

APPENDIX C

THREE DIMENSIONAL GEOMETRY

The IGrds/IG Option provides the capability to define, display, compute and edit three dimensional (3D) geometry elements. These elements are displayable and measurable in plan profile and cross section views, as well as any MicroStation view, including isometric and perspective views. The 3D capability is completely compatible with the 2D capability so that users can operate in the “top” (i.e., X,Y or N,E plane) view only, if desired. To accomplish this compatibility, all geometry arcs are defined in the top view, and appear as circular arcs in this view. Likewise, all horizontal angles and distances, including radii, are measured and applied in the top view. Elevations can be computed, assigned automatically or entered manually by the user.

The specific 3D capabilities are discussed in the following paragraphs.

GEOMETRY ELEMENT ELEVATION ASSIGNMENT

As mentioned above, elevations for geometry elements can be computed, assigned automatically or entered manually by the user. All linear geometry elements can also have a profile associated in lieu of the elemental elevation capability discussed in this section. Profiles for geometry elements are discussed later in this Appendix.

Elevation Tool

Some geometry commands offer a tool for assigning elevations to geometry points or the ends of lines or arcs. This tool has four options:

Key-In: The user enters the elevation in the elevation text field. If the user snaps to a 3D MicroStation element, then the elevation of that element is displayed in the text field. If the user merely digitizes a location in the graphic area, then the active depth is displayed in the text field.

DTM Surface: When the user digitizes a location in the graphic area, the elevation of that location from the active DTM surface as reflected in a 3D design file is displayed in the elevation text field. If the user enters planar (X,Y or N,E) coordinates, then the DTM elevation can be obtained by “tabbing” in and out of the elevation text field.

Design Finish Grade Surface: When the user digitizes a location within the limits of construction of the active baseline, then the elevation of that location from the design finish grade surface is displayed in the text field. If the digitized location is outside the design area, then the user is alerted and no elevation is displayed. As with the DTM surface option, if the user enters planar coordinates, then the elevation can be obtained by tabbing in and out of the elevation text field.

Design Subgrade Surface: The operation of this option is exactly the same as the design finish grade surface option, except the subgrade elevation is displayed.

Many elevations are computed as the result of geometry calculations, such as the intersection of two geometry elements. The rules for these computations are discussed later in this Appendix.

Geometry Point Elevations

As described above, elevations for geometry points can be entered, assigned or computed, and are stored along with the planar coordinates and other values such as feature codes. There are two commands which create geometry points by projection from an existing point that have a vertical angle tool. The user enters the vertical angle, and the elevation of the point being projected is calculated using this vertical angle. 3D geometry points can also be defined in roadway or geometry element reference lines. Likewise, 3D geometry points defined in normal MicroStation views can be projected into roadway or geometry element reference lines. See the discussion on projecting geometry elements into reference lines later in this Appendix.

When a 3D geometry point is created, it is automatically displayed in all open MicroStation views. Figure C-1 shows how 3D geometry points appear in the normal MicroStation top, front, right and isometric views.

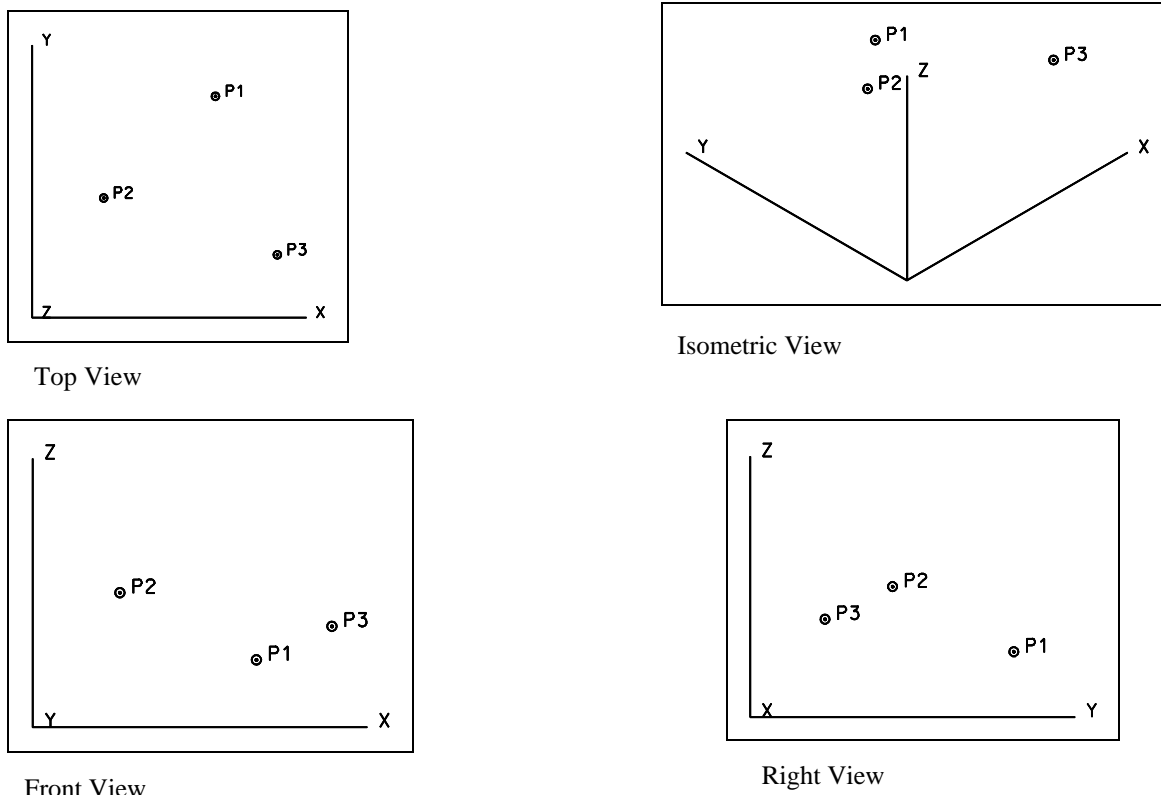
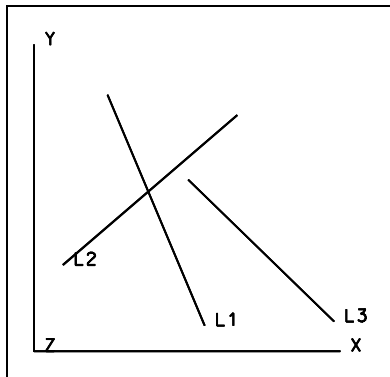


Figure C-1 - 3D Geometry Points

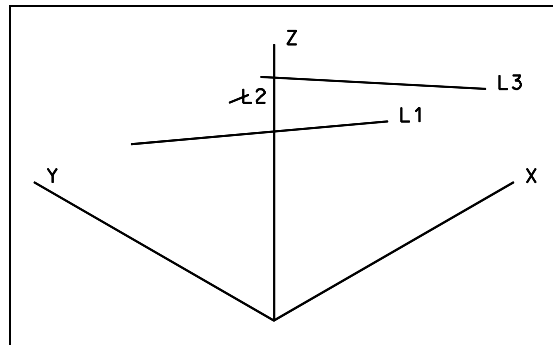
Geometry Line Elevations

To maintain compatibility with the 2D geometry capability, any distance, direction or horizontal angle used to define a 3D geometry line is measured and applied to the top view (X,Y or N,E plane). For geometry lines, elevations are established and stored for the beginning and ending points of the line. The elevations can be entered, assigned or computed. 3D geometry lines cannot be defined in roadway or geometry element reference lines, but may be projected into reference lines. Likewise, 3D geometry lines can be projected into cross section views; see the discussion on projecting geometry elements later in this Appendix. Very importantly, 3D geometry lines can have 3D shapes attached to them. This capability is also discussed in detail later in this Appendix.

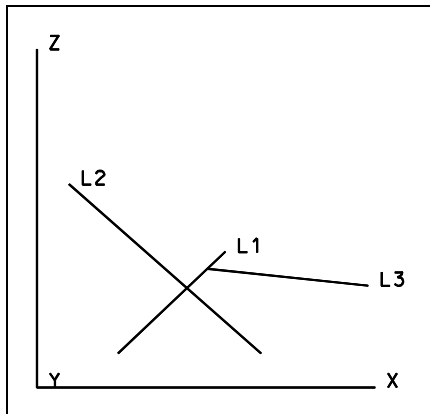
When a 3D geometry line is created, it is automatically displayed in all open MicroStation views. Figure C-2 shows how 3D geometry lines appear in the normal MicroStation top, front, right and isometric views.



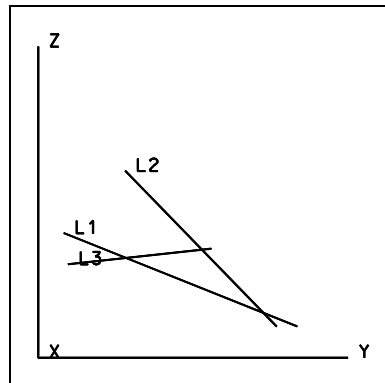
Top View



Isometric View



Front View



Right View

Figure C-2 - 3D Geometry Lines

Geometry Arc Elevations

To maintain compatibility with the 2D geometry capability, all arcs are defined in the top view (X,Y or N,E plane), and appear as circular arcs in this view. As with 3D geometry lines, elevations are established for the beginning and ending points of the arc. These elevations can be entered, assigned or computed. Also, 3D geometry arcs cannot be defined in roadway or geometry element reference lines, but may be projected into reference lines and cross section views; see the discussion on projecting geometry elements later in this Appendix. Again, as with geometry lines, 3D shapes can be attached to 3D geometry arcs, as discussed later in this Appendix.

When a 3D geometry arc is created, it is automatically displayed in all open MicroStation views. As mentioned earlier, arcs appear as circular elements in the top view. In space, arcs travel a helical path along the surface of a right cylinder with a radius equal to the radius of the 3D geometry arc. The right cylinder is parallel to the Z axis and the helical path extends from the beginning elevation to the ending elevation. Figure C-3 shows how 3D geometry arcs appear in the normal MicroStation top, front, right and isometric views.

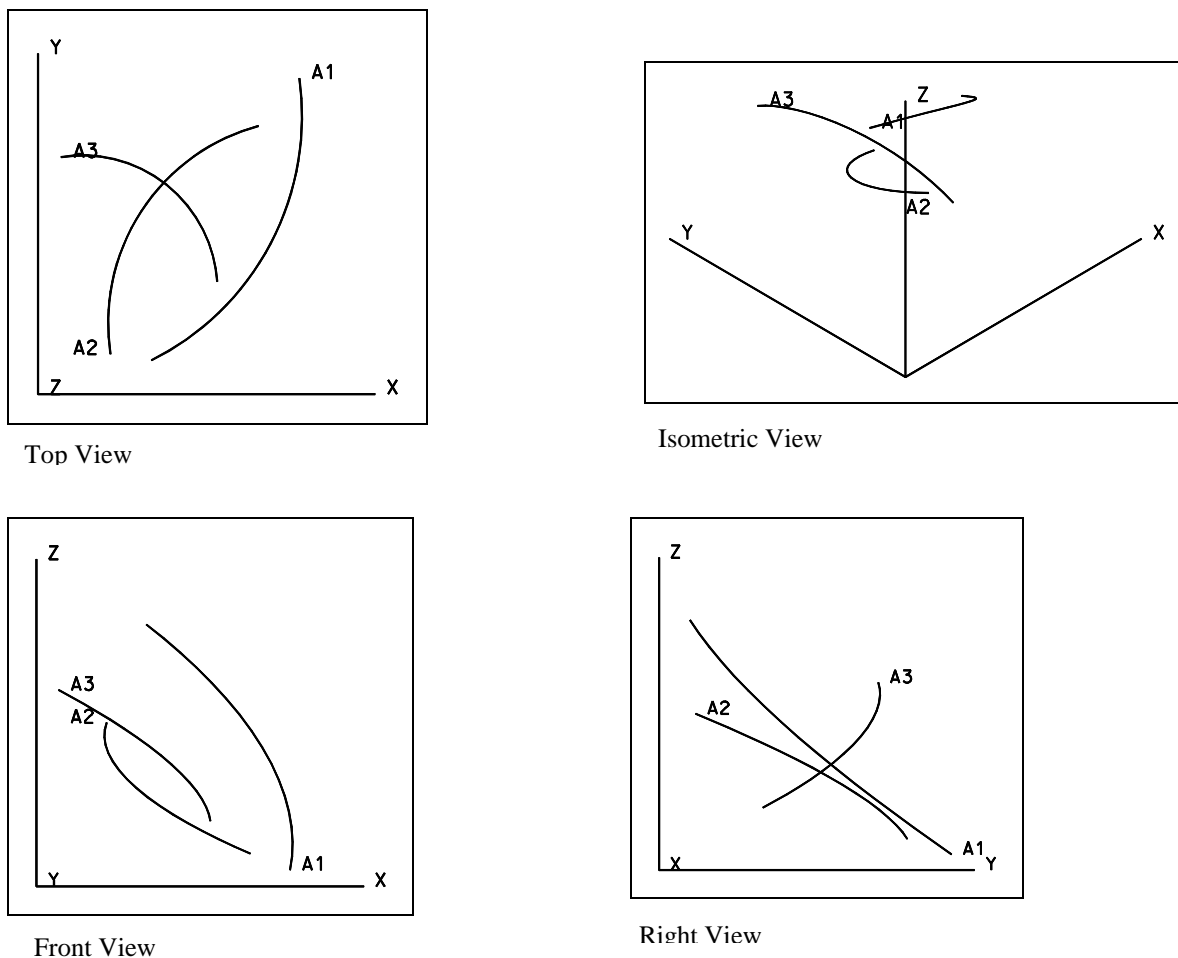
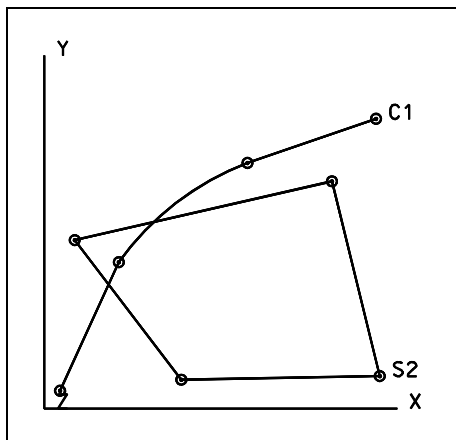


Figure C-3 - 3D Geometry Arcs

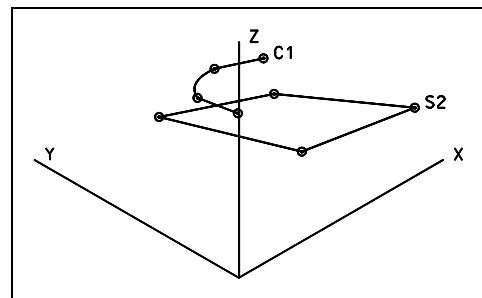
Geometry Chain and Shape Elevations

3D geometry chains and shapes take on the characteristics of the 3D geometry elements which make up the chain or shape. Hence, elevations of the chain or shape elements are the same as the elevations of the original component elements. 3D geometry chains and shapes differ slightly from 2D geometry chains in that a vertical component (same X,Y; different elevation) can be included in a 3D chain. This component is ignored in 2D geometry calculations. As with other linear 3D geometry elements, 3D geometry chains and shapes cannot be defined in reference lines, but may be projected into them and cross section views. Also, 3D shapes can be attached to 3D geometry chains and shapes, as discussed later in this Appendix.

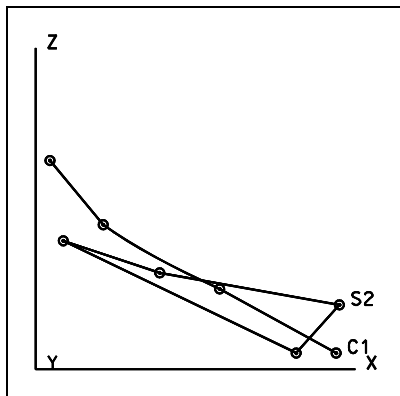
When a 3D geometry chain or shape is created, it is automatically displayed in all open MicroStation views. Figure C-4 shows how 3D geometry chains and shapes appear in normal MicroStation top, front, right and isometric views.



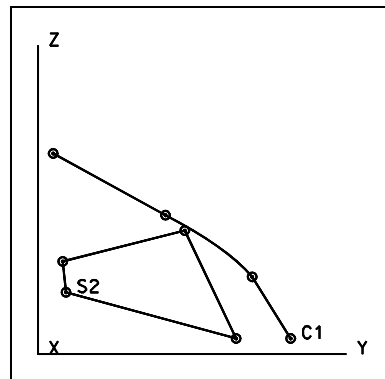
Top View



Isometric View



Front View



Right View

Figure C-4 - 3D Geometry Chains and Shapes

GEOMETRY ELEMENT ELEVATION COMPUTATION

As mentioned above, elevations for geometry elements can be assigned automatically, entered manually by the user or computed. For most geometry commands, the elevations are computed. Generally elements that are created relative to another element or elements take on the characteristics of the referenced element(s).

The following paragraphs discuss the specific processing rules for computing elevations under varying conditions.

Referenced Geometry Points

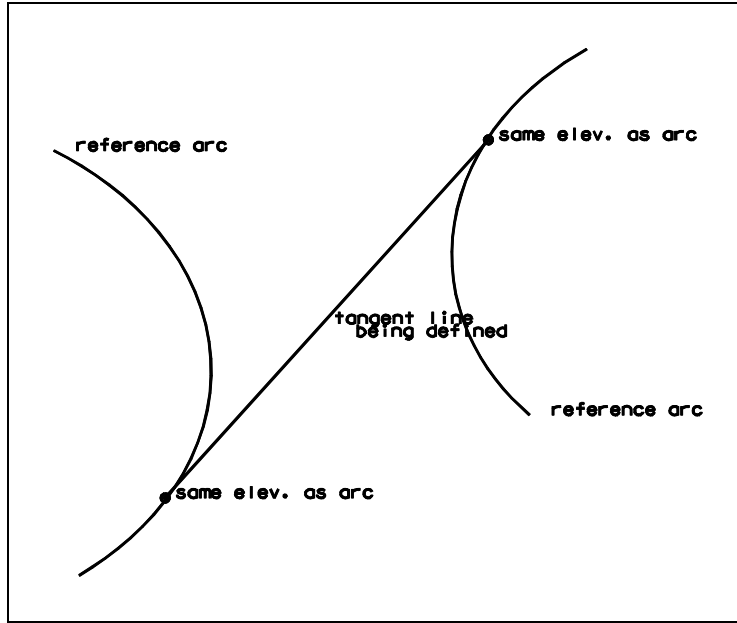
Several geometry commands for creating lines, arcs, chains and shapes reference stored geometry points. Whenever stored 3D points are used to create all or a portion of a 3D linear element, the elevation of the stored point is used for the linear element. For example, if a geometry line is created from two stored geometry points, then the elevations of the ends of the line are the same as the reference point elevations. If the line being created is at an offset, the elevations are still the elevations of the referenced points.

Points Along Elements

There are several commands that create geometry points along referenced linear geometry elements. For points established in this fashion, the elevation of the point is calculated precisely on the referenced element or an extension to that element. If the point being created is at an offset to the element, the elevation of the point of offset is the same as if the point were on the element.

Elements Tangent to Elements

There are several commands that create geometry elements that are tangent to other elements. For points, lines and arcs created in this fashion, the point or element end that is established by the point of tangency takes on the elevation of the referenced element at this location. The example shown in Figure C-5 illustrates how the Line Tangent to Two Arcs command solves elevations for the ends of the line being defined. Again, if the line being defined is at an offset, the elevations are the same as if there were no offset.

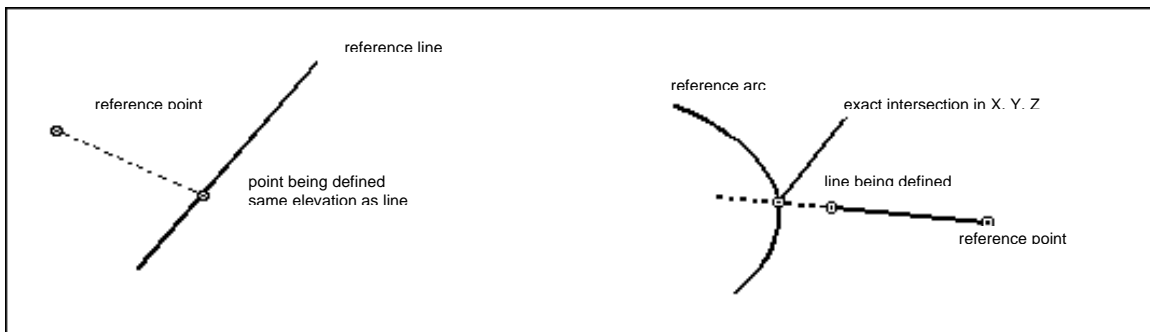


Isometric View

Figure C-5 - Isometric View of Element Tangent to Elements

Elements Projected to Elements

There are several commands that create lines or points projected to other linear geometry elements. For points and lines created in this fashion, the point or line end that is established by the point of projection takes on the elevation of the referenced element at this location. If a point is established in this fashion with an offset, then the elevation is the same as if the point were on the element. If a line is being established in this fashion, without an end point on the referenced element, then the line (or an extension of the line) still passes through the referenced element in all three dimensions. In other words, the two elements would intersect exactly in X, Y and Z at the theoretical point of projection. See Figure C-6 for an example of elements projected to elements.



Isometric View

Figure C-6 - Isometric View of Elements Projected to Elements

Elements Parallel to Elements

There are several commands that create geometry elements parallel (concentric for arcs) to other geometry elements. For line and arc elements created in this fashion, the end points take on the elevation of the referenced element end points. For chains and shapes, the ends of all component elements take on the elevations of the referenced elements.

Points at Intersections

Normal IGrds 2D geometry processing rules are followed for establishing the planar (X,Y or N,E) intersection of two geometry elements. Since it is very likely that the two elements do not intersect exactly in the Z dimension (elevation), elevations are displayed for the planar intersection location of both elements. The user selects which elevation to use, and a 3D geometry point is created at the intersection location with the chosen elevation. If offsets are given, then the offset elements are intersected in the same manner as are primary elements, and the elevations displayed are those of perpendicular projections to the referenced elements from the offset intersection point. Figure C-7 shows an example of points created at intersections.

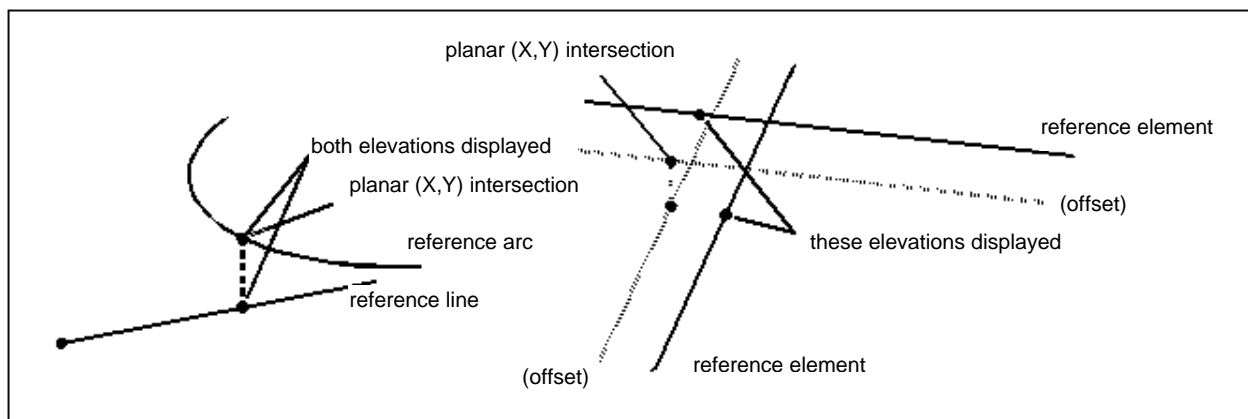


Figure C-7 - Isometric View of Points Created at Intersections

Measurements and Calculations

Several commands perform geometric calculations such as calculating the distance and direction between points, the angle between lines, the station and offset of a point, etc. All planar (X,Y or N,E) calculations are performed in the top view for compatibility with the 2D capability. All angles, distances, and directions reported or displayed are planar. Likewise, stations and offsets are also planar. One command, Calculate Bearing and Distance, also displays the slope distance and vertical angle between the referenced points. These values are identified as such in the display.

GEOMETRY ELEMENT PROFILES

As an alternative, design roadway type profiles can be established for any linear 3D MicroStation or IGrds geometry element, including lines, arcs, chains and shapes. When a MicroStation element is selected, it is automatically converted to an IGrds geometry element. With a few exceptions, the full vertical alignment capability is available for geometry elements. Design profiles, including vertical curves if desired, can be defined. Also, design profiles can be generated by “draping” the element over the DTM, design finish grade, or design subgrade surfaces. VPIs can be edited in the standard fashion. Likewise, vertical geometry computations can be performed. Other geometry elements and design roadways can be projected into the reference line for geometry elements.

Procedurally, the user first identifies the element for which a profile is to be established. The process allows the user to create an identical element for which the profile is to be established, if the user wishes to preserve the existing element’s 3D specification. Once the element is identified, the user establishes a reference line for the element using the standard reference line editor tool. Then the user establishes the design profile using the full vertical alignment tool set. See Appendix D for a detailed discussion of vertical alignments.

Once a profile has been established for a 3D geometry element, the profile is used for all elevation calculations involving the element. Planar calculations are performed in the standard 2D style, as described above. Figure C-8 shows examples of geometry element profiles.

GEOMETRY ELEMENT 3D SHAPES

Three dimensional shapes can be assigned to linear 3D geometry elements. Three shape types can be defined: circular, rectangular or elliptical. Likewise, two dimensional MicroStation cells can also be attached to 3D linear geometry elements. In essence, these shapes or cells are extruded along the geometry element creating renderable surfaces. See Figure C-9 for examples. When linear 3D elements are projected into reference lines or cross section views, these 3D shapes are displayed. 3D shapes, alignment points and cells are discussed in more detail in the following paragraphs.

3D Shapes

As mentioned earlier, three shape types can be defined: circular, rectangular or elliptical. For each type, the user enters the dimensions, wall thickness and alignment point. See Figure C-10 for examples of shapes that can be attached to linear geometry elements.

Alignment Point

3D shapes can be attached to 3D geometry elements at five different alignment points, as shown in Figure C-11. The alignment point for a cell is always the cell origin.

MicroStation Cells

Any 2D MicroStation cell can be attached to a 3D geometry alignment. As mentioned, the cell is always attached at the cell origin. Cells are useful for many applications, including curbs, barriers, guard rails, etc.

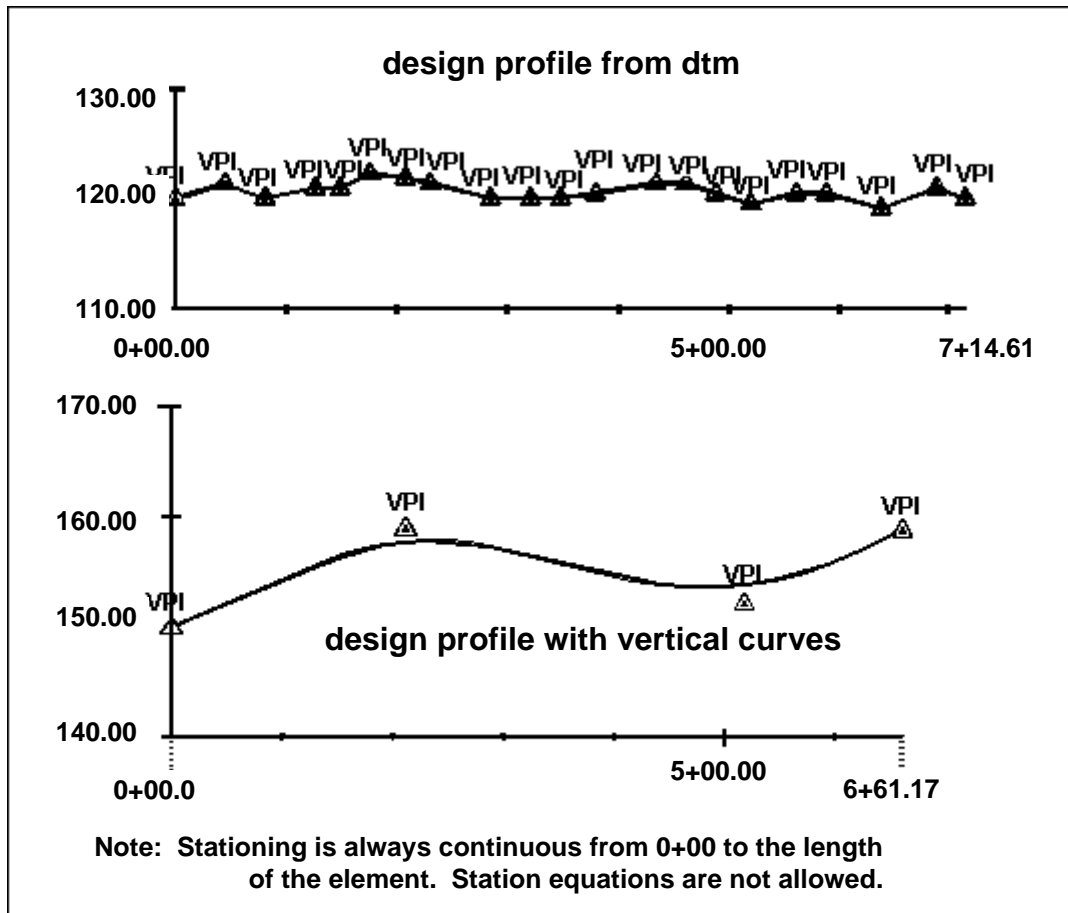


Figure C-8 - Examples of Geometry Element Profiles

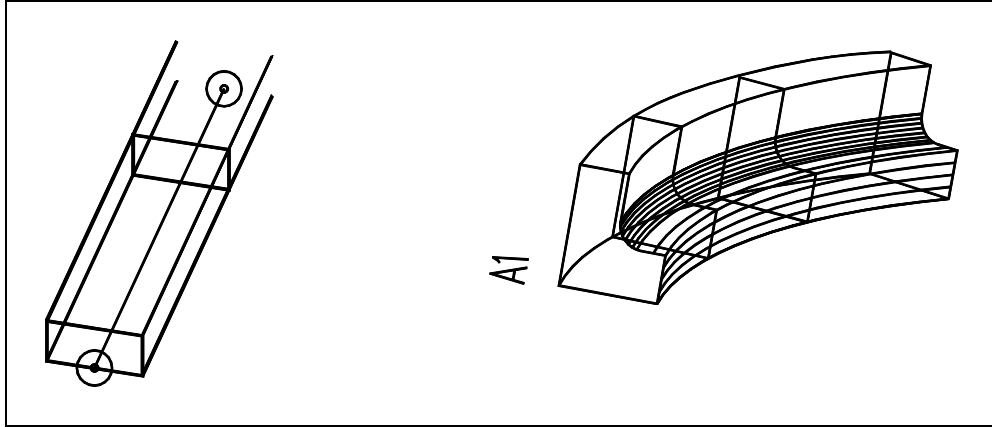
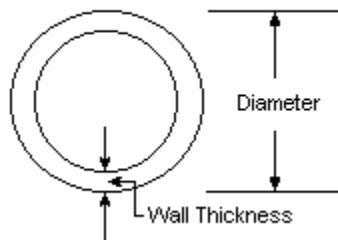
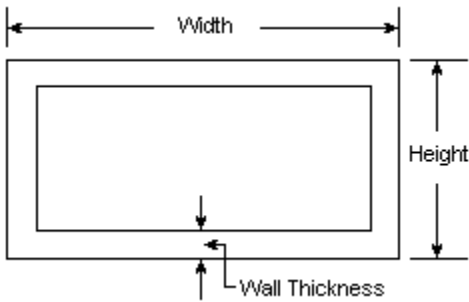


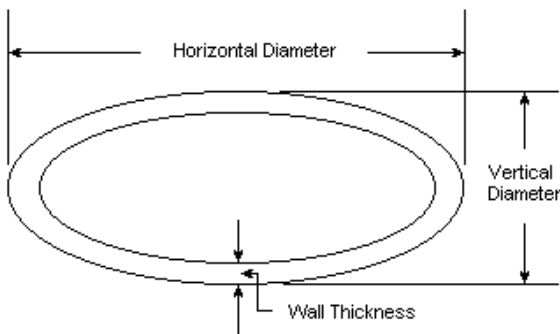
Figure C-9 - 3D Shapes and Cells Attached to Geometry Elements



Circular - Outer diameter and wall thickness

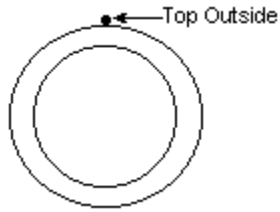


Rectangular - Height, width, and wall thickness

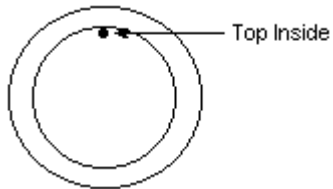


Elliptical - Vertical and horizontal diameters and wall thickness

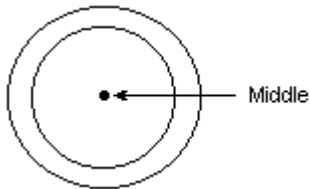
Figure C-10 - 3D Shape Types



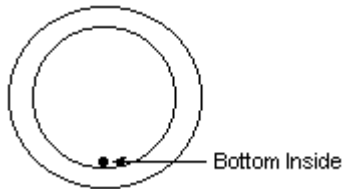
The top outside alignment point is normally used if cover is important



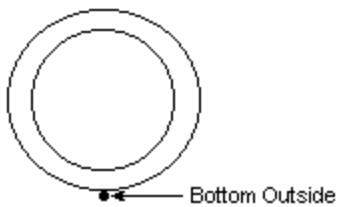
The top inside alignment point is normally used if the soffit elevation controls



The middle alignment point is used for centerline designed elements



The bottom inside alignment point is used if flowline elevation controls

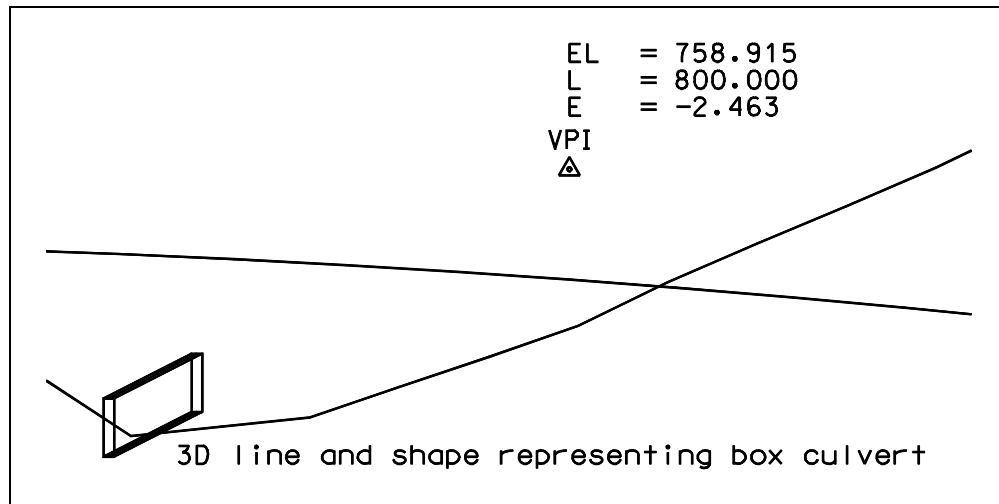


The bottom outside alignment point is normally used when structural excavation is important

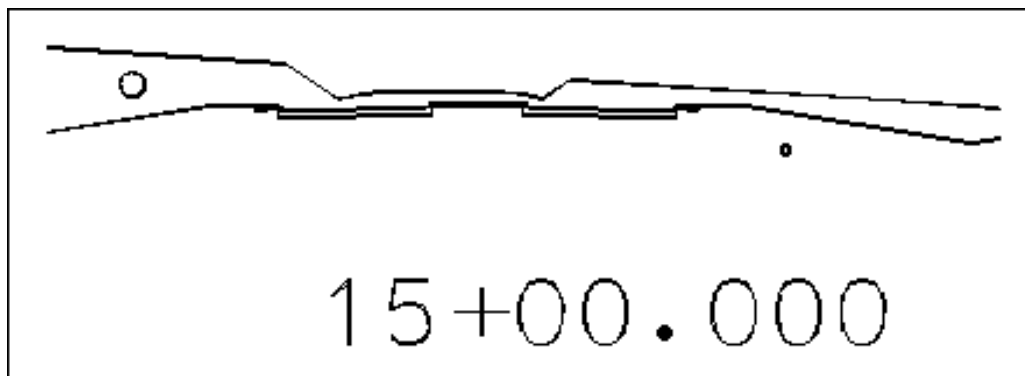
Figure C-11 - 3D Shape Alignment Points

GEOMETRY ELEMENTS PROJECTED INTO REFERENCE LINES AND IGrds CROSS SECTION VIEWS

Any 3D geometry element with an associated 3D shape, if relevant, can be projected into the reference line for any design roadway or geometry element. The selected geometry element is projected into the reference line in true relationship to the reference alignment or geometric element. Likewise, 3D geometry elements can be projected into IGrds cross section views; specifically Design Section Display, XSM, and IGrds Cross Section Plots. The selected element is shown in cross section view at the correct offset and elevation. See Figure C-12 for examples of projected geometry elements.



3D Elements Projected to Reference Line



3D Elements Projected to Cross Section View

Figure C-12 - Examples of Projected Geometry Elements

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