compartment?______________________________

2. Aggregate Batching Scales

   a. Make______________________________
   b. Type: Beam______________________ Dial______________________
   c. Smallest division______________lbs. Capacity______________lbs.
   d. Are scales of sufficient capacity to weigh a complete batch of aggregate?______________________________

e. Have scales been checked to the satisfaction of the Engineer?____________________
f. Who checked the scales?__________ Date__________
g. Can scales be adjusted quickly at zero to provide for any tare change?____________________
h. Are scales equipped with a pointer or a "tell-tale" indicator of the springless dial type to indicate full load?__________
i. Is pointer or indicator in full view of operator while charging weigh box?____________________

IV. CEMENT STORAGE EQUIPMENT:

1. How is cement furnished? Bulk__________ Sacks__________
2. Is a suitable, weather-tight building or bin provided to protect the cement from dampness?____________________

V. CEMENT BATCHING EQUIPMENT:

If bulk cement is used, complete the following:

1. Cement Weigh Box

a. Is weigh box of sufficient size to hold a complete batch of cement without wasting or leveling by hand?__________
b. Is weigh box sufficiently tight to prevent leakage?__________
c. Is the weigh box constructed so that, if in charging an excess is introduced into the weigh box, it may be removed by the operator?____________________
d. Is weigh box discharge gate quick-operating, close-fitting, and leak-proof?____________________
e. Is weigh box designed so that the entire batch of cement will be discharged quickly?____________________
f. Is weigh box satisfactorily attached to the batching scales?____________________
g. Is the weigh box fitted with an approved vent?__________
h. Is the weigh box fitted with a tightly covered inspection opening of not less than 12 inches by 12 inches?__________

2. Cement Batching Scales

a. Make____________________
b. Type: Beam__________ Dial__________
c. Smallest division__________lbs. Capacity__________lbs.
d. Are scales of sufficient capacity to weigh a complete batch of cement?____________________
e. Have scales been checked to the satisfaction of the Engineer?____________________
f. Who checked the scales?__________ Date__________
g. Can scales be adjusted quickly at zero to provide for any tare change?____________________
h. Is provision made for indicating to the operator that the required weight of cement in the weigh box is being approached?____________________
i. Does the device indicate at least the last 50 pounds of the load of cement?____________________

j. If a closed-type weigh box is used, is a springless dial provided to indicate when the weigh box is empty?____________

VI. ADDITIONAL INFORMATION AND REMARKS:

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____

Inspected by________________________ ____________
Signature and Title Date

Approved by________________________ ____________
Signature and Title Date

APPENDIX

D. PORTLAND CEMENT CONCRETE
PAVING EQUIPMENT CHECK LIST
(Example)

County:___________ Project:___________ Control:___________ Hwy:___________

Contractor:____

I. MIXER:

1. Make____________ Model____________ Manufactured (Year)___________
2. Type: Single drum_______________ Multiple drum___________________
3. General condition____
4. Size of mixer as established by manufacturer______________________
5. Is mixer equipped with a power controlled boom and bucket?_________
6. Is the boom so designed as to permit uniform distribution of concrete across the subgrade?_______________________________
7. Manufacturer's recommended drum speed of mixer while in operation?____
8. Amount of wear on the pick-up and throw-over blades in the drum?____
9. Is the mixer equipped with an approved automatic device for timing the mix and for locking the discharge device to assure the specified mixing time?___________________________
10. Does the timing device operate an audible signal when the mixing period has elapsed?_________________________________
11. Is the mixer equipped with a water measuring device accurate to plus or minus 1 percent of the total amount of water required for each batch?_________________________________
12. Do all the valves cut off promptly and are they free of leaks?____
13. How does the device measure the water? Weight______ Volume______
14. If by volume, does the measuring equipment include an auxiliary tank with a capacity greater than that of the measuring tank?____
15. Is the measuring tank filled from the auxiliary tank by gravity flow?____
16. Is the measuring tank open to the atmosphere?____________________
17. Is the measuring tank so placed and constructed that the water for a batch can be discharged into a calibrated tank or weighing device for checking the accuracy of the water measurement?_______________________________________

II. HAULING EQUIPMENT:

1. Number of batch hauling trucks provided__________________________
2. Are the compartments on each truck large enough to retain the batches without spillage even when the bed is raised to its highest possible position?_____________________________
3. Are all of the compartment dividers on each truck tight-fitting and leak-proof?____

4. Are all of the compartment dividers equipped with a positive latching device that will prevent dumping of more than one batch at a time?__________
5. Are all of the trucks equipped with covers?__________

III. SUBGRADE PLANER AND TEMPLATES:

1. Subgrade Planer

   a. Is a subgrade planer provided?__________
   b. Is the planer frame of such strength and rigidity that, when the support is changed from the wheels to the center, a deflection of no more than 1/8 inch is developed?__________

2. Subgrade Template

   a. Is a subgrade or "scratch" template provided?__________
   b. Is the template frame heavy enough to remain on the forms at all time?__________
   c. Is the template frame of such strength and rigidity that, when the support is changed to the center, a deflection of no more than 1/8 inch is developed?__________

IV. FORMS:

1. Dimension of the forms: Length__________ft. Depth__________in.
   Width of the base__________in.
2. If the height of forms is less than the pavement thickness by not more than 1 inch, are approved type of strips for increasing the forms to the required edge thickness provided?__________
3. How many pins are provided for staking each section in position?__________
4. Are the forms free from warps, bends, or kinks?__________
5. Are the forms sufficiently true to provide a reasonably straight edge on the concrete?__________
6. Does the top of any of the form sections deviate from a 10-foot straightedge by more than 1/16 inch per foot from the nearest point of contact with the straightedge or more than 1/8 inch at any point?__________
7. If so, were such sections rejected or repaired?__________
8. Give the total lengths of forms provided.__________ft.

V. MECHANICAL VIBRATORY EQUIPMENT:

1. Is an approved mechanical vibratory unit provided for consolidating the concrete?__________
2. Give the length of the vibratory member.__________ft.
3. Will the vibratory member come in contact with the side forms?__________ Reinforcement?__________
4. Is this equipment equipped with synchronized vibratory units?__________
5. How many vibratory units?__________
6. Spacing of vibratory units__________ft.
7. Are the vibrators sufficiently rigid to insure control of the operating position of the vibrating head?__________
8. How many hand manipulated mechanical vibrators are furnished?__________

VI. FINISHING EQUIPMENT:

1. Transverse Finishing Machine

   a. Is a power driven transverse finishing machine provided?_________
   b. Is it equipped with two screeds?_________
   c. Are the screeds mounted in a rigid frame?_________

2. Longitudinal Finishing Machine

   a. General operating condition_________
   b. Is it free from deflection, wobble, or vibration?_________
   c. Give the length of the longitudinal float._________ft.
   d. Is the machine power driven?_________
   e. Is the machine mounted in a substantial frame equipped to ride on the forms?_________

3. Hand Finishing Equipment

   a. Is a belt provided for finishing the pavement?_________
   b. Dimensions of belt: Width_________in. Length_________ft.
   c. Are at least two standard 10-foot steel straightedges furnished?_________
   d. Number of bridges equipped to ride on the forms and span the pavement for finishing operations and for the installation and finishing of joints and center stripes?_________
   e. Are all necessary finishing and edging tools furnished?_________

VII. ADDITIONAL INFORMATION AND REMARKS:

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Inspected by_________________ _________
Signature and Title Date

Approved by_________________ _________
Signature and Title Date