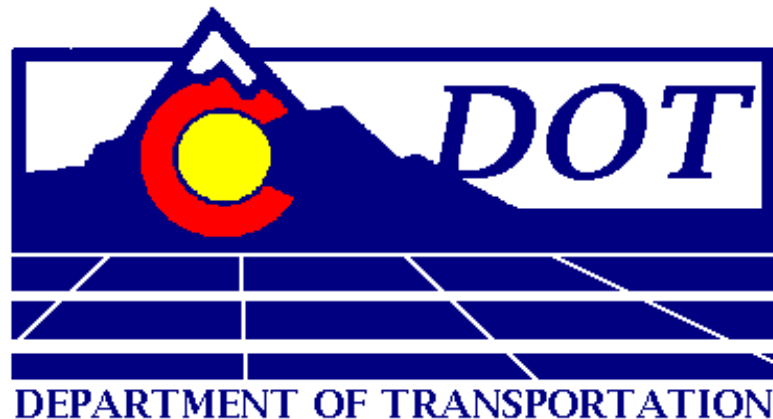


METRIC BRIDGE GEOMETRY USER'S MANUAL

by

**Project Engineering Customer Support Unit
Revised: December 15, 1995**



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Accessing Metric Bridge Geometry For CDOT - Staff Bridge Employees

Metric Bridge Geometry is available on the VAX cluster computer system at the Colorado Department of Transportation. At the main CDOT Bridge menu, enter 'GEOM' as follows:

Colorado Department of Transportation

A1	ALL-IN-1 Office Applications	EMS	Equipment Management System
EM	Electronic Messaging	ENG	Engineering Tools (MOSS, etc.)
DS	Directory Services	KER	Kermit File Transfer
FS	File Services	FV	File Viewer
PS	Print file(s)	DSUB	Bridge design sub menu.
US	User Services	DSUP	Bridge design super menu.
TK	TK Solver (Equations)	DMSC	Bridge design misc. menu.
ARCH	File archival system	GEOM	Bridge geometry menu.
BAMS	Bid Analysis Mgt System	RATE	Bridge rating menu.
FSS	Financial Subsystems	INV	Bridge inventory menu.
F463	DOH Form 463	IRIS	IRIS Beta test
GEOH	GeoHwy		
GGCC	SNA link to GGCC		
PMIS	ProMIS		

Enter option and press Return: **GEOM<Return>**

EXit <KP0> **TOP**menu <PF1> **Help** <PF2> **REF**resh <PF3> **LOG**out <PF4>

Enter 'MBGM' at the following Bridge Geometry menu:

BRIDGE GEOMETRY MENU

A1 ALL-IN-1
EM Electronic Messaging
DS Directory services
FS File services
US User services
KER Kermit file transfer
BRGM Bridge Geometry
MBGM Metric Bridge Geometry
CMBR Camber cutting diagram
COGO Coordinate Geometry
DAT DATENT bridge data entry
PCSO Picasso II
BR2S Geom to stick figure data trans
BR2C Geom to Camber data trans

Enter option and press RETURN: **MBGM**<Return>

EXit <KP0> **TOP**menu <PF1> **H**elp <PF2> **RE**fresh <PF3> **LO**gout <PF4>

This gives you access to Metric Bridge Geometry.

Accessing Metric Bridge Geometry For Consultant Employees

Metric Bridge Geometry is available on the VAX cluster computer system at the Colorado Department of Transportation. At the main CDOT Consultant menu, enter 'GEOM' as follows:

Colorado Department of Transportation

EM Electronic Messaging
DS Directory Services
FS File Services
US User Services
KER Kermit File Transfer
STAB Engineer's Estimate Tabulation
ENG Engineering Tools (MOSS, etc.)
DSUB Consultant design sub menu.
DSUP Consultant design super menu.
DMSC Consultant design misc. menu.
GEOM Consultant geometry menu.
RATE Consultant rating menu.
INV Consultant inventory menu.

Enter option and press Return: **GEOM<Return>**

EXit <KP0> **TOP**menu <PF1> **Help** <PF2> **REF**resh <PF3> **LOG**out <PF4>

Enter 'MBGM' at the following Bridge Geometry menu:

CONSULTANT GEOMETRY MENU

EM Electronic Messaging
DS Directory services
FS File services
US User services
KER Kermit file transfer
BR2S Geom to stick figure data trans
BR2C Geom to Camber data trans
BRGM Bridge Geometry
MBGM Metric Bridge Geometry
CMBR Camber cutting diagram
COGO Coordinate Geometry

Enter option and press RETURN: **MBGM**<Return>

EXit <KP0> **TOP**menu <PF1> **H**elp <PF2> **RE**Fresh <PF3> **LO**Gout <PF4>

This gives you access to Metric Bridge Geometry.

Chapter 1 - Synopsis

The bridge geometry program computes three-dimensional coordinates of points on a structure and on the roadway approaches to a structure. The input data consists of eight essential items:

1. Horizontal alignment data
2. Vertical alignment data
3. Superelevation and cross-slope data
4. Reference line and layout data
5. Girder/longitudinal lines
6. Bent/transverse lines
7. Dead load deflections
8. Roadway approach data

The surface deck of the structure is considered a grid of intersecting girder lines and bent lines. Output results include the coordinates of each intersection point, together with intermediate "fractional" points, printed sequentially along each girder line. Two independent coordinate systems locate the points in the horizontal plane: (1) the surveyor's station and offset from the horizontal control line, and (2) a right-hand rectangular Cartesian coordinate system (X,Y) with respect to a selected layout line.

Results printed for intersection and fractional points include: finished elevation, elevation adjusted for dead load deflection, girder line length, and roadway cross-slope (when continuous). For intersection points, bent line length and the skew angle of the bent line (with respect to the girder line) are also printed.

On roadway approaches, finished grade elevations and roadway cross-slopes are printed at given stations for each designated offset line.

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Chapter 2 - Metric Bridge Geometry Overview

TERMINOLOGY

"Col" means a column position (1 to 80) of a Hollerith punch card. Every input card begins with a two col Card Type field, precoded on forms.

"Default" value refers to the number, amount or option that will be used if a field is blank. In many cases default and zero have the same effect.

Except in the instance of normal crown section, "normal" is used in the sense of perpendicular (at right angles).

Directions such as left/right, back/ahead, in/out, or begin/end are with respect to ahead station unless otherwise specified.

Throughout this manual, the term "girder line" is used in a generic sense to mean any longitudinal line; i.e., a line running the length of the structure which intersects each bent line. Thus outside edge of deck, gutter line, back tangent, layout line, horizontal control line, and profile line are all examples of girder lines. Similarly, "bent line" is used generically to mean any transverse line (more accurately, a transverse vertical plane); i.e., a line running across the structure which intersects each girder line. Thus splice line, diaphragm, centerline of bearing, face of cap, and back face of abutment are all examples of bent lines. Girder lines have the attribute of elevation; bent lines do not.

A "straight" line means that its projection in the horizontal plane (disregarding elevation) is straight.

Unless otherwise specified the terms "reference bent," "reference line," or "reference bent line" mean the primary reference (bent) line. Each set of 04-07 cards is associated with a single primary reference line; there may be many secondary reference lines or none in a set.

After the program has located all bent lines, they are sorted in order of increasing station (at the point where they cross the horizontal control line). This means that the order of 06 cards is not significant: a group of 06 cards may be shuffled in any order without significantly affecting output. References to order of bent lines (such as "first," "next" or "last") refer to this sorted order, not to the sequence of 06 cards on input.

Two girder lines are always known to the program: (1) The station line controls horizontal alignment and is the line where, even through a curve, one station is equal to 1000 meters; it is commonly coincident with the profile (vertical control) line. (2) The layout line is a straight line determined by parameters on 04 card.

The term "intersection point" is used for points at the intersection of a girder line and a bent line. "Intermediate points" or "fractional points" occur in a "span" between two (not necessarily consecutive) intersection points. A "span" of deflection points corresponds to a "span" of fractional points.

The skew of a bent line, with respect to a girder line, is the angle measured from a normal on the girder line (drawn at the point of intersection) to the bent line. When the angle turns to the right, the skew is positive; to the left is negative, as shown in Figure 1.

"Finished" elevation does not necessarily mean finished grade. The finished surface of the deck means top of concrete, which may be below finished grade if, for example, a 50 mm asphalt overlay is to be required. Finished elevation for a line representing bottom of girder may be several hundred millimeters below finished grade.

When reference is made to an option being "selected" (or a card being "designated"), it is frequently to be inferred that the option is selected by coding ANY non-blank character in the indicated (single) col position of the card.

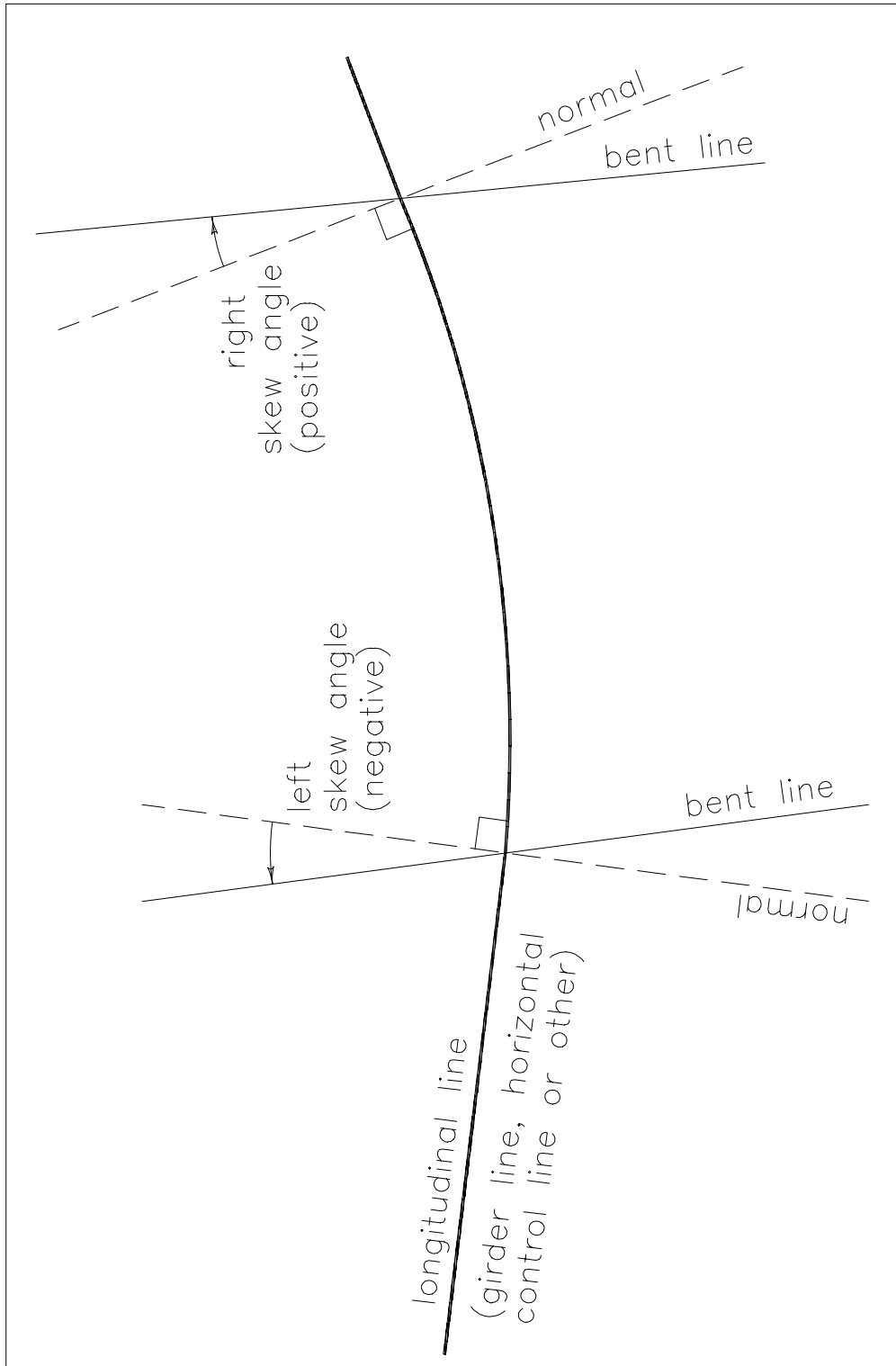


Figure 1 : Skew Convention

DECK ORGANIZATION

The input data deck consists of a set of 00 through 08 cards for one structure. Only one structure may be processed at a time.

One data set for a structure consists of:

- a. at least one (or arbitrarily many) 00 card(s)
- b. optional 01 card
- c. one 02 card
- d. at least one (or up to 16) 03 card(s)
- e. at least one (or arbitrarily many) sequence(s) of:
 - i. one 04 card
 - ii. at least one (or up to 30) 05 card(s)
 - iii. at least one (or up to 80) 06 card(s)
 - iv. (up to 200) optional 07 cards
- f. optional 08 card

Cards with Card Type 99 are transparent to the program; they may be used for comments anywhere in the deck.

If the program fails to find a required card in this sequence, it will ignore the card read and continue reading and ignoring cards until it finds the card type for which it is searching. In this case a fatal error message, listing (at least some of) the cards that were ignored, will be printed at the end of the output.

Chapter 3 - Input Data

DESCRIPTIVE DATA

00 CARDS (refer: "IDENTIFICATION AND ALIGNMENT" Form)

STRUCTURE ID

(cols 3-12, first card only)

This field provides a ten character identification which will appear in the banner line at the top of each page of output.

DESCRIPTION

(cols 3-80)

Provide a detailed description of the structure and its design including: project number, designer, detailer, location, method and materials of construction, span lengths, etc. An M in col 80 is required on the first 00 card to distinguish Metric input from English input files. In unusual or complicated situations, also include remarks regarding special considerations made for the input data, such as:

- a. nonstandard treatment of superelevation
- b. station equations or curves resulting in begin or end station coded in 04 card, cols 59-80
- c. nonuniform elevation shifts on 05 cards
- d. nominal offsets specified on 05 cards (line type 4)
- e. reasons for any adjustment to alignment data taken from line sheets

An unlimited number of 00 cards may be used, so make remarks thorough, detailed and complete. If more than seven cards are needed, eighty col forms may be used with first two cols blank. Formatting for double spaced lines may be accomplished by inserting blank cards as appropriate.

The information on these cards will be printed on the first page of output.

HORIZONTAL ALIGNMENT DATA

01 CARD(refer: "IDENTIFICATION AND ALIGNMENT" Form)

If the entire structure and roadway approaches lie on horizontal tangent at nominal cross-slope (no superelevation transitions or run-out), cols 3-43 may be blank.

When the entire structure and roadway approaches lie on horizontal tangent, the profile offset is zero, and no station equation is used, cols 3-80 may be blank. Equivalently, the card may be left out entirely.

CAUTION: It is usually better to code a proximal horizontal (or vertical) curve than to assume it will not affect elevations. For example, a bridge begins at station 1+120.0, just after a horizontal curve with P.T. at station 1+020.0 and with 50 meter transitions. The person coding the deck for a geometry run figures that the end of transition (station 1+060.0) occurs before the beginning of the 50 meter roadway approach (station 1+070.0); so they omit the horizontal curve.

Later, someone else wants to run the same deck for elevation sheet plots and decides to give 70 meter roadway approaches. If they merely change the approach length on the 08 card to 70.0, the translucent output will have errors in elevation at the first six stations (three-meter stations) of the approach.

A similar problem can occur with vertical curves near the structure. To prevent such problems, make full use of the Limits of Valid Elevation and Cross-Slope Data field (04 card, cols 59-80). If, in this example, the person originally coding the geometry deck had coded the end of transition station in the Begin Station field (despite the fact that the P.T. is nearly 100 meters before the structure), no errors would have cropped up in the later run.

DELTA

(cols 3-12)

Code the central deflection angle (including spirals) in degrees, minutes and seconds and indicate whether deflection is to the left (L) or right (R). Equivalent to an L is a minus sign for left deflections; equivalent to an R is a plus, a blank or any character other than L or minus.

Allowable range for delta is:

$$0^{\circ} 00' 04.13'' < |\text{DELTA}| < 179^{\circ} 59' 55.32''$$

P.I. STATION

(cols 13-23)

Code the station of the P.I. of the horizontal curve. This is a tangent station, not a station on the horizontal control line.

DEGREE OF CURVE

(cols 24-31)

Not used in the metric version.

SPIRAL LENGTHS

(cols 32-37 & 38-43)

Code the length in meters of spiral transitions into and out of the curve. If spirals are not used (simple curve), leave this field blank; but see "Crown and Superelevation Data" (03 cards) regarding smooth profiles.

PROFILE OFFSET

(cols 44-51)

If the horizontal control line is also the profile line, leave this field blank. If not, code the offset in meters from horizontal control to profile line. Positive offset indicates profile line is to the right of horizontal control; negative indicates offset is to the left.

RADIUS OF CURVE

(cols 52-58)

Code the radius in meters with EXPLICIT decimal point. The radius will be shown in the output under "Horizontal Alignment Data."

Allowable range for radius is: $43 \text{ m} \leq \text{rad} \leq 30,784 \text{ m}$

Exception: If spirals are not used (simple curve), a shorter radius may be used. The minimum radius permitted in this case is 3.1 meters.

STATION EQUATION

(cols 59-80)

If an equation occurs in the neighborhood of the structure, code the back station and ahead station of the equation in these fields. A station equation is permitted only at tangent alignment, never in the middle of a horizontal curve.

Metric Bridge Geometry

The first col of every station field (see list below) is for an equation number, a digit that "floats" in front of the station. If the equation is non overlapping (i.e., back station is less than ahead station), equation numbers are never required. For an overlapping equation (i.e., back station is greater than ahead station), equation numbers are required.

When equation numbers are required (for overlapping equations), equation number in the Back Station field may be any digit from 0 to 8 (blank is equivalent to zero); equation number in the Ahead Station field must be (at least) one greater than the digit in Back Station field.

When equation numbers are used (whether equation is overlapping or not), all stations in ALL station fields MUST be coded consistently with the required equation number.

The following are station fields:

- a. 01 card, cols 13-23 (P.I. Station)
- b. 01 card, cols 59-69 and 70-80 (Back and Ahead Stations)
- c. 02 card, cols 18-26 and 48-56 (P.I. Stations)
- d. optional 03 cards, cols 3-11
- e. 04 card, cols 3-13 (Reference Station)
- f. 04 card, cols 59-69 and 70-80 (Begin and End Stations)
- g. 08 card, cols 3-9 and 10-16 (Begin and End Structure)

VERTICAL ALIGNMENT DATA

02 CARD (refer: "IDENTIFICATION AND ALIGNMENT" Form)

It is usually better to code this card fully for the two vertical curves nearest the structure than to assume that roadway approaches will not extend into curves. (See caution given under "Horizontal Alignment Data.") Certain abbreviated forms, however, are acceptable:

When the entire structure and roadway approaches lie on vertical tangent, give either (1) two P.I. stations and elevations, or (2) a grade (either field) and P.I. (either field). For reasons of accuracy (see Percent Grade, cols 3-11) the first method is recommended. Curve lengths are ignored in this case.

When the entire structure and roadway approaches lie on a single vertical curve, give either (1) a grade (either field, as appropriate) and two P.I.'s, or (2) two grades and a P.I. (either field). Again, for reasons of accuracy, the first method is recommended and a curve length for the P.I. not associated with a change in grades is ignored.

PERCENT GRADE

(cols 3-11)

Code the signed percent grade (i.e., rise in meters per 100 meters of run) approaching the first vertical curve. Note: Grades on line sheets are frequently given to four decimal places. Better accuracy can be obtained by recomputing these grades (from P.I. stations and elevations) to six decimal places, especially when the structure is some distance away from the P.I.

LENGTH OF VERTICAL CURVE IN

(cols 12-17 & 42-47)

Code the prior length of the vertical curve (that portion of the curve prior to the P.I.) in meters. In the usual case of a symmetrical curve, this will be half the total curve length.

STATION OF P.I.

(cols 18-26 & 48-56)

Code the station of the P.I. of the vertical curve.

ELEVATION OF P.I.

(cols 27-35 & 57-65)

Code the tangent elevation of the P.I. (in meters above sea level). There is a difference between "elevation of the P.I." and "grade elevation at the P.I. station"; this field is NOT a grade elevation.

LENGTH OF VERTICAL CURVE OUT

(cols 36-41 & 66-71)

If the vertical curve is asymmetrical, code the post P.I. length of the vertical curve (that portion of the curve beyond the P.I.) in meters. In the usual case of a symmetrical curve, the half-length need be given only once (in either the IN or OUT field) with the other field blank.

PERCENT GRADE

(cols 72-80)

Similar to cols 3-11 (see above) for the grade beyond the second (or only) vertical curve.

CROWN AND SUPERELEVATION DATA

03 CARD (refer: "SUPERELEVATION AND LAYOUT DATA" Form)

The initial 03 card is required for each data set. It may optionally be followed by up to fifteen superlevation override 03 cards for nonparabolic crowns only; parabolic crowns are not superelevated.

To obtain smooth profiles along girder lines (especially important for welded-plate steel girders and precast box girders), the program will insert a transition vertical curve (of 15.24 meters) at every station where the cross-slope changes nonlinearly. See Chapter 4, "Table of Roadway Cross-Slopes," for a complete description of transition vertical curves. This applies to all superelevated crowns (see Maximum Length of Transition Vertical Curve, cols 51-53). There remain two situations where a kink (a discontinuity in the first derivative of elevation as a function of length) can occur and the user is cautioned to avoid them unless the significance of the kink is clearly understood and is considered negligible.

One situation occurs at the P.C. or P.T. of a horizontal curve that does not have spiral transitions (simple curve). Regardless of whether the curve is superelevated, a kink will occur at this station in any girder line that is some distance from the horizontal control line. The severity of the kink depends on the offset from horizontal control and on the radius of curve. The best way to avoid this situation is to put spiral transitions (of length 15.24 meters when not superelevated [e=NC] or transition length when supered) in all horizontal curves.

The second situation occurs in the middle of a center crown (crown type C) when a girder line runs across the crown at a significant skew, or when curved and not superelevated with segmented girder lines (line type 1). This situation may be avoided by calling for a parabolic crown (crown type P) and adjusting vertical P.I. elevations downward or by NOT selecting offset option for segmented girder pattern shift (04 card, col 29).

CROWN TYPE

(col 3)

Indicate the typical section crown type by coding A, B, C or P in this field:

- A) shoulder crown, high side right
- B) shoulder crown, high side left
- C) center crown (center pivot or shoulder pivot)
- P) parabolic crown (see cols 57-80 below)

(The characters 1, 2 and 3 are equivalent to A, B and C respectively. Equivalent to a P is any character other than A, B, C, 1, 2 or 3.)

NOMINAL CROSS-SLOPE

(cols 4-8)

Code the typical section cross-slope (on tangent) in meters per meter with or without a sign.

SUPER RATE (e)

(cols 9-12)

Code the maximum rate of superelevation (never less than zero) in meters per meter for the horizontal curve. If e=RC (remove adverse crown), code this field the same as nominal cross-slope. If e=NC (normal crown), leave this field and cols 21-50 blank.

If the superelevation transitions meet in the middle of the horizontal curve, a 15.24003 meters transition vertical curve will prevent the cross-slope from actually attaining e. The table of roadway cross-slopes printed on output will give the maximum cross-slope attained. In such cases, it may be advantageous to slightly augment the value given for e so that this maximum more nearly approximates the desired e value.

PIVOT OFFSET FROM PROFILE LINE

(cols 13-20)

Code the offset in meters from profile line to the pivot point. This dimension, usually found on the roadway typical section, may depend on the direction of the horizontal curve. For example, a center crown with shoulder pivot may have a pivot offset of +8.0 meters for a curve to the right or -8.0 meters for a curve to the left.

TRANSITION LENGTH FOR SIMPLE CURVE

(cols 26-30 & 41-45)

If the horizontal curve does not have spiral transitions, code the length of transition for superelevation in meters. Cols 41-45 may be blank if transition out is the same length as transition in.

PERCENT OF TRANSITION OUTSIDE SIMPLE CURVE

(cols 31-35 & 46-50)

Code the percent of superelevation transition length to be placed before the P.C. (cols 31-35) and after the P.T. (cols 46-50) only if it is not the standard 60 percent. See Standards M-203-10, -11, -12 and -13.

MAXIMUM LENGTH OF TRANSITION VERTICAL CURVE

(cols 51-53)

Default value for curve lengths is 15.24003 meters. If no curves are desired, code zero in this field. See Chapter 4, "Table of Roadway Cross-Slopes" for a complete description of transition vertical curves.

(cols 54-55, 56 & 57-65)

In general, these phantom fields should be blank.

Cols 54-55 are provided as an overflow for Maximum Length of Transition Vertical Curve field, so that a maximum length greater than 100 meters may be input by coding an explicit decimal point.

Col 56 provides an option to override the insertion of a 15.24003 meters vertical curve at a vertical P.I. that has no vertical curve. Standard roadway design practice allows: "Vertical curves are not required where algebraic difference" in grades "is less than 0.20 percent." (CDOH Roadway Design Manual, January 1987, page 2-10.) When this condition is encountered (and cols 51-53 are blank or nonzero), the program will automatically insert a vertical curve at the P.I. unless overridden by selecting this option.

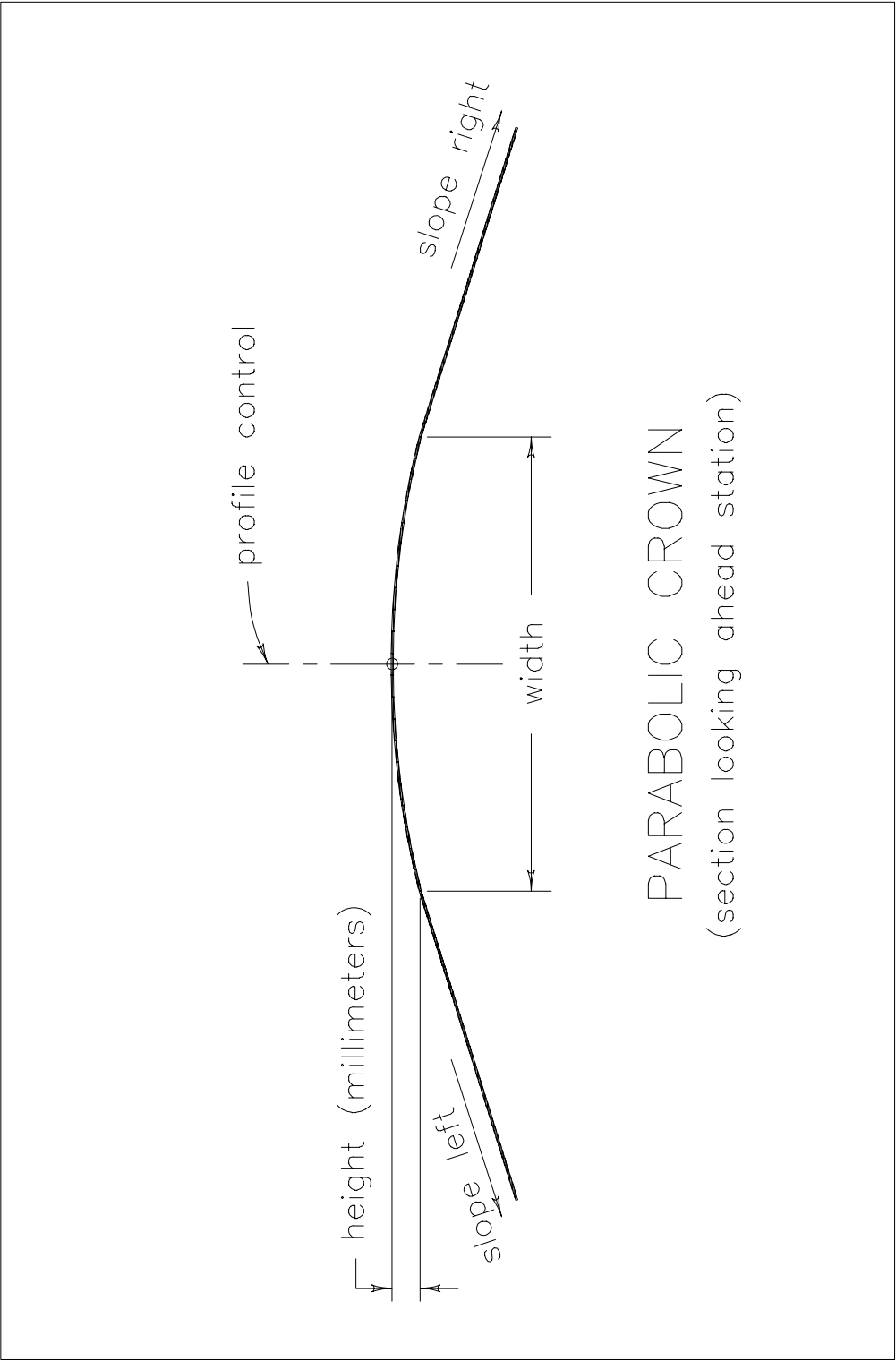
Cols 57-65 provide a correction factor for superelevation of type C crowns when the high point (profile line) is not in the center of the roadway.

PARABOLIC CROWN DATA (cols 57-80)

When col 3 is a P, leave cols 4-56 blank and code the width (in meters) and height (in millimeters) of the parabolic section in cols 57-65 and cols 66-70 respectively. The parabola is constructed symmetrically about the profile line at its apex. Shoulder slopes (cols 71-75 and cols 76-80) should be negative. If either shoulder slope is blank (or coded level), it will be constructed tangent to the parabola. See diagram, "Parabolic Crown."

Crown type P may also be useful in cases of a three-piece template with a level median since zero (level) is a valid crown height. Usefulness of this method is limited by the restriction that parabolic crowns may not be superelevated.

Optional superelevation override 03 cards may not be used with parabolic crown.



PARABOLIC CROWN
(section looking ahead station)

Figure 2 : Parabolic Crown

OPTIONAL SUPERELEVATION OVERRIDE

03 CARD (refer: "SUPERELEVATION AND LAYOUT DATA" Form)

Superelevation transitions that conform to Standards M-203-10, -11, -12, and -13, as well as most transitions that do not conform for reasons of asymmetry, can be handled with the single 03 card. Some nonstandard transitions, however, may require quite different methods.

One such case arises when the standard transition needs to be overridden only in a localized area. For example, when a cross-street forms an intersection in the middle of a spiral transition on the mainline, the superelevation must be held constant across the intersection. Code the initial 03 card for the standard superelevation transition, calculate the super rate at the middle of the intersection, and add two extra 03 cards with this cross-slope (adjusted for grade when appropriate) specified at stations before and after the intersection.

A sample table of roadway cross-slopes for such an instance might resemble:

STATION	SLOPE LEFT	SLOPE RIGHT	VC LENGTH	
(ON TANGENT)	.0150	-.0150	15.24 (MAX)	
1+059.9000	.0150	-.0150	15.24	begin
1+079.9000	0.0000	0.0000	15.24	run-out
				begin
				108 m
				spiral
1+120.0000	-.0333	.0333	15.24 -U-	8 m
				cross
				-street
1+140.0000	-.0333	.0333	15.24 -U-	at sta
				1+130
1+187.9000	-.0750	.0750	15.24	end
				spiral
				. . . etc. . . .

The "-U-" note indicates a user-specified cross-slope from optional 03 cards. The three 03 cards used in this instance were:

```
03 B .015 .075 -1.0
03 1+120 -.0333
03 1+140 -.0333
```

Stations were adjusted to put most of transition vertical curves outside of the 8 meter intersection. Cross-slopes were calculated assuming mainline grade was negligible.

Other such cases arise with compound curves, reversing curves or any instance where transitions are crowded together. In these cases, it is often preferable to inhibit the program's standard superelevation by leaving cols 9-12 blank (e=NC) and to code an optional 03 card for every station where the cross-slope changes nonlinearly. Up to fifteen optional 03 cards may be used in a structure data set.

STATION

(cols 3-11)

Code the station at which the given cross-slope is to be attained. In any instance where this station conflicts (tolerance 0.3048 meters) with a station computed by the program, cross-slopes given on optional 03 card will override those computed by the program.

SLOPE LEFT/SLOPE RIGHT

(cols 12-16 & 17-21)

Code cross-slopes in meters per meter using the sign convention shown on forms. For crown types A and B, only one field need be coded; if both are given, slope given in Slope Right field, cols 17-21, will be ignored. For crown type C, both fields must be coded; a blank field will be considered zero (level).

REFERENCE AND LAYOUT LINE DATA

04 CARD (refer: "SUPERELEVATION AND LAYOUT DATA" Form)

The orientation of the rectangular coordinate system is determined by the "reference line" and the "layout line." The layout line is a straight longitudinal line which may be defined in a number of different ways (see Layout Line Definition, col 26). The reference line is a bent line defined by station and skew given in cols 3-14 and 15-24. The origin of the coordinate axes is located at the intersection of the reference line and the layout line (unless altered by use of Transform Constant field, cols 41-58). The Y-axis is directed along the layout line, in the direction of ahead station unless reversed by col 30. The X-axis is normal to the layout line directed by the right-hand rule (i.e., i crossed into j is "up").

REFERENCE STATION

(cols 3-13)

Code the station of a point on the reference line. This point must be on either the horizontal control line, the back tangent or the ahead tangent (of the horizontal curve).

STATION TYPE

(col 14)

Indicate whether the reference station in the previous field is a station on horizontal control, back tangent or ahead tangent by coding, 0, 1 or 2 respectively. If no horizontal curve data were given on 01 card, these three options are all equivalent. If the reference station is before the T.S. (or P.C.), options 0 and 1 are equivalent. Similarly if the reference station is beyond the S.T. (or P.T.), options 0 and 2 are equivalent.

If the structure has been sectioned with more than one sequence of 04-07 cards (see Chapter 2, "Deck Organization"), any 04 card after the first may have col 14 designated 3, indicating that reference and layout lines from the previous section are to be left unchanged in the current section. Any 04 card with a 3 in this field should have only blanks in cols 3-13, 15-24, 26, 30, 34-80; information coded in these fields will be ignored. Conversely, all other cols (* fields on form) must be specified as needed.

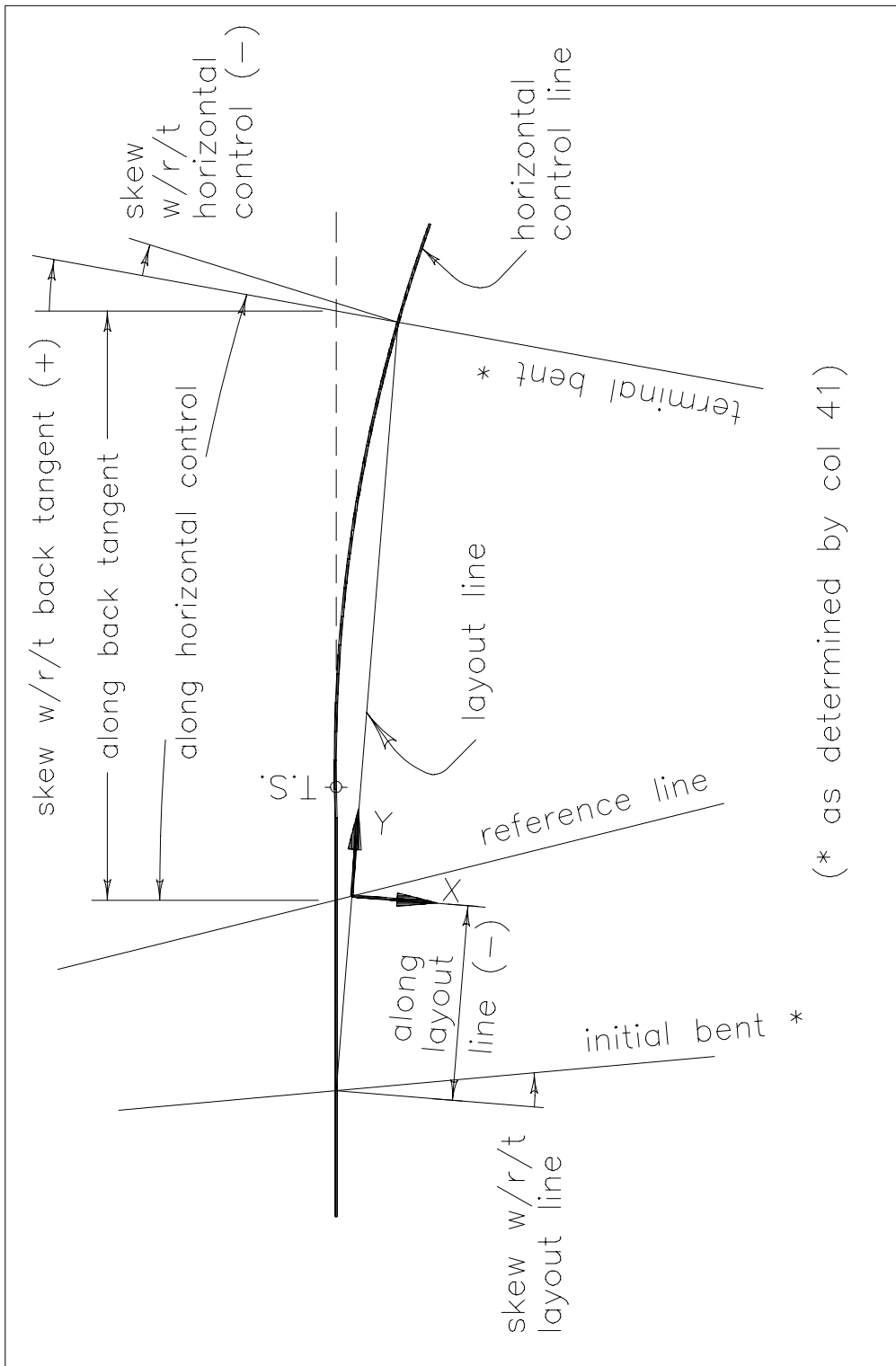


Figure 3 : Layout Line

SKEW

(cols 15-24)

Code the skew angle of the reference line in degrees, minutes and seconds and indicate whether skew is to the left or right. Equivalent to an L is a minus sign for left skews; equivalent to an R is a plus, a blank or any character other than L or minus.

In col 24, indicate whether the skew is with respect to the horizontal control line, the layout line, the back tangent or the ahead tangent by coding 1, 2, 3 or 4 respectively.

- 1) the horizontal control line
- 2) the layout line
- 3) the back tangent
- 4) the ahead tangent

In general, skew type 1 should be used only if station type (col 14) is designated 0 (on horizontal control). If no horizontal curve data were given on 01 card, skew types 1, 3 and 4 are equivalent.

DEFAULT SKEW

(col 25)

This option determines the skew to be used for bent lines (06 cards) that have distance type (col 11) 0, 1, 2 or 3 and that have blank skew field (cols 12-21). These bent lines will be constructed either parallel to the reference line or at the same skew (with respect to horizontal control) as the reference line according as this field is coded with 0 or 1 respectively. Equivalent to 1 is any character other than 0 or blank.

This field has no effect for 06 cards having, distance types 4, 6 or 7 (default is parallel to primary or secondary reference line) or having skew type other than default.

In general, when col 25 is designated 1, any 06 card with default skew (blank or zero in col 21) should NOT have distance type (col 11) designated 1, 2 or 3.

LAYOUT LINE DEFINITION

(col 26)

Code a 1 or 3 if layout line is to be the back tangent or ahead tangent of the horizontal curve. If no horizontal curve data were given on 01 card, either of these options will locate the layout line at the horizontal control line.

All other layout line defining methods should have col 26 designated 2 for "chord" definition. With this option, three methods for defining the layout line are available: (1) all 05 cards have col 51 blank; (2) the 05 card designated in col 51 is a girder line of type 0 (parallel to horizontal control); and (3) the 05 card designated in col 51 is a girder line of type 3 (flared girder line).

First method: no girder line designated. In this case, the layout line is constructed as a chord on the horizontal control line between two bent lines (06 cards) designated in col 41 (define chord layout line).

A line tangent to some point on the horizontal curve may be approximated by making the two bent lines very close together. In most cases, "very close" should be taken as not closer than 0.00012 meters; for a very short radius (less than 60 meters), 0.00006 meters will suffice.

Second method: type 0 girder line designated. In this case, similar to the first method, the points of intersection of the designated girder line with each of two bent lines (06 cards) designated in col 41 (define chord layout line) are found. The layout line is then constructed to pass through these two intersection points.

This method may be used to construct a layout line parallel to and offset from the back (or ahead) tangent by putting the two bent lines before the T.S. (or after the S.T.). A better alternative in this situation would be to define the layout line as the back (ahead) tangent by coding a 1 (3) in col 26 and to shift the Y-axis by coding the appropriate offset in the X field (cols 41-49) of the transform constant for layout coordinates.

With either first or second method, when no horizontal curve data have been given on 01 card, col 41 of 06 cards is ignored.

Third method: type 3 girder line designated. In this case, the flared girder line is constructed in the usual manner (see "Girder Line Data" [05 cards], line type 3), and the layout line will be that same line. Col 41 of 06 cards is ignored in this case.

When this method is used, care must be taken to ensure that the designated flared girder line is located independent of the layout line; that is, e.g., a 06 card designated in col 40 may not have distance type 1 (along layout line).

SEGMENTED GIRDER LINES TO BE BROKEN AT REFERENCE LINE

(col 27)

This field has the same effect for the reference line as 06 card, col 39 has for other bent lines. See "Girder Line Data" (05 cards), line type 1.

SUPPRESS LISTING

(col 28)

Select this option to suppress listing of reference line intersection points on translucent output. This option does not affect output on either 8.5X14 stripe or page printer.

OFFSET OPTION FOR SEGMENTED GIRDER PATTERN SHIFT

(col 29)

The purpose of this option is to make base chords balance on the curved girder line. When this option is selected, each base chord for segmented girder lines is shifted (before segmented girder offsets are measured) by an offset equal to half the maximum divergence (from base chord) of the girder line chosen for base chords (05 card designated in col 50).

The effect is to shift the entire girder pattern toward the outside of the curve by an offset that is independent for each span and is proportional to the net change in central deflection through the span. Offsets depend on radius of the girder line chosen for base chords, length of span, and eccentricity of spirals; but are independent of bent line skews, offsets of segmented girder lines, and whether or not fractional points are used.

This option is particularly useful in a situation of slight (or no) skew where the girder line chosen for base chords represents centerline of the structure. Selecting this option will then make base chords that are more nearly balanced in the center of the structure.

REVERSE LAYOUT LINE

(col 30)

In unusual situations it may be desirable to have points on output listed in order of decreasing, (rather than increasing) stations, or to have the positive Y direction in the direction of decreasing (rather than increasing) stations. Using, this field, four options are available:

- 0) print by increasing station, layout line not reversed (default)
- 1) print by DECREASING station, layout line REVERSED
- 2) print by DECREASING station, layout line not reversed
- 3) print by increasing station, layout line REVERSED

In general, options 0 and 1 will print in order of increasing Y ordinate, options 2 and 3 in order of decreasing Y ordinate.

Note: For a data set that already has a non zero Transform Constant field (cols 41-58), deciding to reverse the layout line (by options 1 or 3) will require reversing the sign of both elements of the transform constant.

This option may be used when the horizontal control line reverses on itself (as by a cumulative delta greater than 90.0 degrees), the structure is broken into more than one structure data set (see Chapter 2, "Deck Organization"), and it is necessary to use the same layout line in both data sets: use option 3. This option may also be useful when two station lines are stationed in opposite directions: use option 1.

This option affects listing of girder lines only (not roadway approaches). Use of this option has no effect on the program's orientation of back/ahead, left/right, begin/end.

REQUEST X-0 POINTS

(col 31)

Select this option to request X-type fractional points (X-0 and X-n points) opposite the intersection points at beginning and end of each span of fractional points (in addition to those opposite the intermediate points). X-0 points will not be plotted on elevation sheets. See "Girder Line Data" (05 cards), X-type Fractional Points, cols 52-53.

EXTENDED PRINT CAPABILITY

(col 33)

Because a slight error in punching Fractional Points fields (06 cards, cols 22-28) may result in an excessive number of points on output of girder lines, the program will estimate the number of points to be printed, and if it seems to be a large number, will terminate (after printing one girder line) with a fatal error. A "large number" means more than 200 points per girder line, approximately five pages of output, with more than three girder lines.

If Fractional Points fields have been carefully checked, one may select this option to override the error detection and indicate to the program that a large number of points is expected. When this option is selected or when fewer than four girder lines are being run, the program has the capacity to handle up to 2,000 points (per girder line), approximately 50 pages of output.

TRANSFORM CONSTANT FOR LAYOUT COORDINATES

(cols 41-58)

To move the origin of the coordinate axes to any desired location (by translation without rotation), code the desired coordinates of the reference-line-layout-line intersection in these fields.

For example: If the origin is currently at the intersection of reference line and layout line and the desired location of the origin is a point that currently has coordinates (-16.47, 23.85), one would code these fields as:

X	Y
16.47	-23.85

For a data set that already has a non zero Transform Constant field, deciding to reverse the layout line (by use of col 30, see above) will require reversing the sign of both elements of the transform constant.

LIMITS OF VALID ELEVATION AND CROSS-SLOPE DATA

(cols 59-69 & 70-80)

Code in these fields the limits of valid station, elevation and cross-slope data known to the program. Any intersection point, fractional point, or roadway approach point that has a station before the Begin Station entry or after the End Station entry will not be printed.

The Begin (or End) Station limit is generally determined by whichever of the following four conditions occurs nearest the beginning (end) of the structure:

- a. a station equation not given on 01 card
- b. a superelevation transition not given on 03 cards
- c. the P.T. (P.C.) of a vertical curve not given on 02 card
- d. the S.T. or P.T. (T.S. or P.C.) of a horizontal curve not given on 01 card

Use of these fields is optional; if either field is blank, valid station and elevation data are assumed to be unlimited at that end. See caution given under "Horizontal Alignment Data"; also see Chapter 4, "Table of Roadway Cross-Slopes," for other limiting conditions.

This field may be used only on the first 04 card (following a set of 03 cards). When more than one set of 04 thru 07 cards occurs (in the same set of 00 thru 08 cards), this field is ignored on all 04 cards after the first set of 04 thru 07 cards.

GIRDER LINE DATA

05 CARD (refer: "GIRDER LINE DATA" Form)

LINE TYPE

(col 3)

Code 0, 1, 2, 3 or 4 accordingly as the girder line being described is:

- 0) a curved line parallel to the horizontal control line (used principally for outside edges, gutter lines, profile line, or pivot point)
- 1) a segmented girder line
- 2) a straight line parallel to the layout line (used principally for parallel girders where the layout line lies along one of the girder lines)
- 3) a flared girder line
- 4) a curved line whose offset varies with superelevation (used principally for box girder structures)

LINE TYPE 1

A segmented girder line is a broken line composed of line segments which are parallel to the base chords on a girder line (05 card, line type 0 only) designated in col 50 (see col 50 below). The program first locates the points where the designated type 0 girder line intersects each bent line (06 card) designated in col 39 (segmented girder lines to be broken). Through each consecutive pair of such intersection points, a base chord is constructed (and then shifted if 04 card, col 29 has been selected). For each span subtended by a base chord, the segmented girder line offset (offset type 5) is measured perpendicular from the base chord to determine the line segment used for the girder line in that span.

Output for segmented girder lines will show two intersection points for each bent line where segmented girder lines are broken (06 card designated in col 39, except first and last). The first of these two intersection points is where the segment in the previous span intersects the bent line; the second is where the segment in the next span intersects the bent line.

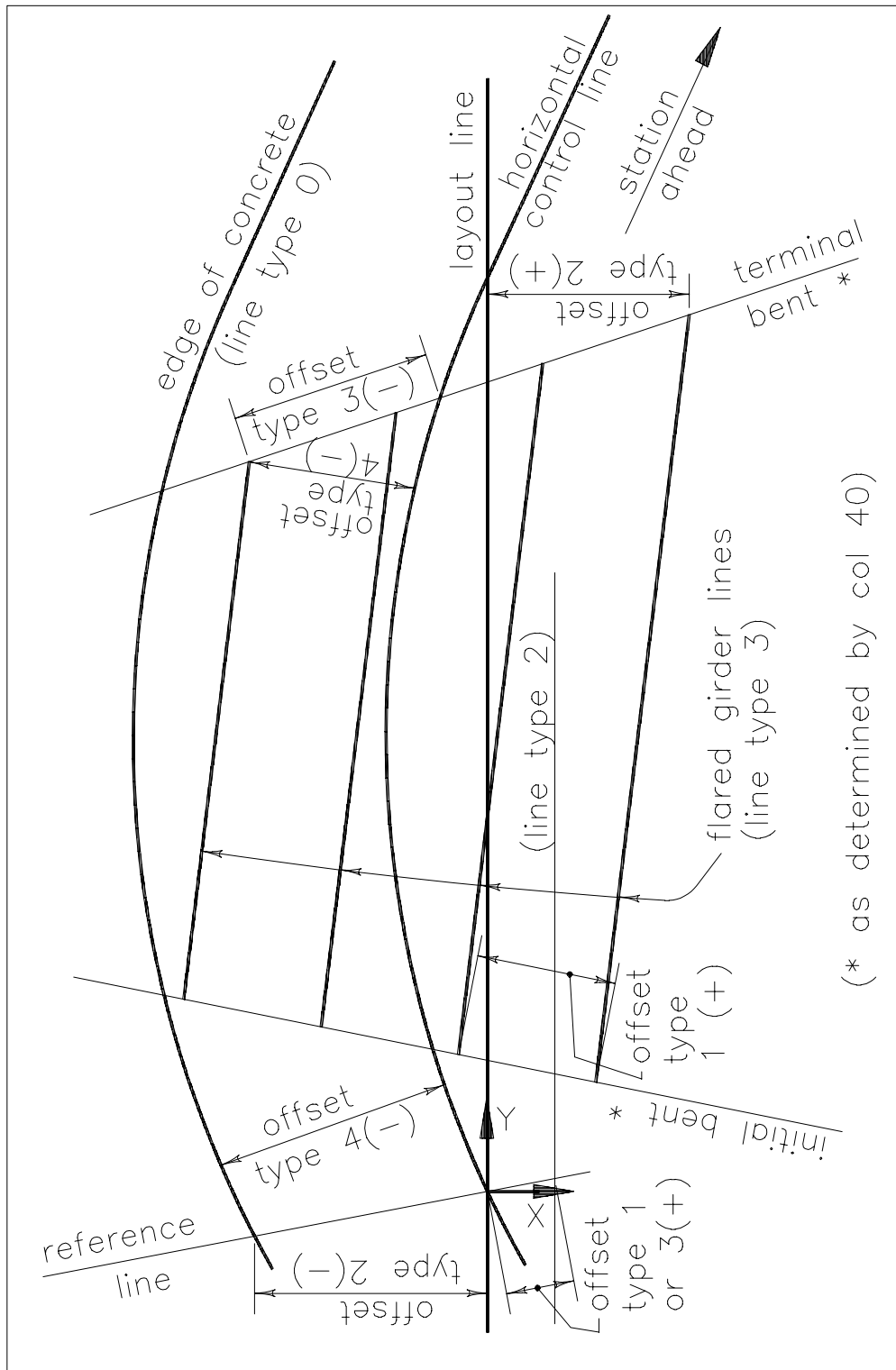


Figure 4 : Girder Lines

LINE TYPE 3

A flared girder line is a straight line passing through two points which are determined by the given offset distances and by two bent lines (06 cards) designated in col 40 (bent to define offsets for flared girder lines). The program first locates the two designated bent lines and sorts them in order of increasing station (at the point where they cross the horizontal control line). On the first bent line, the point that has the initial offset (cols 4-12) is located; on the second bent line, the point that has the terminal offset (cols 13-21) is located; then the girder line is constructed to pass through these two points. Note that the sequence of initial/terminal offsets is independent of the sequence of 06 cards on input; that is to say, reversing the card positions of the two 06 cards designated in col 40 will not change the output.

LINE TYPE 4

For a box girder structure, the dimensions of a section in the vertical plane of a station must be kept constant. When the cross-slope of the deck is constant, type 0 girder lines may be used to represent points on the box. Under conditions of varying cross-slope, however, type 4 girder lines must be used to keep a section of constant shape. The offset of a type 4 girder line varies (when the cross-slope changes) in such a way as to keep a constant distance from the point of finished grade at horizontal control (or other type 0 girder line, 05 card designated in col 56, see below).

Type 4 girder lines may be used only with shoulder crowns (03 card, col 3, crown type A or B). Failure to meet this requirement will cause a fatal error.

The nominal offset of a type 4 girder line is calculated by the program by first finding an average cross-slope and then determining, what the offset of the girder line would be at that cross-slope. The nominal offset then is like a type 0 girder line (parallel to horizontal control) for which the actual offset of the type 4 girder line is expected to be as often to the left of this nominal offset as to the right. Output from the program will include the stations between which the average cross-slope is calculated and the resultant average.

Girder line lengths are calculated along the (imaginary) type 0 girder line at the nominal offset. Other than the location of fractional points, the determination of girder line lengths is the only significance of nominal offset.

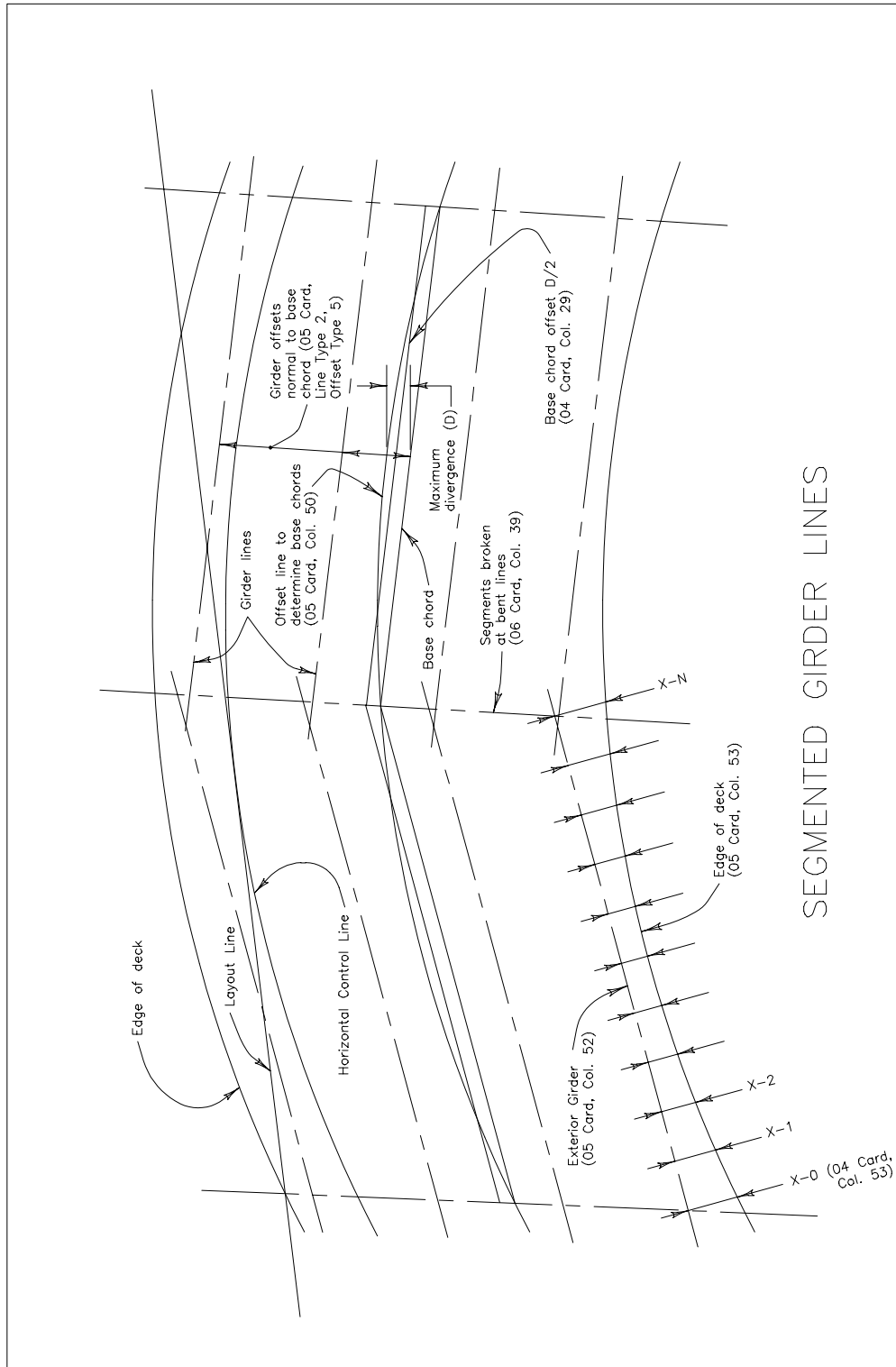


Figure 5 : Segmented Girder Lines

OFFSET DISTANCE

(cols 4-21)

For type 0 and type 2 girder lines, code the offset in cols 4-11 and the offset type (1, 2, 3 or 4) in col 12 and leave cols 13-21 blank. For type 3 (flared) girder lines, code both initial and terminal offsets and offset types (1, 2, 3 or 4).

- 1) along bent line from layout line
- 2) along a normal from layout line
- 3) along bent line from horizontal control
- 4) along a normal from horizontal control

Offset types 1 and 3 mean that the given offset is to be measured along the bent line (reference line for type 0 or type 2 [parallel] girder lines; bent line [06 card] designated in col 40 for type 3 [flared] girder lines) from the layout line or horizontal control line. Offset types 2 and 4 mean that the given offset is a perpendicular offset, from the layout line or horizontal control line, located at the reference line (parallel girder lines) or designated bent line (flared girder lines).

For type 1 (segmented) girder lines, code the perpendicular offset from base chord in cols 4-11 and offset type 5 in col 12 and leave cols 13-21 blank. Offset type 5 must be used on all segmented (type 1) girder lines and only on segmented girder lines. If any offset other than type 5 is specified for a segmented girder line, a nonfatal error message (indicating that col 12 is assumed to be 5) will be printed: COL 3 CONFLICTS WITH COL 12.

For type 4 girder lines (offset varies with super), code the offset in cols 4-11 and the offset type (1, 2, 3 or 4) in col 12

- 1) from horizontal control at nominal cross-slope
- 2) from horizontal control at level cross-slope
- 3) from pivot point at nominal cross-slope
- 4) from pivot point at level cross-slope

Offset types 1 and 3 mean that the given offset is the offset that the type 4 girder line would have if the deck attained nominal cross-slope (03 card, cols 4-8). Offset types 2 and 4 mean that the given offset is the offset that the type 4 girder line would have if the deck attained level cross-slope. See diagram, "Offsets for Type 4 Girder Lines."

Also code an elevation shift (in meters, not millimeters) in cols 22-29 (see cols 22-29 below). Leave cols 13-21 blank unless a nominal offset is to be specified.

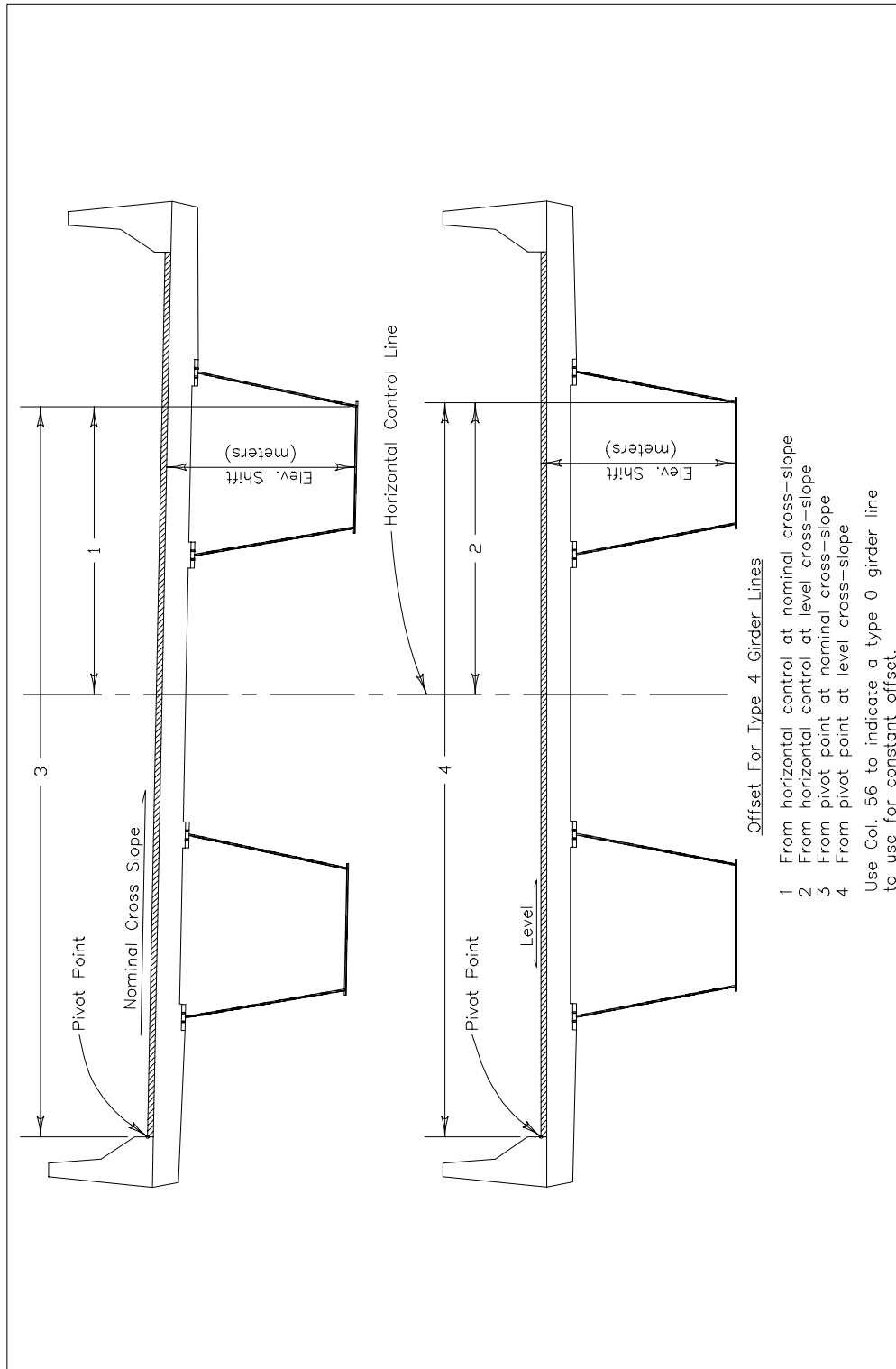


Figure 6 : Offsets for Type 4 Girder Lines

In most cases it is preferable to let the program calculate the nominal offset of a type 4 girder line (see col 3, line type 4, above). In certain cases however, it may be desirable to specify a nominal offset for the program to use regardless of the average cross-slope. Such a case may arise, for example, when the structure is broken into more than one structure data set (see Chapter 2, "Deck Orientation") and it is necessary to use the same nominal offset in both data sets. Code the nominal offset from horizontal control in cols 13-20 (Terminal Offset field) and code offset type 8 in col 21. Offset type 8 may be used only in col 21 and only for nominal offset of a type 4 girder line.

ELEVATION SHIFT

(cols 22-29)

For line types 0, 1, 2 or 3, the "elevation shift" is a bias term (measured in millimeters vertically) which will be added to the calculated finished grade elevations at every point on the girder line before elevations are printed. If elevations on the girder line are desired at finished grade, this field may be blank. Otherwise, code the desired elevation shift, in millimeters and decimals of a millimeter, in this field; e.g;., if elevations 50 millimeters below finished grade are desired, code -50.0 in this field. Note: For line types 0, 1, 2 or 3, implied decimal place is between cols 26 & 27.

For line type 4 (offset varies with super), the elevation shift is measured in meters at a normal to the cross-slope of the deck. See diagram, "Offsets for Type 4 Girder Lines." Note: For line type 4, implied decimal place is between cols 24 & 25.

If any girder line does not represent top of concrete deck, be sure to select Suppress Listing option (see col 57 below) so that the girder line will not be plotted on the elevation sheets. When elevation sheet plots are requested, a check is made for all girder lines having constant elevation shift, since the plotted sheets have a "top of concrete deck" note. If elevation shift varies from one girder line to another, a nonfatal error message will be printed (on plotter output only): ELEVATION SHIFT IS NOT CONSTANT.

DESCRIPTION

(cols 30-49)

Provide a twenty character description of the girder line in this field. Longer descriptions stand out better in headings on output, so use abbreviations only where necessary.

SEGMENTED GIRDER LINES ARE PARALLEL TO CHORDS ON THIS LINE

(col 50)

When type 1 (segmented) girder lines are used, a girder line parallel to horizontal control (line type 0), which is toward the outside of the curve from center of the structure, should be designated in this field. Base chords will then be constructed as chords on this girder line, each chord determined by bent lines (06 cards) designated in col 39 (segmented girder lines to be broken). See col 3, line type 1, above.

By default, when all 05 cards are blank in col 50, the horizontal control line will be used to construct base chords; this option should only be used when horizontal control is toward the outside of the horizontal curve at the center of the structure or when skew is very slight.

For example: Where a severe skew is involved with a structure curving to the right, one might use a line near (or even beyond) the left outside edge of deck to construct base chords. This construction has benefits of shorter girder lines and smaller skew angles than base chords constructed at center of the structure. Using a line that is too far to the left will cause an extreme overhang in the acute corner on the right side of the structure.

In a situation of mild skew, the girder line representing centerline of the structure may be designated in col 50. See "Reference and Layout Line Data" (04 card), col 29.

If this option is selected for a girder line of line type other than 0, a nonfatal error message (indicating that col 50 has been ignored) will be printed: COL 3 CONFLICTS WITH COL 50.

LAYOUT LINE IS A CHORD ON THIS LINE

(col 51)

See "Reference and Layout Line Data" (04 card), Layout Line Definition, col 26. This option may be selected only if line type (col 3) is 0 (parallel to horizontal control) or 3 (flared), and offset type (cols 12 and 21) is 3 or 4 (from horizontal control). If these conditions are not met, a nonfatal error message (indicating that col 51 has been ignored) will be printed: COL 51 CONFLICTS WITH COL 3, 12 or 21.

When 04 card, col 26 is designated 2 and all 05 cards are blank in col 51, the horizontal control line will be used to construct a chord layout line (by default).

X-TYPE FRACTIONAL POINTS

(cols 52-53)

X-type fractional points (commonly used along outside edge of deck and gutter line) are located at perpendicular offsets from fractional points (whether F-, D-, E- or X-type) on the nearest (exterior) girder. When 04 card, col 31 is designated, X-0 and X-n points are also located at perpendicular offsets from intersection points at the beginning and end of each span of fractional points.

Note: It is recommended that X-type fractional points be used only when the exterior girder is a straight line (i.e., line type is not 0 or 4). When the exterior girder is curved, fractional points on the gutter line may be projected as X-type points from F-type fractional points on the outside edge (designated as "exterior girder").

Designate the exterior girder (alternatively, any desired girder line) with a unique alphabetic character or non-zero digit (A to Z or 1 to 9) in col 52. Designate the outside line(s) whose fractional points are to be X-type (from this exterior girder) with this same character in col 53.

For example: Left outside edge of concrete deck and left gutter line each have a 1 in col 53. Girder G-1 has a 1 in col 52. Girder G-6 has a 6 in col 52. Right gutter line and right outside edge each have a 6 in col 53. Left outside and left gutter will each have X-type fractional points at perpendicular offsets from fractional points on girder G-1; similarly, right outside and right gutter will each have X-type fractional points at perpendicular offsets from fractional points on girder G-6.

No more than one girder line may have the same nonblank character in col 52, though any number may have the same character in col 53. X-type fractional points may be nested iteratively but not recursively. That is, e.g., different girder lines may have this field coded: 2b, 42, 14, 51, ad infinitum; but two different girder lines may NOT have this field coded: 42 and 32.

Col 53 may also be used to select girder lines that are to intersect bent lines (06 cards) using col 43 (see "Bent Line Data," Selective Intersections) even when no exterior girder is designated. In this case, the character in col 53 does not occur in col 52 of any other 05 card, and this girder line will not have X-type fractional points.

MATCHING CHARACTER FOR DEAD LOAD DEFLECTIONS

(col 54)

See "Dead Load Deflection Data" (07 cards). When girders of different type or different length occur in the same span, different deflection values can be assigned for different girder lines by coding in this field an alphabetic character (A to Z) which is to match col 3 of a 07 card. Any number of 05 cards may have the same character in col 54.

LINE OF CONSTANT OFFSET

(col 56)

When type 4 girder lines (offset varies with super) are used, a point on finished grade is taken as a center for rotation of the section (as cross-slope changes). See col 3, line type 4, above. A girder line parallel to horizontal control (line type 0) may be designated in this field to indicate that the point on finished grade is to be used for the center. A type 4 girder line (with zero in Elevation Shift field, cols 22-29) at this offset would then be identical to a type 0 girder line (with zero elevation shift) at this same offset.

By default, when all 05 cards are blank in col 56, the horizontal control line will be used for line of constant offset.

If this option is selected for a girder line of line type other than 0, a nonfatal error message (indicating that col 56 has been ignored) will be printed: COL 3 CONFLICTS WITH COL 56.

The diagram, "Line of Constant Offset," shows an example of how the program uses this line in keeping, a constant shape for sections of a box girder. Note that type 0 (parallel) girder lines should be used for edge-of-concrete-deck in the case of welded-plate steel boxes; but type 4 (offset varies with super) girder lines should be used for edge-of-deck in the case of segmental (concrete) boxes. The top portion of the diagram shows how the various girder lines are defined (on 05 card), in this case, at level cross-slope (regardless of whether the superstructure ever really attains level cross-slope); the bottom portion shows a superelevated section and the offsets calculated by the program.

SUPPRESS LISTING

(col 57)

The girder line defined by a 05 card designated in this field will not appear on the plot file. This option does not affect output on either 8.5X14 stripe or page printer. This option should be used particularly for any girder line that does not represent top of concrete deck. See Elevation Shift, cols 22-29, above.

This option may not be used when col 52 (X-type fractional points) is nonblank, unless all girder lines (05 cards) with same character in col 53 are also suppressed.

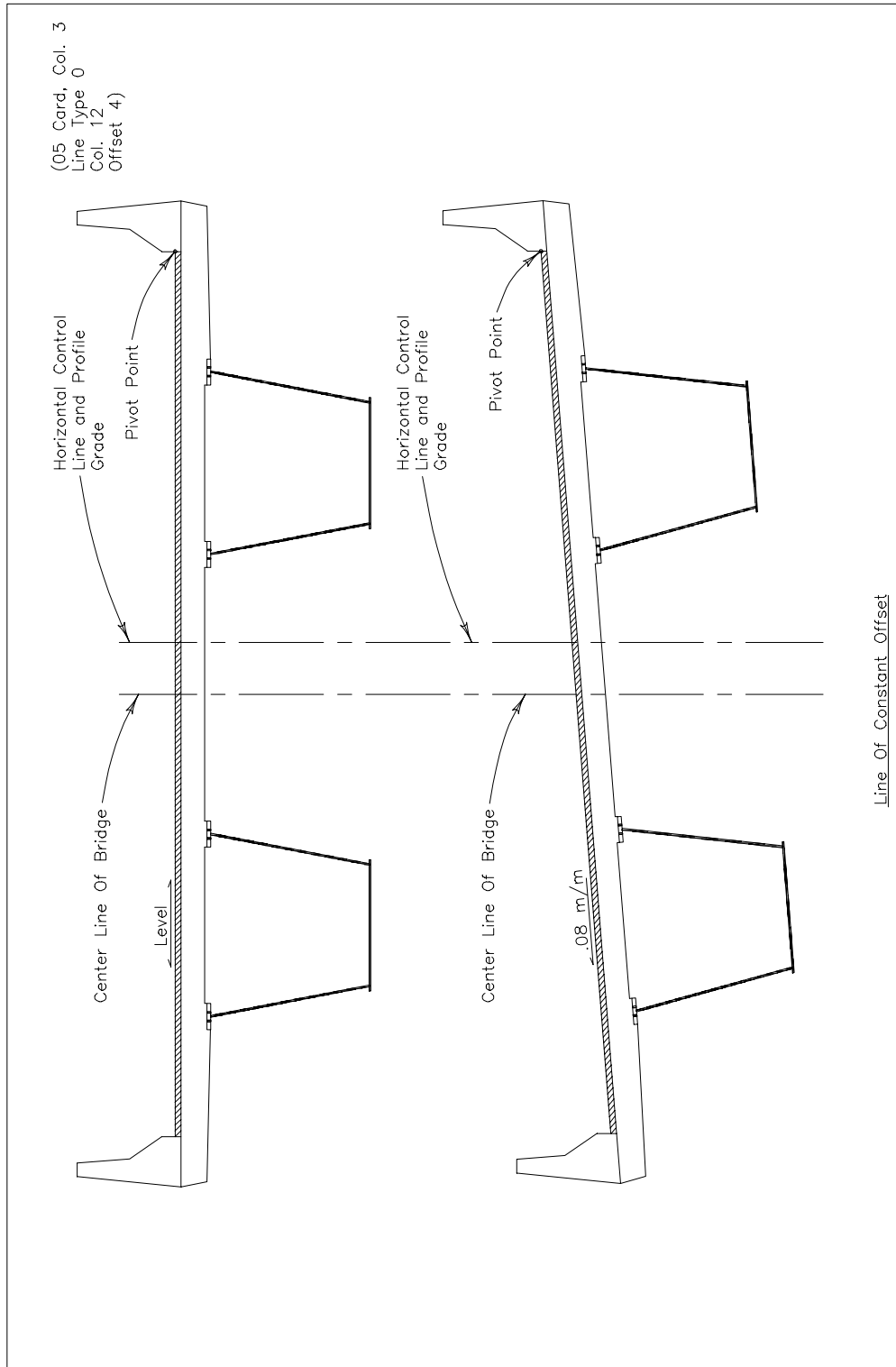


Figure 7 : Line of Constant Offset

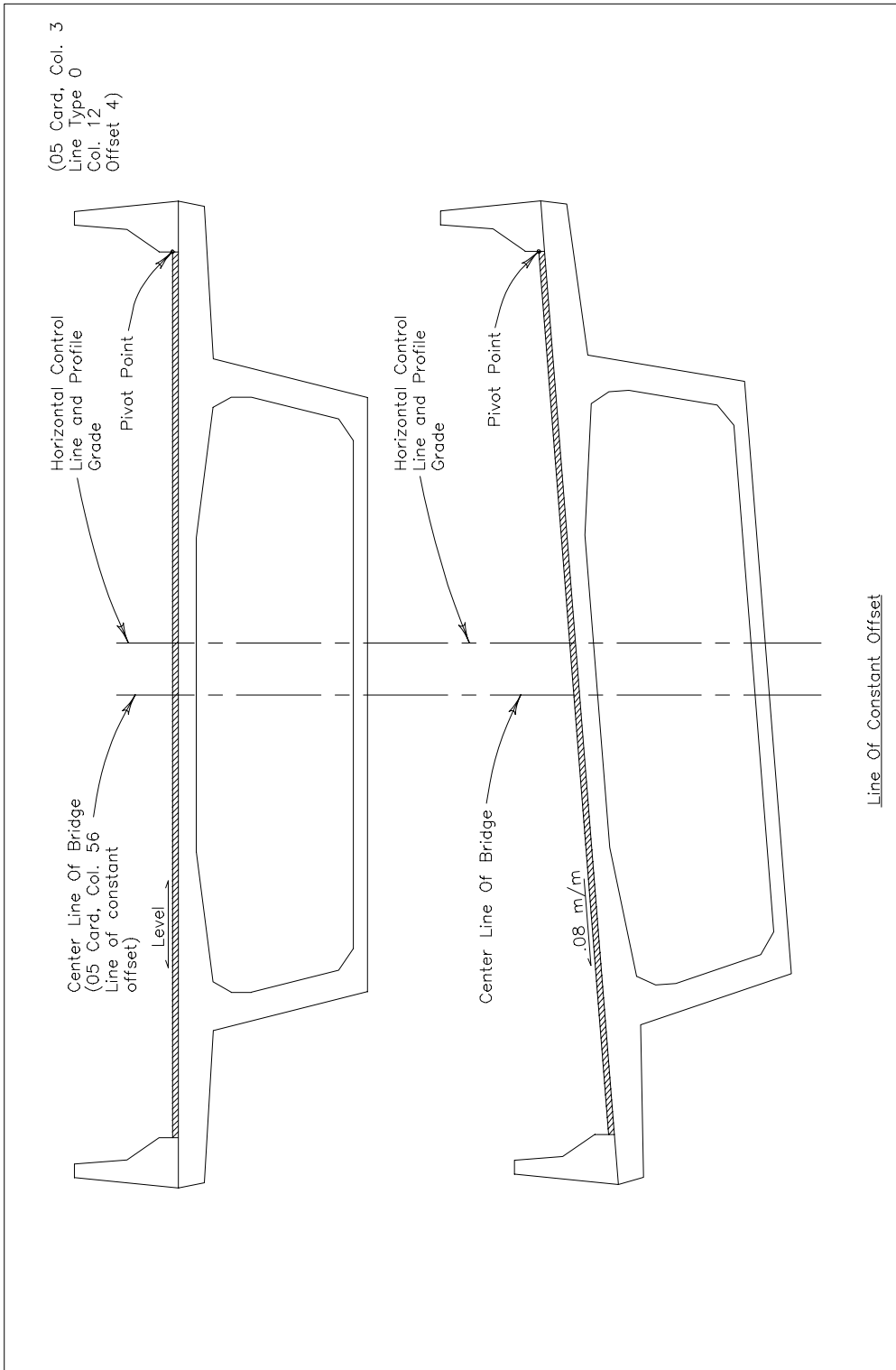


Figure 8 : Line of Constant Offset

BENT LINE DATA

06 CARDS (refer: "BENT LINE DATA" Form)

Bent lines that intersect, either on the deck of the structure or between horizontal control and outside edge, should be avoided. Consequently, one should not use more than one 06 card to describe the same bent line, though a 06 card may be used to describe the reference line.

One may use more than one 06 card to represent the same bent line only if they never intersect the same girder line; this may be useful when different Fractional Points fields are required at different girder lines.

Considering each substructure feature (abutment or pier) as a family of parallel bent lines (e.g., centerline of bearing, face of cap, spring line, centerline of piling, etc.) one may choose a principal member of each family to be defined by a distance from the primary reference line (or from the previous family if parallel). Designating the principal member as a secondary reference line permits other members to be defined by perpendicular offsets from it. Certain program features are designed to work consistently and predictably when the principle member is used for attributes of cols 39, 40, 41 and 45. Unless explicitly forbidden, these options may be used for other than principle members; but performance of such features as distance type 7 and offset option for segmented girder pattern shift may seem inconsistent.

DISTANCE FROM PRIMARY OR SECONDARY REFERENCE LINE

(cols 3-11)

Positive distances are measured ahead from the (primary or secondary) reference line; negative distances are measured back from the reference line.

If the bent line is to be described by a distance from the primary reference line, code the distance in meters to a point on the bent line in cols 3-10 and specify how the distance is to be measured by coding 0, 1, 2, 3 or 4 in col 11 according as distance is to be measured along:

- 0) the horizontal control line
- 1) the layout line
- 2) the back tangent
- 3) the ahead tangent
- 4) a line perpendicular to the primary reference line

If no horizontal curve data were given on the 01 card, distance types 0, 2 and 3 are equivalent. If distance type 4 is used for a bent line not parallel to the primary reference line, results may be unpredictable.

Distance types 6 and 7 are located from a secondary reference line indicated by col 46 (see Secondary Reference Lines, cols 45-46). Distance type 6 means that the distance given in cols 3-10 is to be measured from the secondary reference line by a normal offset. Distance type 7 means that the given distance is to be measured from the secondary reference line along the base chord of segmented girder lines (before the shift option is applied).

Both of these distance types may only be used where the bent line is parallel to the secondary reference line; col 21 (skew type) MUST be blank or zero. Default skew in this case is parallel to the secondary (not primary) reference line. If col 11 is designated 6 or 7 and skew type is not default, a nonfatal error message (indicating that cols 12-21 have been ignored) will be printed: COL 11 CONFLICTS WITH COL 21.

Bent lines that use distance type 6 or 7 must have cols 40 and 41 blank; that is, they may not be used to define a chord layout line nor to define offsets for flared girder lines.

A bent line that uses distance type 7 may have col 39 (segmented girder lines to be broken) selected only if the secondary reference line also has col 39 selected. When this condition is not met, a nonfatal error message (indicating that col 39 has been ignored) will be printed: A BENT LINE WHERE SEGMENTS ARE BROKEN MAY BE REFERENCED BY A CHORD DISTANCE ONLY FROM A SECONDARY REFERENCE LINE WHERE SEGMENTS ARE BROKEN.

For distance types 6 and 7, if col 39 is used with a negative distance (in cols 3-10), results may be unpredictable.

SKEW

(cols 12-21)

If the bent line is to have the default skew, leave this field blank. Default skew depends on distance type (col 11): (1) For distance types 0, 1, 2 or 3, default skew is determined by 04 card, col 25 (see "Reference and Layout Line Data," Default Skew). (2) For distance type 4 (along normal to primary reference line), default is parallel to the primary reference line (regardless of 04 card, col 25). (3) For distance types 6 and 7, default is parallel to the secondary reference line (the ONLY valid skew type). When col 21 is blank or zero, cols 12-20 are ignored.

When the skew of the bent line is to be specified, code the skew angle in degrees, minutes and seconds and indicate whether skew is to the left or right. Equivalent to an L is a minus sign for left skews; equivalent to an R is a plus, a blank or any character other than L or minus.

Indicate the skew type in col 21 by coding 1, 2, 3 or 4 according as skew is measured with respect to:

- 1) the horizontal control line
- 2) the layout line
- 3) the back tangent
- 4) the ahead tangent

In general, skew type 1 should be used only if distance type (col 11) is designated 0 (along horizontal control line). If no horizontal curve data were given on 01 card, skew types 1, 3 and 4 are equivalent.

FRACTIONAL POINTS

(cols 22-28)

A span of fractional points begins from a bent line with any number coded in this field. Except when segmented girder lines are used, the end of the span is determined by the next bent line with a nonblank Fractional Points field (default is the last bent line). Hence to indicate the terminal bent of a span of fractional points without initiating a new span of fractional points, it is necessary to code the integer 1 in this field ("oneth" points).

In the context of X-0 points or dead load deflections, a 06 card with the integer 1 coded in col 24 may still be considered to "begin" a span of (nil) fractional points.

When segmented girder lines are used, the end of the span is determined by the next bent line with either col 39 selected (segmented girder lines to be broken) or with a nonblank Fractional Points field. This means that fractional points may not span across a bent line where segmented girder lines are broken.

F-type fractional points are nth points (i.e., quarter points, tenth points, twentieth points, etc.) where the span is divided into n equal lengths, and are selected by coding the integer n, right justified, in cols 22-24 (cols 25-28 MUST be blank) on the 06 card representing the bent at the beginning of the span.

D-type fractional points are located at intervals of length d along the girder line (the last interval on the span having length less than or equal to d), and are selected by coding the distance d in meters in cols 22-28 (with trailing zeros if necessary to insure that cols 25-28 are not all blank) on the 06 card representing the bent at the beginning of the span.

Thus the integer 10 in this field requests tenth points (F-type) on the span, whereas the number 10.0 requests D-type points at every ten meters on the span.

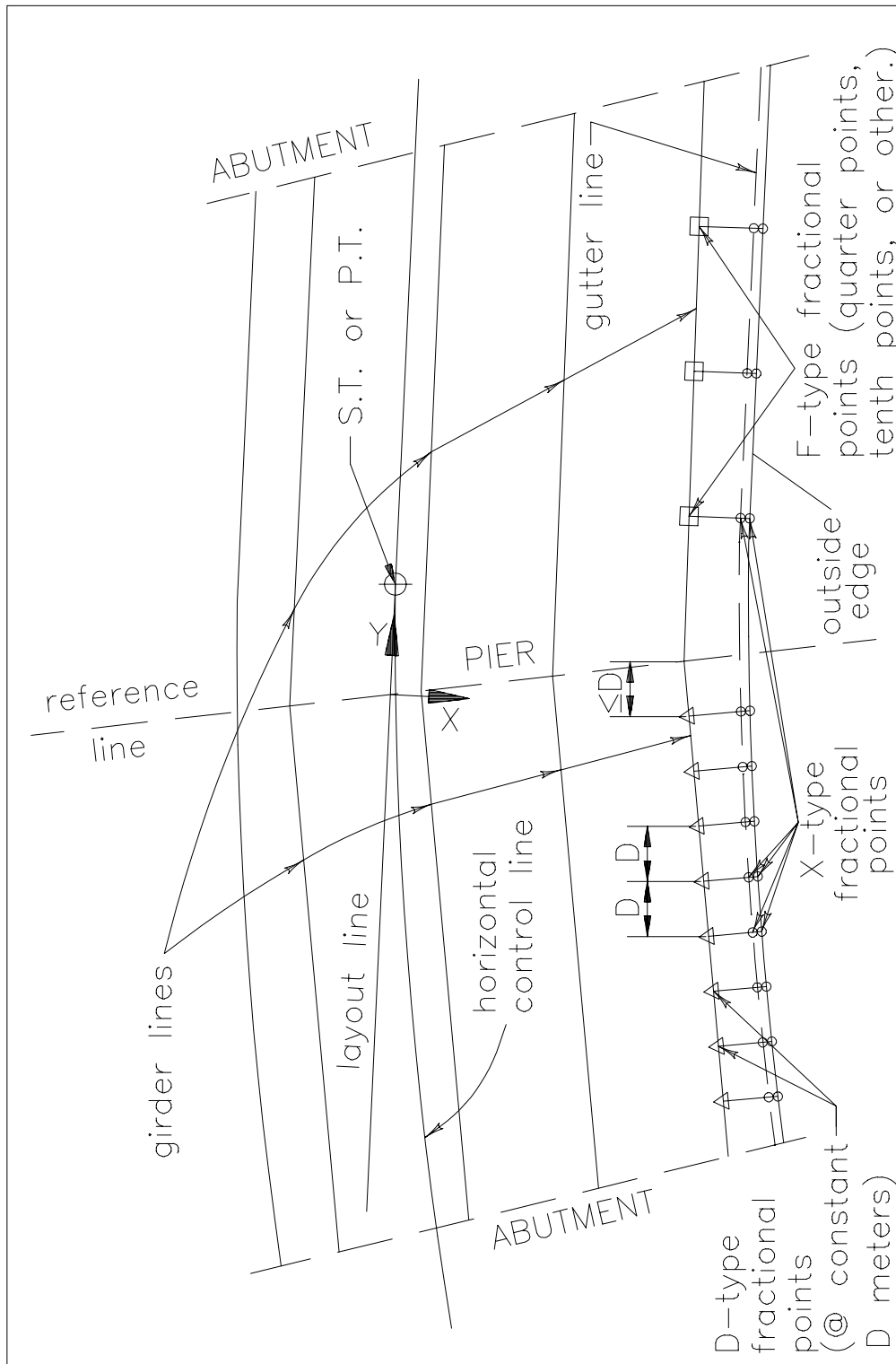


Figure 9 : Fractional Points

E-type fractional points are similar to D-type except that it is the first (rather than the last) interval on the span which will have length less than or equal to d . Select E-type fractional points by coding the distance d in meters (as with D-type) preceded by a minus sign.

DESCRIPTION

(cols 29-38)

Provide a ten character description of the bent line in this field.

SEGMENTED GIRDER LINES TO BE BROKEN AT THIS BENT LINE

(col 39)

See "Girder Line Data" (05 cards), line type 1; also see cols 3-11, above, for restrictions on use of this field with distance types 6 and 7 (from secondary reference line). In simple span cases, segmented girder lines should be broken only once at each pier (at centerline), not at each bearing. Suppress Listing (col 42) and Selective Intersections (col 43) fields on this 06 card must both be blank for this option to be functional.

BENT TO DEFINE OFFSETS FOR FLARED GIRDER LINES

(col 40)

See "Girder Line Data" (05 cards), line type 3. A 06 card designated in this field may not use distance type (col 11) 6 or 7 (from a secondary reference line); failure to meet this requirement will cause a fatal error.

If only one bent line has col 40 selected where two are required, the reference line is used for the other bent line (by default). If more than two 06 cards are designated in this field, the first two encountered on input sequence are used; col 40 is ignored on remaining 06 cards.

BENT TO DEFINE CHORD LAYOUT LINE

(col 41)

See "Reference and Layout Line Data" (04 card), Layout Line Definition, col 26. A 06 card designated in this field may not use distance type (col 11) 6 or 7 (from a secondary reference line). A 06 card designated in col 41 may have distance type 1 (along the layout line) ONLY IF the other 06 card designated in this field has distance type 0 (or can be otherwise located independent of the layout line), and layout line is a chord on horizontal control line. Further, for a 06 card designated in col 41, skew type (col 21) may be 2 (with respect to layout line) ONLY IF distance type is 0 (along horizontal control) or 1 (along, layout line) and layout line is a chord on horizontal control line.

If these conditions are not met, a nonfatal error message (indicating that col 41 has been ignored) will be printed: COL 41 CONFLICTS WITH COL 11 OR 21.

If only one bent line has col 41 selected where two are required, the reference line is used for the other bent line (by default). If more than two 06 cards are designated in this field, the first two encountered on input sequence are used; col 41 is ignored on remaining 06 cards.

SUPPRESS LISTING

(col 42)

A bent line defined by a 06 card designated in this field will not appear on the plot file. Fractional Points field (cols 22-28) on this 06 card must be blank for this option to be functional. This option must not be used if col 39 (segmented girder lines to be broken) has been selected. This option should be used only when intersections with girder lines are desired on 8.5X14 stripe but not on plot file; for fictitious bent lines it is better to use an asterisk in Selective Intersections field (see col 43 below).

SELECTIVE INTERSECTIONS

(col 43)

A bent line defined by a 06 card that is blank in this field will intersect every girder line. This condition is required if col 39 (segmented girder lines to be broken) has been selected.

It may be desirable for certain bent lines (e.g., splice line or bent line to locate end of wingwall) to intersect only selected girder lines (centerline of web or gutter line and outside edge of concrete deck). Any bent line having a character (A to Z or 1 to 9) in col 43 will be intersected only with girder lines (05 card) having the same character in col 53. A bent line having the digit zero in this field will be intersected only with girder lines having any digit (1 to 9) in col 53. A bent line having an asterisk in this field will not be intersected with any girder line; using this option, a fictitious bent line (used to establish a chord layout line or flared girder lines) can be deleted.

Using the asterisk option causes the fractional points field (cols 22-28) to be ignored.

For example: Wingwalls at abutment 1 are to be 3 meters at the left end and 5 meters at the right end; wingwalls at abutment 3 are both 3 meters long. Left outside edge of deck and left gutter line each have a 1 in col 53 (for X-type fractional points from left exterior girder); right outside edge and right gutter line each have a 6 in col 53 (for X-type fractional points from right exterior girder). The bent line which locates the end of the abutment 1 left wingwall should have a 1 in col 43; that which locates the end of the abutment 1 right wingwall should have a 6 in col 43; and that which locates the end of both abutment 3 wingwalls should have a 0 in col 43.

A bent line locating end of wingwall may be skewed parallel to back face of abutment, intersecting outside edge only (elevation at gutter to be calculated at same station from printed cross-slope) or may be skewed zero to the horizontal control line, intersecting both outside edge and gutter line.

In the case of welded-plate box girders, an initial run with skewed splice lines may be used to locate splice at centerline of each box. The final run should be made without these skewed lines and with a radial splice line (one for each box) which intersects both webs (and centerline), using col 43 to prevent intersections at other girder lines. Each radial line can be located by difference in stations (with distance type 0), skew of zero and skew type 1.

MATCHING CHARACTER FOR DEAD LOAD DEFLECTIONS

(col 44)

For a bent line beginning a span of fractional points (06 card with non-blank Fractional Points field, cols 22-28), elevations adjusted for dead load deflection will be calculated and printed at each point in the span if this field is coded with an alphabetic character (A to Z) which is found to match col 4 of a 07 card.

More than one 06 card may have the same non-blank character in col 44 only if they all begin spans that are to have the same deflection values applied. See "Dead Load Deflection Data" (07 cards).

SECONDARY REFERENCE LINES

(cols 45-46)

A bent line may be selected as a secondary reference line by coding an alphabetic character (A to Z) in col 45. Other bent lines that use distance type 6 or 7 (see cols 3-11 above) from the indicated secondary reference line must have this same character coded in col 46. A bent line using distance type 6 or 7 must be parallel to the secondary reference line from which it is measured

Metric Bridge Geometry

No more than one 06 card may have the same non-blank character in col 45, though any number may have the same character in col 46. Secondary reference lines may be used recursively; that is, a bent line which has distance type 6 or 7 (from a secondary reference line indicated in col 46) may itself be used as a secondary reference line by coding a different character in col 45. A truly cyclic recursion (as, e.g., a 06 card with this field coded: CD, and a 06 card with this field coded: DC) causes a fatal error.

Note: If col 39 (segmented girder lines to be broken) is used in a recursive sequence, results may be unpredictable.

DEAD LOAD DEFLECTION DATA

07 CARDS (refer: "DEAD LOAD DEFLECTION DATA" Form)

In addition to finished elevations, the program calculates and prints elevations adjusted for dead load deflection if 07 cards are included in the data set. The adjusted elevation (printed under column heading "ELEV+DL" with significant digits dropped) is to represent the elevation to set concrete forms so that, after deflecting, the top of deck will attain the finished elevation. Deflection values for adjusted elevations are coded on 07 cards with col 6 blank.

Deflection values may be specified at tenth points with a single 07 card. If more than tenth points are needed, the initial 07 card (with cols 3-6 properly coded) may be followed by an arbitrary number of continuation 07 cards coded with cols 3-6 all blank. This sequence of initial and continuation 07 cards may be repeated for any number of spans or any number of girder lines.

For example: If it is desired to specify values at quarter points in the span, one would code two 07 cards: the initial card having a value specified in the 5 field (cols 45-50, for the fifth 20th point) and a value specified in the 10 field (cols 75-80, for the midpoint or tenth 20th point); the continuation card having a value specified in the 5 field (cols 45-50, for the fifteenth 20th point).

An initial card and nine continuation cards allow values to be specified at hundredth points. The generalized case: n-1 continuation cards allow values to be specified at 10 n th points.

Field 05/54

(col 3)

When all girder lines are to have the same deflection values applied, leave this field (and 05 cards, col 54) blank. When different girder lines require different deflection values (whether due to different girder lengths, different girder designs, or significant weight of formwork and reinforcing steel for screed rails), an alphabetic character in col 3 means that these deflection values are to be applied to all girder lines (05 cards) having the same character in col 54.

More than one initial 07 card may have the same character in col 3 only if they have different characters in col 4.

Field 06/44

(col 4)

Each initial 07 card must have a non-blank character in this field. If this same character is found in col 44 of a 06 card (bent line) with non-blank Fractional Points field, cols 22-28, the specified deflection values will be applied to all intermediate and intersection points in the span. The terminal bent for the span is defined by the next 06 card with a non-blank Fractional Points field (see 06 card, "Fractional Points" discussion for segmented girder lines).

More than one initial 07 card may have the same character in col 4 only if they have different characters in col 3.

M (METERS)

(col 5)

If deflection values are in millimeters, leave this field blank. Code an M in col 5 to indicate that deflections are specified in meters. 07 cards may be mixed meters with millimeters, but all continuation cards must have the same unit of measure as specified on the corresponding initial card.

DEFLECTION VALUES

(cols 15-80)

Deflection values must always be specified for the 0 and 10 fields (i.e., the 0 field, cols 15-20 of the initial card and the 10 field, cols 75-80 of the last continuation card). Blank entries in these two fields are assumed to specify zero deflection (the typical deflection at a bearing point); default is the same as specifying zero. The intermediate fields 1 to 9 (and intermediate 0 and 10 fields when continuation cards are used) may have values specified or be left blank; default means unspecified. Hence if the span of fractional points determined by corresponding 06 cards (see "Bent Line Data," cols 22-28) begins or ends at a point other than a bearing line (splice point, for example), be certain to specify a non-zero deflection at that end (0 or 10 field).

Positive values mean downward deflection; negative values mean upward.

The number or location of deflection values given on 07 cards has no necessary relation to number or type of fractional points selected on the corresponding 06 card. The deflection given in the 0 field is to be applied at the bent line beginning the span of fractional points and the deflection given in the 10 field is to be applied at the bent line ending the span.

Given deflection values are never applied directly to an elevation; instead the program will first fit a polynomial curve to the points given in a span and then calculate deflections (for adjusted elevations) from the fitted curve. For this purpose, a "least squares" curve fitting, method (polynomial of degree no greater than six) is employed by mapping the scatter points into the interval from 1.0 to 2.0. Coefficients of the polynomial are then converted to millimeters on the interval from 0.0 to 1.0 and printed along with polynomial deflection values at tenth points. See Chapter 4, "Dead Load Deflection Data."

A measure of control over the degree of polynomial to be fit may be provided by restricting the number of deflection values given. For an nth degree polynomial, give only n-1 intermediate values; in particular, if a linear curve fit is desired, give deflection values only at the two end points (0 and 10 fields).

Field 15-20 Implied decimal place is between cols 16 & 17 for meters.
Implied decimal place is between cols 18 & 19 for millimeters.

Field 21-26 Implied decimal place is between cols 22 & 23 for meters.
Implied decimal place is between cols 24 & 25 for millimeters.

Field 27-32 Implied decimal place is between cols 28 & 29 for meters.
Implied decimal place is between cols 30 & 31 for millimeters.

Field 33-38 Implied decimal place is between cols 34 & 35 for meters.
Implied decimal place is between cols 36 & 37 for millimeters.

Field 39-44 Implied decimal place is between cols 40 & 41 for meters.
Implied decimal place is between cols 42 & 43 for millimeters.

Field 45-50 Implied decimal place is between cols 46 & 47 for meters.
Implied decimal place is between cols 48 & 49 for millimeters.

Field 51-56 Implied decimal place is between cols 52 & 53 for meters.
Implied decimal place is between cols 54 & 55 for millimeters.

Field 57-62 Implied decimal place is between cols 58 & 59 for meters.
Implied decimal place is between cols 60 & 61 for millimeters.

Field 63-68 Implied decimal place is between cols 64 & 65 for meters.
Implied decimal place is between cols 66 & 67 for millimeters.

Field 69-74 Implied decimal place is between cols 70 & 71 for meters.
Implied decimal place is between cols 72 & 73 for millimeters.

Field 75-80 Implied decimal place is between cols 76 & 77 for meters.
Implied decimal place is between cols 78 & 79 for millimeters.

ROADWAY APPROACHES

08 CARD (refer: "ROADWAY APPROACHES" Form)

The program calculates and prints finished grade elevations at 3 meters stations for 45.7201 (or more) meters of roadway approaches before and after the structure if 08 card is included in the data set. Stations beyond limits of valid elevation and cross-slope data (04 card, cols 59-80) are not printed. Particularly in the case of a severe skew, it is recommended that approaches should lap well onto the deck of the structure.

BEGIN STRUCTURE

(cols 3-9)

Code a station at least 3 meters ahead of the beginning of the structure (usually back face of abutment). Elevations on the roadway approach will begin 45.7201 meters back of this station. If this field is blank, no approach elevations at this end will be printed.

END STRUCTURE

(cols 10-16)

Code a station at least 3 meters back of the ending of the structure (usually back face of abutment). Elevations on the roadway approach will end 45.7201 meters ahead of this station. If this field is blank, no approach elevations at this end will be printed.

APPROACH LENGTH

(cols 17-24)

If more than 45.7201 meters of approach is needed, code the desired approach length in meters in this field. Maximum length is 277 meters.

OFFSETS FROM HORIZONTAL CONTROL

(cols 25-80)

Code up to seven offset distances for lines where approach elevations are to be calculated. These offset lines should be where roadway grade stakes ("blue-tops") are being run; i.e., edge of shoulder, edge of travel lane, profile line, etc. (Dimensions can usually be found on the roadway typical section). Offset values will be sorted by the program; input fields are order independent.

Chapter 4 - Output Results

At the top of each page of output (8.5X14 stripe or page printer) is a one-line banner composed of the "structure identification" (taken from cols 3-12 of first 00 card), a sequence number in parentheses (when more than one sequence of 04-07 cards are used), program name (and version), date and time of run, and page number. Beginning on page one, six left-justified headings label the input data from 00-04 cards: "Description," "Horizontal Alignment Data," "Vertical Alignment Data," "Table of Roadway Cross-Slopes," "Limits of Valid Elevation and Cross-Slope Data," and "Layout Line Data." Following this information, selected input data from 05, 06 and 07 cards are echoed (interspersed with appropriate warning messages).

If 05 card, col 21 (terminal offset) is used for a girder line of line type (col 3) other than 3 (flared) or 4 (offset varies with super), a nonfatal error message (indicating that cols 13-21 have been ignored) will be printed: COL 3 CONFLICTS WITH COL 21. See Chapter 3, 05 cards, cols 4-21.

Various warning messages describe nonfatal error conditions involving girder lines with incorrectly coded X-type Fractional Points field (05 card, cols 52-53). Each message describes the condition encountered and the action taken by the program: col 52 or col 53 of the indicated girder line is ignored. See Chapter 3, 05 cards, cols 52-53.

A bent line that does not intersect both the horizontal control line and the layout line will cause a nonfatal error message with the result that the indicated bent line is discarded.

DESCRIPTION

A direct listing of all 00 cards is printed under this heading.

HORIZONTAL ALIGNMENT DATA

If no horizontal curve data were given on 01 card, the comment HORIZONTAL TANGENT will be printed. Otherwise, input and calculated curve data (for comparison with line sheets) will be printed: stations at critical points (P.C., T.S., T.S.C., S.C., P.I., S.C.S., etc.), tangent lengths (T), spiral lengths (LS), spiral deflection angles (SA) in degrees, minutes and seconds, length of circular curve (LC), total deflection angle (DELTA), and radius of curve (RADIUS).

If a station equation has been given (01 card, cols 59-80), it will be echoed under this heading. The following conditions will cause a nonfatal error message to be printed: AMBIGUOUS OR NONEXISTENT STATION USED.

- a. if an ambiguous station is used (when equation is overlapping)
- b. if a nonexistent station is used (when equation is nonoverlapping,) or
- c. if equation numbers are not used consistently (See Chapter 3, 01 card.)

For an equation that occurs at the T.S. (P.C.) or S.T. (P.T.) of a horizontal curve (tolerance of 0.009 meters), the program will make an adjustment to put the equation precisely at the critical point. (An adjustment to the station of the P.I. may be used to negate this effect.)

If a non zero profile offset has been given (01 card, cols 44-51), it will be echoed immediately below horizontal curve data.

VERTICAL ALIGNMENT DATA

Calculated vertical curve data are printed under this heading for comparison with line sheets. Grades between P.I.'s, station and elevation at P.C., P.I. and P.T. and tangent elevation at P.I. are formatted to show crest or sag condition.

If a P.I. is found to have an associated change in grades but a zero length vertical curve (and transition vertical curves are not inhibited), a nonfatal error message will be printed: P.I. AT STATION ...+... HAS BEEN ASSIGNED CURVE LENGTH = ... METERS. See Chapter 3, 03 card, col 56.

PARABOLIC CROWN DATA

For crown type P, crown width and height and shoulder slopes are echoed under this heading.

TABLE OF ROADWAY CROSS-SLOPES

For crown types A, B and C the printed table provides all information used by the program in calculating finished elevations from profile grade elevations. When the station and offset of a point have been determined, the elevation of the pivot point at that station is calculated from vertical alignment data (profile grade elevation), pivot offset and nominal cross-slope. Next the table is consulted to find final (finished grade) cross-slopes at that station. Then the elevation of the given point is calculated from pivot point elevation, pivot and profile offsets, final cross-slopes and elevation shift.

For type 4 girder lines (offset varies with super), since the final offset cannot be determined without first determining the cross-slope, an iterative procedure is invoked which adjusts station and offset, calculates a new cross-slope, then adjusts station and offset again, etc.

To obtain smooth profiles along, girder lines ("smooth" in the sense that elevation is a continuously differentiable function of line length), the program will insert a transition vertical curve (typically one half station in length) at every station where there is a break in the rate of change of cross-slope. An entry in the table does not mean that final cross-slopes at the given station are those specified; on the contrary, final cross-slopes are generally not those specified. The entry means that at the given station the cross-slope changes at a nonlinear rate and a transition vertical curve (centered at the given station) has been provided.

The "VC LENGTH" column gives the length of the transition vertical curve in meters at horizontal control. Curve length will be greater (or less) than the given length when outside (inside) of horizontal control in a region of horizontal curve.

The note "-U-," appearing to the right of curve length column, indicates that cross-slopes were specified with an optional superelevation override 03 card.

At any point where the rate of change of cross-slope changes from increasing to decreasing (or from decreasing to increasing), a relative maximum (minimum) cross-slope is attained at some point in the transition vertical curve. When this condition is encountered, the program prints a line in the table (informative only, not a true table entry) giving the station at which the relative maximum or minimum is attained and the final (finished grade) cross-slopes at that station.

A table entry that is found to represent the linear variation between its two neighboring entries is deleted from the table since the transition vertical curve would be flat. Hence when using optional 03 cards, it is possible that no table entry will be shown for a station specified on one of the override cards. This does NOT mean that the 03 card is superfluous (unless Super Rate field, cols 9-12 on initial 03 card, is blank).

Metric Bridge Geometry

The algorithm used to find final cross-slopes from the table is demonstrated by the following example.

Assume the fourth, fifth and sixth entries in the table are:

STATION	SLOPE LEFT	SLOPE RIGHT	VC LENGTH
		. . . etc. . . .	
1+623.4000		-.0500	.0500 15.24
1+763.4000		-.0150	.0150 15.24
1+883.4000		-.0150	-.0150 15.24
		. . . etc. . . .	

representing the transition of a type C crown (center pivot) out from a left curve: P.T. at station 1+703.40, transition length = 60 meters, $e = 0.0500$ m/m, run-out = 20 meters.

CASE 1: sta 1+842.60

Since the station is between the fifth and sixth entries and does not occur within either vertical curve (occurs after 1+788.40 and before 1+858.40), cross-slopes are the straight line interpolations between fifth and sixth entries:

slope left = $-.015000$
slope right = $-.004800$

CASE 2: sta 1+762.10

Since the station is between the fourth and fifth entries and occurs within the latter transition vertical curve (occurs after 1+738.40 and before 1+788.40), cross-slopes are the parabolic interpolations between cross-slopes at 1+738.40 and cross-slopes at 1+788.40 (found as in case 1):

at 1+738.40 slope left = $-.021250$
slope right = $.021250$ *

at 1+788.40 slope left = $-.015000$
slope right = $.008750$ *

at 1+762.10 slope left = $-.016729$
slope right = $.015325$ *

* Note that these are the same as the straight line interpolations between fourth and sixth entries.

When the first entry in the table does not have nominal cross-slopes (and Begin Station [04 card, cols 59-69] does not exclude the first transition vertical curve), this condition will result in a begin station entry for limits of valid elevation and cross-slope data.

Similarly if the last entry in the table does not have nominal cross-slopes (and End Station [04 card, cols 70-80] does not exclude the last transition vertical curve), this condition will result in an end station entry for limits of valid elevation and cross-slope data.

If transition vertical curves have not been inhibited and tabular stations are so crowded that a transition vertical curve is shorter than 6.0960 meters, a nonfatal error message will be printed: SHORT TRANSITION VERTICAL CURVES / GIVEN ALIGNMENT IS NOT SUITABLE. Possible remedies for this condition include: (1) combining two or more transition breaks; (2) straightening a series of complex transition breaks; or (3) coding 03 card Nominal Cross-Slope field (cols 4-8) blank and controlling transitions entirely using optional 03 cards. See Chapter 3, "Optional Superelevation Override."

Offset from profile line to the pivot point is echoed below the table.

LIMITS OF VALID ELEVATION AND CROSS-SLOPE DATA

When a Begin or End Station entry is found in cols 59-80 of 04 card, it is echoed under this heading.

LAYOUT LINE DATA

Under this heading is printed a description of how the layout line is defined; girder line (05 card, col 51) and bent lines (06 card, col 41) defining a chord layout line; station, offset and X-Y coordinates of reference-line-layout-line intersection; and how the layout line crosses horizontal control (including skew). If a "chord" layout line does not cross horizontal control, the description will show how it crosses the back and ahead tangent lines. Skew of the layout line with respect to horizontal control (or back/ahead tangent lines) is measured from the tangent (not the normal) since layout line is a longitudinal (rather than transverse) line.

BENTS TO DEFINE OFFSETS FOR FLARED GIRDER LINES

When flared girder lines (05 card line type 3) are used, initial and terminal bent lines (06 cards designated in col 40) are echoed under this heading.

SEGMENTED GIRDER LINE DATA

When segmented girder lines (05 card line type 1) are used, the girder line chosen for base chords (05 card designated in col 50), bent lines where broken (06 cards designated in col 39), and offset option for segmented girder pattern shift (when selected by 04 card, col 29) are printed under this heading.

If relatively large skew angles affect the suitability of segmented girder lines, a nonfatal error message will be printed: DUE TO LARGE SKEW ANGLES, USE OF SEGMENTED GIRDERS... Besides reducing skews of bent lines, other means of alleviating this condition include shortening the span lengths, flaring the exterior girders, or moving the girder line for base chords further toward the outside of the horizontal curve.

For segmented girder lines, two intersection points are printed for each bent line where segmented girder lines are broken (06 card designated in col 39, except first and last). The first of these two intersection points is where the segment in the previous span intersects the bent line; the second is where the segment in the next span intersects the bent line.

DEAD LOAD DEFLECTION DATA

For each 07 card (or set of initial and continuation 07 cards), the program prints an initial line (describing cols 3, 4), coefficients of the polynomial (fitted curve), and deflection values at tenth points (in millimeters and in meters). The initial line gives a bent line description (cols 29-38) from a 06 card found to have a character in col 44 which matches col 4 of the 07 card. If no matching character was found, UNKNOWN is printed. The initial line shows the number of 07 cards in the set (greater than one if continuation cards are used) and also gives the character in col 3 (to be matched with 05 cards, col 54).

The polynomial coefficients, printed in a column to the right, are labeled A4 through A0 and represent the curve

$$A4*Y^4 + A3*Y^3 + A2*Y^2 + A1*Y + A0$$

for Y on the closed interval from 0 to 1. If either end point has a zero deflection value, the coefficients are those of a reduced polynomial which must be expanded by the corresponding factor to find the curve which was fit to the input deflection values. If the left end point is zero, the polynomial must be expanded by a factor of Y ; if the right end point is zero, the polynomial must be expanded by a factor of $(1-Y)$; and if both end points are zero (the typical case when the span goes from bearing to bearing), the polynomial must be expanded by a factor of $(Y-Y^2)$.

The expanded polynomial (representing deflection values in millimeters as a function of the proportionate span length) is used by the program so that deflections at any intermediate point (whether intersection or fractional point) may be calculated without interpolation. From the larger view, the curve fitting procedure itself is an interpolation method; but a method which applies uniformly over the entire span.

Deflection values at tenth points on the span are printed in millimeters (top line) and in meters (bottom line). These values are calculated from the fitted curve and should always be compared with input values to be certain that the polynomial comes reasonably close to the desired dead load deflections.

For example, assume that deflection values were input in millimeters at quarter points (with zero values at the end points) on two 07 cards:

$$\frac{5}{20} = 20.1422$$

$$\frac{10}{20} = 26.1874$$

$$\frac{15}{20} = 20.0152$$

On output, deflection value at the midpoint (0.5) is shown as 26.1874 millimeters and the coefficients are given:

$$\begin{aligned} A4 &= 0.0 \\ A3 &= 0.0 \\ A2 &= 38.4658 \\ A1 &= -39.0449 \\ A0 &= 114.6048 \end{aligned}$$

By inspection, the deflection at the midpoint is close enough; but the question remains: how close to the input values would the first and third quarter points be, when calculated from the fitted curve. Rather than interpolating between tenth points, the direct calculation is done by expanding the polynomial and evaluating at $Y=0.25$ and $Y=0.75$. The expanded polynomial becomes:

$$(38.4658*Y^2 - 39.0449*Y + 114.6048)*(Y - Y^2)$$

$$\text{at } Y=0.25 \text{ (107.2477) * (0.1875) = 20.1089 mm}$$

$$\text{at } Y=0.75 \text{ (106.9581) * (0.1875) = 20.0546 mm}$$

and it is seen that the (fourth degree) polynomial curve fits the input values very accurately.

Beneath deflection values is a line giving the slope of the fitted curve at each end of the span. If the slope at the left end is less than zero or if the slope at the right end is greater than zero, the comment DEFLECTIONS SHOW SIGNIFICANT UPLIFT will be printed. This indicates a condition that should occur only for continuous (not simple span) girders.

When a girder is continuous across a bearing, the slope at the ahead end of the previous span should be compared with the slope at the back end of the next span to ensure that the two fitted curves do not form a cusp at the bearing. Printed slopes are in units of meters per span; so for spans of unequal length, each slope must be divided by the length of the span (in meters) to find slopes in meters per meter which can then be compared for equality.

If the first 07 card is found to be a continuation (rather than initial) card, a nonfatal error message will be printed: IMPROPER USE OF DEAD LOAD DEFLECTION DATA CARDS.

When continuation cards are used, the 10 field of one card and the 0 field of the next card represent the same point. Though both fields may be coded, if the values given do not agree a nonfatal error message will be printed: INCONSISTENT DEFLECTIONS GIVEN AT THE SAME POINT.

AVERAGE CROSS-SLOPE

When a girder line whose offset varies with superelevation (05 card line type 4) is used, the program computes an average cross-slope for purposes of determining nominal offset. The stations between which the average is computed and the resulting average are printed under this heading.

* HORIZONTAL CONTROL LINE * and * LAYOUT LINE *

Beginning on the next page is a listing of each bent line and the point where the bent line crosses horizontal control, followed by a similar listing for the layout line. These listings do not include fractional points; hence, when fractional points are needed or when the line is needed on deck elevation plot file, the line must also be input as a girder line (05 card). All elevations in these listings are at finished grade. Points which are outside limits of valid elevation and cross-slope data (04 card, cols 59-80) are printed nonetheless. Information in these ten columns is essentially similar to that provided for other girder lines; see "General Girder Line," below.

In the listing for intersections at horizontal control, an extra column, printed between elevation and X-offset, indicates value found in Fractional Points field (06 card, cols 22-28) and condition of Selective Intersections field (col 43).

In general, both horizontal control and layout lines should always be run as girder lines for deck elevation sheets.

* BACK TANGENT LINE * and * AHEAD TANGENT LINE *

When reference is made to either of the two tangent lines on the horizontal curve, intersection points for each bent line are listed for the tangent line(s). Stations given here are horizontal control stations (NOT tangent stations, which may be calculated from Girder Length column). In addition to intersection points, critical points (T.S., S.T., P.C., or P.T.) at beginning and end of the horizontal curve are also listed.

GENERAL GIRDER LINE

On succeeding pages immediately beneath the banner line and above the column headings, is a line giving:

- a. the girder line description (05 card, cols 30-49)
- b. the line type (col 3)
- c. the notation (CONT) for "continued" only if it is not the first page for the specified girder line
- d. the offset from the base chord if girder line is segmented (line type 1)
- e. the nominal offset from horizontal control if girder line offset varies with super (line type 4)
- f. the elevation shift (cols 22-29) in meters above or below finished grade (at normal to cross-slope of deck if line type 4, vertical otherwise)

Beneath this are headings for eleven columns of information describing each intersection point or fractional point on the indicated girder line.

BENT LINE

This column gives either the bent line description (06 card, cols 29-38) if the point is an intersection point, or a fractional point designation in the form F-n, D-n, E-n or X-n.

STATION and OFFSET

These columns give the coordinates of the point with respect to the surveyor's station and offset from the horizontal control line.

ELEVATION

This column gives finished (deck) elevations (in meters above sea level), which differ from finished grade elevations by the elevation shift (05 card, cols 22-29).

ELEV+DL

If 07 cards are used, this column gives the elevation (with significant digits dropped) adjusted for dead load deflection.

OFFSET (X) and ORDINATE (Y)

These columns give the coordinates of the point with respect to a coordinate system determined by the reference line and the layout line (see Chapter 3, 04 card). These coordinates are in the horizontal plane and, together with the elevation, make a three-dimensional Cartesian system useful in finding distances between points by the Euclidean norm.

BENT LENGTH

At intersection points, this column gives the horizontal length (measured along the bent line) from the point of intersection of the bent line with the Y-axis to the point of intersection of the bent line with the girder line. Positive lengths are right of the Y-axis; negative lengths are left of the Y-axis. At X-type fractional points, this column gives the horizontal offset of the point from the corresponding fractional point on the exterior girder. (See Chapter 3, 05 cards, cols 52-53.)

SKEW

At intersection points, this column gives the skew (in degrees, minutes and seconds) of the bent line with respect to the girder line. Negative skew is to the left; positive skew is to the right. Skew angles are not printed on elevation sheets.

GIRDER LENGTH

For girder lines of type 0 and type 2 (parallel), this column gives the horizontal length (measured along the girder line) from the point of intersection of the girder line with the reference line to the designated point (whether intersection or fractional point). For type 1 (segmented) girder lines, girder line lengths are measured independently on each line segment from the initial bent line where segmented girder lines are broken (06 card, col 39). For type 3 (flared) girder lines, girder line lengths are measured from the initial bent line defining offsets for flared girder lines (06 card, col 40). For type 4 girder lines (offset varies with super), girder line lengths are measured from the reference line along the corresponding parallel line at the nominal offset.

Positive lengths are ahead of the reference or initial bent line; negative lengths are back. If the girder line is curved (line type 0 or 4), this length is an arc length.

CROSS-SLOPE

This column gives the roadway cross-slope at the station of the designated point when the slope is continuous. For crown types A and B cross-slopes at the profile line are printed in absolute value (with "+/-" sign). For crown type C cross-slopes are typically discontinuous at the profile line (due to the sign convention). For crown type P, cross-slopes in the parabolic section are instantaneous values; cross-slopes are typically discontinuous only at the edge of the parabolic section. Roadway cross-slopes are not printed on elevation sheets.

ROADWAY APPROACHES

When 08 card is used, station, offset, elevation and cross-slope are printed for each station on the roadway approaches. All elevations are at finished grade. Cross-slope is blank where discontinuous (see "General Girder Line," Cross-Slope, above). Portions of approaches that extend beyond limits of valid elevation and cross-slope data (04 card, cols 59-80) are deleted.

On elevation sheets, approach elevations are arranged in a table format: stations printed in the left column, offsets printed across the top. Roadway cross-slopes are not printed on elevation sheets.

When the Approach Length field (08 card, cols 17-24) is used, the program will sometimes extend the approaches (in the direction that laps further onto the structure) by 5 or 10 meters. This is done to make the number of stations (where approach elevations are output) a multiple of four.

Chapter 5 - Fatal Error Messages

Fatal errors have different effects according to their severity. Any fatal error will inhibit the printing of alternative media files (elevation sheets or page printer) and will limit output on 8.5X14 stripe to no more than one girder line. Some errors will prevent printing of even one girder line; some will prevent printing of horizontal control and layout lines. Errors associated with horizontal or vertical alignment data will abort the run immediately.

FATAL ERROR -- NO n CARD FOUND

Where n = 00, 02, 03, 04, 05 or 06; the indicated card type was not found due to cards out of sequence or required card missing.

THE FOLLOWING INPUT LINES WERE IGNORED: . . .

The program found a card out of sequence (see Chapter 2, "Deck Organization") or an invalid Card Type field, cols 1-2. Comment cards with card type 99 will not be listed.

INVALID STATION EQUATION

Equation number of back station was found to be greater than equation number of ahead station. See Chapter 3, "Horizontal Alignment Data" (01 card).

RADIUS OF CURVE OR DELTA ANGLE OUT OF RANGE

See Chapter 3, "Horizontal Alignment Data" (01 card), for allowable range for radius of curve and delta.

SPIRAL LENGTH OUT OF RANGE

Spiral lengths must (each) be less than π times radius of curve.

SPIRALS LAP

Sum of the two spiral angles was found to be (significantly) greater than the given delta.

Metric Bridge Geometry

HORIZ CIRCULAR CURVE NOT LONG ENOUGH TO PREVENT SUPER TRANSITIONS FROM LAPPING

End of transition in was found to be more than 0.3048 meters ahead of beginning of transition out. Generally indicates an error in coding 03 card, cols 21-50 for a simple curve. (See Chapter 3, "Crown and Superelevation Data.") May also be caused by incorrect delta, or radius given on 01 card. (See Chapter 3, "Horizontal Alignment Data.")

VERTICAL CURVES LAP

P.T. of first vertical curve was found to have station (significantly) ahead of P.C. of second vertical curve.

FATAL ERROR -- 02 CARD

In the absence of a more detailed diagnostic, this indicates insufficient or redundant data on 02 card. See Chapter 3, "Vertical Alignment Data."

INVALID TRANSITION LENGTH FOR SIMPLE CURVE

A superelevated horizontal curve that does not have spiral transition at one end (or both ends) must be given a non-zero transition length for superelevation on 03 card (cols 26-30 or 41-45).

INVALID PARABOLIC CROWN WIDTH

A parabolic crown must be given a non-zero crown width (03 card, cols 57-65). This error may also be due to incorrect crown type (col 3). See Chapter 3, "Crown and Superelevation Data."

IMPROPER USE OF OPTIONAL 03 CARDS

Stations on optional superelevation override cards were found to be in conflict or too close together.

COL 14, 24, 25 OR 26 OUT OF RANGE (OR LAYOUT LINE NOT FOUND ON PREV SECTION)

See Chapter II, "Reference and Layout Line Data" (04 card), for allowable range for these fields. Col 14 is considered "out of range" if it is a 3 and a fatal error in the previous section of 04-07 cards resulted in an undefined layout line.

COL 14 CONFLICTS WITH COL 24

If skew of the reference line is with respect to horizontal control, then reference station must be on horizontal control. (Applies only when reference station is in horizontal curve.)

ESTIMATED NUMBER OF POINTS EXCEEDS DEFAULT MAXIMUM

See Chapter 3, "Reference and Layout Line Data" (04 card), Extended Print Capability, col 33.

GIRDER LINE TYPE 4 MAY BE USED ONLY WITH CROWN TYPE A OR B

See Chapter 3, "Girder Line Data" (05 cards), line type 4.

- COL 3, 12 OR 21 OUT OF RANGE -- GIRDER LINE: . . .
See Chapter 3, "Girder Line Data" (05 cards), for allowable range for these fields.
- COL 11 OR 21 OUT OF RANGE -- BENT LINE: . . .
See Chapter 3, "Bent Line Data" (06 cards), for allowable range for these fields.
- COL 11 CONFLICTS WITH COL 21 -- BENT LINE: . . .
If a 06 card has skew type 1 (with respect to horizontal control), then distance type must be designated 0 (along horizontal control line). (Applies only when horizontal alignment is not tangent.)
- COL 11 CONFLICTS WITH COL 40 -- BENT LINE: . . .
A 06 card designated in col 40 (bent to define offsets for flared girder lines) may NOT use distance type 6 or 7 (from a secondary reference line). See Chapter 3, "Bent Line Data."
- COL 46 CONFLICTS WITH COL 11 OR 45 -- BENT LINE: . . .
Indicates improper use of secondary reference lines. See Chapter 3, "Bent Line Data" (06 cards), cols 45-46.
- BENT LINES NOT LOCATED BECAUSE SECONDARY REFERENCE LINE WAS NOT FOUND
Indicates improper use of secondary reference lines. See Chapter 3, "Bent Line Data" (06 cards), cols 45-46. This message may result from a combination of: 06 card with distance type 7 but no 05 card for segmented (line type 1) girder line.
- EITHER (1) 04 CARD HAS ERROR IN COL 24 OR 26
OR (2) NOT ENOUGH 06 CARDS HAVE VALUE IN COL 41
OR (3) NO 05 CARD HAS VALUE IN COL 51
- A chord layout line was requested but one of two rules was violated. If reference line is used as initial or terminal bent to define chord layout line (i.e., only one 06 card has been designated in col 41) and if skew of reference line is with respect to layout line (skew type 2), then layout line must be a chord on horizontal control line. Only two cases permit no 06 cards designated as initial or terminal bent to define chord layout line, viz.: (1) 05 card designated in col 51 is a girder line of type 3 (flared), or (2) 05 card designated in col 51 is a girder line of type 0 (parallel to horizontal control) AND horizontal alignment is tangent (i.e., no curve data given on 01 card). See Chapter 3, "Reference and Layout Line Data" (04 card).
- NOT ENOUGH 06 CARDS HAVE PUNCH IN COL 39
When segmented girder lines are used, at least two bent lines (06 cards) must be designated in col 39 (segmented girder lines to be broken). See Chapter 3, "Girder Line Data" (05 cards), line type 1.

NOT ENOUGH 06 CARDS HAVE PUNCH IN COL 40

A flared girder line was requested but no bent line (06 card) was designated in col 40 (bent to define offsets for flared girder lines). See Chapter 3, "Girder Line Data" (05 cards), line type 3.

FATAL ERROR -- LAYOUT LINE IS RECURSIVELY DEFINED

Generally results from using a bent line to locate a "chord" layout line when the location of the bent line itself depends on the layout line.

FATAL ERROR -- INTERSECTION OF REFERENCE LINE WITH HORIZONTAL CONTROL OR WITH LAYOUT LINE OR WITH TANGENT LINE IS ILL-CONDITIONED

The reference line must intersect both horizontal control and layout line. (It must intersect back or ahead tangent only if a 06 card has distance type 2 or 3.) This message indicates that the point of intersection could not be found (as, e.g., reference line being parallel to layout line).

FATAL ERROR -- INTERSECTION OF INITIAL OR TERMINAL BENT WITH HORIZONTAL CONTROL OR WITH LAYOUT LINE OR WITH TANGENT LINE IS ILL-CONDITIONED

For initial or terminal bent line to define offsets for flared girder lines (06 card, col 40), point of intersection could not be found (due to, e.g., bent line being defined so as to make it exterior to the horizontal curve).

Chapter 6 - CDOT Forms

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GIRDER LINE DATA : Page 6-4

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DEAD LOAD DEFLECTION DATA and ROADWAY APPROACHES : Page 6-6

IDENTIFICATION AND ALIGNMENT see following page

SUPERELEVATION AND LAYOUT DATA see following page

GIRDER LINE DATA see folloing page

BENT LINE DATA see following page

DEAD LOAD DEFLECTION DATA and ROADWAY APPROACHES see following pages

Chapter 7 - Example

The following example shows a five span structure which had to be split into two structure data sets because of a reversing horizontal curve. The coding forms used to prepare each input deck are on the following pages. A listing of each data deck follows the coding forms. After each deck listing is the actual output from the program, pages 1 through 16 in upper-right-hand corner, for each structure. The hermaphroditic aspects of this example are merely to demonstrate use of program features.

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Chapter 8 - Use of Cartesian Systems

The following summarizes some of the basic formulas for Cartesian coordinate systems.

For implicitly distinct points:

P(1) represented by coordinates (X_1, Y_1)

P(2) represented by coordinates (X_2, Y_2) ,

P(3) represented by coordinates (X_3, Y_3) , etc.

P(1), P(2) and P(3) lie on the same line (are colinear) if

$$Y_3 = Y_2 + \frac{(X_3 - X_2)(Y_1 - Y_2)}{(X_1 - X_2)} \quad \text{OR} \quad X_3 = X_2 + \frac{(Y_3 - Y_2)(X_1 - X_2)}{(Y_1 - Y_2)}$$

$$\text{OR } \det \begin{vmatrix} X_1 & Y_1 & 1 \\ X_2 & Y_2 & 1 \\ X_3 & Y_3 & 1 \end{vmatrix} = 0$$

Distance from P(1) to P(2) (in the horizontal plane)

$$\sqrt{(X_1 - X_2)^2 + (Y_1 - Y_2)^2}$$

The Euclidean norm (including difference in elevation)

$$\sqrt{(X_1 - X_2)^2 + (Y_1 - Y_2)^2 + (ELV_1 - ELV_2)^2}$$

Line through P(1) and P(2) is perpendicular to line through P(3) and P(4) if and only if

$$(X_1 - X_2)(Y_3 - Y_4) = (X_3 - X_4)(Y_1 - Y_2)$$

Line through P(1) and P(2) is perpendicular to line through P(3) and P(4) if and only if

$$(X_1 - X_2)(X_3 - X_4) = (Y_1 - Y_2)(Y_3 - Y_4)$$

Metric Bridge Geometry

Area of triangle with vertices P(1), P(2) and P(3)

$$\begin{aligned} &= \left| X_1 Y_2 + X_2 Y_3 + X_3 Y_1 - X_1 Y_3 - X_2 Y_1 - X_3 Y_2 \right| / 2 \\ &= \left| (X_1 - X_2)(Y_3 - Y_2) - (X_3 - X_2)(Y_1 - Y_2) \right| / 2 \end{aligned}$$

Area of quadrilateral with sequential vertices P(1), P(2), P(3) and P(4)

$$= \left| X_1 Y_2 + X_2 Y_3 + X_3 Y_4 + X_4 Y_1 - X_1 Y_4 - X_2 Y_1 - X_3 Y_2 - X_4 Y_3 \right| / 2$$

Distance of P(3) from the line through P(1) and P(2) is equal to twice the area of triangle P(1), P(2), P(3) divided by distance from P(1) to P(2)

$$\frac{(X_1 - X_2)(Y_3 - Y_2) - (X_3 - X_2)(Y_1 - Y_2)}{(X_1 - X_2)^2 + (Y_1 - Y_2)^2}$$

Transit at P(0), the angle turned from the line $x = X_0$ (parallel to Y-axis) to sight P(1) is given by

$$\tan(\theta) \frac{X_1 - X_0}{Y_1 - Y_0}$$

The angle turned from sight on P(1) to sight P(2) is given by

$$\tan(\theta) = \frac{(Y_1 - Y_0)(X_2 - X_0) - (X_1 - X_0)(Y_2 - Y_0)}{(X_1 - X_0)(X_2 - X_0) + (Y_1 - Y_0)(Y_2 - Y_0)}$$

If $\tan(\theta)$ is > 0 , θ may be either to the right $0 < \theta < 90$ or to the left

$$-180 < \theta < -90$$

If $\tan(\theta)$ is < 0 , θ may be either to the left $-90 < \theta < 0$ or the right

$$90 < \theta < 180$$

INDEX OF NONFATAL ERROR MESSAGES

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