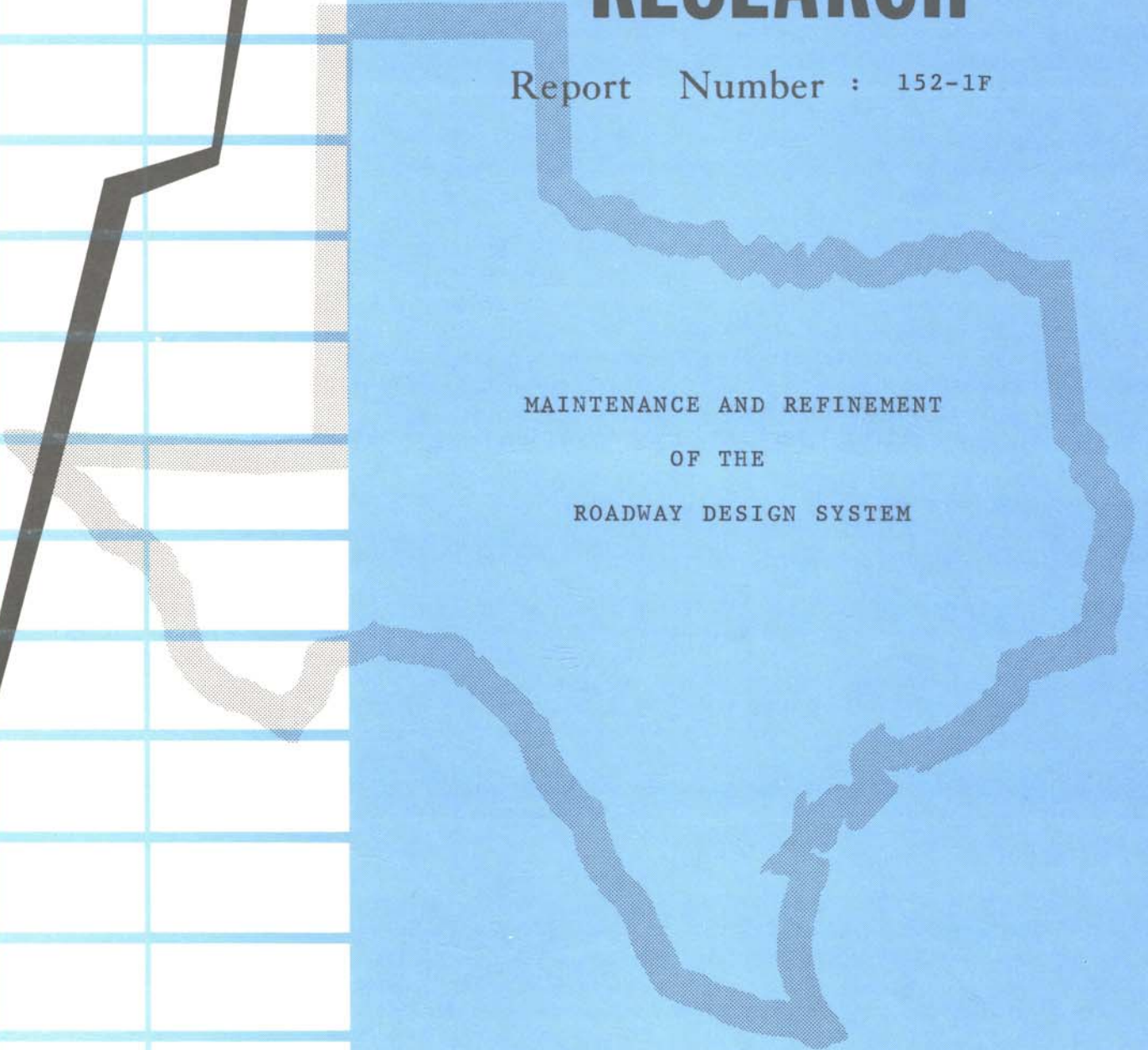
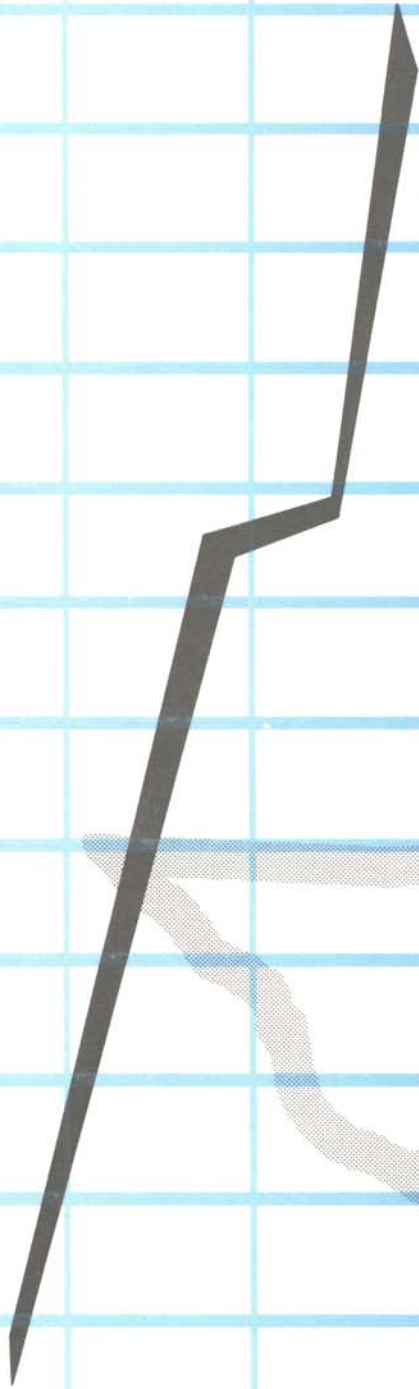


DEPARTMENTAL RESEARCH

Report Number : 152-1F

MAINTENANCE AND REFINEMENT
OF THE
ROADWAY DESIGN SYSTEM

TÉXAS HIGHWAY DEPARTMENT



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MAINTENANCE AND REFINEMENT OF THE
ROADWAY DESIGN SYSTEM

by

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FCP Research Report 152-1F
Maintenance and Refinement of the
Roadway Design System

FCP Research Study 1-19-73-152



Conducted by
Division of Automation
Texas Highway Department
In cooperation with the
U.S. Department of Transportation
Federal Highway Administration
DOT-FH-11-7977

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

SUMMARY

The objective of this contract was to provide program maintenance to the Roadway Design System (RDS), to upgrade the program documentation to reflect Version 4.0 of RDS, to revise and update the self-instructional training materials, and to provide system enhancements on a time available basis. This work has been performed as follows:

1. The program maintenance which has been forwarded to the Federal Highway Administration at intervals throughout this contract is in the form of program corrections, deletions or additions.
2. The program documentation has been upgraded to reflect the current version of the Roadway Design System. One reproducible copy of the documentation changes was furnished.
3. The self-instructional training materials that were prepared by Roy Jorgensen Associates, Inc., have been revised and updated. A copy of the revised self-instructional training course ready for reproduction was also furnished.
4. Numerous system enhancements have been incorporated into RDS and these are detailed in this report.

IMPLEMENTATION

The Roadway Design System is a valuable tool of the Highway Design Engineer. Portions of the System have been used for more than four years, and the full system has been in production for about two years. All program changes and enhancements that have been made in the System under this contract have already been placed into the production environment of the Texas Highway Department and of the other users.

The program documentation and user manual which reflect these changes have been updated and forwarded to FHWA. The self-instructional course has also been updated and forwarded to FHWA.

ACKNOWLEDGEMENTS

The ROADWAY DESIGN SYSTEM was developed, maintained and enhanced by the Division of Automation of the Texas Highway Department, Hubert A. Henry, Engineer-Director, in cooperation with the Federal Highway Administration.

Special recognition is given to members of the project staff for their dedicated efforts and technical capabilities in bringing the Roadway Design System (RDS) to its present stage of development. The members of the present staff are Mr. Fred Herber, Mrs. Karen Jordahl and Mr. Randy Guess.

Recognition is also given to the numerous other personnel who worked on RDS prior to this project. Special recognition must go to Messrs. Larry G. Walker and Gene Mangum who are responsible for RDS being the powerful and versatile tool it is. Their designing flexibility into RDS makes meaningful enhancements to the system possible.

Special thanks are given to Messrs. Clifford Powers and Dan Wyly for their long hours spent in upgrading the user manual and training materials, testing the system, designing the enhancements, and making sure the needs of the engineer user were met. Acknowledgement is given to Messrs. Roger Merrell and Hanson Clark for their valuable assistance in providing consultation on engineering matters pertaining to the system.

Mrs. Margaret Walter is given grateful acknowledgement for her assistance in editing and final preparation of the technical reports and manuals.

William L. Crawford
Project Supervisor

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MAINTENANCE AND REFINEMENT OF THE ROADWAY DESIGN SYSTEM

I. Introduction

The Roadway Design System (RDS) which is a tool for Highway Designers was developed by the Division of Automation of the Texas Highway Department in cooperation with the Federal Highway Administration. The programming standards established for the original TIES programs and implemented under HPR Project 1-(6), 1-19-67-107 were used throughout the project. RDS has already been released by the Federal Highway Administration to interested states and the capabilities of the system have been published in the following Research Reports:

Report No.	Title
72D-104R-2	Roadway Design System, Volume 2, User Manual
171-1	Extensions of the Roadway Design System- Bridge Design
171-2	Extensions of the Roadway Design System- Preliminary Location and Design Studies
171-3F	Extensions of the Roadway Design System- Final Report

The purpose of this maintenance contract was to provide (1) program maintenance and updating in the critical period when more designers would begin to use the system, (2) up-to-date maintenance documentation, (3) revised self-instructional training materials, and (4) system enhancements as time permitted. In the fulfillment of the contract, the Texas Highway Department has performed the following work:

1. The program maintenance which has been forwarded to the Federal Highway Administration at intervals throughout this contract is in the form of program corrections, deletions or additions.
2. The program documentation has been upgraded to reflect the current

version of the Roadway Design System. One reproducible copy of the documentation changes has been furnished.

3. The self-instructional training materials that were prepared by Roy Jorgensen Associates, Inc., under FHWA Contract Number FH-11-7458 have been revised and updated. A copy of the revised self-instructional training course ready for reproduction has also been furnished.
4. Numerous system enhancements have been incorporated into RDS and these are detailed in this report.

A general description of the changes in the program documentation is outlined in Section II of this report. Section III details the work accomplished on the self-instructional training materials. The system enhancements are given in Section IV and the changes in the user manual which reflect the various enhancements are detailed in Section V.

The Roadway Design System has proven itself to be a versatile and useful tool to designers and the changes brought about under this contract have provided expanded capabilities to the users.

II. Documentation

The original version of the Roadway Design System (Version 3.0) which was developed under HPR Project 1-(6), 1-19-67-107 was transmitted to the Federal Highway Administration with thirteen volumes of documentation covering the system design and program documentation for each subroutine and common block used.

The extensions to the Roadway Design System which were produced under Research Project 1-19-70-171 required major change in some of the RDS programs and files. These extensions resulted in Version 4.0. The changes were partially documented by the three Research Project 171 reports that were submitted following the release of this version of the system. A major purpose of this contract was to bring the remainder of the system documentation up-to-date to reflect Version 4.0 of RDS.

In updating the documentation, the original format was retained as well as any information that did not change. Anyone familiar with the original documentation will have a working knowledge of the present system. Since there were many changes, the entire documentation was resubmitted. An indication of the changes is given below.

Volume 1 contains the overall description of the RDS structure, the general description of the documentation structure, and a description and example of the individual process documentation. The common blocks have had additions and deletions; therefore, their descriptions have been revised. Since there were changes to existing data forms and new ones were added, the general key punching instructions have been revised to reflect the current input forms. The overlay structure of Version 4.0 has undergone extensive changes which have enabled the enhancements of the later version to be incorporated into the system with a

smaller core requirement than the original version. These changes are reflected in the Overlay Chart and Linkage Editor Map contained in the appendices to Volume 1.

Volume 2 contains the user documentation for the system. The user documentation has been revised to reflect all the improvements and enhancements that have been incorporated into RDS by Research Project 171 and this maintenance contract. The changes and additions to the original user manual are detailed in Section V of this report. Research Report 171-1, "Extensions of the Roadway Design System-Bridge Design" has been added to Volume 2 as the user documentation for the bridge subsystem of RDS.

The documentation for the individual processes in the system was originally contained in Volumes 3 through 12. With the additional routines which have been added to the system due to enhancements, this documentation now requires 3 more volumes. These are 3 through 15. The basic format of this documentation remains unchanged. The Sample Problem is in the final volume which has changed from Volume 13 to Volume 16. This problem has been revised to run on Version 4.0 of RDS. Example problems for the bridge routines are a part of Research Report 171-1 which has been included in Volume 2.

III. Self-Instructional Training Materials

The self-instructional training materials were originally prepared by Roy Jorgensen Associates, Inc., in cooperation with the engineering and development staff of the Automation Division of the Texas Highway Department. However, the training materials Roy Jorgensen developed were considered to be deficient and inadequate for use in either orientation or training of Texas Highway Department personnel. The decision was then made for the Division of Automation to revise and update these materials so that they would be adequate for training.

The training material consists of three separate books which are a "Training Text", "Forms Book" and "Certification Exam". The general format of each of these books is given below.

The Training Text is divided into five runs. In Run 1 a control traverse is established, and the angles and distances measured for this traverse are input. In Run 2 the designer establishes his horizontal alignments for the proposed roadway; in Run 3 he develops the terrain or original cross-section data and requests original ground profile plots from this terrain along the proposed alignments. These are used in establishing his design profiles. In Run 4 the designer inputs the vertical alignments, roadway templates, side slopes, median templates, special ditch grades, compaction factors, and all the remaining design data. He also requests an earthwork design (which merges all his design data into a completed design cross-section), quantities and haul plots. In Run 5 the designer uses the earthwork design data and establishes right-of-way requirements, computes these right-of-way areas, and computes blue top staking and alignment relations needed for construction staking.

The Forms Book contains the required input forms and frequently used tables and charts which explain selected functions of the system.

The Certification Exam requests the designer to complete input forms to design a simple, two-lane roadway design, compute the right-of-way requirements, and request construction staking and blue top information. In addition to this he is asked pertinent questions concerning input and output for the Roadway Design System.

Many changes were made to all three books in order to improve their training value. The changes to each one are given below, and the Figures are in the appendix.

The changes that were made in the Training Text were very extensive and, therefore, they are listed by Run number. Run 1 required only minor corrections and revisions. The changes made in Run 2 were extensive. The first of these was to completely replace the example problem which was used to introduce the designer to the command functions of the System. The example problem that was originally in the text was an abstract example which represented a wagon when it was completed. A right-of-way problem was substituted which requested the designer to compute the area of the remainder for a parcel and also to compute the length of fencing required for the right-of-way line along this parcel. A portion of this problem is shown in Figures 1 through 3. In addition to being a more practical problem for road designers, this problem is unique in that it illustrates almost every geometry command provided by RDS but has practically no duplication of commands. A completely new section for horizontal alignments was added to this run. This new section includes a thorough discussion of roadway equations. Experience has shown that there are three items about alignments that cause continuing problems to the user. These are the forward tangent, overlap equations, and gap equations. As a result of this an example problem was included which illustrates the input and output for these three items (Figures 4 and 5).

There were only minor corrections and additions needed for Run 3. The most significant of these was the new Version 4.0 capabilities which are shown with respect to original and design profile plots (Figure 6).

Run 4 required very extensive modifications and in some cases the text had to be completely rewritten. These modifications are too extensive to discuss in detail; only the major areas of change will be mentioned. Pages 4-27 through 4-78 were completely rewritten. These pages covered how to complete the design cross-section by linking roadway surfaces to one another or to natural ground. This includes the slope selection process and the median design process (Figures 7 through 13). Another section was added (pages 4-97 through 4-101) to provide a thorough discussion of the earthwork request input form (Figures 14 through 18). Run 5 required only minor corrections and modifications.

In the Forms Book, Plates 11 through 29 contain a description of each geometry command and its function. Sketches are also included to illustrate the purpose of the commands. Corrections were made in many of the sketches and additional explanations were given with respect to the command and its function. Plate 34A was added (Figure 19). It tabulates the slope options for the template input form. Plate 37 (Figure 20) which explains the superelevation and widening input form was revised to show the three different superelevation transition types. Plates 40 and 41 (Figures 21 and 22) which illustrated the intercept codes of the medians were changed to provide sketches and additional information as to what action the program takes under different conditions. In addition to these changes, the revised input forms were inserted.

The Certification Exam for this course was completely rewritten. In the original exam the designer merely filled in a few missing blanks on previously selected and partially completed input sheets. The project staff felt that upon completing this course the road designer should be able to use the Roadway Design System to complete an earthwork design. This is what the new exam asks the designer to do. A simple, two-lane roadway design is used for the roadway design problem, and all information required for the design is given. The designer is requested to select and complete 23 input forms in their entirety. He is also requested to answer 100 questions regarding the capabilities of the Roadway Design

System. In this way, he gains experience in using the System on a typical roadway design. This is an open book exam and the designer may use any information at his disposal to complete it. This includes the Training Text and the Forms Book. Examples of the material in the exam are shown in Figures 23 through 32.

These self-instructional training materials should provide an orientation and overall idea of the capabilities of this flexible roadway design system. A reproducible copy of this material has been forwarded to the Federal Highway Administration.

IV. System Enhancements

A number of enhancements were added to the system. Some of these caused changes in the user manual, and new data forms had to be prepared. The changes in the user manual are detailed in Section V.

The enhancements to the system are as follows:

- + The command instruction LMBR was added for entering a Lambert correction factor. When it is entered, all following input and output coordinates will be adjusted by the given factor.
- + A plot field of 33 by 240 inches is now available for all command plotting.
- + The plot field established by the automatic orientation option of the command APLT is now held so that other command plots can be superimposed on it.
- + The command STAF was added. It will plot a plan view of roadway catch, crown and ditch points. This plot may be requested at given station limits for any combination of roadways A through F for right-of-way, drainage and other design features. All other command plots may be superimposed on this plot.
- + All options of each geometry command were tested and studied to determine if any errors resulted from the conversion of Version 3.75 to Version 4.0. Any errors were corrected and the program was retested.
- + All commands that compute station offset and elevation will now compute the station and offset regardless of whether or not there is vertical and template data.

- + Two new cross-section input formats were added to the Terrain Edit and Store Process. One of these is a revised format of the original THD (Texas Highway Department) format which allows turning point data to be input in a format more compatible to the rest of the data. A column was added for entering a bias distance in thousands of feet for such areas as interchange design. The second new cross-section data format will be known as TEX. It allows for all data entry of station, offset, elevation, and rod readings to one hundredth of a foot.
- + A new input format has been added in the Terrain Edit and Store Process for deleting, at given cross-section stations, certain types of data from the station file. At any cross-section station any of the following may be deleted: the original cross-section, the design cross-section, the final cross-section, the data for horizontal position of roadways A, B, C, D, or F, right-of-way and maximum slope data, and the hub data for hubs 1, 2, 3, 4, 5, or 6.
- + The input format for the terrain header card was changed to read three additional print type columns. These columns are used to produce listings of the existing horizontal position data, right-of-way and maximum slope intercept data, and hub data. In addition, a print request format has been added to print station file data at given cross-section station limits.
- + An input format has been added to interpolate or extrapolate a complete original cross-section at a given station using two existing original cross-section stations.

- + A cross-section modification input format was added to the system. This allows the user to adjust the original or final cross-section by a given plus or minus distance, elevation or station change. It also allows the user to make a composite of the design section and that portion of the original section outside of the design points. A similar composite may be made of originals and finals. The resulting sections of any of these composite sections may be punched or rewritten on tape as final or original cross-sections.
- + Final cross-sections or final extensions now may be added to the station file for use in final volume calculations, and final and original cross-section plots.
- + Input formats were developed to calculate final (as built) quantities. The user may input balance stations, bridge exceptions and added quantities and may then request final volume and haul calculations.
- + The structure of the design data files was changed to accommodate an extra 50 horizontal PI's for roadways A through G. This allows the user to have 100 PI's for each of these alignments.
- + Previously, when any type of design data was updated all design data on the file was printed and all paged design data was repaged. This repaging took execution time and in many cases there were no changes to the paged data. This was revised so that when non-paged design data is updated, none of the paged design data will be repaged or printed if no changes were made to that data.

- + A feature was added in earthwork design for using an original ground profile as a design profile for roadways A through F. This feature is especially useful in applications where an existing roadway is to be widened.
- + A special slope option was added to the template input. This allows the designer to specify that the subgrade surface to be constructed is only parallel to the travel lane portion of the finished grade template.
- + Programming changes were made so that the fill widening option in the fill selection table would widen the roadway template before building the variable slope.
- + Revisions were made so that a connecting median would be inserted between two roadway crowns when a side slope pattern and a template pattern intersected or overlapped. In this case and in cases where two side slope patterns intersect, revisions were made to the program so that end areas for each roadway would always be calculated, and the correct roadway letter scheme would be retained.
- + The profile plotting process was revised so that a more accurate original ground profile could be plotted along an offset roadway's stationing. An addition was made for plotting an original ground profile at an offset distance to roadways A through F.
- + A new capability was added to the profile plot routine to allow the user to request ditch profiles from the station file. A ditch profile may be plotted to the left or right of roadways A through F selecting the lowest elevation between the roadway's crown and catch point. Another profile plot may be

requested which selects the lowest elevation between one roadway's crown and the adjacent roadway's catch point including the terrain outside of the limits of the catch points. For either type of profile plot, when a median is used, the low elevation will be selected between the two roadway crowns.

Additional changes and revisions were made but are not listed here. Most of these are documented in the revisions to the user manual.

V. User Manual Changes

The changes in the User Manual (Volume 2 of the system documentation) are outlined below. The additional and corrected pages to the manual can be identified by (Revised 3/74) in the lower outside corner of each affected page. In addition all revisions and additions are marked by a bar along the outside edge of the page. The changes are described by chapter and are given on the following pages.

Chapter 3

The explanation of the use of the system card was revised and expanded to reflect the added bridge capabilities.

Chapter 5

In Chapter 5 the following changes were made:

1. A section was added for the new command STAF. This command is used for plotting a plan view of a roadway's catch, crown and ditch points which are retrieved from the station file.
2. A section was added for the use of the CONT command which will plot a roadway surface contour. This explanation is the same as the one on pages 42 and 43 of "Extensions of the Roadway Design System-Bridge Design" which is Research Report 171-1.
3. All references to plot page dimensions of 29 and 168 inches were changed to 33 and 240 inches.
4. Multiple revisions were made to reflect Version 4.0, to correct any errors and to expand on some explanations.

Chapter 6

This chapter was completely rewritten. The following revisions were made:

1. A new discussion of the revised Terrain Header Input Form was included and data entry under each job type was discussed.

2. Illustrations and discussions of data entry for the following terrain data forms were included:
 - + Terrain Input Form (THD)
 - + Terrain Input Form (TEX)
 - + Interpolated or Extrapolated Cross-Sections
 - + Station File Delete
 - + Print Request for Station File Data
 - + Construction Hub Data Input Form
 - + Cross-Section Modification
3. A revised discussion of output was also included.

Chapter 7

The following changes were made to this chapter:

1. A revised and expanded discussion on updating design data was included to more accurately explain the existing capabilities.
2. The store/recall feature explanation was revised.
3. A discussion was added on the use of original ground as a design profile for earthwork design.
4. A revised discussion was inserted on finished grade templates including new template slope option "F" which allows the designer to specify that the subgrade surface to be constructed is only parallel to the travel lane portion of the finished grade template.
5. Multiple revisions were made to correct any errors, to reflect the Version 4.0 and to enhance explanations of various features.

Chapter 8

The Chapter 8 changes were as follows:

1. A revised discussion was inserted of profile plotting

including a section on requesting ditch profiles from data stored on the station file.

2. A discussion was added on requesting ROW arrows to be plotted on cross-section plots.
3. Multiple revisions were made to correct any errors, to reflect the Version 4.0 and to enhance explanations of various features.

Chapter 9

This chapter was added. It covers final volume and haul calculations and the necessary parameters to be used for data input.

The new and revised data forms for Version 4.0 appear in the user manual as figures.

VI. Conclusions and Recommendations

The Roadway Design System (RDS) has been implemented and run in a production environment for about two years. In this time it has proven itself to be a flexible and versatile system which can be used in many areas of highway design and construction. It is the opinion of the authors that RDS has applications in other areas, either as now programmed or with minor revisions. Some of the areas where RDS has applications are:

- + Earthen dam design
- + Railroad roadbed design
- + Channel earthwork calculations
- + Airport runway grading and earthwork calculations
- + Numerous geometric applications

Areas that need to be explored for future enhancements to RDS include the following:

- + Interactive graphics
- + Bridge subsystem refinements
- + Additional modifications for preliminary location and design studies
- + Automated cost tabulations
- + Evaluation of level of service, operation costs, noise pollution and air pollution

It is felt that a forum such as a user group should be established to provide a continuing communication on common problems. In this way, any modifications and enhancements made by various users could be exchanged.

Appendix

Working with Commands

Try using commands to compute and plot the remainder on the left of the centerline for the right of way parcel shown below. Also compute the length of fencing required to fence the left right of way line along this parcel.

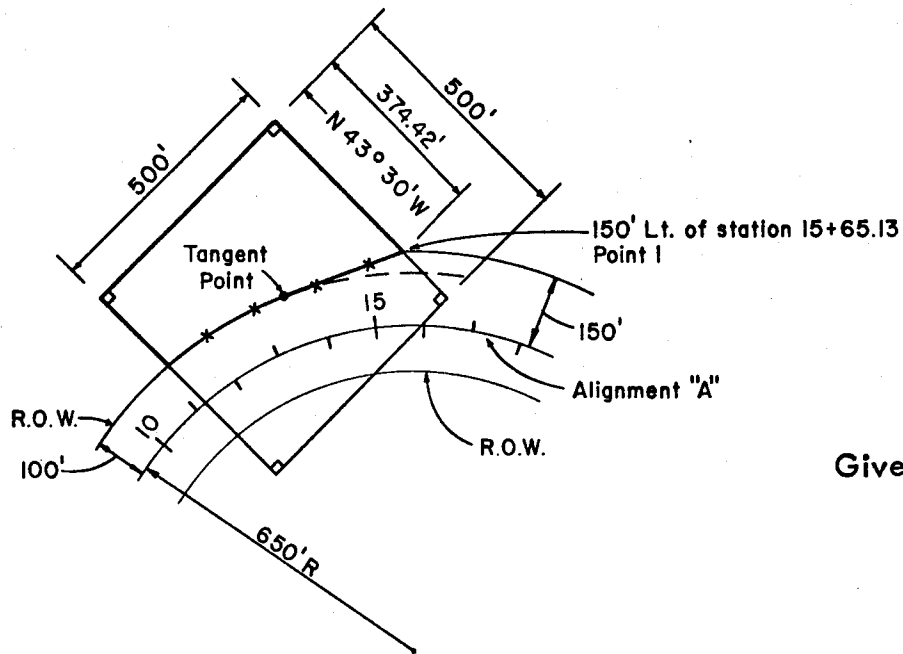


Figure 1

- Given:**
- + Alignment "A" previously stored.
 - + The total parcel is 500' square.
 - + Point 1 is 150' left of station 15+65.13.
 - + Bearing of northeast boundary is $N43^{\circ}30'W$
 - + R.O.W. limits as shown.
- Find:** The remaining area on the left and the length of new fencing required.

This problem will give you a basic introduction to the use of Commands. A more detailed look at Commands will be given later in this chapter and in Run 5.

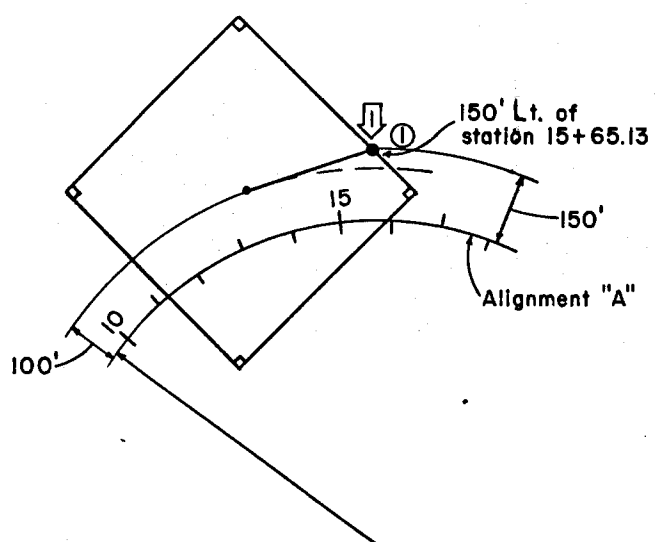
PONT

Here's how to do it, step by step.

Step 1 Store the first point. Select the command and enter it on the input form. PONT is the correct command. It is on Plate 19 (Forms Book) and stores the point like this.

CARD NO.	COMMAND	A	B	C	D	E	F	X-COORDINATE OR CORRECTION	Y-COORDINATE OR STATION	RADIUS, OFFSET, DISTANCE, ETC.	BEAR, AZ, OR SKEW																													
											N S	DEG	MIN	SEC	E W																									
10	1																																							
	CMNT							STORE POINT	1																															
	PONT	1					A		1565.13																															

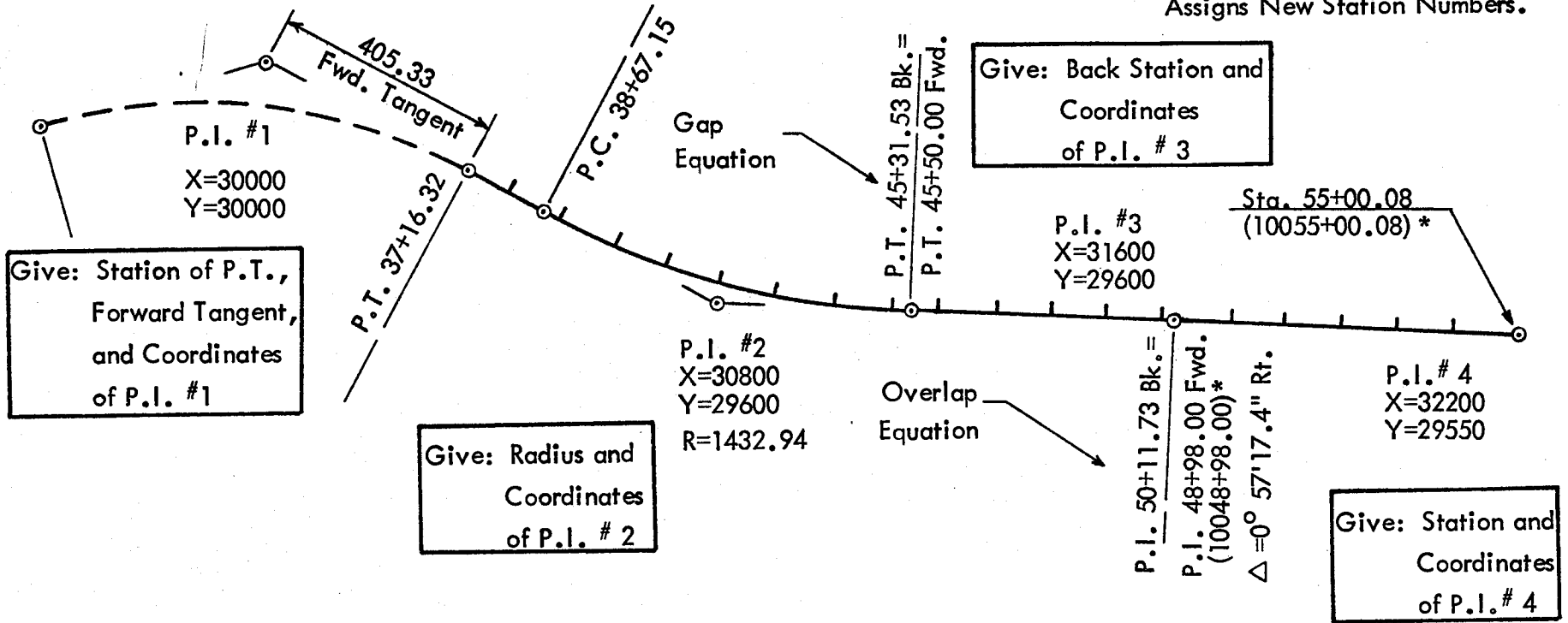
Figure 2



Comments are optional. Put them any place you feel that they may be useful.

Example Problem

*NOTE: The Program Automatically Assigns New Station Numbers.



This is the input to describe the alignment.

ROADWAY	P.I. NO.	STATION	BEG. STA. I.D.	DEGREE OF CURVE			RADIUS OR FORWARD TANGENT	SPIRAL		P. I. COORDINATES		GEOM. POINT STOR. NUMBER	RND BRG OR HOLD																																																									
				DEG	MIN	SEC		IN	OUT	X				Y																																																								
										10	11			12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68
	1	37+16.32	PT				405.33			30000		30000																																																										
	2	*					1432.94			30800		29600																																																										
	3	50+11.73								31600		29600																																																										
	4	55+00.08								32200		29550																																																										

Now let's look at the output.

Figure 4

HORIZONTAL ALIGNMENT PROCESS
CONTROL 1234 SECTION 568

*** DESIGN DATA ***
HORIZONTAL ALIGNMENT LIST
FOR ROADWAY C

OCT 31, 1973
COUNTY & HIGHWAY - SMITH CO US 81

COMPUTATIONS BASED ON ARC DEFINITION

Coordinates of
Beginning P.I.

X	Y
30000.0000	30000.0000
30362.5382	29818.7309

P.I.	Station	Point	Offset	Angle	Distance	Bearing	X	Y
1	37+16.3200	PT	405.3300					
	Begin Station				489.0972	S 63 26 5.82 E		
	38+67.1459	PC	338.2712				30497.4410	29751.2795
2	42+05.4172	PI		3 59 54.5 D	664.3792	26 33 54.2 LT	30800.0000	29600.0000
	45+31.5251	PT	338.2712				31138.2712	29600.0000
	45+50.0012	AHEAD EQUATION						
					800.0000	N 90 0 0.0 E		
3	50+11.7300	PI		4 45 49.1 RT			31600.0000	29600.0000
	10048+98.0003	AHEAD EQUATION						
					602.0797	S 85 14 10.89 E		
4	10055+00.0800						32200.0000	29550.0000

Figure 5

PROFILE PLOTS

As many as five profile plots (original, design, or any combination of original and design) may be requested between the same station limits.

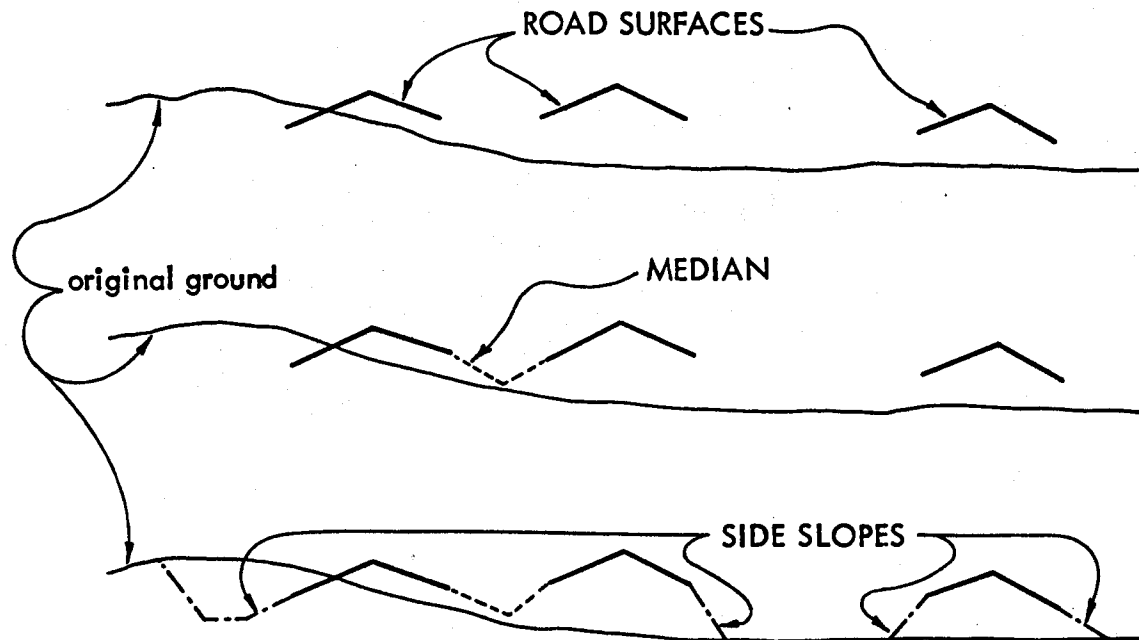
The station limits (FROM STATION and TO STATION) may be referenced to any roadway but the data input and the plotted output may differ according to the selected reference roadway. The table below shows the differences.

Reference Roadway	Original Profiles	Design Profiles	Remarks
G (Terrain Roadway) Blank assumes G	At offset distances and along previously defined roadways	Along previously defined roadways only	Profiles drawn are projected to the plane of the baseline (alignment G)
A-F (Roadways used in earthwork design)	<u>Only</u> along the centerline of the referenced roadway	Along the centerline of the referenced roadway or at an offset distance from that roadway	True profile plots of the design vertical alignments are plotted
H-Z (Roadways not available for earthwork design)	Not available	Same as A-F	Same as A-F

Completing the Design Cross-Section

Now you have learned to describe the surface of roadways and how to modify the surfaces by superelevating and widening. Next you need to know how to complete the design cross-section by linking roadway surfaces to one another or to original ground.

Study the illustrations below.



The design section is incomplete.

Adjacent roadways may be linked by **MEDIANS**--This will be discussed later.

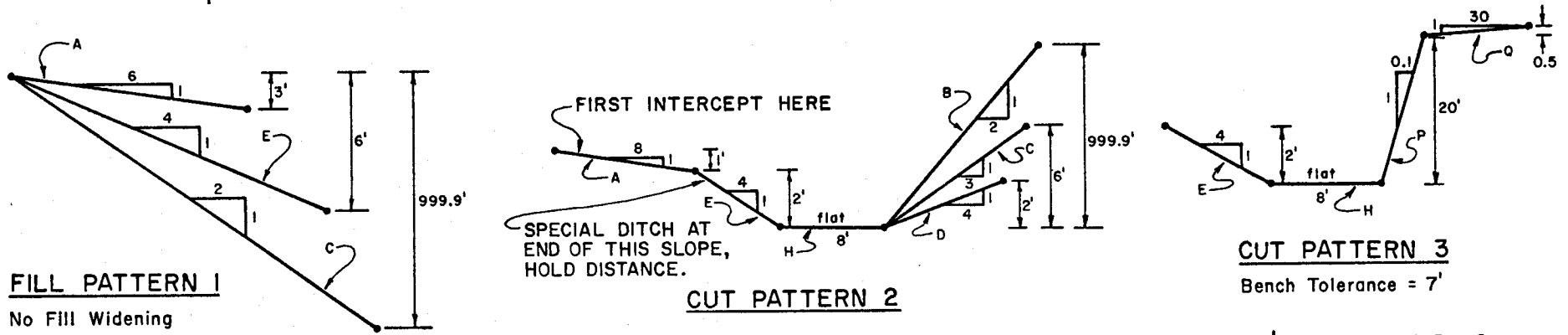
The remaining crowns can be linked to the original ground by **SIDE SLOPE PATTERNS**.

Now the design section is complete.

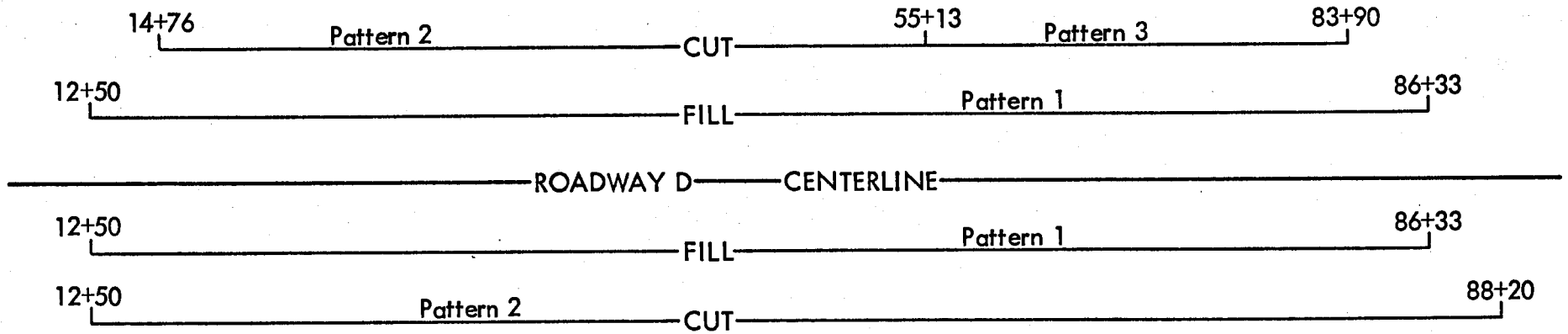
It should be clear that complete design sections are made up of **ROAD SURFACES**, **MEDIANS**, and **SIDE SLOPE PATTERNS**. Which one is not always present? If you answered "MEDIAN", you're right.

Now let's see if we can put it all together.

Here is the complete information on three SIDE SLOPE PATTERNS.



MAXIMUM CATCH FOR ALL PATTERNS IS 100' FROM TEMP. C.
MINIMUM CATCH FOR ALL PATTERNS IS THE SHOULDER POINT.



FIRST fill out the CUT/FILL Slope Table on the next page -- Use the letters shown for the segments for convenience.

THEN enter the patterns on the SLOPE SELECTION input form.

Figure 8

INDEX	WIDTH	VERT. DIST.	SLOPE	WIDTH	VERT. DIST.	SLOPE	WIDTH	VERT. DIST.	SLOPE	WIDTH	VERT. DIST.	SLOPE	WIDTH	VERT. DIST.	SLOPE
	A			B			C			D			E		
3	5	A	3.0	-6.00			9.999	-2.00					6.0	-4.00	

FILL TABLE

CUT TABLE

		A			B			C			D			E		
4	O	A	1.0	-8.00	9.999	2.00	6.0	3.00	2.0	4.00	2.0	-4.00				
F		F					8.0	9.999	9.999							
L		L							2.0	0.10	0.5	30.00				

ROADWAY	BEGIN STATION	END STATION	CORNER	STORE / RECALL NUMBER	BENCH TOLERANCE	MAX. DIST. FROM CENTER-LINE	MIN. DIST. FROM CENTER-LINE	NO. FIXED SLOPES																	
								OPTION SLOPE	OPTION SLOPE	OPTION SLOPE	OPTION SLOPE	OPTION SLOPE	OPTION SLOPE	OPTION SLOPE	OPTION SLOPE	OPTION SLOPE	OPTION SLOPE	OPTION SLOPE	OPTION SLOPE	OPTION SLOPE	OPTION SLOPE				
4	5	D	12	50.00	86	33.00	F B 01	T 100.0		A	E	C													
		D	14	76.00	55	13.00	C L 02	T 100.0		3	I	A	E	H	D	C	B								
		D	55	13.00	83	9.00	C L 03	7 T 100.0		2	E	H	B	P	R	Q									
		D	12	50.00	88	20.00	C R 02																		

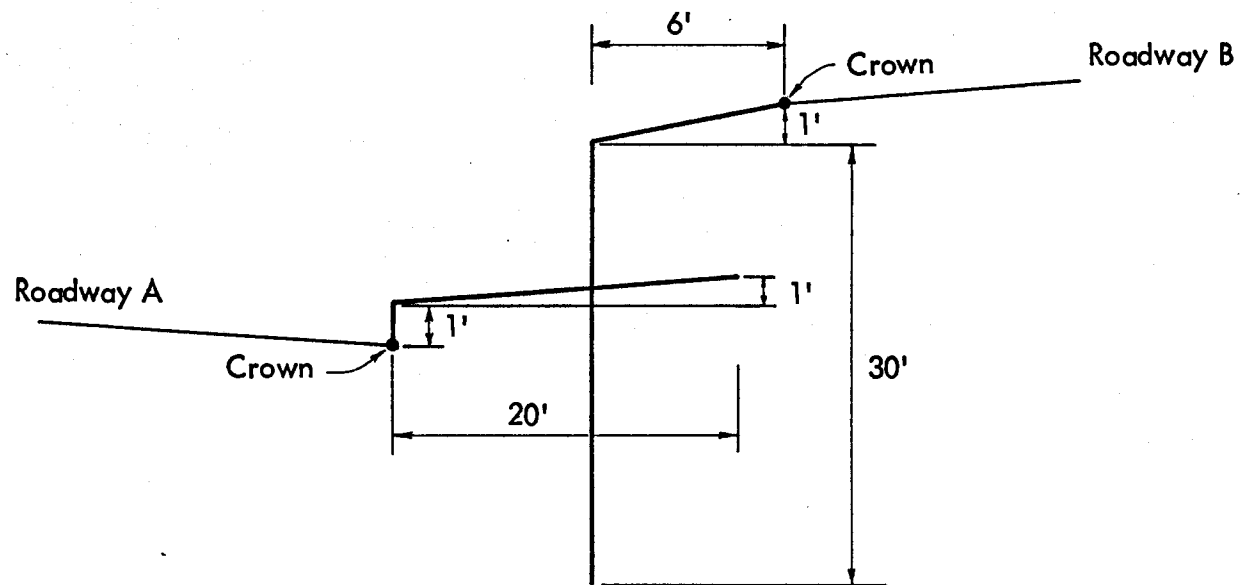
Did you get it right? Good. If not, go back and review.

Figure 10

Defining a Retaining Wall With Medians

Here is a sample median design.

- + Two adjacent roadways extend from baseline station 35+00 to station 65+00.
- + The two roadways require a retaining wall to be built between them.
- + This retaining wall is to be located at a known horizontal and vertical distance from the right roadway.



It's described by the input on the next page.

This input covers the median design shown on the previous page.

CONTROL & SECTION								
1	2	3	4	5	6	7	8	9
								R/D

DISTRICT _____ RES. NO. _____
 I.P.E. _____ PROJ. _____
 CO. _____ HWY. _____

ROAD DESIGN SYSTEM
 MEDIAN DESIGN INPUT FORM

SHEET _____ OF _____
 DATE _____
 PREPARED BY _____

ROADWAY	BEGINNING STATION	ROADWAY	ENDING STATION	LEFT RDWY	RIGHT RDWY	STORAGE / RECALL	NO-T-D-O	LEFT ROADWAY						RIGHT ROADWAY								
								SEGMENT 1		SEGMENT 2		SEGMENT 3		I N T C	SEGMENT 3		SEGMENT 2		SEGMENT 1			
								HOR. DIST.	VERT. DIST.	HOR. DIST.	VERT. DIST.	HOR. DIST.	VERT. DIST.		HOR. DIST.	VERT. DIST.	HOR. DIST.	VERT. DIST.	HOR. DIST.	VERT. DIST.		
50	G		35+00.00	G		65+00.00	AB	01	00	10	200	10						00	-300	60	-10	

Figure 12

No intercept codes were needed.

For the resulting median design, look at the next page.

The resulting median will be formed by the intersection of segment 2 of Roadway A with segment 2 of Roadway B. Both were defined longer than needed to insure intersections as the horizontal and vertical distances between the roadways change.

Two of the resulting medians are below:

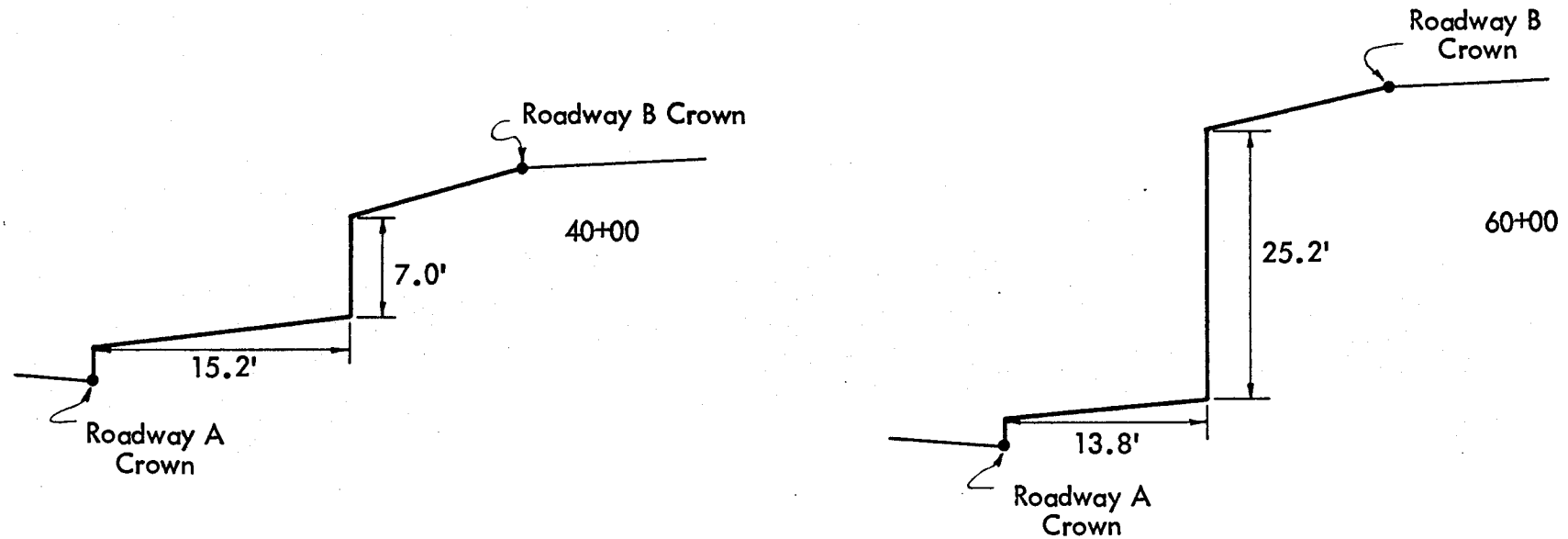


Figure 13

If you're not sure you understood --

+ using MINUSES -- turn to page 4-62.

+ the INTERCEPT CODE -- turn to page 4-64.

REQUESTING EARTHWORK

Let's consider what we've done in Run 4.

We have:

- + Established profile grades on each design roadway
- + Established template shapes and where they are used
- + Applied superelevation and widening modifications to the road surfaces
- + Defined side slope patterns and indicated where they apply at the sides of each roadway
- + Defined median patterns where applicable
- + Defined volume parameters and design exceptions.

In Run 2 we established horizontal alignments to position the design roadways.

The Earthwork Request Input Form

We can merge all this data and complete the earthwork design with the Earthwork Request Input Form.

Flip the page to see the form.

ROAD DESIGN SYSTEM EARTHWORK REQUEST INPUT FORM

SHEET _____ OF _____
DATE _____
PREPARED BY _____

CONTROL & SECTION	DISTRICT _____	RES. NO. _____
	I.P.E. _____	PROJ. _____
	CO. _____	HWY. _____

FROM BASELINE STATION		TO BASELINE STATION		HORIZONTAL POS- ITION CALCULATION						ROW & MAX. SLOPE INTCP. UPDATE	EARTH- WORK DESIGN (YES OR NO)	VOLUME & HAUL CALCULATIONS												CONSTRUCTION STAKING REPORT			AUXILIARY LISTINGS																																												
				YES OR NO	ROADWAYS INCLUDED							VOL- UMES (YES OR NO)	ROADWAYS INCLUDED IN VOLUME						LIST EVEN STAT- IONS ONLY (VOLUME)	HAUL PLOT, PRINTER (YES OR NO)	HAUL PLOT, DIGITAL (YES OR NO)	YES OR NO	ROADWAYS INCLUDED						H U B N O																																										
					A	B	C	D	E				F	A	B	C	D	E					F	A	B	C	D	E		F																																									
9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80

WHERE

WHAT

Figure 15

This form is similar to the others you have studied. It requests that you enter the station limits (WHERE) and then tell WHAT you want done by answering YES or NO.

- | | |
|-------|--|
| WHERE | + From baseline station -- To baseline station |
| WHAT | + Horizontal Position Calculation (Yes or No) |
| | + R.O.W. and Max.Slope INTCP. Update (Yes or No) |
| | + Earthwork Design (Yes or No) |
| | + Volumes (Yes or No) |
| | + Haul Plot (Yes or No) |
| | + Construction Staking Report (Yes or No) |

Now let's discuss the form column by column.

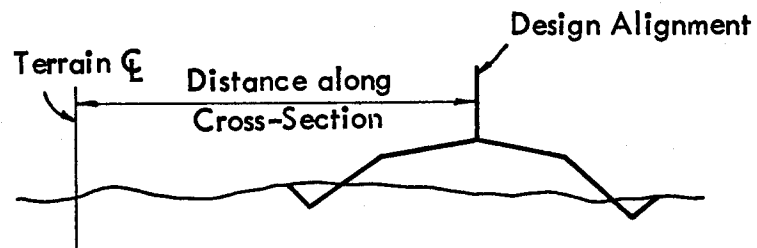
FROM BASELINE STATION - TO BASELINE STATION

This is the WHERE for the WHAT requested on the right side of the form.

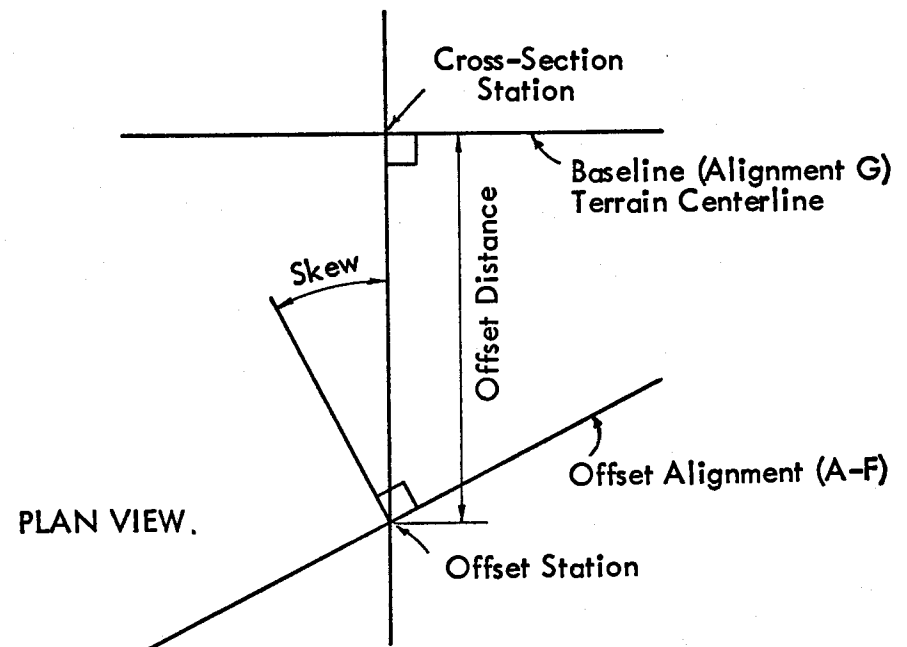
HORIZONTAL POSITION CALCULATION

A YES in the HORIZONTAL POSITION CALCULATION column on the earthwork request form and an X for the roadways to be designed will provide the computation, storage and output of skew, distance and station for each design roadway at each cross-section station.

This process is required in order to locate each design roadway with respect to the terrain centerline.



CROSS-SECTION VIEW



PLAN VIEW.

R.O.W. & MAXIMUM SLOPE INTCP. UPDATE

A YES in the R.O.W. and Max. Slope Intcp. Update column will use data input on the R.O.W. and Max. Slope Input form to compute and store R.O.W. and Max.Slope Intercept distances at each cross-section station.

EARTHWORK DESIGN

A YES in this column causes the computation and storage of the design cross-section at each terrain station. It also computes and stores separately the cut and fill end areas for each designed roadway.

VOLUMES

A YES in this column along with an X in the appropriate column for each roadway to be included will provide a tabulation of the earthwork quantities. If you leave the columns under roadways used in volume computations blank, all roadways will be included in the tabulation.

If you want a tabulation that lists only even stations, put a YES in the LIST EVEN STATIONS ONLY column.

A YES in the appropriate HAUL PLOT columns will produce a printer or digital haul plot.

CONSTRUCTION STAKING REPORT

A YES in this column along with an X for the roadways to be included and the reference hub number will give you a construction staking report.

Nothing hard about that.

Now let's complete the EARTHWORK REQUEST INPUT FORM for your SH 55, Edwards County job.

SELECTING SLOPE OPTIONS ON THE TEMPLATE INPUT FORM		
SYMBOL	USE	RESULTS
Blank	When no option is required	Slopes will be built exactly as indicated
H	To override superelevation	Slopes with this option will not be modified by superelevation
V	To define vertical slopes or trench slopes	The slopes with this option will be $\frac{\text{horizontal distance}}{\text{vertical distance of 1}}$ and the distance that accompanies this slope will be a vertical distance. Also, this slope will not be modified by superelevation.

Figure 19

CONTROL & SECTION
 1 2 3 4 5 6 7 8 9 RD

DISTRICT _____ RES. NO. _____
 I.P.E. _____ PROJ. _____
 CO. _____ HWY. _____

ROAD DESIGN SYSTEM
 SUPERELEVATION & WIDENING INPUT FORM

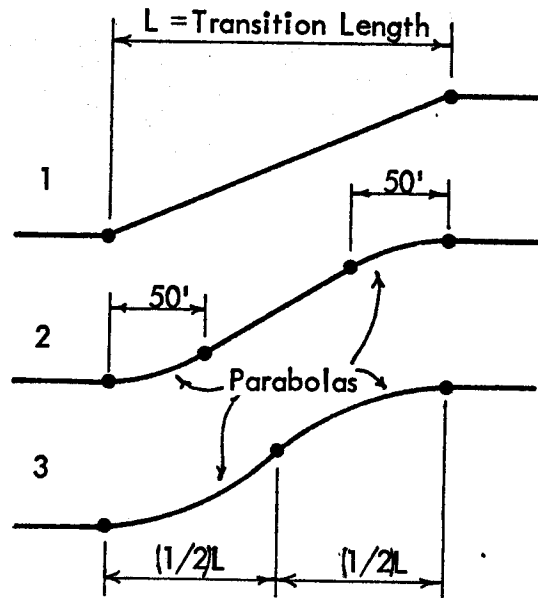
SHEET _____ OF _____
 DATE _____
 PREPARED BY _____

ROADWAY	STATION	TRANS LENGTH	BORER	SUPER RATE	LORR	TRANSITION POINT
20	10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33					

Superelevation Transition Type

Transition of all segments of the roadway template occurs simultaneously around designated pivot points to provide smooth transitions. Three options are available for controlling crown lines. The effect of these on outside crowns is shown schematically below:

Option



ROADWAY	STATION	WIDENING NO.	WIDENING	SEGMENT NUMBER	TRANS LENGTH	BORER
25	10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34					

Figure 20

SELECTING INTERCEPT CODES WHEN THE MEDIANS DO NOT INTERCEPT

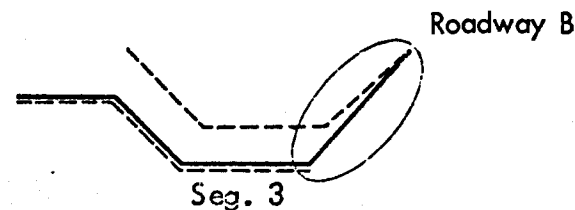
INTC Code of
Roadway B

Computer Action

Median Design

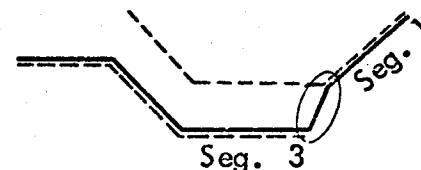
Blank

- The last segment of the median pattern at the lowest elevation is connected to the crown point of the other roadway.



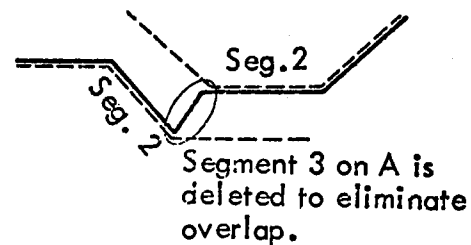
1

- The last segment of the median pattern at the lowest elevation is connected to segment 1 of the other pattern.



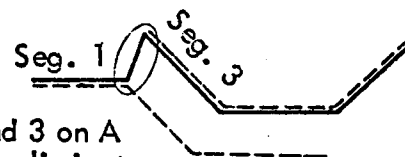
2

- The last segment of the median pattern at the lowest elevation is connected to segment 2 of the other pattern.



3

- The last segment of the median pattern at the lowest elevation is connected to segment 3 of the other pattern.



Segments .2 and 3 on A
are deleted to eliminate
overlap.

SELECTING INTERCEPT CODES WHEN THE MEDIANS INTERCEPT

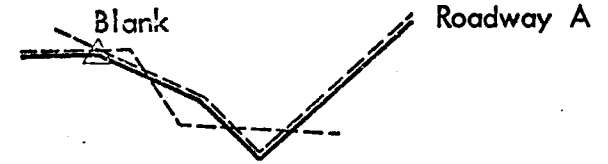
INTC Code of
Roadway A

Computer Action

Median Design

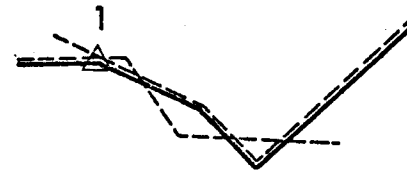
Blank

- The first intersection of the median patterns controls.



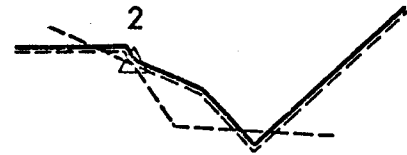
1

- The intersection on segment 1 of Roadway A controls.



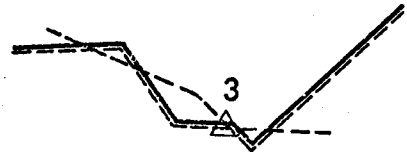
2

- The intersection on segment 2 of Roadway A controls.



3

- The intersection on segment 3 of Roadway A controls.



When the segment has more than one intersection as segment 3 shows, the first intercept on the higher median pattern controls.

Strategy is important when using RDS because of its versatility. If you have provided sufficient information to RDS you can make RDS requests in any sequence.

Therefore, you should always be aware of what information you have stored in previous runs and you should develop a logical sequence of storing required information.

Number the following in the proper sequence for RDS based on what previous information is required.

- _____ Request earthwork design.
- _____ Obtain and store cross-section data.
- _____ Request earthwork quantities.
- _____ Reduce and store traverse data.
- _____ Input the remaining design data (vertical alignment, templates, medians, etc.).
- _____ Use terrain intercepts to determine R.O.W. requirements. Then use commands to obtain R.O.W. areas.
- _____ Request terrain profiles to use in determining the design vertical alignments.
- _____ Use the original traverse and commands to locate the baseline and the roadway alignments.

Questions

1. Find and list the requested values from this output.

HORIZONTAL ALIGNMENT LIST

183+98.2587 PC	882.1535 T					2797332.1268	273099.5972
192+80.4121 PI	2 0 0.0 D	34 13 49.1 RT	1711.5150 L	2864.7890 R		2796572.9549	273548.8774
201+09.7737 PT	882.1535 T					2796198.0136	274347.3846

Degree of curve _____, Radius _____, Delta angle _____,

Tangent length _____, Length of curve _____

2. Overlapping equations are eliminated by adding _____ to the ahead stations.
3. For alignments with no equations, only the _____ PI requires an entry in the station field.
4. The PI's for an alignment may be defined by entering X,Y coordinates or a previously stored _____.
5. Horizontal curves are defined by entering either the degree of curve or a _____.

Questions

1. The station label increment must be an even multiple of the _____ increment.
2. Tangent bearing labels may be eliminated from an alignment plot by placing a _____ in column _____.
3. The _____ command will cause a line to be plotted through a specified series of previously stored points.
4. The _____ command establishes a new plotting field.
5. Find and list the requested values from this output.

Figure 25

GENERAL GEOMETRY PROCESS										JAN 03, 1974		
CCNTROL 0113 SECTION 13T										COUNTY & HIGHWAY - TRAVIS LOOP 360		
GENERAL GEOMETRY LIST												
COMMAND	A	B	C	D	E	F	X-COORDINATE OR CORRECTION	Y-COORDINATE OR STATION	RADIUS, OFFSET DISTANCE, ETC.	ELEV.	BEAR, AZ, SKEW D M S	STORE
****GEOMETRY TO SET UP AXIS												
BRDS	10	50	1000	0	0		0.0 2799051.8072	0.0 272081.8855	0.0 9044.8803	0.0	0 0 0.0 N 75 37 21.97 W	SC 1000
PONT	1000	0	0	0	G	0	0.0 2797539.7102	16500.0000 269723.1649	-2800.0000 0.0	0.0	0 0 0.0 0 0 0.0	SP 1000

The bearing and distance from point 10 to point 50 are _____, _____ feet.

All you need to define the vertical alignments for Roadways A and B is shown on this page.

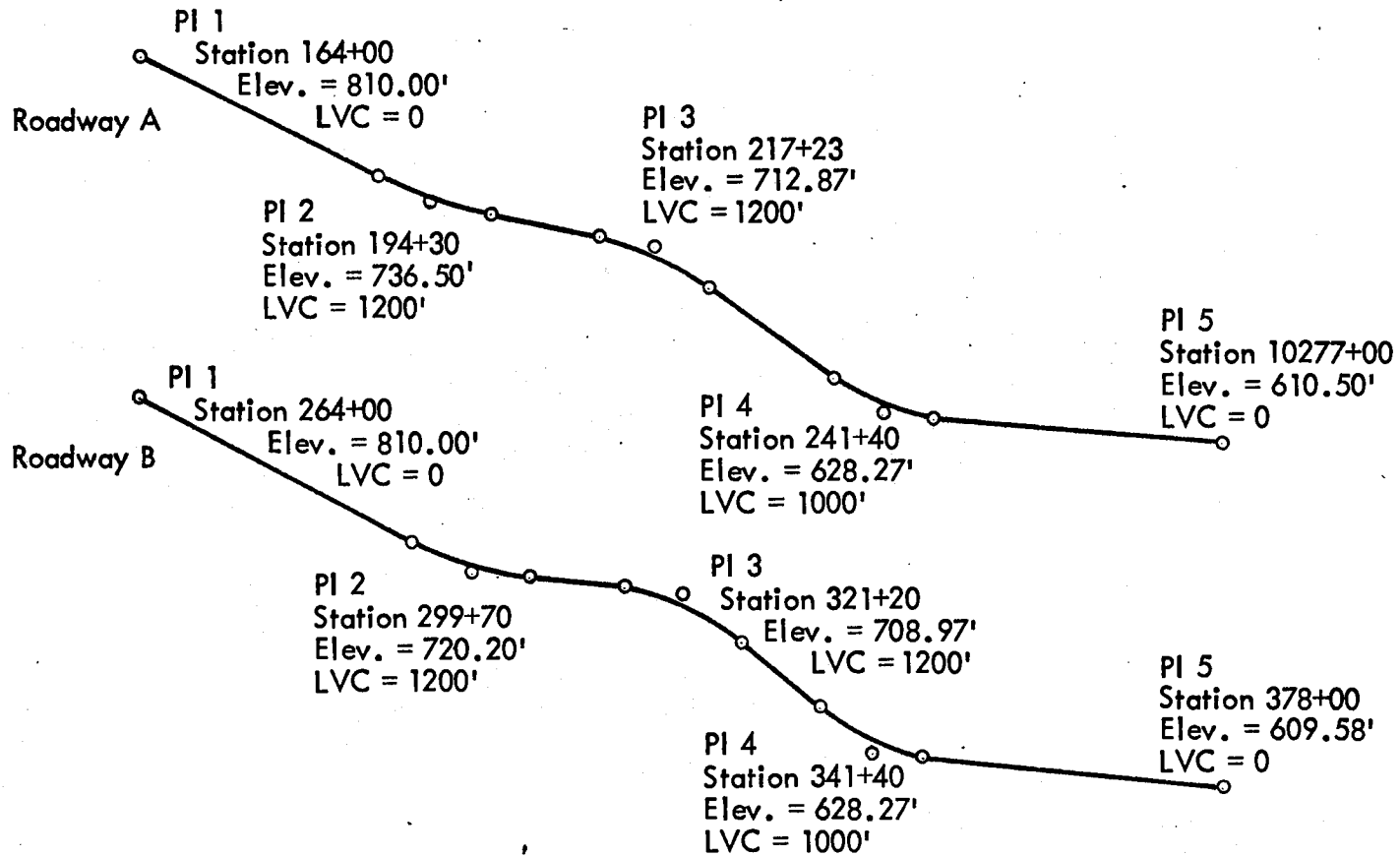
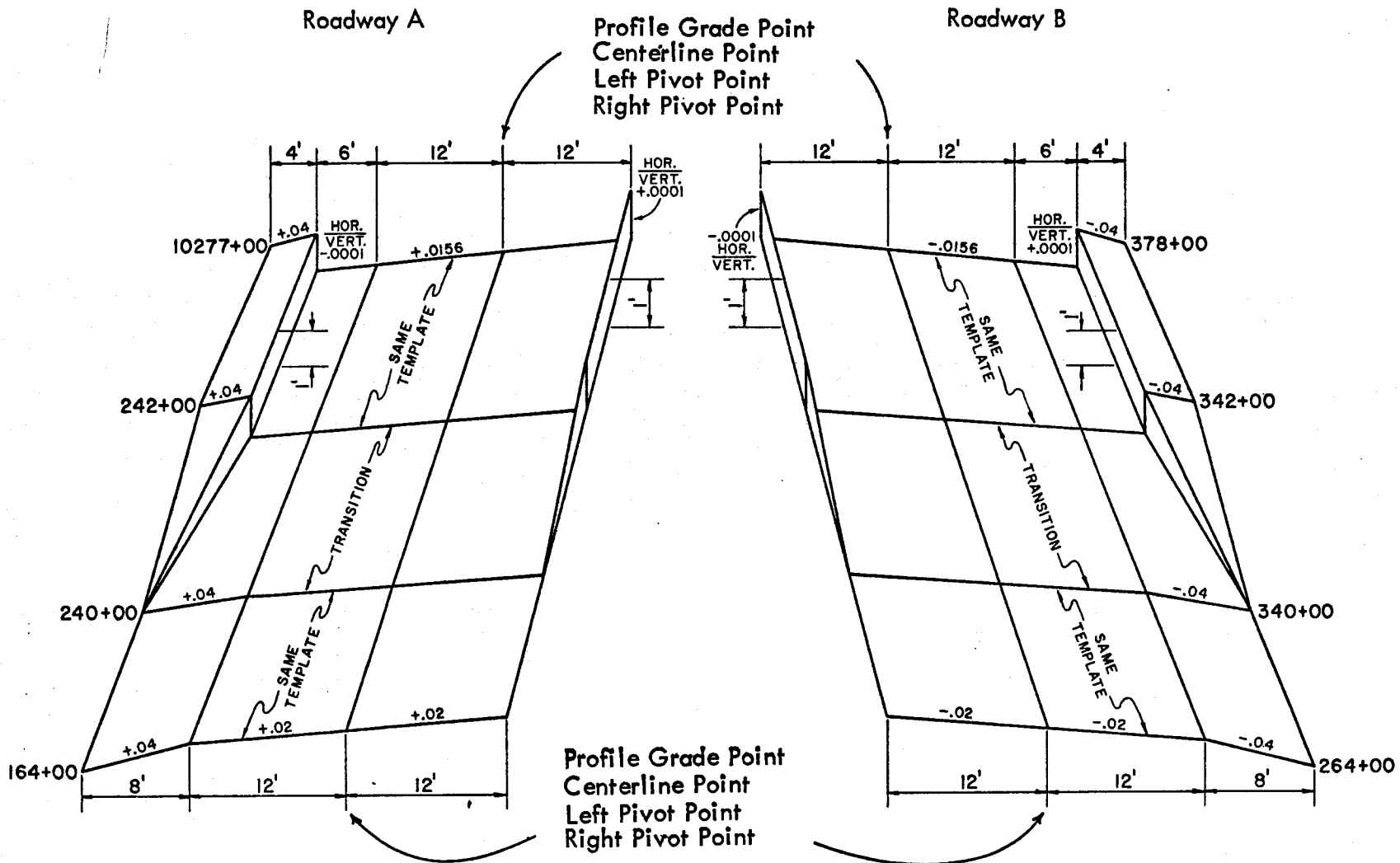


Figure 26

Select the proper form and complete it.
 Number it 9 of 23.

Input the data shown below to define the shape and location of the subgrade roadway templates.



Select the proper form and complete it.
 Number it 10 of 23.

Figure 27

Here are the patterns for cuts and fills and the station limits where they apply.

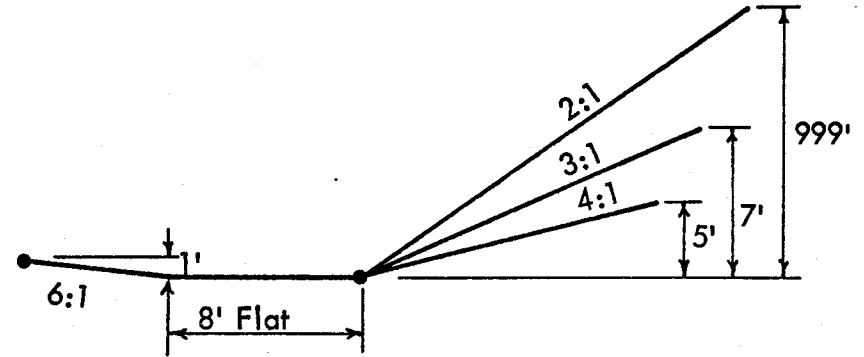
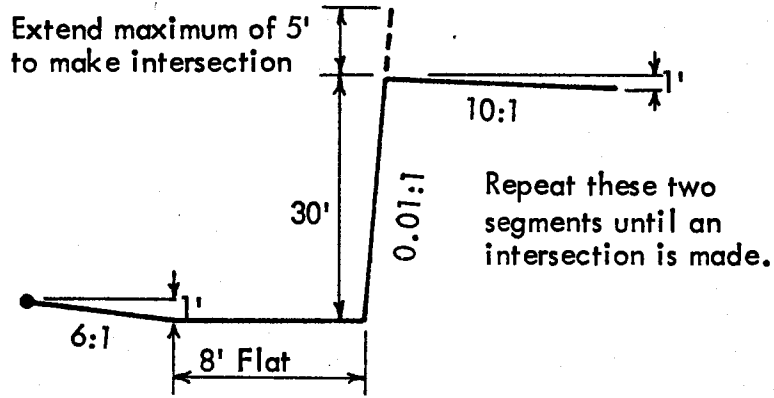


Figure 28

<u>Station Limits</u>	<u>Roadway</u>	<u>Side</u>
164+00 - 228+50	A	Left
264+00 - 328+50	B	Right

<u>Station Limits</u>	<u>Roadway</u>	<u>Side</u>
228+50 - 10277+00	A	Left
328+50 - 378+00	B	Right

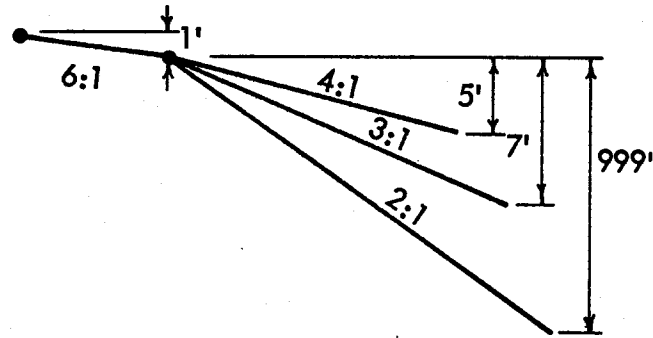


Figure 29

Use this data to define your fill slopes for both sides of Roadway A and B from beginning to end.

Select the proper forms and complete them.

Number them 13 and 14 of 23.

Questions

1. To describe slopes that go down, you input _____ slope ratios and _____ vertical distances.
2. The last slope of every slope pattern must be a _____ slope.
3. The last slope of every slope pattern should have a large _____ to insure an intercept with the terrain.
4. The hinge point for every slope pattern is located at the end of the _____ fixed slope.

Now that the design is complete, the next step is usually to calculate the right-of-way. Compute and plot the alignment and the right-of-way area shown in the sketch below. Assign geometry point and curve numbers as shown below. Refer to the baseline alignment on page 8 for needed radius lengths.

HINT: Use automatic orientation on the alignment to set up the plotting field with a plot scale of 1"=200'.

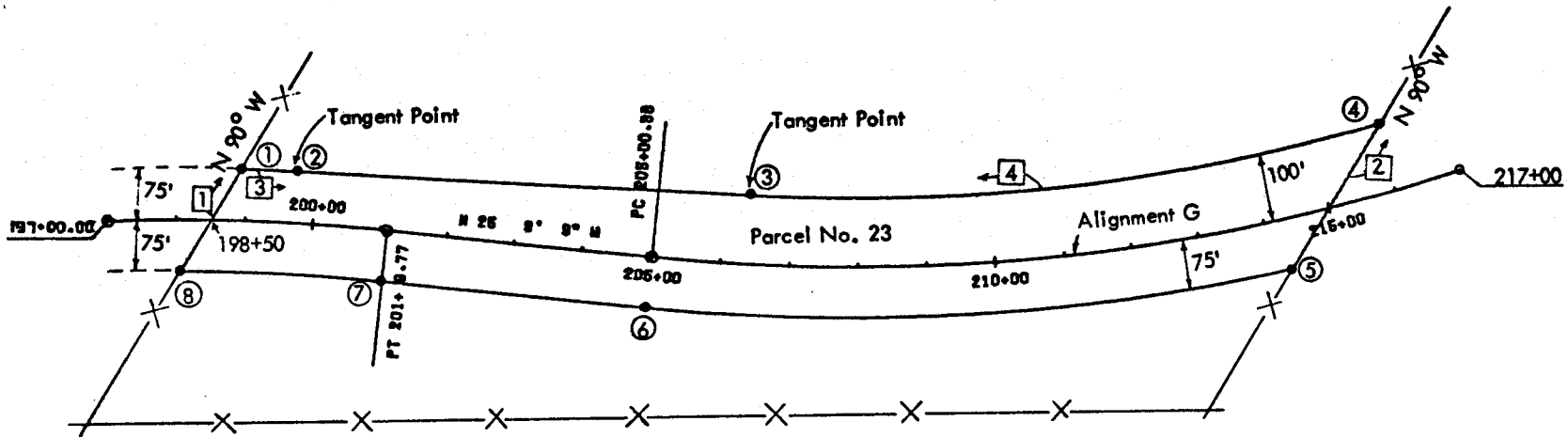


Figure 31

Select the proper form and complete it.
 Number it 22 of 23.

Questions

1. There are four commands that can be used to store lines or circles. They are CURV, _____, _____, and _____.
2. The _____ command is used to intersect a previously stored curve with an alignment.
3. The _____ command will compute the station, offset and elevation of a previously stored point.
4. The _____ command computes tangent points on previously stored curves.
5. When using the AREA command a _____ is input when a segment area is to be subtracted from the computed area.