Visual Bridge and Roadway Geometries
Version 1.2 Users’ Manual

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Chapter 1 Introduction and Installation

1.1 Introduction

Visual Bridge and Roadway Geometries - Visual BRG is a Windows-based GUI application that provides bridge engineers abilities to generate bridge and roadway geometry models. The leading edge software technologies, such as Windows Presentation Foundations (WPF), DirectX 3D Rendering, Data Event Driven and .NET, are employed in its development. Rich of graphical user interfaces and the instant responses to data changes in 3D rendering are exceptional features of Visual BRG.

Roadway geometries including horizontal and vertical curves, super-elevations, super-widening and transverse curves can be modeled by “parametric” method. Bridge components such as supports, girders, diaphragms can then be defined on the basis of roadway geometries. Roadway cross sections at designated stations can be graphically shown on screen. Coordinates of bridge deck control points (longitude, latitude and elevation) can be exported as a data file so that it can be plotted in Microstation. As a supplemental feature to modeling bridge geometries, girders, diaphragms and supports information can be modeled seamlessly at the same time. To facilitate further structural analysis, such a bridge geometry model can be exported as a DESCUS data file so that it can be analyzed by using DESCUS programs. In addition to export functions, Visual BRG also provides import functions to allow users to build geometry models from AutoCAD Exchange File (DXF) or to reproduce bridge models from existing DESCUS program analysis data file.

1.2 System Requirements

Visual BRG was developed on the Microsoft .NET Framework 4 platform. The underlying rendering technology is DirectX 3D 9. Both are native part of Windows 7. When running under an earlier system such as Windows XP, both software components can be downloaded from Microsoft and installed separately. In addition to these two primary dependencies, Microsoft C Runtime Library 10.0 is required. DirectX 3D and Microsoft C Runtime Library have different versions for 64/32 bits Windows systems. When downloading and installing these components, the correct version should be used.

1.3 Installation

Run Installation Package to get Visual BRG installed. During setup, destination system will be detected and 64/32 bit version will be installed accordingly. Above dependent components may also be installed by users’ selection.
Chapter 2  Visual BRG Main Window and Menus

2.1  Visual BRG Main Window

When Visual BRG starts, the main window as shown in Figure 2.1 will open. The main toolbar is on the top of the window. The main window is split into two portions. Left portion is the data forms area. Right portion is the graphics area. A default roadway and bridge model is preset initially.

![Visual BRG main window](image)

Figure 2.1 – Visual BRG main window

All geometry parameters are entered and edited in the data forms. In the graphic area, another toolbar, which allows user to manipulate a view, is on top. There are three different graphical views can be shown in graphics area: 1) plane view, 2) roadway frame view and 3) 3D view of deck. Since Visual BRG is an interactive graphics processing system, all geometric parameters can be entered or modified interactively. Whenever conflicts among parameters arise, system will output certain error message reminding users that certain types of exception happened. All error messages are redirected to Visual BRG Error Message Window as shown in Figure 2.5.

In the plane view, by clicking in the main toolbar, mainline, transverse lines, longitudinal lines, and transverse roadway cross sections will be shown in the upper part of the window (Figure 2.1). Elevation of mainline and span layout will be shown in the lower part of the screen.

In the roadway frame view, by clicking in the main toolbar, mainline and all designated roadway cross sections are shown in 3D as frames on the top of the window (Figure 2.2). Transverse road curves of these cross sections are shown in 2D on the bottom of the window (Figure 2.3).
In the 3D view of deck, by clicking 🏆 in main toolbar, roadway surface and railing are rendered in 3D, and mainline and all deck control points are rendered on their relative positions (Figure 2.4).

Whenever an error or exception happens, the error message window as shown in Figure 2.5 will open, by default. It can be closed by clicking the cross icon on top the window. The error message content can be cleared by clicking Clear Content button. If the window is closed, by clicking 🔄 in the main toolbar, the error message window will show up again. Uncheck Auto Open, the message window will not open automatically, but until 🔄 in the main toolbar is clicked.
2.2 Visual BRG Data Forms

Input data to build roadway and bridge model are categorized into six different groups: 1) Project, 2) Mainline, 3) Longitudinal Lines, 4) Transverse Lines, 5) Points and 6) Diaphragms. The first five groups are common data and are primary to build a bridge geometry model. The last group, Diaphragms, is available only when Bridge Modeling is enabled, which provides a data form to allow users to specify individual diaphragms.

2.2.1 Project Data Form

General information about a project such as the project name can be entered in Project Data Form as shown in Figure 2.6.

By default, Bridge Modeling is not enabled, and only bridge roadway geometry can be defined. When Visual BRG is used for creating a bridge model for DESCUS analysis programs, click Enable Bridge Modeling to specify additional individual diaphragms.
2.2.2 Mainline Data Form

Mainline is a key component in building a roadway and bridge model. All geometries are based on or derived from mainline. As shown in Figure 2.7, the definitions of a mainline contain 1) Horizontal alignments (plane curve), 2) vertical profile (elevation curve) and cross sections (transverse curve). When Bridge Modeling is enabled, two types of locations on mainline, POI – Point Of Interest and POC – Point Of section Changes, can be defined and associated with mainline. These POIs and POCs on mainline can then be referred by girders so that these locations will be accounted for when a bridge model is meshed and exported to DESCUS program. In this respect, POI is purely a guaranteed mesh point on girder; while POC is the same but a section number for segments forward can be specified.

Refer to Mainline chapter for details.
2.2.3 Longitudinal Lines Data Form

In Visual BRG, bridge roadway geometry is modeled as lines along the bridge axis and lines across the bridge axis. The former is called Longitudinal Line and the latter is called Transverse Line. Mainline is a special Longitudinal Line with extra vertical and roadway information. A longitudinal line contains only plane curve, which may be defined by referring other longitudinal line or by independent curves or explicit reference points.

Information needed to define a longitudinal line includes line ID and Name, Line Type, Offset distance, Angle, Reference Longitudinal Line, Starting Bent and Ending Bent defining span scope of a line, Starting Point or Ending Point for an explicitly point defined a line, whether or not a longitudinal line is a Girder center line, or a Railing. ID of a longitudinal line is assigned automatically when a line is created, and cannot be changed so that its uniqueness is maintained. Figure 2.8 shows the longitudinal line data form.
Refer to Longitudinal Line chapter for details.

2.2.4 Transverse Lines Data Form

A transverse line is used to define where a bent or a deck control point locates. When defining a deck control point, its horizontal location is the intersection of a longitudinal line and a transverse line.  When defining a bent, a transverse line defines its location and orientation.

Figure 2.9 – Transverse Lines data form

A transverse line is usually a straight line. However, it can be defined by a series of explicit points connected by a transverse line. In that case, a transverse line may be connected line segments. A transverse line may not necessarily be radial of a curve segment, i.e. skewed transverse line. When such a skewed transverse line reached to the reference longitudinal line of another longitudinal line that is marked as Railing, it may change back to radial of a curve segment where it intersects. This feature of a transverse line is indicated by Use Radial Line for Railing. In this case, a transverse line may contain two or three straight line segments.

As shown in Figure 2.9, information needed to define a transverse line includes the primary and the secondary information. Primary information includes, Line ID and Name, Line Type, Distance or Station, Distance Ratio, Angle, First Reference Transverse Line, Second Reference Transverse Line, Reference Longitudinal Line and Points. The secondary information is to specify if a transverse line is a Bent, Suppress Output and Use Radial Line for Railing. When Suppress Output is checked, deck control points will not be output. When Use Radial Line for Railing is checked, a transverse line will turn to radial at the intersection with the reference line of a Railing longitudinal line. Similarly to longitudinal lines, ID of transverse lines is automatically assigned and cannot be modified so as to maintain its uniqueness.
Refer to Transverse Lines chapter for details.

### 2.2.5 Points Data Form

Visual BRG can define different points that can be used as a reference of other locations. For examples, an independent curves of a longitudinal can be defined to start from a predefined point, a longitudinal line can connect two predefined points, and etc.

As shown in Figure 2.10, information needed to define a point includes ID and name, Point Type, Origin Point, X and Y coordinates, Distance, Sita angle, First reference transverse line, Second transverse line and Reference longitudinal line.

Refer to Points chapter for details.

![Points data form](image)

**Figure 2.10 – Points data form**

### 2.2.6 Diaphragms Data Form

When Bridge Modeling is enabled, diaphragms can be defined in Diaphragm data form. A diaphragm can be a grouped or ungrouped diaphragm. The location of a grouped diaphragm is defined by a Transverse Line while an ungrouped diaphragm is defined by starting girder, starting location, ending girder and ending location. An ungrouped diaphragm may contain several diaphragm segments that connect all girders from starting girder to ending girder. Locations for an ungrouped diaphragm can be defined by mainline stations or girder stations. When station is referred to mainline, it starts from or ends with a girder intersecting with a mainline radial line at specified mainline station. This type of measurement of diaphragm locations should be used by default, as a consistent reference – mainline is used. However, in cases where measurements are taking on girders, stations can be specified are based on individual girder instead, i.e. girder start station plus girder curve length. Use Girder Station in locating an ungrouped diaphragm is the same as that in independent POIs/POCs of a girder. One example of this case is when diaphragm geometries are imported from DXF file, in which only intersections with girders can evaluated. Another example of Use Girder Station is when importing from DESCUS data file, in which diaphragms are located by member nodes on girders and mainline does not exist at all.

In addition to diaphragm geometries, type and section number can be specified in the form, which will be associated to its corresponding members when exporting to DESCUS program.

Figure 2.11 shows the Diaphragms data form. For details about diaphragms, please refer to Diaphragms chapter.
2.3 Main Menu and Toolbar

As shown in Figure 2.12, the main menu and toolbar contain the following items:

- **New**: Create a new *Visual BRG* project
- **Open**: Open an existing *Visual BRG* project
- **Save**: Save changes of the current project
- **Save As**: Save the current project as a different project
- **Import from a DESCUS data file**: Import geometries from a DESCUS data file
- **Import from a DXF file**: Import geometries from a DXF file
- **Export to a DESCUS data file**: Export bridge model to a DESCUS data file
- **Export to RES files**: Export bridge geometries to Camber program input files
- **Exit**: Exit *Visual BRG*
2.4 **Other Main Toolbar**

The other toolbar as shown in Figure 2.12 contains the following items:

- Undo an edit
- Redo an edit
- Switch to plane view
- Switch to 3D roadway frame view
- Switch to 3D deck rendering view
- Show error message window

2.5 **2D Graphics Area Toolbar**

As shown in Figure 2.13, toolbar of 2D graphics area contains commands for 2D graphics operations. The same toolbar appears in plane view, elevation view and roadway cross section view. In 3D roadway frame view, view operations can be switched among 2D and 3D. When operation is in the 2D mode, what currently appeared in camera view can be operated in 2D mode. Toolbar will be switched from 3D to 2D mode accordingly. Go to next section for details about 2D operations in 3D view.

The following lists each item of the 2D graphics toolbar:

- Pan view. When clicked, it enters pan mode. Holding left button and moving cursor to pan, and releasing button to stop pan
- Zoom to full extent
- Zoom in one level at current cursor location
- Zoom out one level at current cursor location
- Zoom by window. Move cursor to one corner and hold left button while moving to other corner. Release left button to zoom
- Set up **Visual BRG** display properties. See Display Properties for detail
- Collapse the toolbar so to have more viewing space
- Expand the toolbar

![Toolbar of 2D graphics area (expanded and collapsed)](image)

2.6 **3D Roadway Frame View Toolbar**

As shown in Figure 2.14, toolbar of 3D roadway frame view has two modes: 3D mode and 2D mode. Like other 2D graphics area toolbar, it can also be collapsed and expanded. The
following lists only these items that are not listed in 2D graphics area toolbar:

- Switch to 2D mode
- Elevation view
- Plane view
- Side view
- Perspective view
- Walk along the mainline towards big stations
- Stop at current position
- Switch to 3D mode

![Toolbar of 3D roadway frame view (3D mode, 2D mode and Collapsed)](image)

2.7 3D Deck Rendering View Toolbar

As shown in Figure 2.15, toolbar of 3D deck rendering view is similar to 3D roadway frame view toolbar. Most icons are the same as those in 3D roadway frame view with the same functions.

![Toolbar of 3D deck rendering view](image)

The setting icon ![Setting Icon](image) will pop up the Scene Options dialog box as shown in Figure 2.16, which allows users to set up properties to control 3D deck rendering, such as whether or not to show railings. The first four check boxes from top to bottom in the dialog box are for mainline, road surface, deck points and railings, respectively. Check/uncheck them to turn them on/off in the 3D deck rendering view. Driving Forward controls the walking direction of simulation and Driving Speed controls the speed of walking.

Marker Size controls the size of deck point markers as yellow crosses shown in Figure 3.6.
Figure 2.16 – Scene Options

The last icon shows a window (Figure 2.17) briefing short cut keys to control 3D views, such as how to move the camera close to a highlight object.

Figure 2.17 – Brief instructions for 3D rendering view controls
Chapter 3  3D Camera Controls

With adopting DirectX 3D, an advanced underlying rendering technology for gaming industry, Visual BRG provides engineers with unparalleled 3D viewing experience. Roadway, together with railings, mainlines and deck control points can be shown in 3D rendering. Roadway frames together with all designated cross sections can be shown in 3D as a frame view. Another exceptional graphics transformation technique adopted in Visual BRG is the 2D operations in 3D camera’s view space. After 3D camera parameters are adjusted, what obtained in camera’s 2D view space shown on screen can be operated further in 2D mode such as zoom in or zoom out. This ‘digital zooming on the fly’ feature greatly enhances 3D view operations.

Along with the employment of DirectX 3D technology, a standard camera/model/light control technique, which is widely used in modern games, is also introduced in Visual BRG.

As the basis to use Visual BRG, the principles of 3D rendering and camera controls will be briefly introduced in this chapter.

3.1  3D Transformation

3D objects such as deck surface and railings are built in 3D world coordinate system. The world coordinate system XYZ as shown in Figure 3.1 is a right-hand-rule system. When rendering objects on computer screen, 3D objects are first translated to the CX CY plane of camera coordinate system CX CY CZ as shown in Figure 3.1. Camera system is a left-hand-rule system, which means its Z axis goes away from the observer.

![Figure 3.1 – World Coordinate System and Camera Coordinate System](image)

Road and bridge objects are actually built in the model space. Light source (position and direction) is built in the light space. And both are identical to the world space initially. Having
model space, light space and world space separated, different transformation can be applied to each space. For example, bridge objects can be rotated separately from the rotation of a light source. Objects in both model space and light space are then translated into the unique world space. Further, they will be transformed into the camera space.

Therefore, transformations could be applied to model space, light space and camera space. To be realistic and in easy operations, model space can only be rotated. No scaling and translating will happen to model space as these operations are not necessary to engineering model, and effects of such transformation can be achieved by camera transformation. Light space can be rotated and translated as turning light direction and moving light position are expected.

Camera transformation is the most important and could be complicated. Understanding its primary properties will help to understand how to control the camera. A camera transformation needs 1) camera position – the location of its origin in world space as shown in Figure 3.1, 2) direction – CZ in Figure 3.1, 3) horizontal or vertical alignment – direction of CX or CY, 4) Field of View – controls zoom in and out and 5) near side clipping and far side clipping – controls how close and far an object can be seen (this is preset and fixed to see everything front of camera).

Yaw and Pitch of a camera are major operations. Yaw is to rotate camera along its CY axis, and Pitch is to rotate camera along its CX axis. Both are to control camera direction CZ. To simplify users operation, Roll of camera – to rotate along CZ axis is not implemented currently, horizontal/vertical alignment cannot be adjusted.

3.2 Camera controls

Camera controls in 3D views are done by keys and mouse movement. The following list the ways to control camera:

1. Camera position
   - Left key – move camera left by one step. The movement is towards -CX.
   - Right key – move camera right by one step. The movement is towards +CX.
   - Page Up – move camera up by one step. The movement is towards -CY.
   - Page Down – move camera down by one step. The movement is towards +CY.
   - + - increase the step.
   - - decrease the step.

2. Change Field of View
   - Up key or wheel forward – zoom in or decrease FOV.
   - Down key or wheel backward – zoom out or increase FOV.

3. Yaw and Pitch
   - Move cursor while holding left button. Horizontal movements of cursor controls Yaw (turning along CY axis) and vertical movements of cursor controls Pitch (turning along CX axis).
Figures 3.2 and 3.3 show results of a Camera Yaw and Pitch respectively.
3.3 Model controls

Model controls include to rotate model (Yaw and Pitch) and to change model space locations. When model is being rotated, the rotation center is the model space origin, which is preset to the center of model bounds. Often the center is needed to be moved to a new location so that to archive an expected rotation. For example, when to rotate the entire bridge along the center of pier, rather than the center of the bridge, the model center has to be moved to the pier center first. This is archived by selecting an object.

1. Yaw and Pitch

Move cursor while holding right button. Horizontal movements of cursor controls Yaw (turning along Y axis, the elevation axis) and vertical movements of cursor controls Pitch (turning along X axis, the longitude axis).

2. Highlight an object

Move cursor over an object and left click. The highlight object will be shown in pink color.

3. Zoom and set the model center to highlighted object

When an object been selected, press F2 to zoom to the extent of highlighted object. This zoom operation is not a simple FOV change, but a shift of camera position so that it appears in front of the highlighted object. Once it is zoomed to, the model center will be automatically moved to the center of the highlight object bounds.
Further, Yaw and Pitch of model space will be along the center of the highlighted object. To reset the model center back, view needs to be reset (change to plane view, elevation view, side view or perspective view).

Figures 3.4 to 3.7 illustrated the controls of model.

Initial view

Results of a combination of Yaw and Pitch in model space along the current center

Figure 3.4 – Model controls – Yaw and Pitch along center of entire bridge
After change of camera FOV and position so as to see close

Click over a deck point mark so as to make it highlighted

Press F2 to zoom and move the center to the highlighted deck point

Figure 3.5 – Model controls – Zoom and move center to highlighted object
Increase FOV so as to see more extent than the highlighted deck point

Yaw and Pitch along the new center of the deck point

Figure 3.6 – Model controls – Yaw and Pitch along a new center
3.3 Light controls

What the roadway surface and other objects in Visual BRG are illuminated on screen depends on material properties preset to each surface, for example asphalt like material is designated to roadway surface, and the light source properties. A light source has a position and an aiming direction, which is similar to a camera in this respect. Also a light source contains other complicated properties such as light intensity, attenuation, color and range. To simplify the control, only light source position and direction can be adjusted, and all other properties are preset and fixed.

The control of light source direction is the same as the control of camera direction or model rotations (Yaw and Pitch). The only difference is to hold Middle Button while moving cursor around to adjust the aiming direction. Based on the same view as Figure 3.7, Figure 3.8 shows the results after an adjustment of light direction.

In most cases, users do not need to concern about the position of a light source. Where the program preset location works well for the purpose of illumination of roadway surface. However, Visual BRG provides a short cut key (F8) to align the light source with the current position and direction of camera, simulating a spot light on where camera aims at. Figures 3.9 and 3.10 show a comparison of light alignment on a close look at a deck control point.
Figure 3.8 – Light controls – Final view obtained by Yaw and Pitch along a new center

Figure 3.9 – Light controls – Close look on a deck point mark (without alignment of light)
Figure 3.10 – Light controls – Effects after light is aligned with camera (F8)
Chapter 4 2D View Controls

2D view controls are relatively simpler than 3D controls. The command icons and definitions are the same among different 2D views (Plane View, Elevation View and Roadway Cross Section View). Some 2D view control commands are simple and can be done by a simple clicking. Some will need further mouse movement or click. In addition to view controls, brief tips on certain elements, such as a location of support, can be shown on-the-fly when cursor hovering over an element.

4.1 Pan

When clicking on 2D view toolbar as shown in Figure 11, move the cursor to one location in the graphics area, then hold the left button and drag the graphics to a new location. When the left button is released, Pan command is completed. Pan is a toggle command, which means it can be repeated till it is deactivated. When Pan is activated, the icon will be changed to . To deactivate a toggle command, simply click its icon again or click any other toggle command.

4.2 Zoom to full extent

When a full extent view is needed, simply click to zoom the view to full extent. Zoom to full extent command is an instant command, which does not need further mouse movement or clicks.

4.3 Zoom in/out

The current view can be zoomed in or out by one level. To zoom in or out, click or respectively, and then click over the graphics area. The point clicked in graphics area will be the center of the view after zoomed in or out.

Zoom in/out are toggle commands like Pan. When they are activated, the icons are changed to or accordingly.

4.4 Zoom by window

By specifying two corner points on screen, the current view can be zoomed to that window. To zoom by window, click . After the command is activated, move the cursor to one point in the graphics area as one corner of the window. Click left button and drag to another point as the second corner of the window, and then release left button to complete the command. During the drag to other corner, a pink rectangle will be drawn to indicate the window area.

Figures 4.1 and 4.2 show the operation of Zoom by Window. Zoom by Window is also a toggle command that can be executed repeatedly.
Figure 4.1 – Specify two corner points of a window

Figure 4.2 – After zoomed by a window
Chapter 5  Display Settings

As a new generation of bridge geometry program, Visual BRG is rich of graphics content. Control of display properties is an important part to use it efficiently. Many items can be selected to show or hide individually, and when showing each type of items can use their own symbologies.

Display control is done by changing Display Settings, which can be started by clicking in any 2D graphics toolbar. When clicking, the Display Settings dialog box as shown in Figure 5.1 will pop up. As shown in the top of dialog box, the display settings are grouped into 1) Points, 2) Mainline, 3) Girders, 4) Diaphragms, 5) Bents, 6) Labels, 7) Transverse/Longitudinal Lines and 8) Background. In the bottom of dialog box, there are three global settings. Enable Edit on the Fly is to control whether or not to pop up an edit window when mouse is hovering over an editable item. Enable Cursor Tracking is to control whether or not to track cursor positions. When it is checked, cursor position will be displayed in a tooltip window while moving mouse. Use Decimal For Hovering Report is to control whether or not to use decimal format to report positions. When it is checked, positions and length will be shown in decimal in tooltip window.

![Figure 5.1 – Display Settings dialog box](image)

5.1  Point

Point group is a collection of settings to control display symbologies of each type of point. Symbologies of a point include: 1) On/Off, 2) Style, 3) Size and 4) Color.

Click over Show column to turn on or off of a type of points. Enter the size directly in the Size column. Style and Color can be selected from drop down boxes as shown in Figure 5.2. When hovering over a point, a tip window can be selected to open to show detailed information of the point. Figure 5.3 shows an example of showing point information. This feature can be turned off by checking Suppress Point Identification.
Figure 5.2 – Point style and color selection

Figure 5.3 – Show information of the point hovered when Suppress Point Identification unchecked

Point is a key concept introduced in Visual BRG, which was developed on the basis of key point in Visual Des-Mesh. Points are locations on mainline and girder geometries where a specific
characteristic is distinguished or designated. Below lists all types of point on mainline and girder geometries:

1. **POG** – Point Of Geometry is a point to control mainline or girder geometries. Wherever geometry property changes on mainline or girder, a POG will be designated so that geometry properties on both sides can be differentiated. Taking a mainline shown in Figure 2.5 as an example, locations on mainline at stations of 0’, 100’ and 600’ are three POG points. That at 100’ is the point where the geometry starts to change to spiral from a straight line segment. When girders are derived from such a mainline, locations at 100’ on all girders are POG points too. The green rectangle points shown in Figure 5.4 are correspondent POG points on mainline and girders.

![Figure 5.4 – Example of POG on both mainline and girders (Green solid rectangles)](image)

2. **POC** (Bridge Modeling only) – Point Of section Changes is a point on mainline or girder where girder section changes. Unlike POG, which is predefined by geometry characteristic, POC is manually specified in either mainline POC form or girder POC form. POCs of the mainline are used to share same section change locations among all girders, while POCs of a girder are only designated for one girder. Figure 5.5 shows an example of POC.
3. **POI** (Bridge Modeling only) – Point Of Interest is a point on mainline or girder where is of interest. POIs are merely points to ensure a girder is meshed. Like POC, POI is manually specified in either mainline POI form or girder POI form. POIs of the mainline are used to share same interest locations among all girders, while POIs of a girder are only designated for one girder. Figure 5.6 shows an example of POI.

4. **POD** (Bridge Modeling only) – Point Of Diaphragm is a point on girder where a diaphragm intersects with the girder. Unlike POC and POI, POD is defined by diaphragms. POD changes whenever definitions of diaphragms are changed. The red solid rectangles in Figure 5.6 show an example of POD.
5. **POS** – Point Of Support is a point on mainline or girder where a support line intersects with the mainline or girder. Like POD, which is defined by diaphragms, POS is defined by support line. POS changes whenever definitions of supports are changed. The green solid circles in Figure 5.6 show an example of POD.

6. **POA** – Point Of Additional control point is a point on mainline or girder within a spiral segment where an additional point is automatically inserted so as to retain geometry accuracy. Both in displaying on screen and in FEM analyzing, a spiral segment cannot be taken as a primitive. It has to be tessellated into small arc segments. Each arc segment is used for displaying on screen and for meshing as arc girder FEM element. The tessellation is performed on any segment between two consecutive ensured points. For example, when a segment between two diaphragm locations happens to be a spiral segments, the tessellation is performed based on two diaphragm locations, which are theoretically accurate. **Visual BRG** assumes that dividing a full spiral (a curve with a degree of 360°) into certain segments, 400 for example; both accuracies for engineering and visualization should be satisfied. The theoretical curve degree of such above spiral segment is known. Tessellation segments can be determined further, and then POA will be inserted into spiral segments. It should be noted that same length of spiral does not necessarily need the same number of POAs. POA is determined by the curve degree. Figure 5.6 shows an example of POA. The mainline (and girders) shown in Figure 5.6 is a spiral, which starts from straight line from top left and ends with an arc in bottom right. Curvature of the spiral goes higher to bottom right, which explains why girder segments in top left part has only one POA while each of the last 4 segments have 2 POAs instead.

![Figure 5.6 – Example of POA on girders (read crosses)](image)

7. **POR** – Point Of Reference is a point explicitly defined by either direct coordinates or referring some other geometry components. Unlike any other points, a POR is used for reference when defining other geometry. For example, the origin of an independent longitudinal line can be chosen from a list of PORs; when defining a Two-Point
longitudinal line or a Multiple-Point transverse line, all points involved have to be predefined as PORs. When a POR is defined by direct coordinates, its location will be locked and will not be updated when other geometries are updated. When a POR is defined by referring other geometry, its location will be automatically updated whenever its reference component is changed. A point on mainline by span ratio, for example, will be changed dynamically whenever the mainline or its two bent locations are changed. Figure 5.7 shows an example of POR and its use in a transverse line.

![Figure 5.7 – Example of POR (read triangles)](image)

### 5.2 Mainline

Mainline group is a collection of settings to control display symbologies of mainline. Symbologies of mainline: 1) On/Off, 2) Style, 3) Width and 4) Color. Mainline symbologies are associated with section number. Taking what shown in the row with section number of 1 in Figure 5.8 as an example, segment on mainline after section number changes to 1 will be using red Dash-Dot-Dot line with a width of 2. Any new symbologies can be added to the table as shown in Figure 5.8. The default symbologies are used for any section number which is referred but not defined in the table.

![Figure 5.8 – Display settings for mainline](image)
Check/uncheck **Show Mainline** can turn mainline on or off from plane view screen. Similar to points, mainline can be identified and certain geometric information can be shown in a popup window as shown in Figure 5.9. When hovering over the mainline, be noted the cursor orientation, which is plotted, truly reflected the curve tangent. The identifying on the fly feature can be turned off by checking **Suppress Mainline Identification**.

Mainline will be shown in plane view, elevation view and 3D roadway frame view. In order to be able to observe vertical curvatures of the mainline, theoretical elevations on mainline can be exaggerated when showing in 3D roadway view. Enter a scalar in **Vertical Exaggeration in Roadway Frame View** if want to see exaggerated results. A value of 1 means using theoretical value.

![Figure 5.9 – Identify mainline information on the fly](image)

### 5.3 Girders

Girders group is a collection of settings to control display symbologies of girders. As shown in Figure 5.10, this group is identical to Mainline, except all symbology settings are for girders.

![Figure 5.10 – Display settings for girders](image)
5.4 Diaphragms and Bents

Diaphragms/Bents group is a collection of settings to control display symbologies of diaphragms/bents. As shown in Figures 5.11 and 5.12, this group is identical to Mainline, except all symbology settings are for diaphragms or bents respectively.

![Figure 5.11 – Display settings for diaphragms](image1)

![Figure 5.12 – Display settings for bents](image2)

5.5 Labels

Labels group is a collection of settings to control display labels for FEA nodes and elements. Figure 5.13 shows the label group settings and an example of labels.

![Figure 5.13 – Display settings for labeling and example of labels](image3)
5.6 Longitudinal/Transverse Lines

Similar to mainline and girders group, Longitudinal/Transverse Lines group is a collection of settings to control display for road longitudinal and cross sections on both plane view and 3D roadway frame view. As shown in Figure 5.14, each longitudinal line and all transverse lines can be turned on or off and shown in different symbologies.

![Figure 5.14 – Display settings for road sections and example of road section display](image)

Point in this group means each deck control point as triangles shown in Figure 5.14. It has two different colors associated. The second color in the bottom is used for error detections. As Visual BRG uses interpolation on roadway surface to obtain the elevation of a control point, it may fail to interpolate a point if it is beyond the roadway scope defined by the mainline. When a point fails to interpolate the elevation, it will be shown in the second color so that users get notified.

Deck point is also called POE – Point of Elevation. Together with any longitudinal or cross section, its information can be shown when mouse is hovering over it. Figure 5.15 shows three different tip windows related to road sections and POE.

When evaluating POEs, a transverse line will be fully extended at both ends to reach all longitudinal lines. For the purpose of displaying on screen, its display length can be changed in Transverse Line Display Length.
Figure 5.15 – Road section related identification and tip windows

Road sections can be shown by an exaggeration scalar as shown in Figure 5.14. Road section vertical exaggeration is similar to mainline vertical exaggeration, but it is additional to mainline vertical exaggeration. When showing in the frame view in Figure 5.16, a point in a section is a combination of mainline vertical exaggeration and road section vertical exaggeration. Since both are controlled separately, results of each can be seen separately. Figure 5.16 shows an example of such a feature.
5.7 Background

Background group, as shown in Figure 5.17, is used to control background colors of certain views.

![Figure 5.17 – Background settings](image)

Figure 5.17 – Background settings
5.8 Performance Consideration

Visual BRG employs WPF, the state-of-the-art of graphics user interface technology. Each graphic entity is able to be identified on the fly. In the current release of the underlying .NET platform, this feature drains extra computing resources and therefore reduces the performance overall. Microsoft has promised that the overall performance of WPF will be dramatically enhanced by the end of year 2015.

Within the aspect of Visual BRG system, turning off certain unnecessary graphics will always help to boost the performance. For example, when editing diaphragms or other components, transverse lines and deck control points can be turned off screen as shown in Figure 5.18.

![Figure 5.18 – Turn off the display of certain graphics component to boost performance](image_url)
Chapter 6  Mainline

As the reference line of a roadway, mainline is a key geometry component in modeling roadway geometries. Geometries of all other roadway elements or bridge components are related to or derived from mainline. From the perspective of roadway design, mainline is the base line to control both horizontal (plane) and vertical curves of a roadway. Therefore, the mainline geometry model contains definitions of both horizontal (plane) and vertical curves. According to roadway design and engineering practice, the actual roadway curves in space are separately defined by its plane curve and vertical curve. In the definition of vertical part, the horizontal ordinate is what obtained by unfolding plane curves, while the vertical ordinate is always the same as elevation, or altitude.

In addition to plane and vertical curves, super-elevation and super-widening are two other characteristics in terms of sectional variations of a roadway. In Visual BRG, key cross sections are used to describe roadway cross sections and its variations.

Having mainline plane and vertical curves, and key cross sections defined, as shown in Figure 2.3, the true 3D roadway surface as shown in Figure 2.4 can be formed.

6.1  Alignment of Mainline

As in most cases, the mainline locates in the ‘middle’ transversely and aligns at top vertically. Transversely, it does not have to be in the middle as super-widening may exist any way. However, vertically it always locates at the top of the road surface. Figure 6.1 shows an example of roadway cross section, in which the mainline aligns at the point where the middle triangle shows.

![Figure 6.1 – Mainline alignment](image)

6.2  Horizontal Alignment of Mainline

The horizontal alignment (plane curves) of a mainline contains one or many curve segments. This type of curve is also called Compound Curve. When containing more than one curve segment, they usually are connected smoothly, which means the curve tangent is continuous and this continuity is guaranteed. However, the curvature continuity, which is recommended by roadway design practice so as to ensure a smooth transition, is not required or guaranteed by Visual BRG. The compound curve, including its definitions and input method used for the horizontal alignment
of mainline is exactly the same as that use in a longitudinal line that has an independent curve. When used in later (other than the mainline), kink can be defined to define a true situation such as kinked girders.

To be more flexible to construct a mainline in real situation, **Visual BRG** allows curve tangent being discontinued when transiting from one segment to another. This discontinuity of mainline curve is explicitly specified by a “kink” value, or the tangent change at connection, or by forcing a segment passing through a predefined point.

Curve segment can have different types of curve: 1) Tangent, 2) Circular, 3) Spiral, 4) Straight Line Ends at Point Ahead and 5) Circular Ends at Point Ahead.

As shown in Figure 6.2 and its correspondent mainline shown in Figure 6.3, the definition of a curve segment contains:

1) **Length** of a curve segment, the curve length of a segment that is not a type of Straight Line Ends at Point Ahead or Circular Ends at Point Ahead.

2) **Radius** of a circular curve segment or ending radius of a spiral segment. Positive value indicates the curve goes counter-clockwise, and negative value goes clockwise. For a spiral segment, the radius is the ending curve radius of the segment. When there is no preceding segment or a straight line segment preceded, the starting curve radius of the spiral segment is infinity. Otherwise, the ending curve radius of the preceded segment will be the starting curve radius. The spiral used in **Visual BRG** is so defined a curve that its curvature change is proportional to curve distance. For a Tangent or Straight Line Ends at Point Ahead segment, radius is not defined.

3) **Curve Type** of a curve segment is the type of a curve segment, and can be selected from a dropdown list as shown in Figure 6.2.

4) **Kink** of a curve segment is the additional tuning angle of the curve tangle at the start of the curve segment. The default value of zero means no additional turning and the tangent at the start of the segment is the same as the end of last segment.

5) **Ends At Point** is the explicitly specified end point of a curve segment. A predefined point can be forced as the end point of a curve segment of **Straight Line Ends at Point Ahead** or **Circular Ends at Point Ahead**.

![Figure 6.2 – Mainline Horizontal Alignment Definitions](image)
Figures 6.2 and 6.3 show a typical example of a mainline plane curves. It contains five segments: 1) a straight line segment ends at Reference Point 1 (actual length calculated is 269' 3 1/10"), 2) a smoothly connected spiral of 300’ long changes from infinity at beginning to a curve with a radius of 200’ at end, curve goes clockwise, 3) a smoothly connected 100’ long circular segment with a radius of 200’, maintaining the ending curvature of previous spiral segment, 4) a circular segment ends at Reference Point 3 with a radius of 300’, curve goes clockwise and 5) a smoothly connected 100’ long tangent segment.

When a segment of Straight Line Ends at Point Ahead or Circular Ends at Point Ahead succeeded, tangent continuity at the connection is not guaranteed and the curve may be kinked. For example, the curve as shown in Figure 6.3 is kinked at the connection point of the third and the fourth segment, as an arc of a radius of 300’ is forced to end at Reference Point 3.

![Figure 6.3 – Mainline Horizontal Curves](image)

If there is a known kink at the starting point of a segment, the tangent change value in degree can be entered as Kink in Figure 6.2. For example, a value of -20° as shown in Figure 6.4 will force the curve tangent at the start of the second segment change 20 degree in clockwise. Figure 6.5 shows its correspondence curves.

![Figure 6.4 – Enter tangent changes as Kink](image)
When a spiral segment is used, it should be noted that the change of curvature will not go cross over zero point. Having the starting and ending curvatures predefined, the curvature at any point on a spiral, by definition, is linearly interpolated according to the curve length of that point. Thus, when curvatures of two ends have different signs, the starting radius is positive and the ending radius is negative or vice versa; for example, a spiral is mathematically defined. However, **Visual BRG** excludes this scenario as it is not practical to have a spiral goes from counter clockwise to clockwise, or vice versa. When such plane curves are defined as shown in Figures 6.4 and 6.5, the preceding radius will automatically be overridden to have the same sign as the end radius. For the circular segment with a positive radius of 300’ as shown in Figure 6.6, it goes counter-clockwise as shown in Figure 6.7 by definition. However, the spiral segment with a negative radius of 800’, it goes clockwise monotonically, with a curvature change from $\frac{-1}{300}$ to $\frac{-1}{800}$, rather than a change from $\frac{1}{300}$ to $\frac{-1}{800}$. The starting radius of the spiral segment is -300’ instead.
6.3 Mainline Location and Start Station

In addition to mainline plan curve definitions, mainline starting point and starting tangent are required to completely define the mainline. The coordinates of the mainline starting point (PI(1) East and PI(1) North) can be entered in Figure 6.4. The earth coordinate system is used in describing the mainline. As shown in Figure 6.5, the West-East axis is horizontal and goes from left to right; the South-North axis is vertical and goes from bottom to top (the elevation/altitude axis goes towards observer). The Start Tangent is the mainline tangent angle to positive X-axis (East). The tangent can be entered as bearings such as N30°15′20.126″E. Figures 6.7 and 6.8 show the same mainline with a Start Tangent of 0° and 45°, respectively.

In most cases, referring to length ordinate of the mainline is enough to locate a point on mainline. However, the Start Station of the mainline can be specified when the starting point of the mainline is not aligned at zero station. When station is used in Visual BRG, it means the Start
Station plus a curve length ordinate.

### 6.4 Mainline Vertical Curves

Vertical curves of a mainline are used to define grade transitions. It is optional to model roadway and bridge geometries. When ignored, a flat horizontal line is used as default. Unlike plane curves, vertical curves are relatively simple as they contain only straight lines and transition curves. The transitions curves transit the grade from one to another by using Vertical Parabola as commonly used in roadway engineering practices.

Figure 6.9 – Mainline Vertical Curves

Figure 6.9 shows an example of mainline vertical curves. The vertical curves are defined along the unfolded centerline of mainline plane curves, i.e. the horizontal axis is the plane curve length ordinate. As mainline **Start Station** is introduced in plane curves, mainline station, which is the Start Station plus plane curve length ordinate, is used when addressing horizontal ordinate of vertical curve. The vertical axis is normal as shown in Figure 6.9.

Considering the fact that a transition curve is always connected by two adjacent straight grade lines, defining a transition curve can be simplified by specifying the locations of PI (point of intersection, shown as V in Figure 6.10) and the external distance, the vertical distance from curve to PI (shown as e in Figure 6.10).

The definition of a Vertical Parabola in vertical curve is similar to a spiral in plane curve. The grade of a vertical parabola is proportional to the horizontal distance, while the curvature of a spiral is proportional to the curve length ordinate. Once the location of PI (station and elevation) is defined, the connecting grades \( g_s \) and \( g_e \) are known and the parabola function can be derived corresponding to the total horizontal transition distance and external distance (shown as X and e in Figure 6.10, respectively).
Although circular vertical transition curve is rarely used in roadway engineering, Visual BRG does support this type of curve as the secondary to vertical parabola. The middle part of the mainline data form as shown in Figure 2.6 and Figure 6.11 shows the data form for vertical curve.

Each record in vertical curve data form represents one interior PI. If the start station or the end station is not specified, default ones that have zero elevation will be used automatically. For example, if the vertical curve records as shown in Figure 6.11 are of a mainline that has a total length of 600’ and a start station of 0’, two exterior points will be used by default as (0’,0’) and (600’,0’). When either one exterior point’s elevation is not zero, a record with the station of start station or end station and an actual elevation can be inserted into the data grid.

For these interior PI, enter a negative External Distance for a Vertical Parabola transition curve, or a positive one for Circular curve. External Distance is ignored for either explicitly specified exterior PI. For a parabolic curve, Horizontal Length of Parabolic Curve can be specified instead. If the horizontal length is known, enter it in Horizontal Length of Parabolic Curve. The curve definition via External Distance will then be overridden. When External Distance is entered, its corresponding Equivalent Horizontal Length of Parabolic will be shown in Equivalent H.L. of P.C. When Horizontal Length of Parabolic Curve is entered, its corresponding Equivalent External Distance will be shown in Equivalent E.D.

As shown in Figure 2.2, mainline curves can be shown in both plane and vertical views. The lower part of Figure 2.2 shows an example of vertical curve.

6.5 Transverse curve and super-elevation/-widening
Plane and vertical curves and starting point locations only define the mainline as a spatial curve. Transverse curves and their variations are needed in order to define the roadway surface as a spatial surface.

Similar to the separation of plane curves and vertical curves when defining the spatial mainline, the definitions of transverse curves are separated from mainline itself. Following the roadway design practice, ‘crowning’ or ‘capping’ is used in defining transverse curves and, thus, the spatial roadway surface. The ‘crowning’ or ‘capping’ process is to identify a series of key points or control points along the mainline and to define the cross section at each of these key points. The cross sections at these key points are called Key Cross Sections of a roadway.

The intermediate cross sections between any two or three consecutive key cross sections are obtained by interpolation methods.

Figure 6.12 – Roadway Cross Section

Figure 6.12 illustrates parameters used in defining a cross section. It should be noted that the mainline alignment point (o) in cross section, the crown point of the cross section, is not necessarily in the middle of a roadway. The left and right are defined when travelling along mainline towards big stations. The standard or default cross sections usually have equal left/right widths and left/right slopes. By default, the mainline alignment point aligns with the mainline, i.e. both transverse offset and vertical offset as shown in Figure 6.12 are zero. When there is a need, however, the Crown Point can be offset from the mainline. In that case, Transverse Offset and Vertical Offset values of a key cross section should be specified. When facing larger mainline stations, a positive Transverse Offset is on the right hand of the mainline location. A positive Vertical Offset is above the mainline (Section 14.7).

The definitions of transition curve in the middle of transverse curve are similar to mainline vertical curves. However, a circular curve transition is allowed as in mainline vertical curves because the transverse grade change is not restrained by vehicle moving physics.

Where super-elevation and/or super-widening exists, left/right slopes and/or left/right width can be greater or less than these of standard cross sections respectively. The widths and the slopes interpolation method for all intermediate cross sections can be specified separately as shown in Figure 6.13. However, the interpolation method for Transverse Offset and Vertical Offset is fixed and preset as linear (Straight Line).

**Straight Line** will be suitable for most situations, by which unknown variables will be
obtained by linear interpolation. For example, given two key sections at stations 0’ and 250’ as shown in Figure 6.13, the left slope at 125’ will be -0.75%. When **Width Interpolation** and/or **Slope Interpolation** of a record in **Super Elevations and Widths** data form is selected as Straight Line, this record and the other one that has a station immediately greater than this one will be the two key sections. Be noted that, the second key section is not necessarily the immediate next record. Cross sections in between these two stations are linear interpolated.

Interpolation can also be **Circular** or **Parabolic**. Unlike Straight Line, both Circular and Parabolic need three key stations to perform interpolation. When one record in the form is selected to use **Circular** or **Parabolic**, this record and another two key sections that have stations greater than but most close to this ones will be the three key sections. Cross sections in between these three stations are interpolated by **Circular** or **Parabolic** method.

Visual BRG uses incremental ordinates when performing Circular or Parabolic interpolation. Taking left slope interpolation as an example, the incremental ordinate interpolation method can be illustrated below.

Given three key sections’ left slopes as \((s_1, v_1), (s_2, v_2)\) and \((s_3, v_3)\), where \(s\) and \(v\) stand for station and slope respectively, points \((0,0), (s_2-s_1, v_2-v_1)\) and \((s_3-s_1, v_3-v_1)\) will be used as key points for interpolation instead. The interpolation is performed by drawing an arc or parabola crossing above three points. Interpolated results will be translated back to global coordinates by adding the origin of \((s_1, v_1)\).

6.6 **Mainline POIs and POCs (Bridge Modeling only)**

POI and POC are indeed a part of girder’s properties, rather than of the mainline because they specify explicit points on girders where merely FEA mesh points and section change points
are required. The reason of attaching POI and POC to mainline is based on the fact that most girders of a bridge share the same locations of such points. Having them defined along mainline gives different girders opportunity to share same locations easily. As POI and POC are girder related features, they will not be available when Bridge Modeling is disabled as shown in the left of Figure 2.6.

When a girder is not using Independent POIs or Independent POCs, its POIs or POCs are obtained by intersecting radial lines at these POIs or POCs locations with the girder curves. Figure 6.15 shows an example of Mainline POIs and POCs.

![Figure 6.15 – Mainline POI and POC (solid circles – POIs, hollow circle with cross - POCs)](image)

When Bridge Modeling is enabled, Mainline POIs or POCs are entered in the lower part of the data form as shown in Figure 6.15.

### 6.7 Kinked Mainline

Although a mainline in a real situation is rarely kinked, Visual BRG does support kinked plane curves (in mainline and longitudinal lines/girders). The kink, or the curve tangent changes, happens only at transition from one segment to another, and it is controlled by the kink value of each curve segment or by specifying a point ahead of the curve where a curve segment ends at. Either of above happens, the smooth, or the continuity of curve tangent, will be violated.

Visual BRG does not have any constraint on the consequence of a kinked mainline/longitudinal line/girder. For examples, a girder whose geometry is offset from a kinked mainline will be kinked as shown in Figures 6.16 to 6.18. The location of kink on a derived geometry is determined by simple geometry calculations. Users should pay more attention on the derived geometry and ensure the kink locations are correctly positioned. In real situations, girder may allow to be kinked, but the kink locations have to be on the bent centerlines.
Figure 6.16 – Kinked Mainline at Circular to Circular

Figure 6.17 – Kinked Mainline at Tangent to Circular

Figure 6.18 – Kinked Mainline at Tangent to Tangent
Chapter 7  Reference Points

Reference points are used to help to locate other geometry components. For example, an independent curve of a longitudinal line can be located at a reference point that is predefined separately from the defining of the curve. Visual BRG separates these reference points’ definition from other geometry so that they can be shared and updated dynamically. A typical example of a reference point and its separate definition would be a bent passing through a point which locates on the mainline with a specified span ratio. The bent location will be automatically adjusted when the referred bents are adjusted.

Reference Point is different from Point introduced in section 5.1, which are mere specific locations on curves and not explicitly defined by users. To enter and edit Reference Points, use Point data form as shown in Figure 2.9 and Figure 7.1.

### 7.1  Point Types

Visual BRG supports 11 types of points. Different type of point uses different way to determine the point location on the plane (East-North plane).

1. **Absolute Cartesian** – a point defined by absolute Cartesian coordinates. The location of an Absolute Cartesian is fixed by entering X (East) and Y (North) ordinates in Figure 7.1. When this type is selected, only X and Y in Points form will be enabled.

2. **Absolute Polar** – a point defined by absolute Polar ordinates. The location of an Absolute Polar is fixed by entering Distance (Radius) and Sita (θ) ordinates in Figure 7.1. The format of Sita is degree, minute and second, no bearing is allowed. For example, 30°0’10.352” is 30 degree and 10.352 seconds measured from East axis.

3. **Relative Cartesian** – a point defined by relative Cartesian coordinates and a reference origin. The location of a Relative Cartesian is defined by entering relative X (East) and Y (North) ordinates in Figure 7.1, and selecting an origin from Origin Point. The location of a relative Cartesian point will be floated and depends on its origin. Whenever its origin is changed, its location will be updated automatically. When this type is selected, only X, Y and Origin Point in Points form will be enabled.
4. **Relative Polar** – a point defined by relative Polar ordinates and a reference origin. The location of a Relative Polar point is defined by entering Distance (Radius) and Sita (θ) ordinates in Figure 7.1, and selecting an origin from Origin Point. The format of Sita is degree, minute and second, no bearing is allowed. Similar to Relative Cartesian point, the location of a relative Cartesian point depends on its origin and will be updated automatically when origin is changed. When this type is selected, only Distance, Sita and Origin Point in Points form will be enabled.

5. **On Mainline by Station** – a point on the mainline measured by the mainline station. The point locates on the mainline by a curve length of mainline Station – mainline Start Station, measured from start of the mainline. The location of this type of point is related to the mainline. When this type is selected, only Distance, which interprets as mainline Station, is enabled.

6. **On Mainline by Length Ordinate** – similar to On Mainline by Station, except that the value entered in Distance is already an absolute curve length measured from start of the mainline.

7. **On T-Line by Distance to L-Line** – a point locates on a transverse line at a distance along the transverse line, measured from the intersection with a longitudinal line. When this type is selected, Distance, 1st T-Line and L-Line are enabled. Enter distance in Distance, select a transverse line in the dropdown list of 1st T-Line and select the mainline or other longitudinal lines in the dropdown list of L-Line. Positive distance along a transverse line is on the right side of the mainline while facing towards large mainline stations.

8. **On T-Line by Offset from L-Line** – similar to On T-Line by Distance to L-Line, except that the point is the intersection of the transverse line and offset of the L-Line. The Distance for this type is the offset value of the longitudinal line. Positive offset from a longitudinal line, such as the mainline, is on the right side of the longitudinal line while facing towards large mainline stations.

9. **On L-Line by Offset from T-Line** – a point on a longitudinal line at the intersection with a transverse line measured by offset distance. When this type is selected, Distance, 1st T-Line and L-Line are enabled. Enter the offset value in Distance, select a transverse line in the dropdown list of 1st T-Line and select the mainline or other longitudinal lines in the dropdown list of L-Line. Positive offset from a transverse line is on the large mainline station side.

10. **On L-Line by Curve Distance to T-Line** – similar to On L-Line by Offset from T-Line, except that the point locates at a specified curve length to the intersection of the longitudinal line with the transverse line. Positive curve length is on the large mainline station side.

11. **On L-Line by Curve Distance Ratio to T-Line** - a point on a longitudinal line between two transverse lines, with a specified curve distance ratio of distance from the first transverse lien to that to the second transverse line. When this type is selected, Distance, 1st T-Line, 2nd T-Line and L-Line are enabled. Enter the curve length ratio in Distance, select the first transverse line in the dropdown list of 1st T-Line, the second transverse
line in 2nd T-Line and select the mainline or other longitudinal lines in the dropdown list of L-Line. A curve distance ratio of 0 will locate the point at the intersection of longitudinal line with the first transverse line, and 1 will locate at the intersection with the second transverse line.

12. **Intersection of a TL and an LL** – the intersection of a TL and an LL. When this type is selected, 1st T-Line and L-Line are enabled. Select the first transverse line in the dropdown list of 1st T-Line, and the mainline or other longitudinal lines in the dropdown list of L-Line. When this type of point is used for locating a LL, the starting bent will be implied by the transverse line if it is a bent. This rule is also applicable to types 7 and 8.

### 7.2 Point Examples

Cartesian and Polar coordinate points, Absolute Cartesian, Absolute Polar, Relative Cartesian and Relative Polar, are common type of reference points. Reference Point 1, as shown in Figure 7.2, locates at (250’,100’). Reference Point 2 locates at (-100’,20’) based on Reference Point 1. Reference Point 3 locates at (100’,45⁰). Reference Point 4 locates at (50’,90⁰) based on Reference Point 2.

![Image showing points by Cartesian and Polar ordinates](image)

Figure 7.2 – Points by Cartesian and Polar ordinates

Figure 7.3 shows two points on mainline. Reference Point 5 is measured by station, and Reference Point 6 is by curve length.
Figure 7.3 – Points on Mainline

Figure 7.4 shows two points on a transverse line. Reference Point 7 is measured by distance to the intersection with a longitudinal line, and Reference Point 8 is the intersection with an offset of a longitudinal line.

Figure 7.4 – Points on a Transverse Line

Figure 7.5 shows two points on a longitudinal line. Reference Point 9 is the intersection with an offset of a transverse line, and Reference Point 10 is measured by curve distance to the intersection with a transverse line.
Figure 7.5 – Points on a Longitudinal Line

Figure 7.6 shows a point on a longitudinal line that is measured by curve distance ratio between two transverse lines. Figure 7.7 shows the update of such a point when the reference transverse lines are changed.

Figure 7.6 – A point on a Longitudinal Line by curve length ratio

Figure 7.7 – Location of a point on a Longitudinal Line by curve length ratio updates

Section 14.10 and Figure 14.51 illustrate an example of Intersection of a TL and an LL.
Chapter 8 Longitudinal Lines

As introduced in Chapter 2, bridge roadway geometry is modeled as longitudinal lines along bridge axis and transverse lines cross bridge axis. Mainline is a special longitudinal line with extra vertical and roadway information. A longitudinal line has similar characteristics with mainline. Defining longitudinal lines is the basis of Visual BRG. In addition to that all bridge deck control points are defined on longitudinal lines, the plane curves of girders are defined by longitudinal lines. When Bridge Modeling is enabled and girders are to be modeled, longitudinal lines that representing girders’ plane curves have to be defined first.

Information needed to define a longitudinal line includes line ID and Name, Line Type, Offset distance, Angle, Reference Longitudinal Line, Starting Bent and Ending Bent defining span scope of a line, Starting Point or Ending Point for an explicitly point defined line, whether or not a longitudinal line is a Girder center line, and whether or not a line is Railing. ID of a longitudinal line is assigned automatically when a line is created, and cannot be changed so that its uniqueness is maintained. Figure 8.1 shows the longitudinal line data form.

Figure 8.1 – Longitudinal Line Data Entry Form

8.1 Longitudinal Line Types

Visual BRG supports eight (8) types of longitudinal lines. Different types of lines use different ways to determine their plane curves (East-North plane).

1. **Chords Formed by an Offset of Another LL and Bents** – this is the so called Chord longitudinal line. This type of longitudinal line is formed by intersections of a virtual longitudinal line that is by offset from another LL with involved bents. When selecting this type of LL, a reference LL, Offset, Starting Bent and Ending Bent are needed. When starting bent or ending bent is missing, the first or the last bent will be taken, respectively. The blue line in Figure 8.2 shows an example of a chord longitudinal line which is offset from the mainline. The outer most green dot line is the offset longitudinal line.
2. **Offset from Another LL** – this is the so-called Offset longitudinal line. When this type of LL is selected, information required is the same as **Chords Formed by an Offset of Another LL and Bents**. An offset longitudinal line is made by paralleling to a reference LL. The reference LL could be any type of LL. When the reference LL contains tangents and/or circular segments, the offset is straight forward and the offset curve is eccentric with the reference LL. Although concentric spiral is not defined mathematically or not manageable in practice, **Visual BRG** does allow a LL parallel to another one that contains spiral segment. This is achieved by tessellating a spiral segment of a LL into many small segments. Theoretical properties such as location, radius and tangent of each tessellated point on spiral can be obtained by spiral theory. Curve segments between any two consecutive tessellation points are treated as an arc segment with a radius of average of these theoretical values at two end points. When reporting radius on the fly, i.e. when mouse is hovering over a point within such an arc segment, the reported radius is linearly interpolated of these two end theoretical values according to the length along arc segment. When the reference LL contains spiral segments, the offsetting is based on its tessellated curve segments, not the true mathematics spiral curve. The tessellating of a spiral segment considers roadway engineering practice so that mathematical error of offsetting a spiral curve is limited. When the reference LL is kinked such as a compound curve with explicitly kink, curve segment ending at a predefined point, or a chord LL, the offset LL will be kinked as well. Please refer to section 6.7 and Figures 6.16 to 6.18 for details. **Visual BRG** does not validate whether or not such a kink LL is allowed. The referring to a LL may be recursive. When recursive reference happens, the ultimate base LL will be used when offsetting, rather than the immediate reference LL. Figure 8.3 shows two examples of Offset LL. The red line (Girder 11) is an offset from mainline with the first and the third bents as boundaries. The blue line (Girder 12) is an offset from Girder 11 with the second and the fourth bents as the boundaries.
3. **Offset from an LL's Virtual Chord of a Span Through the Intersection of an Offset LL and Ending Bent** – this is the so called PIA. When this type of LL is selected, information required is the same as **Chords Formed by an Offset of Another LL and Bents**. This type of longitudinal line is formed by offsetting virtual chords of a longitudinal line with starting bent and ending bent. The chord will be aligned at the intersection of the offset LL and ending bent, and will be extended all way back to starting bent. The two bents should form one span and no validation will be checked if crossing over one span. Figure 8.4 shows an example of PIA line.

4. **Offset from an LL's Virtual Chord of a Span Through the Intersection of an Offset LL and Starting Bent** – this is the so called PIB. Same as **Offset from an LL's Virtual Chord of a Span Through the Intersection of an Offset LL and Ending Bent**, except that the chord is aligned at starting bent. Figure 8.5 shows an example of PIB line.
5. **Independent Curves at Starting Bent** – an arbitrary curve that defined by independent curve segments and a starting point. When this type is selected, information required includes Starting Bent, Ending Bent, Starting Point and Independent Curve Segments. Figure 8.5 shows an example of independent curves. If the starting point refers to a bent as this example shows, the starting bent can be ignored and the bent implied in the starting point will be taken. The definition of an independent curve for longitudinal line is the same as the horizontal alignment of mainline. Please refer to section 6.2 for detail.

6. **Straight Line by Two Points** – a straight line defined by two points. When this type is selected, information required includes Starting Point, Ending Point, Starting Bent and End Bent. The longitudinal line will be cut by Starting Bent and Ending Bent. When starting bent or ending bent is missing, the first or the last bent will be taken, respectively. Figure 8.6 shows an example of straight line by two points.
7. **Left Road Edge** – the left road edge line defined by roadway. When this type is selected, only Starting Bent and Ending Bent are needed. If either one of them is missing, the first or the last bent will be taken. Road edge is defined by roadway cross section. The left edge is on the left side, and the right side is on the right side. Please refer to section 6.5 for detail about roadway cross section. Figure 8.7 shows two Road Edge lines and two longitudinal lines derived from road edges.

8. **Right Road Edge** – the right road edge line defined by roadway, same as **Left Road Edge**, except it on the right side of the roadway.

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**8.2 Railings**

A longitudinal line can be designated as a railing. A railing is special only when intersecting with transverse lines for output of deck control points. When a transverse line that is marked to Use Radial Line for Railing, transverse line will be forced to turn to radial line direction after intersecting with its reference longitudinal line. For example, if a railing line is offset from a longitudinal line A, when a skewed transverse line intersected with line A at point a, it will pick the radial line at point a to further evaluate intersection with the railing line.

To mark a longitudinal line as a railing, check Railing as shown in Figure 8.8.

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**8.3 Girders**

A longitudinal line can be designated as a girder as well. When generating bridge analysis model for DESCUS input, only girder longitudinal lines will be used to create girder members.

Geometrically, a girder is no different from a longitudinal line. When defining a girder’s
geometry, instructions and notes for longitudinal lines discussed in Chapters 6 to 8 should be followed.

When a girder is regarded, it is often related to bridge modeling and certain specific information about a bridge girder will be involved. For example, it needs to define points where cross section changes and where are of analytical interests. When a girder is exporting to DESCUS data file, its intersections with transverse lines that are marked as bent and diaphragm will be enumerated and analyzed for FEA models. Together with these points, any other geometry control points (both explicitly defined and additionally tessellated) will be treated as a Node of FEA model. The portion of a girder defined by any two consecutive Nodes is referred as a girder segment. When a girder segment is exported to DESCUS data file, a girder member will have a constant radius though.

In addition to having a regular longitudinal line’s information such as boundary bents, a girder may have POC, POI information. To mark a longitudinal line as a girder, check Girder as shown in Figure 8.8.

![Figure 8.8 – Girder and Railing longitudinal lines](image)

8.3.1 **Girder POIs and POCs**

A girder usually has POIs and POCs. POI is a point on a girder where an explicit FEA mesh point is specified, while POC is where a girder changes sections. POC will also cause a FEA mesh point. A girder can have its independent POIs or POCs, or share them defined along mainline. Location measurements for independent POIs or POCs can use Girder Station or use mainline station. While location for shared POIs and POCs always use mainline station.

To use independent POIs, check Independent POIs and enter POI stations in data form shown in Figure 8.8. To use independent POCs check Independent POCs and enter POC location and section numbers in Figure 8.8.

8.3.2 **Use Girder Station and Girder Start Station**

When station is referred, it often is regarding the mainline. For example, a girder at station 100’ has a POC usually means where the girder intersection with a mainline radial line at station 100’. However, the measurement of girder station can be directly along the girder. In that case, a station difference truly reflects the length of a girder segment.

To use girder station to measure locations on girder, rather than by using of mainline stations, check Use Girder Station in Figure 8.8.
When **User Girder Station** is checked, location on girder by given a station is determined by length ordinate which equals to girder station less girder start station, i.e. a girder has a length ordinate of zero at start location.

Girder Start Station is the mainline station at the intersection of its starting bent with the mainline. All girders starting from the same bent will have the same start station, no matter if a bent is skewed or not. Girders as shown in Figure 8.9 have the same start station as the bent has. In this case, a girder station of 110’ (Use Girder Station is checked) on each of these girders will be 10’ away on the right from the skewed bent.

![Figure 8.9 – Girder start station](image)

### 8.3.3 Other Points on a Girder

As discussed in section 5.1, **Visual BRG** introduces many types of points on mainline and other longitudinal lines. Each type of point on girder defines a particular characteristic of a girder. Refer to section 5.1 for definitions of each type of point. In addition to **POCs** and **POIs** introduced in section 8.3.1, which are of a girder only, a girder has other types of point below.

Although all of these points on girder cause mesh points when exporting to DESCUS data file, specifying or controlling of these types of points are different.

**POG** – Point Of Geometry is to control the girder geometry. It is determined by girder geometry. Wherever a curve segment changes, a POG will be created at that location. It cannot be controlled by any other means. Figure 8.10 shows an example of **POGs** corresponding to three curve segments.
Figure 8.10 – Example of POG/POD/POS/POA (green rectangles/orange circles/triangles/crosses)

**POD** – Point Of Diaphragm is where a diaphragm intersects a girder (orange circles as shown in Figure 8.10). It is controlled by diaphragm locations.

**POS** – Point Of Support is where a bent line intersects a girder (triangles as shown in Figure 8.10). It is controlled by bent locations and angles.

**POA** – Point Of Additional control point is automatically inserted within a spiral segment to retain geometry accuracy. Refer to the description in section 5.1 for details. Pay attention to how a POA is inserted. Also be noted as shown in Figure 8.10 that there is no POA inserted between two PODs in the first span, but some are inserted between two PODs in next span. This is because the first span falls in a circular segment and the curvature does not change in circular segment as it does in spiral segment.

**POE** – Point of Elevation is a point on deck surface and used to output finished grading and other geometric information. The locations of POEs are determined by a set of longitudinal lines (girders) and transverse lines (bents and diaphragms). POEs will be shown on girders (when seeing the plane view). It should be noted that POEs are different from any other points. A POE seeing on a girder centerline does not affect girder meshes at all. POE is simply not a part of girder property. Figure 8.11 shows an example that some POEs due to non-diaphragm and non-bent transverse lines are not numbered for FEA model.
8.4 Road Edges

As introduced in section 8.1, two longitudinal line types are related to roadway edges: **Left Road Edge** and **Right Road Edge**. Road edges are defined by roadway cross sections as discussed in section 6.5. When there is no super-widening, road edges are parallel to mainline, and a longitudinal line offset from a road edge is equivalent to offsetting from the mainline.

When super-widening exists, however, a longitudinal line that parallels to a road edge cannot be achieved by referencing mainline. Figure 8.12 shows an example of a road edge and another longitudinal line that parallels to a road edge. In this example, the roadway on the right side has super-widening. The road edge on the right is not parallel to the mainline as left edge does. A longitudinal line (Right Curb) that refers to **Right Road Edge** will parallel to road edge on the right, not the mainline as other blue dash line shown in Figure 8.12.

It should be understood that **Visual BRG** computes the road edge in a special way. When super-widening does not exist (on a side), the road edge is parallel to the mainline and its curve information can be maintained or derived from mainline. As the left side edge shown in Figure 8.12, road edge curve information (radius) can be reported when hovering over a road edge (or a longitudinal line that is referring to a road edge).

When super-widening does exist (on a side), the mainline will be tessellated for the road edge evaluation first. This tessellation aims at only road surface geometry, not considering girder meshes. The ensured theoretical points are geometry control points (both plane and vertical), super-elevation/super-widening control points plus all **Transverse Lines** locations. Once having these tessellation points ready, corresponding points on road edge can then be obtained by translating mainline tessellated points along its radial lines. As the translated distances (controlled by super-widening) varies from point to point, the mainline curve information is lost in this respect. Tangent and radius information at road edge (of a super-widening side) cannot be
sustained. The curves as shown in screen or deck points output are simply straight lines connecting all these theoretical points on road edge. As an example of this, the right edge (red dash curve) in Figure 8.12 is straight lines connecting all these control points. The left edge, however, is a curve derived from mainline. When hovering over such edges (or these deriving from edges), it will be shown as straight lines (as popup box shown in Figure 8.12)

Figure 8.12 – An example of road edge and an LL offset from road edge
Chapter 9  Transverse Lines

As introduced in Chapter 2, transverse lines are used to define where a bent or a deck control point locates. Transverse lines have to be defined first in order to output deck control points. The intersections with longitudinal lines are planar locations of deck control points. Bents are primary geometry components that control the boundaries of a longitudinal line and where a support line locates. The defining of a bent is done by defining a transverse line. Therefore, together with the longitudinal lines, the transverse lines are major part of a bridge geometry model.

The data form to define transverse lines is shown in Figure 9.1, and Figure 2.8 as well.

![Figure 9.1 – Transverse Lines data form](image)

9.1  Transverse Line Types

Visual BRG supports seven (7) types of transverse lines. Different types of lines use different ways to determine their location on plane (East-North plane).

1. **On Mainline by Station** – this is the most commonly used type of transverse line. It locates on mainline by specifying the mainline station, and its orientation is determined by an angle to mainline tangent. Transverse lines (bents) in examples in Chapter 8 are all this type of transverse lines. When this type is selected, information required includes Distance (Station) and Angle. Enter the mainline station in Distance (Station), and angle in degree in Angle. An angle of zero degree has the same direction as the mainline tangent. Counterclockwise is positive.

2. **Parallel to Transverse Line by Normal Distance** – a transverse line parallels to an existing one by a given normal distance. When this type is selected, 1st Transverse Line
and Distance are needed. The Distance specifies the normal distance offset from the existing transverse line selected. Figure 9.2 shows two transverse lines that are parallel to an existing bent by a normal distance of -20’ and 40’, respectively. When facing the upper direction of a transverse line, which is on the left side when facing large stations or the last point side of a By Multiple Points transverse line, the positive distance is on the right side of the transverse line. For example, the TL of 240’ shows in Figure 9.2 has a normal distance of 40’, the 180’ has a distance of -20’, respectively. A longitudinal line can be selected as additional information. If an LL is presented, the center of the TL will be translated to the intersection with the LL. Please see section 14.3 for an example of this case. As the translation is along the TL, this relocation only affects the visual of the TL. When a TL actually intersects with any LL, its extension will be used. For examples, deck control point locations on this TL will not be affected by this relocation.

Figure 9.2 – Transverse lines parallel to an existing one by normal distance

3. **Parallel to Transverse Line by Curve Distance** – similar to Parallel to Transverse Line by Normal Distance, but the location is measured by curve distance to the existing transverse line. When this type is selected, a reference longitudinal line, on which the curve distance is measured, is needed to be selected in L-Line. The Distance (Station) will be interpreted as curve distance. The signs of curve distance have the same definition as Parallel to Transverse Line by Normal Distance. Figure 9.3 shows two transverse lines parallel to an existing transverse line, measured by curve distances. As a comparison, another two lines by normal distance are shown as well. The difference between curve distance and normal distance shows well in Figure 9.3.
4. **Parallel to Transverse Line by Curve Distance Ratio** – similar to Parallel to Transverse Line by Curve Distance, but the location is measured by curve distance ratio to a span length defined by two existing transverse lines. When this type is selected, a reference longitudinal line, on which the curve distance is measured, is needed to be selected in L-Line. The second transverse line is also needed. The transverse line will be parallel to the first transverse line. The curve distance ratio is entered in Distance Ratio. The ratio is the curve distance to the first transverse line to the distance to the second transverse line. Figure 9.4 shows two transverse lines measured by curve distance ratio. When location of either transverse line is changed, locations of transverse lines determined by curve distance ratio will automatically be updated as shown in the lower part of Figure 9.4.

Figure 9.3 – Transverse lines parallel to an existing one by curve distance

Figure 9.4 – Transverse lines parallel to an existing one by curve distance ratio
5. **On a Longitudinal Line by Curve Distance** – similar to Parallel to Transverse Line by Curve Distance, but the angle of the transverse line, which is measured from tangent of the reference longitudinal line, can be specified. Figure 9.5 shows an example of this type of line.

6. **On a Longitudinal Line by Curve Distance Ratio** – similar to Parallel to Transverse Line by Curve Distance Ratio, but the angle of the transverse line can be so specified as On a Longitudinal Line by Curve Distance. Figure 9.5 shows two lines, one by distance and one by ratio. The lower part of Figure 9.5 shows the automatic update when a reference transverse line is adjusted.

7. **By Multiple Points** – a series of line segments connecting predefined points. When this type is selected, currently available reference points list will be shown in data form. Points can be selected by clicking left arrow. When one is selected, it will be added to points list, and it will be removed from the available points. The point order is important when determining an offset distance from this transverse line. Figure 9.6 shows an example of a transverse line by multiple points, and its automatic update when any dependency is adjusted.

![Figure 9.5](image)
9.2 **Bents and Span Layout**

In **Visual BRG**, a bent is defined through a transverse line. In order to define a bent, define its location by a transverse line, then check Bent to mark it as a bent. Geometrically, a bent has no different from a transverse line in general. However, a kinked bent is not practical so a type of By Multiple Points is not recommended for defining a transverse line as a bent.

A bent will be used as a support when Bridge Modeling is enabled. Also, bents are used to define boundaries of a longitudinal line or a girder. When defining a longitudinal line including these are not designated as girders, the starting bent and ending bent are required. However, these boundaries bents can be missed or ignored. When starting bent is missing, the first bent in the model will be used instead. When ending bent is missing, the last bent will be used. The first and the last bents are not necessarily the one created first and last, respectively. The intersection of the first bent and the mainline has the least mainline station, and the last has the most respectively.

A bridge span is simply and automatically defined by two consecutive bents. A bridge may contain multiple spans. When Bridge Modeling is enabled, bridge model may need to export to a DESCUS data file. When exporting DESCUS data file, the topologic relationship between the first bent and all girders will be analyzed so that girders will be output in an order defined by their location, not by the order of creation.

9.3 **Deck Points (POE) and Road Cross Sections**

One primary function of **Visual BRG** is to show and output deck control point coordinates and finished grading. When the deck surface is composed by three different types of curves (mainline plane curves, vertical curves and road transverse curves), computation of these points becomes complicated. The computation processes are further impeded considering super-elevation and super-widening. The **Deck Point** is also referred as **POE, Point Of Elevation**. The plane locations of **Deck Points** are the intersections of longitudinal lines and transverse lines. The vertical locations or the elevations of **Deck Points** are computed from road surface definitions. **Visual BRG** also draws **Road Cross Sections** at the mainline intersections with transverse lines. When drawing cross sections, it always goes radial at the intersections, no matter a transverse line is perpendicular to the mainline tangent or skewed.
**Visual BRG** uses triangular net to interpolate the elevation of a POE. Based on mainline horizontal curves and vertical profiles, transverse curves (super-widening/super-elevation), the 3D road way surface will be established. When forming the 3D surface, certain tessellation key sections are inserted to ensure interpolation accuracy. For examples, many key sections are evaluated within a curved segment of horizontal alignments, even if there is no transverse line defined in that segment; many key sections are inserted into a segment that contains vertical grade transitions, and etc. Once the 3D triangular net is established, a POE’s elevation is interpolated from three nodes elevations of a triangle which the POE falls in.

9.4 Use Radial Line for Railing

A transverse line can be marked as Use Radial Line for Railing so that it will turn back to the radial direction when it reaches the reference line of a longitudinal line that is marked as Railing. When a transverse line is skewed, its direction may be necessarily the same as the radial line at where it intersects with a longitudinal line. There is a special type of longitudinal line that is marked as Railing. A railing longitudinal line is offset from another longitudinal line, or the reference LL of a railing. If a TL is marked as Use Radial Line for Railing, it will turn back to radial direction when it reaches the reference LL of a railing. This feature is designed for output deck points in situations where a bridge is skewed but points on railing are measured in radial.

Section 12.8 illustrates an example of this feature.

9.5 Suppress Output

A transverse line can be marked as Suppress Output to skip output deck control points. Chances are that certain transverse lines are used only for reference, and there is no requirement to output deck points on these lines. In that case, check Suppress Output of a transverse line to skip output.

9.4 Incorporating with Camber Program

When exporting POEs to Microstation Camber RES file, the location (or interval) of the transverse lines should be the same as what its corresponding GRH file (created by DASH program) defined. Camber values plotted in Camber program contain 4 different types of cambers: A) camber due to weight of girder, B) camber due to weight of concrete slab, C) camber due to weight of parapets and others, and D) camber due to vertical curve. The Camber plotting program reads the first three camber values (A, B and C) from a separated GRH file, which is output from the DASH analysis program, and reads the D values from RES file, which is exported from **Visual BRG**. Number of values in A, B, C and D is required the same. Therefore, for the purpose of Camber plotting locations of Transverse Lines should match what GRH file defines.

In case more locations in **Visual BRG** are defined, Camber program will read sequentially and match A, B and C values one by one from GRH file.

In case fewer locations in **Visual BRG** are defined, missing locations of D values will be plotted as X.

Also refer to Import and Export chapter for detail.
Chapter 10  Diaphragms (Bridge Modeling only)

A diaphragm of a girder bridge connects two adjacent girders. Connecting girders, locations, type of diaphragm and section number are essential to define a diaphragm. As introduced in section 2.1.6, Visual BRG classifies diaphragms into two categories regarding the ways a diaphragm is defined: 1) grouped and 2) ungrouped.

10.1  Grouped Diaphragm

The location of a grouped diaphragm is defined by a predefined transverse line. When defining a diaphragm, select a transverse line in T Line dropdown list as shown in Figure 10.1. When a transverse line is associated, the diaphragm is defined as a grouped diaphragm. A grouped diaphragm connects all girders that intersect with the transverse line.

As shown in Figure 10.1, a grouped diaphragm is defined by transverse line 140’, which connects all four girders. If the transverse line of a grouped diaphragm is not defined yet, follow instructions in Transverse Lines chapter to define it first. Be noted that the default settings are preset for bridge and roadway geometry modeling, not for Bridge Modeling. Users should following instructions in Section 5.6 to turn off transverse lines and turn on diaphragms so that to show bridge models as shown in Figure 10.1.

![Figure 10.1 – Diaphragm examples and data form](image)

When a predefined transverse line is selected in T Line, only Diaphragm Type and Section Number will be enabled, and all others will be disabled. Select the type of the diaphragm and assign a section number in Diaphragm Type and Section Number, respectively. These information of a diaphragm will be exported to data file when export to DESCUS.

One thing should be noted that a diaphragm of a grouped diaphragm may not have all girders connected. Taking the blue diaphragms shown in Figure 10.2 as an example, the first diaphragm contains only two so-called girder diaphragm which connects the three girders; while the other grouped diaphragm shown in red connects all four girders. Each component, one diaphragm of a
grouped diaphragm, will determine its own connectivity according to girders geometries at its location.

Whenever girders of a bridge are changed, such as a new girder is added or an existing one is changed, all grouped diaphragms will automatically be updated.

![Figure 10.2 – A grouped diaphragm not connecting all girders](image)

### 10.2 Ungrouped Diaphragm

Unlike a grouped diaphragm, which always tries to connect all girders currently a bridge has, an ungrouped diaphragm connects girders from a start girder at start location to an end girder at end location. The diaphragms shown as red in Figure 10.1, for example, is an ungrouped diaphragm, which connects only 3 girders.

When to define an ungrouped diaphragm, first select **Not by a TL** in T Line dropdown list. All columns as shown in Figure 10.1 will be enabled. **Start Girder ID** defines which girder the diaphragm starts from, and **End Girder ID** defines which girder the diaphragm ends at. **Start Station** and **End Station** define the start and end locations of the diaphragm. Locations can be measured on the mainline or girder. When **Use Girder Station** is unchecked, the measurement is on mainline. Both **Start Station** and **End Station** are the mainline station. Locations on start and end girders are intersections with mainline radial lines at these mainline stations respectively. This type of measurement of diaphragm locations should be used by default, as a consistent reference – mainline is used.

When **Use Girder Station** is checked, the measurements are on start and end girders respectively. In this case, **Start Station** is the station on the start girder (**Girder Start Station** of start girder plus curve length on start girder); and **End Station** is the station on the end girder (**Girder Start Station** of end girder plus curve length on end girder). Locations on start and end girders are purely located by these stations, and mainline and its radial lines are not involved at all. Also refer to section 8.3.2 for **Girder Start Station** in detail.

**Visual BRG** provides this option to allow measuring on individual girders mainly because of
the need to handle data imports. As introduced in chapter 12, Visual BRG can import bridge geometries from DXF and import a bridge FEA model from DESCUS data file. These data sources do not contain mainline information or the relationships between mainline and girders do not exist. Locations of diaphragm ends have to be measured along each individual girder.

Users should pay attention to locations of diaphragm ends when mainline station is used. As mainline radial line is used to intersect the corresponding girders, stations reported on these end PODs may not be the same as specified by Start Station and End Station. When hovering a POD, the reported station is always measured on girder.

10.3 Diaphragm Identifications and Other Properties

Similar to a girder, a grouped or ungrouped diaphragm has ID and Name as the identifications. It will be automatically assigned when a diaphragm is created. ID cannot be modified, but users are free to modify Name.

A diaphragm has also associated Diaphragm Type and Section Number. Currently, Visual BRG does not interpret this information, but simply carry over when exporting to DESCUS program. However, user can specify different symbologies for different Section Number and thus diaphragms can be shown as different colors, styles and line weights in Visual BRG.
Chapter 11 Import and Export

Visual BRG provides functions to allow data exchanging with other programs. As building a bridge model for DESCUS analysis and a geometry model for Camber plotting are two primary functions of Visual BRG, currently the data exchanges are aiming at the connections with these programs. In addition to these connections, plane geometries of a bridge including mainline, supports, girders and diaphragms can also be imported from a DXF file. In further releases, Visual BRG may expand to cover functions Camber plotting currently provides and export a DXF file of all CAD plotting.

11.1 Exports to DESCUS data file (Bridge Modeling only)

After a bridge model is created, it can be exported to a DESCUS data file that contains data types 0101, 0102, 0103, 0601, 0701 and 0801. Some minor modifications or appending, especially girder and diaphragm sections, are required to make it a complete data input file to DESCUS I/II program. In chapter 13, a bridge modeling example is introduced. Please refer to section 13.2.8 for detail about Export to DESCUS data file.

To start Export to DESCUS data file, click on toolbar or Export to a DESCUS data file in File menu. The command can be started any time. When it starts a window as shown in Figure 11.1 will open.

Enter data in types 0101, 0102 and 0103 in Project Data and Options tab. This group of data is additional to a bridge model and required merely for exporting to a DESCUS data file. When it is changed, click Save Changes to save it to the model.

Currently, only Project Data and Options can be changed. Supports, Girders and Diaphragms, as shown in Figures 11.2 to 11.4, are automatically generated from the bridge model. These groups of data cannot be changed. Member and node numbers shown in Supports, Girders and Diaphragms are the same as labels shown in Plane View (Figure 5.12). Also refer to section 5.5 for changing labeling properties.

Click Save and follow the Open File Dialog Box to select a DESCUS data file. Once a data file is saved, it can be opened and edited further so as to perform DESCUS analysis.

![Figure 11.1 – Export to DESCUS data file – Project Data and Options](image-url)
Figure 11.2 – Export to DESCUS data file – Supports

Figure 11.3 – Export to DESCUS data file – Girders

Figure 11.4 – Export to DESCUS data file – Diaphragms
11.2 Import from DESCUS data file (Bridge Modeling only)

Visual BRG models can also be rebuilt from a DECUS data file, which could be prepared by any other means or be exported from Visual BRG. When importing, however, it should be noted that DESCUS data file is an “abstract” model for the purpose of FEA analysis and Visual BRG has more data to describe a bridge and roadway geometry model. One typical data that Visual BRG needs but what is lacking in DESCUS is the mainline information.

After importing, Visual BRG will construct a mainline based on girder information in the data file. All girder geometries will be set to mainline Independent, and all measurements for diaphragms are set to Use Girder Station.

To import a DESCUS data file, click in the toolbar or Import from a DESCUS data file in File menu.

When command starts, follow the Open File Dialog Box as shown in Figure 11.5 to select the data file to import.

The importing process may take few minutes to complete.

![Figure 11.5 – Select a DESCUS data file to import](image)

11.3 Import from DXF file

Geometries for building a girder bridge model can be created in a CAD system such as Microstation or AutoCAD. Visual BRG can import these geometries in a form of DXF file, a commonly used CAD drawing exchange file.

When importing from DXF file, certain requirements should be noted. Visual BRG requires that graphics entities in the DXF file are layered according to different categories, i.e. all graphics for mainline, support lines, girders and diaphragms are in separated layers. Unused graphic entities can be kept in the DXF file, but they have to be separated from any layer that contains mainline, support line, girders and diaphragms. Entities have to be in XY plane. Any two dimensional entity in a plane other than XY will be filtered out during import.

Legal graphic types for mainline are straight line, arc and smooth LWPOLYLINE. A
LWPOLYLINE is a string of connected straight lines and arcs. All entities for mainline can be separated as more than one entity or connected as one. When it is imported, **Visual BRG** will connect them into one if the mainline layer contains more than one entity. It has to be ensured that only one entity exists after connection and the connected entity is smooth.

Requirements for longitudinal entities are the same as for mainline except that entities after connection can be more than one.

The legal graphic types for transverse lines are straight line and non-curve LWPOLYLINE. Also, **Visual BRG** will connect entities first. Kinked separated straight lines and non-curve LWPOLYLINE will be connected. The number of entities after connection for transverse lines has to be more than one. Layer that contains only one connected straight lines cannot be the transverse lines layer, because two transverse lines are needed to define the two end bents. The two end bents are determined by intersections of transverse lines and the mainline. The transverse line that has the first intersection with the mainline is the first bent, and the transverse line that has the last intersections is the last bent.

A DXF file has to contain at least a legal mainline layer. Otherwise, no further entities can be imported. Longitudinal lines can only be imported if transverse lines are successfully imported. Only the mainline is required if imported from a DXF file, others are optional.

To start importing from DXF, click in the toolbar or **Import from a DXF file** in **File** menu. When command starts, a dialog box as shown in Figure 11.6 will open. Click **Select a DXF File** and follow the **Open File Dialog Box** to select a DXF file.

![Import from a DXF file dialog box](image)

Figure 11.6 – Import from a DXF file dialog box

After a DXF file is opened to import, the dialog box as shown in Figure 11.6 will change to Figure 11.7. In Figure 11.7, a data grid will be filled with information analyzed from the input DXF file. Layers in the DXF file are listed in the left column. Rows shown in the last cell as **Unassigned** are legal **Visual BRG** layers. Click **Unassigned** in the last column to assign that layer to **Mainline**, **Transverse Lines**, or **Longitudinal Lines**.

**Valid Entities** list the number of separated legal entities in a layer. **Invalid Out-Of-Plane Entities** list the number of separated illegal entities that are not in XY plane. **Invalid Unsupport Entities** list the number of entities that are not straight line, arc and LWPOLYLINE. **Connected Compound Entities** list the number after connection. Not all components can be selected in the **Assign To** column. For example, **Transverse Lines** will be excluded from **Assign To** in the row of **Mainline** as it contains only one entity after connection. Figure 11.8 shows an example of layer assignments.
For mainline and longitudinal entities, there is a smooth detection process during the import. When tangent change from the end of one entity to the start of another one is over certain limit, it will be taken as kinked mainline or longitudinal line. Only when the tangent change is below that limit will it be processed as smoothly connected mainline or longitudinal lines. The default value of such a limit (The kink limit for smooth mainline/longitudinal entities detection (in second)) is preset to two (2) second, which should be suitable for most cases. Users can enter a higher limit to lower the restriction though.

After layer assignment and entering of kink limit are done, click OK to proceed. A dialog box as shown in Figure 11.9 will open.

**Visual BRG** needs to know which end the mainline starts from. Therefore, the start of longitudinal lines and the order of transverse lines can be derived further. **Visual BRG** will
assume the start and end points first and then asks if the user wants to reverse it as shown in Figure 11.9. Usually, it has to go back to the bridge plan to identify these two end points of mainline so that to keep orders in Visual BRG the same as what engineers assumed.

Click Yes or No in Figure 11.9 to proceed the importing. It may take few minutes to complete the whole process.

After a DXF file is imported, only mainline, transverse lines and longitudinal lines are constructed in Visual BRG. They may look different from its DXF drawing as unused entities are filtered or trimmed out. However, the geometry of mainline, transverse lines and longitudinal lines are truly the same as DXF defined.

Figure 11.10 shows an example of geometry in a DXF and Figure 13.11 shows the bridge geometry model after import.

The X ordinate in DXF is mapped to East in Visual BRG, which goes from left to right; and the Y ordinate is to North, which goes from bottom to up.

It should be noted that only planar information of Mainline, Transverse Lines, and Longitudinal Lines of a Visual BRG project will be affected by importing a DXF file. Others such as mainline vertical curves will maintain its default.

As Visual BRG is primarily to support bridge geometry modeling, bridge modeling component such as diaphragms will not be read in from DXF file directly. When importing a bridge modeling model from DXF file, all diaphragms and support lines should be grouped into one layer, and all girders should be in another layer. When imported, manually indicate an LL as a girder and recreate diaphragms from each imported transverse lines.

![Figure 11.10 – AutoCAD drawing of an example geometries](image-url)
11.4 Export to RES files

All POEs defined in Visual BRG by using Road Sections can be exported so that Camber plotting program can plot Deck Elevations and Cambers in Microstation.

The export will create two different RES files, one for Deck Elevations and one for Cambers. The RES file for Deck Elevations is self-contained for the plotting purpose as it is the only file required to plot Deck Elevations. There will be no special requirement in building a model in Visual BRG and to plot Deck Elevations in Camber.

However, Camber needs to read another GRH file (from Merlin-DASH program ?) in addition to the RES file so that all four different camber values can be plotted. Camber values A, B and C are read from GRH file, and only D values in RES file are prepared by Visual BRG. The Transverse Sections interval in Visual BRG should be the same as those in the GRH file. Also refer to section 12.4 for more information about this requirement.

The previous Camber program restricts intervals be the same from GRH to RES. As Visual BRG does not have such a restriction on where to place Transverse Sections, Camber plotting program is modified in this regard so that unmatched intervals will be treated as warnings, not critical errors. As mentioned in section 12.4, ‘X’ will be plotted where D value is missing in RES.

When using Camber program to plot Deck Elevation and Camber, it is encouraged to refer to its user manual.

Attention also should be paid to what D values Visual BRG prepared for Camber are. By definitions, D values of cambers are due to vertical curve. Due to transverse curves, vertical curves vary from girder to girder. Given a particular girder within a particular span, D values are defined as offsets from the finished grade on the true curve to the straight line connecting two ends of the true curve at two support locations.
Chapter 12  BDGM Examples

In order to help users getting started with Visual BRG, few examples illustrated in the User’s Manual of The Geometric Solution of Highway Bridges are replicated in Visual BRG. The original example number is referred in this chapter.

Visual BRG has certain initial settings to help users to model a real bridge in general. To replicate these examples, these settings should be changed so that screen graphics can be as close to original example as possible. These changes are briefed in the first section, and would apply to all examples.

12.1  Change initial settings

Start Visual BRG and the main window will be shown as Figure 12.1.

![Figure 12.1 – Main window and initial settings](image)

Go to Longitudinal Lines data form. Highlight each row and press Del to remove predefined Longitudinal Lines one by one. Be noted that an LL should be not referred by other components in order to remove it. To remove an LL that is referred by others, the referring component should be removed first or its reference be changed to others. After deleted, the main window will be shown as Figure 14.2
12.2 Example 1-1 - Mainline

In this example, basic layout data is set. The mainline contains a tangent and an arc. The tangent is perpendicular to a known line passing through origin.

12.2.1 Define Reference Points

Change the existing Reference Point 1 to Absolute Polar. Select Absolute Polar in Point Type, enter 5000’ in Distance and 45° in Sita. Then move the cursor away the current row to make the change into effect.

Click Zoom All button in Plane View to see the changes. The changed Reference Point 1
will be shown in top right (Figure 14.4).

![Figure 12.4 – Change Reference Point 1 to Absolute Polar](image)

Add the second reference point as the starting point of the mainline. Move the cursor to Name cell in the empty row beneath Reference Point 1. Click to add a new point.

Select **Relative Polar** as the **Point Type**; select **Reference Point 1** in **Origin Point** as the origin of this relative polar system. Enter 200’ in **Distance** and 135° in **Sita**. Click Zoom All to see the changes in Plane View (Figure 12.5)

![Figure 12.5 – Main window after second point added](image)

**12.2.2 Define the Mainline Starting Information**

Hover the cursor over Reference Point 2, a popup tooltip will show the coordinates as X
(3394' 1 7/20") and Y (3676' 11 13/28"). Take the coordinate down. Figure 12.6 shows the coordinates of Reference Point 2.

Figure 12.6 – Read coordinates of Reference Point 2

Enter 2300' in Start Station as the start station of the mainline. Enter 3394' 1 7/20" into PI(1) East and 3676' 11 13/28" into PI(1) North, respectively. Click Zoom All to review the changes. The mainline on plane will be shown as in Figure 12.7. The bents will be disappeared as their initial stations are out of range.

Figure 12.7 – Mainline after starting information changed

12.2.3 Change Mainline to Pass Through a Point

Change the first segment of mainline Horizontal Alignment to Straight Line Ends at Point Head, select Reference Point 1 in Ends At Point. This will force the mainline go through the predefined reference point 1.
12.2.4 Change the second segment to tangent

Change the second segment of mainline Horizontal Alignment to **Tangent** with a length of 100’. The Radius can be ignored as it is a tangent segment. The mainline and data form will be shown as Figure 12.9.

12.2.5 Add a new circular segment

Click the empty row after the second segment of Horizontal Alignment, enter 500’ in Length, -1910’ in Radius and select **Circular** in **Curve Type**, corresponding to a 3° curve of 500’ long. The curve turns counter clockwise. The changed mainline and data form will be shown as Figure 12.10.
12.2.6 Change two transverse lines

Go to Transverse Lines tab. Change the first and the second transverse line to represent the back and ahead limiting stations, 2300’ and 2700’ respectively. Click Zoom all to show the entire mainline. The final mainline with back and ahead transverse lines are shown in Figure 12.11.

12.3 Example 1-3 – Mainline and Transverse Lines

Similar to Example 1-1, this example is to set basic layout. The mainline contains an arc of 1° curve and the absolute origin as the center. A reference point on mainline locates as the intersection with a radial line at 60° to the East axis. Please see the original manual for details.

12.3.1 Define Three Reference Points

Define three reference points to represent two limits and the middle reference point on mainline. The middle one is optional. However, it can be used as the base point to create another two points aligned vertically, so that a vertical bent can be created alternatively.
All the three points have the same type as **Absolute Polar**. The polar radii (Distance) are same, 5729.577'. The **Sita** angles are 61.5⁰, 58.5⁰ and 60⁰, respectively.

Change Name of the existing point to **Start Point**, select **Absolute Polar** as **Point Type**, enter 5729.577' in **Distance** and 61.5° in **Sita**. Add a new point as **End Point** by clicking the empty row beneath the first row. Same as Start Point except the Sita value is 58.5°. Repeat this to add the third point as **Middle Point** with a Sita value of 60°. Click Zoom all to show the plane view in full extent (Figure 12.12).

![](image)

**Figure 12.12 – Three Reference Points**

### 12.3.2 Define the Mainline

Read out the coordinates of Start Point by hovering the mouse over the point. The coordinates read as X:2733’11”, Y:5035’3” as shown in Figure 12.23.

![](image)

**Figure 12.13 – Read the coordinates of the Start Point**

Enter 2733’11” in PI(1) East and 5035’3” in North, respectively. Enter 1850’ in Start Station.

Change the first segment of Horizontal Alignment to **Circular Ends at Point Ahead** and select **End Point** in Ends at Point. Enter -5729.577’ in **Radius** as curve goes clockwise.

Remove the second Spiral segment by highlight it and pressing Del.
Click Zoom all to view the mainline in full extent (Figure 12.14).

![Image of mainline with transverse lines](image1)

**Figure 12.14 – Mainline in final of Example 1-3**

### 12.3.3 Define Two Transverse Lines for Limits

Go to Transverse Lines data form and change the existing transverse lines to lines simulating mainline limits. Change Name to Start and enter 1850’ in Distance in the first row. Change Name to End and enter 2150’ in Distance and 90° in Angle in the second row, respectively.

Click Zoom all and view the mainline in full extent (Figure 12.15).

![Image of two transverse lines](image2)

**Figure 12.15 – Two transverse lines for limits**

### 12.3.4 Define the Transverse Line for Road Survey Line

The road survey line underneath locates on mainline at a station of 2000’ with an angle to mainline tangent of 120°.

Click the empty row in Transverse Lines data form to add a new line. Change **Name** to **Survey Line**, enter 2000’ in **Distance**, and 120° in **Angle**. Make sure **Line Type** is **On Mainline by Station**.

Click Zoom all and view the full extent of mainline with transverse lines (Figure 12.16).
12.3.4 Define two bents by offsetting Survey Line

The normal distances of the two bents to the survey line are not mentioned in the original example. 100’ is assumed in this example.

Click the empty row in Transverse Line data form to add a new TL. Change the Name to First Bent, select Parallel to a Transverse Line by Normal Distance as Line Type, enter -100’ in Distance, select Survey Line as the 1st T Line, and select Mainline as L Line.

Click the empty row in Transverse Line data form to add a new TL. Change the Name to End Bent, select Parallel to a Transverse Line by Normal Distance as Line Type, enter 100’ in Distance, select Survey Line as the 1st T Line, and select Mainline as L Line.

Click Zoom all and view the mainline with transverse lines (Figure 12.17).

12.3.5 Mark transverse lines as Bents

Change transverse lines of First Bent and End Bent to Bents by checking Bent, change transverse lines of Start and End to regular transverse lines by unchecking Bent. The final mainline with transverse lines will be as shown in Figure 12.18.
12.3.6 Alternative way to create the survey line

Create two points by referring to Middle Point. When creating, select Relative Cartesian as Point Type, select Middle Point as Origin Point. Name one point as Lower Point and enter -50’ in Y, the other one as Higher Point and enter 50’ in Y. Figure 14.18 shows the points aligned with Middle Point.

Create a new TL named as Survey Line by selecting By Multiple Points as Point Type. As shown in Figure 12.19, two list boxes will be available for selecting points. Select Lower Point in Available Points and click to add it as one point. Select Higher Point in Available Points and click to add it as another point. Figure 12.19 shows data form and the transverse line created By Multiple Points. Figure 12.20 shows the final view created by this alternative way.
12.4 Example 3-1 – Vertical Profile

This example demonstrates the setting of a vertical profile stated in original example 3-1. The horizontal alignment is 400’ long tangent with a start station of 1800’. The vertical profile of the mainline is a straight grade of +2.0%. The elevation at end is 1008’.

Start Visual BRG and go to Mainline data form. Change Length of the first segment of Horizontal Alignment to 400’. Highlight the second row (spiral segment) and press Del to remove this segment. Enter 1800’ in Start Station.

Change the first record in Vertical Profile. Enter 1800’ in Station, 1000’ in Elevation and 0’ in External Distance. Add a new record to Vertical Profile by clicking the empty row below this record. Enter 2200’ in Station, 1008’ in Elevation and 0’ in External Distance.

Go to Transverse Lines data form; change the two existing transverse lines. Modify Name and Station to reflect the start and end stations of the mainline.

Figure 12.21 shows the final example and 12.22 shows the data form for transverse line modifications.
12.5 Example 3-2 – Vertical Profile

This example demonstrates the setting of a vertical profile stated in original example 3-2. The horizontal alignment is 600’ long tangent with a start station of 14200’. The vertical profile of the mainline is a down grade of -1.5% and an upgrade of +2.25% starting at station of 14600’. The horizontal length of the parabolic curve (grade transition curve) is 400’.

Follow steps in section 14.4 to build a tangent mainline. Enter 3 records in Vertical Profile with stations of 14200’, 14600’ and 14800’, and elevations of 500’, 494’ and 499’, respectively. Enter 400’ in Horizontal Length of Parabolic Curve to override the regular definition of a vertical curve using External Distance.

Figure 12.23 shows the correspondent data form and final mainline.
Figure 12.23 – Define vertical profile by specifying Horizontal Length of Parabolic Curve

12.6 Example 3-3 – Vertical Profile

Similar to Example 3-2, this example demonstrates the setting of a vertical profile stated in original example 3-3. The start station of the mainline is 1000’, two intermediate PVIs at stations of 2000’ and 3000’, respectively. The first slope starting from beginning to the first PVI is +1.0%. The second slope starting from the first PVI to the second PVI is -1.5%, transited by a parabolic curve with a horizontal curve length of 800’. The third slope starting from the second PVI is -3.0%, transited by a parabolic curve with a horizontal length of 600’. The ending station of the mainline is not specified, but is taken as 5000’ in this example.


Figure 12.24 shows the correspondent data form and final mainline.
12.7 Example 4-1 – Offset of Crown Point

When defining a key cross section of roadway as described in Section 6.5, the mainline alignment point or the crown point of the cross section, can be offset from the mainline. By default, the offset values are zero, i.e. the Crown Point is aligned on mainline.

Following Example 4-1 in, this example demonstrates the setting of an offset of the Crown Point from the mainline.

Start Visual BRG with a default project. The roadway cross section will not have any offset by default. Figures 12.25 and 12.26 show the plane view and 3D rendering of the default project with no offset.
In order to view the 3D rendering view as shown in Figure 12.26, click \( \text{ } \) icon on top of the 3D rendering view to start walking along the mainline, then click \( \text{ } \) to stop walking.

![Figure 12.26 – 3D rendering of road surface of the default project without crown point offset](image)

Go to the mainline form. As shown in Figure 12.27, enter \(-4'\) in Transverse Offset column for both key cross section records at stations of \(0' 0''\) and \(600'\). Leave Vertical Offset as-is, as no vertical offset in this example. Visual BRG always uses linear (Straight Line) interpolation method to determine these offset values for any intermediate cross sections. In this case, the crown point of all cross sections will be shifted to left of the mainline by \(4'\).

![Figure 12.27 – Roadway cross section offsets from mainline](image)

Figures 12.28 and 12.29 show the plane view and 3D rendering after the crown point offset is set.
Figure 12.28 – Plane view after crown point offset is set

Figure 12.29 – 3D rendering of road surface after crown point offset is set
12.8 Example 7-1 Longitudinal Lines

This example replicates the original example 7-1 to demonstrate chord longitudinal lines formed by connecting chords of an offset of mainline with bents. Also gutter line and railing are also included in this example.

The mainline of this example contains only one arc segment. Four chord longitudinal lines and 4 gutters and railings. The bridge contains two spans. Curve parameters are not given. However, they are not critical to illustrate the steps to define longitudinal lines that are formed by chords of an offset from another longitudinal line (mainline in this example). For detail description and data, please refer to the original example.

12.8.1 Define the Mainline

Start Visual BRG with a new project. Delete the second curve segment in Horizontal Alignments of Mainline tab by highlighting the record and pressing DEL. Change Curve Type of the first segment to Circular, change Length to 600’, Radius of -500’, respectively. Enter 20° into Start Tangent. A mainline with a simple arc segment with a radius of 500’ and total length of 600’, tangent at starting point of 20° will be created as shown in Figure 12.30.

![Figure 12.30 – A mainline with a simple arc segment](image)

12.8.2 Set Bents and Transverse Lines

Delete all existing transverse lines preset in the default project. Keep only 3 bents in the Transverse Lines table. When deleting a bent, to uncheck Bent first, and then to delete it. Change locations and skew angles of remaining bents to 100°/70°, 220°/80° and 350°/110°, respectively. Uncheck Use Radial Line for Railing for all 3 bents.

Add another two Transverse Lines at 220° and 180°. For the one at 220°, use the same parameters as the bent at 220°, except that the Use Radial Line for Railing is checked. For the
purpose of Bridge Modeling, a bent cannot be kinked while a regular transverse line may. Therefore an extra transverse line at the same location is added to demonstrate the situations that a kinked transverse line with Use Radial Line for Railing checked overlaps with a bent. The second transverse line at 180’ is merely to show the turning of a TL when intersecting with a railing line’s reference ling.

Figure 12.31 shows the data form of Transverse Lines, and Figure 12.32 shows the plane view after the modifications.

<table>
<thead>
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<th>ID</th>
<th>Name</th>
<th>Mainline by Station</th>
<th>Distance Difference</th>
<th>Distance Rate</th>
<th>Angle</th>
<th>1st T-Line</th>
<th>2nd T-Line</th>
<th>x-Line</th>
<th>Points</th>
<th>Bents</th>
<th>Suppress</th>
<th>Use Radial</th>
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<td>On Mainline by Station</td>
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<td>0</td>
<td>70°</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>200'</td>
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</tr>
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<td>220'</td>
<td>0</td>
<td>80°</td>
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<td>-</td>
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<td>-</td>
</tr>
</tbody>
</table>

12.8.3 Add Longitudinal Lines for Girders

Delete all existing longitudinal lines from Longitudinal Line data form. When deleting a line that is referred by others, delete others first. Figure 12.33 shows the data forma and the plane view after cleaning of existing longitudinal lines.
Add 4 longitudinal lines with line type of **Chords Formed by an Offset of Another LL and Bents**, and **Offset** by -12\', -4\', 4\' and 12\', respectively. The **Reference L-Line** of all is the same as Mainline. The names of them are Beam A, Beam B, Beam C and Beam D, respectively. Check **Girder** of all of them to indicate the longitudinal lines are for girders. The **Starting Bent** and **Ending Bent** can be ignored as they are by default the first one and the last one. Figure 12.34 shows the data form and the girders.

**Figure 12.34 – Four longitudinal lines as girders**

**12.8.4 Add a Longitudinal Lines for Comparison**

For the purpose of comparison, add a longitudinal line with line type of Offset from Another
LL. The offset from mainline is 12'. Together with Beam D, the comparison line shows the difference between an offset LL and Chords Formed by an Offset of Another LL and Bents. Be noted that chord LL also depends on the intermediate bents. Figure 12.35 shows the data form and the plane view.

<table>
<thead>
<tr>
<th>Project</th>
<th>Mainline</th>
<th>Longitudinal Lines</th>
<th>Transverse Lines</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam A</td>
<td></td>
<td>Chords Formed by an Offset of Another LL and Bents</td>
<td>Beam B</td>
<td>Offset Angle Reference L Line Beating Point Beating Point Beating Point Order Railing</td>
</tr>
<tr>
<td>Beam B</td>
<td></td>
<td>Chords Formed by an Offset of Another LL and Bents</td>
<td>Beam C</td>
<td>Offset Angle Reference L Line Beating Point Beating Point Beating Point Order Railing</td>
</tr>
<tr>
<td>Beam C</td>
<td></td>
<td>Chords Formed by an Offset of Another LL and Bents</td>
<td>Beam D</td>
<td>Offset Angle Reference L Line Beating Point Beating Point Beating Point Order Railing</td>
</tr>
<tr>
<td>Beam D</td>
<td></td>
<td>Chords Formed by an Offset of Another LL and Bents</td>
<td>Comparison D</td>
<td>Offset Angle Reference L Line Beating Point Beating Point Beating Point Order Railing</td>
</tr>
<tr>
<td>Offset from Another LL</td>
<td>12</td>
<td>Mainline</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Offset from Another LL</td>
<td>-14</td>
<td>Mainline</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Offset from Another LL</td>
<td>14</td>
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<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Offset from Another LL</td>
<td>-3</td>
<td>Mainline</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Offset from Another LL</td>
<td>3</td>
<td>Mainline</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Figure 12.35 – An offset LL for comparison

12.8.5 Add Longitudinal Lines for Gutters and Railings

Add two longitudinal lines for gutters by offsetting from mainline for -14' and 14', respectively. Name them as Left Gutter and Right Gutter, respectively. After gutters added, add another two longitudinal lines by offsetting from Left Gutter and Right Gutter, respectively. The offset distances are -3' and 3'. Check Railing of two railing LLs to indicate the LLs are railings. Figure 12.36 shows the data form and Figure 12.37 shows the plane view after the gutters and railings are added.

<table>
<thead>
<tr>
<th>Project</th>
<th>Mainline</th>
<th>Longitudinal Lines</th>
<th>Transverse Lines</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam A</td>
<td></td>
<td>Chords Formed by an Offset of Another LL and Bents</td>
<td>Beam B</td>
<td>Offset Angle Reference L Line Beating Point Beating Point Beating Point Order Railing</td>
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<tr>
<td>Beam B</td>
<td></td>
<td>Chords Formed by an Offset of Another LL and Bents</td>
<td>Beam C</td>
<td>Offset Angle Reference L Line Beating Point Beating Point Beating Point Order Railing</td>
</tr>
<tr>
<td>Beam C</td>
<td></td>
<td>Chords Formed by an Offset of Another LL and Bents</td>
<td>Beam D</td>
<td>Offset Angle Reference L Line Beating Point Beating Point Beating Point Order Railing</td>
</tr>
<tr>
<td>Beam D</td>
<td></td>
<td>Chords Formed by an Offset of Another LL and Bents</td>
<td>Comparison D</td>
<td>Offset Angle Reference L Line Beating Point Beating Point Beating Point Order Railing</td>
</tr>
<tr>
<td>Offset from Another LL</td>
<td>12</td>
<td>Mainline</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Offset from Another LL</td>
<td>-14</td>
<td>Mainline</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Offset from Another LL</td>
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<td>Mainline</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Offset from Another LL</td>
<td>-3</td>
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<td>-</td>
</tr>
<tr>
<td>Offset from Another LL</td>
<td>3</td>
<td>Mainline</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Figure 12.36 – Longitudinal Line data form after gutters and railings added
Figure 12.37 – Plane view of after gutters and railings added

Figure 12.38 – The turning of TLs

Figure 12.39 – Close up of the turning of TLs
As there are two transverse lines (For Deck Points and 180°) are marked as Use Radial Line for Railing as shown in Figure 12.31, Figures 12.38 and 12.39 shows the turning of these TLs and in close up, respectively. Skewed transverse lines that are marked as Use Radial Line for Railing will turn to radial line after intersect with the reference LL of a railing LL.

12.9 Example 7-2 Longitudinal Lines (PIA/PIB)

This example follows the original example 7-2 to demonstrate chord longitudinal lines by PIA/PIB method.

12.9.1 Define the Mainline and Transverse Lines

Follow instructions in sections 12.8.1 and 12.8.2 to create the mainline and three bents with the same parameters.

Figure 12.40 shows the mainline data form and the plane view. Figure 12.41 shows the transverse line data form.

12.9.2 Define Longitudinal Lines by PIA/PIB method

Define eight longitudinal lines as Girder by using Offset from an LL’s V. C. of a Span Thru Int of Ofst LL and E. B. / Offset from an LL’s V. C. of a Span Thru Int of Ofst LL and S. B. These two line types are used to create LLs as PIA/PIB methods in original BDGM program.

These two line types first construct a chord within one span formed by an LL. The chord at
LL’s location is virtually created. Then the chord will be offset to a location through the intersection of a TL and the LL at offset location. The difference between these two types is that the offset chord is aligned at the intersection with bent ahead or bent back.

The limitation of these two types is only one span can be specified as virtual chord cannot be kinked. As there are only three bents defined in this example and all offset chords aligned at the transverse line 220’, the starting bent or ending bent can be ignored. If one is missing, the first or the last bent will be used. Figure 12.42 shows the longitudinal line data form and Figure 12.43 shows the plane view.

**12.9.3 Comparing with Offset LL and Chords Formed at Offset Location**

In order to understand the offsetting of a virtual chord, add another two longitudinal lines of Offset from Another LL and Chords Formed by an Offset of Another LL and Bents, respectively. The comparison longitudinal lines are offset from mainline by 12’, as shown in Figure 12.44. Figure 12.45 shows the plane view after comparison lines are added. The curved longitudinal line is simply offset from mainline, and the straight red dot lines are chords formed at offset location. Unlike chords offset from virtual chords, chords formed at offset locations can go over one span. In that case, the longitudinal line will be a series of kinked straight lines.

Figure 12.46 shows the close-ups of areas that demonstrate the differences.
Figure 12.44 Data form for comparison longitudinal lines

Figure 12.45 Plane view after comparison longitudinal lines added

Figure 14.46 Close-ups of comparison lines at three bents areas

12.10 Example 7-2 Extended (Straight Line by Two Points)

Based on Example 7-2 illustrated in section 12.9, another longitudinal line by Straight Line
by Two Points is added to a new span connecting a PIB line (Beam D – PIB) defined in previous example. Reference point type of Intersection of a TL and an LL is also demonstrated.

12.10.1 Copy Example 7-2

Copy Example 7-2 project xml file as Example 7-2-Extended xml file. Open the extended project in Visual BRG.

Add a new bent at 450’ station. The data form and the plane view are showing in Figure 12.47. Be noted that the existing PIB lines in span from 220’ to 350’ are missing because the ending bent of these lines are not specified and the newly added bent at 450’ will be used instead. Chords formed by offsetting virtual chords are allowed only for one span.

12.10.2 Specify PIB Lines’ Ending Bents

Explicitly specify 350’ as the Ending Bent for these PIB lines as shown in Figure 12.48. Figure 12.49 shows the longitudinal lines with a new span added.
12.10.3 Add two Reference Points

Add two reference points for building a straight longitudinal line. One is by **Intersection of a TL and an LL.** When selecting the transverse line and longitudinal line, select the bent of 350° and Beam D – PIB, respectively. Add another point **On a TL by Offset from an LL.** Select 450’ as the transverse line and Mainline as the longitudinal line, enter 16’ in **Distance.** Figure 12.50 shows the reference point data form.

![Reference Point Data Form](image1)

**Figure 12.50 Add two reference points**

Change the symbologies for Reference Points for easy identification as shown in Figure 12.51. Figure 12.52 shows the plane view after the points are added.

![P.O.R. Symbologies](image2)

**Figure 12.51 Change P.O.R. symbologies**
12.10.4 Add a Longitudinal Line Connecting Two Reference Points

Add a longitudinal line by using **Straight Line by Two Points**. Select Reference Point 1 and Reference Point 2 in **Starting Point** and **Ending Point**, respectively. Check Girder to indicate the longitudinal line is used as a girder. Figure 12.53 shows the data form, and Figure 12.54 shows the plane view.

![Figure 12.53 Data form showing adding of Straight Line by Two Points as a longitudinal line](image)

**Figure 12.52 Plane view after two reference points added**

**Figure 12.53 Data form showing adding of Straight Line by Two Points as a longitudinal line**
Figure 12.54 A longitudinal line connecting to the end of a PIB line
Chapter 13 Other Examples

In order to help users getting started with Visual BRG, a ten-span curved bridge is taken as an example to demonstrate the building of a bridge model. In this example, all girders are parallel to the mainline, and the mainline curve is defined by a set of parameters.

In this example, only basic functions for building a bridge model are introduced. Users can study this example to get started with Visual BRG. For more comprehensive functions for editing the bridge and roadway geometry model, refer to previous chapters.

13.1 Basic Data of an Example Bridge (all in feet)

Mainline (assumed to be the bridge centerline)

Start Station: 20700.00 (this should not be the start of the bridge)

Curve: 1) Straight line with a length of 1096.78, 2) Arc with a length of 465.09 and a radius of 520 (clockwise), 3) Straight line with a length of (455.96), 4) Arc with a length of 316.08 and a radius of 800 (counterclockwise), 5) Straight line with a length of 275.09 and 6) Arc with a length of 290 and a radius of 5700 (counterclockwise).

Bridge starts at station 21767.5.

Four Girders are offset from the mainline: –14.0, -8.75, 8.75 and 14.0 respectively.

10 Span lengths are 106.75, 180.0, 200.0, 200.0, 200.0, 200.0, 200.0, 200.0, 180.0 and 156.33.

All support lines are perpendicular to the tangent of the mainline.

Diaphragm spacing is approximately 20’ in the first and the last spans, 30’ in the second and the eighth spans, 40’ in all other spans.

Mainline vertical curve: control point at station 22,000’, elevation: 50’; parabolic transition curve with an external distance of 15’.

Left and right widths of roadway are same: 18’, left and right slope are same: -2.5%, no super-elevation, no super-widening.

13.2 Steps to Create a Bridge Model

13.2.1 Start Visual BRG and Enable Bridge Modeling

Locate Visual BRG in Windows Start menu and start the program. The main window as shown in Figure 2.1 will open. What shows in the window is a default project defined by Visual BRG. The default project is not set for bridge modeling. Check Enable Bridge Modeling as shown in Figure 13.1.
13.2.2 Create Mainline

In Mainline data form, enter the mainline parameters in the form as shown in Figure 13.2:

Change the Length of the first row of Horizontal Alignments from 100’ (default value) to 1096.78’ (make sure ’is followed).

Change the Length of the second row of Horizontal Alignments from 500’ (default value) to 465.09’. Change Radius from -200’ to -520’. Change Curve Type from Spiral to Circular.

Click the Length in the third row (the empty line) to add a new record. Enter 455.96’. Move cursor away from the current line.

Click the Length in the fourth row (the empty line) to add a new record. Enter 316.08’. Enter 800’ in Radius. Change Curve Type from Tangent to Circular. Move cursor away from the current line.

Click the Length in the fifth row (the empty line) to add a new record. Enter 275.09’. Move the cursor away from the current line.

Click the Length in the sixth row (the empty line) to add a new record. Enter 290’. Enter 5700’ in Radius. Change Curve Type from Tangent to Circular. Move cursor away from current line.

Enter 20700’ in Start Station.

Change the Station in the first row of Vertical Profile to 22000’, Elevation to 50’ and External Distance to -15’

Change the Stations in the first and the second rows of Cross Sections to 20700’ and 23599’ respectively. Change Left Width and Right Width of both rows to 18’. Change Left Slope and Right Slope of both rows to -2.5%.

Click in Plane View and Vertical View to zoom the view to extent.
13.2.3 Setup Span Layout

After the mainline is created, the span layout needs to be set up. Follow the instructions below to set up the span layout.

Click Transverse Lines tab to bring the transverse line data form on top. Change the existing values of Distance (Station) from 100’, 200’, 269’ and 350’ to 21767.5’, 21874.25’, 22054.25’ and 22254.25’ respectively. Change Angle in the second row to 90°, and leave values of Angle as 90° in other rows.

Modify other existing transverse lines to bents. Change the existing values of Distance (Station) in lines 5 to 11 from 450’, 110’, 120’, 140’, 160’, 180’ and 200’ to 22454.25’, 22654.25’, 22854.25’, 23054.25’, 23254.25’, 23434.25’ and 23590.58’ respectively. Leave Angle in these rows as 90°.

Remove all other existing transverse lines by highlighting a row and pressing Delete.

Check Bent of rows from 6 to 11.

Change Name of the eleven transverse lines to Bent 1, Bent 2, ..., and Bent 11.

Figure 13.3 shows the Transverse Line data form. Figure 13.4 shows the plane view and vertical view.
13.2.4 Create Girders by Offsetting from Mainline

After the mainline and bents are defined, it is ready to create girders.

Click **Longitudinal Lines** tab to bring the longitudinal line data form on top. Leave curbs and edges (rows from ID 2 to 7). Modify the existing girders (existing rows from ID 8 to 11). Change **Offset** of the 4-default girders to −14.0, −8.75, 8.75 and 14.0 respectively. Change **Name** of these 4 girders to Girder 1, Girder 2, Girder 3 and Girder 4, respectively. Figure 13.5 shows data.

(When adding a new girder, click the empty row at the bottom of the form and a new record will be added. When deleting a girder, click a row to highlight it and press DEL.)

Turn on Girders and turn off Girder Centerlines. Girders are for creating Bridge Modeling and Girder Centerlines are the longitudinal lines of girders when Deck Control Points are regarded. Turn on Girders and turn off Girder Centerlines will have a better display and easy identification of girders.

Click 🍁 at the top of the plane view window. Check **Show Girders** under Girder tab in
Figure 5.10. Uncheck **Girder Centerlines** and **Points** under **Transverse/Longitudinal Lines** in Figure 5.14.

Figure 13.6 shows the plane view.

![Figure 5.14](image1)

![Figure 13.5 – Longitudinal Line data form](image2)

![Figure 13.4 - Create girders](image3)

13.2.5 Create Transverse Lines for Diaphragms

The following procedures illustrate the placing of diaphragms, assuming that diaphragms are placed around 20’ apart and are perpendicular to the tangent of the mainline where they are placed.

In Visual BRG, locations of diaphragms that are cross over all girders are defined by transverse lines. Therefore, transverse lines have to be defined at diaphragm locations.

Click **Transverse Lines** to bring transverse line data form on top.

Click the empty row beneath Bent 11 (the last row of transverse line). Add a transverse line named as D1, Line Type of **On Mainline by Station**, and **Distance (Station)** of 21767.5’.

Diaphragms in the first span have a space of 21.35’. Repeat above process to add other 5 transverse lines named as D2,D3,D4,D5 and D6, and **Distance (Station)** of 21788.85’, 21810.2’, 21831.55’, 21852.9’ and 21874.25’, respectively.
Diaphragms in span 2 have a space of 30’. Repeat above process to add other 6 transverse lines named as D7, D8, …, D12 and **Distance (Station)** of 21904.25’, 21934.25’, … and 22054.25’, respectively.

Diaphragms in spans 3 to 8 have a space of 40’. Repeat above process to add other 30 transverse lines named as D13, D14, …, D42 and **Distance (Station)** of 22094.25’, 22134.25’, …, 23214.25’ and 23254.25’, respectively.

Diaphragms in span 9 have a space of 30’. Repeat above process to add other 6 transverse lines named as D43, D44, …, D48 and **Distance (Station)** of 23284.25’, 23314.25’, … and 23434.25’, respectively.

Create diaphragms in the last span by the following two steps, as not an evenly spacing existed: 1) create 7 transverse lines starting at 23453.75 with a spacing of 19.5 and 2) create 1 diaphragm starting at 23590.58.

Figure 13.5 shows the transverse line data form.

**Figure 13.5 – Transverse Line data form**

### 13.2.6 Create Diaphragms

After the transverse lines are created for diaphragms, click Diaphragms tab to bring Diaphragms data form on top.

Modify the first row in the form, which is the default diaphragm. Use the default **Diaphragm Type (X Truss)**. Enter a section number for diaphragms, 3, for example in **Section Number**. In **T-Line** dropdown box, select D1 to use transverse line D1 as the diaphragm location.

Add another 55 more diaphragms (D2 to D56) to the form as shown in Figure 13.6.

Click ![Zoom Window] (Zoom Window) to zoom in first span area. The diaphragms will be shown as Figure 13.7. Figure 13.8 shows the bridge model in full view.
### Figure 13.6 – Diaphragms form

<table>
<thead>
<tr>
<th>Project</th>
<th>Mainline</th>
<th>Longitudinal Lines</th>
<th>Transverse Lines</th>
<th>Points</th>
<th>Diaphragms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>X Truss</td>
<td>D12</td>
<td>3</td>
<td>1.10'</td>
<td>1.10'</td>
</tr>
<tr>
<td>2</td>
<td>X Truss</td>
<td>D2</td>
<td>3</td>
<td>1.10'</td>
<td>1.10'</td>
</tr>
<tr>
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<td>X Truss</td>
<td>D3</td>
<td>3</td>
<td>1.10'</td>
<td>1.10'</td>
</tr>
<tr>
<td>4</td>
<td>X Truss</td>
<td>D4</td>
<td>3</td>
<td>1.10'</td>
<td>1.10'</td>
</tr>
<tr>
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<tr>
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<td>X Truss</td>
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<tr>
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<td>1.10'</td>
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</tr>
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<td>D11</td>
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</tr>
<tr>
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<tr>
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<td>X Truss</td>
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<td>27</td>
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<td>D27</td>
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<td>1.10'</td>
</tr>
</tbody>
</table>

### Figure 13.7 – Diaphragms in first span
13.2.7 View POEs and Mesh Labels

Change Display Settings by clicking 📈. Turn on Transverse/Longitudinal Lines as shown in Figure 13.9 and turn off Girders as shown in Figure 13.10.

Figure 13.9 – Display Settings for Transverse/Longitudinal Lines

Figure 13.10 – Display Settings for Girders
Zoom in to a span and hover the cursor over a POE. The tooltips in popup window will show the information of the POE. Figure 13.11 shows an example.

![Figure 13.11 – Hover the cursor over a POE](image)

Change the Display Settings back (Turn off Transverse/Longitudinal Lines and turn on Girders). Turn on labels under **Labels** tab as shown in the top of Figure 13.12. Zoom in to a span to view the mesh members and labels.

![Figure 13.12 – Mesh Labels](image)

### 13.2.8 Export the bridge model to a DESCUS data input file

When the diaphragms are created, the bridge model is ready to export to a data file that is fully compatible with DESCUS I/II. It should be noted that only data types 0101, 0102, 0103,
0601, 0701 and 0801 will be generated in the data file. It is the user’s responsibility to supply other types of data the analysis needs, such as section and load information, to the data file.

Click 🗄️ from the main toolbar to export to DESCUS data file. The Export to DESCUS data file window, as shown in Figure 13.13, will open.

![Export to DESCUS data file window](image)

Figure 13.13 - Export to DESCUS data file

When exporting to DESCUS data file, only **Project Data and Options** can be modified. Data in **Supports**, **Girders** and **Diaphragms** are generated from the bridge model. They are read-only.

Click **Save** to save to a data file which the DESCUS analysis program can read in. When the save command is issued, the Open File Dialog Box will appear on the screen. Enter a new file name and click **OK**.

When finished, the window can be closed by clicking cross in the top right corner of the window.

### 13.3 3D Roadway Frame and Deck Rendering Views

Click 🏃️‍♀️ in the main toolbar to switch to **3D Roadway Frame View**. Click 🏃️‍♀️ to walk along the mainline and click 🛑 to stop walking in the middle.

User views toolbar in the **Road Section View** to zoom in to one road section. Figure 13.14 shows an example of these views.
13.4 Export the geometry model to Camber Res File

Click in the main toolbar to export the geometry model to Camber Res File. Select the Deck Elevation Res file first in the file selection dialog box. Enter deck.res as an example shown in Figure 13.16.
Figure 13.16 – Enter a Deck Elevation Res file for export

Click **Save** to proceed. When confirmation dialog box as shown in Figure 13.17 showing up, click **OK** to proceed. Be noted that a succeeded export will show as successfully, and a failed export will show as with errors. The correspondent error message will be written to Res file.

Figure 13.17 – Confirmation of Deck Elevation Res export

Continue the same procedure for the second Res file for Camber Res file. In this example, Camber Res is not demonstrated further.

13.5 **Save project**

Click **Save** in the main toolbar to save the project. When command starts, a dialog box as shown in Figure 13.18 will open.

Figure 13.18 – Confirmation of saving changes
Click **Yes** to proceed. Select a project file in the following dialog box as shown in Figure 13.19. Click **OK** in the following confirmation dialog box as shown in Figure 14.15.

![Figure 13.19 – Enter a project file](image1)

![Figure 13.20 – Confirmation of successful save of a project file](image2)

13.6 **Exit Visual BRG**

Click ✖️ to exit Visual BRG.

13.7 **Plot Deck Elevation in Microstation**

Start **Microstation** and load **camber v08000732.mvba** program. Figure 13.21 shows the main interface of Microstation after camber program is loaded.
Highlight Camber program and click play button to run the program. A dialog box as shown in Figure 13.22 will open. Highlight Deck Elevation item and Click Run.

Click OK in the following welcome message box(Figure 13.23).

Select the Deck Elevation Res file exported in section 13.4 in the following file selection dialog box as shown in Figure 13.24.

There will be 10 spans listed in the following selection dialog box as shown in Figure 13.25. Select 6 as an example to plot. Click OK to proceed.
Figure 13.23 – Welcome message of Camber program

Figure 13.24 – Select the Deck Elevation Res file exported in Visual BRG

Figure 13.25 – Select a span to plot

Click OK in Deck elevation settings box as shown in Figure 13.26.
Click over a point in drawing area as the origin of this span. Deck elevation of span 6 will be plotted. Use Microstation command to zoom in and out to check the results. Figure 13.27 shows a full extent view and a zoomed in view.

Figure 13.26 – Deck elevation settings

Figure 13.27 – Plotted deck elevation of Span 6