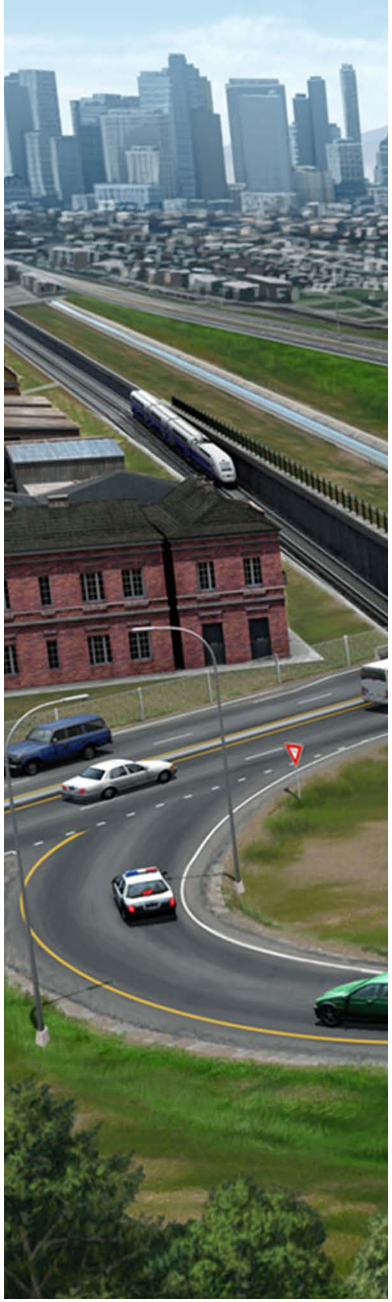


Regression for Surveyors

This course is for the **2024 Release 2** *version of:*

OpenRoads Designer CONNECT Edition

About this Practice Workbook...

- This workbook is designed for use in Live instructor-led training and for OnDemand self study. OnDemand videos for this course are available on **learning.bentley.com**
- This PDF file includes bookmarks providing an overview of the document. Click on a bookmark to quickly jump to any section in the file.
- Only Metric files are included in the dataset.
- This course workbook uses the *Training and Examples* WorkSpace and the *Training-Metric* WorkSet delivered with the software.
- The terms “Left-click”, “Click”, “Select” and “Data” are used interchangeably to represent pressing the left mouse button. The terms “Right-click” and “Reset” are also used interchangeably to represent pressing the right mouse button. If your mouse buttons are assigned differently, such as for left-handed use, you will need to adjust accordingly.

Have a Question? Need Help?

If you have questions while taking this course, you can submit questions to the *Civil Design Forum* on Bentley Communities where peers and Bentley subject matter experts are available to help.

Bentley Institute

Edition: **03-01**

Course Level: **Intermediate**

Course Overview

The project that we are going to undertake in this course is to create a Geometric Horizontal Alignment that follows, as closely as possible, the existing Surveyed centerline of a road using the regression tools available in OpenRoads Designer.

A vertical alignment will be generated that follows the existing road profile, using the Best Fit Profile tool.

Regression Overview

The regression tools are used to help define an alignment along the path of an existing road. Regression is a “best fit” process whereby the new alignment geometry is defined to fit as close as possible to a collection of known coordinate points surveyed along the existing road.

Typical Regression Workflow:

1. Create a Regression Line horizontally to match, as closely as possible, to the existing road centerline.
2. Create a Curvature Diagram to create the alignment and use horizontal regression tools for single or quick method.
3. Regress the horizontal alignment.
4. Report the slews.
5. Create a best fit vertical alignment.

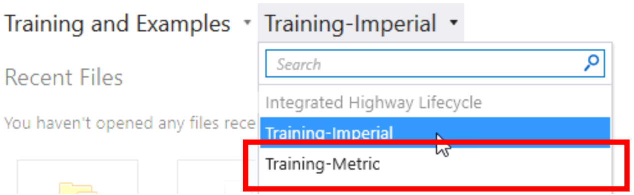
1. Start the software.
2. Set the WorkSpace and WorkSet.

   The WorkSpace and WorkSet define standards that are used by the software, and the ones used for this training are installed during the software installation.

   Typically, the WorkSpace contains organizational standards and the WorkSet contains project standards.

   a. Select **Training and Examples** from the *WorkSpace* drop-down menu.

   b. Select *Training-Metric* from the *WorkSet* drop-down menu.

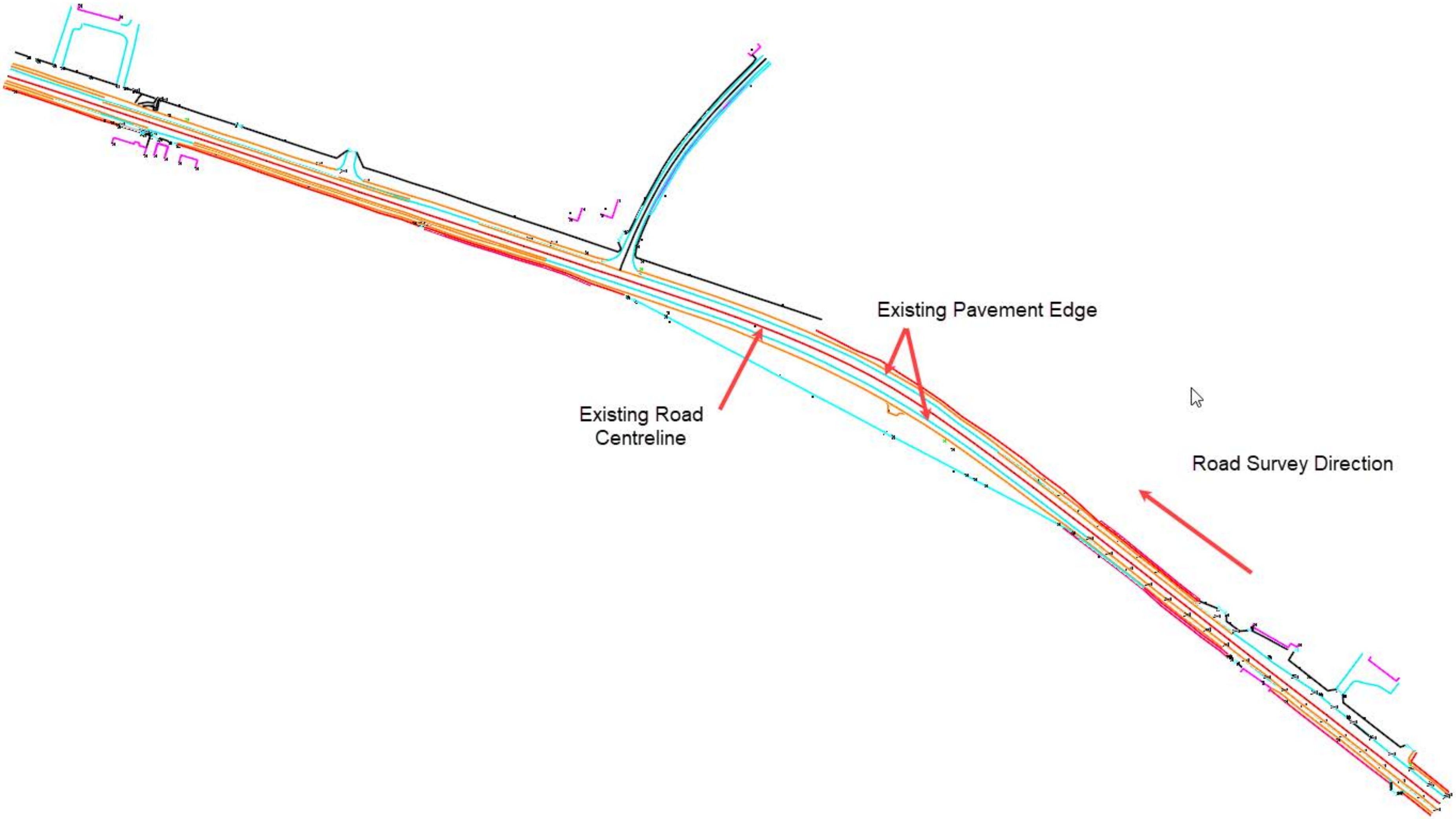


3. Open a 2D file.

   a. Select **Browse**

   b. Browse to *C:\Bentley Training\Regression for Surveyors* or other folder where you unzipped the dataset files.

c. Open the file named **Road Survey.dgn**

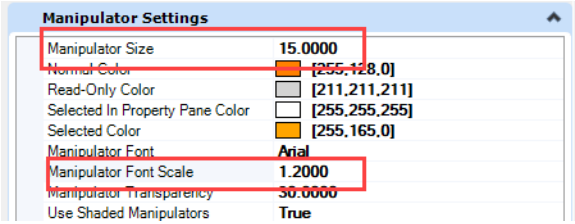


The existing road is a single carriageway that runs from east to west and is approximately 650m long and each carriageway is roughly 3.5 m wide. The main parts of the Survey from our prospective are the Existing centerline and Existing Pavement edges.

Preference Settings

In this section, we are going to make some changes to the User Preference settings. These changes are not mandatory when using the Regression tools but will help with the viewing of certain objects.

1. Select > *File* > *Settings* > *User* > **Preferences**
   a. In Left Hand Pane, *Select* > **View Options - Civil**
   b. Scroll to *Manipulator Settings* > *Manipulator Size* > **15**
   c. *Manipulator Font Scale* > **1.2**
   d. Scroll to *Regression Display Settings - Show Point Name* > **True**
   e. Select > **OK**
   f. Select > **Save Settings**
   g. Select > **Back**



Exercise 1: Create Horizontal Alignment Using Existing Centerline

In this exercise, you will learn how to create a horizontal alignment using the Horizontal Regression tools.

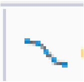
Skills Taught

- Create Regression Line
- Create a Horizontal Curvature Diagram
- Single Horizontal Regression
- Create Connecting Curves and Spirals
- Create Complex Alignment from Elements

Regression Line from Existing Centerline

In this section, you will create a new road centerline alignment from the existing surveyed centerline.

1. Open an existing 2D DGN file.
   a. Select *File >* **Open**
   b. **Browse** to *C\Bentley Training\Regression for Surveyors* or other folder where you unzipped the dataset files.
   c. Select*, File >* **Road Geometry.dgn**
   d. Select > **Open**
2. **Click** anywhere in *View 1* to make it active.



3. From the ribbon menu select *Geometry > Regression > Create Regression Line >* **Regression Line From Line**
   a. Set the *Points Feature Definition* to **Regression_Point**
   b. *Name Prefix* to **CL Pnt**
   c. *Complex Feature Definition >* **Geom_Baseline**
   d. *Name Prefix >* **Road CL**

e. Set the *Feature Definition > Alignment > Regression >* **Regression_Line**

f. Set the *Name Prefix* to **Regression Line**

g. *Minimum Distance Tolerance:* **5.000**

h. *Maximum Distance Tolerance:* **50.000**

i. *Maximum Deviation:* **2.000**

j. *Minimum Deviation:* **0.000**

k. *Unacceptable Slew Left*: **0.100**

l. *Unacceptable Slew Right*: **0.100**

m. *Maximum Lift:* **0.100**

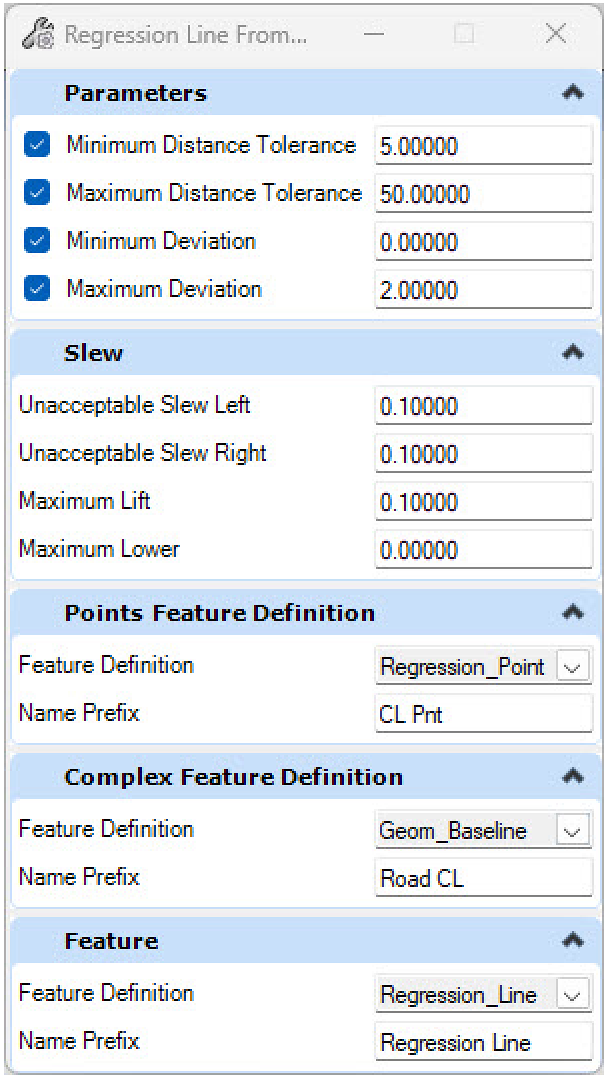
n. *Maximum Lower:* **0.000**

o. Follow the prompts, *Locate Line,* Select > **Complex Chain** (Survey - E_Road_ Centerline)

The centerline has now been created. The centerline alignment exists but no profile has been created even though the existing road centerline has elevations. This is the normal procedure for this operation. We will deal with the vertical later in the course.

Even though a complex chain has been created there are no elements stored within it, its just a place holder for what is to come.

p. Select **<Esc>** to *Exit*



Parameter Settings Definitions

Minimum Distance Tolerance

- Defines a minimum distance in the search for the next point during the process of ordering regression points. Points must lie beyond the Minimum Distance Tolerance from the current regression point to be considered as candidates to be the next regression point. This value should be selected as less than the standard distance between consecutive survey points.

Maximum Distance Tolerance

- Defines a maximum distance in the search for the next point during the process of ordering regression points. Points must lie closer than the Maximum Distance Tolerance from the current regression point to be considered as candidates to be the next regression point.

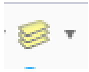
Maximum Deviation

- Specifies an offset, measured from a line projected through the current regression point and the previous one, that defines a zone inside which points must lie to be considered as candidates to be the next regression point. The purpose of the Maximum Deviation is to ensure that the search for the next regression point is restricted to points that lie generally in the path of the previously ordered regression points.

Minimum Deviation

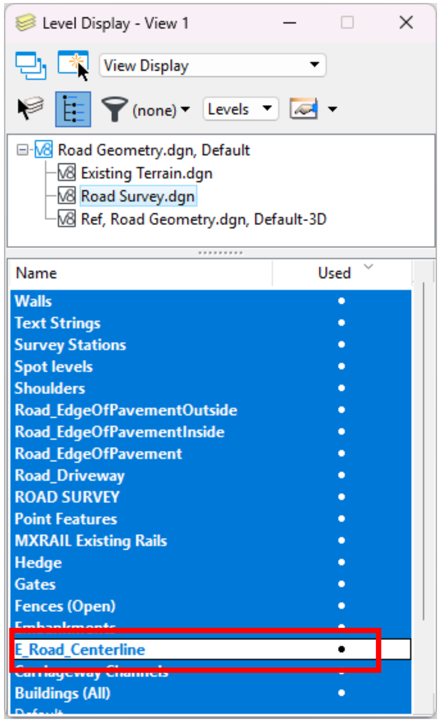
- Specifies an offset, measured from a line projected through the current regression point and the previous one, that defines a zone inside which points will not be considered as candidates to be the next regression point. Minimum Deviation parameter is used for removing near collinear points that does not contribute to the analysis, reducing the number of points to have a lighter dataset. This parameter is especially useful in the cases where survey points are extracted automatically from laser readings or reality models and has excessive number of points

4. From *Home > Primary >* **Level Display**

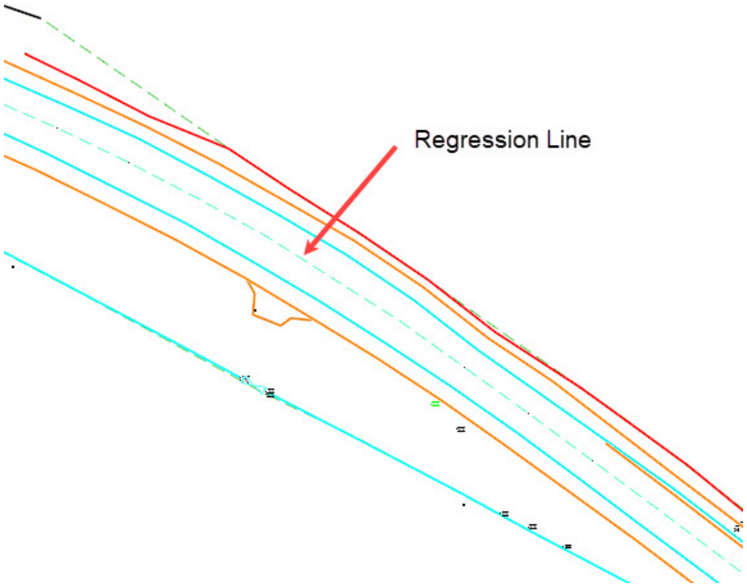


a. Select the **Road Survey.dgn** file in the list of files in the top pane of the **Level Display** panel.

b. In the Level pane click on the level *E_Road_Centerline* to de-select and this switches the level off.



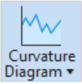
c. **Close** the *Level Display* dialog



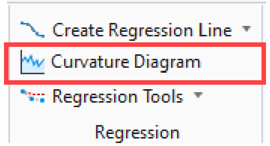
Create Horizontal Curvature Diagram

In this section you will learn how to create the *Horizontal Curvature Diagram*.

This tool displays a diagram representing curvature along the path of regression points in a horizontal alignment. While regression analysis can be done directly on the regression line, a curvature diagram makes it easier to identify curves, tangents and spirals. This tool operates on the raw regression line; you do not need to perform any regression analysis before running this tool.



1. Select *Geometry > Regression >* **Curvature Diagram**.

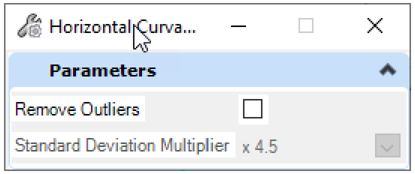


2. Un-Check **Remove Outliers**.

   When the option for the *Horizontal Curvature Diagram* is selected, there is an initial panel that appears known as **Remove Outliers**. This removes the statistical outliers spikes in the curvature diagram. The points are removed from the raw regression data and are not displayed in the curvature diagram. If you see spikes in the curvature diagram use this option to remove them.

   On the **Remove Outliers** tool settings if you check on **Remove Outliers** there are 3 options:

   - *x 1.5* > This the most aggressive option as it removes points that are more than 1.5 standard deviation away from the mean. (this option will remove most number of points).
   - *x 3.0* > This is a moderate option as it removes points that are more than 3.0 standard deviation away from the mean. (this option will remove a modest number of points).
   - *x 4.5* > This the least aggressive option as it removes points that are more than 4.5 standard deviation away from the mean. (this option will remove least number of points).

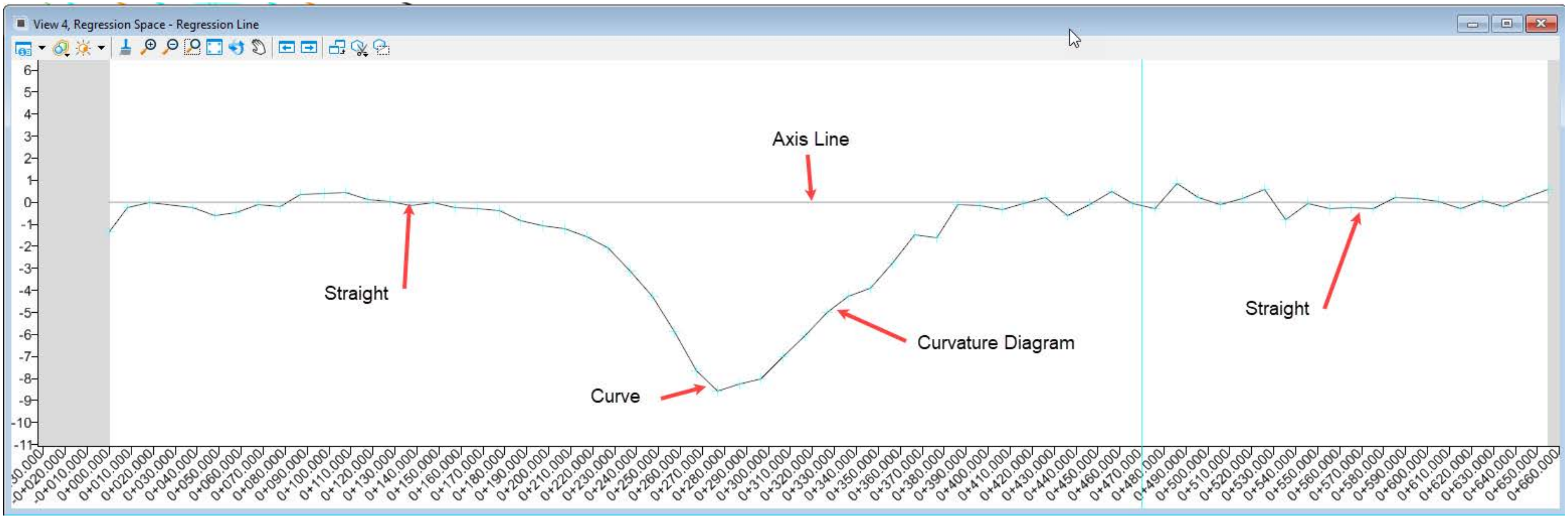


3. Follow the prompts:

   a. *Locate* the **Regression Line** in the plan view

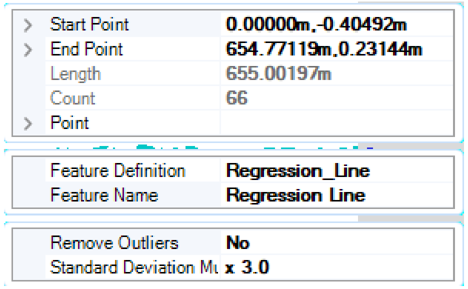
   b. Select *Regression View:* Select **View 4** from the *Manage View Groups* toolbar

   c. From *View Attributes >* Change the *Vertical Exaggeration* to **10**



- The horizontal axis represents stationing along the alignment.
- The vertical axis represents deflection of each point relative to its neighboring points.The absolute value of the vertical does not provide much information about the geometry. It is the relative value of the points that represents the curvature.
- In the diagram, points closer to horizontal axis have low deflection values, which means these points are on a tangent line. Points that are away from horizontal axis represents curves. Transition zones (that is the deflection of the points that are increasing or decreasing) represents transition curves and/or spirals.

- The sign of the vertical value is negative for left-hand curves (below the axis line) and positive for right-hand curves (above the axis line).

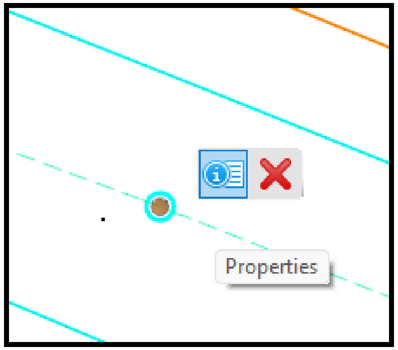


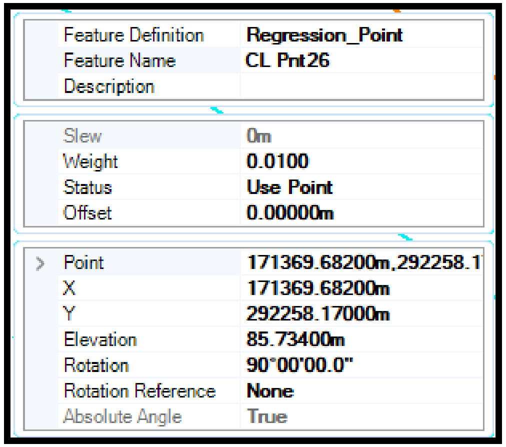
- Selecting the Properties of the Regression Line will show if you have used the Remove Outliers. Also the settings for the outliers can be changed from here.

Review/Edit Horizontal Regression Points

In this section you will learn how Review and Edit Regression points. Regression Points are stored with horizontal alignments, similar to the way that event points are stored.

1. Window to any where on the design so you can locate the Regression points
2. Select a Regression point, wait for the *Context Sensitive toolbar* and Select > **Properties**





   a. Review the part of the Properties where there is *Weight*, *Status* and *Offset*
   b. *Click* anywhere on the display close the properties dialog

Weight

You can control the relative significance of regression points. Points are weighted with unit less numerical values, usually ranging from 0.01 to 1000.0 (although the range of values is arbitrary). The command will place a priority on honoring the points with higher weightings. The points with higher weighting attempt to “pull” the element more strongly towards them than do points with lower weightings.

Status

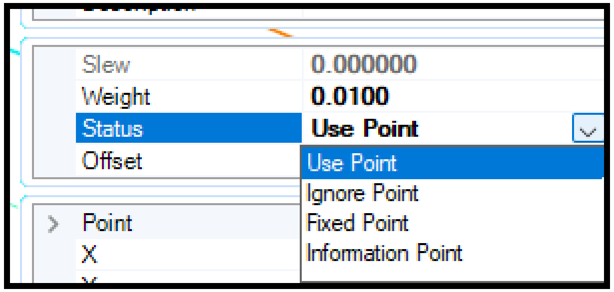
The status is designated for each point as either *Fixed, Use, Ignored, Information Point* . The meanings of these three values are as follows:

Fixed Point– Assigns a weight of 1000, which designates the point as extremely significant, particularly compared to Normal points, which are assigned a weight of only 0.01.

Use Point – Assigns a weight of 0.01 (although this value can be globally modified).Most points are assigned a Normal status. All points with a weight of 0.01 are equally significant; however, they are far less significant than Fixed points, which are given a weight of 1000.

Ignored Point – Excludes the point from consideration during regression analysis but still includes the point in reporting. This option allows you to keep track of a point (perhaps for grading purposes) but prevents the point from affecting the regression analysis. Points marked as Ignored are not assigned a weight.

Information Point - This point can be used as a reference point for information.



Offset

This specifies an offset from the regressed element. The offset allows you to incorporate a point in regression analysis even if the point lies offset from the alignment. For example, if you know that a surveyed point should lie exactly 5 meters to the left of the centerline, you could assign it an offset of –5.0. Regression analysis would then be able use this point in positioning the alignment. Regression analysis would attempt to run the alignment 5 meters to the right of the point. The end result would be that the regression point would lie 5 meters to the left of the alignment

Single Horizontal Regression

In this section you will learn how to use the *Horizontal Curvature Diagram* to create the individual elements that will make up our Horizontal Regression alignment.

This tool creates a single horizontal geometry element that is a “best fit” to a set of regression points. Best fit means that the orthogonal projection from the element to the regression points is minimized. This tool generates either a linear element or a circular element. The length of the element will be all regression data (each point) that can project orthogonally onto the element.

This tool can work both on the plan view (regression line) or on the horizontal curvature view (curvature line). While it is possible to create a geometry in parts, using both regression line and curvature line, when you switch from one view to other, the tool should be restarted.

This tool creates a regression rule between the created geometry element and the regression line. This link allows dynamic regression analysis, that is changing the points used in the analysis of that element. Depending on where you use the regression tool (on plan or curvature diagram), you can modify the regression as follows:

- If you use the *Horizontal Curvature Diagram* to create the elements, you can use the manipulators on the regression box for that element. You can also view updated slews and standard error values if the properties of the box are selected.

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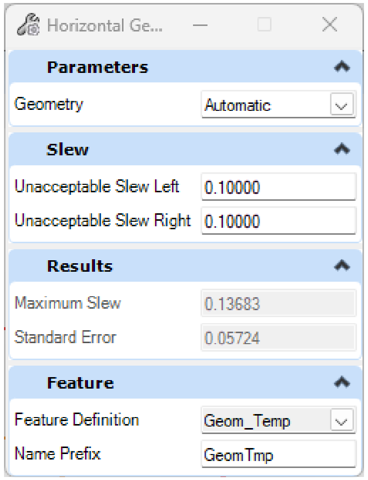
1. We are going to Regress a section of road that contains 3 elements. The start of the Regression Analysis is around Station **0+000** and ends around Station **0+150.**

2. From the ribbon menu select *Regression > Regression Tools > Horizontal Regression >* **Single Horizontal Regression**
3. Select the *Curvature line* in the Curvature Diagram *(View 4)*.
4. In the Tool Settings window set the following values
    a. *Geometry*: **Automatic**
    b. *Unacceptable Slew Left*: **0.100**
    c. *Unacceptable Slew Right*: **0.100**
    d. *Feature Definition: Alignment >* **Geom_Temp**
    e. *Name Prefix:* **Geom Tmp**



5. Regress the First straight section.

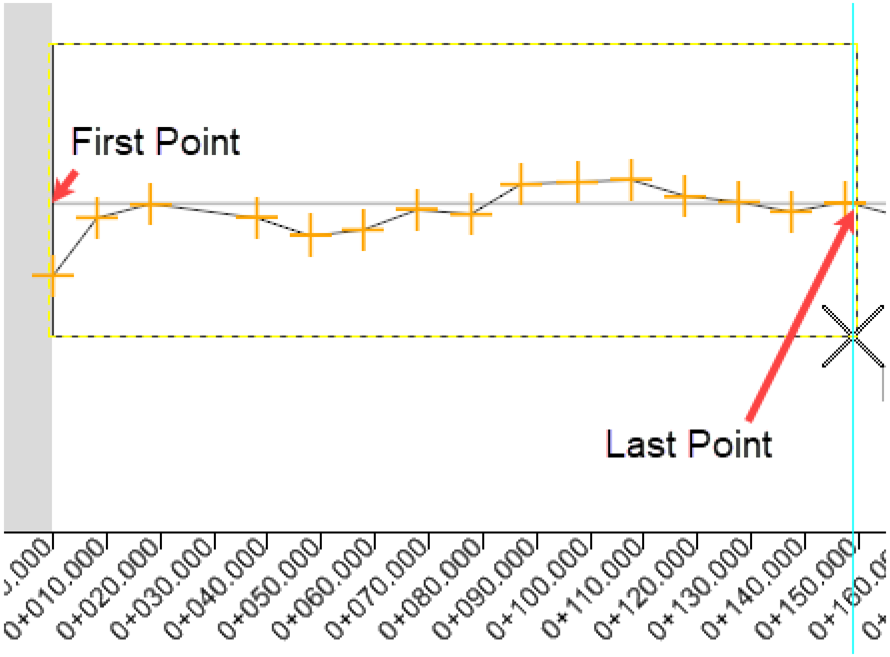
   a. Zoom in to the **Profile View** so that station **0+000** or *0.000* and station **0+190.000** or *190.0* are visible. Note the station formatting may vary depending on how you have your civil formatting set up.

   b. At the first prompt, **Data Point** at the left (start) end of the curvature line to define the start of the left boundary of the points to be regressed. Approximately Station **0+000** or *0.000.*

   c. **Data Point** to the right end of the first tangent section to define the end of the right boundary of the points to be regressed. Approximately Station **0+150.000** or *150.0.*

   d. Move the cursor vertically and click to select which points will be included in the regression analysis.

Points outside of the boundary box will not be included in the regression analysis.

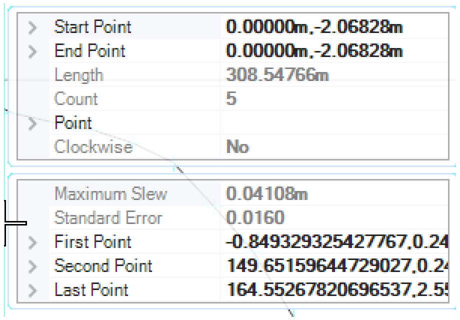


The Regression Point Boundary is like other Bentley Civil objects: it can be adjusted graphically or via its Properties.

6. Using the *Element Selection* tool in the **Regression Space View**, select the boundary box just placed around the regression points.

   a. Select > **Quick Properties**

Note: In the *Single Horizontal Regression* analysis panel the **Maximum Slew and Standard Error** are displayed after the points have been selected.



Maximum Slew

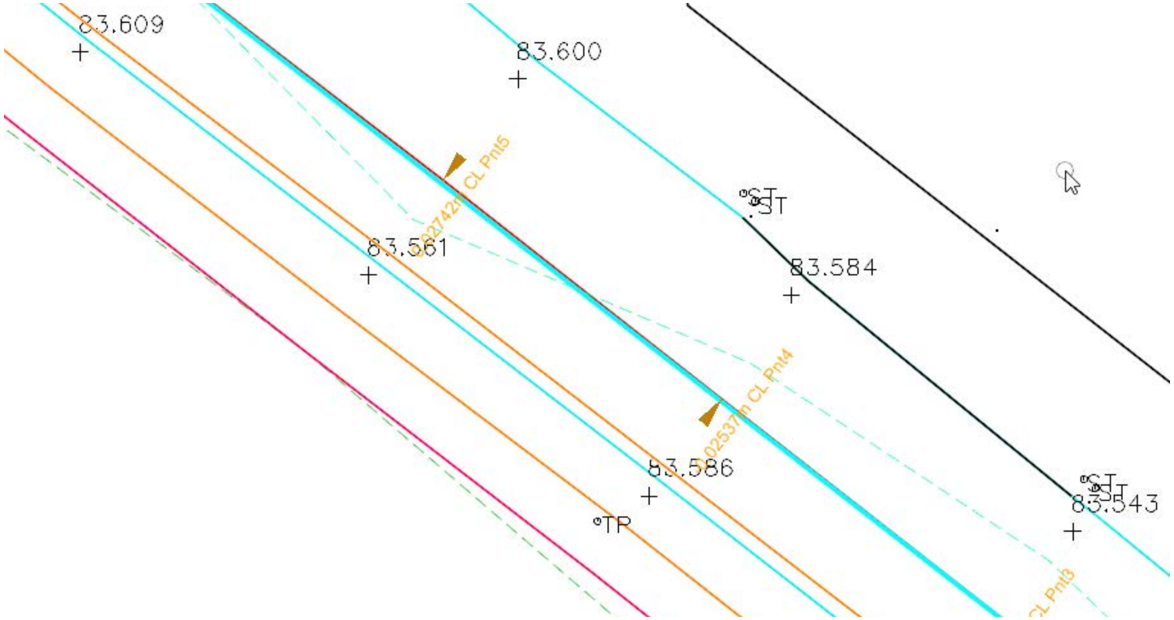
- Displays the offset of the point that is farthest away from the created element. Values close to zero indicate a tight fit.

Standard Error

- Displays the standard error of the regression analysis. The standard error of the regression provides the measure of the typical distance that the data points fall from the regression line representing how tightly the element fits the regression data. Values close to zero indicate a tight fit.

If you look in the Plan View and select the regression geometry element. You will see the slews at each regression point and this will give you an idea of the slews values. Also, you will notice a tracking line which tracks both in the Plan and Profile View.

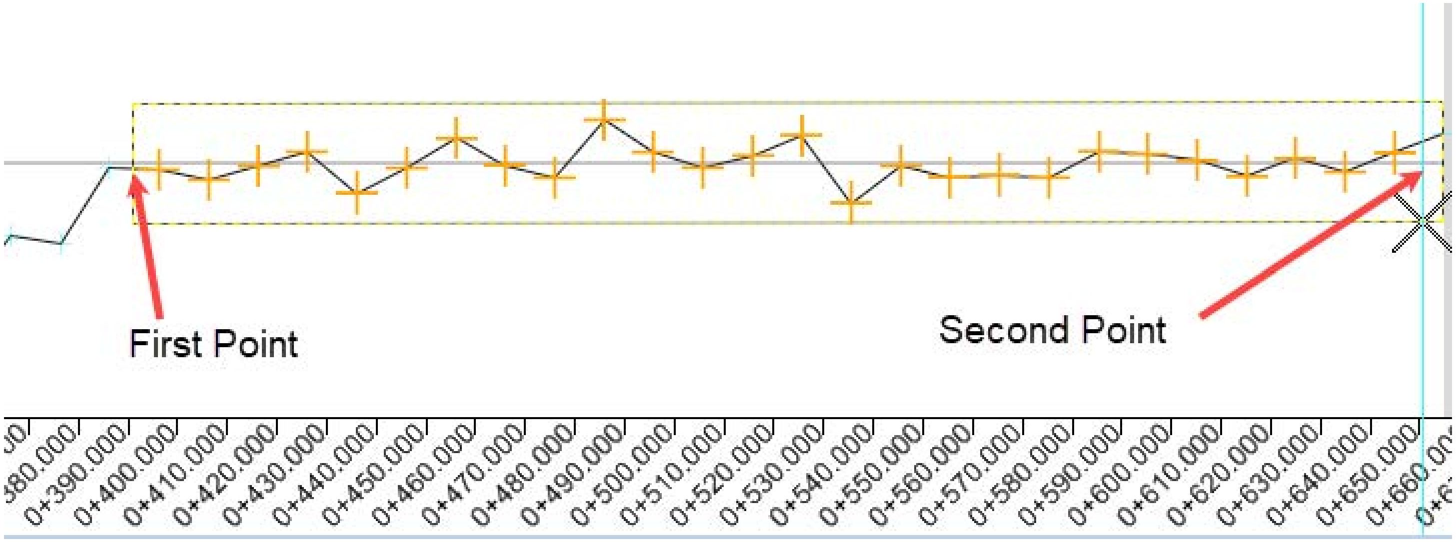
These slews are only visible during the Point Selection process.



7. Continue using the **Single Horizontal Regression** tool to regress the next **Straight**

a. Regress the Second Straight section.

- Zoom in to the **Regression Space** so that station **0+380** or *380.000* and station **0+660.000** or *660.0* are visible. Note the station formatting may vary depending on how you have your civil formatting set up.
- At the first prompt, **Data Point** at the left (start) end of the curvature line to define the start of the left boundary of the points to be regressed. Approximately Station **0+390** or *390.000.*
- **Data Point** to the right end of the first tangent section to define the end of the right boundary of the points to be regressed. Approximately Station **0+660.000** or *660.0.*
- Move the cursor vertically and click to select which points will be included in the regression analysis.
- The shape of the boundary boxes should look similar to below. **Straight** is from Station **0+390.0 to 0+660.0** (approximately) or *390.0 to 660.0*. The box should include all points within the station range.

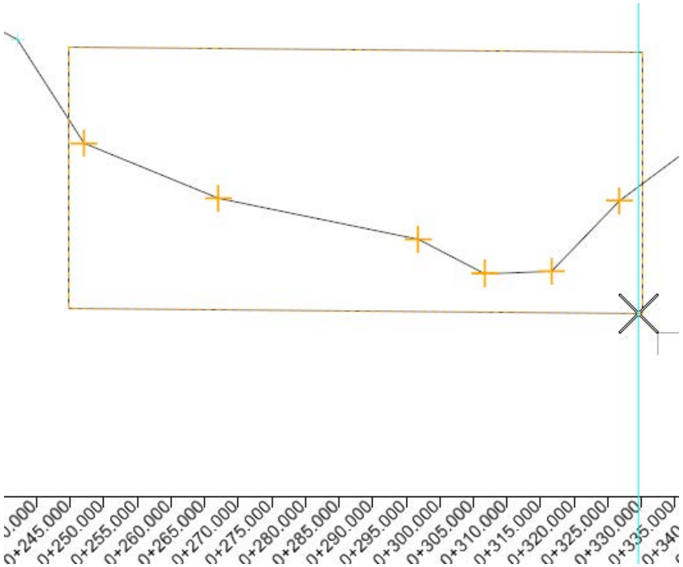


b. Regress the Curved section.

- Zoom in to the **Profile View** so that station **0+150** or *150.000* and station **0+390.000** or *390.0* are visible. Note the station formatting may vary depending on how you have your civil formatting set up.

- At the first prompt, **Data Point** at the left (start) end of the curvature line to define the start of the left boundary of the points to be regressed. Approximately Station **0+245** or *245.000.*
- **Data Point** to the right end of the second curved section to define the end of the right boundary of the points to be regressed. Approximately Station **0+330.000** or *330.0.*
- Move the cursor vertically and click to select which points will be included in the regression analysis.

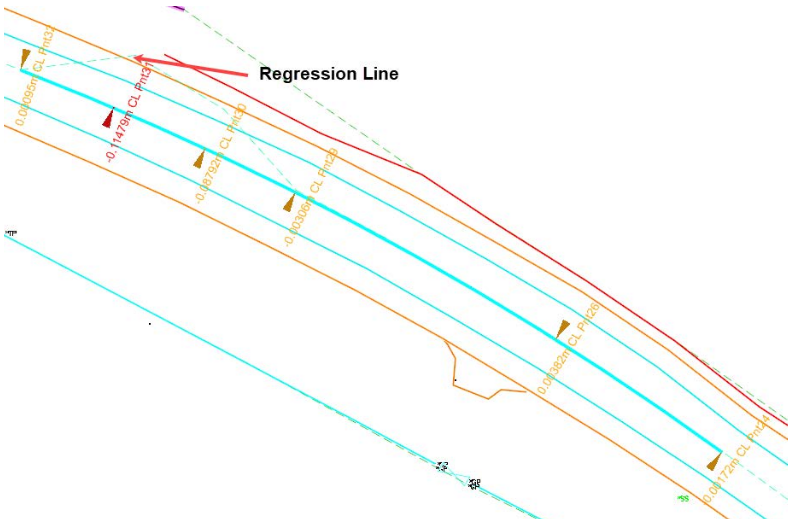
Curve is from Station **0+245.0 to 0+330.0** (approximately) or *245.0 to 330.0***.** The box should include all points within the station range.



c. Select **<Esc>** to *Exit* command

d. Close the *Horizontal Curvature Diagram (View 4).*

8. Turn off the display of the reference **Road Survey.dgn**



a. Select, *Home > Primary > Attach Tools >* **References**

b. On the *Reference dialog* highlight the reference **Road Survey.dgn**

c. *Uncheck* the **display icon**

d. **Close** the *Reference dialog*

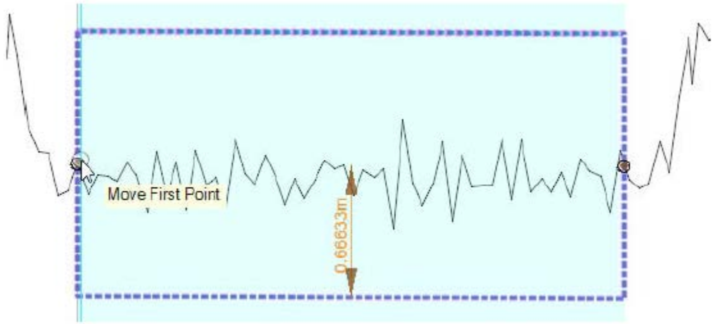
Editing the Regression Boundary Box

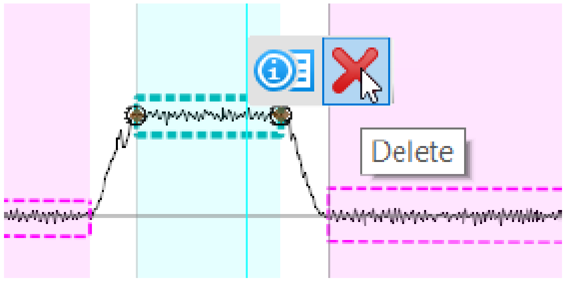
The 'Regression Boundary Box' is an editable element. You can select it to activate the manipulators. You can adjust the start and end positions by dragging the handles on the midpoints of the boundary box sides.

The depth of the boundary box can also be adjusted by selecting the text manipulator. The Regression Boundary Box can be deleted and this will also remove the regressed geometry from the plan view.

Note if you delete the regressed geometry from the plan view this does not remove the Regression Boundary Box from the curvature diagram.

1. Select one of the regression boxes in the regression view.





2. The frame of the box highlights and using the left mouse the area of the box can be adjusted as can the box envelope value.

Creating Complex Geometry and Adding Spirals

In this exercise, you will learn how to add the spirals between the elements created by *Single Horizontal Regression* and then create a single complex geometry alignment.

The creation of the Complex Geometry can be done before the spirals are introduced. The benefit of this method is that the link to the Regression rules is removed, which means that the alignment can be edited using the Civil Geometry tools.

If you add the spirals first and then create the Complex Geometry the regression rules have to be removed manually and then the Civil Geometry rules added afterwards.

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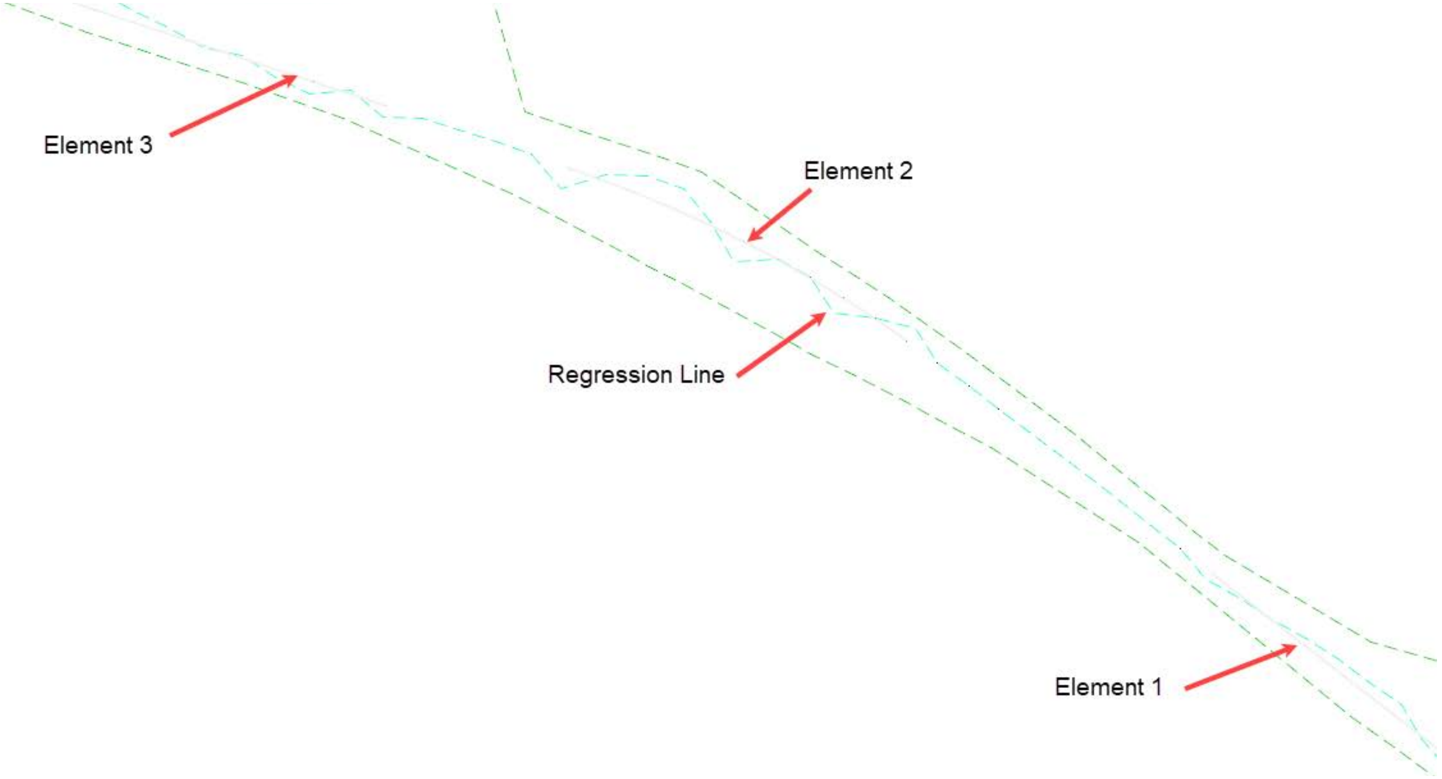
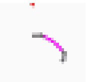
1. Expand *View 1* to fit view so that the complete regression geometry is visible.



The regressed tangent and curve elements are displayed with gaps between them where spiral transitions need to be added

Now to connect the elements with Spirals.

Zoom to the gap between the first two elements.



2. Use *Geometry > Horizontal > Spirals >* **Spiral Between Elements**

From the Heads Up prompts select the following:-

a. Set the *Feature Definition >* **Geom_Temp**

b. *Locate the First Element* > Select the **First Straight** (Hold *<Alt>* key down to select element)

c. *Enter Start Offset* > **0.00m**

- Click anywhere in the display to accept.

d. *Locate the Second Element* > Select the **First Curve**

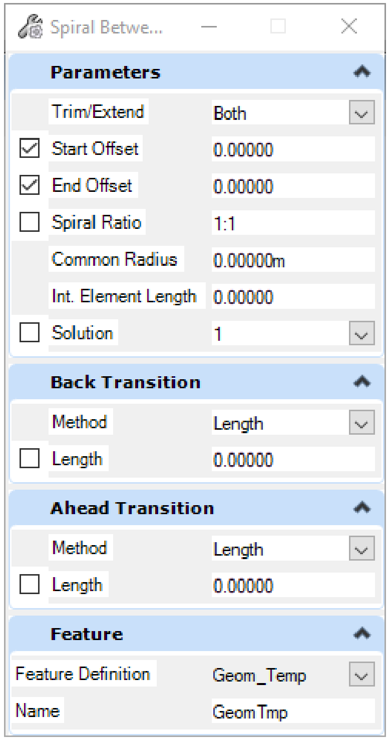
e. *Enter Start Offset* > **0.00m**

- Click anywhere in the display to accept.

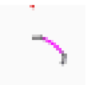
f. *Back Transition Length* > **0.000m** (If we leave the length as 0.000m the software will calculate the length required)

g. *Solution* > **1**

h. *Trim/Extend* > **Both**



Zoom to the gap between the curve and the end straight



3. Use *Geometry > Horizontal > Spirals >* **Spiral Between Elements**

From the Heads Up prompts select the following:-

a. Set the *Feature Definition >* **Geom_Temp**

b. *Locate the First Element* > Select the **First Curve**

c. *Enter Start Offset* > **0.00m**

- *Click anywhere in the display to accept*.

d. *Locate the Second Element* > Select the **Second Straight**

e. *Enter Start Offset* > **0.00m**

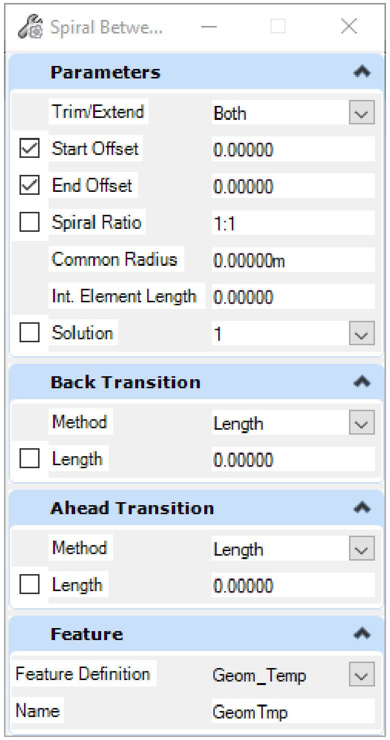
- *Click anywhere in the display to accept*.

f. *Back Transition Length* > **0.000m** (If we leave the length as 0.000m the software will calculate the length required)

g. *Solution* > **1**

h. *Trim/Extend* > **Both**

We **DO NOT** need to join all the elements into a Complex Chain as the Complex chain was created when we created the regression line.



Exercise 2: Reporting and Annotating

In this section, you will learn how to create horizontal alignment reports and also how to annotate the centerline alignment.

Skills taught:

- Horizontal Alignment Reporting
- Horizontal Regression Reporting
- Horizontal Alignment Annotation

Create the Horizontal Alignment Report

1. From the ribbon menu select *Geometry > General Tools > Reports >* **Horizontal Geometry Report**

   a. Follow the heads up prompts:

   b. *Locate the First Element: Select the Regression Alignment >* **Road_Centerline**

   c. *Locate Next Element:* **Reset**

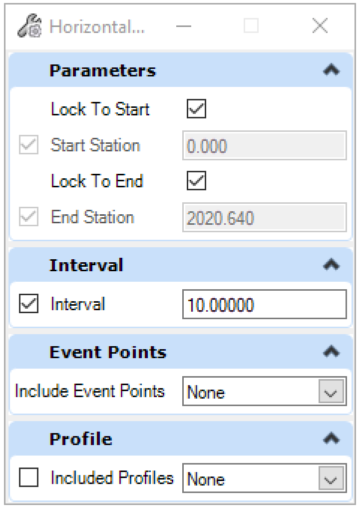
   d. *Start Station:* **<Alt> Lock to Start**

   e. *End Station:* **<Alt> Lock to End**

   f. *Interval:* **10.000.**

   g. *Event Points:* **None**

   h. *Profiles Included:* **None**



2. The *Bentley Civil Report Browser* dialog will appear and the report will be displayed.

   a. **Review** the Horizontal Alignment Review Report.

3. Save the report.

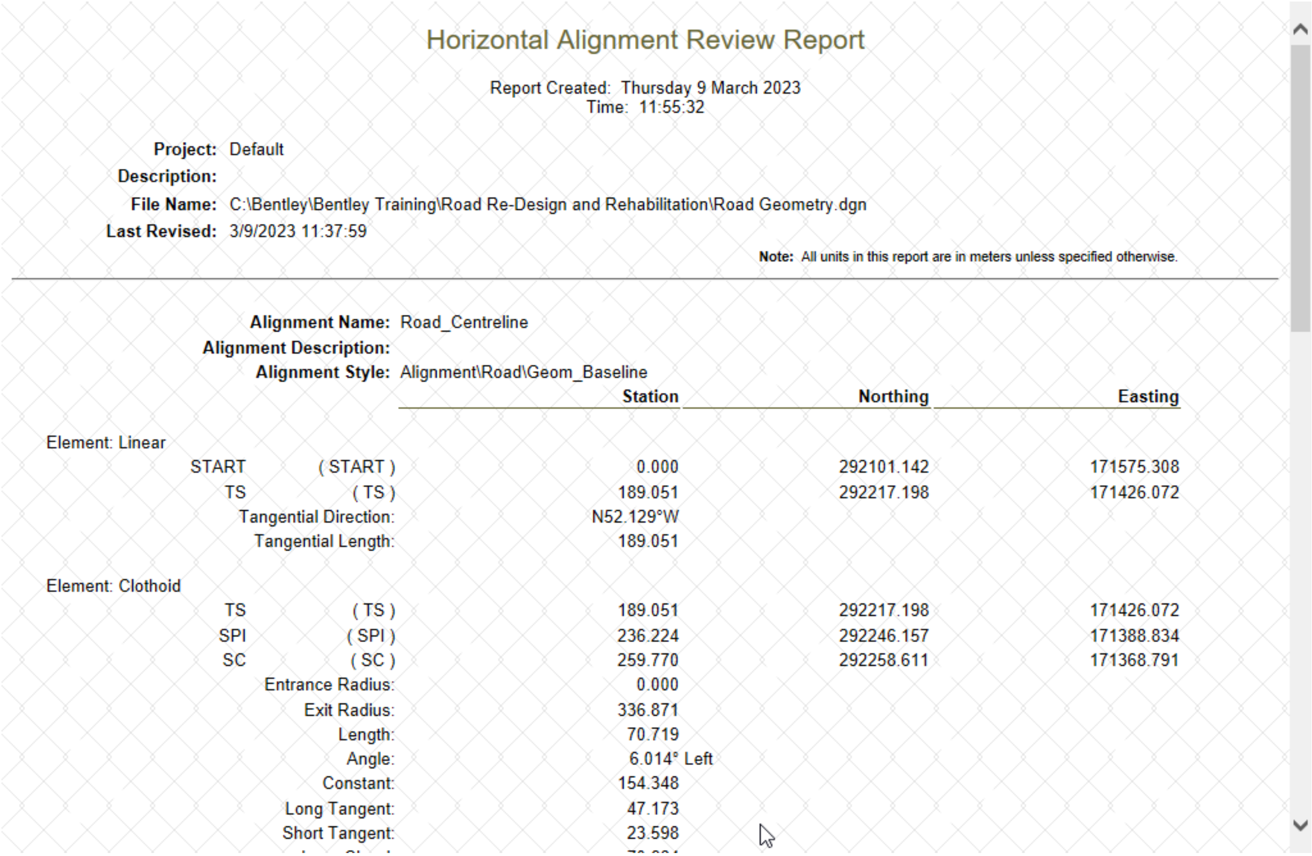
   a. In the *Bentley Civil Report Browser* window select *File >* **Save As**

   b. *File Name:* **Road CL Horizontal Report**

   c. *Save as type:* **Doc file (*doc)**

   d. **Click Save**

   e. Close the *Bentley Civil Report Browser* window.



Horizontal Alignment Review Report

Report Created: Thursday 9 March 2023
Time: 11:55:32

Project: Default
Description:
File Name: C:\Bentley\Bentley Training\Road Re-Design and Rehabilitation\Road Geometry.dgn
Last Revised: 3/9/2023 11:37:59

Note: All units in this report are in meters unless specified otherwise.

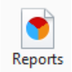
Alignment Name: Road_Centreline
Alignment Description:
Alignment Style: Alignment\Road\Geom_Baseline

			Station	Northing	Easting
Element: Linear					
	START	(START)	0.000	292101.142	171575.308
	TS	(TS)	189.051	292217.198	171426.072
		Tangential Direction:	N52.129°W		
		Tangential Length:	189.051		
Element: Clothoid					
	TS	(TS)	189.051	292217.198	171426.072
	SPI	(SPI)	236.224	292246.157	171388.834
	SC	(SC)	259.770	292258.611	171368.791
		Entrance Radius:	0.000		
		Exit Radius:	336.871		
		Length:	70.719		
		Angle:	6.014° Left		
		Constant:	154.348		
		Long Tangent:	47.173		
		Short Tangent:	23.598		

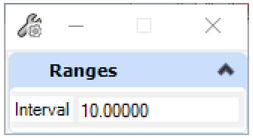
The list in the left hand pane of the *Bentley Civil Report Browser* dialog shows the different report categories and report types available. Clicking on each category will give you access to a list of report types known as *XSL Style Sheets* (or simply called *Style Sheet*). Each *Style Sheet* contains the formatting for how the report is displayed. Selecting a *Style Sheet* will display the report in the right pane of the dialog.

Create the Horizontal Regression Report

This type or report is more commonly known as a **Slew Report.**



1. From the ribbon menu select *Regression > Regression Tools >* **Horizontal Regression Report**



   a. In the settings dialog, set the *Interval* to **10.0**

   b. Follow the heads up prompts:

   c. *Locate Centre Line: Select the Regression Alignment >* **Road_Centerline**

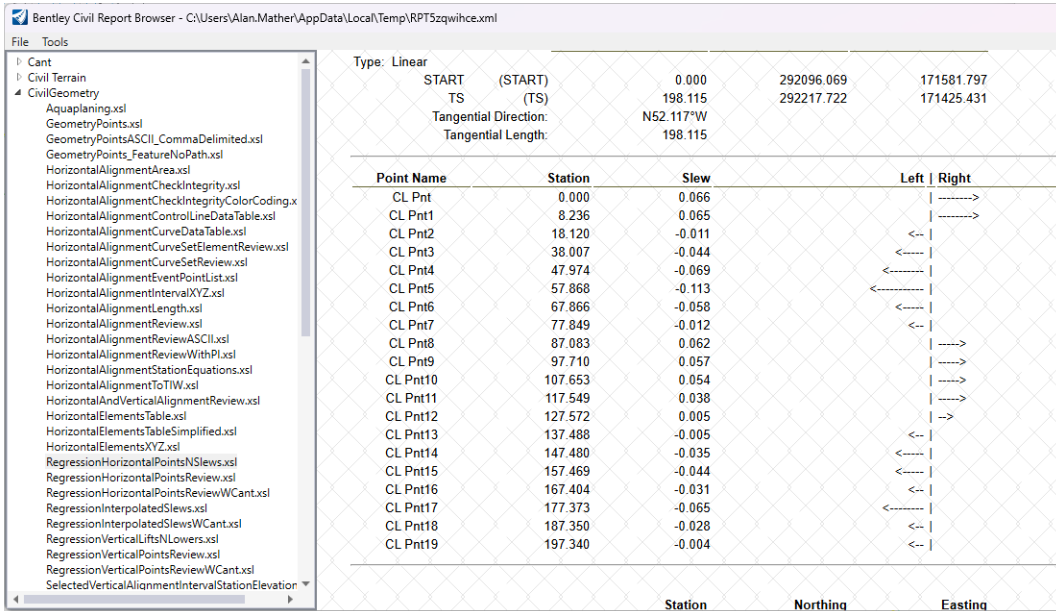
   d. *Locate Regression Line >* **Regression Line**

2. In the left hand pane select *HorizontalRegressionPointsNSlews*

   - Review the report

   The Right hand pane has four columns:

   - Column 1 is the *Regression Point* number
   - Column 2 is the *Station Value and Interval*
   - Column 3 is the *Slew* (Negative Slew is to the left)
   - Column 4 is a diagrammatic view of the slew



3. Save the report

   a. In the *Bentley Civil Report Browser* window select *File >* **Save As**

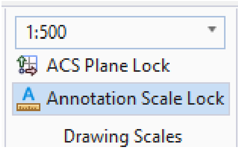
   b. *File Name:* **Road_CL Regression Report**

   c. *Save as type:* **Doc file (*doc)**

   d. **Click** > *Save*

   e. **Close** the *Bentley Civil Report Browser*.

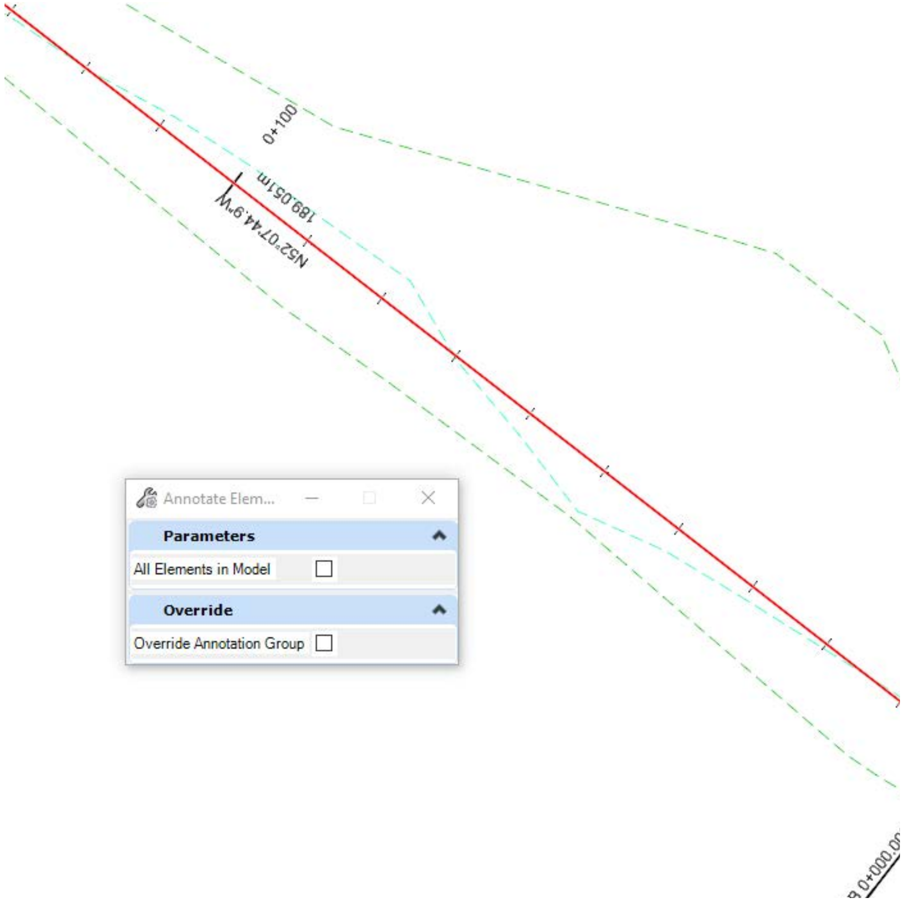
Annotate the Horizontal Alignment



1. From the ribbon menu, select *Drawing Production > Drawing Scales >* **Annotation Scale Lock**
   a. Set the scale to *1:500.*

2. From the ribbon menu, select *Drawing Production > Element Annotation >* **Annotation Element**
   a. Check off *All Elements in Model.*

3. At the prompt *Locate Elements:* Select the **Road_Centerline** alignment and then right click to complete.



The alignment is now annotated. The annotation is also dynamic and is associated to the alignment. Any changes made to the alignment will automatically update the annotation.

The annotation is defined by an *Annotation Group* which is associated with the *Feature Definition.* The text size is controlled by the *Annotation Scale Lock.*

Exercise 3: Geometry Connector

In this exercise, you will learn how to amend a Horizontal Alignment using the Geometry Connector.

Skills Taught

- How to load an Alignment into the Geometry Connector
- Amend elements in the Geometry Connector
- Create a New Regressed Alignment

Geometry Connector Overview

Multiple Element Connection (MEC) Problems

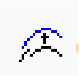
In a typical MEC problem, the goal is to define connecting geometry to close a disconnection in the active horizontal alignment. In other words, you are starting with an alignment that contains a disconnection (where the endpoint of one element fails to coincide with the beginning point of the next element) and modifying it so that you end up with a smoothly connected alignment. In a smoothly connected alignment, the elements are all connected and meet with matching tangents.

Multiple Element Regression (MER) Problems

In an MER problem, the intent is to simultaneously resolve a disconnection (always maintaining connections) and minimize orthogonal projection to a set of regression data. The connection problem always exists, but MER problems are more complicated than MEC problems.

An MER problem is really two problems in one, and the two problems can often present competing demands. That is, the goal of connecting the geometry elements may conflict with the goal of fitting those connecting elements to your regression points. The existence of conflicting demands makes a problem more complicated, but does not rule out the possibility of solving it. The purpose of the Multiple Horizontal Element Regression Analysis command is to solve such problems.

Load Alignment into the Geometry Connector



1. From the ribbon menu, select *Geometry > Horizontal > Complex Geometry >* **Geometry Connector**

   The Geometry Connector Opens.

   We need to select which element is the beginning element and which element is the ending element on our Alignment.

2. From the Geometry Connector we are going to choose the element at the beginning, select *Select Element.*

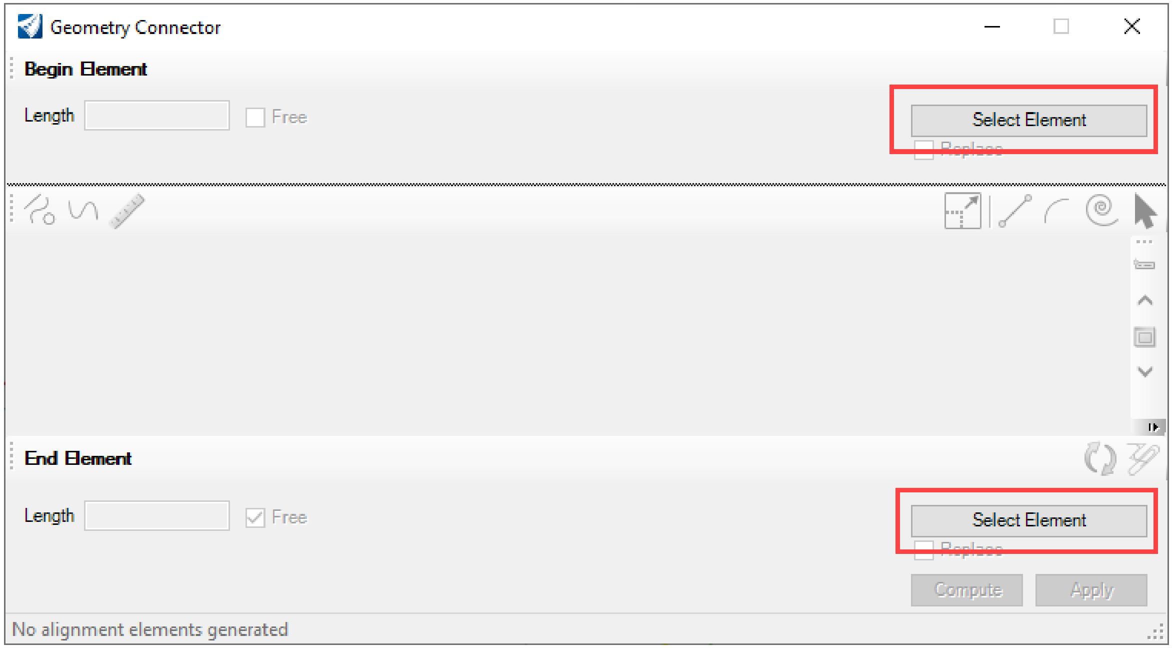
   a. From the heads up prompts, *Identify Element* select alignment *Road_Centerline* (at the beginning)

   b. Click to *Accept*

3. Next choose the end element again by selecting *Select Element.*

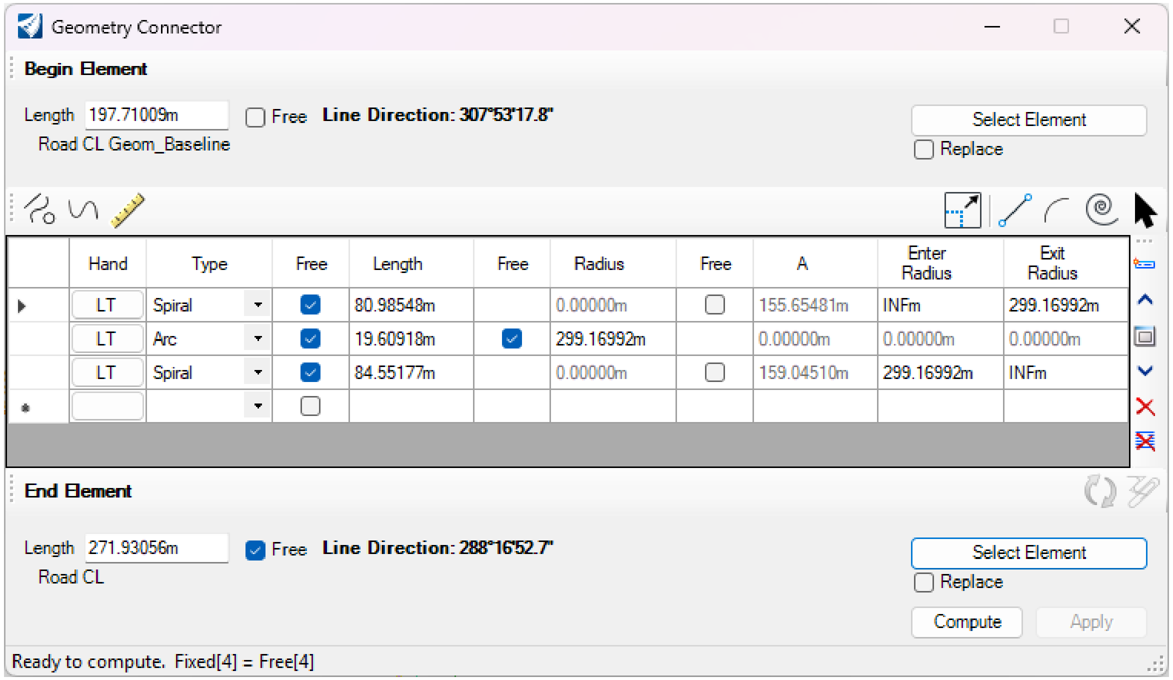
   a. From the heads up prompts, *Identify Element* select alignment *Road_Centerline* (at the end)

   b. Click to *Accept*



The Alignment is now loaded into the Geometry Connector.

The values that appear in the dialog box are subjective to where you selected the points in the Horizontal Curvature Diagram.



Note: The Geometry Connector works on a basis of having Fixed and Free parameters within elements. For example a curve has two properties, a radius and curve length, in reality if you fix the radius then in order for the curve to try to fit into the alignment the length needs to flex, either increases or decrease in length so that value is set to free.

At the bottom left of the Geometry Connector dialog there is a prompt to inform whether the alignment can be computed or not *(Ready to Compute)*. Also the number of Fixed and Free elements is also noted. If there are too many Free or Fixed elements the alignment can not be computed.

When using the Geometry Connector, the whole of the alignment does not have to loaded, the user could just amend part of the alignment.

Amending the Alignment using the Geometry Connector

Before any changes are to be made to the alignment we are going review the Regression report created earlier.

1. Review the Regression Report

   a. **Open** the saved *Regression Report* from the previous exercise

   b. *Scroll* to **Station 227.129** (this is on the Spiral curve)

   If we look at the slews you can see that they are quite large and if there is a tight corridor for the right of way we can look to see if we can improve those offsets.

   So we are going to use the **Geometry Connector** to see if we can reduce the slew offsets.

Point Name	Station	Slew	Left | Right
CL Pnt20	207.193	0.066	| -------->
CL Pnt21	217.155	0.199	| -------------------->
CL Pnt22	227.129	0.252	| ----------------------->
CL Pnt23	237.110	0.289	| -------------------------->
CL Pnt24	247.040	0.225	| ----------------------->
CL Pnt25	257.043	0.087	| -------->
CL Pnt26	267.025	0.039	| ----->
CL Pnt27	276.934	-0.070	<-------- |

2. Make a change to the radius value in row 2.

   a. Click on the *Exit Radius* value for *LT Spiral* in row 1

   b. Change the radius on the *Exit Radius >* **320.000**

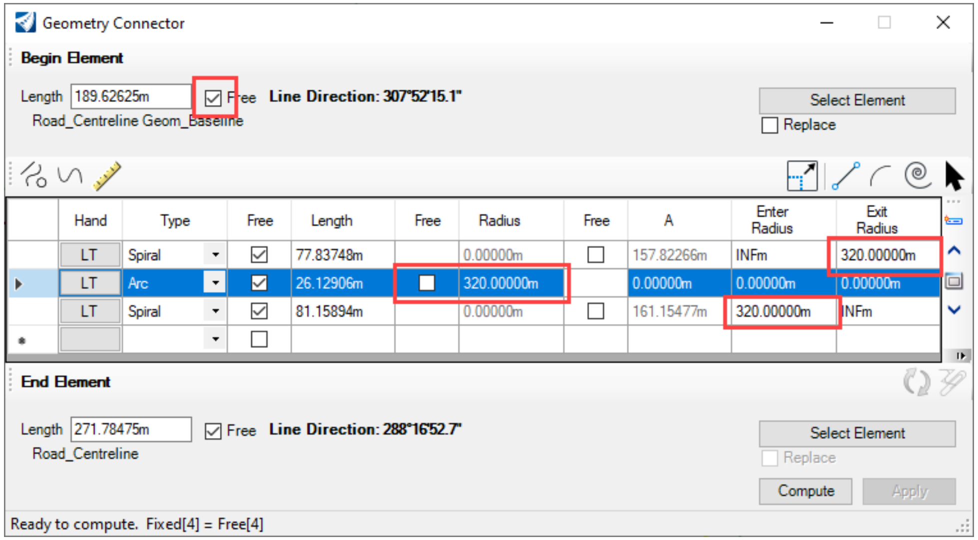
   c. In row 2 change the *Radius >* **320.000**

   d. *Uncheck* the *Free* option for the *Curve Radius*

   e. Click on the *Entry Radius* value for *LT Spiral* in row 3

   f. Change the *Radius >* **320.000**

If you look at the bottom left hand corner of the *Geometry Connector* dialog, there is a message saying *'Too Many Fixed. Need to Free (1) more'*. As we are amending the *LT Spiral Exit Radius* we need to free up the length of the *Beginning Element* so the spiral can flex either shorter or longer.



3. *Check* on the *Free Length* on the Beginning Element.

   The notification at the bottom left of the dialog states *Ready to compute*, which means there are enough *Fixed and Free Elements*.

4. Ensure *Replace* is unchecked.

   Replace will amend your existing alignment, if you want to keep that alignment uncheck *Replace* and a new alignment will be generated.

   We are keeping the existing alignment until we are sure we have the alignment we require.

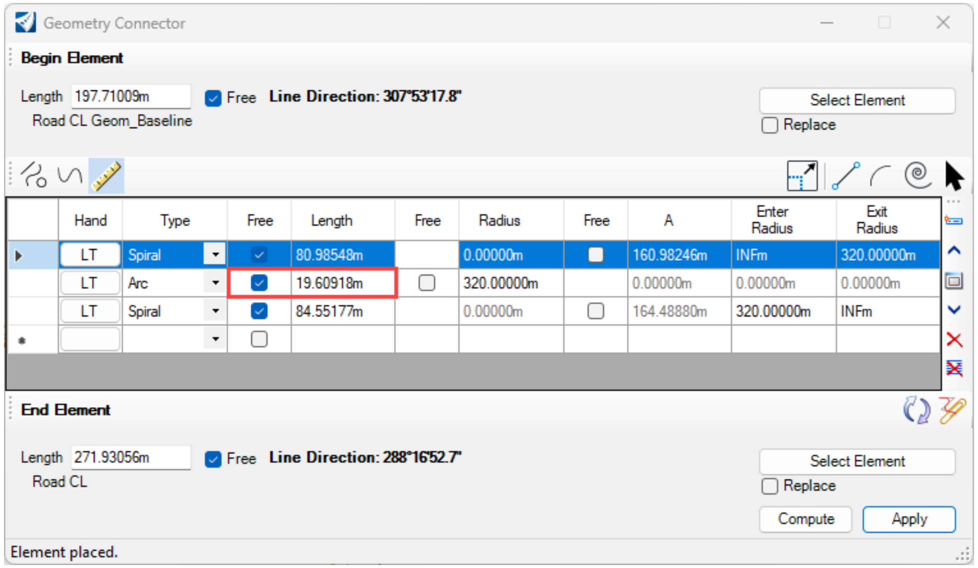
5. Select > **Compute**

   The Geometry Connector will assess the alignment and if there are no errors the *Apply* button becomes active.

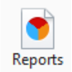
6. Check on > **Create Ruled Civil Elements**

7. Select > **Apply**

- The length of the Curve has been amended to *19.609m*
- A new alignment has been created

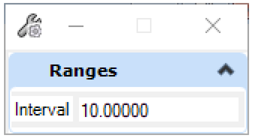


Before we close the Geometry Connector we need check the slews but doing another slew report.



8. From the ribbon menu select *Regression > Regression Tools >* **Regression Report**

a. In the settings dialog, set the *Interval* to **10.0**



b. Follow the heads up prompts:

c. *Locate Centre Line: Select the Regression Alignment* > **New Element Geometry 1**

d. *Locate Regression Line* > **Regression Line**

e. In the left hand pane select *HorizontalRegressionPointsNSlews*

Inspect the Slews, whilst we have improved the Slews around the leading transition and curve slightly, we have made them worse on the trailing transition.

9. **Close** the *Geometry Connector*

- *Decision* - Which Alignment do you want to use?
- **Delete** the new alignment and we will continue with our original regressed alignment.

Further changes could be made if required. Also elements can be added using the tools at the top left corner of the dialog or an element can be added using the bottom row (*) and then moved to the location required using the using the move up and move down icons on the right hand side of the dialog.

Exercise 4: Create Horizontal Alignment Using Quick Regression

In this exercise, you will learn how to create a horizontal alignment using the Quick Horizontal Regression tools.

Skills Taught

- Create Regression Line from Line
- Create a Horizontal Alignment within a set of tolerances
- Quick Horizontal Regression
- Create Regression Report

Create a 2D DGN File and Attach the Survey and Terrain Files

In this exercise, you will learn how to create a quick horizontal alignment using the Horizontal Regression tools, attach reference files and set the active terrain model.

1. Create a new 2D file.

   a. Select > **New File**

   b. Browse to *C:\Bentley Training\Road Regression and Re-Design* or other folder where you unzipped the dataset files.

   c. Set the *Seed* to **Seed 2D - Metric Training.dgn**

   d. Create a new file named **Quick Regresssion.dgn**

2. Attach the existing terrain model file.

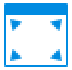
   a. From the ribbon menu select *Home > Primary > Attach Tools >* **References**

   b. Select > **Attach Reference**

   c. Select the files **Road Survey.dgn** and **Existing Terrain.dgn**

   d. Set **Attachment method** to *Coincident World*

   e. Select > *Open* to attach the file.



3. **Click** in *View 1* to make it active and select *Fit View*

Regression Line from Line

In this section, you will create centerline alignment from surveyed centerline alignment. The centerline will contain only line strings and curves but no spirals.

1. **Click** anywhere in *View 1* to make it active.

2. From the ribbon menu select *Geometry > Regression> Create Regression Line >* **Regression Line from Line**
   a. Set the *Points Feature Definition* to **Regression_Point**
   b. *Name Prefix* to **CL Pnt**
   c. *Complex Feature Definition >* **Geom_Baseline**
   d. *Name Prefix >* **Road CL**
   e. Set the *Feature Definition >* **Regression_Line**
   f. Set the *Name Prefix* > **Quick Regression Line**
   g. *Minimum Distance Tolerance:* **0**
   h. *Maximum Distance Tolerance:* **50**
   i. *Maximum Deviation:* **1**
   j. *Unacceptable Slew Left*: **0.100**
   k. *Unacceptable Slew Right*: **0.100**
   l. Follow the prompts and select the **Surveyed Road Centerline**
   m. Select **<Esc>** to Exit command

   The centerline has now been created. The centerline alignment exists but no profile has been created.

Quick Regression

In this section we will use Quick Horizontal Regression to make an initial best guess of all elements (line, circular arc and transition spirals). The software computes the existing versine from the regression points then determines the approximate location of transition spirals and assumes that everything outside of these zones are linear or circular arcs.

1. From the ribbon menu select *Geometry > Regression > Regression Tools >* **Quick Horizontal Regression**
2. From the Heads Up prompt select the following:-

   a. *Regression Line >* **Quick Regression Line**

   b. *Feature Definition >* **Geom_Baseline**

   c. *Name Prefix >* **Quick CL**

   d. *Start Station >* **<Alt> Lock to Start**

   e. *End Station >* **<Alt> Lock to End**

   f. *Tolerance >* **0.100**

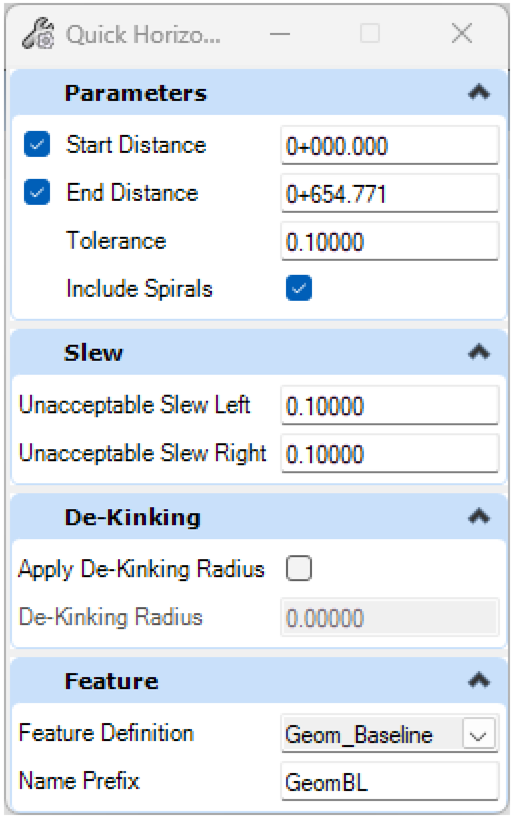
      - The tolerance value relates to a theoretical band width either side of the Regression Line that your Regressed alignment will be analyzed within. So in this case setting the value to 0.1m, you expect to get no slew values greater then 0.1m.

   g. *Include Spirals >* **Check**

      Obviously if spirals are NOT required then un-check this box.

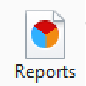
   h. *Apply De-Kinking Radius >* **Uncheck**

      - Defines a radius that is used to insert a circular arc, if possible, between adjacent linear elements. Adjacent lines occur, when a “long line” is broken into multiple lines, so that the Tolerance is not exceeded. In these situations, the angle between the adjacent lines is very small, so a very large radius is required. A de-kinking radius of zero, will bypass the insertion of circular arcs.

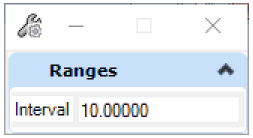


Create the Horizontal Regression Report

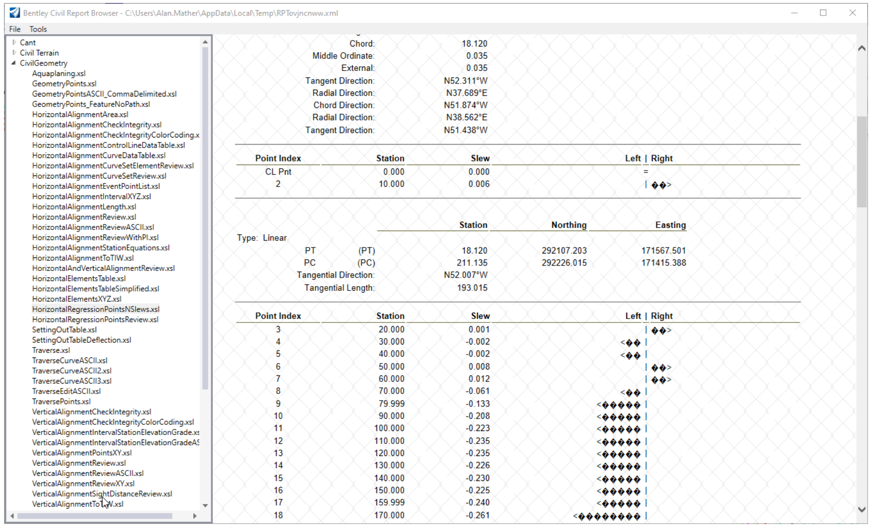
This type or report is more commonly known as a **Slew Report.**



1. From the ribbon menu select *Rail > Regression > Reports >* **Horizontal Regression Report**
   a. In the settings dialog, set the *Interval* to **10.0**



   b. Follow the heads up prompts:
   c. *Locate Centre Line: Select the Regression Alignment >* **Quick CL**
   d. *Locate Regression Line:* **Quick Regression Line**
2. In the left hand pane select *HorizontalRegressionPointsNSlews*
   a. Review the results
3. **Close** the *Report Browser*



Exercise 5: Create Vertical Alignment Using Best-Fit Profile

In this exercise, you will learn how to create a vertical alignment using the Best-Fit Profile tools.

Skills Taught

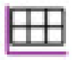
- Create Complex Alignment from Best Fit Profile
- Create Complex Alignment from Define Profile by Best Fit
- Create a Profile Alignment Report

Create the Profile

In this section, you will learn how to create the vertical profile. You could if required create a new vertical profile using the vertical geometry tools. But in this exercise we are going to create a vertical profile using the ‘Best-Fit Profile’ tools.

---

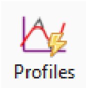
1. Select *File > Browse > Open >* **Road Geometry.dgn**
2. In *View 1* Select > **Road_Centerline**



   a. From the *Context Sensitive toolbar* Select > **Open Profile Model**

   b. Select *View 7* from the *model views toolbar* and **Data Point** in the view

3. From the ribbon menu Select > **Site**



4. Select *Grading > Profiles >* **Best-Fit Profile**
   - On the *Best-Fit Profile* dialog set the following

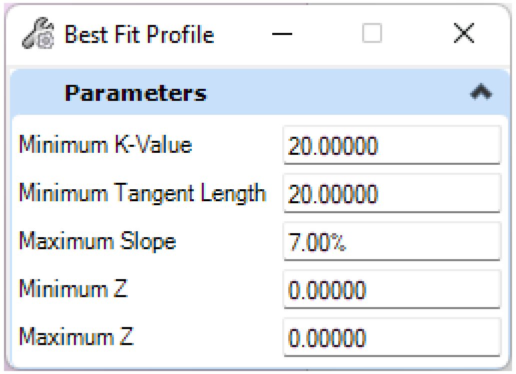
   a. *Minimum K Value >* **20**

   b. *Minimum Tangent Length* > **20m**

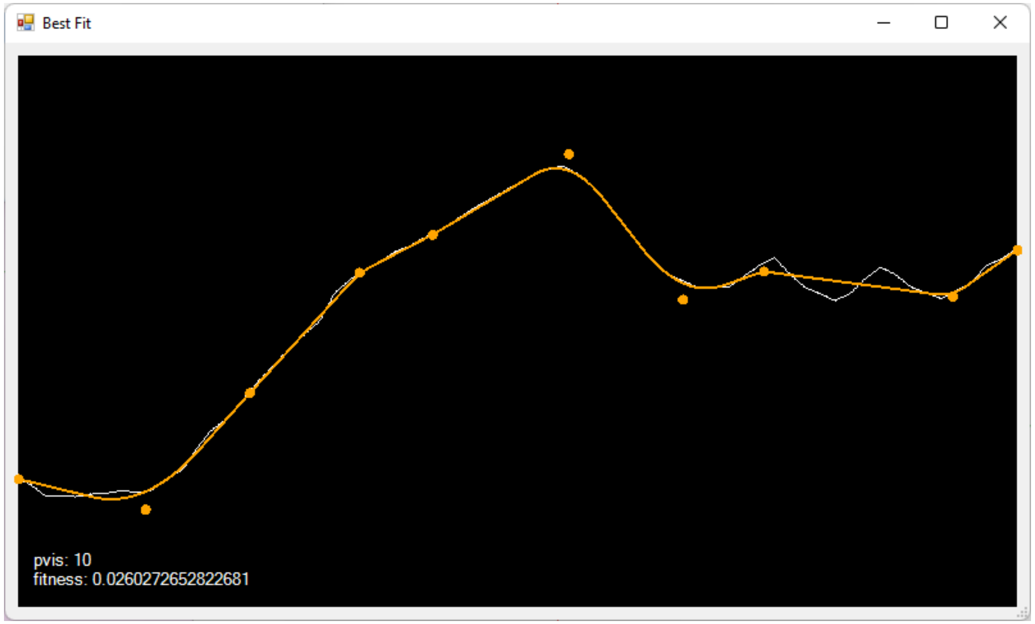
   c. *Maximum Slope* > **7.00%**

   d. *Minimum/Maximum Z* > **0.000**

   e. *Locate Element* > Select **Ground Profile** in *View 7*



The *Best-Fit calculation* dialog appears and iterates the Vertical alignment to the parameters set.

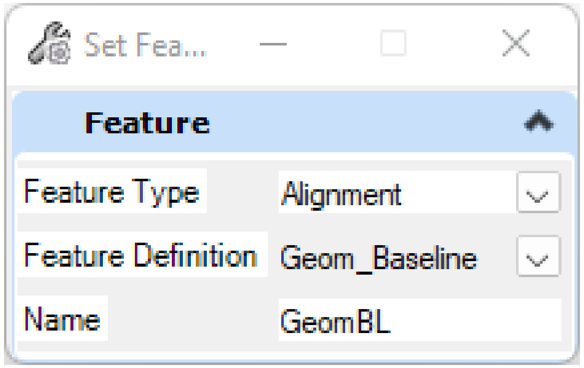


When the *Best-Fit calculation* dialog is closed the Vertical alignment is generated

f. **Close** the *Best-Fit Profile* dialog

g. Select > *Geometry > General Tools > Standards* > **Set Feature Definition**

- *Set Feature Type* > **Alignment**
- *Feature Definition* > **Geom_Baseline**
- *Name* > **Road_Centerline Prof**
- *Locate Elements* > **Select Vertical Alignment**
- *Reset* to Complete



h. Select the Profile and from the *Context Sensitive toolbar* Select > **Set as Active Profile**

i. **Close** *View 7*

Create another Profile

In this section, we are going to create another vertical profile using a slightly different method, *Design Profile by Best Fit*. In reality there is no reason to do this but we are going to explore which of the methods we have used for profiling this road is the most economical.

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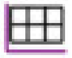
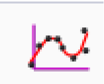
1. Continuing in **Road Geometry.dgn**
2. In *View 1* Select > **Road_Centerline**



   a. From the *Context Sensitive toolbar* Select > **Open Profile Model**
3. Select *View 7* from the *model views toolbar* and **Data Point** in the view



4. Select *Geometry > Vertical > Complex Geometry >* **Define Profile by Best Fit**
   - On the *Design Profile by Best Fit* dialog set the following

   a. *Best Fit Method >* **Make Complex**

   b. *Upper Envelope* > **0.1m**

   c. *Lower Envelope* > **0.0m**

   d. *Desirable Crest Curve Length* > **30.0m**

   e. *Desirable Sag Curve Length* > **30.0m**

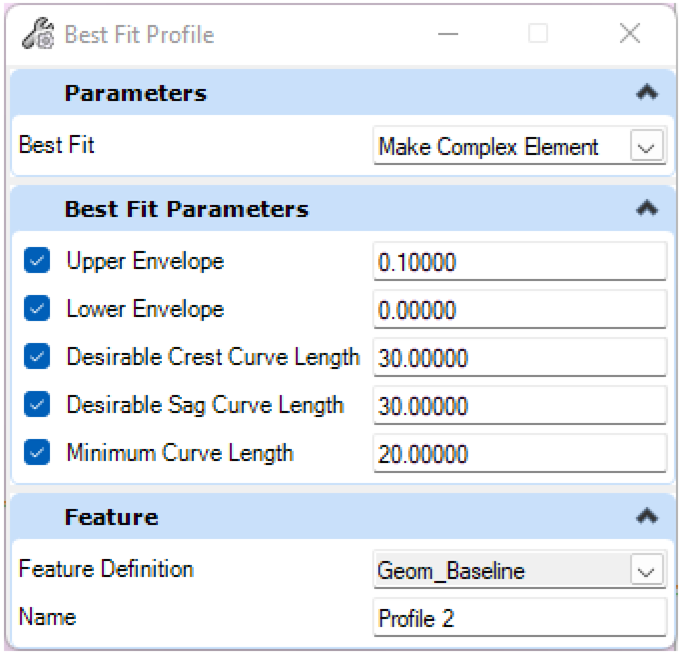
   f. *Minimum Curve Length* > **20m**

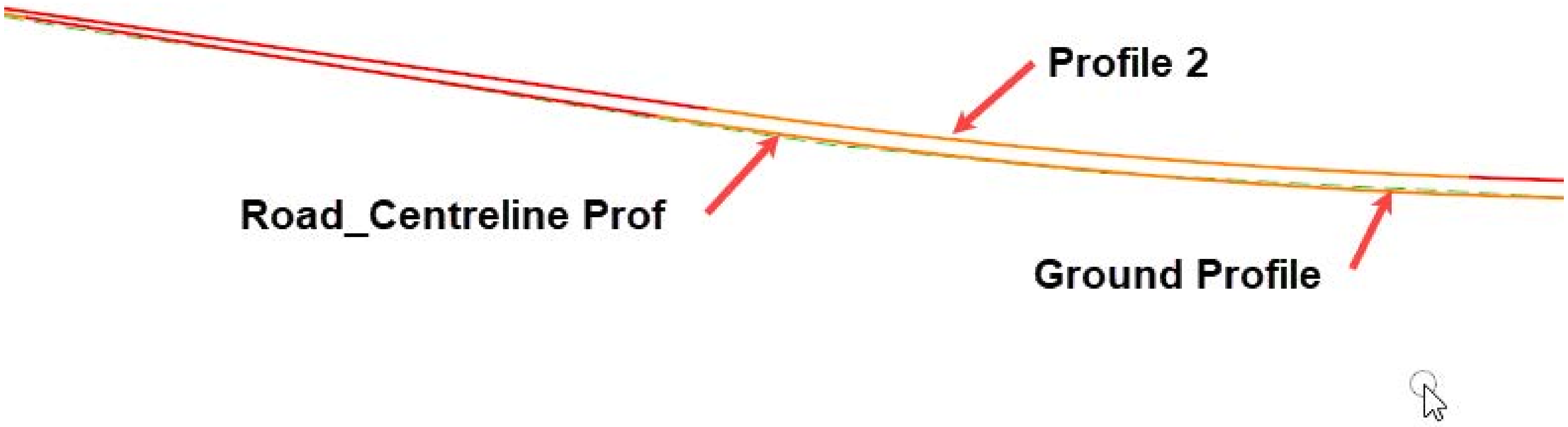
   g. *Locate Profile to Fit* > Select **Ground Profile** in *View 7*

   h. Run through the prompts

   i. To finish <**Esc**>

   j. **Close** *View 7*





The new profile is generated.

Skills Assessment

The questions below will test your retention of the skills covered in this course.

1. The Create Regression Line tool creates a line string that represents the centerline of the road
    a. True
    b. False
2. The Single Regression Analysis tool creates a single geometric element that is a best fit of the regression points.
    a. True
    b. False
3. The Create Profile from Surface tool creates the "best fit" profile
    a. True
    b. False

Skills Assessment - Answers

The answers to the skills assessment questions are highlighted below.

1. The Create Regression Line tool creates a line string that represents the centerline of the road.
    a. **True**
    b. False
2. The Single Regression Analysis tool creates a single geometric element that is a best fit of the regression points.
    a. **True**
    b. False
3. The Create Profile from surface tool creates the "best fit" profile
    a. True
    b. **False**

Summary

The Project that we undertook in this course is to create a Geometric Horizontal Alignment that follows, as closely as possible, the existing Surveyed centerline of a road using the regression tools available in OpenRoad Designer.

A vertical alignment was generated that follows the existing road profile, using the Best-Fit Profile tool.