APPENDIX B

HORIZONTAL ALIGNMENT

A roadway horizontal alignment is defined in terms of straight lines, circular curve sections, and, optionally, spiral transitions. The data for a horizontal alignment consists of horizontal PI locations and curve data.

Horizontal PI locations can be established by IGrds geometry computations or screen selections. They may also be established by using commands which project PI locations from previous PIs. This process is discussed later under Automatic Generation of Data.

Curve data can be input or may be automatically computed, based on design criteria and design parameters. Other data which is related to horizontal alignments may also be computed. The process is discussed later.

The IGrds/IG Option provides interactive commands for defining horizontal alignments and controlling displays. The graphic environment allows screen selections, real time additions and revisions, and various output options. Any number of separate alignments, designated by up to eight ASCII characters, may be entered. Any alignment may be a construction alignment, terrain baseline alignment, or both. Alignments may be renamed as desired. This is especially handy when upgrading older single character alignments so that more meaningful names can be used.

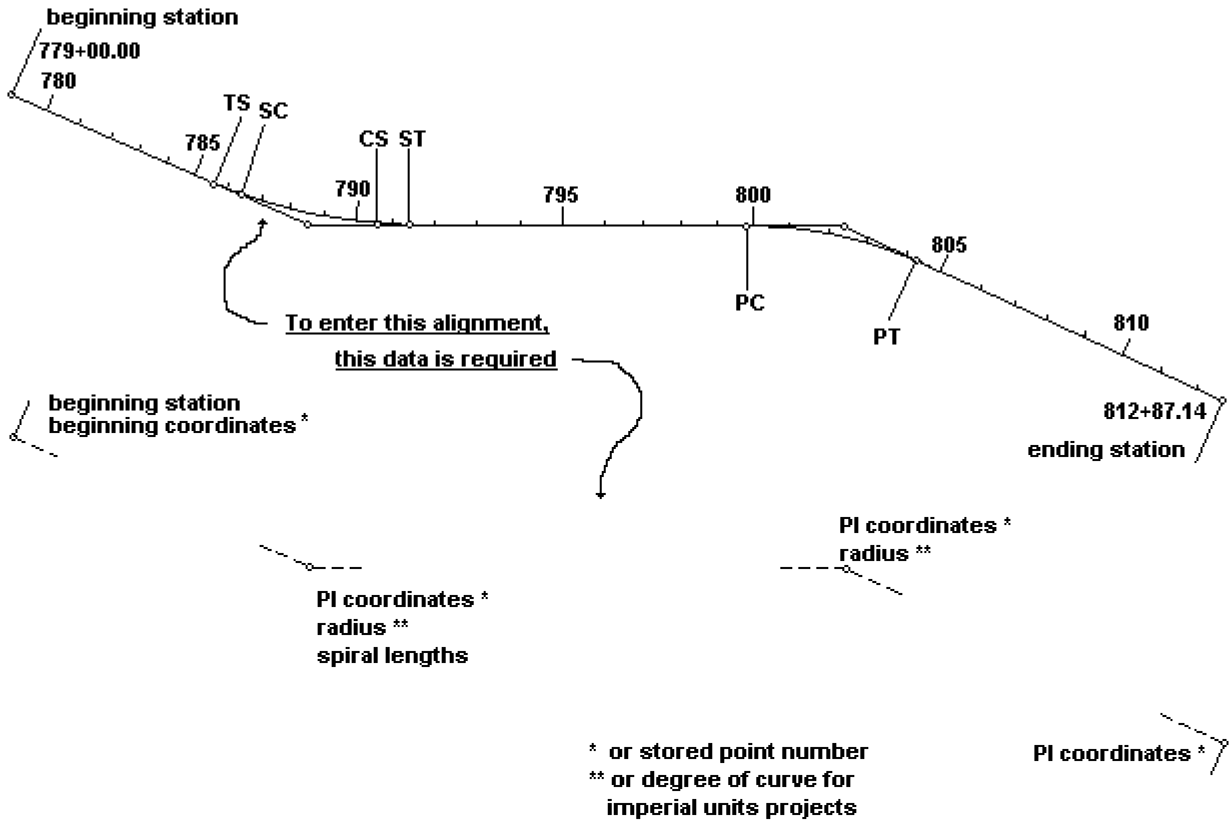
The horizontal alignment calculation process is used to compute and store the horizontal alignments in IGrds. Equations are also defined as part of the process, when applicable.

Figure B-1 shows a simple alignment and indicates the limited amount of data that is required to cause the alignment to be stored.

IGrds uses the Talbot Transition Spiral to transition between tangent and normal sections. The Talbot Transition Spiral, by definition, is a spiral whose radius varies inversely with the spiral length. The spiral traces a path where the change in rate of change in direction (second derivative) is a constant.

The formulae for compound spirals are essentially the same. One new equation is added to compute ls (length of the parent spiral) given lcs (length of the compound spiral) and the two radii (r_1 and r_2 where $r_1 > r_2$).

$$ls = lcs\ (r_1/r_1 - r_2)$$



Note: Radius (curvature) spiral lengths, and superelevation can be automatically calculated, if desired.

Figure B-1 - Alignment

LOCATING PIs BY PROJECTION

The location of a horizontal PI from the previous PI by specifying direction and distances in one of several ways, such as:

Previous Delta Angle and Distance PI to PI
PT to PC, etc.

AUTOMATIC GENERATION OF DESIGN DATA

Automatic generation of data is an option which requires that design criteria be available. IGrds/IG provides for storing criteria from the Road Design Manual or user agency criteria. The applicable criteria must then be assigned to each alignment and in some cases to the individual PI's. From this criteria, the system can generate the following data:

° curve properties for horizontal PIs based on design speed

° superelevation data corresponding to curvature

° automatic widening on sharp horizontal curves

Automatically generated data can be modified as desired.

The required AASHTO Design Standards from the 1990/1994 and 2001 versions of *A Policy on Geometric Design of Highways and Streets* are embodied in the design criteria table as separate partitions. The standards to be used (1990/1994 or 2001) are user selectable and the indication of which standard to be used is stored in the project .ini file. The design criteria are associated with IGrds alignments using the roadway design parameters dialog box. Using these criteria and AASHTO standard methods and formats imbedded in the calculation processes, users are able to request automatic horizontal curvature, including spiral lengths, automatic superelevation and transition length calculations, automatic pavement widening on sharp horizontal curves, and automatic vertical curve length calculations and adjustments. The following paragraphs discuss the features relating to horizontal alignments in more detail.

Design Criteria Table

The design criteria table contains AASHTO Green Book standards for horizontal and vertical alignment related data in both Metric and Imperial units. The table contains horizontal curvature and superelevation criteria for rural, high speed urban and low speed urban design. It also contains criteria used in solving transition length calculations for all design conditions. Criteria used in determining if and how much pavement widening is required for sharp horizontal curves are included as well. Sight distance (stopping, decision and passing) criteria are included for automatic vertical curve length calculations. The table also contains various rounding factors and switches, default design parameters, and user defined template segment options. This design criteria table is an ASCII editable file that can be customized by user agencies whenever the agency's standards differ from the AASHTO Standards.

Roadway Design Parameters Dialog Box

The key to assigning attributes to an IGrds alignment is the roadway design parameters dialog box. The user can select default design parameters for particular classes of facilities, which loads the dialog box with the selected characteristics. The user is also able to select or modify design characteristics, including the roadway class, number of lanes, lane width, location and terrain from the option buttons. The available options for each of these elements come directly from AASHTO nomenclature and are stored in the design criteria table. Likewise, the user can enter or edit the maximum and minimum grades and, if 2001 standards are in effect, the design vehicle. The user is also able to select or edit other design parameters, including the maximum superelevation rate and design speed for the alignment. The maximum friction factor, running speed and desirable stopping sight distance are then displayed directly from the design criteria table. Finally, the user is able to select or edit the superelevation type (0-4) and, where appropriate, the crown runoff length (Type 0) or the normal crown cross slope rate (Types 1, 2 or 3). Most of these parameters can be assigned to individual PI's, as discussed in the User Manual.

The location option button sets the method to be used for superelevation and transition length calculations and controls which maximum e and design speed values are available. For example, if the user selects Rural from the location option button, then the values for maximum e vary between 4% and 12%, and the values for design speed vary between 15 and 80 mph (20 and 130 Km/h if Metric). If the user selects Low Speed Urban, then the values for maximum e vary between 0% and 6%, and the values for design speed vary between 15 and 45 mph (20 and 70 Km/h if Metric). Note: Not all design speeds are used if the 1990/1994 standards are in effect.

Automatic Curvature for Horizontal PIs

Based on the selected criteria for a PI within an alignment, the user can request automatic curve properties for a PI. The desirable radius for the design speed selected for the PI is automatically shown in the radius field. This value can be overridden by the user, if desired. Likewise, for spiral curves, the spiral length is automatically calculated based upon the number of lanes, lane width, and calculated superelevation rate for the curve and shown in the spiral length fields. These values can also be overridden by the user, if desired. If the user enters the curvature, then, during the create/update process, the radius is checked to see if it is less than the minimum radius. If so, the user is alerted. Similarly, the create/update process will check the minimum curve length for each PI based on design speed and type of facility. If the 2001 standards are in effect, the process also checks calculated or entered spiral lengths against the suggested minimum and maximum lengths and alerts the user as required.

Automatic Superelevation and Transition Length

Automatic superelevation and transition length computations can be requested by the user by selecting the automatic superelevation option when the alignment is being created or updated. For rural or high speed urban design conditions, the superelevation rate for a particular curve is calculated using the standard AASHTO process for development of the finalized super rate distribution known as "Method 5". Calculations are based on the curve radius, and the design speed, running speed, maximum superelevation rate, and maximum friction factor for the PI being processed. The transition length is calculated using the standard AASHTO method and the number of lanes, lane width, calculated super rate, design and superelevation type. For low speed urban design conditions, the superelevation rate and transition length for a particular curve are calculated using the appropriate formulas from the AASHTO Green Book and the low speed urban criteria. See Appendix F for a detailed discussion of the methodologies used.

Note: Automatic superelevation is not available for compound curves.

Automatic Pavement Widening on Sharp Horizontal Curves

Pavements on curves are sometimes widened to make operating conditions on curves comparable to those on tangents. If automatic widening is desired, the user can request this by selecting the automatic widening option when the alignment is being created or updated. The standard AASHTO methodology is used, based on the selected AASHTO design vehicle and lateral clearances from the AASHTO Green Book. Other data used involves the number of lanes, lane width, design speed, and the radius of the curve being processed. See Appendix G for a detailed description of the methodology used.

When 2001 standards are in effect, the design vehicle is selectable from those included in the ha.tbl; for the 1990/1994 standards only one design vehicle is allowed.

PARALLEL HORIZONTAL ALIGNMENTS

Often designers may wish to establish new alignments in relation to previously defined alignments. This is commonly accomplished using the IGrds parallel alignment command. This command is augmented by capabilities within the IGrds point at a station and offset command. These features are:

- Define a station beyond the alignment station range
- Define a station with a geometry point
- Define an offset with a geometry point

With these features and the reverse curve feature described in Appendix M, parallel alignment command is a powerful method for creating alignments.

COPYING HORIZONTAL ALIGNMENTS

For some designs, especially major arterials with “off template” style templates both left and right alignments are coincident. The IGrds copy alignment command can be used to create these coincident alignments. The copy alignment command can copy the horizontal and vertical alignments as well as any superelevation and/or automatic curve widening.

HORIZONTAL ALIGNMENT FROM A GEOMETRY CHAIN

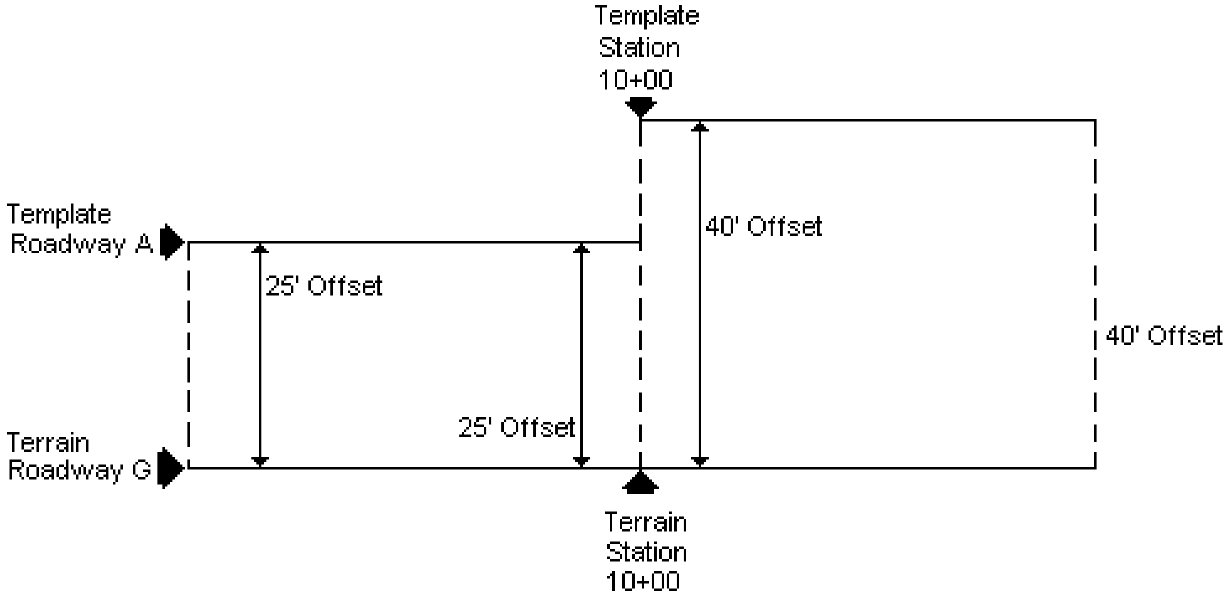
The Create Alignment from a Geometry Chain is another powerful method for defining horizontal alignments. See the discussion regarding ramp design in Appendix M.

HORIZONTAL ALIGNMENT BY OFFSET

Under certain circumstances, it may be preferable to define a horizontal alignment in terms of its offset from the terrain centerline rather than in terms of normal alignment properties. Alignment definitions by offset should be limited to those situations where the offset alignments will be essentially parallel to the terrain centerline. Design roadways may be defined by offsets.

Alignments defined by offsets can be included in design cross section definitions and, hence, in earthwork volume calculations. However, the alignments defined in this way may not be plotted graphically, displayed in the IGrds/IG Option, or used with geometry commands (as may alignments defined in terms of their normal alignment properties).

Any station equations that exist on any of the roadways must be specified on the offset data and roadway equations form (IGrds/AN) or the offset roadway dialog box (IGrds/IG) whenever an alignment is to be defined using offset data. The form, or the dialog box, is used to define an alignment in terms of designated offsets from the terrain centerline at stations specified by the designer. The designer must give distances from the baseline to the roadway centerline, along with corresponding stations on both lines at points where the distance changes. Abrupt and varying transitions are handled as illustrated in Figure B-1.



Uniform offset transitions are based on:

- ? Terrain baseline stationing
- ? Template stationing
- ? Offset distance

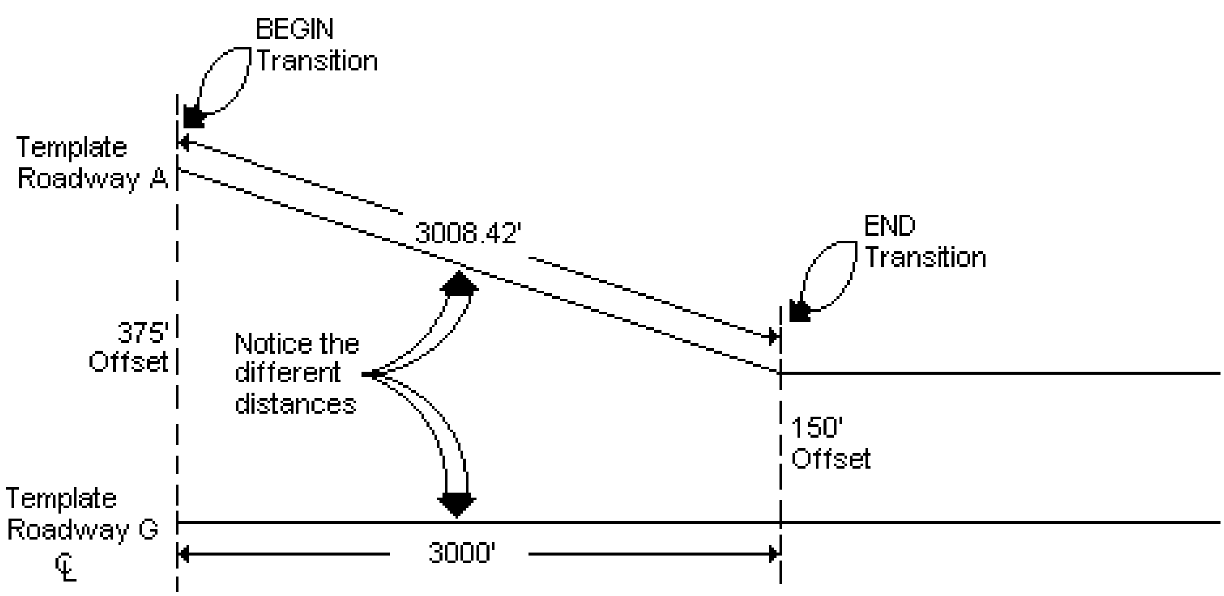


Figure B-2 - Offset Alignments

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