HIGHWAY PERSPECTIVE PLOTTING BY COMPUTER: A USER'S GUIDE FOR HWYPPLOT

by

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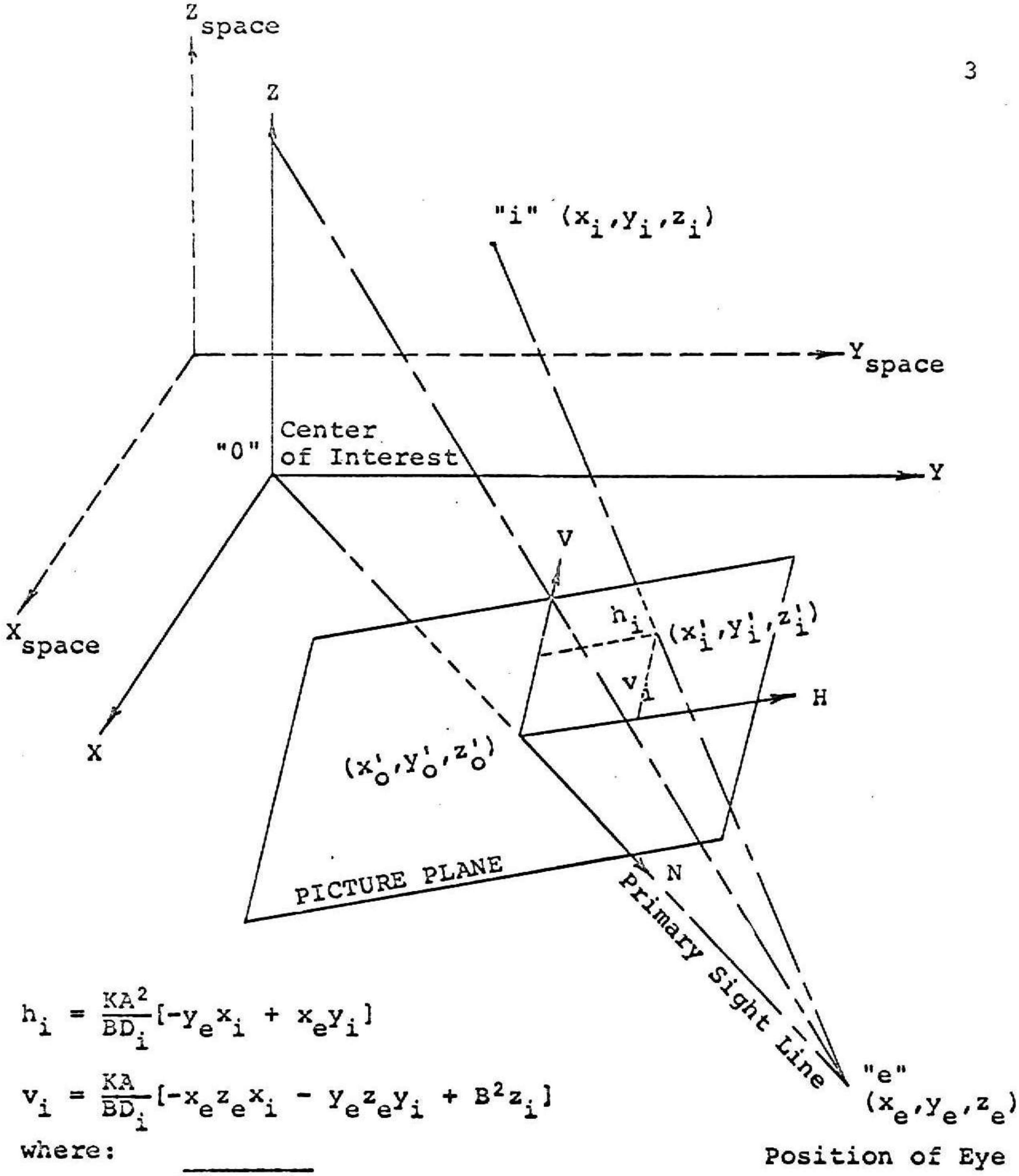
BACKGROUND

Today, with the emphasis more and more on ecology and aesthetics, the highway designer must be made aware of the importance of visual aspects in his design. The designer must realize that it is his responsibility to create aesthetically pleasing designs which are also functional, safe and economical.

In conventional design procedures, the highway designer depends only on his ability to visualize or "see" the roadway in perspective, based on plan and profile views of the roadway. Considering the complexity of some of our modern highways it would truly be a formidable task to visualize the roadway from a functional, safe and aesthetic point of view. Undoubtedly there have been details which would have improved the safety and efficiency of a highway if they had only been detected at the design stage. Therefore, it would be highly desirable that some means be developed whereby the designer could visualize his design from the driver's point of view, prior to construction (3).

One technique, which is the basis of this Report, is to prepare highway perspective views through the use of a computer and an electronic plotter. Presently, the Department of Civil Engineering, Kansas State University, has a computer program (written in FORTRAN G) with the capability of producing these highway perspectives. This program, hereafter referred to as HWYPPLOT and found in Appendix A, was developed under a research project by Dr. Bob L. Smith, Edward E. Yotter and Jerry S. Murphy, in conjunction with the State Highway Commission of Kansas and the Federal Highway Administration.

In order to make these perspective drawings, it is first necessary to determine the three-dimensional (space) coordinates of all points and then transform these space coordinates into two-dimensional (picture plane) coordinates. The approach used in HWYPPLOT to accomplish this transformation is based on a procedure developed by Dr. Walter Bernhart (Appendix A of reference 4), School of Engineering, Wichita State University. This approach, depicted in Figure 1, first determines the space coordinates of all points and then selects the center of interest (0). Next, through a simple subtraction of the space coordinates of the center of interest from the space coordinates of all points, the space coordinate axes are translated to the center of interest axes. Then the position of the eye (e) is chosen and also translated to the center of interest coordinate system. After the center of interest and the position of the eye is selected, the line between the center of interest and the eye position is taken as the primary line of sight. The picture plane is then positioned perpendicular to the primary line of sight and located between the center of interest and the eye position. (The location of the picture plane between 0 and e is determined by a scale factor, K. In HWYPPLOT, a scale factor of 50/A is used which places the picture plane 50 ft. in front of the observer.) The desired transformation is now accomplished by rotating the center of interest axes (X,Y,Z) so that the X



$$h_i = \frac{KA^2}{BD_i}[-y_e x_i + x_e y_i]$$

$$v_i = \frac{KA}{BD_i}[-x_e z_e x_i - y_e z_e y_i + B^2 z_i]$$

where:

$$B = \sqrt{x_e^2 + y_e^2}$$

$$A = \sqrt{x_e^2 + y_e^2 + z_e^2}$$

$$D_i = A^2 - (x_e x_i + y_e y_i + z_e z_i)$$

K = Scale Factor, $K>0$

Figure 1. Transformation of Space Coordinates to Picture Plane Coordinates

axis coincides with the line 0-e. Another rotation of the center of interest axes places the Y and Z axes parallel to the H and V axes in the picture plane. Then by analytical geometry, a point in space (X_i, Y_i, Z_i) is related to the H and V axes on the picture plane by the equations given in Figure 1 (6).

HWYPPLOT utilizes a main program and twelve subroutines to accomplish the transformation of input data to picture plane coordinates which are then used by the KSU Computing Center's CalComp Digital Incremental Plotter to form the perspective plot. An abbreviated flow chart of HWYPPLOT is shown in Appendix B.

PURPOSE

The purpose of this report was to document HWYPPLOT, with explanations and examples, for subsequent use by Civil Engineering students in graduate and undergraduate transportation design courses at Kansas State University.

SCOPE

The scope of this Report was limited to the following:

1. Complete test runs of HWYPPLOT and check the output of the horizontal and vertical alinement.

2. Addition to HWYPPLOT of circular curve superelevation through the use of spiraled and unspiraled transitions.

3. Complete test perspective plots of HWYPPLOT.

CAPABILITIES OF HWYPPLOT

The horizontal geometry of HWYPPLOT can consist of combinations of tangents, circular curves, spirals or unspiraled transitions and superelevation, while the vertical geometry consists of tangents and parabolic curves. HWYPPLOT has the capability of producing perspective plots of two-lane roadways with or without backslopes and four-lane roadways with backslopes. (The standard cross-sections for the two- and four-lane roadways are shown in Figure 2 and Figure 3.) Superelevation (with rotation about the centerline of the roadway) can be used only with the two-lane roadway, and then, either through the use of spirals or unspiraled transitions. One major drawback to the four-lane roadway capability is that it is not possible to create independent alinements for the two sets of roadways. Backslopes, for both two- and four-lane roadways, are drawn at a fixed slope of 6:1 from the outside edges of shoulder to an elevation designated by the input data.

HWYPPLOT utilizes one center of interest and one or more observer positions in creating a specific perspective plot. The center of interest can be input in terms of either X,Y,Z coordinates or by centerline station; the latter will then be converted ahead to the nearest point on the centerline of the roadway. The observer's positions can also be input in terms of either X,Y,Z coordinates or by centerline station, but in this case the station value will be converted ahead to the

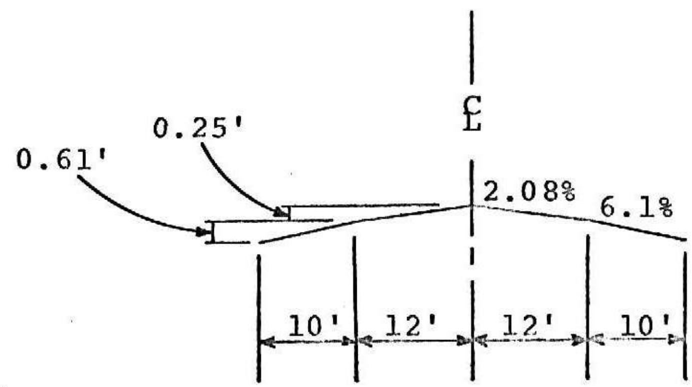


Figure 2. Cross-Section for Two-Lane Roadway

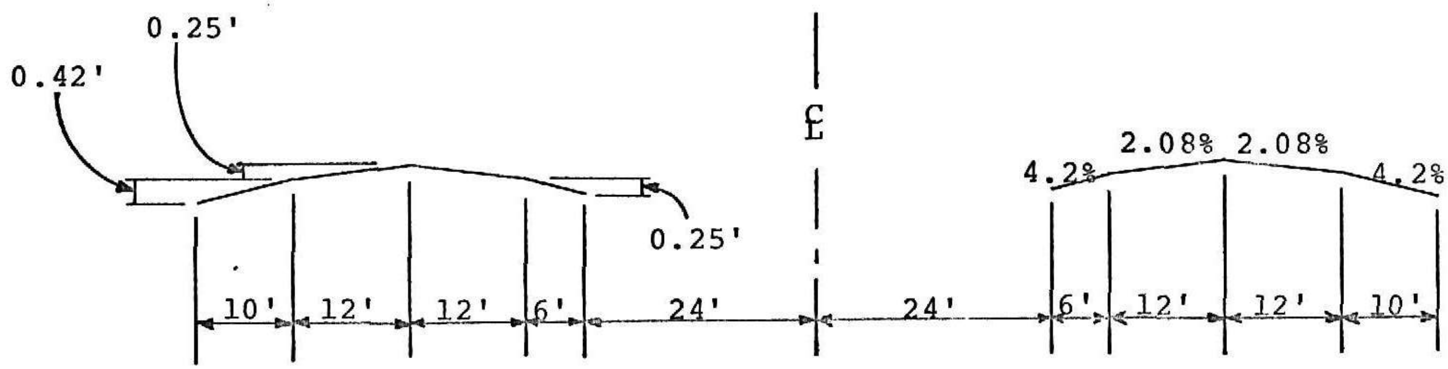


Figure 3. Cross-Section for Four-Lane Roadway

nearest point on the roadway centerline and also to a point 4.0 ft. right of centerline and 3.5 ft. above the roadway. This additional conversion of the observer's position is done to simulate the position of the driver's eye in a vehicle traveling along the roadway. Since coordinate values can be input for both the center of interest and the observer's positions, the observer can thus be located wherever it is desired and the observer can then sight at any desired location.

The output from HWYPPLOT consists of both a printed and perspective plot output. The printed output gives the characteristics of the horizontal and vertical geometry as well as the stationing and X,Y,Z coordinates of all points on centerline. The lengths of spiraled and unspiraled transitions and the rate of superelevation are included when used. Provisions of input data card #1 allow for the additional printed output of stationing and X,Y,Z coordinates of all points on each cross-section generated. The perspective plot output consists of the desired perspective views, each with the respective plot number printed adjacent to the perspective view.

HWYPPLOT USER'S GUIDE

The User's Guide is divided into the following three sections:

1. Procedure for Plot Creation - contains information on the types of tapes that can be used and the formatted job control language required to "run" HWYPPLOT.

2. HWYPPLOT Input Cards - describes the information to be entered on the input data cards, specifys the computer input FORMAT and explains the use of the input data.

3. HWYPPLOT Example Input and Output - contains representative example problems of various combinations of circles, spirals (and unspiraled transitions), superelevation and backslopes. Each example is composed of first, the plan and profile views of the example problem; second, the formatted example input; and finally, the perspective plot outputs.

Section 1:

Procedure for Plot Creation*

*Source: Reference 1.

<u>Plot Tapes</u>

A 9-track tape is required to plot information on the CalComp Plotter. These tapes are usually generated from a FORTRAN G or FORTRAN H program and can either be a user owned (Civil Engineering) tape or a scratch tape maintained by the Computing Center.

A. User-Owned Tapes

1. A Plotting Information Card (PIC) must be completed before these tapes can be plotted. This PIC is available from the Dispatcher in the Computing Center. The information that is required on the PIC is the sequence number of the computer run (assigned by the Dispatcher), the label of the tape (use either 913400 or 913600), the numbers of the plots to be plotted (usually this will be "All"), the account number and the user's name. These tapes are maintained by the Computing Center for future use by the user.

2. The following types of tapes can be plotted:

(a) A tape generated by the job just submitted. If a PIC accompanies the job and if the plot function of the job normally terminates, the tape will automatically be plotted.

(b) A tape just created can be re-plotted by completing a PIC with the sequence number of that job.

B. Computing Center Tapes

1. These tapes will automatically be mounted on the plotter after the tape is generated from the HWYPPLOT program, provided that the plot function of the job normally terminates. (If there are any special instructions or if more than one copy

of the tape is needed, the user will need to fill out a PIC.)

2. The Computing Center's tapes will be plotted and then returned to the stack of scratch tapes to be reused as needed. These tapes will not be held for future use by a user.

JCL for Plot Tape Creation

The job control language required with HWYPPLOT for creating plot tapes, for both the user-owned and Computing Center's tapes, is shown in Table 1 and Table 2.

ILLEGIBLE DOCUMENT

THE FOLLOWING DOCUMENT(S) IS OF POOR LEGIBILITY IN THE ORIGINAL

THIS IS THE BEST COPY AVAILABLE

Table 1. Job Control Language for Plot Creation with User-Owned (Civil Engineering) Tapes

```
//HWYPPLOT JOB (See Appendix C)
//       EXEC  RINGWTR,PARM=yyyyyy
//       EXEC  FTGCLGKS
//FORT.SYSIN  DD  *


            HWYPPLOT
            Program


//GO.PLOTTAPE  DD  VOL=SER=yyyyyy,UNIT=TAPE9,DISP=(,KEEP)
//GO.SYSIN  DD  *


            Data
            Cards                   NOTE:
                                     yyyyyy=CE Tape Number
                                              Use either 913400
/*                                            or 913600
```

Table 2. Job Control Language for Plot Creation with Computing Center's Tapes

```
//HWYPPLOT JOB (See Appendix C)
//       EXEC  RINGWTR,PARM=PLOT
//       EXEC  FTGCLGKS
//FORT.SYSIN  DD  *

        HWYPPLOT
        Program


//GO.PLOTTAPE  DD  DSN=PLOT,VOL=SER=PLOT,UNIT=TAPE9,DISP=(,KEEP)
//GO.SYSIN  DD  *

        Data
        Cards


/*
```

Section 2:

HWYPPLOT Input Cards

CARD #1

Description: Number of highway locations (LOC) and coordinate print-out control (MODE).

Format: (2I5)

Explanation: 1. If it is desired to run several locations during one computer operation, stack the data decks (Cards 2-14) for the respective locations consecutively and then enter the total number of locations on Card #1. Thus there is only one Card #1 required, irrespective of the number of locations to be run.

2. If MODE is a positive integer, the X,Y,Z coordinates of all points will be printed. If MODE is negative or zero, only the centerline coordinates will be printed.

CARD #2

Description: Number of horizontal curves (NPHI), number of spirals (NSPIR), number of vertical curves (NPVI) and a cross-section indicator (KEY).

Format: (4I5)

Explanation:

1. The maximum number of horizontal curves (NPHI) per location is ten (10).
2. The number of spirals (NSPIR) refers to the number of horizontal curves that are to be spiraled. Thus, if there are two horizontal curves to be spiraled, then the number of spirals would be two.
3. The maximum number of vertical curves (NPVI) per location is eight (8).
4. Cross-section indicator (KEY):
   a. If KEY is negative, program aborts.
   b. If KEY = 0, a two-lane roadway (12 ft. lanes and 10 ft. shoulders) is plotted; five lines with centerline, pavement edges and shoulder edges.
   c. If KEY = 1, a two-lane roadway is plotted; six lines with pavement edges, shoulder edges and top or bottom of backslopes. Cards 10 and 11 are also used which contain backslope inflection points.

CARD #2 (continued)

d. If KEY = 2 or 3, program aborts.

e. If KEY = 4, a four-lane roadway (two lanes each direction with 12 ft. lanes, 10 ft. outside and 6 ft. inside shoulders and a 48 ft. median between inside shoulder edges) is plotted; twelve lines with centerlines, roadway edges, shoulder edges and top or bottom of backslopes. Cards 10 and 11 are also used which contain backslope inflection points. This KEY indicator does not allow for split alinement of the four-lane roadway. Thus, only one set of horizontal and vertical alinement is required to plot the four-lane roadway.

f. If KEY = 5, program aborts.

g. KEY = 6 is for a two-lane roadway used with earthwork cut and fill quantities. Due to the unreliability of the cut and fill subroutine, this KEY value is not to be used and thus will not be further described.

h. If KEY is greater than 6, program aborts.

CARD #2 (continued)

5. Appendix D contains a description of the cross-sectional computer output numbering sequence for the three types of roadway perspectives, i.e., KEY = 0, 1 and 4.

CARD #3

Description: Distance desired between the centerline points to be generated (DIST), distance desired between crosslines on the roadway perspective (XDIST) and the initial direction of the tangent in degrees, minutes and seconds.

Format: (3F5.0, F3.0, F6.2)

Explanation: 1. Any logical distance can be used as the distance between centerline points (DIST), but use of 50 ft., 100 ft. or 200 ft. is recommended. The maximum number of centerline points is dimensioned as one-hundred ten (110). Thus with 50 ft., 100 ft. or 200 ft. between centerline points, the highway section may not exceed 5,500 ft., 11,000 ft. or 22,000 ft., respectively. If required, a highway section longer than 22,000 ft. could be generated by increasing DIST.

2. The distance between crosslines (XDIST) should be an even multiple of DIST. Use of 200 ft. for XDIST is recommended as distances less than 200 ft. tend to "muddy up" the plot and distances greater than 200 ft. tend to reduce the effectiveness of the crosslines in creating perspective depth.

CARD #3 (continued)

3. Use an initial tangent direction of 0° 0' 0" (due north), as this is the most reliable procedure.

CARD #4

Description: X and Y coordinates and station of the initial point.

Format: (3F10.2)

Explanation: 1. Unless otherwise specified, assign arbitrary values to the X and Y coordinates of the initial point. (For example, 1000.00 and 1000.00)

2. The station number of the initial point (and other stationed points) should be input without the "+". (For example, 20+00.00 would be entered on the data card as 2000.00).

CARD #5

Description: Deflection angles (central angles) and the degree of curve for the deflection (both with units of degrees, minutes and seconds), the rate of superelevation, the transition length and the transition factor.

Format: (F5.0, F3.0, F6.2, 6X, F5.0, F3.0, F6.2, F5.2, F10.2, F5.2)

Explanation: 1. Deflections to the right are positive and deflections to the left are negative. For a deflection to the left, enter a "-" on the data card immediately prior to the number of degrees in the first F5.0 Format. For deflections to the right, enter only the number of degrees; no "+" is required.

2. The degree of curve must always be positive.

3. Input the rate of superelevation in units of ft./ft. (For example, 0.08). Superelevation can only be used with a two-lane roadway (KEY = 0 or 1) and either through the use of spirals or transitions, but not both on a single horizontal curve, i.e., a spiral may not be used on one end of a curve and a transition on the other.

CARD #5 (continued)

4. The transition length (L_T) refers to the concept in which a circular curve is superelevated without the use of spirals. In this concept (Figure 4), a portion of the superelevation is attained prior to the PC of the curve and the remainder is attained after the PC. Thus the transition length A-B consists of two distances:

a. Distance A-PC - between point A on the tangent of the curve and the PC, and

b. Distance PC-B - between the PC and point B on the curve.

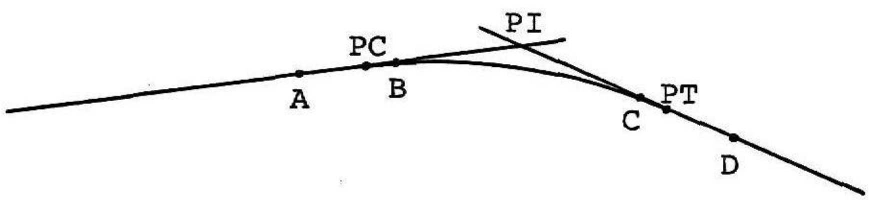


Figure 4. Superelevation with Unspiraled Transitions

5. The transition factor (T_F) is the decimal fraction of the transition length prior to the PC (and after the PT) divided by the transition length. Thus, referring to Figure 4, if distance A-PC (PT-D) and A-B (C-D) were 150 ft. and 200 ft. respectively, then the transition factor would be 0.75.

CARD #5 (continued)

6. For cases in which there are more than one curve in a particular highway alinement, place the respective curve data cards consecutively, with data for the first curve placed first, then the data for the second curve, etc.

7. If two horizontal curves in one alinement are to be superelevated, one by spirals and the other by transitions, the following procedure would be used to input the data:

a. If the first curve was to be spiraled, the central angle of that curve, the degree of curve for the deflection and the rate of superelevation would be input on Card #5. The transition length and the transition factor would be left blank.

b. If the second curve was to be transitioned, the central angle of that curve, the degree of curve for the deflection, the rate of superelevation, the transition length and the transition factor would be input on Card #5.

8. The transition length refers to the lengths of both transitions on a horizontal curve, i.e., both transitions will automatically be set at the same length.

CARD #5 (continued)

9. In cases where it is not desired to use superelevation, transition length or the transition factor, merely leave the last three Formats of Card #5 (F5.2, F10.2, F5.2) blank.

10. The number of cards must equal the number of horizontal curves (NPHI) indicated on Card #2.

CARD #6

Description: Tangent lengths for the horizontal alinement.

Format: (6F10.2)

Explanation: 1. Up to six (6) tangent lengths can be entered on each data card. For additional tangent lengths, merely enter up to six (6) per card and arrange the cards so that the tangent lengths proceed up-station.

2. The tangent length for input is defined as the distance from the initial point to PI, PI to PI, etc., and from PI to the end point.

3. The number of tangent lengths must equal the number of horizontal curves (NPHI) plus one (1).

CARD #7

Description: Number of the horizontal curve to contain the spiral and the length of the spiral to be used.

Format: (I5, F10.2)

Explanation: 1. This data card is read only if the number of spirals (NSPIR) entered on Card #2 was greater than zero (0).

2. There should be one (1) data card for each horizontal curve to be spiraled, with the data cards arranged consecutively through the alinement.

3. In numbering the horizontal curve(s), proceed up-station with the first curve as 1, the second curve as 2, etc. Thus if the second curve was the first curve to be spiraled, a "2" would be entered in the I5 Format.

4. The length of spiral refers to the lengths of both spirals on a horizontal curve, i.e., both spirals will automatically be set at the same length.

CARD #8

Description: Stations and elevations of the initial point, PVI's and the end point.

Format: (2F10.2)

Explanation:

1. The number of cards must equal the number of vertical curves (NPVI) specified on Card #2 plus two (2).

2. The cards must be arranged so that the station on the cards is increasing.

3. One (1) station and elevation value per card.

CARD #9

Description: Length of vertical curve(s).

Format: (F10.2)

Explanation: 1. One (1) length of vertical curve per card.

2. The cards must be arranged consecutively through the vertical alinement, i.e., the first vertical curve length is first, the second length is second, etc.

3. The number of cards must equal the number of vertical curves (NPVI) specified on Card #2.

CARD #10

Description: Number of inflection points on the right and left backslopes of the roadway.

Format: (2I5)

Explanation:
1. This card is read only if KEY = 1 or 4.
2. The number of inflection points on the right and left backslopes need not be equal.
3. The inflection points would normally fall along the top of a cut or bottom of a fill section. The inflection points should generally be spaced about 200 - 400 ft. apart, dictated specifically by the terrain features.

CARD #11

Description: Station and elevation of the inflection points on the right and left sides of the roadway.

Format: (6F10.2)

Explanation:

1. These cards are read only if KEY = 1 or 4.
2. The data for the inflection points on the right side is read first and then the data for the left side. Data for the left side must be started on a new card. Up to three (3) sets of corresponding station and elevation data can be input per card.
3. The backslopes on the perspective are drawn with a 6:1 slope from the outside edge of the shoulders to the elevation of the inflection points.

CARD #12

Description: Number of observer positions.

Format: (I5)

Explanation: 1. The number of observer positions must equal the number of plots (NPLOT) indicated on Card #14a or 14b.

2. The observer positions should normally be about 500 to 1,000 ft. apart, depending specifically on the length of the highway section.

CARD #13a

Description: Center of interest stationing.

Format: (F10.2)

Explanation: 1. The center of interest is the one point on the centerline of the highway which is desired to be viewed by the observer.

2. The station of the center of interest, as entered on the data card, will be converted ahead to the nearest point on the centerline of the road.

3. Card #13b is an alternate method to input the center of interest.

CARD #13b

Description: Center of interest coordinates (X,Y,Z) and an indicator (IDCI) that this card contains the center of interest coordinates and not the center of interest stationing.

Format: (3F10.2, I5)

Explanation: 1. The center of interest is the one point on the alinement which is desired to be viewed by the observer.

2. IDCI must be a positive integer.

3. Card #13a is an alternate method to input the center of interest.

CARD #14a

Description: Number of the plot (NPLOT) and the observer's station (XEP).

Format: (I5, F10.2)

Explanation: 1. The number of cards must equal the number of observer positions indicated on Card #12.

2. In cases where several locations are run in one computer operation, the plot numbers (NPLOT) could be used to identify the different locations as well as the individual plots. Since the Format of NPLOT is I5, there are five (5) integers available for use in identifying the location and plots. (For example, if three locations with four plots each are to be run in one operation, NPLOT could be numbered so that the first digit would be the location and the second digit would be the plot number, i.e., 11, 12, 13, 14; 21, 22, 23, 24 and 31, 32, 33, 34.)

3. The station of the observer, as entered on the data card, will be converted ahead to the nearest point on the roadway centerline and also to a point 4.0 ft. right of the centerline and 3.5 ft. above the roadway.

4. The observer positions should proceed up-station so that the plots will be consecutively

CARD #14a (continued)

arranged and thus give the effect that the observer is moving along the roadway.

5. If the horizontal and vertical perspective coordinates are desired as part of the output, then any positive integer is required in column 45. (These perspective coordinates serve no real purpose as output; therefore, it is recommended that column 45 be left blank.)

CARD #14b

Description: Number of the plot (NPLOT), the observer position coordinates (X,Y,Z) and an indicator (IDOP) that this card contains the observer position coordinates and not the observer position stationing.

Format: (I5, 3F10.2, 2I5)

Explanation:

1. The number of cards must equal the number of observer positions indicated on Card #12.
2. IDOP must be a positive integer.
3. Since the observer position coordinates are to be input on this card, the observer can therefore be located wherever it is desired.
4. The observer positions should proceed up-station so that the plots will be consecutively arranged and thus give the effect that the observer is moving along the highway.
5. If horizontal and vertical perspective coordinates are desired, then any positive integer is required in column 45. (These perspective coordinates serve no real purpose as output; therefore, it is recommended that column 45 be left blank.)
6. Card #14a is an alternate method to input the observers position.

CARD #14b (continued)

7. For method of identification of several locations (and plots) run in one operation, see Card #14a.

8. In general, perspectives can only be drawn up-station unless the X,Y,Z coordinates are specified for both the observer and the center of interest. A procedure utilizing this concept would consist of running the desired roadway alinement up-station as in normally done. Then to view the roadway the opposite direction (or down-station), first select a new center of interest and new observer positions. Then using the X,Y,Z coordinate values from the up-station computer output, re-run HWYPPLOT with the coordinates for the new center of interest and the new observer positions entered on Cards #13b and 14b respectively. Another method would be the conversion of the end point of the alinement into an initial point and then re-station back through the alinement, keeping the PI's and PVI's in the same relative location. Essentially the same data cards could be used with changes such as the direction of the curve(s), station numbers, tangent lengths, etc.

Section 3:

HWYPPLOT Example Input and Output

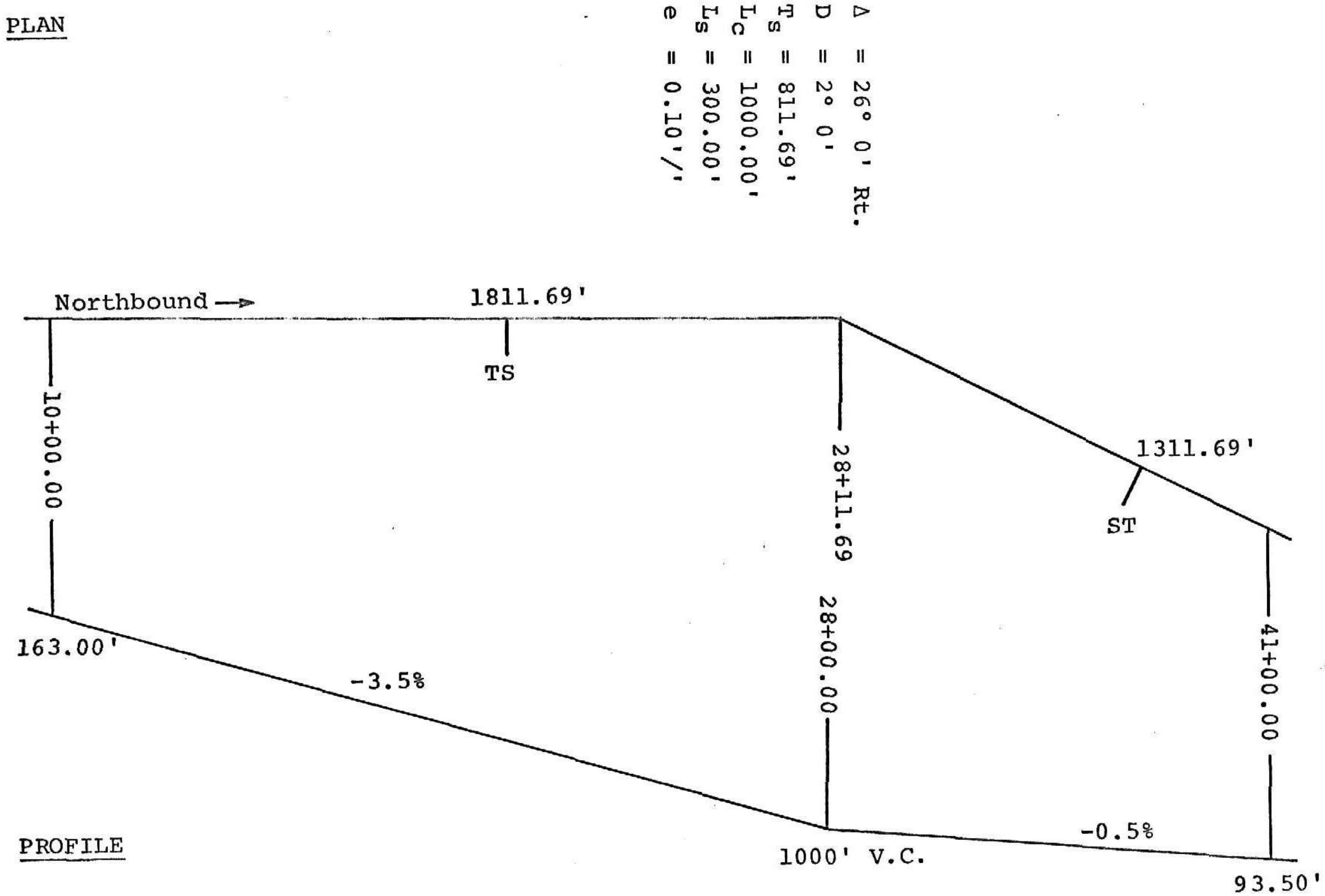


Figure 5. Geometry of Example 1 - Superelevation with Spiraled Transitions

Table 3. Computer Input Data - Example 1

CARD #	1-10	11-20	21-30	31-40	41-50	51-60
1	1 1					
2	1 1	1 0				
3	50. 200.	0. 0.	0.00			
4	1000.00	1000.00	1000.00			
5	26. 0.	0.00	2. 0.	0.00 0.10		
6	1811.69	1311.69				
7	1 300.00					
8	1000.00	163.00				
"	2800.00	100.00				
"	4100.00	93.50				
9	1000.00					
12	4					
13a	2800.00					
14a	1 1000.00					
"	2 1500.00					
"	3 2000.00					
"	4 2500.00					

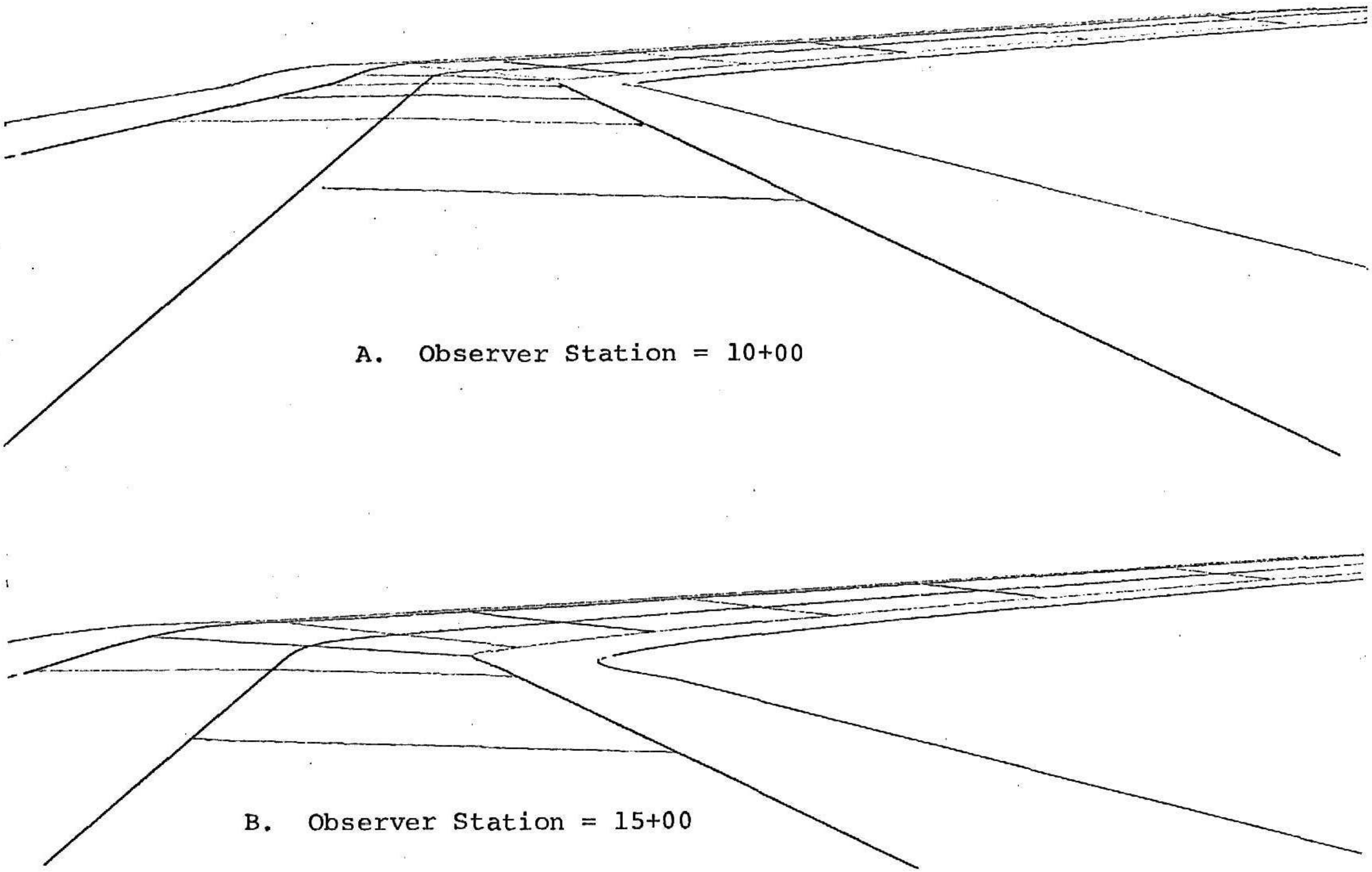
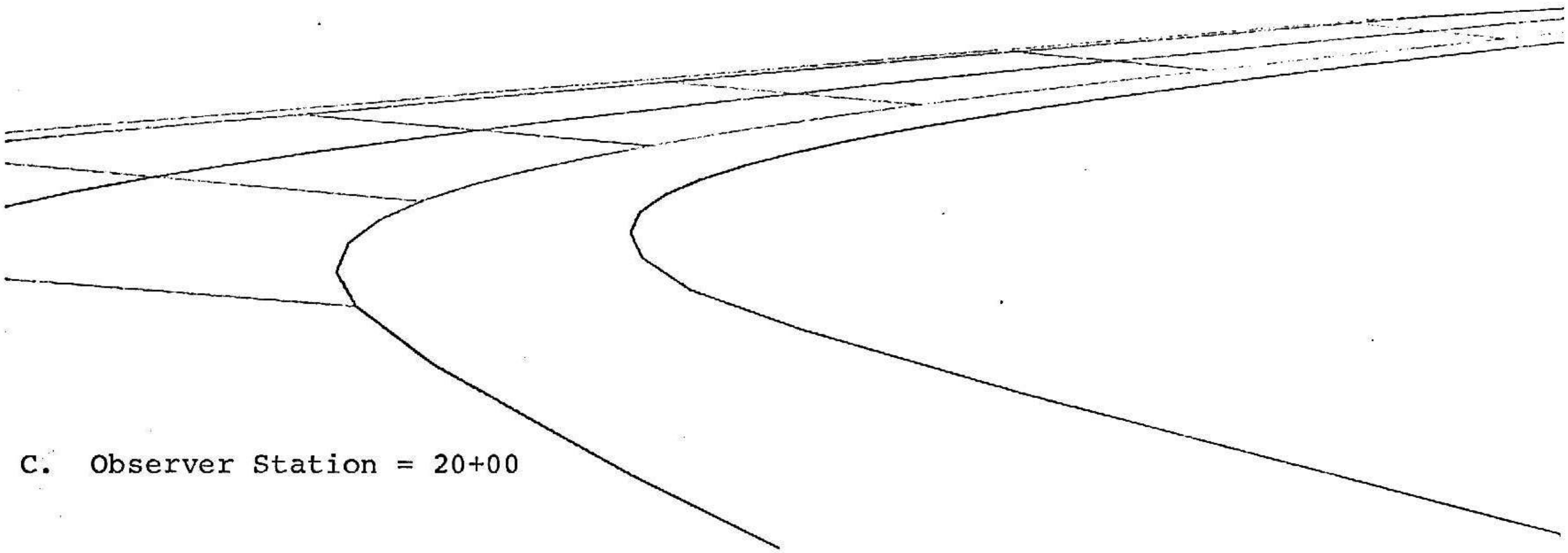
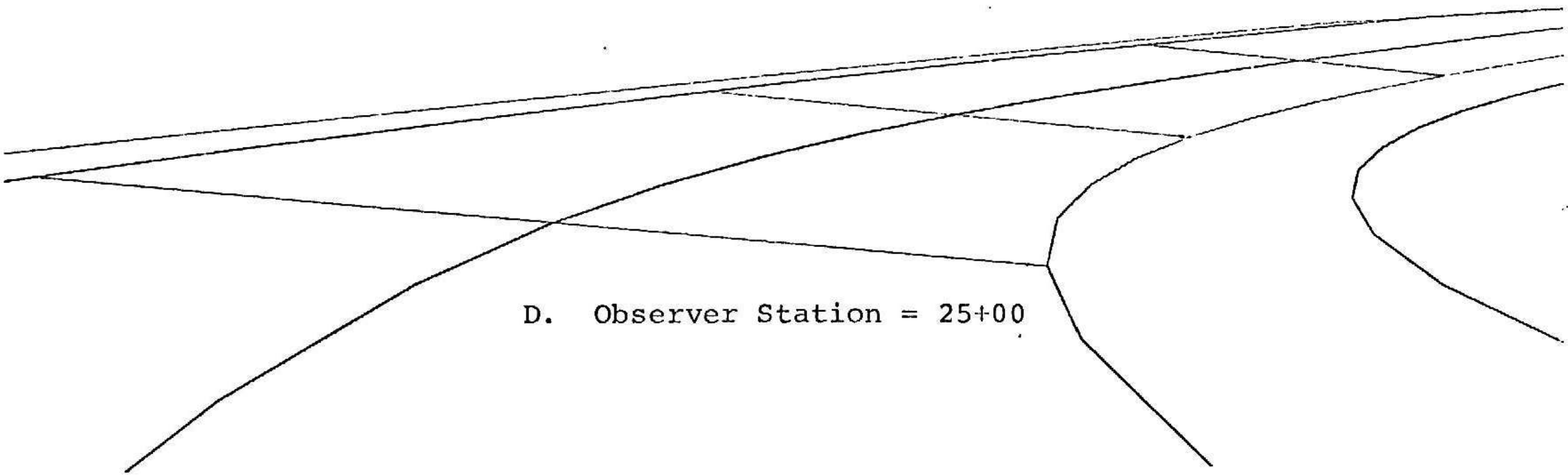


Figure 6. Plotter Output from Example 1, Plate 1



C. Observer Station = 20+00



D. Observer Station = 25+00

Figure 7. Plotter Output from Example 1, Plate 2

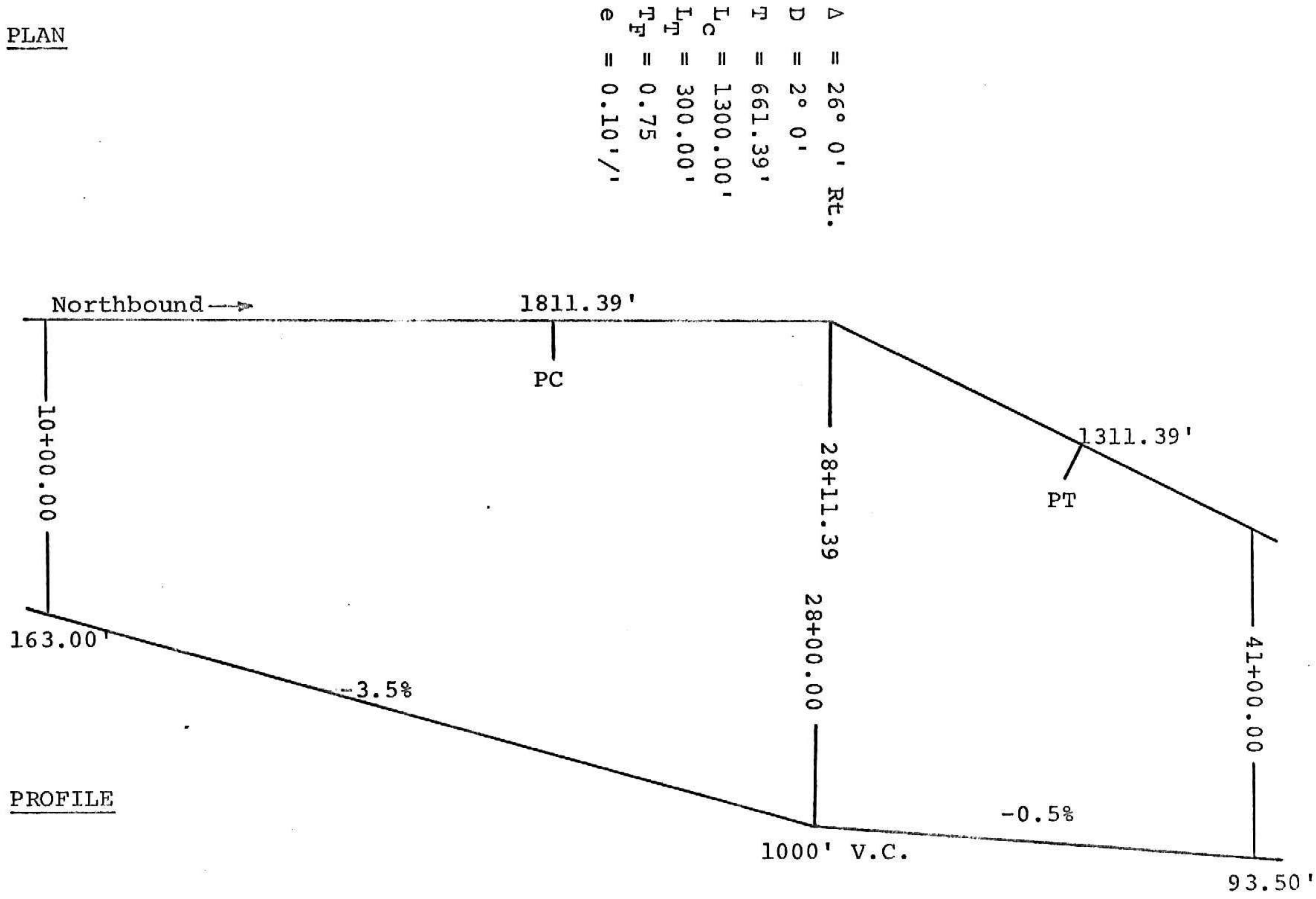


Figure 8. Geometry of Example 2 - Superelevation with Unspiraled Transitions

Table 4. Computer Input Data - Example 2

CARD #	1-10	11-20	21-30	31-40	41-50	51-60
1	1 1					
2	1 0	1 0				
3	50. 200.	0. 0.	0.00			
4	1000.00	1000.00	1000.00			
5	26. 0.	0.00	2. 0.	0.00 0.10	300.00	0.75
6	1811.39	1311.39				
8	1000.00	163.00				
"	2800.00	100.00				
"	4100.00	93.50				
9	1000.00					
12	4					
13a	2800.00					
14a	5 1000.00					
"	6 1500.00					
"	7 2000.00					
"	8 2500.00					

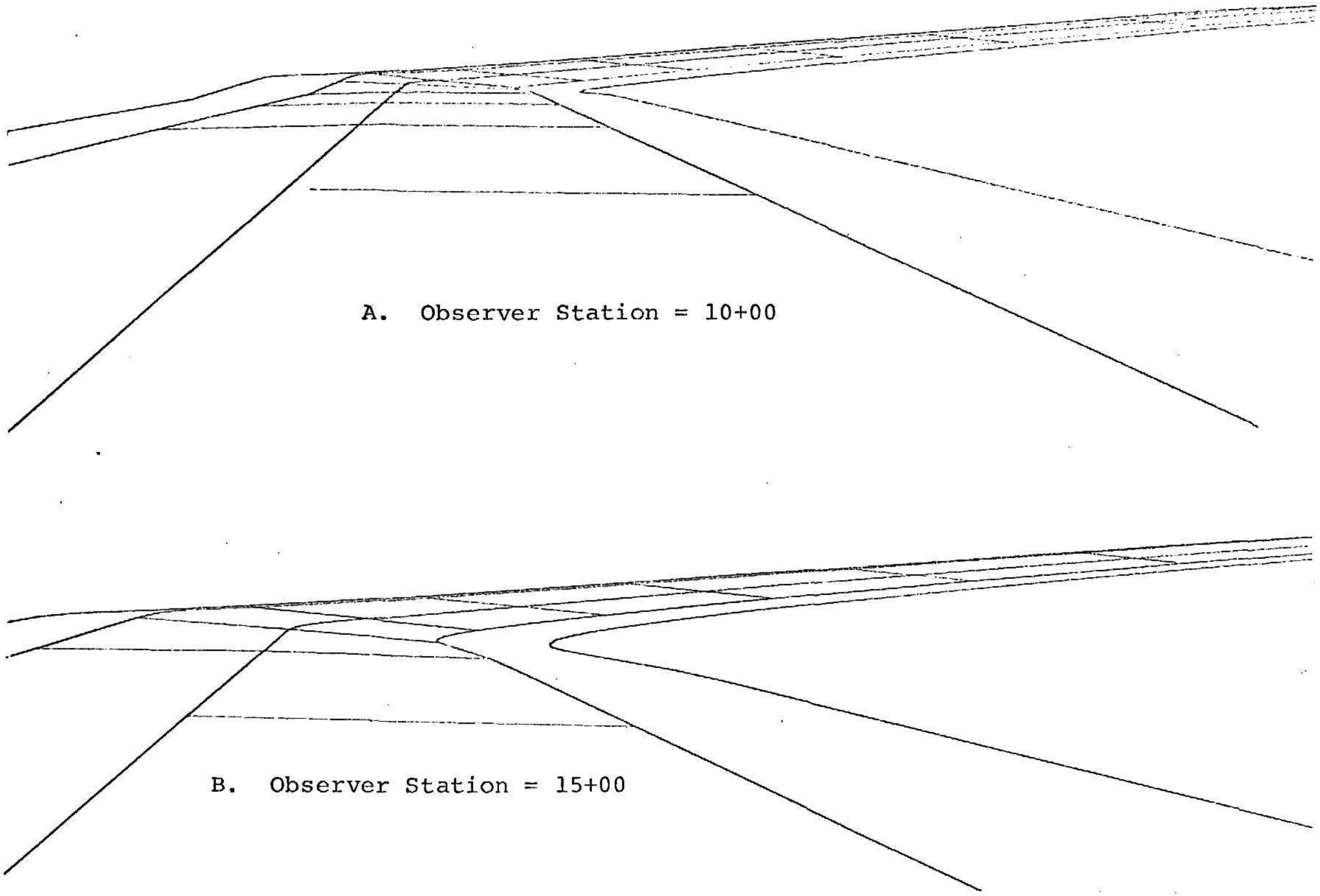
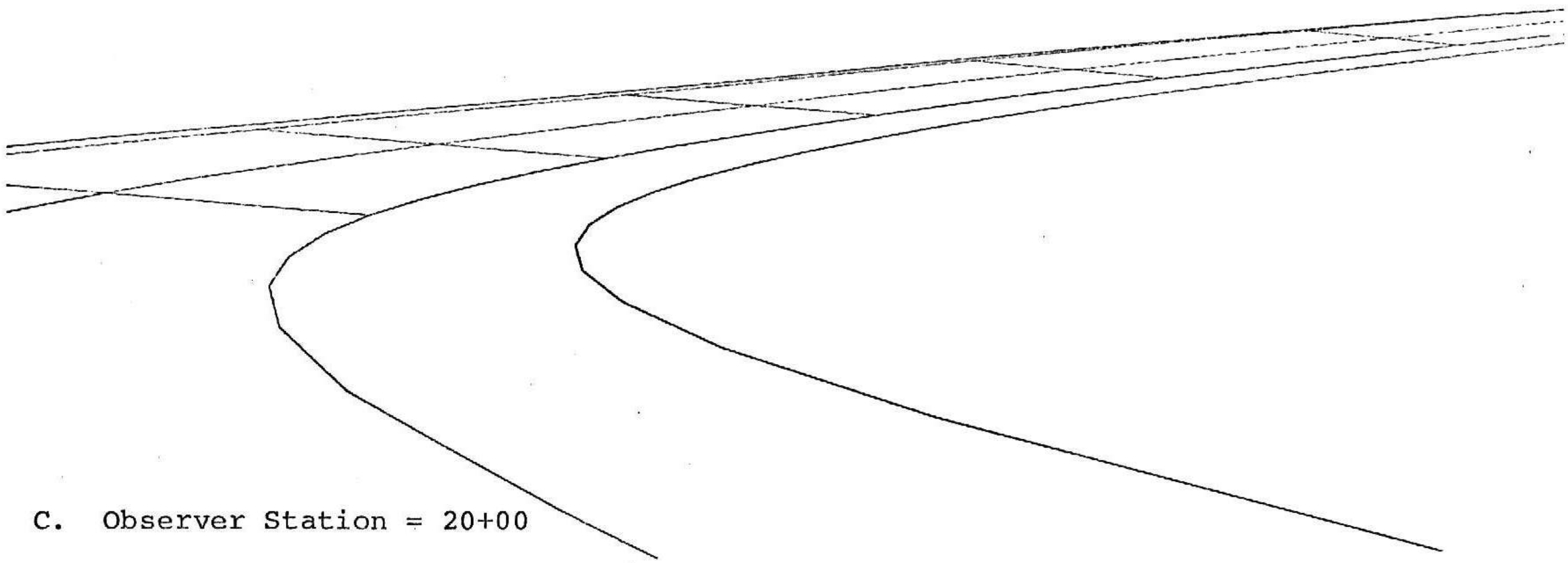
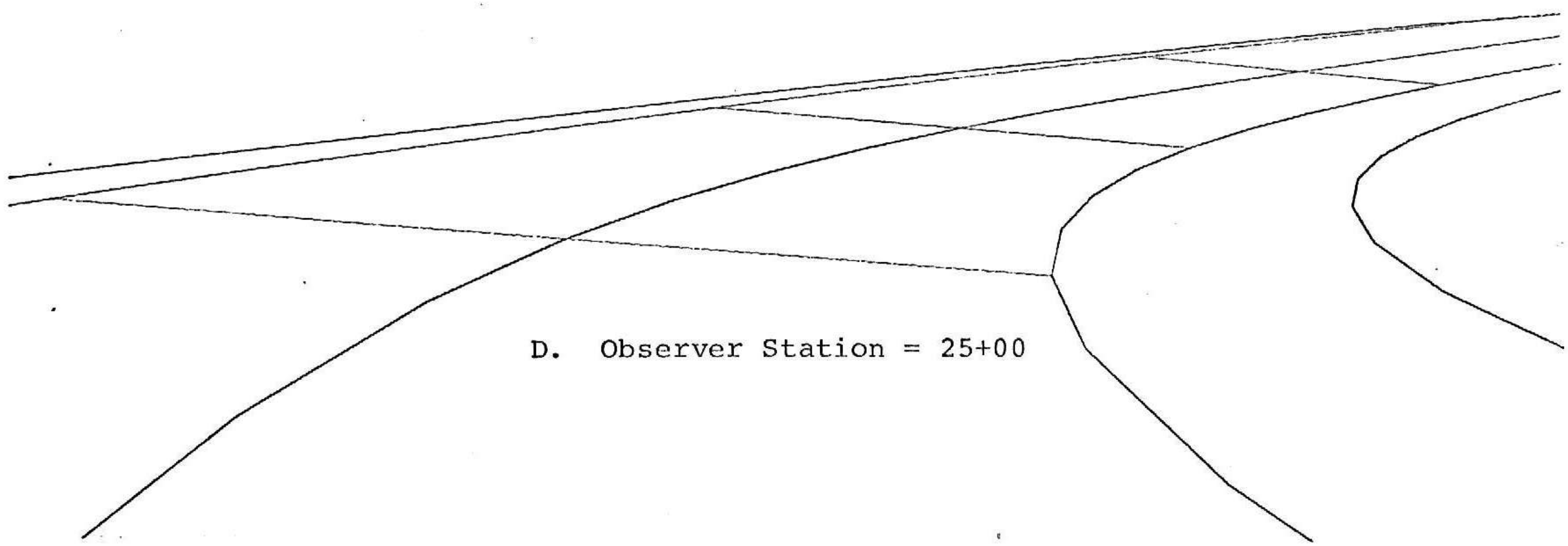


Figure 9. Plotter Output from Example 2, Plate 1



C. Observer Station = 20+00



D. Observer Station = 25+00

Figure 10. Plotter Output from Example 2, Plate 2

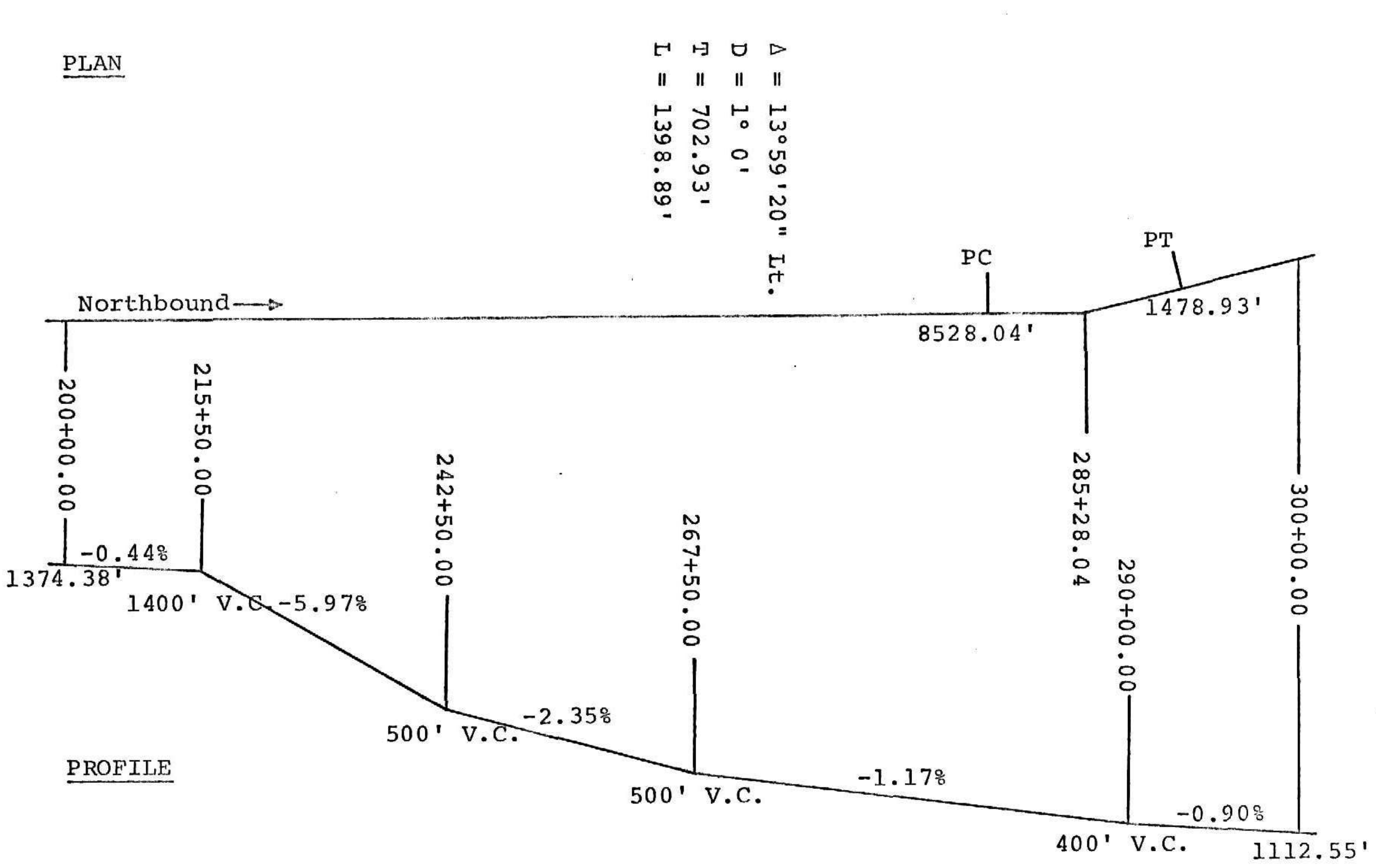


Figure 11. Geometry of Example 3 - Two-Lane Roadway with Backslopes (K-177 Southeast into Manhattan, Kansas)

Table 5. Computer Input Data - Example 3

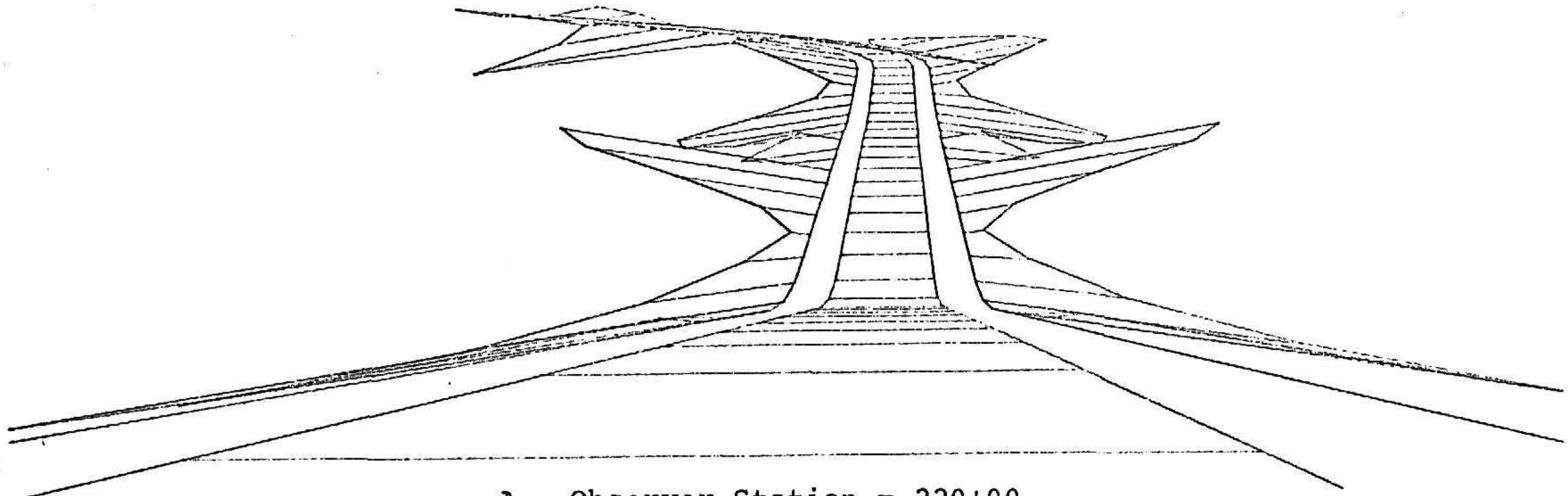
CARD #	1-10	11-20	21-30	31-40	41-50	51-60
	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
1	1 1					
2	1 0	4 1				
3	200. 200.	0. 0.	0.00			
4	1000.00	1000.00	20000.00			
5	-13.59. 2	0.00	1. 0.	0.00		
6	8528.04	1478.93				
8	20000.00	1374.38				
"	21550.00	1367.56				
"	24250.00	1206.52				
"	26750.00	1147.82				
"	29000.00	1121.55				
"	30000.00	1112.55				
9	1400.00					
"	500.00					
"	500.00					
"	400.00					
10	49 49					
11	21500.00	1390.50	21600.00	1388.50	21800.00	1368.50
"	22000.00	1355.00	22200.00	1341.50	22400.00	1324.50
"	22600.00	1288.00	22800.00	1249.50	23000.00	1251.50

Table 5. (continued)

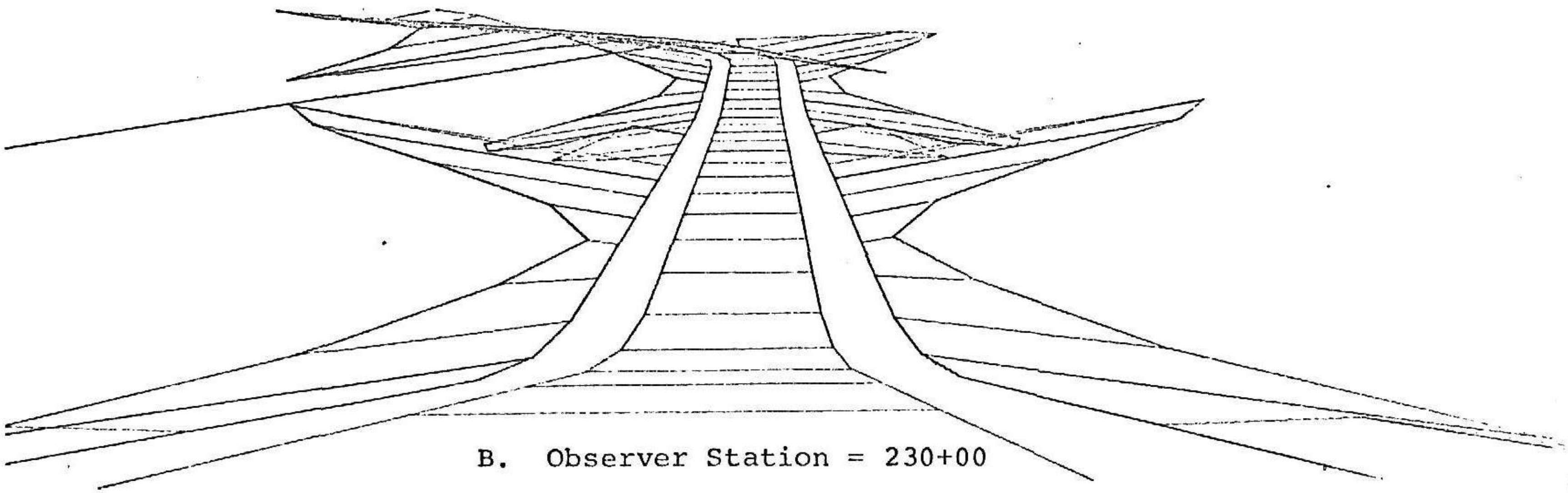
CARD #	1-10	11-20	21-30	31-40	41-50	51-60
	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
11	23150.00	1254.00	23300.00	1261.00	23500.00	1253.00
"	23625.00	1242.00	23750.00	1233.00	23850.00	1212.00
"	24000.00	1202.50	24200.00	1200.00	24400.00	1198.00
"	24600.00	1196.50	24800.00	1193.50	25000.00	1191.00
"	25200.00	1191.50	25400.00	1193.00	25600.00	1191.00
"	25750.00	1186.50	25800.00	1167.50	26000.00	1159.50
"	26150.00	1168.00	26300.00	1152.50	26550.00	1142.00
"	26700.00	1133.00	26900.00	1135.00	27100.00	1139.50
"	27300.00	1140.50	27500.00	1143.00	27700.00	1142.50
"	27900.00	1145.50	28100.00	1145.50	28300.00	1138.00
"	28500.00	1131.00	28700.00	1124.00	28900.00	1111.00
"	29000.00	1093.00	29200.00	1108.00	29350.00	1115.00
"	29500.00	1120.00	29650.00	1120.00	29800.00	1120.00
"	30000.00	1115.50				
"	21500.00	1390.50	21600.00	1388.50	21800.00	1368.50
"	22000.00	1355.00	22200.00	1341.50	22400.00	1324.50
"	22600.00	1288.00	22800.00	1249.50	23000.00	1251.50
"	23150.00	1254.00	23300.00	1261.00	23500.00	1253.00
"	23625.00	1242.50	23750.00	1233.00	23850.00	1212.00
"	24000.00	1202.50	24200.00	1200.00	24400.00	1198.00

Table 5. (continued)

CARD #	1-10	11-20	21-30	31-40	41-50	51-60
11	24600.00	1196.50	24800.00	1193.50	25000.00	1191.00
"	25200.00	1191.50	25400.00	1193.00	25600.00	1191.00
"	25750.00	1186.50	25800.00	1167.50	26000.00	1159.50
"	26150.00	1168.00	26300.00	1152.50	26550.00	1142.00
"	26700.00	1133.00	26900.00	1135.00	27100.00	1139.50
"	27300.00	1140.50	27500.00	1143.00	27700.00	1142.50
"	27900.00	1145.50	28100.00	1145.50	28300.00	1138.00
"	28500.00	1131.00	28700.00	1124.00	28900.00	1111.00
"	29000.00	1093.00	29200.00	1108.00	29350.00	1115.00
"	29500.00	1120.00	29650.00	1120.00	29800.00	1120.00
"	30000.00	1115.50				
12	4					
13a	28500.00					
14a	9 22000.00					
"	10 23000.00					
"	11 24000.00					
"	12 24500.00					

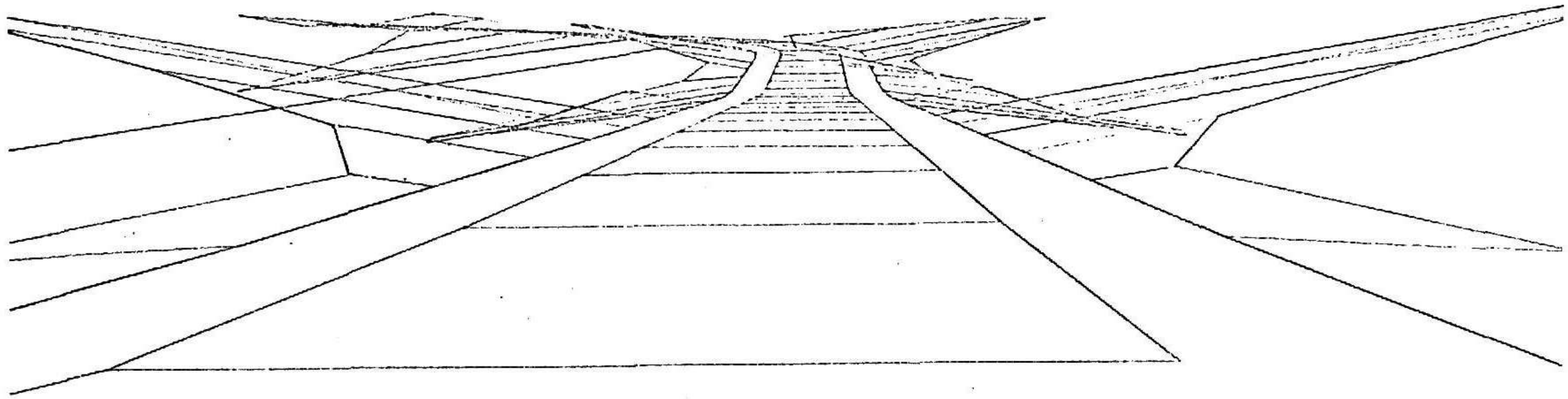


A. Observer Station = 220+00

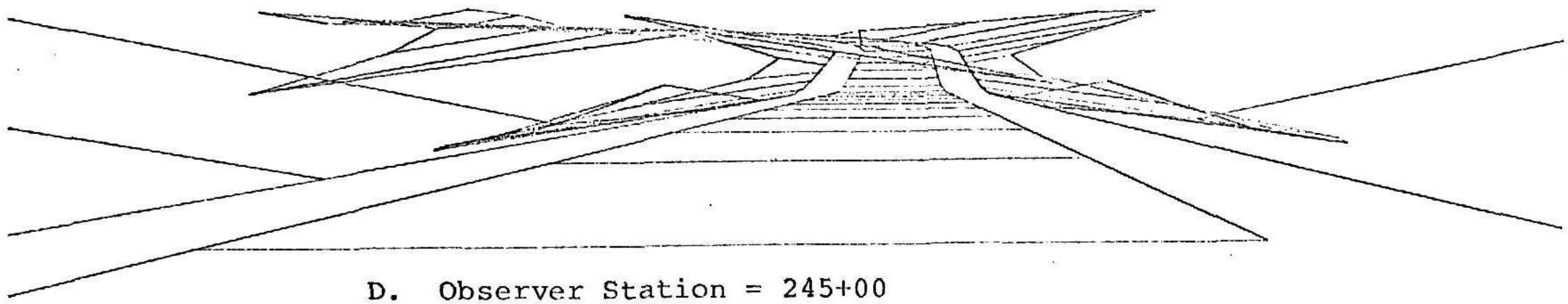


B. Observer Station = 230+00

Figure 12. Plotter Output from Example 3, Plate 1



C. Observer Station = 240+00



D. Observer Station = 245+00

Figure 13. Plotter Output from Example 3, Plate 2

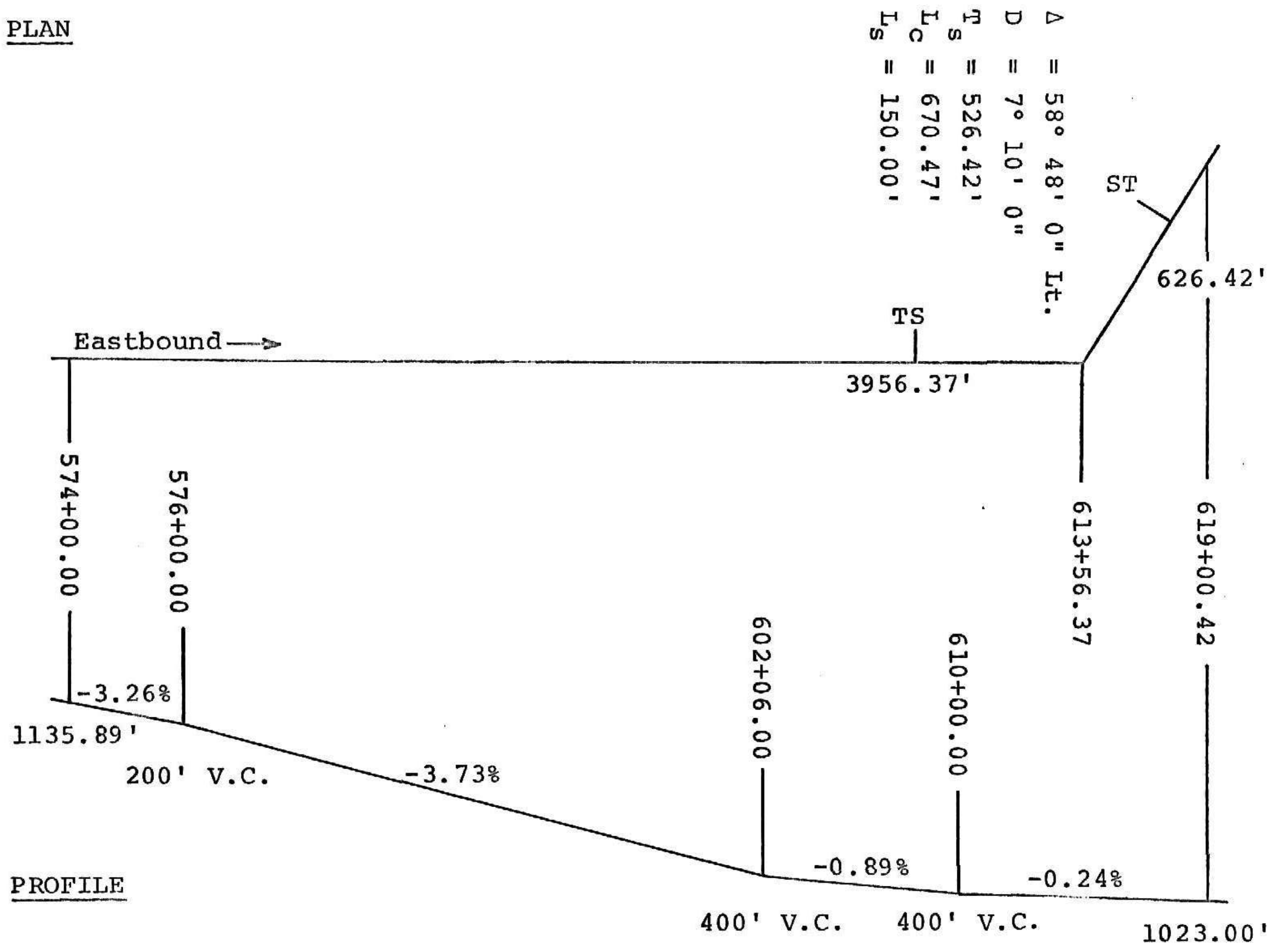


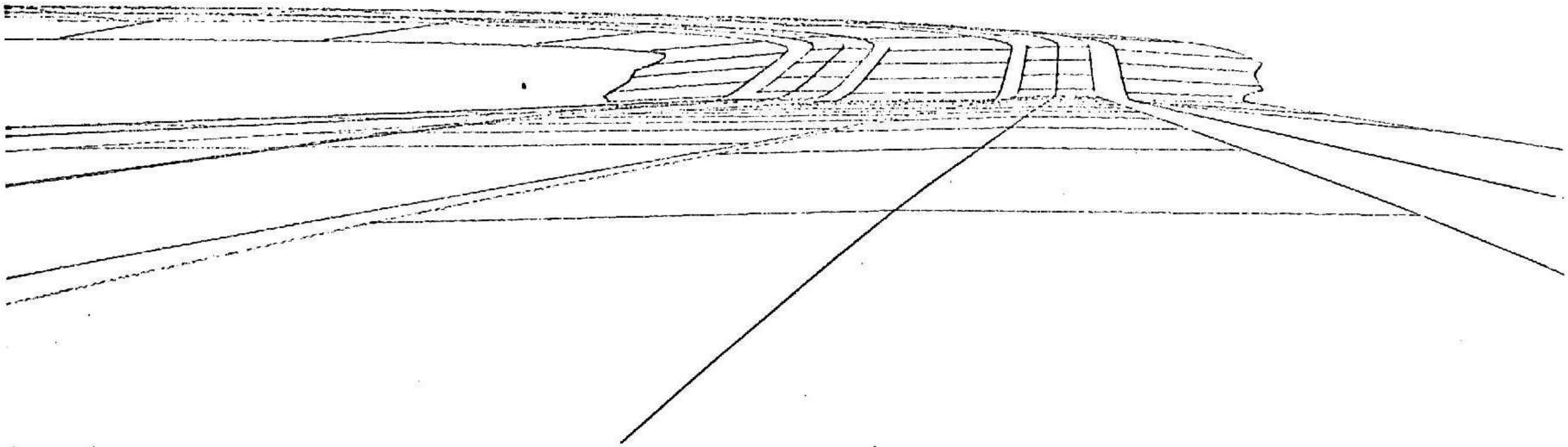
Figure 14. Geometry of Example 4 - Four-Lane Roadway with Backslopes (K-18 West into Manhattan, Kansas)

Table 6. Computer Input Data - Example 4

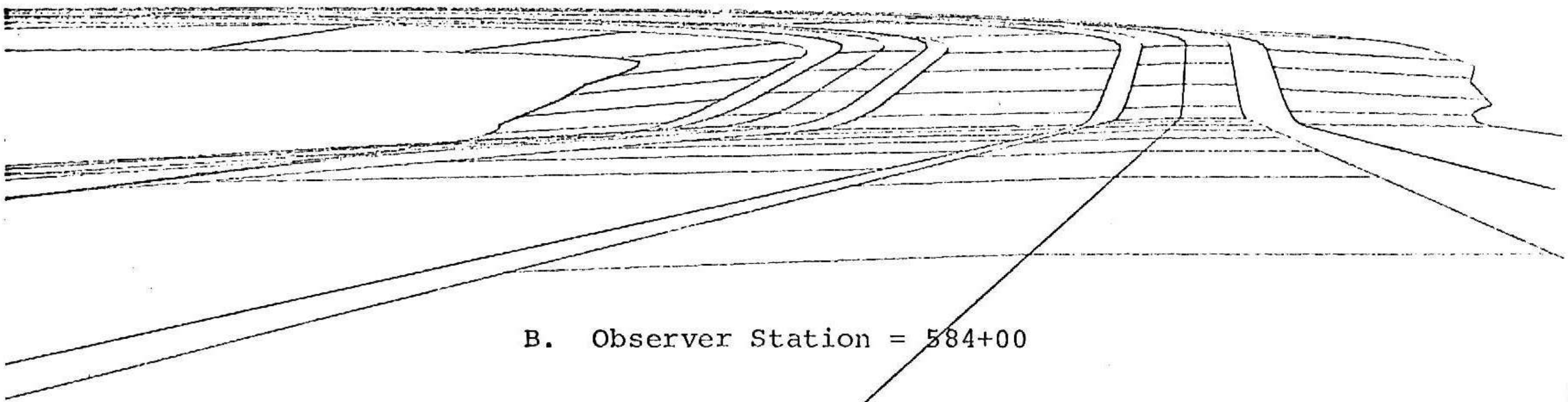
CARD #	1-10	11-20	21-30	31-40	41-50	51-60
1	1 1					
2	1 1	3 4				
3	50. 200.	0. 0.	0.00			
4	1000.00	1000.00	57400.00			
5	-58.48.	0.00	7.10.	0.00		
6	3956.37	626.42				
7	1 1	50.00				
8	57400.00	1135.89				
"	57600.00	1129.38				
"	60206.00	1032.25				
"	61000.00	1025.15				
"	61900.42	1023.00				
9	200.00					
"	400.00					
"	400.00					
10	25 25					
11	57400.00	1127.00	57600.00	1115.00	57750.00	1095.00
"	57900.00	1131.00	58050.00	1132.00	58200.00	1103.00
"	58400.00	1090.00	58600.00	1078.00	58800.00	1066.00
"	59000.00	1055.00	59200.00	1050.00	59400.00	1046.00

Table 6. (continued)

CARD #	1-10	11-20	21-30	31-40	41-50	51-60
	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
11	59600.00	1044.00	59800.00	1041.00	60000.00	1037.00
"	60200.00	1031.00	60400.00	1026.00	60600.00	1024.00
"	60800.00	1021.00	61000.00	1021.00	61200.00	1019.00
"	61400.00	1017.00	61600.00	1015.00	61800.00	1013.00
"	62000.00	1011.00				
"	57[illegible]00.00	1127.00	57600.00	1115.00	57750.00	1095.00
"	57900.00	1131.00	58050.00	1132.00	58200.00	1103.00
"	58400.00	1090.00	58600.00	1078.00	58800.00	1066.00
"	59000.00	1055.00	59200.00	1050.00	59400.00	1046.00
"	59600.00	1044.00	59800.00	1041.00	60000.00	1037.00
"	60200.00	1031.00	60400.00	1026.00	60600.00	1024.00
"	60800.00	1021.00	61000.00	1021.00	61200.00	1019.00
"	61400.00	1017.00	61600.00	1015.00	61800.00	1013.00
"	62000.00	1011.00				
12	2					
13a	61300.00					
14a	13 57400.00					
"	14 58400.00					



A. Observer Station = 574+00



B. Observer Station = 584+00

Figure 15. Plotter Output from Example 4

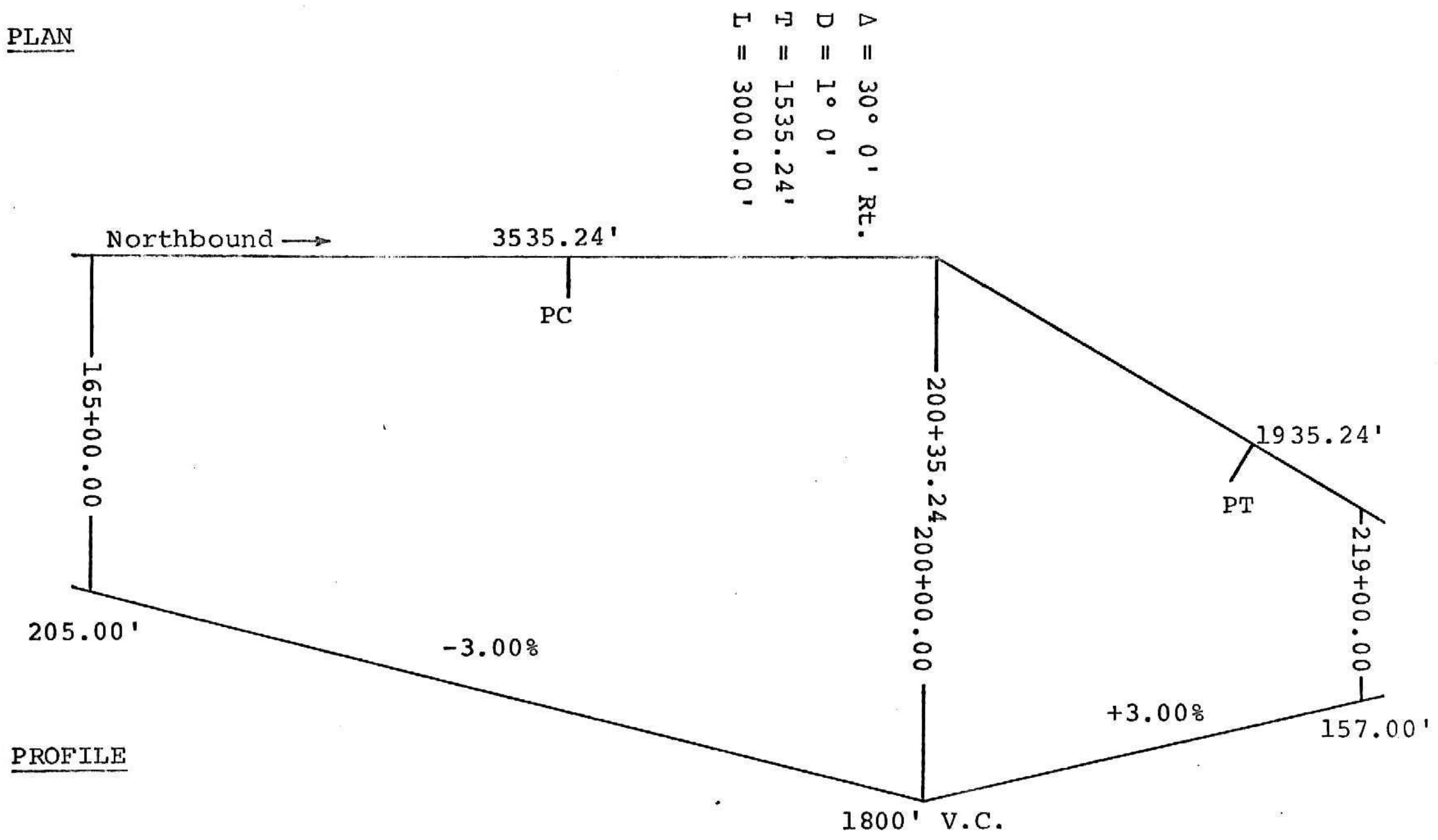


Figure 16. Geometry of Example 5 - Sag in Horizontal Curve

Table 7. Computer Input Data - Example 5

CARD #	1-10	11-20	21-30	31-40	41-50	51-60
1	1 1					
2	1 0	1 0				
3	50. 200.	0. 0.	0.00			
4	1000.00	1000.00	16500.00			
5	30. 0.	0.00	1. 0.	0.00		
6	3535.24	1935.24				
8	16500.00	205.00				
"	20000.00	100.00				
"	21900.00	157.00				
9	1800.00					
12	4					
13a	20000.00					
14a	15 16500.00					
"	16 17500.00					
"	17 18500.00					
"	18 19500.00					

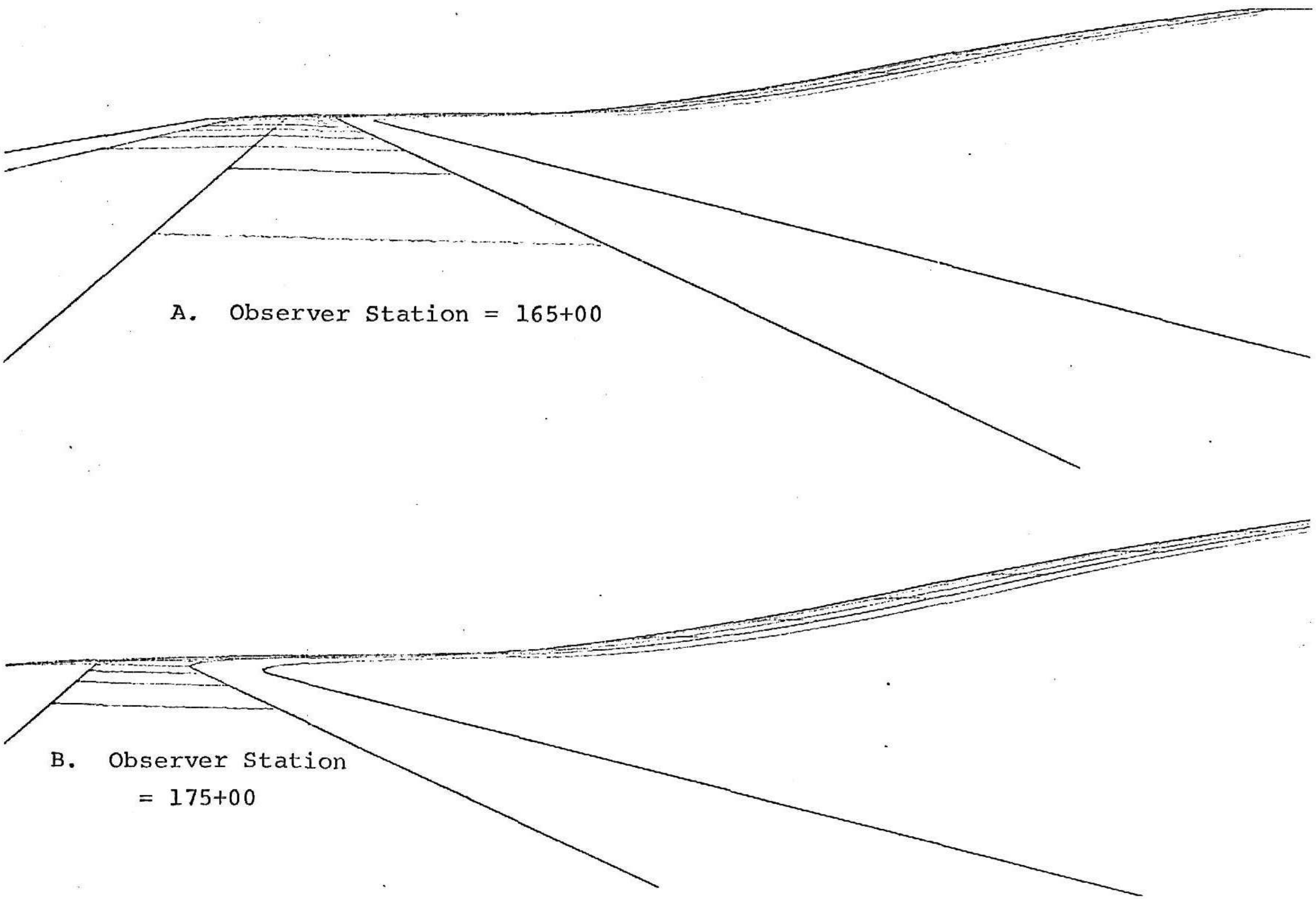
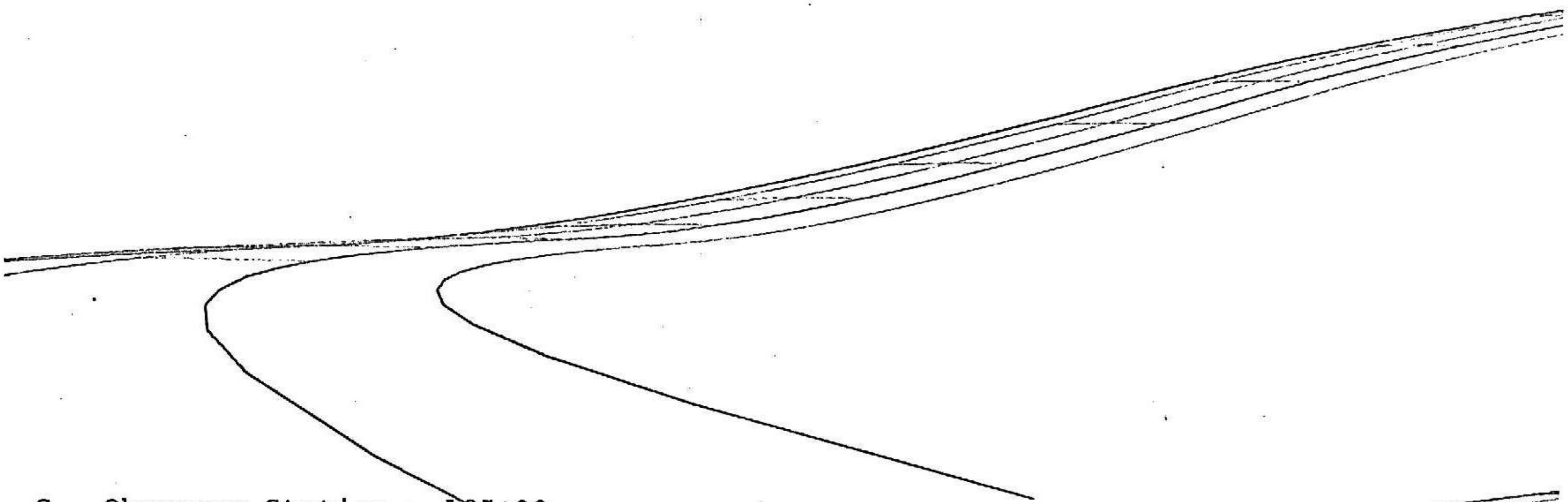
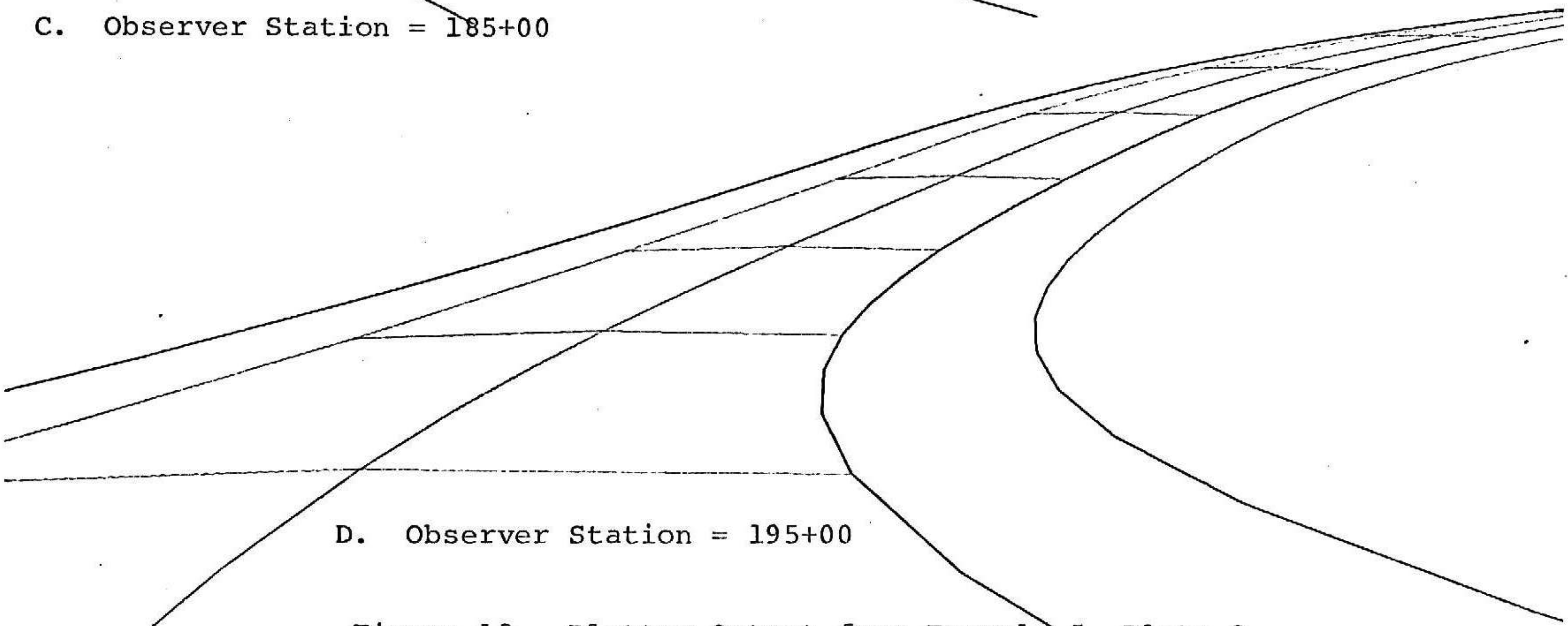


Figure 17. Plotter Output from Example 5, Plate 1



C. Observer Station = 185+00



D. Observer Station = 195+00

Figure 18. Plotter Output from Example 5, Plate 2

CONCLUSION

The result of the work with HWYPPLOT has yielded the conclusion that this program is ideal for viewing a particular location on a roadway. Through the use of HWYPPLOT, the designer can view a particular alinement location from the driver's point of view. Then if any visual discontinuities appear, as the sag in the horizontal curve in Figure 17 and Figure 18, the alinements can be altered and re-plotted for another visual check. HWYPPLOT requires only a minimal amount of input data and only one computer run to produce the perspective plots for a specific location. For example, the computer execution times required on an IBM 360/50 Computer to produce the output for the four plots of Example 3 and the two plots of Example 4 were 4.98 and 4.80 minutes respectively. The main shortcomings of HWYPPLOT are that it does not remove hidden lines, has no provision for independent alinements of four-lane roadways and the representation of the backslopes is fixed at a slope of 6:1.

Although the field of highway perspective drawings is only in an infancy stage, present day developments such as animated perspective films and the superimposing of proposed highway work on oblique photographs show great promise for the future.

REFERENCES

1. Computing Center Notice #187, Kansas State University, Manhattan, Kansas, November 18, 1971.

2. Computing Center Users Guide - Chapter 5, Kansas State University, Manhattan, Kansas, June, 1972.

3. Park, Ross A., Rowan, Neilon J. and Walton, Ned E., "A Computer Technique for Perspective Plotting of Roadways," Highway Research Record 232, Highway Research Board, Washington, D. C., 1968.

4. Smith, Bob L. and Yotter, E. E., "Computer Graphics and Visual Highway Design," Highway Research Record 270, Highway Research Board, Washington, D. C., 1969.

5. Smith, Bob L., Yotter, E. E. and Murphy, J. S., "Alignment Coordination in Highway Design," Highway Research Record 371, Highway Research Board, Washington, D. C., 1971.

6. Yotter, Edward E., "Visual Aspects of Highway Design," report presented to Kansas State University, at Manhattan, Kansas, in 1968, in partial fulfillment of the requirements for the degree of Master of Science.

APPENDIX A

```
                 HIGHWAY PERSPECTIVE PLOT PROGRAM (HWYPPLOT)
                 DEVELOPED BY CIVIL ENGINEERING DEPARTMENT
                 KANSAS STATE UNIVERSITY, MANHATTAN, KANSAS
                 DAVID J. MELLGREN FALL SEMESTER 1972

      C          MAIN PROGRAM
                 DIMENSION X(15,110),y(15,110),Z(15,110),H(15,110),V(15,110)
                 DIMENSION NSKIP(18),BUFF(2000)
                 COMMON /CL/ XY1(110),XY2(110),STA(120)
      C          NSKIP(16)=KEY
      C          NSKIP( 17) = ISKTP
      C          NSKIP(18)=WRITE H AND V
                 CALL PLOTS (BUFF,2000)
                 CALL PLOT (0.,0.,-3)
                 READ (1,902) LOC,MODE
      C     *    SUBROUTINE CLGM CONTAINS READ STATEMENTS
          1      CALL CLGM (X,Y,Z,N,KEY,NSKIP(17))
                 IF(N)899,899,101
        101      IF(KEY)899,102,103
        102      CALL OFR02 (X,Y,Z,N)
                 LINE=5
                 NCL=1
                 GO TO 66
        103      IF(KEY-6) 104,104,79
        104      GO TO (70,71,72,73,74,75),KEY
         70      CALL OFRD2 (X,Y,Z,N)
                 DO 80 I=1,N
                 X(7,I)=X(1,I)
                 Y(7,I)=Y(1,I)
         80      Z(7,I)=Z(1,I)
                 CALL OFLN (X,Y,Z,STA,N,KEY)
                 LINE=6
                 NCL=7
                 GO TO 66
      C          KEY=4--FOUR LANE ROAD WITH BACKSLOPE INFLECTION POINTS GIVEN
         73      CALL OF4L (X,Y,Z,N)
                 CALL OFLN (X,Y,Z,STA,N,KEY)
                 LINE=12
                 NCL=13
                 GO TO 66
         71      CONTINUE
         72      CONTINUE
         74      CONTINUE
         79      WRITE (3,640) KEY
                 GO TO 899
      C     *    SUBROUTINE OF1N2 CONTAINS A READ STATEMENT
```

ILLEGIBLE

THE FOLLOWING DOCUMENT (S) IS ILLEGIBLE DUE TO THE PRINTING ON THE ORIGINAL BEING CUT OFF

ILLEGIBLE

```
0035          75 CALL OFLN2 (X,Y,Z,N)
0036             LINE=6
0037             NCL=9
0038          66 IF(MODE) 68,68,67
0039          67 WRITE (3,201)
0040             WRITE (3,200) ((STA(I),X(K,I),Y(K,I),Z(K,I),K,I,K=1,LINE),I=1,N)
           C   * READ NUMBER OF OBSERVER POSITIONS
0041          68 READ (1,902) NOPS
           C
           C     READ FORMAT
0042         900 FORMAT(3F10.2)
0043         901 FORMAT(I5,3F10.2,2I5)
0044         902 FORMAT(2I5)
           C
           C     WRITE FORMATS
0045         200 FORMAT(2(4F10.2,2I6,10X))
0046         201 FORMAT(2(10H   STATION,7X,1HX,9X,1HY,9X,1HZ,7X,1HK,5X,1HI,10X)/)
0047         620 FORMAT(1H1,16X,13H**PLOT NUMBER,I7,2H**/17X,22(1H*)//)
0048         622 FORMAT(1H ,5X,16HVANISHING POINTS,11X,5HHORZ.,11X,5HVERT.)
0049         624 FORMAT(10X,6HX-AXIS,8X,E14.8,3X,E14.8)
0050         626 FORMAT(10X,6HY-AXIS,8X,E14.8,3X,E14.8)
0051         628 FORMAT(10X,6HZ-AXIS,8X,E14.8,3X,E14.8)
0052         630 FORMAT(///12X,30HCENTER OF INTEREST COORDINATES/21X,3HX =,F9.2/21X
                1,3HY =,F9.2/21X,3HZ =,F9.2//12X29HOBSERVER POSITION COORDINATES,/2
                21X,3HX =,F9.2/21X,3HY =,F9.2/21X,3HZ = F9.2)
0053         632 FORMAT(2(9X,2I8,1X,2F13.2,9X))
0054         634 FORMAT(15X,16HSIGHT DISTANCE =,F8.0/)
0055         636 FORMAT(1X,10(1H*),47HINVALID VALUE FOR CENTER OF INTEREST STATION
                1OF,F15.2)
0056         637 FORMAT(1X,10(1H*),46HINVALID VALUE FOR OBSERVER POSITION STATION O
                1F,F15.2)
0057         638 FORMAT(11H END OF RUN)
0058         640 FORMAT(16H ERROR *** KEY =,I10)
0059         642 FORMAT(1H-)
0060             NSKIP(16)=KEY
           C   * READ CENTER OF INTEREST STATION
0061             READ (1,903) XO,YO,ZO,IDCI
0062         903 FORMAT(3F10.2,I5)
0063             IF(IDCI)4,4,3
0064           4 CISTA=XO
0065             DO 8 I=1,N
0066             IF(STA(I)-CISTA) 8,7,7
0067           8 CONTINUE
0068             WRITE (3,636) CISTA
0069             GO TO 899
0070           7 XO=X(NCL,I)
0071             YO=Y(NCL,I)
0072             ZO=Z(NCL,I)
           C   * READ OBSERVER POSITION COORDINATES
0073           3 READ (1,901) NPLOT,XEP,YEP,ZEP,IDOP,NSKIP(18)
```

```
                IF(IDOP) 16,16,15
             16 IF(KEY.EQ.4) GO TO 12
                DO 11 I=1,N
                X(13,I)=X(NCL,I)
                Y(13,I)=Y(NCL,I)
             11 Z(13,I)=Z(NCL,I)
             12 OPSTA=XEP
                DO 13 I=1,N
                IF(STA(I)-OPSTA) 13,13,14
             13 CONTINUE
                WRITE (3,637) OPSTA
                GO TO 899
             14 D=4.
                IF(KEY.EQ.4) D=46.
                M=I+1
                L=I-1
                IF(L.EQ.0) L=1
                CALL DFOUR (X,Y,M,L,D,CX,CY)
                XEP=X(13,I)+CX
                YEP=Y(13,I)+CY
                ZEP=Z(13,I)+3.5
             15 WRITE (3,620) NPLOT
                SD=SQRT((XEP-XO)**2+(YEP-YO)**2)
                WRITE (3,634) SD
          C     CALCULATE CONSTANTS
                XE=XEP-XO
                YE=YEP-YO
                ZE=ZEP-ZO
                IF(XE.EQ.0.)XE=.00001E-20
                IF(YE.EQ.0.)YE=.00001E-20
                IF(ZE.EQ.0.)ZF=.00001E-20
                B2=XE*XE+YE*YE
                B=SQRT(B2)
                A2=B2+ZE*ZE
                A=SQRT(A2)
          C     CALCULATE SCALE TO PLACE PICTURE PLANE 50 FT AHEAD OF OBSERVER
                SCALE=50./A
          C     CALCULATE VANISHING POINTS
                WRITE (3,622)
                VH=SCALE*A2*YE/(B*XE)
                VV=SCALE*A*ZE/B
                WRITE (3,624) VH,VV
                VH=-SCALE*A2*XE/(B*YE)
                WRITE (3,626) VH,VV
                VH=0.0
                VV=-SCALE*A*B/ZE
                WRITE (3,628) VH,VV
                WRITE (3,630) XO,YO,ZO,XEP,YEP,ZEP
                DO 20 I=1,LINE
                NSKIP(I)=0
```

```
          DO 20 J=1,N
          XX=X(I,J)-XO
          YY=Y(I,J)-YO
          ZZ=Z(I,J)-ZO
          D=A2-(XE*XX+YE*YY+ZE*ZZ)
          IF(D) 5,5,10
        5 NSKIP(I)=NSKIP(I)+1
          H(I,J)=0.
          V(I,J)=0.
          GO TO 20
       10 H(I,J)= SCALE*A2/(B*D)*(XE*YY-YE*XX)
          V(I,J)=SCALE*A/(B*D)*(B2*ZZ-ZE*(XE*XX+YE*YY))
       20 CONTINUE
          IF(NSKIP(18)) 60,60,50
       50 WRITE (3,642)
          DO 40 I=1,LINE
          NN=NSKIP(I)+1
       40 WRITE (3,632) (I,J,H(I,J),V(I,J),J=NN,N)
       60 PLOTN=NPLOT
          CALL NUMBER (+5.,0.,1.,PLOTN,90.0,-1)
          CALL DRAW (LINE,N,H,V,NSKIP)
          CALL PLOT (6.,0.,-3)
          NOPS=NOPS-1
          IF(NOPS) 30,30,3
       30 LOC=LOC-1
          IF(LOC) 898,898,1
      898 CALL PLOT ( 0.,0.,999)
          WRITE (3,638)
      899 STOP
          END
```

```
FORTRAN IV G LEVEL  20                DELTA               DATE = 72237           20/08/

                 SUBROUTINE DELTA (A,B,M,L,DI,CX,CY)
           C     CALCULATE COORDINATE CHANGES FOR ALL POINTS FROM CENTERLINE
                 DIMENSION A(15,110),B(15,110)
                 IF(A(9,M)-A(9,L))30,31,30
              31 THETA=1.5708
                 GO TO 32
              30 ANGLE=ABS((B(9,M)-B(9,L))/(A(9,M)-A(9,L)))
                 THETA=ATAN(ANGLE)
              32 CX=DI*SIN(THETA)
                 CY=DI*COS(THETA)
                 RETURN
                 END
```

```
      SUBROUTINE CIRCLE (C1,ANGLE,T2,DEFL,PCX,PCY,PTX,PTY,PCS,PTS)
      COMMON/RD1/ DIST,I,N,NDEFL(10),RDEFL(10),DC(10),SUP(10,6)
      COMMON/CL/X(110),Y(110),STA(120)
  951 FORMAT(////31X,14HCIRCULAR CURVE/)
  952 FORMAT(31X,1HX,16X,1HY,15X,3HSTA/)
  953 FORMAT(16X,2HPC,3F17.2)
  954 FORMAT(16X,2HPT,3F17.2)
  955 FORMAT(//24X,23HDEFLECTION TO THE RIGHT,F7.2,8H DEGREES)
  956 FORMAT(//24X,22HDEFLECTION TO THE LEFT,F7.2,8H DEGREES)
  957 FORMAT(/32X,7HRADIUS=,F10.2)
  958 FORMAT(/30X,17HDEGREE OF CURVE =,F5.2)
  959 FORMAT(/32X,7HLENGTH=,F10.2)
  960 FORMAT(//29X,18HTRANSITION LENGTH=,F10.2)
  961 FORMAT(/32X,18HTRANSITION FACTOR=,F4.2)
  962 FORMAT(//24X,27HSTA (TANGENT - TRANSITION)=,F10.2)
  963 FORMAT(/24X,27HSTA (TRANSITION - CIRCLE) =,F10.2)
  964 FORMAT(/24X,27HSTA (CIRCLE - TRANSITION) =,F10.2)
  965 FORMAT(/24X,27HSTA (TRANSITION - TANGENT)=,F10.2)
      RAD=5729.58/DC(I)
      CUR=100.*DEFL/DC(I)
      TC=C1
      IF(CUR-TC) 6,8,8
    8 IF(C1) 3,3,1
    1 DA=TC*DC(I)*.000087267
      IF(NDEFL(I))5,5,4
    5 DA=-DA
    4 BNGLE=ANGLE+DA
      X(N)=PCX+TC*SIN(BNGLE)
      Y(N)=PCY+TC*COS(BNGLE)
      STA(N)=PCS+TC
      N=N+1
      IF(CUR-TC)6,3,3
    3 TC=TC+DIST
    2 IF(CUR-TC)6,1,1
    6 T2=TC-CUR
      DA=CUR*DC(I)*.000087267
      IF(NDEFL(I))9,9,10
    9 DA=-DA
   10 ANGLE=ANGLE+DA
      PTX=PCX+SIN(ANGLE)*CUR
      PTY=PCY+COS(ANGLE)*CUR
      PTS=PCS+CUR
C     WRITE CURVE GEOMETRY
      WRITE (3,951)
      WRITE (3,952)
      WRITE (3,953) PCX,PCY,PCS
      WRITE (3,954) PTX,PTY,PTS
      IF(SUP(I,1))21,22,21
   21 T8=SUP(I,1)*SUP(I,2)
      WRITE (3,960) SUP(I,1)
```

```
      WRITE (3,961) SUP(I,2)
      T9=SUP(I,1)-T8
      SUP(I,1)=PCS-T8
      SUP(I,2)=PCS+T9
      SUP(I,3)=PTS-T9
      SUP(I,4)=PTS+T8
      WRITE (3,962) SUP(I,1)
      WRITE (3,963) SUP(I,2)
      WRITE (3,964) SUP(I,3)
      WRITE (3,965) SUP(I,4)
   22 IF(NDEFL(I))23,23,24
   23 WRITE (3,956) DEFL
      GO TO 25
   24 WRITE (3,955) DEFL
   25 WRITE (3,958) DC(I)
      WRITE (3,957) RAD
      WRITE (3,959) CUR
      RETURN
      END
```

```
      SUBROUTINE OFLN2 (X,Y,Z,NPPL)
C     OFFSET SUBROUTINE FOR A TWO LANE ROADWAY
      DIMENSION STA(120),X(15,110),Y(15,110),Z(15,110),DR(110),DL(110)
      DIMENSION BSR(110),BSL(110)
  102 FORMAT(4F10.3)
      NM1=NPPL-1
C     CUT (-)      FILL (+)    FROM CENTERLINE OF ROADWAY
C     DEPTH OF CUT OR FILL ON RIGHT(DR) AND LEFT(DL) SIDE OF ROADWAY
C     BACKSLOPE ON RIGHT(BSR) AND LEFT(BSL) SIDE OF ROADWAY
C   * READ DEPTHS AND BACKSLOPES
      READ (1,102) (DR(I),BSR(I),DL(I),BSL(I),I=1,NPPL)
      WRITE (3,102) DR(NPPL),BSR(NPPL),DL(NPPL),BSL(NPPL)
C     CALCULATIONS
      NLINE=6
      DO 50 K=1,NLINE
      IF(K.EQ.2) D=-22.
      IF(K.EQ.3) D=-12.
      IF(K.EQ.4) D=12.
      IF(K.EQ.5) D=22.
      DO 40 I=2,NM1
      IF(K.EQ.1) D=-22.-ABS(DL(I)*BSL(I))
      IF(K.EQ.6) D=22.+ABS(DR(I)*BSR(I))
      L=I+1
      J=I-1
      CALL DELTA (X,Y,L,J,D,CX,CY)
      X(K,I)=X(9,I)+CX
   40 Y(K,I)=Y(9,I)+CY
      CALL DELTA (X,Y,2,1,D,CX,CY)
      X(K,1)=X(9,1)+CX
      Y(K,1)=Y(9,1)+CY
      CALL DELTA (X,Y,NPPL,NM1,D,CX,CY)
      X(K,NPPL)=X(9,NPPL)+CX
   50 Y(K,NPPL)=Y(9,NPPL)+CY
      DO 60 K=1,NLINE
      DO 60 I=1,NPPL
      IF(K.EQ.1) CZ=DL(I)
      IF(K.EQ.2 .OR.K.EQ.5) CZ=1.0
      IF(K.EQ.3 .OR.K.EQ.4) CZ=.25
      IF(K.EQ.6) CZ=DR(I)
   60 Z(K,I)=Z(9,I)-CZ
      RETURN
      END
```

```
0001                SUBROUTINE VERT (NPVI,NNN,STA,ELEV)
              C     ELEVATION SUBROUTINE
              C
0002                DIMENSION STA(120),ELEV(120),XLVC(10),PCSTA(10),PTSTA(10)
              C     READ FORMATS
0003            900 FORMAT(2F10.2)
0004            901 FORMAT(F10.2)
              C
              C     WRITE FORMATS
0005            953 FORMAT(33X,15HBEGINNING POINT/)
0006            954 FORMAT(31X,9HSTATION =,F11.2/31X,11HELEVATION =,F9.2//)
0007            955 FORMAT(36X,9HEND POINT/)
0008            960 FORMAT(36X,5HCURVE,I3//30X,14HCURVE LENGTH =,F9.2/31X,12HPC STATI
                   1N =,F10.2/31X,12HPT STATION =,F10.2//)
0009                JN=NPVI+2
0010                NP=NPVI+1
0011                KK=NNN+1
0012                KKK=NNN+2+NPVI
              C     END POINTS MUST BE BEYOND STATIONED POINTS
              C   * READ STATIONS AND ELEVATIONS OF PVI'S INCLUDING END POINTS
0013                DO 10 K=KK,KKK
0014             10 READ (1,900) STA(K),ELEV(K)
              C     THE END PVI'S ARE ASSIGNED A CURVE LENGTH OF ZERO
              C     SO THAT THE FIRST PVT AND THE LAST PVC WILL NOT
              C     BE ON THE HORIZONTAL ALINEMENT
0015                XLVC(1)=0.
0016                XLVC(JN)=0.
0017                IF(NPVI) 30,30,15
              C   * ASSIGN LENGTHS OF VERTICAL CURVES AT EACH PVI
0018             15 DO 20 J=2,NP
0019             20 READ (1,901) XLVC(J)
              C     COMPUTE STATIONS OF PC'S AND PT'S
0020             30 DO 40 K=KK,KKK
0021                C2=XLVC(K-NNN)/2.
0022                PCSTA(K-NNN)=STA(K)-C2
0023                PTSTA(K-NNN)=STA(K)+C2
0024             40 CONTINUE
              C     WRITE STATION AND ELEVATION OF BEGINNING POINT
0025                WRITE (3,953)
0026                WRITE (3,954) STA(KK),ELEV(KK)
0027                IF(NPVI) 46,46,42
              C     WRITE VERTICAL CURVE GEOMETRY
0028             42 DO 45 I=2,NP
0029                K=I-1
0030             45 WRITE (3,960) K,XLVC(I),PCSTA(I),PTSTA(I)
              C     WRITE STATION AND ELEVATION OF END POINT
0031             46 WRITE (3,955)
0032                WRITE (3,954) STA(KKK),ELEV(KKK)
              C     COMPUTE ELEVATIONS AT EACH POINT
0033                DO 100 I=1,NNN
```

```
      DO 60 K=KK,KKK
      IF(PCSTA(K-NNN)-STA(I))50,70,70
   50 IF(PTSTA(K-NNN)-STA(I))60,60,80
   60 CONTINUE
C     POINT ON TANGENT
   70 ELEV(I)=(STA(I)-STA(K-1))*(ELEV(K)-ELEV(K-1))/(STA(K)-STA(K-1))
      ELEV(I)=ELEV(I)+ELEV(K-1)
      GO TO 100
C     POINT ON VERTICAL CURVE
   80 ELEV(I)=(STA(I)-STA(K-1))*(ELEV(K)-ELEV(K-1))/(STA(K)-STA(K-1))
      ELEV(I)=ELEV(I)+ELEV(K-1)
      G2=(ELEV(K+1)-ELEV(K))/(STA(K+1)-STA(K))
      G1=(ELEV(K)-ELEV(K-1))/(STA(K)-STA(K-1))
      Y=(G2-G1)*(STA(I)-PCSTA(K-NNN))*(STA(I)-PCSTA(K-NNN))
      Y=Y/(XLVC(K-NNN)*2.)
      ELEV(I)=ELEV(I)+Y
  100 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE INTERP (A1,AEDGE,A2,B1,B2,C2)
      C2=B1+(B2-B1)*(AEDGE-A1)/(A2-A1)
      RETURN
      END
```

```
      SUBROUTINE DRAW (L,N,H,V,NSKIP)
      LSAVE=L
      DIMENSION NSKIP(18),H(15,110),V(15,110),INPIC(15,110)
C     ISKIP IS TWO TIMES THE INTERVAL NUMBER FOR CROSS LINES
      ISKIP=NSKIP(17)*2
      WRITE (3,505)
  505 FORMAT(7(/),16H DRAW SUBROUTINE)
      HMAX=5.
      HMIN=-5.
      VMAX=2.5
      VMIN=-2.5
C     PROGRAM DRAWS LINES BACK AND FORTH
      DO 100 I=1,L,2
      IH1=0
      IV1=0
      NFRST=0
      IHV3=0
      NN=NSKIP(I)
      IF(NN.EQ.0) GO TO 46
      DO 7 K=1,NN
    7 INPIC(I,K)=1
   46 NN=NN+1
C     DRAWS LINES 1,3,5,7 FROM 1 TO N
      DO 98 J=NN,N
C     NEXT POINT H2, V2
      H2=H(I,J)
      V2=V(I,J)
      INPIC(I,J)=0
      IH2=0
C     HMIN CHECK
      IF(H2-HMIN)1,2,2
    1 IH2=1
      INPIC(I,J)=1
      IF(NFRST)2,18,2
    2 IF(IH1-1)3,3,4
    3 IF(IH2-IH1)5,4,6
    5 CALL INTERP(H1,HMIN,H2,V1,V2,V1)
      H1=HMIN
      IF(V1-VMIN)31,9,8
    8 IF(VMAX-V1)47,9,9
   31 IV1=1
      GO TO 10
   47 IV1=2
      GO TO 10
    9 IV1=0
   10 IP1=1
      GO TO 18
    6 H3=H2
      V3=V2
      IHV3=1
```

```
0046            CALL INTERP(H1,HMIN,H2,V1,V2,V2)
0047            H2=HMIN
0048            IH3=IH2
0049            IH2=0
0050            GO TO 18
          C     HMAX CHECK
0051          4 IF(HMAX-H2)11,12,12
0052         11 IH2=2
0053            INPIC(I,J)=1
0054            IF(NFRST)12,18,12
0055         12 IF(IH2-IH1)13,18,14
0056         13 CALL INTERP(H1,HMAX,H2,V1,V2,V1)
0057            H1=HMAX
0058            IF(V1-VMIN)48,17,15
0059         15 IF(VMAX-V1)49,17,17
0060         48 IV1=1
0061            GO TO 16
0062         49 IV1=2
0063            GO TO 16
0064         17 IV1=0
0065         16 IP1=1
0066            GO TO 18
0067         14 H3=H2
0068            V3=V2
0069            IHV3=1
0070            CALL INTERP(H1,HMAX,H2,V1,V2,V2)
0071            H2=HMAX
0072            IH3=IH2
0073            IH2=0
0074         18 IV2=0
          C     VMIN CHECK
0075            IF(V2-VMIN)19,20,20
0076         19 IV2=1
0077            INPIC(I,J)=1
0078            IF(NFRST)20,37,20
0079         20 IF(IV1-1)21,21,22
0080         21 IF(IV2-IV1)41,22,42
0081         41 IF(IH2)37,23,37
0082         23 CALL INTERP(V1,VMIN,V2,H1,H2,H1)
0083            V1=VMIN
0084            IP1=1
0085            GO TO 32
0086         42 IF(IH2)37,24,37
0087         24 H3=H2
0088            V3=V2
0089            IHV3=1
0090            IH3=IH2
0091            CALL INTERP(V1,VMIN,V2,H1,H2,H2)
0092            V2=VMIN
0093            GO TO 32
```

```
C     VMAX CHECK
   22 IF(VMAX-V2)25,26,26
   25 IV2=2
      INPIC(I,J)=1
      IF(NFRST)26,37,26
   26 IF(IV2-IV1)43,29,44
   43 IF(IH2)37,27,37
   27 CALL INTERP(V1,VMAX,V2,H1,H2,H1)
      V1=VMAX
      IP1=1
      GO TO 32
   44 IF(IH2)37,28,37
   28 H3=H2
      V3=V2
      IHV3=1
      IH3=IH2
      CALL INTERP(V1,VMAX,V2,H1,H2,H2)
      V2=VMAX
      GO TO 32
   29 IF(IH2)37,30,37
   30 IF(IV2)37,32,37
C     ORIGINAL POINT OUT OF PICTURE
   32 IF(NFRST)34,33,34
   33 CALL PLOT(-V2,+H2,3)
      GO TO 37
   34 IF(IP1)36,36,35
   35 CALL PLOT(-V1,+H1,3)
   36 CALL PLOT(-V2,+H2,2)
   37 IF(IHV3)38,38,39
   38 H1=H2
      V1=V2
      GO TO 40
   39 H1=H3
      V1=V3
      IH2=IH3
   40 NFRST=1
      IH1=IH2
      IV1=IV2
      IHV3=0
      IP1=0
   98 CONTINUE
C     DRAWS LINES 2,4,6,8 FROM N TO 1
      NFRST=0
      II=I+1
      IF(II.GT.L) GO TO 100
      IH1=0
      IV1=0
      NN=NSKIP(I+1)
      J=N+1
      IF(NN.EQ.0) GO TO 97
```

```
            DO 197 K=1,NN
        197 INPIC(I+1,K)=1
         97 NN=NN+1
            DO 99 K=NN,N
            J=J-1
C           NEXT POINT H2, V2
            H2=H(I+1,J)
            V2=V(I+1,J)
            INPIC(I+1,J)=0
            IH2=0
C           HMIN CHECK
            IF(H2-HMIN)51,52,52
         51 IH2=1
            INPIC(I+1,J)=1
            IF(NFRST)52,68,52
         52 IF(IH1-1)53,53,54
         53 IF(IH2-IH1)55,54,56
         55 CALL INTERP(H1,HMIN,H2,V1,V2,V1)
            H1=HMIN
            IF(V1-VMIN)50,59,58
         58 IF(VMAX-V1)81,59,59
         50 IV1=1
            GO TO 60
         81 IV1=2
            GO TO 60
         59 IV1=0
         60 IP1=1
            GO TO 68
         56 H3=H2
            V3=V2
            IHV3=1
            CALL INTERP(H1,HMIN,H2,V1,V2,V2)
            H2=HMIN
            IH3=IH2
            IH2=0
            GO TO 68
C           HMAX CHECK
         54 IF(HMAX-H2)61,62,62
         61 IH2=2
            INPIC(I+1,J)=1
            IF(NFRST)62,68,62
         62 IF(IH2-IH1)63,68,64
         63 CALL INTERP(H1,HMAX,H2,V1,V2,V1)
            H1=HMAX
            IF(V1-VMIN)96,67,65
         65 IF(VMAX-V1)118,67,67
         96 IV1=1
            GO TO 66
        118 IV1=2
            GO TO 66
```

```
   67 IV1=0
   66 IP1=1
      GO TO 68
   64 H3=H2
      V3=V2
      IHV3=1
      CALL INTERP(H1,HMAX,H2,V1,V2,V2)
      H2=HMAX
      IH3=IH2
      IH2=0
   68 IV2=0
C     VMIN CHECK
      IF(V2-VMIN)69,70,70
   69 IV2=1
      INPIC(I+1,J)=1
      IF(NFRST)70,87,70
   70 IF(IV1-1)71,71,72
   71 IF(IV2-IV1)91,72,92
   91 IF(IH2)87,73,87
   73 CALL INTERP(V1,VMIN,V2,H1,H2,H1)
      V1=VMIN
      IP1=1
      GO TO 82
   92 IF(IH2)87,74,87
   74 H3=H2
      V3=V2
      IHV3=1
      IH3=IH2
      CALL INTERP(V1,VMIN,V2,H1,H2,H2)
      V2=VMIN
      GO TO 82
C     VMAX CHECK
   72 IF(VMAX-V2)75,76,76
   75 IV2=2
      INPIC(I+1,J)=1
      IF(NFRST)76,87,76
   76 IF(IV2-IV1)93,79,94
   93 IF(IH2)87,77,87
   77 CALL INTERP(V1,VMAX,V2,H1,H2,H1)
      V1=VMAX
      IP1=1
      GO TO 82
   94 IF(IH2)87,78,87
   78 H3=H2
      V3=V2
      IHV3=1
      IH3=IH2
      CALL INTERP(V1,VMAX,V2,H1,H2,H2)
      V2=VMAX
      GO TO 82
```

```
      79 IF(IH2)87,80,87
      80 IF(IV2)87,82,87
C        ORIGINAL POINT OUT OF PICTURE
      82 IF(NFRST)84,83,84
      83 CALL PLOT(-V2,+H2,3)
         GO TO 87
      84 IF(IP1)86,86,85
      85 CALL PLOT(-V1,+H1,3)
      86 CALL PLOT(-V2,+H2,2)
      87 IF(IHV3)88,88,89
      88 H1=H2
         V1=V2
         GO TO 90
      89 H1=H3
         V1=V3
         IH2=IH3
      90 NFRST=1
         IH1=IH2
         IV1=IV2
         IHV3=0
         IP1=0
      99 CONTINUE
     100 CONTINUE
         IF(NSKIP(18)) 147,147,148
     148 WRITE(3,501)
     501 FORMAT(1H1,6(13H  I   J   INPIC,8X)//)
         WRITE (3,502) ((I,J,INPIC(I,J),J=1,N),I=1,L)
     502 FORMAT(6(1X,2I3,I5,9X))
C
     147 IF(NSKIP(16)) 140,140,142
     140 L=4
         DO 141 J=1,3
         GO TO (143,144,145),J
     143 JJ=1
         KK=2
         GO TO 146
     144 JJ=3
         KK=1
         GO TO 146
     145 JJ=2
         KK=3
     146 NN=NSKIP(JJ)+1
         DO 141 I=NN,N
         INPIC(KK,I)=INPIC(JJ,I)
         H(KK,I)=H(JJ,I)
     141 V(KK,I)=V(JJ,I)
         NSKIP(2)=NSKIP(1)
         NSKIP(1)=NSKIP(3)
         NSKIP(3)=NSKIP(2)
C        DRAWS CROSS LINES AT EVERY STATION BACK AND FORTH
```

```
C     DETERMINES MINIMUM NSKIP
  142 WRITE (3,504)
  504 FORMAT(7(/),12H CROSS LINES)
      MSKIP=NSKIP(1)
      DO 101 K=2,L
      IF(NSKIP(K)-MSKIP)102,101,101
  102 MSKIP=NSKIP(K)
  101 CONTINUE
      MSKIP=MSKIP+1
      IF(NSKIP(16)-4) 302,300,302
  300 L=14
      DO 301 I=1,N
      H(14,I)=H(12,I)
      V(14,I)=V(12,I)
      H(13,I)=H(11,I)
      V(13,I)=V(11,I)
      H(12,I)=H(10,I)
      V(12,I)=V(10,I)
      H(11,I)=H(9,I)
      V(11,I)=V(9,I)
      H(10,I)=H(9,I)
      V(10,I)=V(9,I)
      H(9,I)=H(8,I)
      V(9,I)=V(8,I)
      H(8,I)=H(7,I)
      V(8,I)=V(7,I)
      H(7,I)=H(6,I)
      V(7,I)=V(6,I)
      H(6,I)=H(5,I)
      V(6,I)=V(5,I)
      H(5,I)=H(4,I)
      V(5,I)=V(4,I)
      INPIC(14,I)=INPIC(12,I)
      INPIC(13,I)=INPIC(11,I)
      INPIC(12,I)=INPIC(10,I)
      INPIC(11,I)=INPIC(9,I)
      INPIC(10,I)=INPIC(9,I)
      INPIC(9,I)=INPIC(8,I)
      INPIC(8,I)=INPIC(7,I)
      INPIC(7,I)=INPIC(6,I)
      INPIC(6,I)=INPIC(5,I)
  301 INPIC(5,I)=INPIC(4,I)
C     STARTS CROSS LINES AT BOTTOM OF PICTURE, PROGRESSES TO TOP
  302 DO 200 JJ=MSKIP,N,ISKIP
      J=JJ
      NFRST=0
      ID=1
      I=L+1
C     DRAWS MSKIP, MSKIP+2,ETC, LINES RIGHT TO LEFT
      DO 198 K=1,L,2
```

```
      I=I-1
      IF(NFRST)104,103,104
  103 IF(INPIC(I,J))106,105,106
  105 SAVEV=-V(I,J)
      SAVEH=H(I,J)
      KH=I
      KV=J
      ID=0
  106 NFRST=1
      GO TO 112
  104 IF(ID)107,108,107
  107 IF(INPIC(I,J))112,109,112
  109 SAVEV=-V(I,J)
      SAVEH=H(I,J)
      KH=I
      KV=J
      ID=0
      GO TO 112
  108 IF(INPIC(I,J))110,111,110
  110 ID=1
      GO TO 112
  111 CALL PLOT (SAVEV,SAVEH,3)
      CALL PLOT(-V(I,J),+H(I,J),2)
  112 I=I-1
      IF(ID)198,114,198
  114 IF(INPIC(I,J))117,116,117
  116 CALL PLOT (SAVEV,SAVEH,3)
      CALL PLOT(-V(I,J),+H(I,J),2)
  117 ID=1
  198 CONTINUE
      J=JJ+NSKIP(17)
      IF(J.GT.N) GO TO 200
      NFRST=0
      ID=1
      I=0
C     DRAWS MSKIP+1, MSKIP+3, ETC, LINES LEFT TO RIGHT
      DO 199 K=1,L,2
      I=I+1
      IF(NFRST)154,153,154
  153 IF(INPIC(I,J))156,155,156
  155 SAVEV=-V(I,J)
      SAVEH=H(I,J)
      KH=I
      KV=J
      ID=0
  156 NFRST=1
      GO TO 162
  154 IF(ID)157,158,157
  157 IF(INPIC(I,J))162,159,162
  159 SAVEV=-V(I,J)
```

```
      SAVEH=H(I,J)
      KH=I
      KV=J
      ID=0
      GO TO 162
  158 IF(INPIC(I,J))160,161,160
  160 ID=1
      GO TO 162
  161 CALL PLOT (SAVEV,SAVEH,3)
      CALL PLOT(-V(I,J),+H(I,J),2)
  162 I=I+1
      IF(ID)199,164,199
  164 IF(INPIC(I,J))167,166,167
  166 CALL PLOT (SAVEV,SAVEH,3)
      CALL PLOT(-V(I,J),+H(I,J),2)
  167 ID=1
  199 CONTINUE
  200 CONTINUE
      L=LSAVE
      WRITE (3,506) MSKIP
  506 FORMAT(//6X,'FIRST POINT ***',I5)
      RETURN
      END
```

```
            SUBROUTINE OF4L (X,Y,Z,NPPL)
            DIMENSION X(15,110),Y(15,110),Z(15,110)
      C     ASSUMES 48 FT MEDIAN, 6 FT INSIDE AND 10 FT OUTSIDE SHOULDERS
            DO 10 I=1,NPPL
            X(13,I)=X(9,I)
            Y(13,I)=Y(9,I)
         10 Z(13,I)=Z(9,I)
            NLINE=11
            SIGN=-1.
            NM1=NPPL-1
            DO 50 K=2,NLINE
            IF(K.GE.7) SIGN=+1.
            D=SIGN*64.
            IF(K.EQ.3.OR.K.EQ.10) D=SIGN*54.
            IF(K.EQ.4.OR.K.EQ.9) D=SIGN*42.
            IF(K.EQ.5.OR.K.EQ.8) D=SIGN*30.
            IF(K.EQ.6.OR.K.EQ.7) D=SIGN*24.
            DO 40 I=2,NM1
            L=I+1
            J=I-1
            CALL DFOUR (X,Y,L,J,D,CX,CY)
            X(K,I)=X(13,I)+CX
         40 Y(K,I)=Y(13,I)+CY
            CALL DFOUR (X,Y,2,1,D,CX,CY)
            X(K,1)=X(13,1)+CX
            Y(K,1)=Y(13,1)+CY
            CALL DFOUR (X,Y,NPPL,NM1,D,CX,CY)
            X(K,NPPL)=X(13,NPPL)+CX
         50 Y(K,NPPL)=Y(13,NPPL)+CY
            DO 60 K=2,NLINE
            CZ=.67
            IF(K.EQ.3.OR.K.EQ.5.OR.K.EQ.8.OR.K.EQ.10) CZ=.25
            IF(K.EQ.4.OR.K.EQ.9) CZ=0.
            IF(K.EQ.6.OR.K.EQ.7) CZ=.50
            DO 60 I=1,NPPL
         60 Z(K,I)=Z(13,I)-CZ
            RETURN
            END
```

```
0001          SUBROUTINE OFLN (X,Y,Z,STA,NP,KEY)
0002          DIMENSION X(15,110),Y(15,110),Z(15,110),STA(120),STAT(2,100)
0003          DIMENSION ELEV(2,100),THETA(300)
0004          NO=NP-1
0005          IF(KEY.GT.4) GO TO 101
0006          GO TO (1,101,101,2),KEY
0007        1 DD=27.
0008          NCL=1
0009          GO TO 3
0010        2 DD=84.
0011          NCL=13
0012        3 DO 30 I=1,NO
0013          IF(X(NCL,I+1)-X(NCL,I)) 20,10,20
0014       10 THETA(I)=1.5708
0015          GO TO 30
0016       20 ANGLE=ABS((Y(NCL,I+1)-Y(NCL,I))/(X(NCL,I+1)-X(NCL,I)))
0017          THETA(I)=ATAN(ANGLE)
0018       30 CONTINUE
0019          THETA(NP)=THETA(NO)
0020          DO 40 I=2,NO
0021       40 THETA(I)=(THETA(I-1)+THETA(I))/2.
     C    * READ NUMBER OF INFLECTION POINTS FOR RIGHT AND LEFT BACKSLOPES
0022          READ (1,900) NR,NL
     C    * READ STATION AND ELEVATION FOR RIGHT AND LEFT BACKSLOPES
0023          READ (1,901) (STAT(1,I),ELEV(1,I),I=1,NR)
0024          READ (1,901) (STAT(2,I),ELEV(2,I),I=1,NL)
0025          BS=6.
0026          DO 100 K=1,2
0027          SIGN=+1.0
0028          N=6
0029          IF(KEY.EQ.4) N=12
0030          NCL=N+1
0031          NN=NR
0032          IF(K-1) 55,55,50
0033       50 NN=NL
0034          N=1
0035          SIGN=-1.0
0036       55 DO 100 I=1,NP
0037          DO 60 J=2,NN
0038          IF(STA(I)-STAT(K,J)) 70,80,60
0039       60 CONTINUE
0040          WRITE (3,940)
0041          RETURN
0042       70 Z(N,I)=ELEV(K,J-1)+(STA(I)-STAT(K,J-1))*(ELEV(K,J)-ELEV(K,J-1))/(S
             1TAT(K,J)-STAT(K,J-1))
0043          DIST=DD+BS*ABS(Z(N,I)-Z(NCL,I))
0044          GO TO 90
0045       80 Z(N,I)=ELEV(K,J)
0046          DIST=DD+BS*ABS(Z(N,I)-Z(NCL,I))
0047       90 X(N,I)=X(NCL,I)+SIGN*DIST*SIN(THETA(I))
```

```
          Y(N,I)=Y(NCL,I)+SIGN*DIST*COS(THETA(I))
      100 CONTINUE
          RETURN
      101 WRITE (3,902) KEY
      902 FORMAT(5H KEY=,I3,10X,39HINVALID VALUE OF KEY IN OFLN SUBROUTINE)
      999 RETURN
      900 FORMAT(2I5)
      901 FORMAT(6F10.2)
      940 FORMAT(10X,'ERROR STATEMENT NO. 60  OFLN SUBROUTINE')
          END
```

```
      SUBROUTINE DFOUR (A,B,M,L,DI,CX,CY)
C     CALCULATE COORDINATE CHANGES FOR ALL POINTS FROM CENTERLINE
      DIMENSION A(15,110),B(15,110)
      IF(A(13,M)-A(13,L))30,31,30
   31 THETA=1.5708
      GO TO 32
   30 ANGLE=ABS((B(13,M)-B(13,L))/(A(13,M)-A(13,L)))
      THETA=ATAN(ANGLE)
   32 CX=DI*SIN(THETA)
      CY=DI*COS(THETA)
      RETURN
      END
```

```
0001                SUBROUTINE CLGM (XX,YY,ZZ,NN,KEY,ISKIP)
              C     MAIN SUBROUTINE FOR CENTERLINE COORDINATES
              C
              C     READ FORMATS
0002            900 FORMAT(10I5)
0003            901 FORMAT(6F10.2)
0004            902 FORMAT(I5,F10.2)
0005            903 FORMAT(3F5.0,F3.0,F6.2)
0006            904 FORMAT(F5.0,F3.0,F6.2,6X,F5.0,F3.0,F6.2,F5.2,F10.2,F5.2)
              C
              C     WRITE FORMATS
0007            925 FORMAT(53X,31HEND OF ROADWAY GEOMETRY PROGRAM//)
0008            926 FORMAT(34X,70H****************************************************
                   -******************//)
0009            940 FORMAT(1H1)
0010            945 FORMAT(//////)
0011            949 FORMAT(1H1//////////)
0012            950 FORMAT(10X,49H*** ALIGNMENT SIZE EXCEEDS DIMENSIONED STORAGE BY,I2
                   1)
0013            951 FORMAT(5X,54HWARNING *** NUMBER OF POINTS MAY EXCEED DIMENSION SIZ
                   1E)
0014            952 FORMAT(10X,62HTHE TANGENT DISTANCE BETWEEN TWO SUCCESSIVE CURVES I
                   1S NEGATIVE)
0015            953 FORMAT(1H+,100X,17HTANGENT DIRECTION,F14.2)
0016            954 FORMAT(1H1,27X,25HHORIZONTAL CURVE GEOMETRY/////)
0017            955 FORMAT(28X,23HVERTICAL CURVE GEOMETRY/////)
0018            956 FORMAT(1H1,47X,9HTHERE ARE, I4,24H POINTS IN THE ALIGNMENT)
0019            957 FORMAT(50X,22HSTATION OF FIRST POINT,F10.2)
0020            958 FORMAT(50X,21HSTATION OF LAST POINT,F11.2)
0021            959 FORMAT(10X,5(1H*),38H INVALID CROSS SECTION INDICATOR VALUE )
0022            960 FORMAT(36X,5HCURVE,I3)
0023            961 FORMAT(36X,8H********)
0024            962 FORMAT(1H1,30X,19HCENTERLINE GEOMETRY/)
0025            963 FORMAT(17X,I5,4F10.2)
0026            964 FORMAT(21X,1HI,6X,1HX,9X,1HY,9X,1HZ,8X,3HSTA)
0027            973 FORMAT(///////////)
0028            974 FORMAT(101X,23HDISTANCE BETWEEN CURVES,F8.2)
0029            975 FORMAT(101X,14HTANGENT LENGTH,F17.2)
0030            976 FORMAT(//48X,23HCROSS LINES DRAWN EVERY,F8.0,5H FEET/48X,24HPOINTS
                   1 ARE DEFINED EVERY,F7.0,5H FEET)
0031            977 FORMAT(24X,32H********************************)
0032            978 FORMAT(/24X,21HSUPERELEVATION RATE =,F5.2,6H FT/FT/)
              C
              C     COMMON AND DIMENSION STATEMENTS
0033                DIMENSION XX(15,110),YY(15,110),ZZ(15,110),Z(120)
0034                DIMENSION SPIR(10),DEFL(10),TANL(11)
0035                COMMON/CL/X(110),Y(110),STA(120)
0036                COMMON/RD1/ DIST,I,N,NDEFL(10),RDEFL(10),DC(10),SUP(10,6)
              C
              C
```

```
      C      READ DATA AND INITIALIZE VALUES
             DO 1 I=1,10
             SUP(I,1)=0
           1 SPIR(I)=0.
             DO 110 I=1,60
         110 STA(I)=0.0
      C    * READ NUMBER OF PIS(NPHI) AND PVIS(NPVI)
             READ (1,900) NPHI,NSPIR,NPVI,KEY
      C    * READ DISTANCE BETWEEN POINTS AND INITIAL DIRECTION FROM NORTH
             READ (1,903) DIST,XDIST,A,B,C
             THETA=(A+B/60.+C/3600.)*0.0174533
             NTAN=NPHI+1
             IF(XDIST-DIST) 109,117,115
         109 XDIST=DIST
         117 ISKIP=1
             GO TO 116
         115 ISKIP=XDIST/DIST
             XDIST=DIST*FLOAT(ISKIP)
         116 IF(10-NPHI)100,101,101
         100 IXCES=NPHI-10
             WRITE (3,950) IXCES
             GO TO 899
         101 IF(8-NPVI) 106,105,105
         106 IXCES=NPVI-8
             WRITE (3,950) IXCES
             GO TO 899
      C    * READ COORDINATES OF INITIAL POINT AND STATION
         105 READ (1,901) X(1),Y(1),STA(1)
      C      DIRECTION CHANGES ARE READ AS DEFLECTIONS
      C      CLOCKWISE IS POSITIVE AND COUNTERCLOCKWISE IS NEGATIVE
      C    * READ DEFLECTION ANGLES (DEFL) AND DEGREES OF CURVE (DC)
             DO 107 I=1,NPHI
             READ (1,904) A,B,C,D,E,F,SUP(I,6),SUP(I,1),SUP(I,2)
             IF(A) 112,113,113
         112 DEFL(I)=A-B/60.-C/3600.
             GO TO 114
         113 DEFL(I)=A+B/60.+C/3600.
         114 DC(I)=D+E/60.+F/3600.
         107 CONTINUE
      C    * READ TANGENT LENGTHS
             READ (1,901) (TANL(I),I=1,NTAN)
             TOTAL=0.
             DO 102 I=1,NTAN
         102 TOTAL=TOTAL+TANL(I)
             NTOT=TOTAL/DIST
             IF(NTOT-110)111,111,103
         103 WRITE (3,951)
         111 DO 104 I=1,NPHI
             RDEFL(I)=DEFL(I)*.0174533
             NDEFL(I)=1
```

```
          IF(DEFL(I))108,104,104
      108 NDEFL(I)=-1
          DEFL(I)=-DEFL(I)
      104 CONTINUE
          SUP(I,5)=NDEFL(I)
          IF(NSPIR)211,210,211
C       * READ SPIRAL CURVE NUMBER AND LENGTH
      211 READ (1,902) (N,SPIR(N),I=1,NSPIR)
C
C
C         MAIN ROUTINE FOR CENTERLINE COORDINATES
      210 T2=0.
          TD1=0.
          N=2
          S1=0.
          I=1
          WRITE (3,954)
          IF(SUP(I,6))213,212,213
      213 WRITE (3,977)
          WRITE (3,978) SUP(I,6)
          WRITE (3,977)
      212 GO TO 97
       99 I=I+1
          DHETA=THETA*57.3
          WRITE (3,953) DHETA
       97 IF(SPIR(I))3,3,4
C
C         PRELIMINARY CIRCULAR CURVE CALCULATIONS
        3 IF(NTAN-I)20,20,22
       20 TD2=0.
          GO TO 23
       22 TD2=5729.58*TAN(.0087267*DEFL(I))/DC(I)
       23 TT=T2
          TB=TANL(I)-TD1-TD2
          WRITE (3,974) TB
          WRITE (3,975) TD2
          IF(TB+10.)209,2,2
      209 WRITE (3,952)
          GO TO 899
        2 IF(T2)6,6,27
       27 X(N)=PTX+T2*SIN(THETA)
          Y(N)=PTY+T2*COS(THETA)
          STA(N)=PTS+T2
          N=N+1
        6 IF(TB-DIST)17,8,8
        8 TT=TT+DIST
          IF(TT-TB)5,7,7
        5 X(N)=X(N-1)+DIST*SIN(THETA)
          Y(N)=Y(N-1)+DIST*COS(THETA)
          STA(N)=STA(N-1)+DIST
```

```
      N=N+1
      GO TO 8
   17 C1=DIST-TB
      D1=TB
      GO TO 9
    7 C1=TT-TB
      D1=DIST-C1
    9 ANGLE=THETA
      PCX=X(N-1)+D1*SIN(THETA)
      PCY=Y(N-1)+D1*COS(THETA)
      PCS=STA(N-1)+D1
      IF(I-NPHI)18,18,799
   18 WRITE (3,940)
      WRITE (3,945)
      WRITE (3,960) I
      WRITE (3,961)
      CALL CIRCLE (C1,ANGLE,T2,DEFL(I),PCX,PCY,PTX,PTY,PCS,PTS)
      THETA=THETA+RDEFL(I)
      TD1=TD2
      GO TO 99
C
C     PRELIMINARY SPIRAL CURVE CALCULATIONS
    4 IF(NTAN-I)24,24,25
   24 TD2=0.
      GO TO 26
   25 RC=5729.58/DC(I)
C     THES IS IN RADIANS
      THES=SPIR(I)/(2.*RC)
      YS=SPIR(I)*THES/3.
      XS=SPIR(I)-(SPIR(I)*THES**2/10.)
      P=YS-RC*(1.-COS(THES))
      DK=XS-RC*SIN(THES)
      TD2=(RC+P)*TAN(.0087267*DEFL(I))+DK
   26 TB=TANL(I)-TD1-TD2
      WRITE (3,974) TB
      WRITE (3,975) TD2
      TT=T2
      IF(TB+10.)10,11,11
   10 WRITE (3,952)
      GO TO 899
   11 IF(T2)28,28,29
   29 X(N)=PTX+T2*SIN(THETA)
      Y(N)=PTY+T2*COS(THETA)
      STA(N)=PTS+T2
      N=N+1
   28 IF(TB-DIST)21,12,12
   12 TT=TT+DIST
      IF(TT-TB)13,14,15
   13 X(N)=X(N-1)+DIST*SIN(THETA)
      Y(N)=Y(N-1)+DIST*COS(THETA)
```

```
          STA(N)=STA(N-1)+DIST
          N=N+1
          GO TO 12
       21 S1=DIST-TB
          GO TO 16
       15 S1=TT-TB
          GO TO 16
       14 S1=0.
       16 ANGLE=THETA
          IF(I-NPHI)19,19,799
       19 WRITE (3,940)
          WRITE (3,960) I
          WRITE (3,961)
          CALL SPIRAL (S1,ANGLE,T2,SPIR,THES,PTX,PTY,PTS)
          THETA=THETA+RDEFL(I)
          TD1=TD2
          GO TO 99
      799 N=N-1
          WRITE (3,956) N
          WRITE (3,957) STA(1)
          WRITE (3,958) STA(N)
          WRITE (3,976) XDIST,DIST
          WRITE (3,940)
          WRITE (3,955)
C       * SUBROUTINE VERT CONTAINS READ STATEMENTS
          CALL VERT (NPVI,N,STA,Z)
          WRITE (3,962)
          WRITE (3,964)
          DO 30 I=1,N
       30 WRITE (3,963) I,X(I),Y(I),Z(I),STA(I)
          IF (KEY) 31,32,33
       31 WRITE (3,959)
          WRITE (2,963) N
          WRITE (2,963) (I,X(I),Y(I),Z(I),STA(I),I=1,N)
          GO TO 899
       32 J=1
          GO TO 34
       33 IF(KEY-1) 32,32,35
       35 J=9
       34 DO 920 I=1,N
          XX(J,I)=X(I)
          YY(J,I)=Y(I)
      920 ZZ(J,I)=Z(I)
      999 WRITE (3,949)
          WRITE (3,926)
          WRITE (3,925)
          WRITE (3,926)
          WRITE (3,940)
          NN=N
          RETURN
```

```
0219      899 NN=0
0220          RETURN
0221          END
```

```
      SUBROUTINE OFPD2 (X,Y,Z,NPPL)
      COMMON/RD1/ DIST,I,N,NDEFL(10),RDEFL(10),DC(10),SUP(10,6)
      COMMON /CL/ XY1(110),XY2(110),STA(120)
      DIMENSION X(15,110),Y(15,110),Z(15,110)
      KPPL=NPPL
      DO 10 K=1,KPPL
      I=K
      X(9,I)=X(1,I)
   10 Y(9,I)=Y(1,I)
      NLINE=5
      NM1=NPPL-1
      DO 50 N=2,NLINE
      K=N
      D=-22.0
      IF(K.EQ.3) D=-12.0
      IF(K.EQ.4) D=12.0
      IF(K.EQ.5) D=22.0
      DO 40 M=2,NM1
      I=M
      L=I+1
      J=I-1
      CALL DELTA (X,Y,L,J,D,CX,CY)
      X(K,I)=X(1,I)+CX
   40 Y(K,I)=Y(1,I)+CY
      CALL DELTA (X,Y,2,1,D,CX,CY)
      X(K,1)=X(1,1)+CX
      CALL DELTA (X,Y,KPPL,NM1,D,CX,CY)
      Y(K,1)=Y(1,1)+CY
      X(K,NPPL)=X(1,NPPL)+CX
   50 Y(K,NPPL)=Y(1,NPPL)+CY
      DO 60 N=2,NLINE
      K=N
      CZ=0.86
      IF(K.EQ.3.OR.K.EQ.4) CZ=0.25
      DO 60 M=1,KPPL
      I=M
   60 Z(K,I)=Z(1,I)-CZ
      ART=1
      DO 800 N=1,NPPL
      DO 500 I=1,10
      IF (SUP(I,1))500,500,200
  200 IF (STA(N)-SUP(I,1)+75)500,500,210
  210 IF (STA(N)-SUP(I,4)-75)220,500,500
  500 CONTINUE
      GO TO 800
  220 IF(SUP(I,5))335,230,230
C      J1=HIGH SHOULDER
C      J2=HIGH PAVT
C      J3=LOW PAVT
C      J4=LOW SHOULDER
```

```
 230 J1=2
     J2=3
     J3=4
     J4=5
     GO TO 240
 335 J1=5
     J2=4
     J3=3
     J4=2
 240 IF (STA(N)-SUP(I,1))280,280,300
 300 IF (STA(N)-SUP(I,2))310,310,345
 345 IF (STA(N)-SUP(I,3))360,360,350
 350 IF (STA(N)-SUP(I,4))410,410,450
 280 HS=.5+(SUP(I,1)-STA(N))*(.36/75.)
     HP=(SUP(I,1)-STA(N))*(.25/75.)
     Z(J1,N)=Z(1,N)-HS
     Z(J2,N)=Z(1,N)-HP
     GO TO 800
 410 X1=(SUP(I,4)-STA(N))
     HP=X1*(SUP(I,6)*12)/(SUP(I,4)-SUP(I,3))
     HS=-.5+(X1)*(SUP(I,6)*14)/(SUP(I,4)-SUP(I,3))
     Z(J1,N)=Z(1,N)+HS
     Z(J2,N)=Z(1,N)+HP
     X1=SUP(I,4)-STA(N)
     X2=SUP(I,4)-SUP(I,3)
     HP=.25+((SUP(I,6)*12)-.25)*X1/X2
     HS=HP+.61
     Z(J3,N)=Z(1,N)-HP
     Z(J4,N)=Z(1,N)-HS
     GO TO 800
 310 HS=-.5+(STA(N)-SUP(I,1))*(SUP(I,6)*14)/(SUP(I,2)-SUP(I,1))
     HP=(STA(N)-SUP(I,1))*(SUP(I,6)*12/(SUP(I,2)-SUP(I,1)))
     Z(J1,N)=Z(1,N)+HS
     Z(J2,N)=Z(1,N)+HP
     X1=STA(N)-SUP(I,1)
     X2=SUP(I,2)-SUP(I,1)
     HP=.25+((SUP(I,6)*12)-.25)*X1/X2
     HS=HP+.61
     Z(J3,N)=Z(1,N)-HP
     Z(J4,N)=Z(1,N)-HS
     GO TO 800
 360 HS=-.5+(SUP(I,6)*14)
     HP=SUP(I,6)*12
     Z(J1,N)=Z(1,N)+HS
     Z(J2,N)=Z(1,N)+HP
     HS=+.62+(SUP(I,6)*12)
     Z(J3,N)=Z(1,N)-HP
     Z(J4,N)=Z(1,N)-HS
     GO TO 800
 450 HS=.86-(.36/75)*(SUP(I,4)+75-STA(N))
```

```
      HP=(.25/75)*(STA(N)-SUP(I,4))
      Z(J2,N)=Z(1,N)-HP
      Z(J1,N)=Z(1,N)-HS
  800 CONTINUE
   70 RETURN
      END
```

```
      SUBROUTINE SPIRAL (S1,ANGLE,T2,SPIR,THES,STX,STY,STS)
      COMMON/RD1/ DIST,I,N,NDEFL(10),RDEFL(10),DC(10),SUP(10,6)
      COMMON/CL/X(110),Y(110),STA(120)
      DIMENSION SPIR(12)
  952 FORMAT(31X,1HX,16X,1HY,15X,3HSTA/)
  953 FORMAT(16X,2HCS,3F17.2)
  954 FORMAT(16X,2HST,3F17.2)
  955 FORMAT(////28X,20HSPIRAL CURVE (AHEAD)/)
  956 FORMAT(////28X,21HSPIRAL CURVE (BEHIND)/)
  964 FORMAT(16X,2HTS,3F17.2)
  965 FORMAT(//27X,25HLIMITING DEGREE OF CURVE=,F5.2)
  966 FORMAT(/30X,14HSPIRAL LENGTH=,F10.2)
  967 FORMAT(/31X,9HTHETA(S)=,F5.2,8H DEGREES)
  974 FORMAT(16X,2HSC,3F17.2)
      DHES=THES*57.30
      DISTS=100.
      IF(DIST-100.) 26,27,27
   26 DISTS=DIST
C     CALCULATIONS FOR SPIRAL TO CIRCULAR CURVE
   27 IF(S1)1,1,2
    1 TSX=X(N-1)+DIST*SIN(ANGLE)
      TSY=Y(N-1)+DIST*COS(ANGLE)
      TSS=STA(N-1)+DIST
      X(N)=TSX
      Y(N)=TSY
      STA(N)=TSS
      N=N+1
      TS=0.
      GO TO 7
    2 T1=DIST-S1
      TSX=X(N-1)+T1*SIN(ANGLE)
      TSY=Y(N-1)+T1*COS(ANGLE)
      TSS=STA(N-1)+T1
      DA=(S1/SPIR(I))**2*THES/3.
      IF(NDEFL(I))5,5,4
    5 DA=-DA
    4 ANGS=ANGLE+DA
      X(N)=TSX+S1*SIN(ANGS)
      Y(N)=TSY+S1*COS(ANGS)
      STA(N)=TSS+S1
      N=N+1
      TS=S1
    7 IF(SPIR(I)-TS)6,6,3
    3 TS=TS+DISTS
      IF(SPIR(I)-TS)6,6,8
    8 DA=(TS/SPIR(I))**2*THES/3.
      IF(NDEFL(I))11,11,12
   11 DA=-DA
   12 ANGS=ANGLE+DA
      X(N)=TSX+TS*SIN(ANGS)
```

```
      Y(N)=TSY+TS*COS(ANGS)
      STA(N)=TSS+TS
      N=N+1
      GO TO 3
    6 C1=TS-SPIR(I)
      DA=THES/3.
      IF(NDEFL(I))9,9,10
    9 DA=-DA
   10 ANGS=ANGLE+DA
      SCX=TSX+SPIR(I)*SIN(ANGS)
      SCY=TSY+SPIR(I)*COS(ANGS)
      SCS=TSS+SPIR(I)
C     WRITE SPIRAL AHEAD GEOMETRY
      WRITE (3,955)
      WRITE (3,952)
      WRITE (3,964) TSX,TSY,TSS
      WRITE (3,974) SCX,SCY,SCS
      WRITE( 3,965) DC(I)
      WRITE (3,966) SPIR(I)
      WRITE (3,967) DHES
      IF(NDEFL(I))21,21,24
   21 ANGLE=ANGLE-THES
      GO TO 25
   24 ANGLE=ANGLE+THES
C     CDEL IS CENTRAL CURVE DEFLECTION IN DEGREES (ALWAYS POSITIVE)
   25 CDEL=(ABS(RDEFL(I))-2.*THES)*57.30
      ANGLA=ANGLE
      CALL CIRCLE (C1,ANGLA,S1,CDEL,SCX,SCY,CSX,CSY,SCS,CSS)
      SUP(I,1)=TSS
      SUP(I,2)=SCS
      CDEL=CDEL*.0174533
      IF(NDEFL(I))19,19,13
   19 CDEL=-CDEL
   13 ANGLE=ANGLE+CDEL
C     CALCULATIONS FOR CIRCULAR CURVE TO TANGENT
      TS=S1
      IF(S1)14,14,15
   14 TS=TS+DISTS
   15 IF(TS-SPIR(I))18,20,20
   18 DA=TS*DC(I)*.000087267-(TS/SPIR(I))**2*THES/3.
      IF(NDEFL(I))16,16,17
   16 DA=-DA
   17 ANGS=ANGLE+DA
      X(N)=CSX+TS*SIN(ANGS)
      Y(N)=CSY+TS*COS(ANGS)
      STA(N)=CSS+TS
      N=N+1
      GO TO 14
   20 T2=TS-SPIR(I)
      DA=2.*THES/3.
```

```
      IF(NDEFL(I))22,22,23
   22 DA=-DA
   23 ANGS=ANGLE+DA
      STX=CSX+SPIR(I)*SIN(ANGS)
      STY=CSY+SPIR(I)*COS(ANGS)
      STS=CSS+SPIR(I)
C     WRITE SPIRAL BEHIND GEOMETRY
      WRITE (3,956)
      WRITE (3,952)
      WRITE (3,953) CSX,CSY,CSS
      WRITE (3,954) STX,STY,STS
      SUP(I,3)=CSS
      SUP(I,4)=STS
      SUP(I,5)=NDEFL(I)
      WRITE (3,965) DC(I)
      WRITE (3,966) SPIR(I)
      WRITE (3,967) DHES
      RETURN
      END
```

APPENDIX B*

MAIN PROGRAM

↓

CALLS CENTERLINE GEOMETRY (CLGM)

Calculates space coordinates (X,Y,Z) of the centerline at a specified distance apart. These coordinates are returned for MAIN'S use. Can contain tangents, spiraled or unspiraled transitions, and circular curves for horizontal geometry and tangents and parabolic curves for vertical geometry.

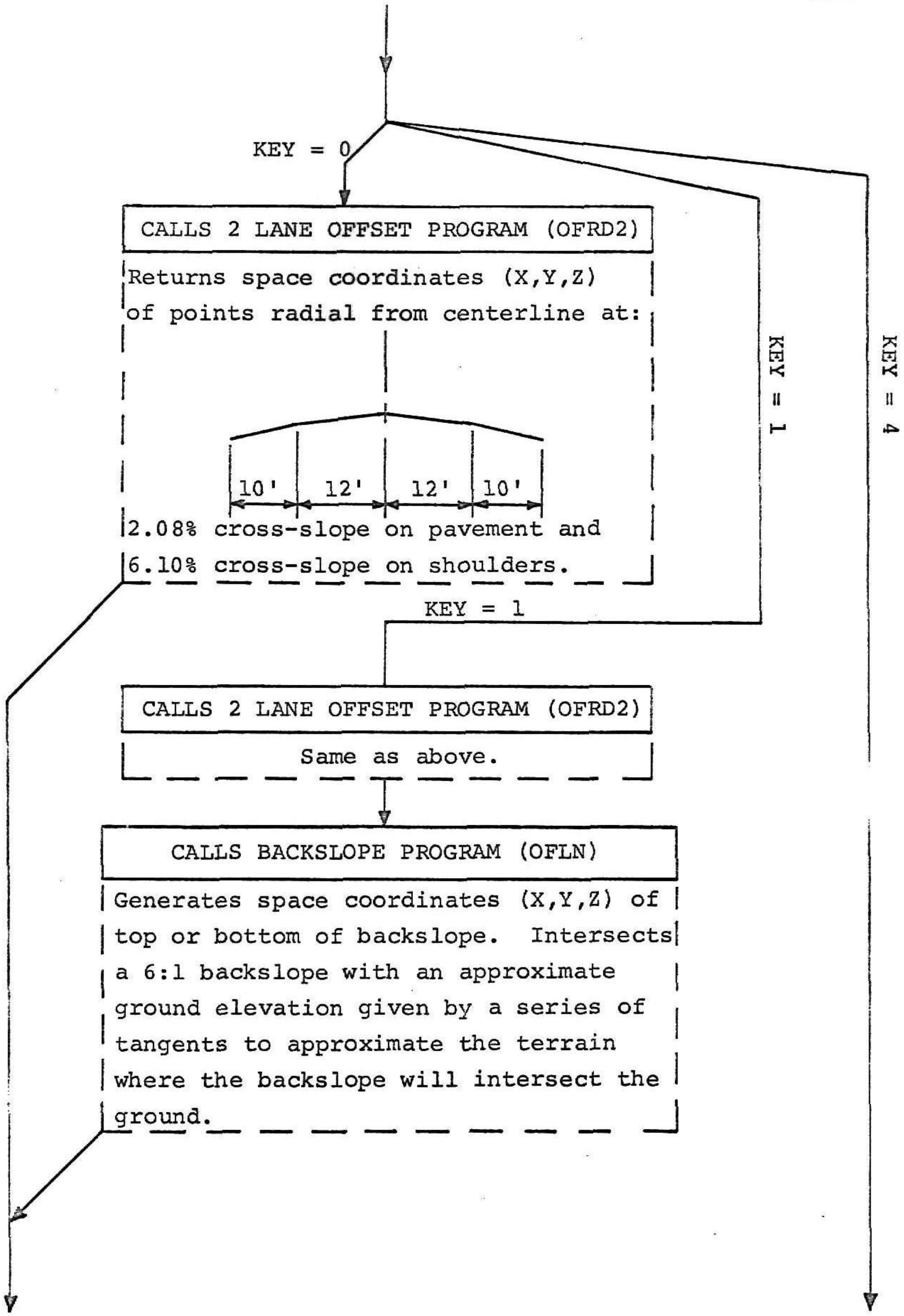
↓

CHECK INDICATOR FOR TYPE OF PERSPECTIVE DESIRED (KEY)

KEY=0; 2 lane roadway; 5 lines with centerline, pavement edges and shoulder edges.
KEY=1; 2 lane roadway; 6 lines with pavement edges, shoulder edges and top or bottom of backslopes.
KEY=4; 4 lane roadway, 2 lanes each direction; 12 lines with centerlines, edges of roadways, edges of shoulders and top or bottom of backslopes.
KEY=6; not used.
KEY=Negative, 2, 3, 5 or > 6, program aborts.

↓

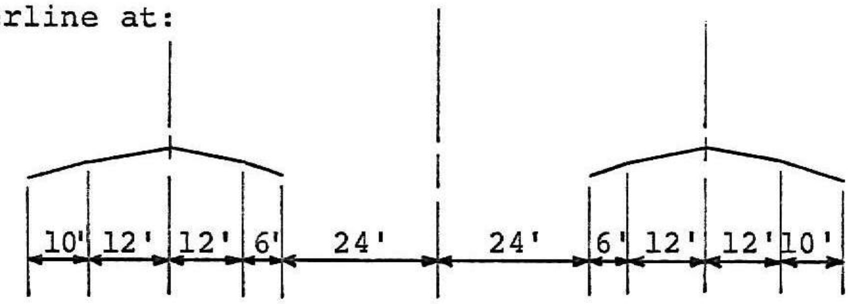
*Source: Reference 5.


KEY = 0
KEY = 1
KEY = 4
CALLS 2 LANE OFFSET PROGRAM (OFRD2)
Returns space coordinates (X,Y,Z) of points radial from centerline at:
10'
12'
12'
10'
2.08% cross-slope on pavement and 6.10% cross-slope on shoulders.
KEY = 1
CALLS 2 LANE OFFSET PROGRAM (OFRD2)
Same as above.
CALLS BACKSLOPE PROGRAM (OFLN)
Generates space coordinates (X,Y,Z) of top or bottom of backslope. Intersects a 6:1 backslope with an approximate ground elevation given by a series of tangents to approximate the terrain where the backslope will intersect the ground.

KEY = 4

CALLS 4 LANE OFFSET PROGRAM (OF4L)

Returns space coordinates (X,Y,Z) of points radial from centerline at:



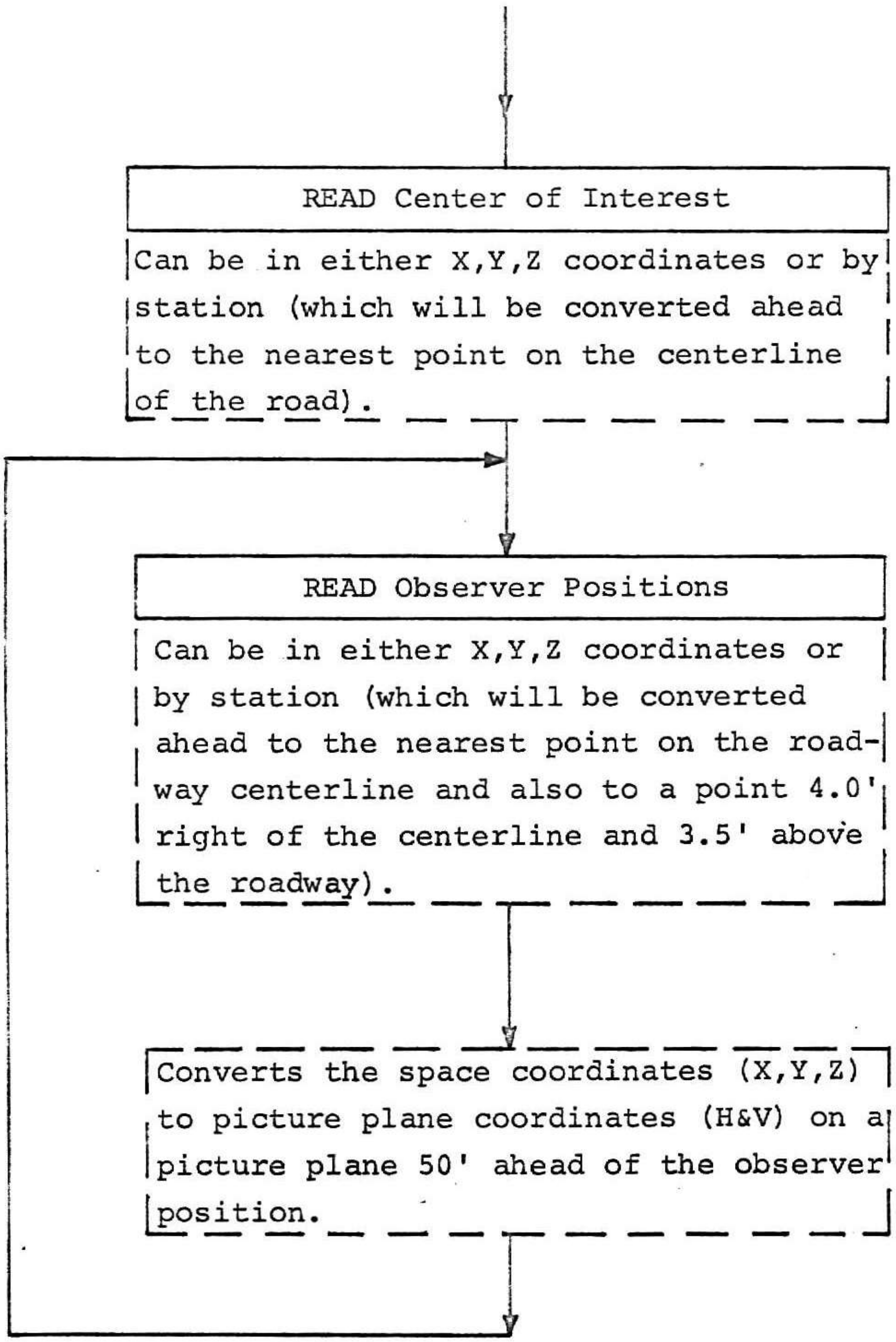
2.08% cross-slope on pavement

4.20% cross-slope on shoulders

CALLS BACKSLOPE PROGRAM (OFLN)

Same as above.

MAIN PROGRAM has now stored the X,Y,Z coordinates of all points along the highway.


READ Center of Interest
Can be in either X,Y,Z coordinates or by station (which will be converted ahead to the nearest point on the centerline of the road).
READ Observer Positions
Can be in either X,Y,Z coordinates or by station (which will be converted ahead to the nearest point on the roadway centerline and also to a point 4.0' right of the centerline and 3.5' above the roadway).
Converts the space coordinates (X,Y,Z) to picture plane coordinates (H&V) on a picture plane 50' ahead of the observer position.

APPENDIX C*

The following is the general format of the JOB card:

//jobname JOB (parameter est.),'name',MSGLEVEL=(1,1),CLASS=jobclass

where (parameter est.) must be in the form
(account#,time,lines,cards,forms,copies,log,lpp).

jobname: 1-8 alphameric characters, the first of which must be alphabetic. This field is required.

account#: The account to which charges are levied. This is a required field of eight characters. A security character may immediately precede this field.

time: Estimated execution time in minutes. This field is optional and may consist of up to four digits. If omitted, one minute is assumed.

lines: Estimated line count in thousands of lines. This field is optional and may consist of up to four numeric digits. If multiple copies are requested, this parameter refers to a single copy, not the total printed output. If omitted, six hundred lines will be assumed. (Example: "6" for 6,000 lines.)

cards: Estimated number of cards to be punched. This field is optional and may consist of up to four numeric digits. If omitted, 100 cards will be assumed. (Example: "200" if 200 cards are to be punched.)

forms: Special forms for printing. This field is optional and may consist of one numeric character. If omitted, single-part standard forms will be assumed. The following are the optional forms codes.

1601	Standard Default	6 lines/inch
1602	White Paper	6 lines/inch
1603	3-ply Paper	6 lines/inch
1803	3-ply Paper	8 lines/inch
1801	Standard Paper	8 lines/inch
1802	White Paper	8 lines/inch
1605	5-ply Paper	6 lines/inch

*Source: Reference 2.

copies: The number of printed copies wanted. This field is optional and may consist of up to two numeric digits. If omitted, one copy is assumed.

log: The HASP System Log. This field is optional and may consist of the letter "N" if the log is to be deleted. The log is a record of messages issued by the system and the operator during the running of your job. If omitted, the log is produced.

lpp: Lines per page. This field is optional and may consist of up to two numeric digits. Placing the number "0" in this position will allow lines to continue through the bottom and top margins of each page. (Example: "45" will give 45 lines per page.) If omitted, 60 lines will be printed per page.

name: The programmer's name. This field is required and is limited to 13 characters. If the field contains special characters other than periods, it must be enclosed in apostrophes (not quotes). If the special characters include apostrophes, each must be shown as 2 consecutive apostrophes.

MSGLEVEL: This field is optional and tells the job scheduler which statements or messages are to be written on output listings. The first number in the parentheses specifies whether JCL statements are to be printed as output. The possible codes are:

- 0 only the JOB statement is written.
- 1 all input statements, cataloged procedure statements, and internal representation of procedure statement parameters after symbolic parameter substitution are written.

The second number determines if allocation and termination messages are to be printed. The codes are:

- 0 no allocation or termination messages are written unless the job abnormally terminates.
- 1 all allocation or termination messages are printed.

If the user codes MSGLEVEL=1 the (1,1) specification will result. If omitted, MSGLEVEL=(1,1) is assumed.

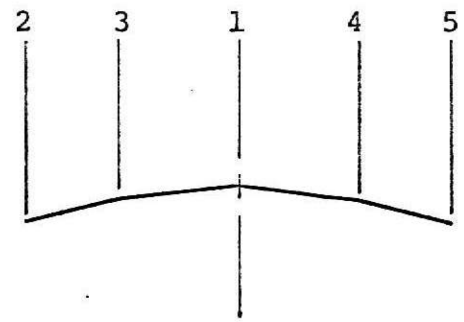
jobclass: specifies in which partition a job will be run. Default will be CLASS A. Section 5.2.3.1 defines the available classes. Jobs requiring more than the maximum time or lines must be scheduled with the Supervisor of Operations.

The following is a sample job card:

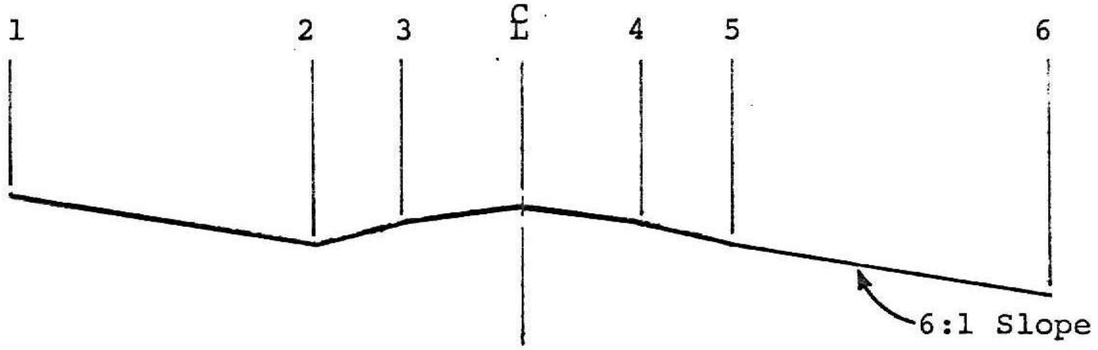
```
//HWYPPLOT JOB (IS08I0F4,10,5,500,1602,2,,66),'DJ MELLGREN'
```

jobname=HWYPPLOT
account number=IS08I0F4
time=10 minutes
lines=5,000
cards punched=500
forms printed=White Paper, 6 lines per inch
number of printed copies=Two(2)
the HASP log=default to HASP log printed
lines per page=66 lines (no top or bottom margins) The code "0" would have the same effect.
users name=DJ MELLGRAN
message level=default taken, all allocations and input printed
jobclass=default of CLASS=A taken

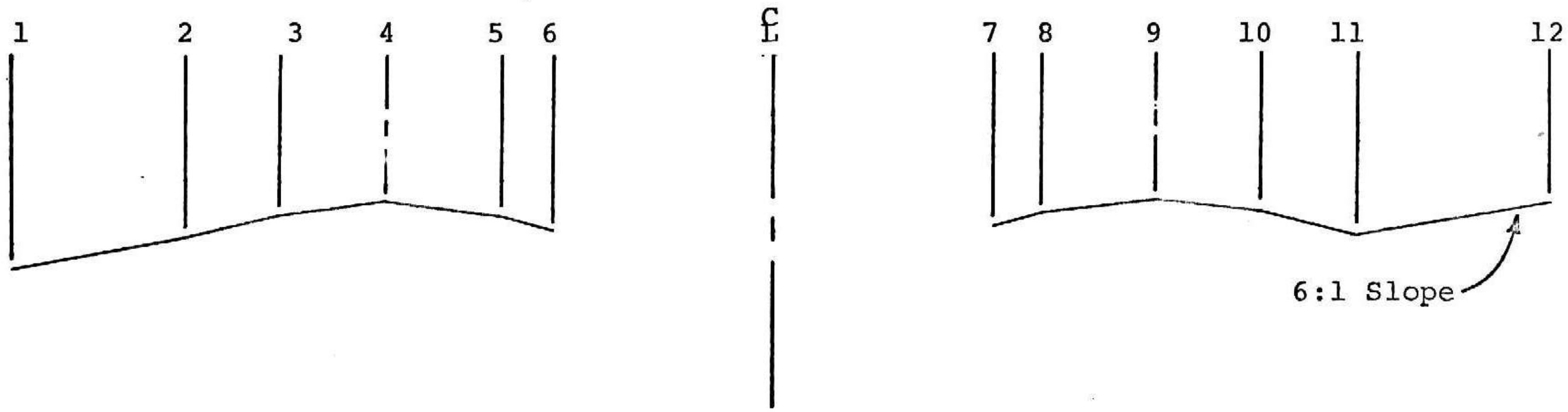
APPENDIX D



Two-Lane Roadway



Two-Lane Roadway with Backslopes



Four-Lane Roadway with Backslopes

HIGHWAY PERSPECTIVE PLOTTING BY COMPUTER:
A USER'S GUIDE FOR HWYPPLOT

by

DAVID J. MELLGREN

B.S., Kansas State University, 1969

AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Civil Engineering

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1972

ABSTRACT

With the present day emphasis on ecology and aesthetics, the highway designer must be made aware of the importance of visual aspects in his design. Normally the only tool that the designer has to visualize the roadway is his ability to "see" the roadway in perspective, based on plan and profile views. Considering the complexity of some of the modern highways, this would truly be a formidable task. Therefore, it would be highly desirable that some means be developed whereby the designer could visualize his design prior to construction.

One technique is to prepare highway perspective views through the use of a computer and an electronic plotter. In order to accomplish this, it is first necessary to determine the three-dimensional (space) coordinates of the roadway. Then, through a transformation of the space coordinates into two-dimensional (picture plane) coordinates, and with an appropriate set of commands, the plotter is able to draw the perspective.

The Department of Civil Engineering at Kansas State University, has such a highway perspective plot program, referred to hereafter as HWYPPLOT. This program consists of a main program and twelve subroutines to accomplish the transformation of input data to picture plane coordinates. Then this output is used by the K-State Computing Center's CalComp Digital Incremental Plotter to form the perspective plot.

HWYPPLOT has the capability to draw two and four-lane roadways utilizing combinations of tangents, circular curves and spirals or unspiraled transitions for the horizontal geometry and tangents and parabolic curves for the vertical geometry. Superelevation can be included in the horizontal geometry, but only with the two-lane roadway. Independent alinements are not possible with the four-lane roadway as it is based only on a single alinement for both sets of roadways. Backslopes can be added to both the two- and four-lane roadways at a fixed slope of 6:1 from the outside edges of shoulder to a designated elevation. HWYPPLOT uses one center of interest and one or more observer positions in creating a specific perspective plot. The center of interest and observer position(s) can be input either in terms of X,Y,Z coordinates or by centerline station.

The purpose of this Report was to document HWYPPLOT with explanations and examples for subsequent use by Civil Engineering students in transportation design courses at K-State. This documentation consisted of first, a description of the required input cards with Format specifications; second, a series of input example problems; and finally, a series of perspective plot outputs from the respective example problems.