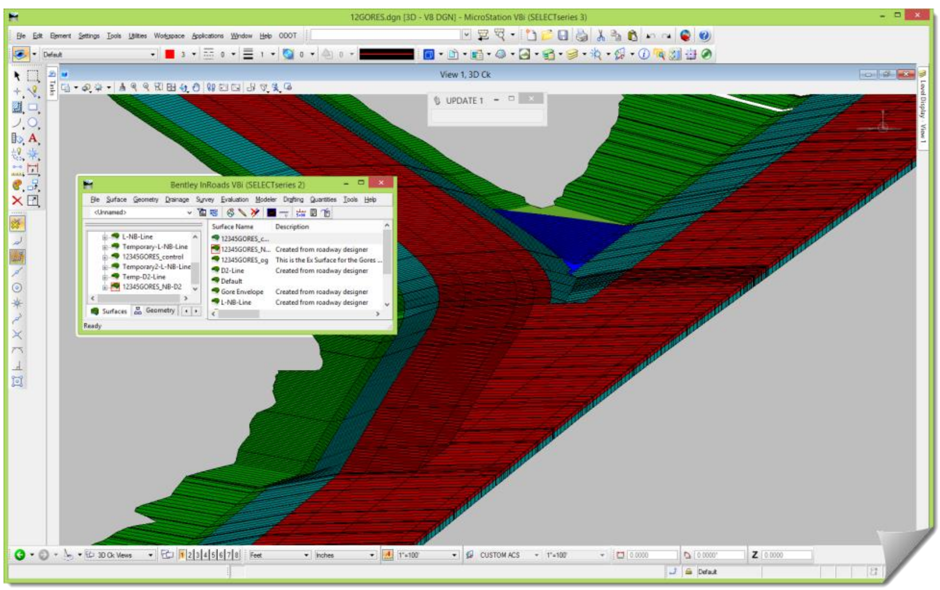
Module 12

MODELING GORES

Using InRoads

Introduction

A noteworthy difference between this type of modeling and modeling an intersection is the degree of convergence, especially between an off ramp / on ramp and the main roadway. This departure or merger is done gradually, whereas intersections are dramatically more abrupt.



The modeling of the gore area at the junction of two roadways such as this requires a union not only of the horizontal alignment between the primary road and the secondary road, but also of the vertical alignments. Additionally, the shoulders on both roads need to be addressed. This module will consider these factors and look at techniques that can be applied to create a clean merger of these two corridors.

Purpose of this Module

The purpose of this module is to demonstrate modeling a freeway gore, using the InRoads **ROADWAY DESIGNER** as the main tool.

Objectives of this Module

At the end of this module, you will be able to incorporate the gore areas of two intersecting roads into your InRoads surface design DTM.

Definition of Audience for future Modules

Please note that this module assumes that you have a certain level of competency with the software tools and will be asking you to execute some commands with very little instruction. This module was designed with a certain technical audience in mind, so ensure that you have the proper prerequisites.

Skill Level / Prerequisites:

The prerequisites for this module are the following:

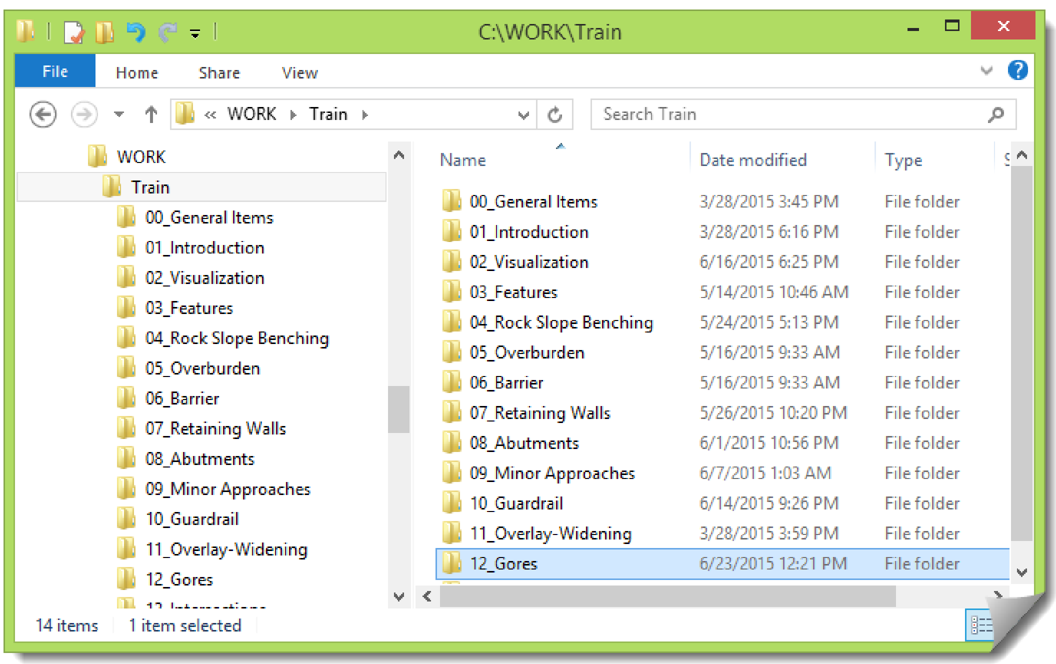
- MicroStation Basics
- InRoads Level 1
- InRoads Level 2
- Module 1 – Introduction to the Training Modules
- Module 2 – Visualization

Module Files and Folders

Training Folders

You will be working on your own hard drive during this training. The module instructions will expect the training files and folders to be set up as shown here in order to align with the module directions.

You should have the `12_Gores` training folder and files on your local drive. The module folder and related files should be placed under the ***C:\WORK\Train*** folder, and look like this:



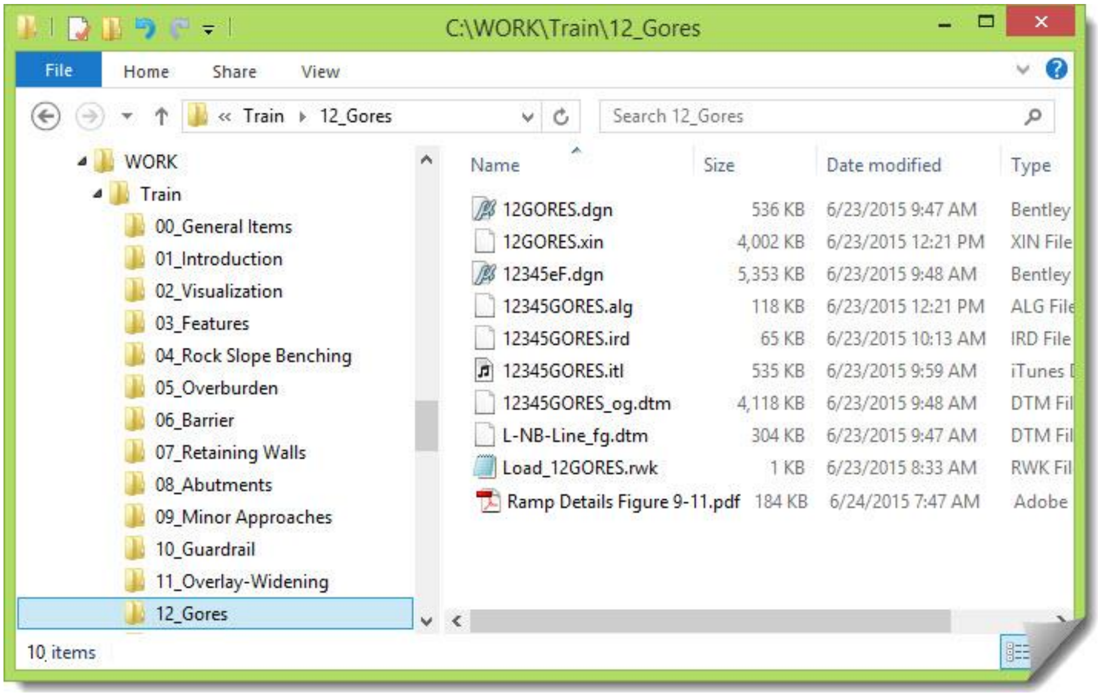
Training Files

The module folder contains all the files that will be used in these exercises including:

- **`12GORES.dgn`**, the initial MicroStation file used at the start of the exercises
- **`12GORES.xin`**, the InRoads configuration file for this work

There is an **RWK** file included in the module folder to assist in opening the InRoads files.

In this module folder, you should have these files:

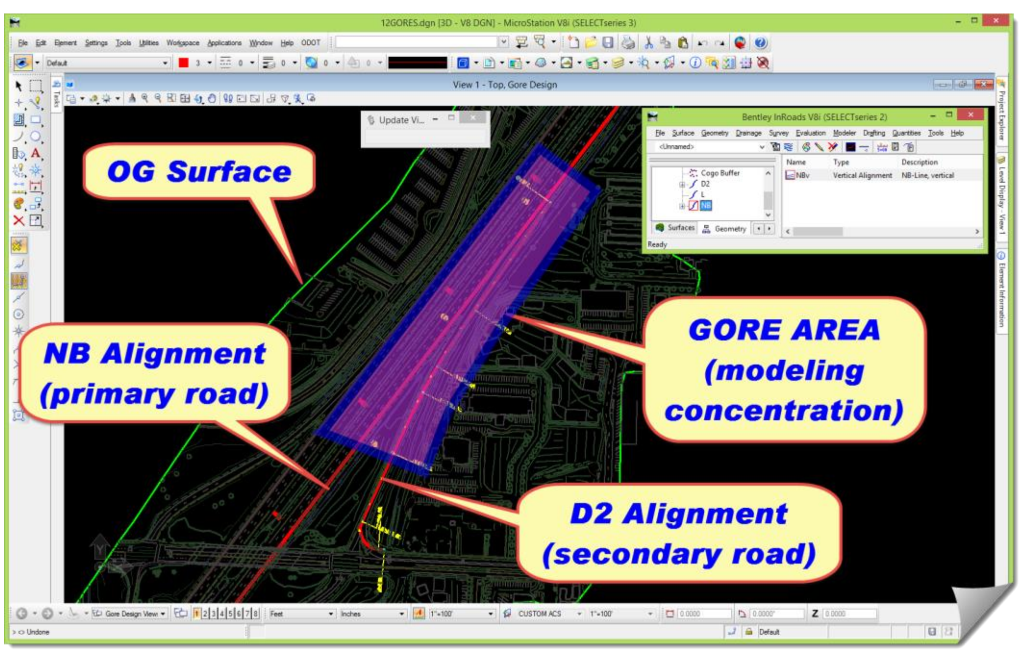


Technical Content of Training:

Project Orientation

REVIEW WORK AREA

The OG surface, as well as the primary (**NB**) and secondary alignments (**D2**) and corridors, are already created. The focus of the modeling work, as shown here, will be in the area of the gore.



PREPARE MICROSTATION / INROADS DATA & FILES

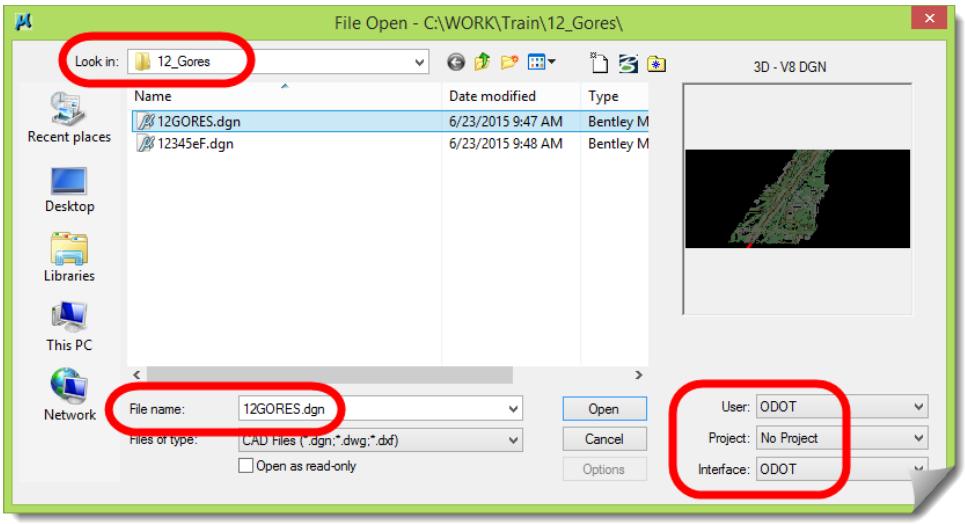
This section will get you into the DGN, load the module-specific XIN and other data files.

1) Launch InRoads.

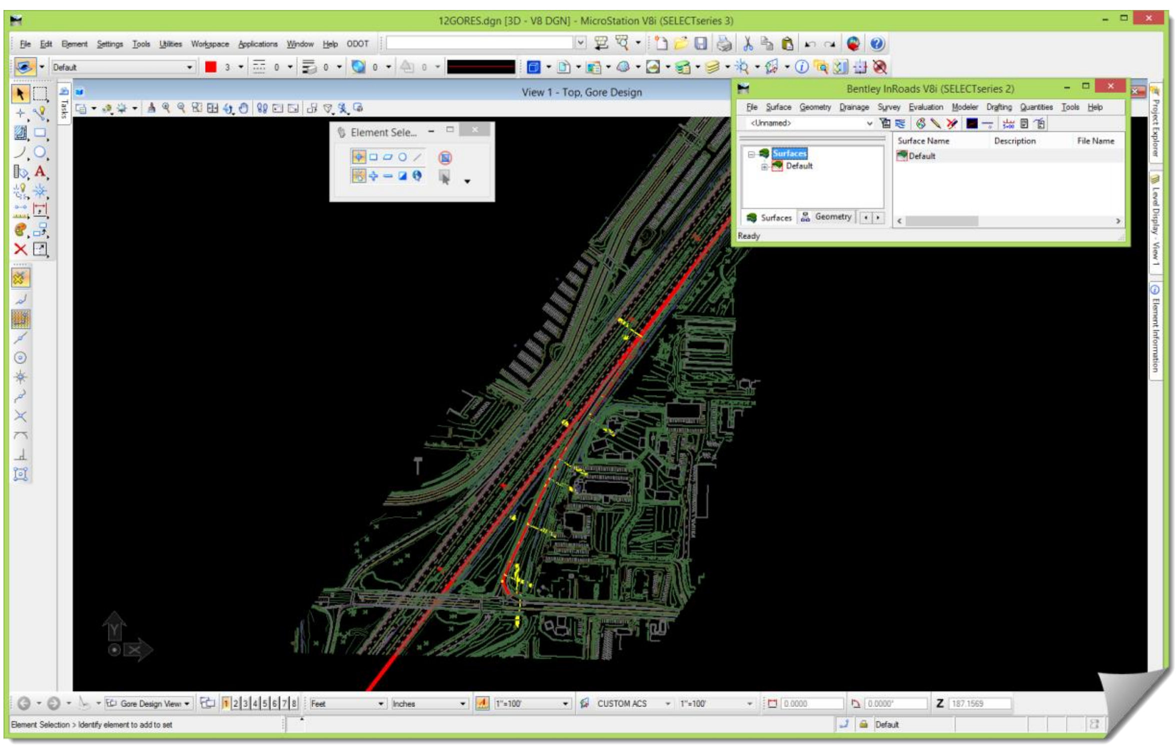
   Use whatever mechanism you are familiar with to get the software started.

2) When the **MicroStation Manager** opens, set the **User** and **Interface** to **ODOT**.

3) Browse ***C:\WORK\Train\12_Gores***, select **12GORES.dgn**, and [**Open**].



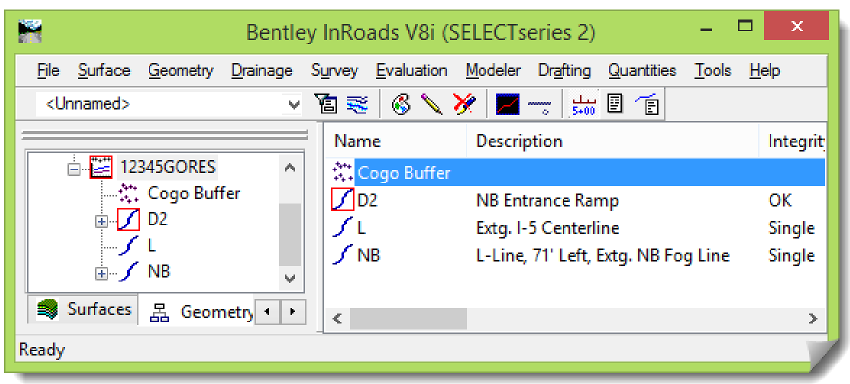
4) When the drawing opens, you'll see that it is has some content.



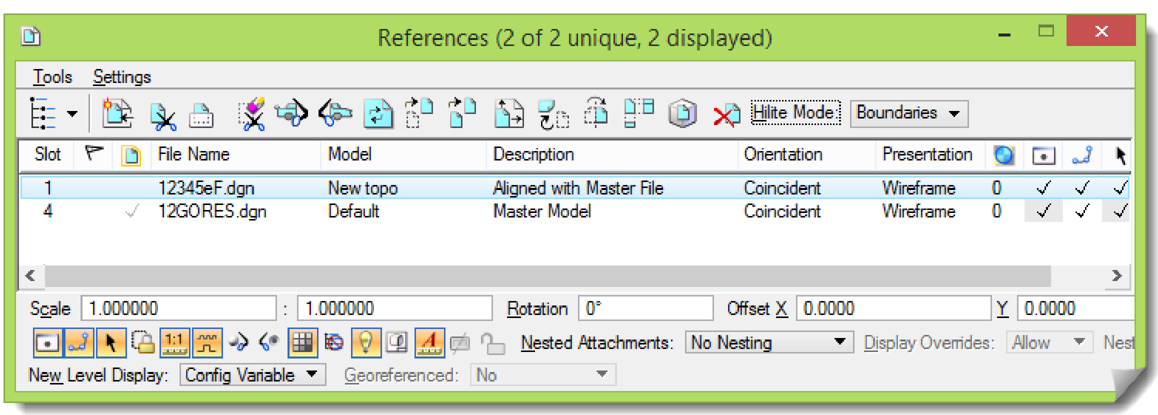
5) Open Windows **File Explorer** and browse to the **12_Gores** folder.

6) Drag & drop **Load_12GORES.rwk** into the InRoads interface to open the InRoads files.

7) Verify inside InRoads that the following files have been opened:
   - **12GORES.xin**
   - **12345GORES_og.dtm**
   - **L-NB-Line_fg.dtm**
   - **12345GORES.alg**
   - **12345GORES.itl**
   - **12345GORES.ird**
8) Feel free to review the project data just opened in any way that you see fit.
   - **12345GORES_og.dtm** – original ground surface as usual
   - **L-NB-Line_fg.dtm** – the design surface along the northbound portion of the primary road. This design surface will eventually be combined with the secondary road, or **D2** ramp.
   - **12345GORES.alg** – contains three of the project alignments
     - **NB** – northbound freeway horizontal and vertical alignment
     - **D2** – ramp horizontal and vertical alignment
     - **L** – freeway centerline horizontal alignment
   - **12345GORES.itl** – contains the base templates for this project
   - **12345GORED.ird** – currently contains the corridor for the NB and D2 roadways



9) Review the MicroStation models and reference files that are attached to this drawing so that you are oriented to the DGN file that is open.



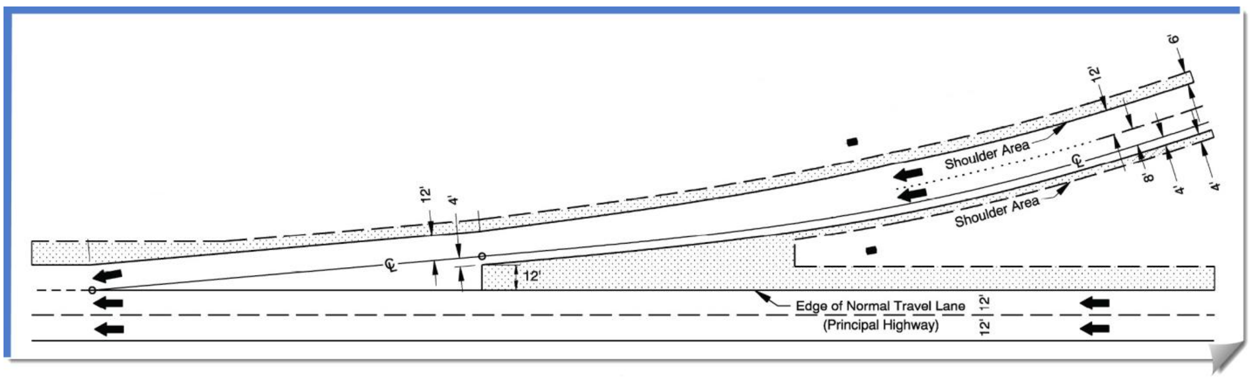
10) Move forward into the study portion of this module. Feel free to interact with the software as needed during your study in order to solidify any of the items under discussion.

Theory - Study

The main topic in this module is the **VERTICAL GORE TOOL**. This is not because it directly helps model the gore area, but because it can help set the stage for *later* modeling success.

Moving into this work, it is expected that the user already knows how to layout a horizontal and vertical alignment, as well as create a corridor model with the correct templates. With that knowledge, there is nothing stopping the user from creating the main road and ramp alignments and corridors independently. Continuing this line of thought, the application of **POINT CONTROLS**, **PARAMETRIC CONSTRAINTS** and **END CONDITION EXCEPTIONS** should all be part of the skill set at this stage.

Beyond the **VERTICAL GORE TOOL**, the bulk of this module will actually consist of details like directing the user to the assigning of **POINT CONTROLS** and **PARAMETRIC CONSTRAINTS** in order to control the adjacent, and eventually joining, corridor models. It will bring attention to specific areas that need to be tied together by external controls, and present a methodology to stitch the main road and ramp together so they can be joined into a single model.



The subject of gores in this section will be broken down like this:

- Things to consider:
  - Defining what a gore is
  - Gore design criteria
  - Effect of Superelevation
- Techniques and Tools:
  - An overall schematic workflow
  - Discussion about external controls
  - The Vertical Gore Tool overview

PROCESS OVERVIEW

Things to Consider

What is a Gore?

A gore is the triangular area between the main roadway and a ramp.

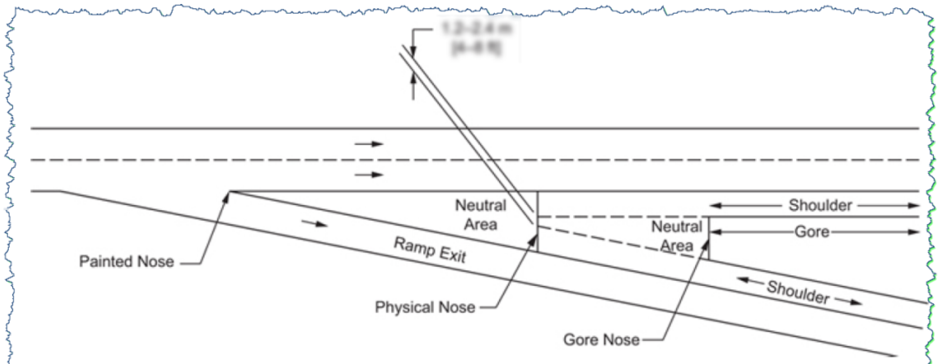


Figure 10-61 Typical Exit Gore Area Characteristics

Gore Design Criteria

The 2012 ODOT Highway Design Manual, Chapter 9 (Grade Separations & Interchanges) offers this guidance on the design of gores:

Per section 9.5.6 VERTICAL ALIGNMENT – *Ramp profiles in gore area need to be developed to match the mainline profile adequately, in order to minimize cross slope variations in that area. It is preferable to develop grades in gore areas based on the mainline profile up to the point where gore paving ends (refer to Figure 9-11 and Figure 9-12 for details). The ramp profile can become independent at that point. In constrained situations, it may be necessary to vary from this practice. Significant cross slope breaks can create problems for vehicles traversing the gore area, especially at exits, so the profile always needs to match mainline to the extent possible in each situation.*

A thumbnail of *Figure 9-11* is shown here since this represents the layout that will be used in this module. This document is included in the module folder as **`Ramp Details Figure 9-11.pdf`** for your reference later.

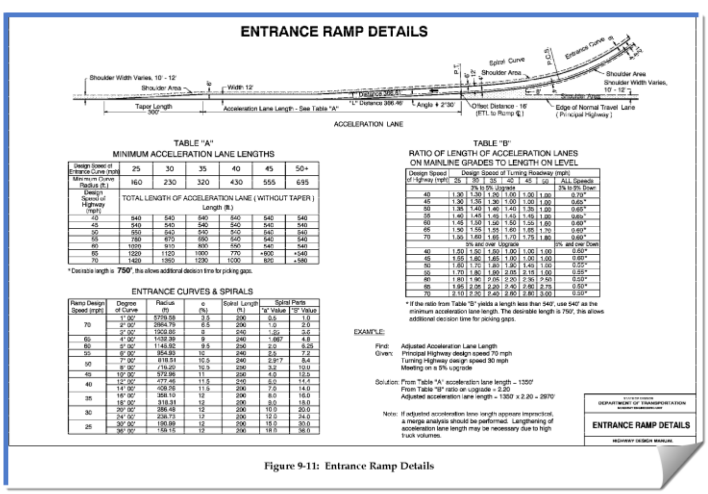
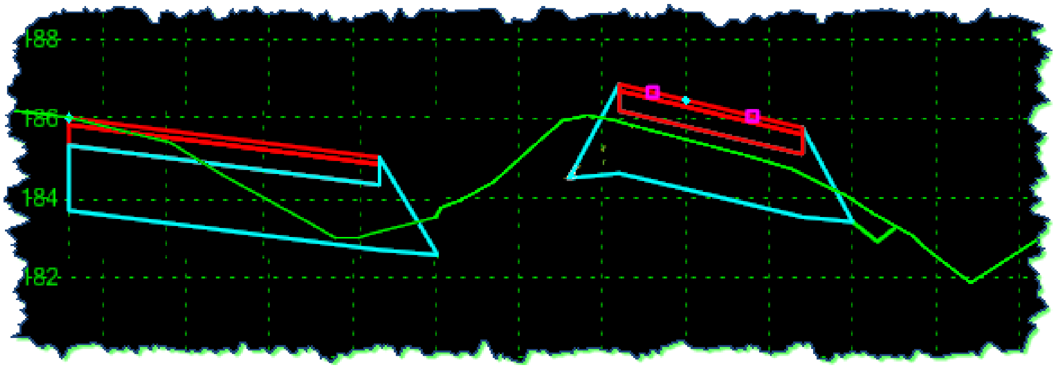

ENTRANCE RAMP DETAILS

Figure 9-11: Entrance Ramp Details

Superelevation

Since the potential for Superelevation exists on both the primary and secondary roadways, there is always the likelihood that it will have to be addressed so that the incoming roadway cross slope synchronizes with the main roadway cross slope.



Techniques and Tools

In this module, the project (geometry, templates and corridor work) is only partially complete. The upcoming hands-on will take this work and incorporate the gore modeling elements into it so the ramp and main roadway can be modeled together to form a complete design surface.

Beyond the expected knowledge, there are only a few key items that will be brought into this module regarding integrating gores with other corridor models:

- **Gore Modeling Overview** – This will be more or less a list of areas that need attention in a gore area and a method of addressing them with the **ROADWAY DESIGNER** tools.
- **Vertical Gore Tool** – This tool will be introduced and used to validate the ramp vertical alignment with the intent to optimize the vertical match with the main road.

Gore Modeling Overview

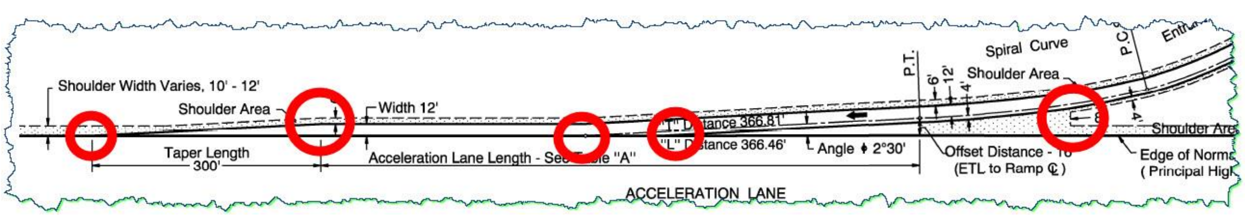
As mentioned earlier, this gore discussion assumes that:

- The primary road (in this case **NB**) has been geometrically laid out and fully modeled with all known information in the **ROADWAY DESIGNER**
- The secondary road (**D2**) has been at least horizontally laid out (and potentially vertically laid out), with a corridor created including any Superelevation
- The gore grade breaks are at the lane line features (**TL**)

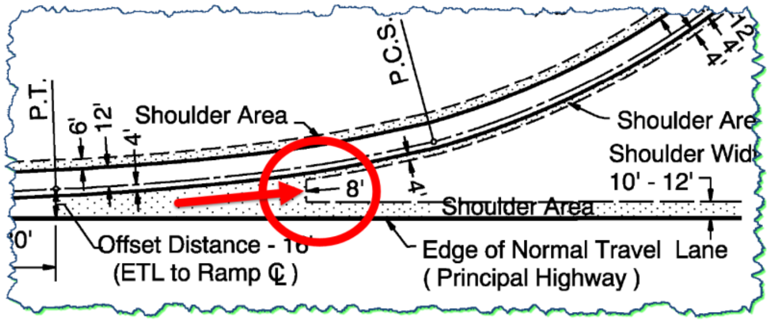
As an overall orientation, gore modeling requires attention in these specific areas (this is based on the design criteria described in figure 9-11 discussed earlier):

Horizontal Locations:

These key horizontal locations will need to be identified (as further described in this section):

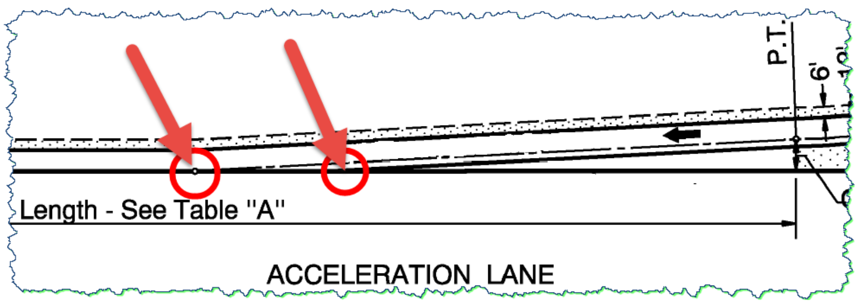


a. Horizontally locate where the 8' offset distance occurs between the shoulder (**EP**) of the ramp and the shoulder (**EP**) of the main road. This should be in the form of a station along the main road as well as a station along the ramp.

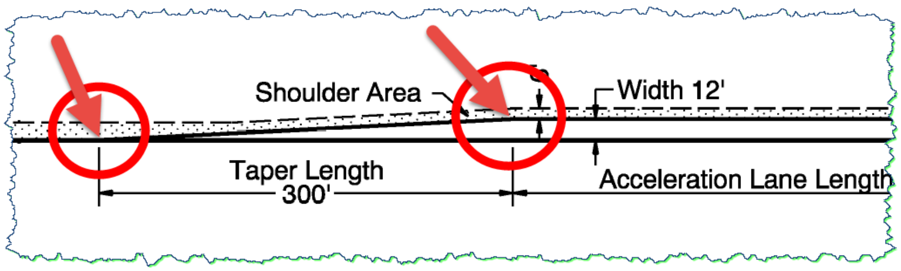


b. Horizontally locate the ramp station where ramp travel lane (**TL**) intersects with the main road travel lane (**TL**).

c. Horizontally locate the station along the main road where the ramp alignment centerline intersects with the main road travel lane (**TL**). This will be at the termination of the ramp corridor model, and more than likely the end of the ramp alignment.



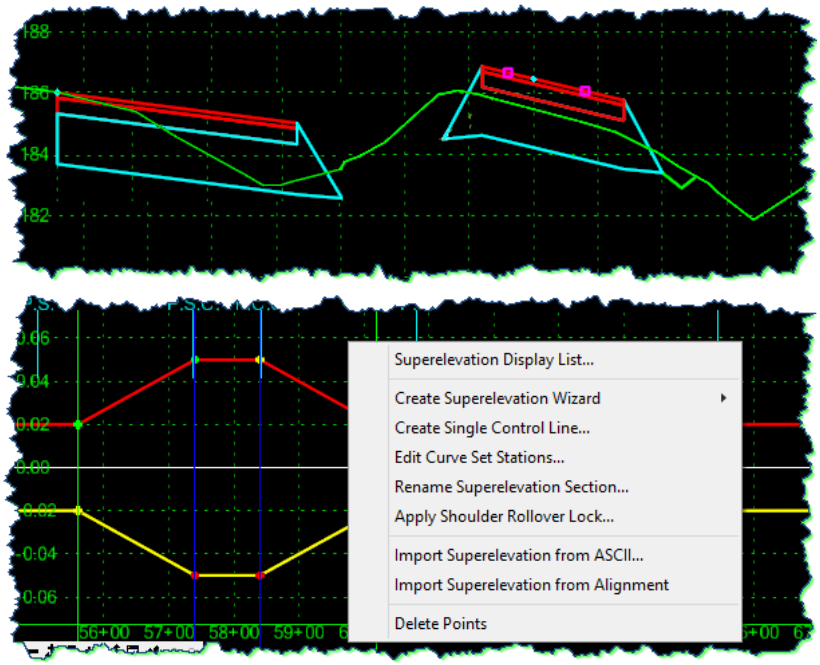
d. Horizontally locate the main road stationing for the end of the Acceleration Lane / Start of Taper, as well as the end of the Taper.



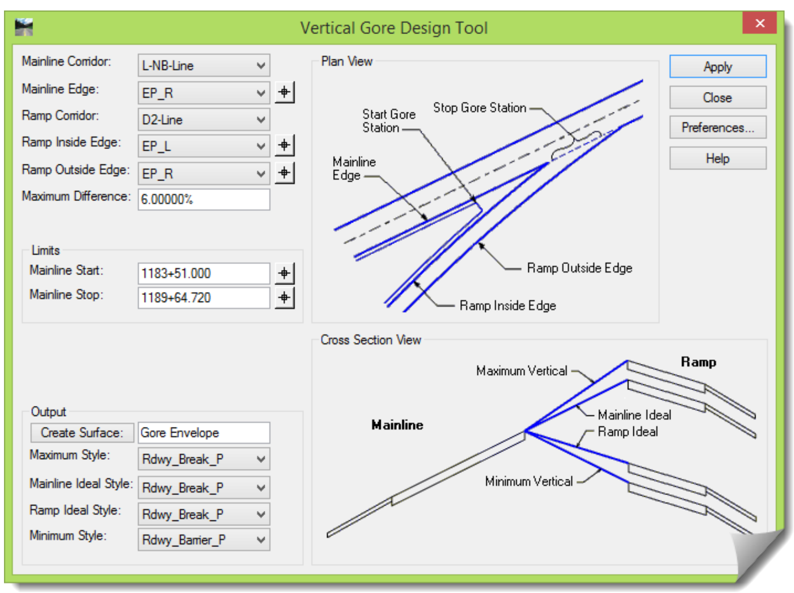
Vertical / Cross Slope Attention:

The next focus will be vertically, relative to the ramp since the main roadway is being considered "designed" at this stage.

a. If the ramp is in Superelevation as it's approaching the main road, the Superelevation of the ramp will need to be addressed by editing the super control lines to create a matching cross slope between the ramp and the main road.



b. Using the **VERTICAL GORE TOOL**, develop the optimal limits of the vertical alignment design either to analyze your current vertical alignment for the ramp, or to construct a new one.



With the information produced by the **VERTICAL GORE TOOL**, the vertical alignment will be either newly created or modified to optimize the gore construction. The process of using this tool, along with the results, will be covered later in this module.

ALERT: The user must be aware of whether they use the EP or TL in this tool. Each point could create slightly different envelopes if there's a grade break between them in your template. Be sure to choose wisely and understand the differences.

Corridor Work:

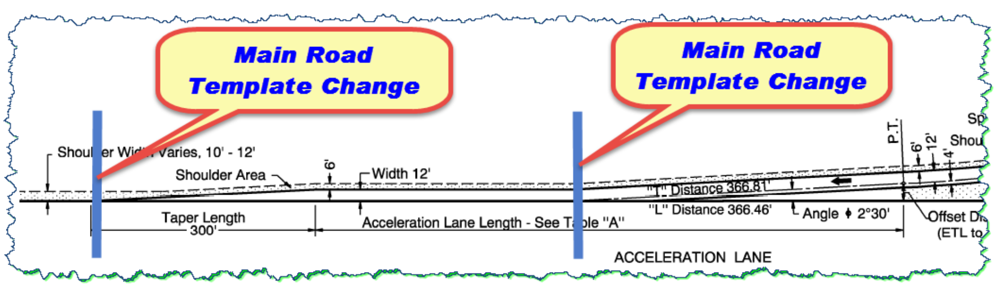
At this stage, the horizontal and vertical alignments are complete for both roads, and the rest of the work will be done with the templates and the **Roadway Designer**. The modifications will consist of:

- Additional **Template Drops** – These will generally only occur along the main roadway and will be minimal, although each model can be different and have additional requirements necessitating additional template drops.
- **End Condition Exceptions** entries – This module will use these entries to disable ECs within certain areas of the model for both the ramp and main road.
- Adding **Point Controls** – The use of **Point Controls** are vital to the integration of the ramp and main road. The key control will be tying the main road **EP** to the ramp **EP**. Additional point controls include tying the travel lanes together, merging the subgrade structural sections, and tying the ECs together leading into the gore area.
- Adding **Parametric Constraints** – Since much of the transitioning in this gore modeling is linear, there are quite a few **Parametric Constraints** used to control these transitions. Keeping these straight will present the largest challenge to this gore configuration work.

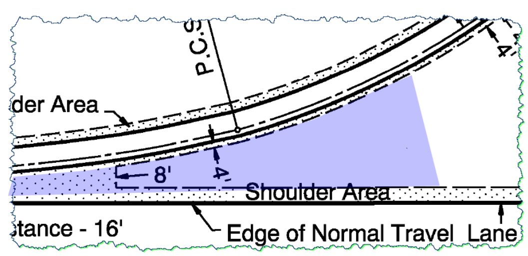
The last thing to note here is the interrelationship between the items listed above. There are areas of the model where some template points are being relocated using **Parametric Constraints** at the same location where **Point Controls** are utilizing these parametrically-repositioned points.

ALERT: When modeling enters this stage of complexity, it's important to keep your wits about you and do whatever necessary to keep these influences straight. Documentation of this type of work can really come in handy several months down the road.

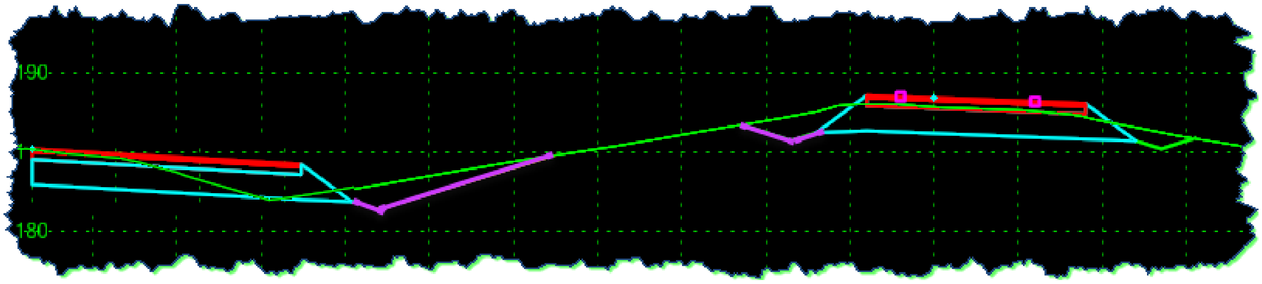
a. **Template Drops** – Templates will be added at specific locations along the main road.



b. **End Condition Exceptions** – There is an area prior to the confluence of the two corridors where the EC side slopes begin to touch. Somewhere along the corridors in that area, a decision will have to be made to address the ECs. **End Condition Exceptions** can be applied to both corridors as they approach the gore, and then can continue throughout the gore area until the end of the ramp model.



This can be seen in the **ROADWAY DESIGNER** when viewing both corridors.



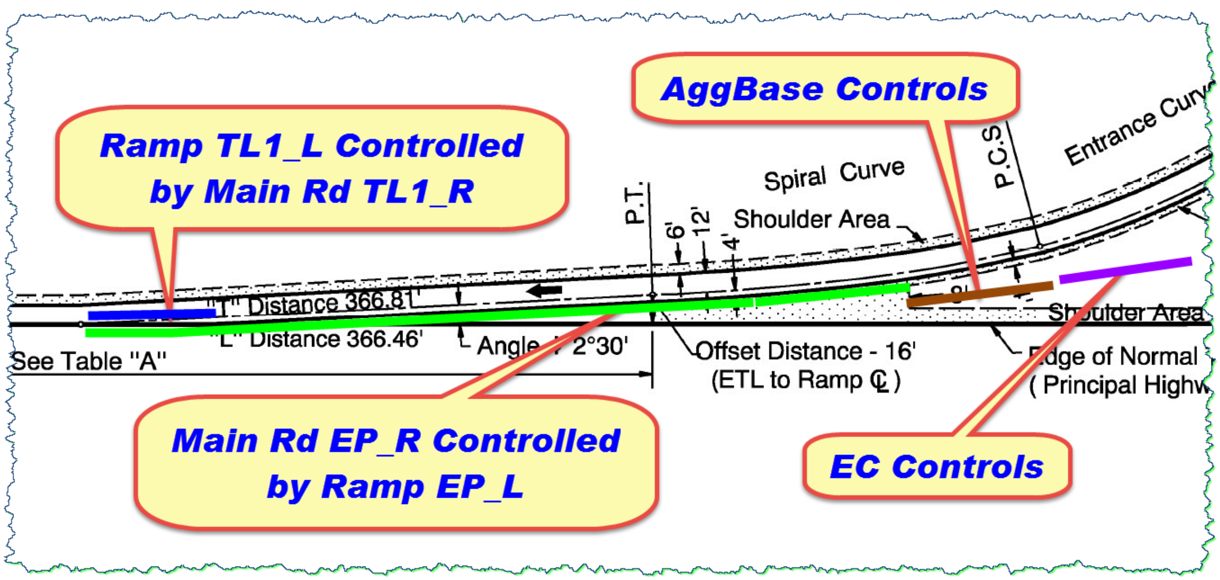
At some point along the model, the ECs will converge and the grading will have to be addressed uniquely. In this module, as these ECs move closer together, a point control will be used from the point they converge until the station where the structural sections begin to converge. Then, the ECs are shut off on both the main road and ramp, remaining disabled from their point of convergence until the end of the ramp modeling. The ECs for the main road are then resumed at the start of the acceleration lane.

c. **POINT CONTROLS** – There will be several **POINT CONTROLS** assigned to both the ramp corridor and the main road corridor. These point controls will tie the corridors together and ensure that there are no overlapping components.

One control will tie the main road `EP_R` to the `EP_L` of the ramp and will begin at the start of the paved gore, continuing until the junction of the main road travel lane and ramp travel lane.

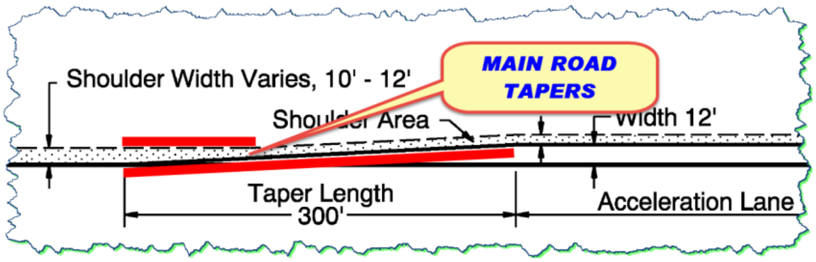
Another control will start from the intersection of the ramp travel lane and main road travel lane, continuing until the intersection of the main road travel lane and ramp centerline.

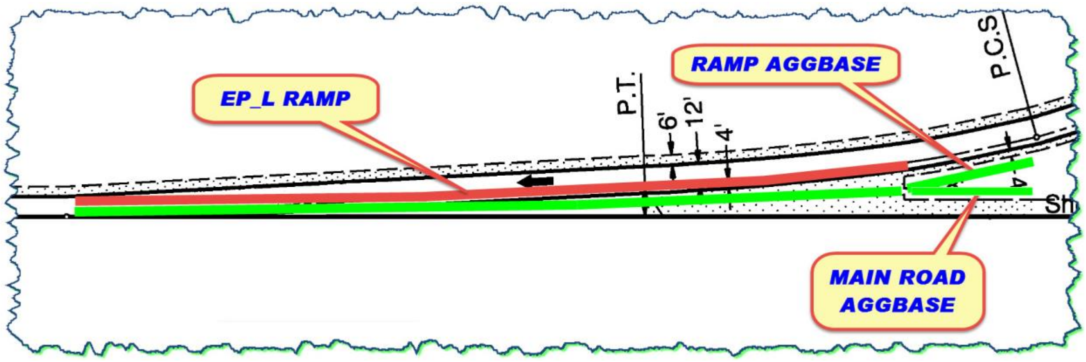
Additional controls will ensure that the end conditions from each corridor do not overlap, as well as addressing the subgrade structural components merger.



d. **PARAMETRIC CONSTRAINTS** – There are a number of **PARAMETRIC CONSTRAINTS** to be assigned in this gore modeling as identified here (more details will be provided on these later):

- Lane Width constraint at the end of the acceleration lane to return it to a normal section
- Shoulder width at the end of the acceleration lane
- Ramp shoulder width (EP) constraint in the gore area
- AggBase width of both roads as they approach the gore, as well as through the gore
- Structural section thickness of the ramp to match the main road

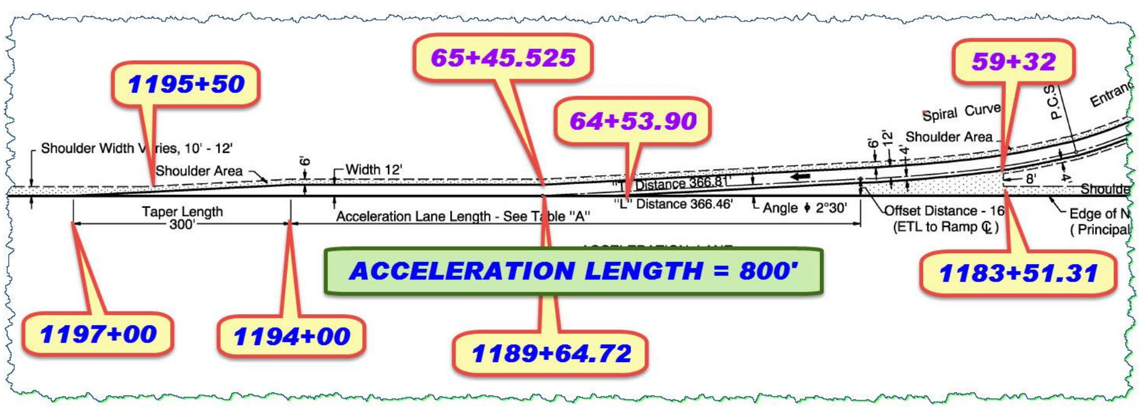




Practical Application - Hands On Lab Exercises

UNDERSTANDING THE DETAILS

Based on everything that has been discussed so far, here are the design criteria and stationing results that will be used moving ahead. Take this time to work out these values for yourself and confirm the information shown here where possible.



Having introduced more of the details of the work to be done along with specific requirements, take this additional opportunity to review the project data, focusing on the alignment geometry, convergence locations, and corridors already set up in the **ROADWAY DESIGNER**.

Review any relevant project data

At this point, you should be in the **12GORES.dgn** file and have loaded the InRoads RWK data.

Final Review of Current InRoads Data

1) Do a final review of the **NB** and **D2** alignments, inspecting the following:
   - Convergence stations for the ramp centerline and main road edge of shoulder
   - Mainline traveled way intercept with the ramp
   - Mainline / ramp edge of shoulder locations
   - Any other significant areas or locations
2) Open the **Template Library**, browse to the **Templates** folder and do your final review of the templates located there.
   - **D2_Normal** – the template used throughout the ramp model
   - **L_NB_Rt** – half of the **FULL** template used to model the main road in the gore area
   - **L_NB_Rt_Wide** – an expanded template that will be used where the ramp meets the main road to bring in the additional acceleration lane

   These will be referred to later, so be familiar with them and their associated point names.

   Note that the inside travel lane width in the main road templates may not conform to your project standards. For this gore illustration we are only concerned with the template points to the outside of **TL1_R**. Everything to the left (inside) of that point will have no bearing on the end results of the gore design.
3) Lastly, review the construction of the corridors in the **Roadway Designer**.

   The majority of the work done in the module will be adding specific modifications to each of the corridors in the **Roadway Designer** (**L-NB-Line** and **D2-Line**), so the more familiar you are with these corridors, the easier it will be for you to understand and make the necessary edits.

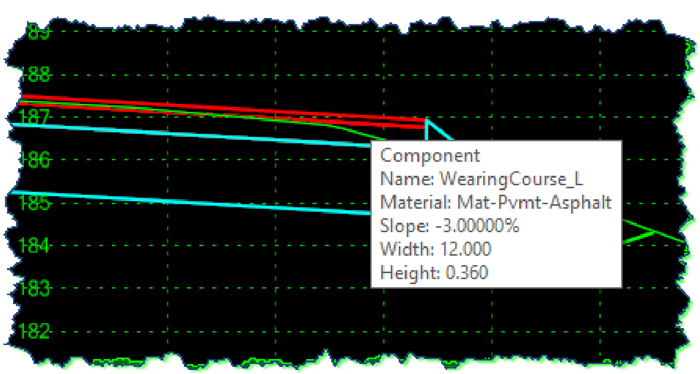
SCENARIO - GORE MODELING

This hands-on will consist of stepping through each of the items from the earlier description of this activity, and eventually updating the **Roadway Designer** corridors to construct the gore area.

Superelevation Adjustment

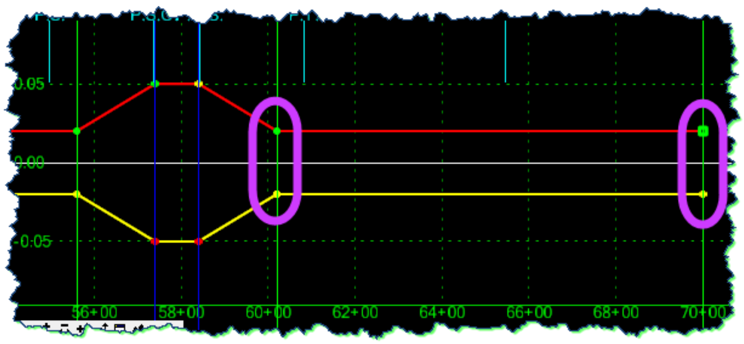
To start, an adjustment to the Ramp Superelevation will be done so the ramp cross slope matches the cross slope of the main road. This needs to be checked on each job and appropriately edited.

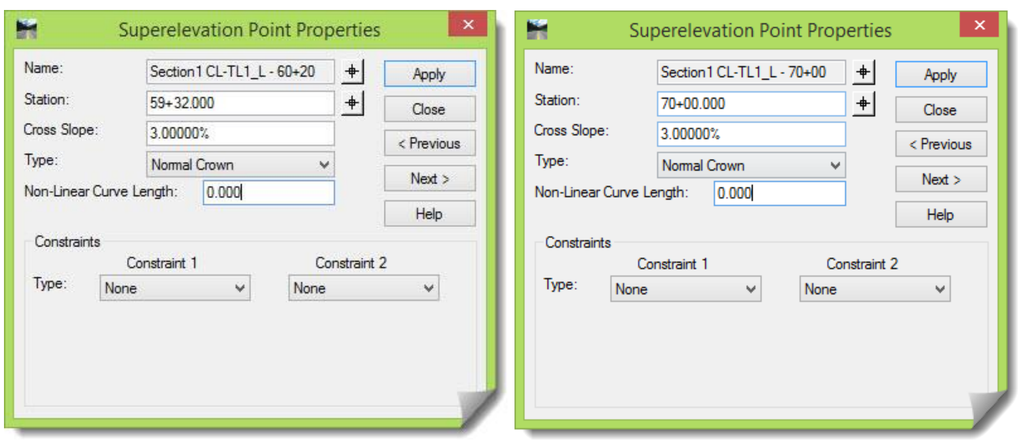
In this case, it is going to be **-3.0%** since that is what the slope of the main road is near the gore. Feel free to verify this for yourself in the **Roadway Designer**.



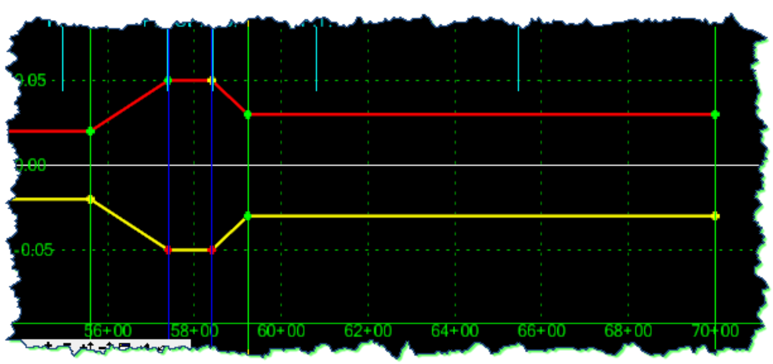
You will do this by editing the **Station** and **Cross Slope** of the existing points in Superelevation. (Station **59+32** is the ramp station where the paved gore area begins.) Be sure to edit this to comply with any design criteria you have on your project while matching the mainline cross slope.

1) In the **Roadway Designer**, set the **Corridor** to **D2-Line**.
2) Toggle *on* the **Superelevation Display Mode** and edit the Superelevation controls so that they are a consistent **3.00%** cross slope beyond the stationing of the gore, **59+32**.





The completed edits should look like this:



3) Toggle the **Display Mode** back to **Normal**.

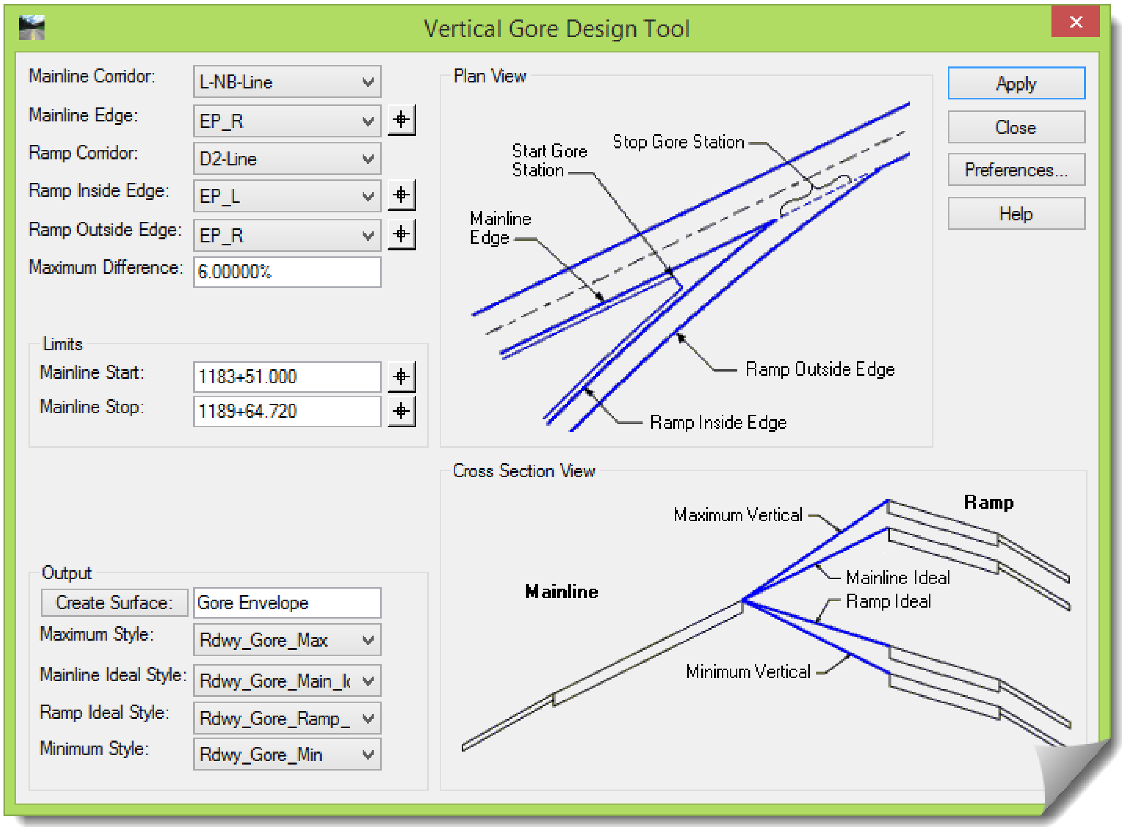
Vertical Gore Tool

The **Vertical Gore Tool** is used as a vertical alignment layout aide within the area of a gore. It consists of defining specific template points on the ramp as well as the main road, along with a **Maximum Difference** slope value. This value is your maximum allowable cross slope delta grade break between the ramp and mainline. Your design standards should be consulted to determine the appropriate value to use here.

The **Limits** allow the entry for a **Mainline Start** and **Mainline Stop** station. Looking at the picture on the dialog box, this is the station range of the gore zone.

The **Output** will be either four features in the defined surface (when **Create Surface** is used) or four vertical alignments under the ramp horizontal alignment (when **Create Verticals** is used).

1) Set up the **VERTICAL GORE TOOL**, under ***ROADWAY DESIGNER > TOOLS***, with the following values:

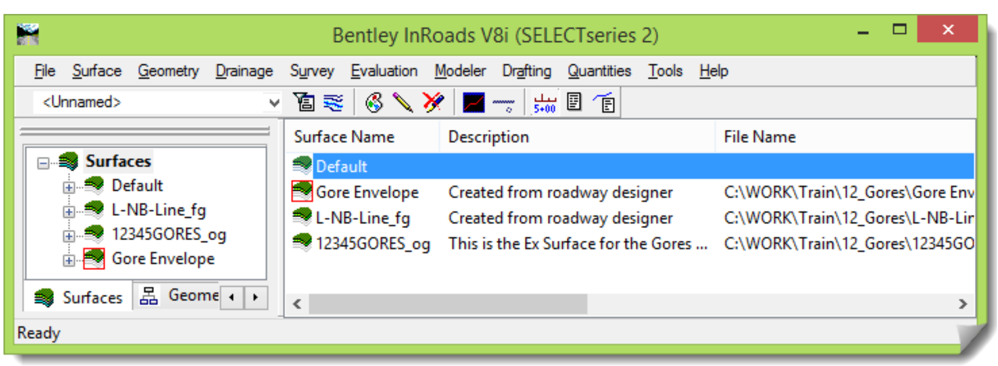


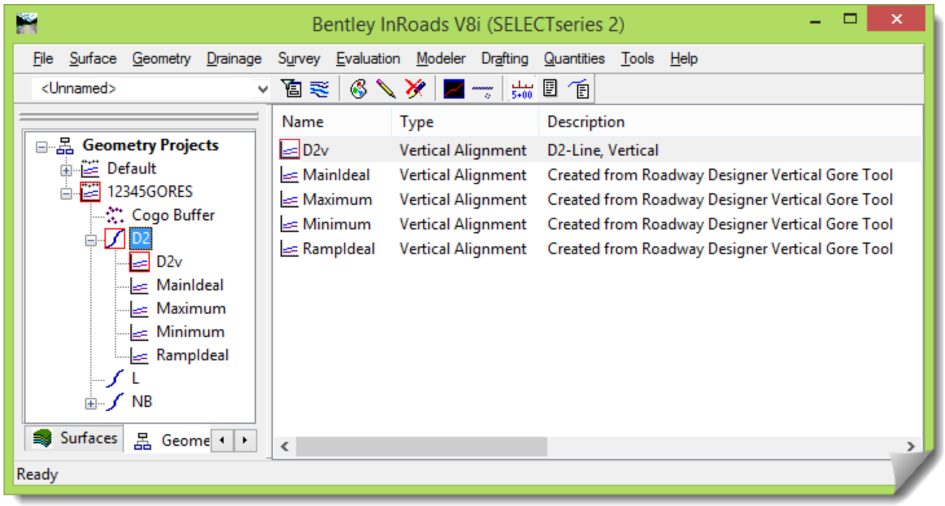
For this module, you can decide whether you want to create the **Output** in a surface or as alignments. Just be aware of the location of these results later.

2) [**Apply**] the tool and wait until it is done processing, and then [**Close**] it.

After you [**Apply**], the command is processed and some movement occurs in the cross section window of the **ROADWAY DESIGNER**. This is normal and an indication that the tool is working, processing the request and developing the **Output**.

3) [**Close**] the **ROADWAY DESIGNER** and verify that either your surface exists or the new vertical alignments were created (depending on which **Output** method was used).





4) [**Save**] that new data.

The next step is to finalize the vertical alignment of the ramp or secondary road by creating a profile along that road and viewing the output from the **VERTICAL GORE TOOL** on the profile. By using these 'guide lines' for the **Minimum**, **Maximum**, and **Ideals**, an existing vertical alignment can be revised, or a new one created.

5) Create a Profile along the ramp **D2** alignment.

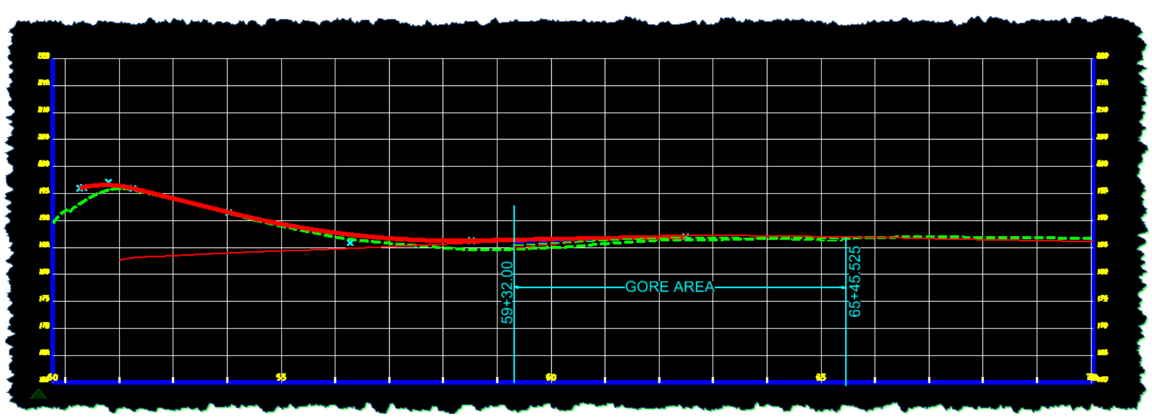
6) View the Vertical alignment (**D2v**) that currently exists for that alignment.

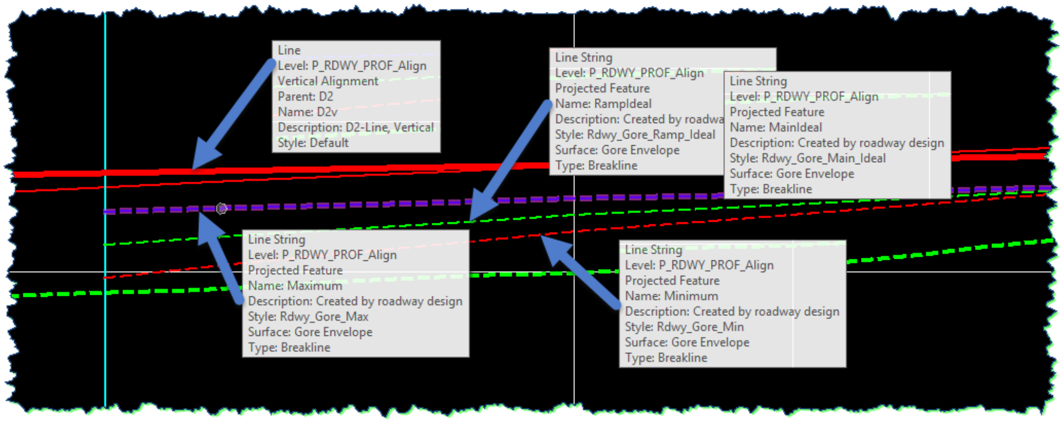
Remember that a vertical alignment for the ramp doesn't need to exist for the tool to function properly, and in some instances, it will not. In this case, you will be making a decision to either modify the current vertical alignment, or create an entirely new vertical.

NOTE: For those who wish to modify the provided vertical alignment (**D2v**), it must be noted that it is not a "finished" alignment. In addition, if you elect to create a new vertical alignment, the corridor limits may need to be changed to include the limits of the new vertical alignment.

7) View the four gore features on the ramp profile and review the results in the area of the gore stationing.

All cases will be different, but in this case, the current vertical alignment is above the **Maximum**.

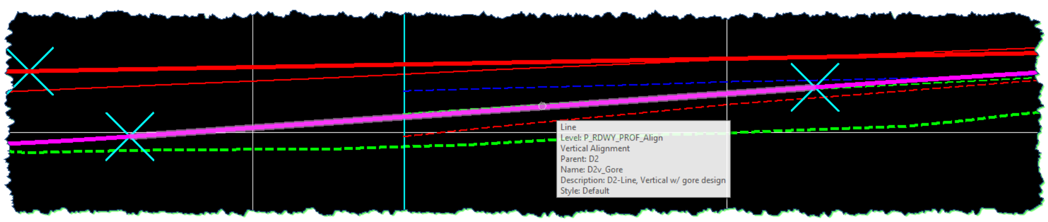




8) Using whatever technique you are comfortable with, address the vertical alignment and do whatever you need to do in order to create a vertical that is not outside the **Minimum** / **Maximum** feature guides.

> **TIP**: Don't limit the display to only these features. View any other information on the profile to help with your design. For instance, the **TL_R** and **EP_R** from the main roadway should also be used to ensure that the end of the vertical alignment merges exactly and smoothly into the main road.

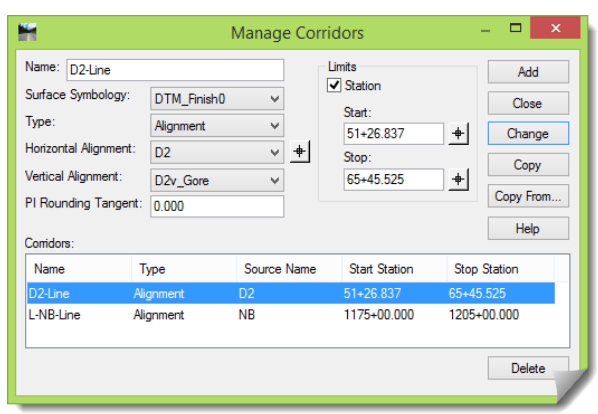
Moving forward, this is how a completed alignment might look in this area.



9) [**Save**] your geometry when you have completed that work.

Now the corridor edits and additions will be started. All of the areas listed above will be done as appropriate for either the ramp or the main road. There will be times when activities are done to the main corridor and then immediately to the ramp corridor. The order of these modeling activities is really up to you and your ability to keep track of what you are doing, what still needs to be done, and what you have already done.

Ramp Work



1) Go to the **Roadway Designer**.
2) Even though you've created a new vertical alignment for the ramp, set the vertical alignment to **D2v_Gore**.

We are using this vertical alignment moving forward (instead of the one you've just created) so that your work matches all the steps as described in this document, including any subgrade or EC tie-ins.

3) Remember to [**Save**] your IRD regularly throughout this work.

Main Road Work - End of Acceleration Lane

Recall that there are a few additional template drops needed on the main road, and none needed on the ramp. Refer back to the earlier illustrations to help you keep track of what is required.

1) Set the active **Corridor** to **`L-NB-Line`** and go to **TEMPLATE DROPS**.

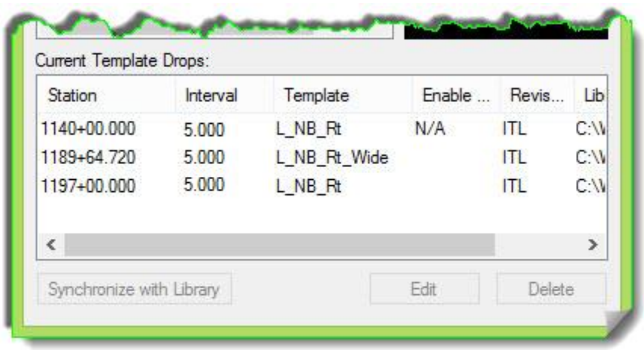
Currently there is only one template in this model.

2) Add the **`L_NB_Rt_Wide`** template at **Station** <u>**`1189+64.72`**</u>.

This is the station where the ramp corridor ends and the main road takes on the acceleration lane.

3) Add the **`L_NB_Rt`** template at <u>**`1197+00`**</u> to get the mainline back to the original section.

These templates will be controlled parametrically, so there is no need for transitioning.


Current Template Drops:

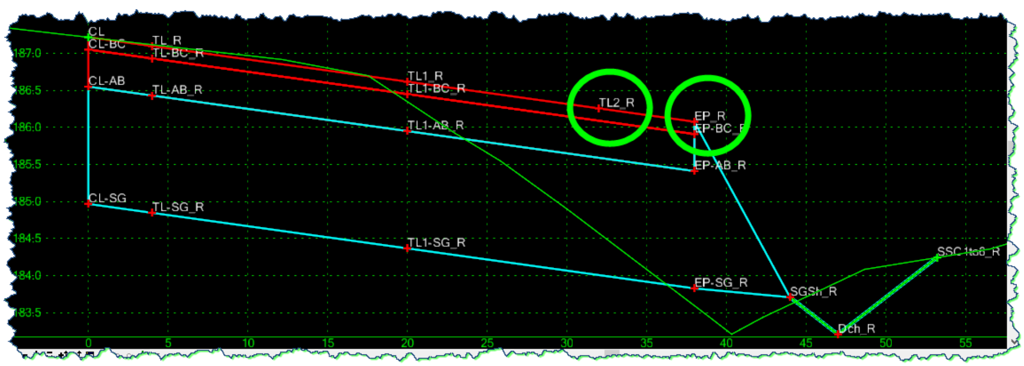
Station	Interval	Template	Enable ...	Revis...	Lib
1140+00.000	5.000	L_NB_Rt	N/A	ITL	C:\\
1189+64.720	5.000	L_NB_Rt_Wide		ITL	C:\\
1197+00.000	5.000	L_NB_Rt		ITL	C:\\

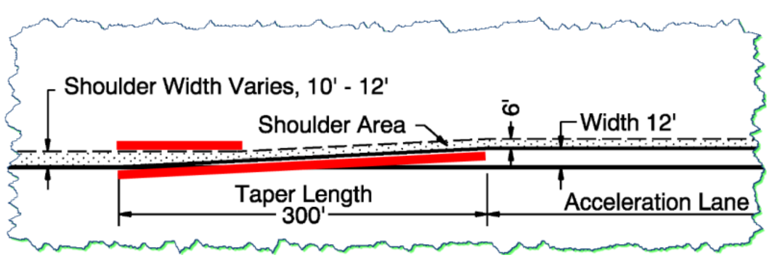
Synchronize with Library | Edit | Delete

Parametric Constraints

While the focus is on this area, a few **PARAMETRIC CONSTRAINTS** to control the acceleration lane will be added. There will be two added here:

- Control the **`TL2_R`** widening of the main road (created by the addition of the first new template drop with the acceleration lane) and bring it back to the normal road section within the taper length
- Control the **`EP_R`** of the main road at the end of the acceleration lane to adjust the shoulder width

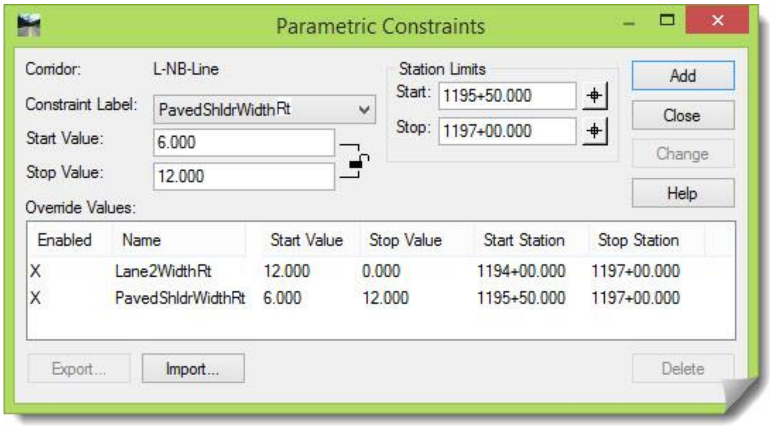


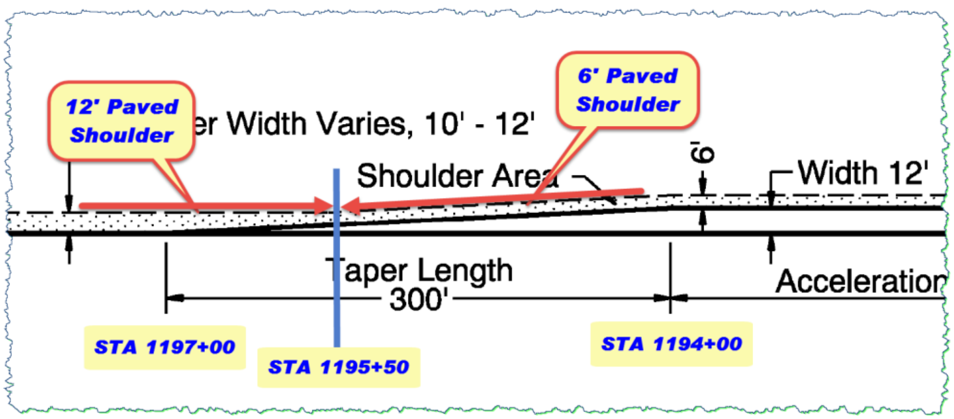


At all times, you should be referring back to any alignments, templates, corridors and any other project information as needed in order to verify and validate what you are doing in these steps. Do not perform a step without understanding what it is and why you are doing it.

4) [**Add**] a new **PARAMETRIC CONSTRAINT** on the main road corridor for the **Label** called **`Lane2WidthRt`** on **`TL2_R`**, from **Station** **`1194+00`** to **`1197+00`**, transitioning that width from **`12.00'`** to **`0.00'`**.
5) [**Add**] another for the **Label** called **`PavedShldrWidthRt`** on **`EP_R`**, from **Station** **`1195+50`** to **`1197+00`**, transitioning that width from **`6.00'`** to **`12.00'`**.

Where did the **`1195+50`** station come from?

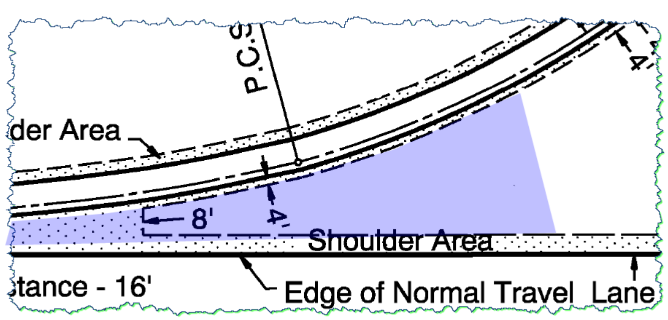




Let's move into the gore area and detail that portion of the model.

EC Point Controls and EC Exceptions

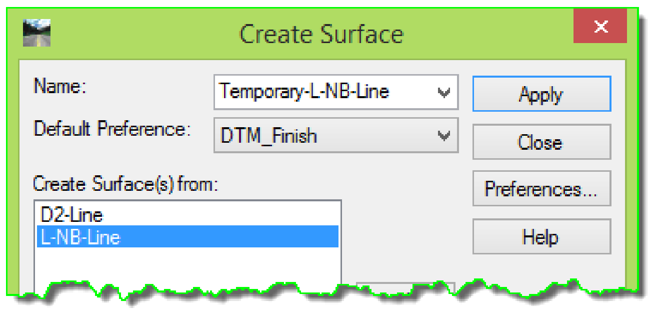
As detailed earlier in this module, the cut / fill slopes will need to be addressed based on your specific design condition on your project just prior to the gore.



This section is here to bring your attention to this area, and make you aware that you will have to analyze your project and make appropriate decisions based on any important design implications like constructability, drainage and so on in this area. Two distinct pieces need to be considered with the End Conditions. One will handle the overlapping of corridor EC solutions, while the other will turn off the ECs where they are not needed at all.

Creating Control Feature

1) While in the **ROADWAY DESIGNER**, turn on all of the **Include Critical Sections** toggles in ***TOOLS > OPTIONS***, and create a temporary surface of the main road corridor that will be used by the ramp corridor as a target for the end condition.

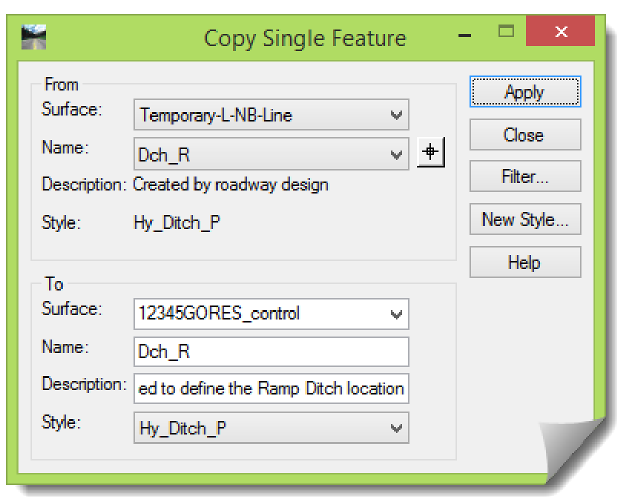


This is where some engineering judgment will be needed. From this point forward, we are going to try to determine how the ramp left end condition (and potentially the main road end condition) needs to be edited in order to merge the two adjacent corridors' EC solutions.

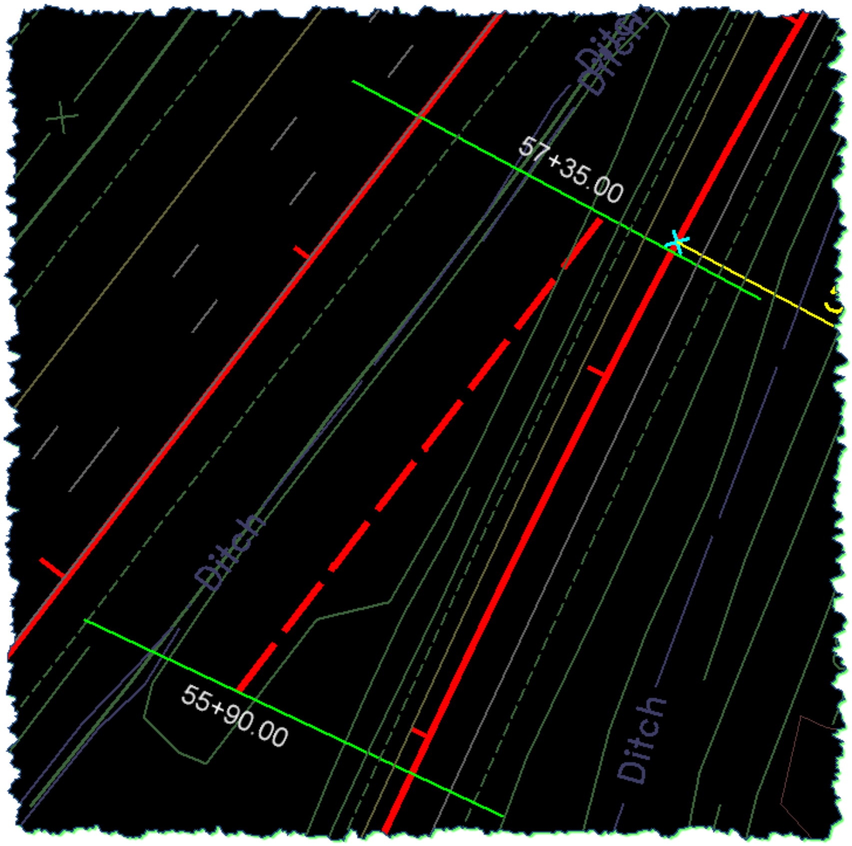
Using this particular project data, we can see that the ramp and main road are both in cut and will require some sort of ditch to collect the runoff. In addition to that, we need to consider the implications with the fact that the main road is running up grade while the ramp is running down grade through this transition area. Based on this engineering evaluation, it has been determined that it is best to keep the ditch point (`Dch_R`) from the main road and use it as a control point for the ramp end condition so that the ramp runoff drains into that ditch.

2) [**Close**] the **ROADWAY DESIGNER** for now.
3) Copy the `Dch_R` feature from the temporary main road surface into a new surface called `12345GORES_control.dtm`. Add a **Description** like `Copied to define the Ramp Ditch location`, or something informative.

The purpose of this surface and its naming convention is explained in the ODOT HDM, Chapter 16.



4) Edit the **Dch_R** feature in the **12345GORES_control.dtm** so that it only runs along the Ramp alignment from 55+90 to 57+35.



The ending station of **57+35**, after the entire model is created, will leave a "gap" between the components of the final model where the EC exception starts to where the rock shoulders begin to merge (although there will be triangulation there completing the model). This is where some engineering judgment comes into play. Depending on what your two corridors are doing vertically, you will have to decide the best approach to addressing the drainage issue in this area. In some cases, you may need to place an inlet to catch the runoff. In others, you may need to manipulate the **Dch_R** feature in the **12345GORES_control.dtm** to extend the feature to the station where the shoulders merge. While doing this, you may need to assign appropriate elevations to the points along the feature to ensure there is adequate drainage.

5) [**Save**] the new control surface (and the temporary surface if resuming later).

Eventually, this feature will be used as a **Target** for the ECs in this area.

EC Modifications

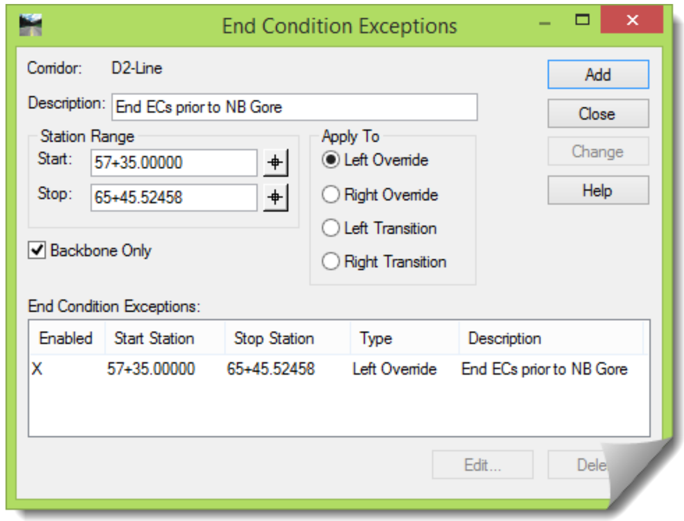
1) Open the **ROADWAY DESIGNER**.

The first area, which will turn off the ECs altogether, is from the point where the two corridors' rock shoulders begin to merge, all the way until the end of the ramp modeling. This area will be handled by utilizing **END CONDITION EXCEPTIONS** and running **Backbone Only**.

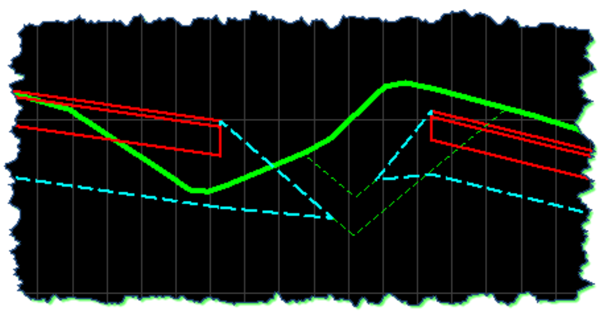
Two **END CONDITION EXCEPTIONS** to run **Backbone Only** will be added here, one for the main road on the right side, and one for the ramp on its left. This is not a requirement, and an alternative would be to modify the templates and remove the ECs altogether. This decision is left to the designer.

2) [**Add**] **END CONDITION EXCEPTIONS** to the inside of the Gore Area on both corridors:

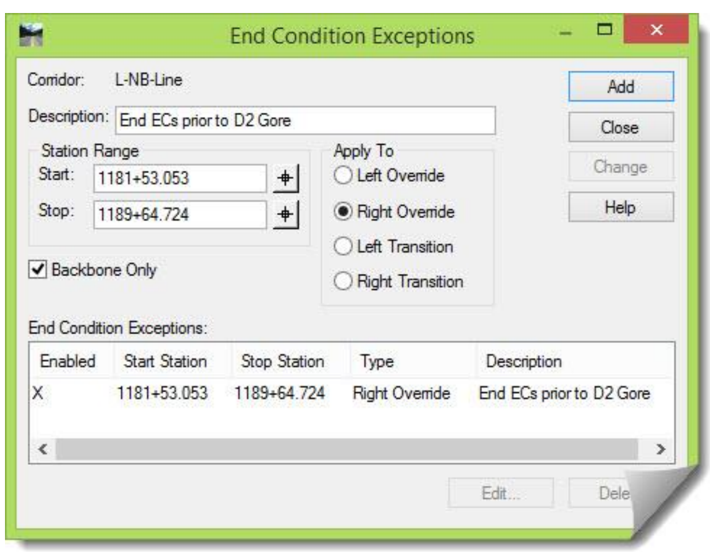
- For the **D2** corridor: <u>**57+35**</u> to the exact end of the alignment



Station **57+35** was chosen to start the **END CONDITION EXCEPTION** based on a review of the cross sections of the two corridors. At this station, the ECs on both corridors began to approach a proximity to each other where the ECs could not be easily connected. This location will have to be determined on a case-by-case basis on your project.



- For the **NB** corridor: <u>**1181+53.053**</u> to <u>**1189+64.724**</u>



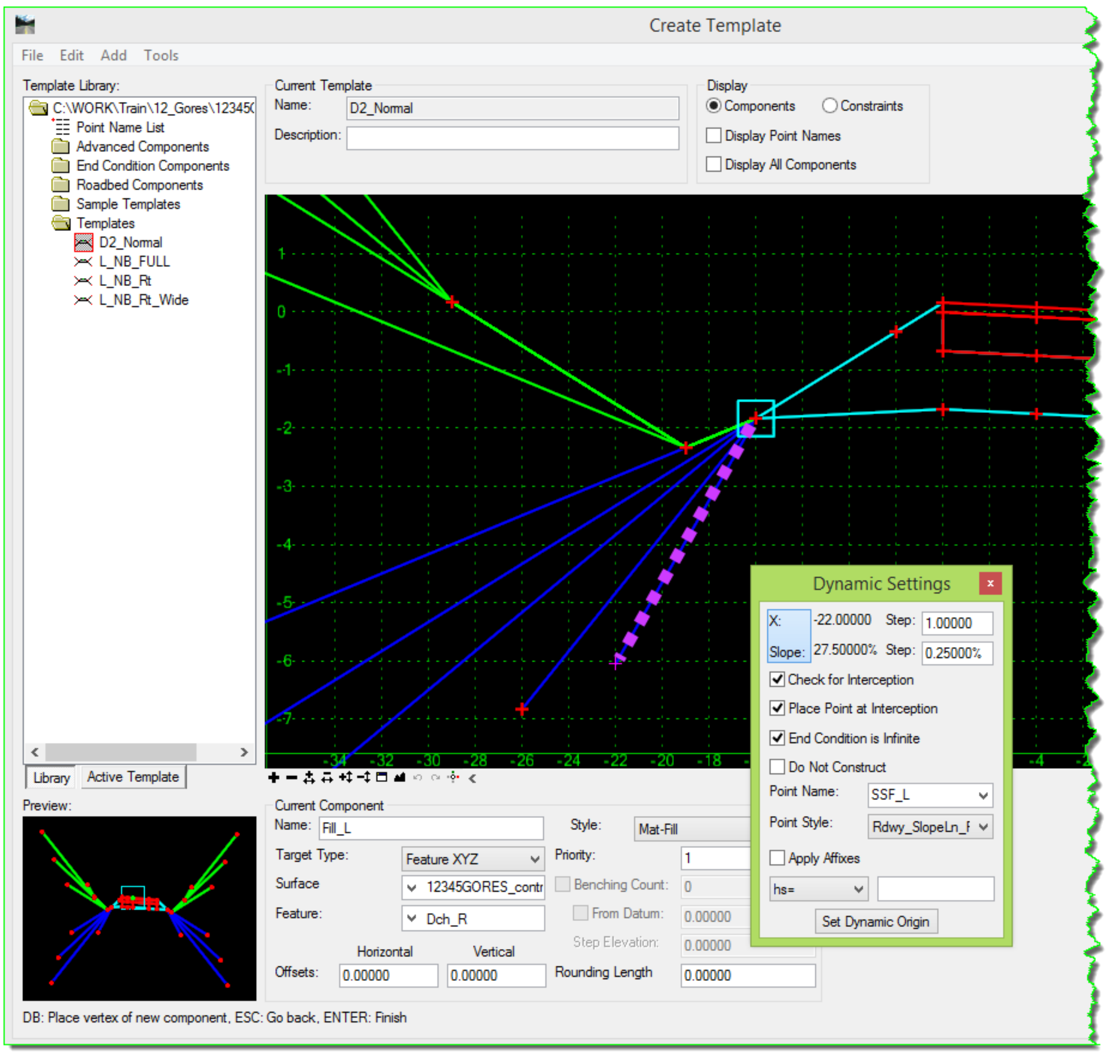
TIP: Colorized entries in InRoads are used to indicate various situations as a flag to the user. For example, a red **Start Station** on an **End Condition Exception** is an alert that the entry is outside of the station range of the corridor. This could sometimes be a precision issue.

The next area to consider is where the two corridors' respective EC solutions would overlap. This area is up-station from the previous one, and begins where the two different corridors' ECs begin to merge, and continue to the station where the two corridors' rock shoulders begin to merge. This area will be handled using point controls (not EC Exceptions) to determine where the 'daylight' line will be located both horizontally and vertically.

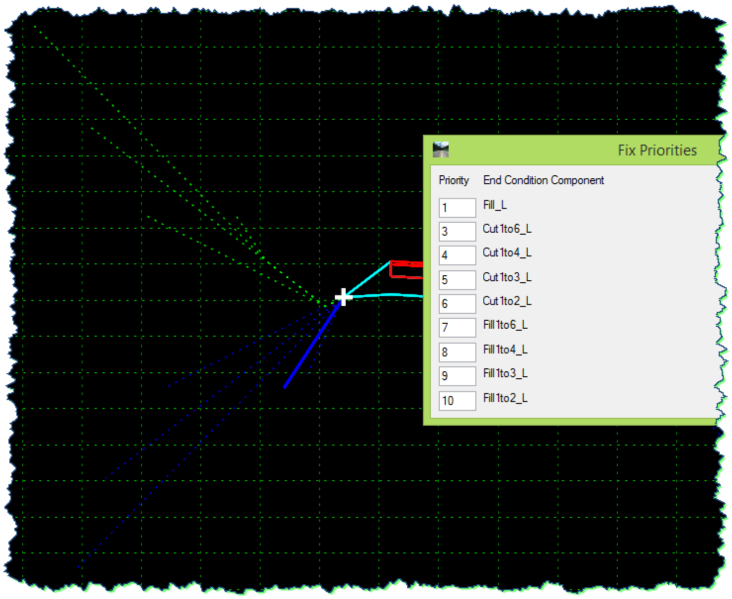
Adding Controls

1) Open the **Create Template** dialog box.
2) Add a new single **End Condition** fill component to the Ramp (**`D2_Normal`**) left side that will target a **`Feature XYZ`** (**`Dch_R`**).

Don't worry too much about its default orientation (i.e. slope, length), as long as it's in a reasonable "fill" orientation. When it solves, its location will be set by the **`Feature XYZ`** **Target**.



3) Check the **End Condition Priorities** to be sure the newly created EC is set to Priority #1 and adjust any of the others accordingly.



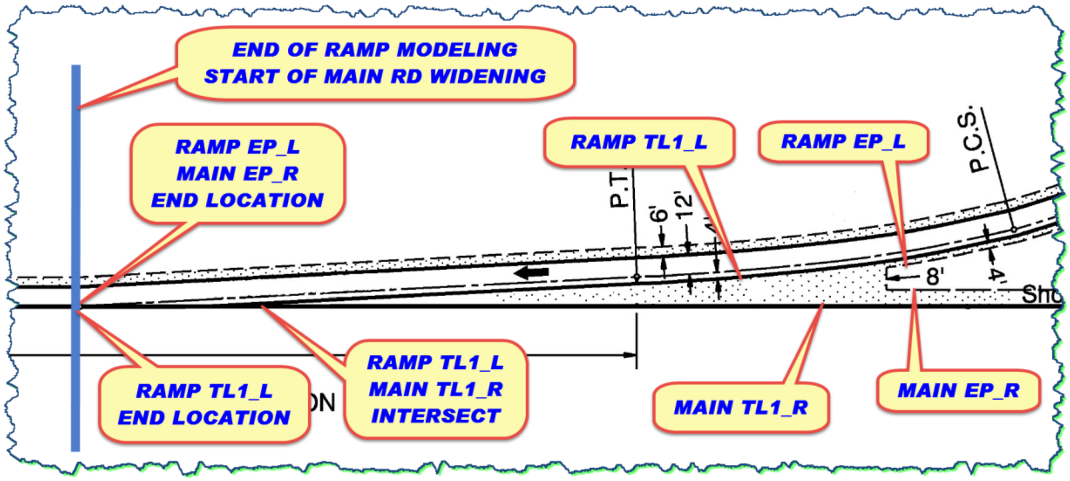
4) [**Close**] and [**Save**] the **TEMPLATE LIBRARY** and open the **ROADWAY DESIGNER**.
5) Set the **`D2-Line`** as the active **Corridor** and **Synchronize with Library** to pull that template modification into the IRD.
6) [**Change**] the **END CONDITION EXCEPTION** inside of the Gore Area for the **`D2`** corridor to be **`57+35.001`**, slightly ahead of the station where the new point control feature ends (**`57+35`**).
7) Now repeat the previous steps for the Main Road Template (**`L_NB_Rt`**).
   - Add a new single segment Fill End Condition to the main road right side
   - Verify the End Condition Priorities and be sure the newly created EC is set to Priority #1
   - Synchronize the **`L-NB-Line`** **TEMPLATE DROP** with the Template Library
   - Edit the **END CONDITION EXCEPTION** to allow the point control to work until the end of the feature (main road station = 1181+53.045)

Gore Controls

Considering the gore modeling, several things need to be thought-out at this stage; namely, both roads contain a shoulder and a traveled way that will need to merge, as well as match grade-wise. There are other ways to approach this and you are expected to take these techniques and apply them to your models, incorporating the project design intent into your future modeling.

A few technical details about this area are (make sure that you understand these and agree):

- The ramp and main road **`EPs`** merge in with the grading between the two traveled ways
- The paved gore grading is a planar connection of the ramp **`TL1_L`** and main road **`TL1_R`**
- There is a location where the ramp **`TL1_L`** and the mainline **`TL1_R`** meet. At this location, the travel lane structural section for the ramp should not extend (paralleling the ramp centerline). If it did, then the travel lane section would overlap into the main roadway. Therefore, the ramp **`TL1_L`** has to terminate at that intersection.



Here is what will be done:

a. The **EP_R** of the main road will have a **POINT CONTROL** that will attach it to the **EP_L** of the ramp, tying the two roads together horizontally and vertically (this is shown in an earlier illustration). This will continue until the end of the ramp modeling.

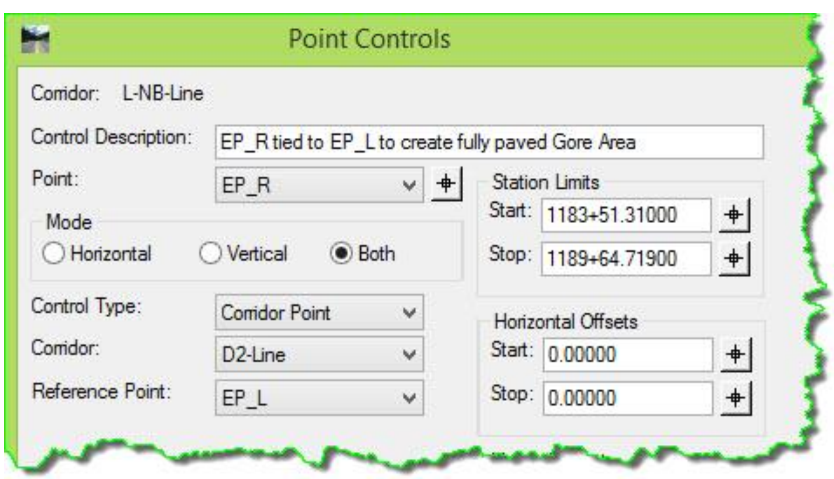
b. The **EP_L** of the ramp converges into **TL1_L**, so a **PARAMETRIC CONSTRAINT** will be assigned to it so that it moves to a 0.00′ distance from the ramp **TL1_L**. This will continue until the end of the ramp modeling, at which point the new main road widened section takes over.

These two steps will create a straight slope from the ramp **TL1_L** to the main road **TL1_R** from the start of the paved gore until the ramp travel lane intersects with the main road travel lane.

c. The ramp **TL1_L** will have a **POINT CONTROL** attached so at its intersection with the main road **TL1_R**, it will connect and travel along **TL1_R**, terminating at the end of the ramp.

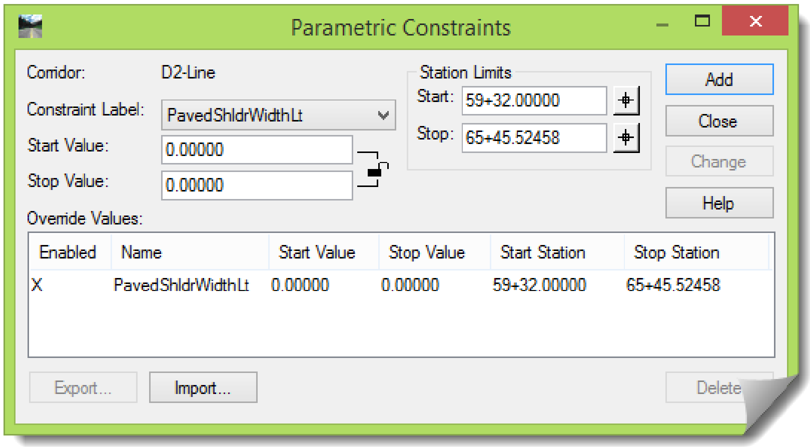
Adding the Controls

1) [**Add**] a horizontal and vertical **POINT CONTROL** on the **EP_R** of the main road from **Station** 1183+51.31 to the end of where the ramp model terminates, **Station** 1189+64.719, tying it to the **EP_L** of the ramp corridor to create the fully-paved gore area.



Next will be reducing the ramp shoulder width at the start of the paved gore until the end of the ramp.

2) On the ramp corridor, [**Add**] a **Parametric Constraint** to the **`PavedShldrWidthLt`** in order to change the **`EP_L`** width to 0.00' from the start of the paved gore until the end of the ramp (**Station** <u>**`59+32.00`**</u> to the end of the alignment).

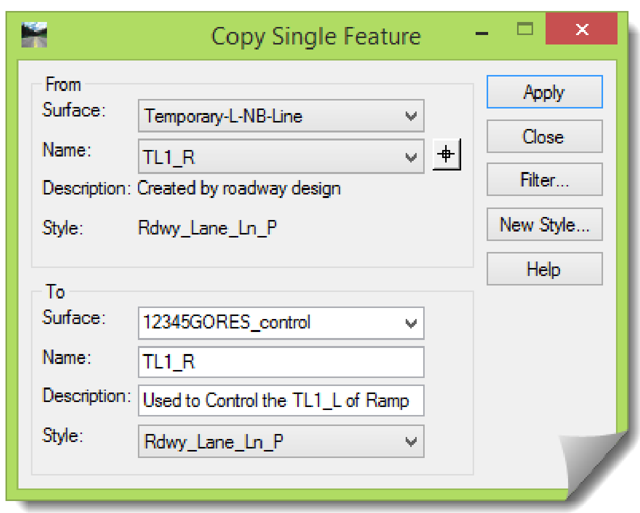


These previous two actions addressed the paved gore area between the two roadways.

This next step will address the ramp travel lane.

3) Close, move, or collapse the **Roadway Designer** for the moment.
4) Using an **Edit Surface** tool, copy the **`TL1_R`** feature from the temporary main road surface (**`Temporary-L-NB-Line`**) that we created earlier to the **`12345GORES_control.dtm`** so that we can assign a Feature-based **Point Control**.

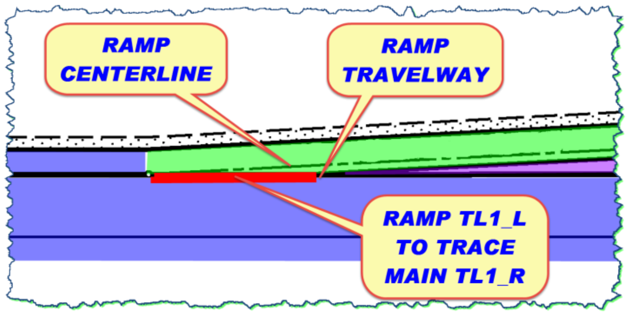
This is required because we already have a **Corridor**-based **Point Control** on the main road corridor, so this functionality is unavailable on the ramp corridor.

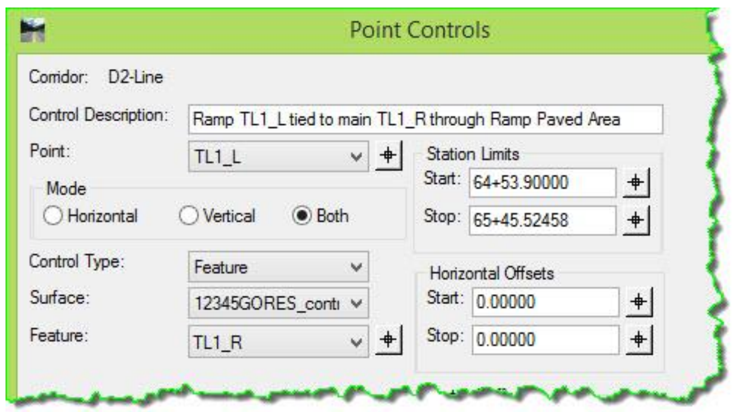


5) Get back into the **Roadway Designer**.
6) [**Add**] a **Point Control** to the ramp **`TL1_L`**, attaching it to the **`TL1_R`** feature just copied.

This will both horizontally and vertically control it from the intersection point of the **`TL`**s to the intersection of the ramp centerline and main road **`TL`** at the end of the ramp.

This addition will create a point control conflict with the <u>**`TL1_L`**</u> Superelevation control. This can be addressed by either using **Priority** or editing the Superelevation **Stop Station** to <u>**`64+53.90`**</u>, since the main road controls in this area anyway.



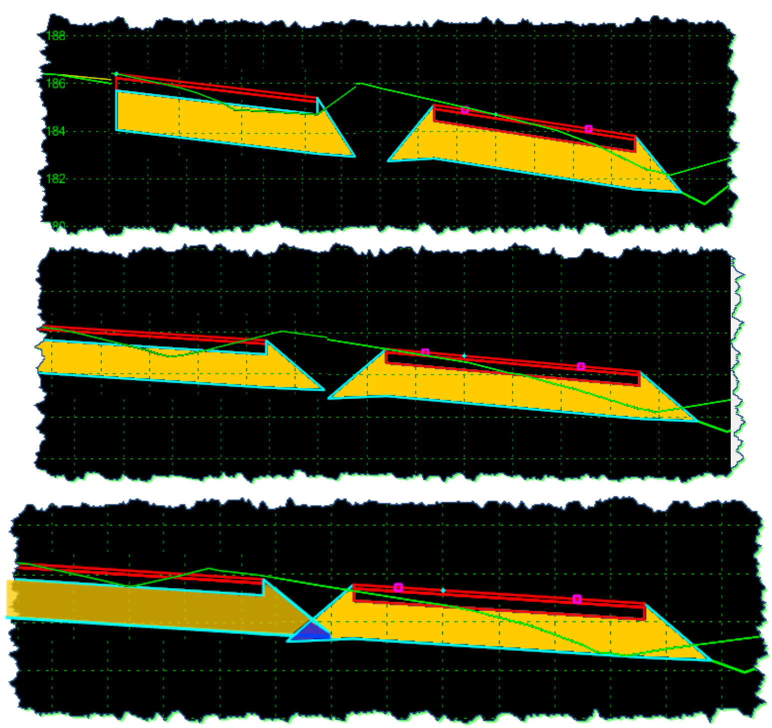


Aggregate Base Course

Most of the work that has been done so far is dealing with the finished grade, and the matching between the ramp top surface and main road.

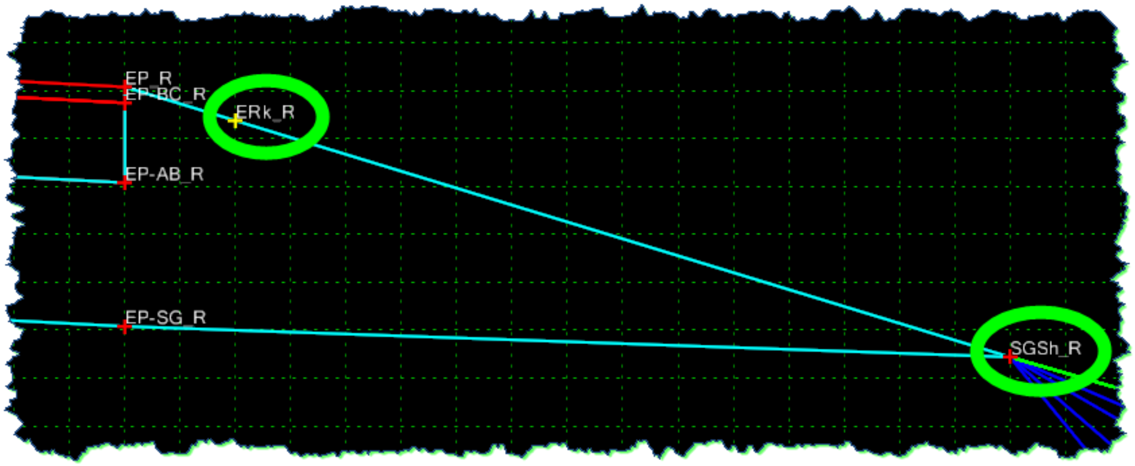
However, another area that requires some attention is the structural section of the ramp as it converges with the main roadway.

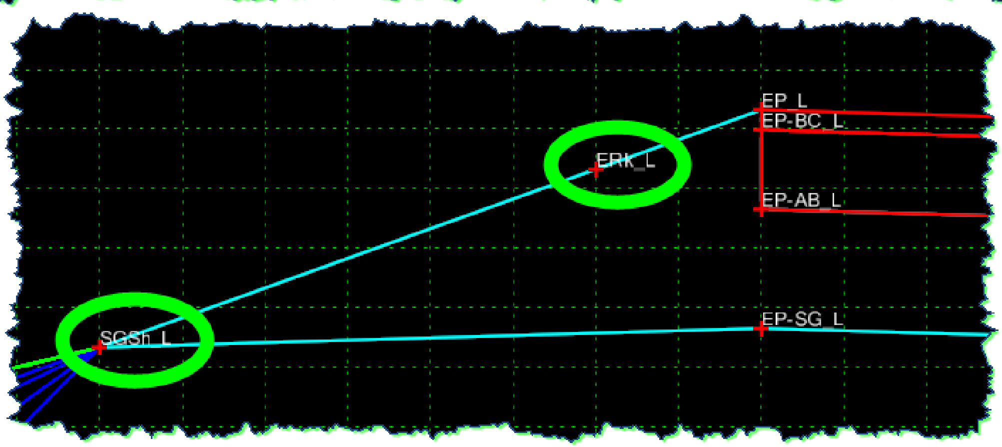
There is a location where the subgrades first touch, and then overlap.



Depending on the structural section of the roadways, their cross slope, and other factors, this may be addressed uniquely in different instances.

In this example, this will be addressed by utilizing point controls on these Rock Shoulder Aggregate Base points on both the main road template (**`L_NB_Rt`**) and the ramp template (**`D2_Normal`**).

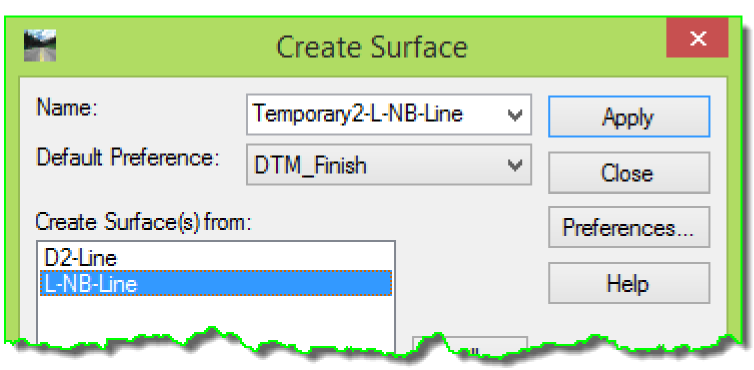




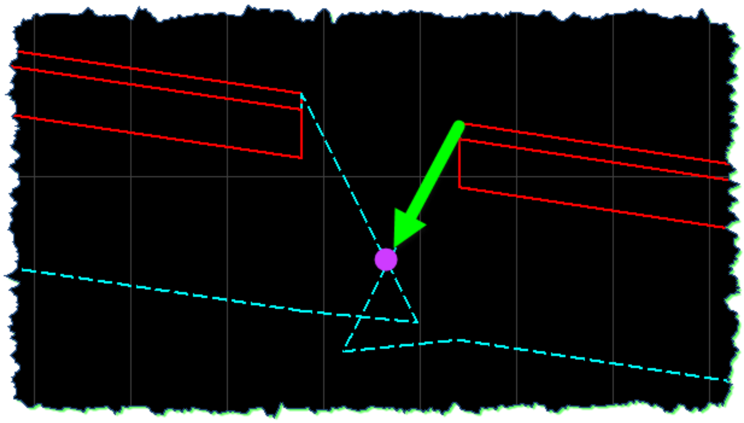
Since both corridor shoulders have a width that will overlap when the two corridors merge, **POINT CONTROLS** will be used to "pull" both of those sloped edges inward while making sure that the rock shoulders actually merge and don't overlap.

To establish the breakline that will be controlling these Aggregate Base points, we will need to generate a couple temporary surfaces that we can use to extract the breaklines for controls.

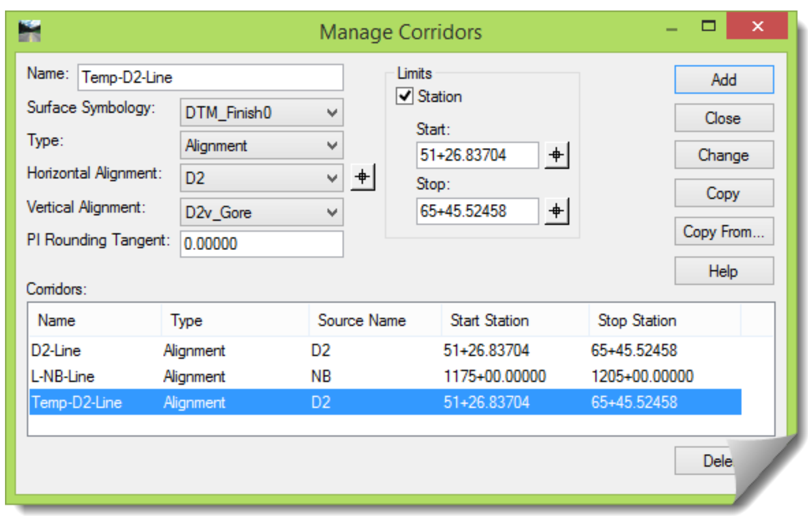
1) First, create a surface from the main road corridor (**`L-NB-Line`**). This surface will be used as a pseudo target for the ramp in an upcoming step.



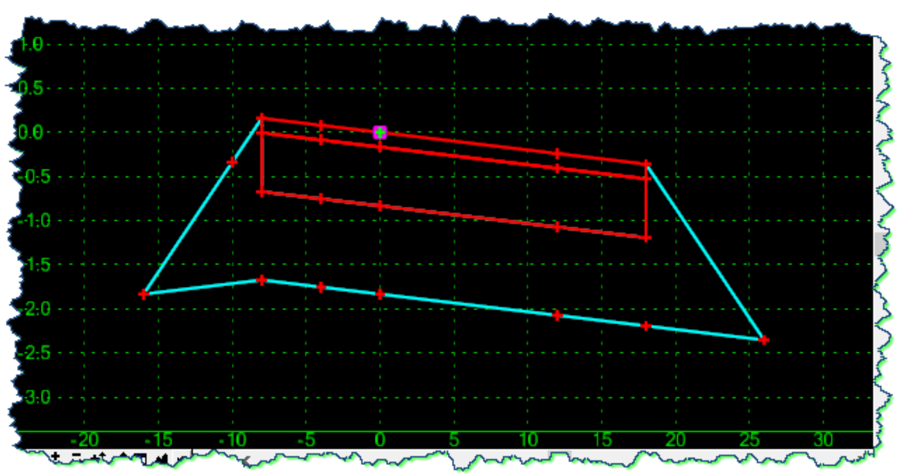
The upcoming steps will create a temporary **Corridor** for the ramp. The purpose of this corridor is to run it against the temporary **`NB`** surface just created. The goal is to determine where a projection of the **`AggBase`** slope of the ramp will intercept the **`AggBase`** slope of the main road. This location will be used as a control to merge the ramp and main road **`AggBase`** components.



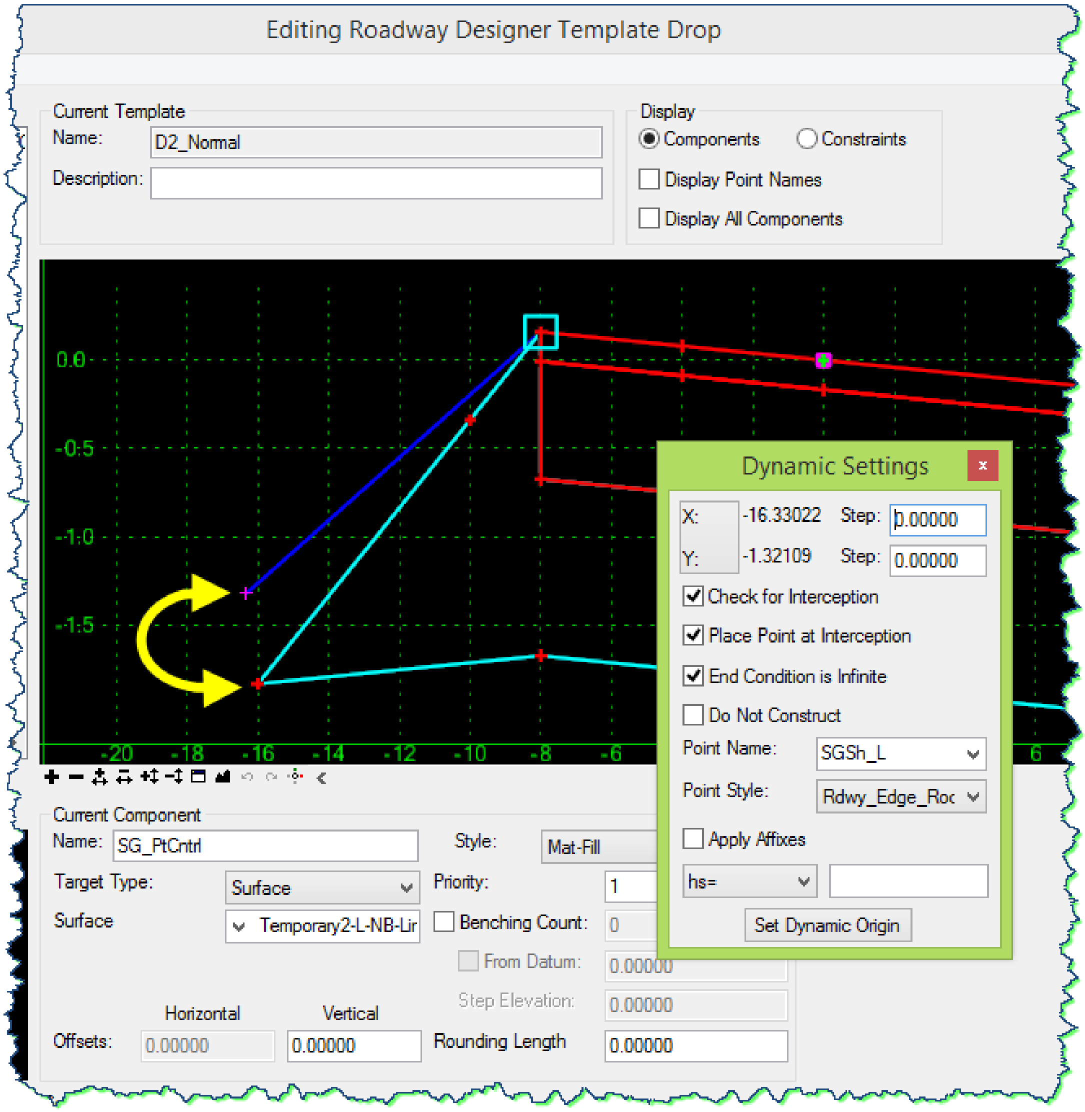
2) [**Copy**] the **`D2-Line`** corridor and name it <u>**`Temp-D2-Line`**</u>.



3) [**Edit**] the **`D2-Line`** **TEMPLATE DROP** by deleting out all of the ECs.

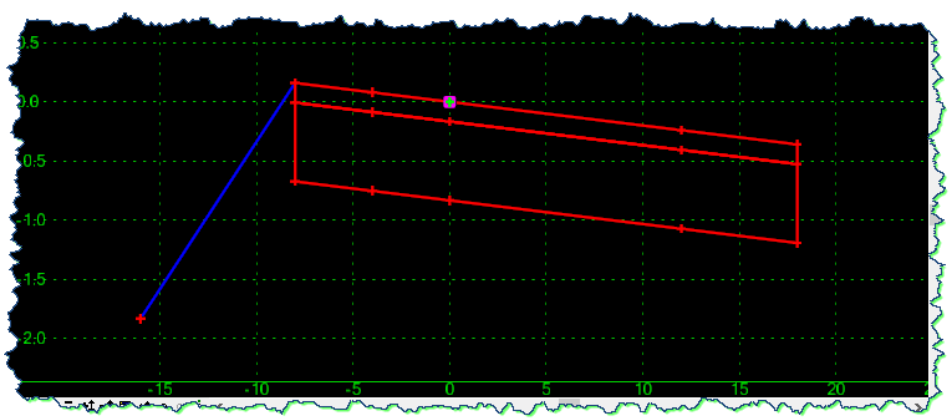


4) Add an **EC** to the ramp left side, starting from the `EP_L` point and ending at `SGSh_L`.

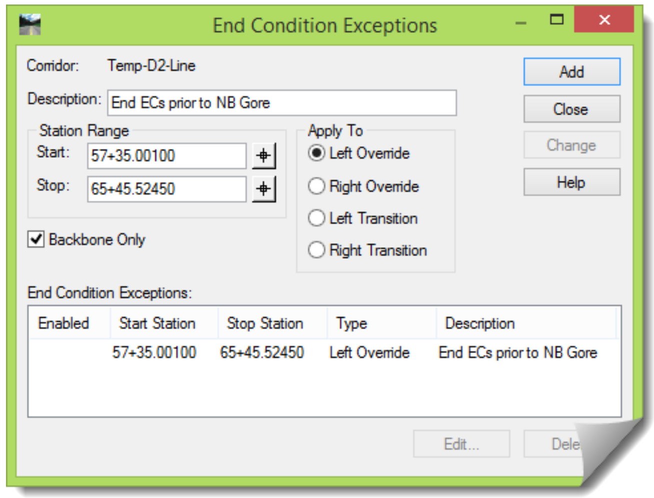


5) Now **Delete** the `AggBase` component.

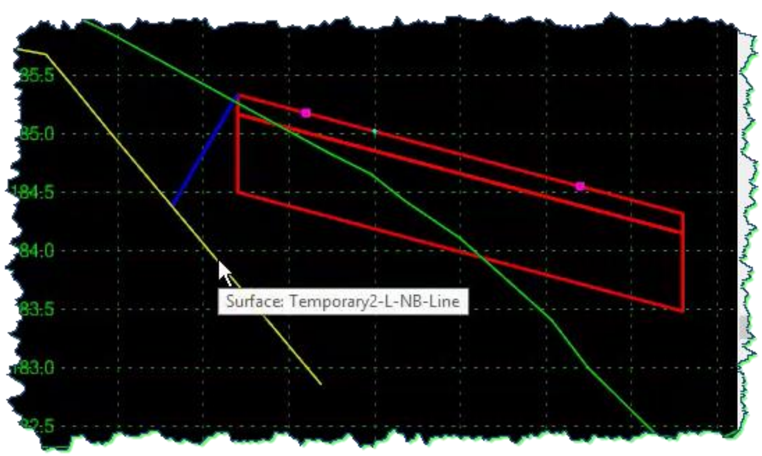
6) Rename `SGSh_L` to `SG_PtCntrl` and constrain it to the `EP_L` with **Horizontal** and **Slope Constraints**.



7) Disable the **End Condition Exceptions** on this temporary ramp **Corridor** by clicking off the **ENABLED** toggle. You can also just select and [**Delete**] this entry.

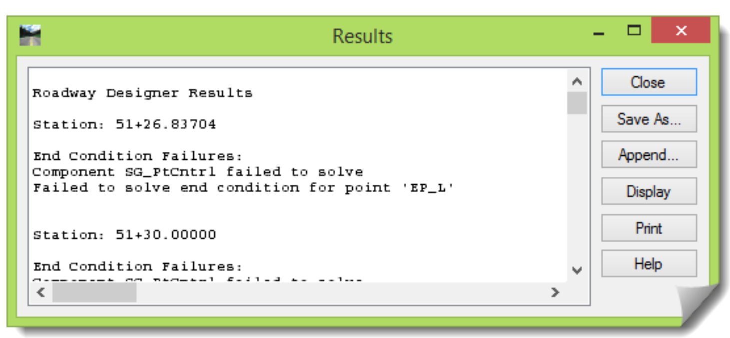


8) Feel free to review the **ROADWAY DESIGNER** cross section view to verify that it's working.



9) Go to **CREATE SURFACE**, select the **`Temp-D2-Line`** corridor, and [**Apply**] to create the **`Temp-D2-Line`** surface.

There will be failure **RESULTS** that appear since the temporary main road is not always within intercept distance.

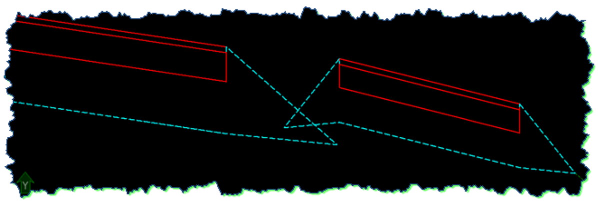


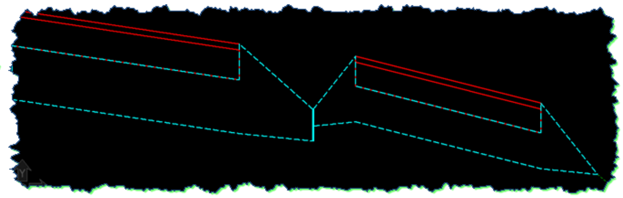
10) Either move or [**Close**] the **ROADWAY DESIGNER** for the moment.

11) Copy the **`SG_PtCntrl`** breakline feature from the **`Temp-D2-Line`** surface into the **`12345GORES_control.dtm.`**

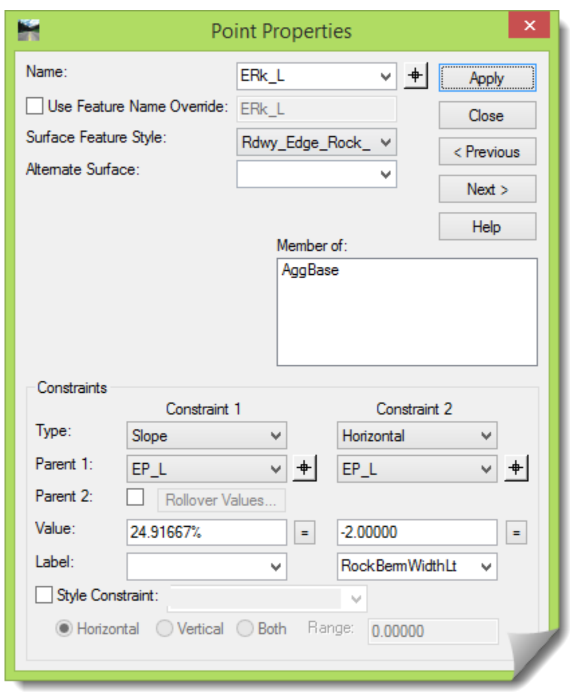
This feature will be used only as a horizontal control so the small kink near station 59+32 can be removed and the control line straightened out and ended at that station.

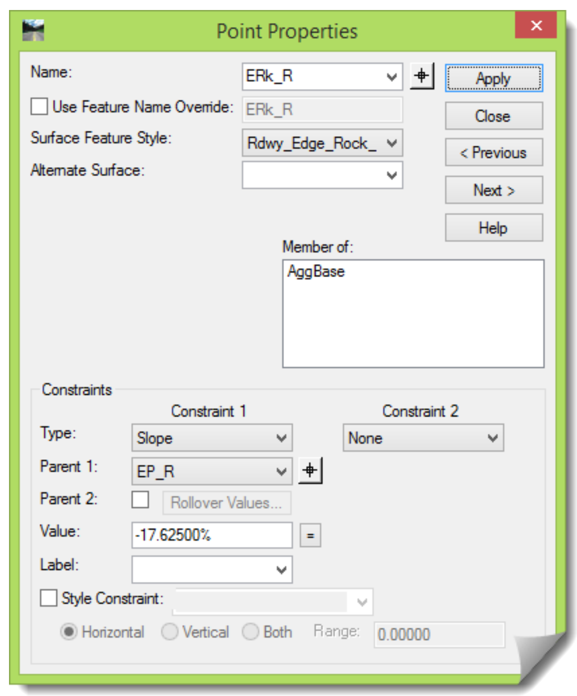
The way that the rock shoulders will merge when the two corridors come together will require the three-point shoulder wedge to morph into a four-point shoulder shape. **POINT CONTROLS** will be assigned to the **ERk** and **SGSh** points on both corridors to create this merging.





The key to getting the point controls to work as expected is to understand the point constraints on each of the points in question. Let's look at the **ERk** point on both templates.





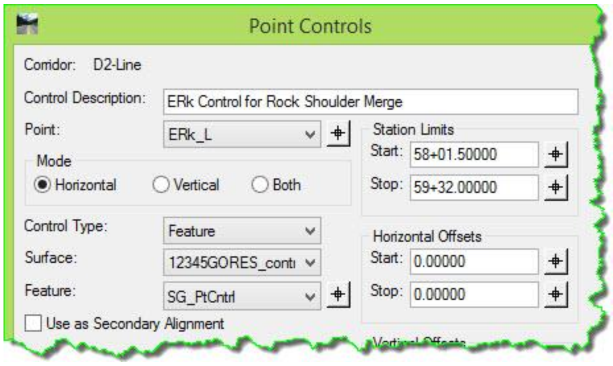
The **ERk** points on both templates (**D2_Normal** and **L_NB_Rt**) have a **Slope Constraint** with the **EP** point as the **Parent**. This is important for the modeling, because the design criteria for the rock shoulder requires it to maintain its slope from the **EP** point as it merges.

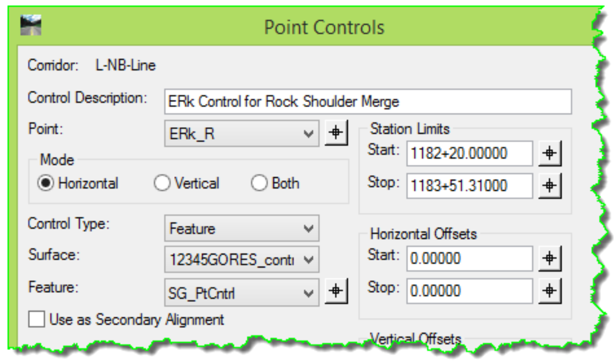
As far as the point control is concerned, these points only need to have a Horizontal control that moves this point left or right. This type of point control will allow these points to maintain their point constraint and it will move left or right along that slope as set in the template.

Adding AggBase Control

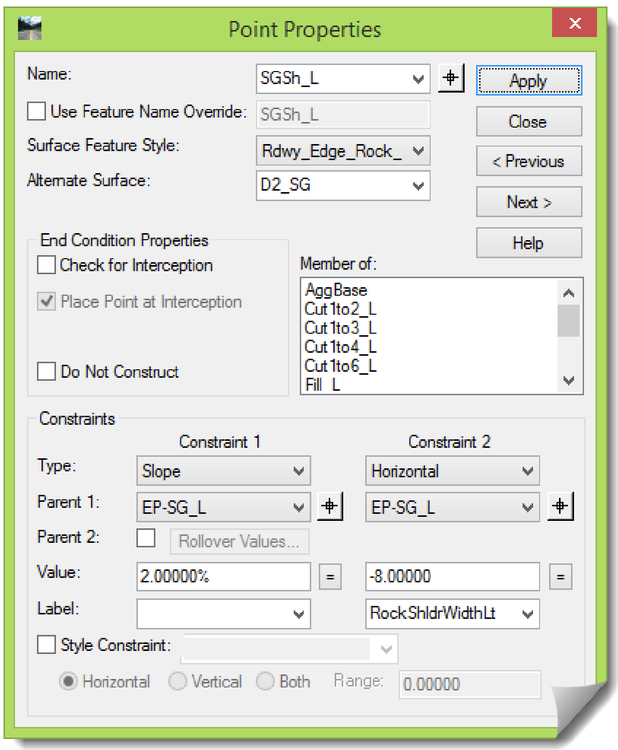
1) Open the **ROADWAY DESIGNER** and create **Horizontal POINT CONTROLS** for each of the **ERk** points, using the **SG_PtCntrl** feature as its control.

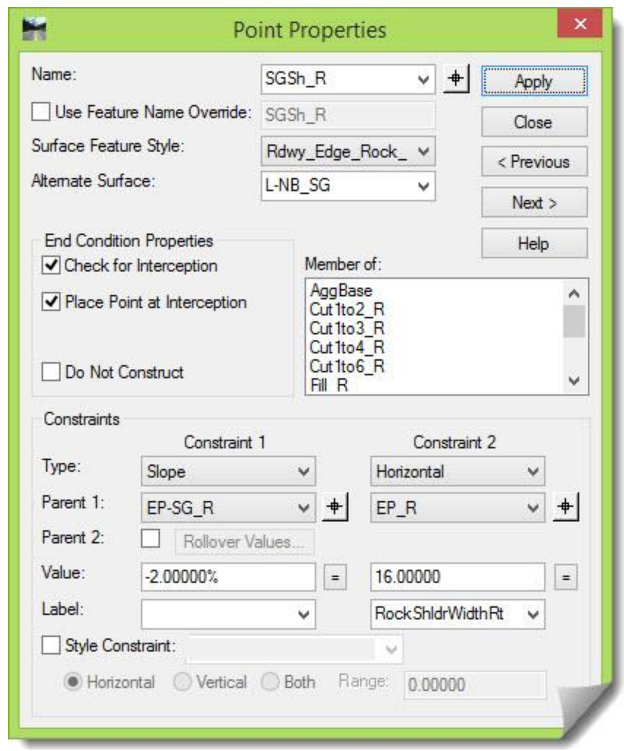
A set of cross sections is used to determine the start station, and in this case it is approximately 1182+20 for the main road. The corresponding station for the ramp will be approximately 58+01.50. The stop stations will be the station where the 8' paved gore begins.





Now let's look at the bottom of the rock shoulder, point **SGSh**.

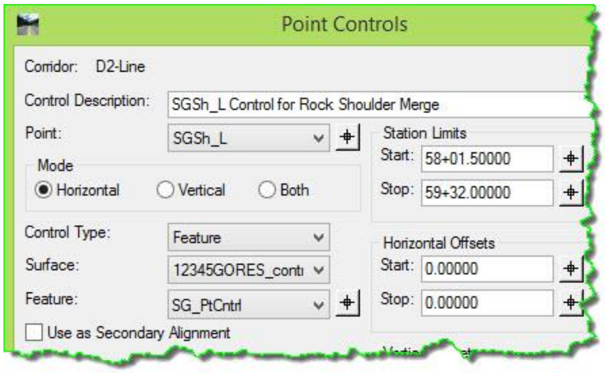


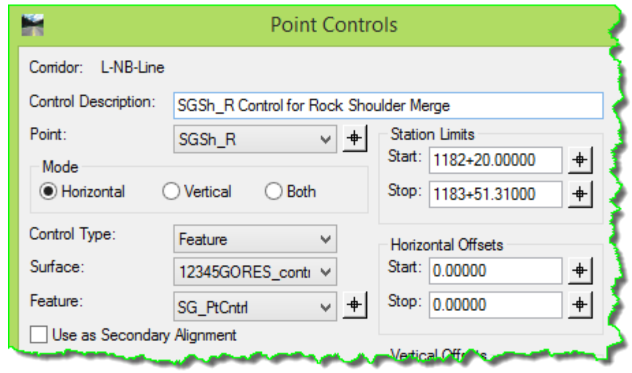


These points are fully constrained with a **Horizontal Constraint** and a **Slope Constraint**. The **Slope Constraint** has a **Parent** point that falls directly beneath the **EP** point. This will allow us to use a **Horizontal Point Control**, which will override **Constraint 2** (the **Horizontal Point Constraint**) while still maintaining the **Slope Constraint**. In effect, what this will do is keep the **SGSh** point on the bottom of the aggregate base layer while adhering to the bottom slope criteria, and still move left or right through the merge area as needed.

2) Create **Horizontal Point Controls** for each of the **SGSh** points, using the **SG_PtCntrl** feature as its control. The **Start** and **Stop Stations** will be the exact same as the **ERk** points that were just set up.

TIP: Knowing how the **Point Controls** dialog works, can simplify the creation of similar point controls. By selecting a **Point Control** entry in the bottom list window, making the necessary changes on the top, and then clicking [**Add**] will speed up entry.



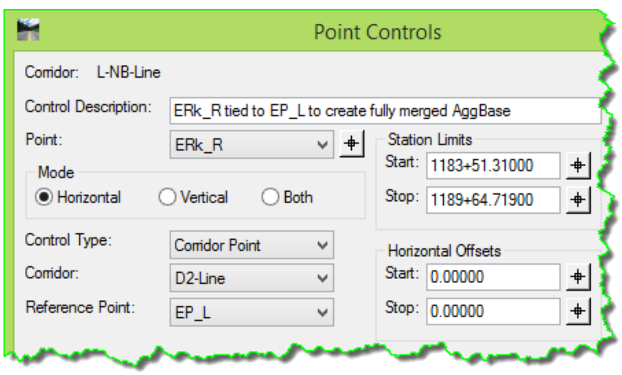


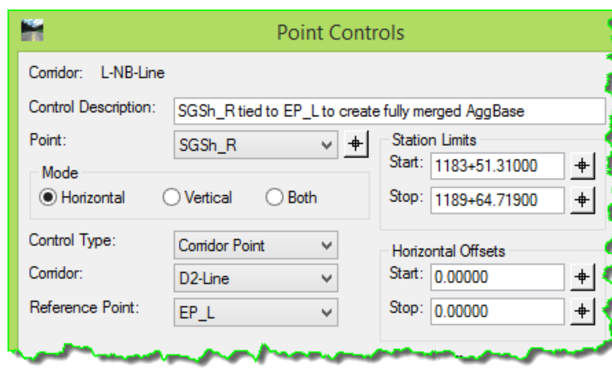
The final step to managing the aggregate base shoulder through the merged area is addressing the portion where the pavement of the two corridors is merging.

This would be station **`59+32`** to **`65+45.525`** (the very end of the ramp modeling) and station **`1183+51.310`** to **`1189+64.719`** on the main road. Each of the corridors will handle their aggregate base points differently.

Since the main road **`EP`** is merging with the location of the ramp **`EP`** via a **Corridor Point Control**, we will use that same technique for the main road shoulder aggregate base points.

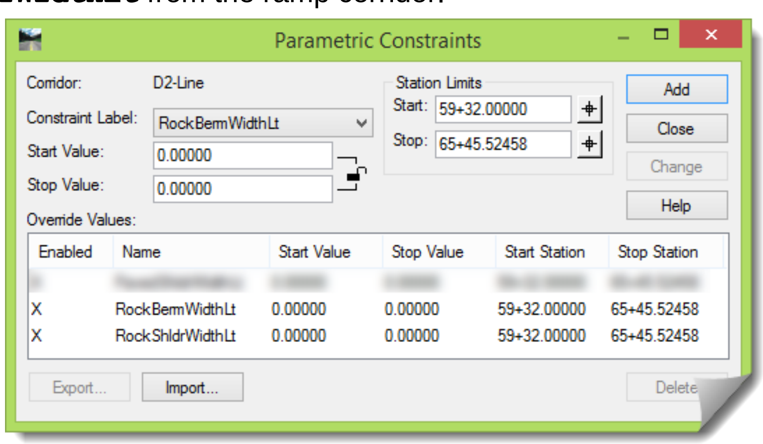
3) [**Add**] these **Point Controls** to address the main road **`AggBase`** shoulder in the paved gore area.





For the ramp **`AggBase`** shoulder points, their **Labels** with a **Parametric Constraint** will be used to adjust the widths so the points are horizontally lined up with the **`EP_L`** point above them.

4) [**Add**] these two **Parametric Constraints** to remove the **`RockBermWidthLt`** and **`RockShldrWidthLt`** from the ramp corridor.



On your project, you will need to determine the exact **Start** of the **Station Limits** of all these various **Point Controls** and **Parametric Constraints** by reviewing your cross sections or seeing where the **SGSh** surface features intersect in plan view.

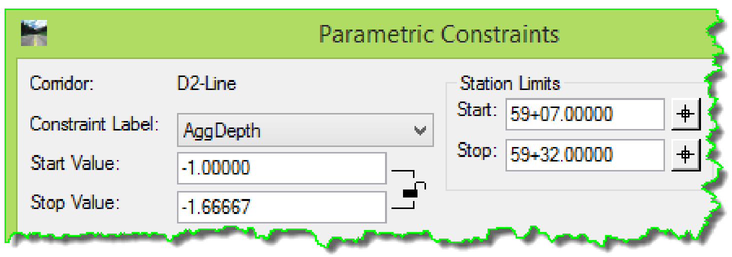
The last part of the aggregate base edits will require matching the bottom of the ramp aggregate to the main road aggregate (subgrade) where they merge, and the corresponding rock shoulder slope on the right side to maintain the 1:4 nominal slope as the aggregate gets thicker.

It has been determined that this transition will occur over **25'** and should be complete by the time the paved gore begins. This means that at station **59+07**, the ramp will begin to transition its aggregate depth to match the main road, and end at station **59+32**.

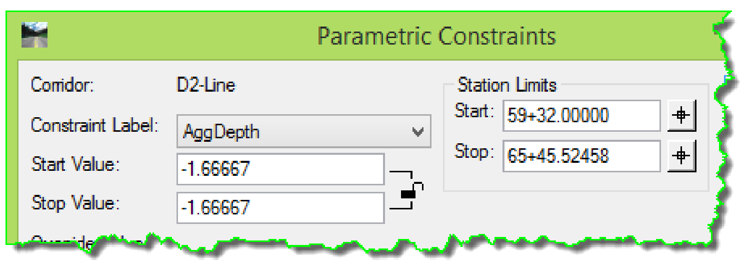
Because the structural sections between the main road and the ramp are different (including the AC) and only the aggregate base depth will be adjusted, we need to account for the difference in AC depth as well in order to match subgrade at the paved gore.

In this project the main road is **12″** of AC over **18″** of aggregate, while the ramp is **10″** of AC over **12″** of aggregate. That means the depth of aggregate will need to transition from **12"** to **20"** (**6"**AB + **2"**AC).

5) **[Add]** a **Parametric Constraint** to transition the **AggBase** from <u>**12"**</u> to <u>**20"**</u> from Station <u>**59+07**</u> to <u>**59+32**</u> of the ramp corridor.

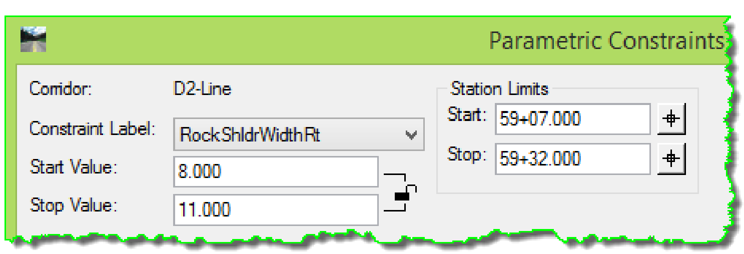


6) **[Add]** a **Parametric Constraint** to continue the new **AggBase** thickness of <u>**20"**</u> from **Station** <u>**59+32**</u> to the end of the ramp modeling.

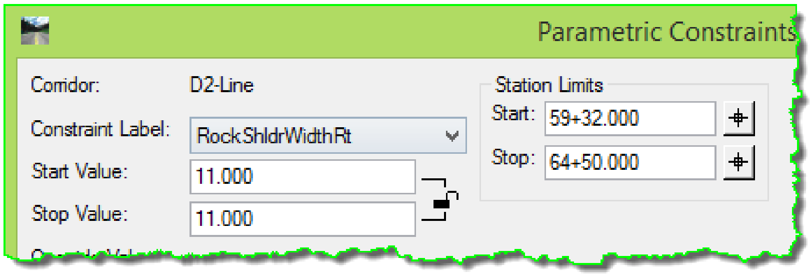


A **Parametric Constraint** will be added to the rock shoulder width on the right side of the ramp to maintain the proper slope. The shoulder width will go from **8'** to **11'.**

7) **[Add]** a **Parametric Constraint** to transition the **RockShldrWidthRt** from <u>**8'**</u> to <u>**11'**</u> from Station <u>**59+07**</u> to <u>**59+32**</u> of the ramp corridor.



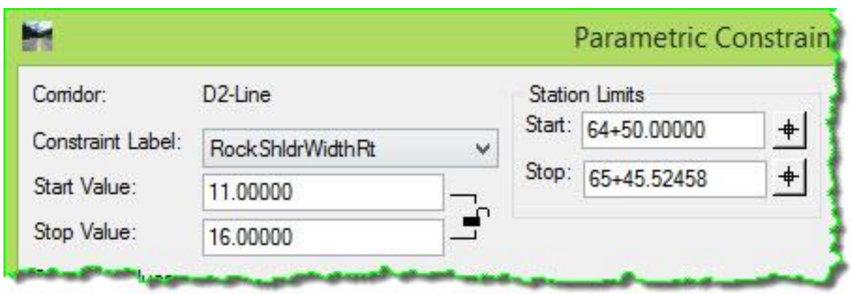
8) **[Add]** a **PARAMETRIC CONSTRAINT** to continue the new **RockShldrWidthRt** width of **11'** from **Station 59+32** to Station **64+50** (the reason for this station will be evident in the next section).



Additional Controls

At the end of the ramp modeling where the main road widened template is dropped, the difference in the width of the rock shoulders has to be addressed.

1) [**Add**] a new **PARAMETRIC CONSTRAINT** on the ramp for the **Label RockShldrWidthRt**, from **Station 64+50** to the end, transitioning the width from **11.00'** to **16.00'**.



Key Stations

The last part will be to add strategic **KEY STATIONS** to the main road and ramp corridors to ensure that the template drops carry through to the next modeled station.

Because of the skew of the ramp relative to the main road, and the fact that the focus is really at the intersection of the outer ends of these two models in the gore area, this work requires a few more **KEY STATIONS** than other types of modeling.

1) Add the following **KEY STATIONS** to the corridors as noted:
   - Main Road:
     - **1180+03.670** (end of normal ECs / before the start of the point controlled ECs)
     - **1183+51.309** (slightly before the pavement merge at the gore)
     - **1183+51.311** (slightly after the pavement merge at the gore)
     - **1183+51.574** (slightly after the pavement merge at the gore, due to skew)
     - **1189+64.723** (right before the template drop at **1189+64.72417**)
     - **1189+65.250** (added model density as it merges with the ramp)
     - **1189+65.510** (at the outer Ramp model point on the widened template)

- Ramp:
  - 55+89.900 (end of normal ECs / before the start of the point controlled ECs)
  - 59+31.990 (slightly before the pavement merge at the gore)
  - 59+32.010 (slightly after the pavement merge at the gore)
  - 65+42.500 (added model density as it ends and merges with the main road)
  - 65+44.000 (added model density as it ends and merges with the main road)
  - 65+44.500 (added model density as it ends and merges with the main road)

Some of the above stations were added after the first corridor model was created and reviewed. As you will see in Module 13, Intersections, there is often a high likelihood when doing modeling such as this, that you will have to create a surface, review it, and return to the Roadway Designer to add modeling refinements such as additional **Key Stations**.

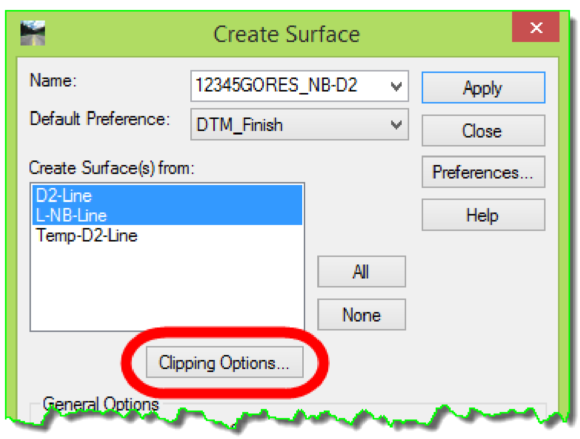
The subject of precision and significant digits can also come into play here. This is discussed further in Module 13.

The stationing of **Template Drops**, **Parametric Constraints**, **Point Controls** and **End Condition Exceptions** may need to be adjusted slightly (+/-0.01 or less), to account for any rounding that may occur while using the "snaps" to select stations or while trimming features used for control.

Final Design Surface

The last section in this module will be to create the final composite surface model and review the results. Based on the review, it may be necessary to return to the **Roadway Designer** and make some modifications to the appropriate corridor. Also, be aware that the ECs leading up to the gore will need to be cleaned up and transitioned into the new slope created with the point control.

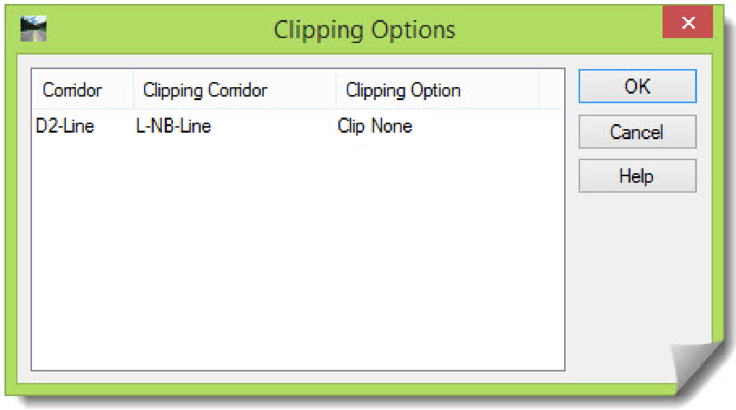
1) Go to the **Create Surface** tool and set it up as usual.
2) Under the **Create Surface(s) from:** area, click on the **Clipping Options…** button.



Whenever surfaces overlap or **Target Aliasing** is used, the **Clipping Options** can be applied for trimming purposes. These options will use one of the corridors as the model to be trimmed, while the other corridor identified here will be used as the trimming edge.

3) Set the **Clipping Option** to **Clip None** and then [**OK**] to exit that dialog box.

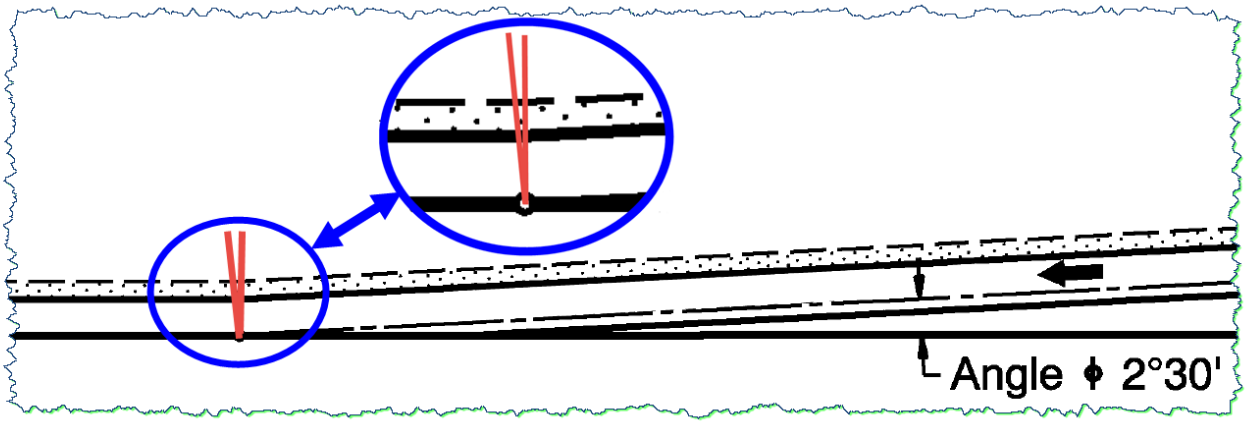
The **Clipping Options** cycle through the three different options (**Clip None**, **Clip All**, and **Clip End Conditions Only**) as you select that area below the header.



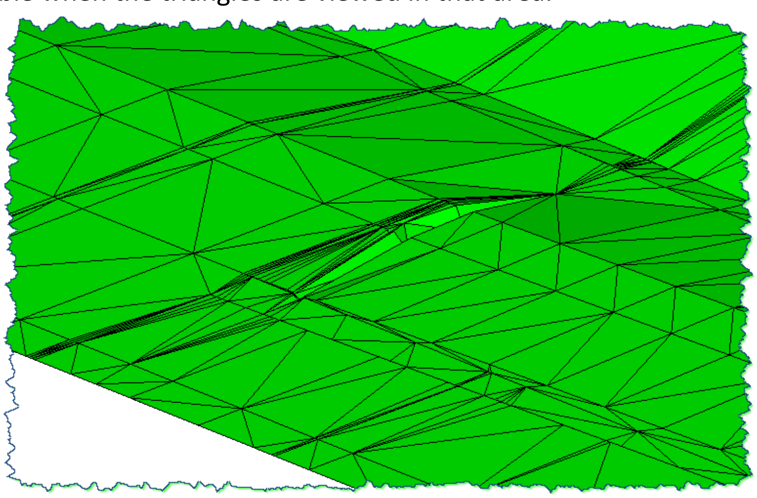
4) Create a single ramp and main road combined surface from **ROADWAY DESIGNER** called **`12345GORES NB-D2`**.

5) [**Save**] the IRD and review the results of the design surface.

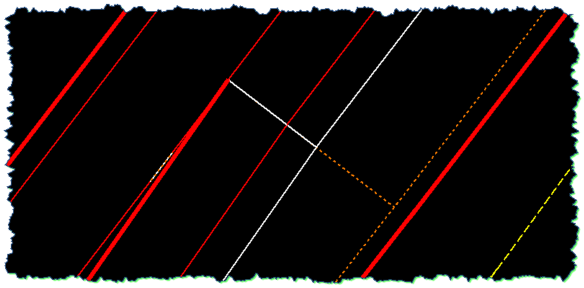
One area to take special note of is the location where the two models come together at a two and half-degree angle. There are features created at this location that will need to be cleaned up.



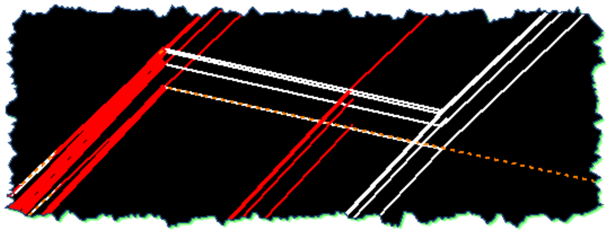
This is noticeable when the triangles are viewed in that area.



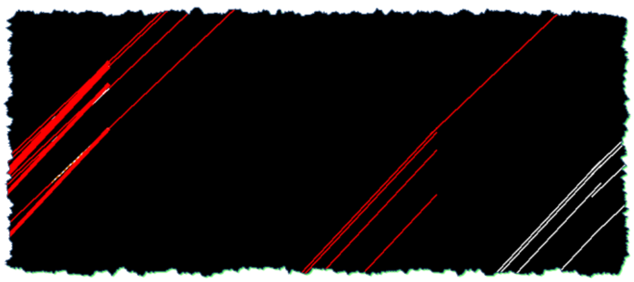
The problem is also visible when viewing the features in that area.



A rotated view reveals the breaklines requiring cleanup.

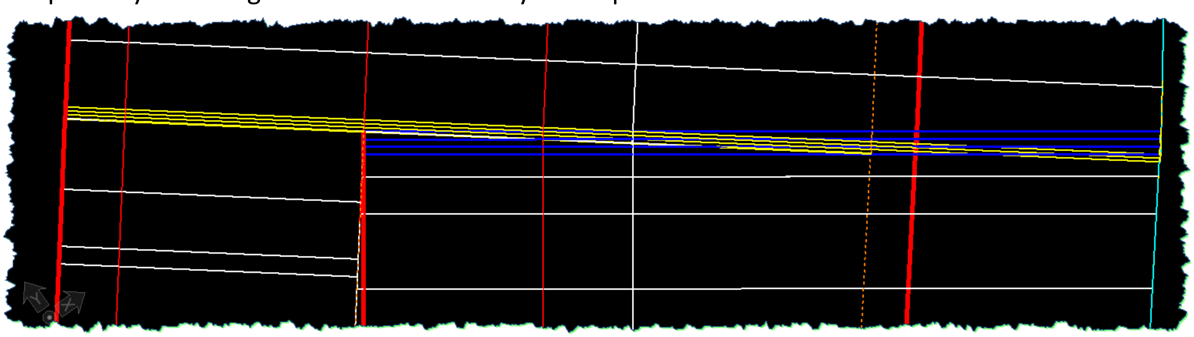


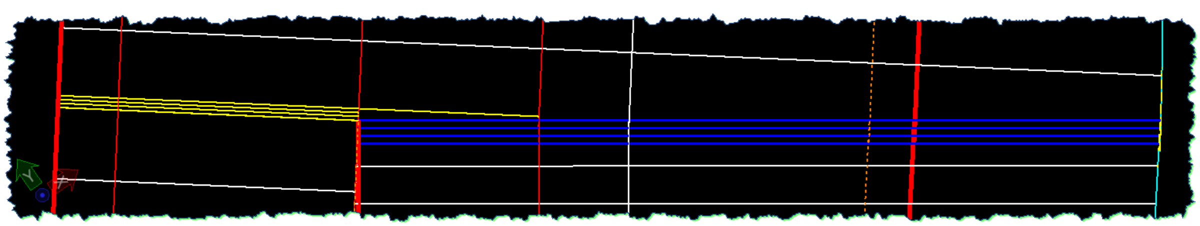
6) **PARTIAL DELETE** any breaklines running transverse to the roadway that are causing triangulation issues. (**`L-NB-Line-EP_R`**, **`L-NB-Line-SGSh_R`**, **`L-NB-Line-EP-SG_R`**, **`L-NB-Line-EP-AB_R`**, and **`L-NB-Line-EP-BC_R`**)



7) Appropriately address the conflicting **Transverse Features** by either deleting or trimming them from the model in the area of the overlap.

These can be addressed in various ways including either completely deleting certain breaklines, or partially trimming them to eliminate any overlap.

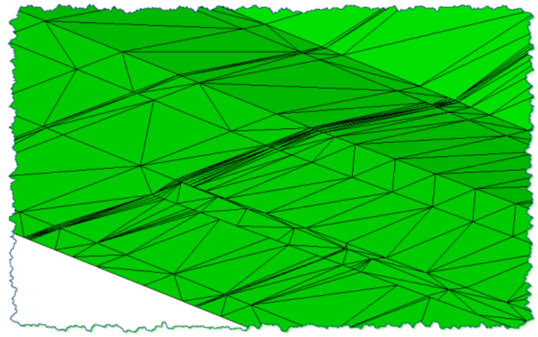




8) Trim any other overlapping features (**SGSh_R**, **Dch_R**, **SSC_R**).

The exact features that need to be modified will be project specific.

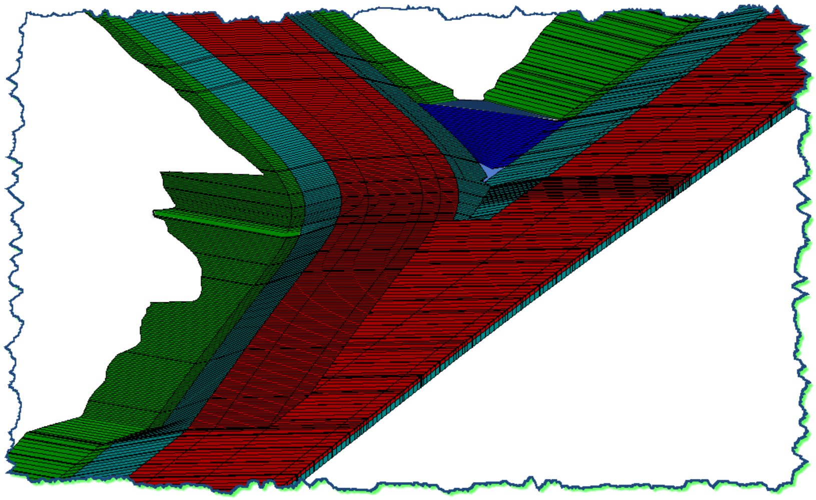
The triangulation conflicts should be resolved in this area now.

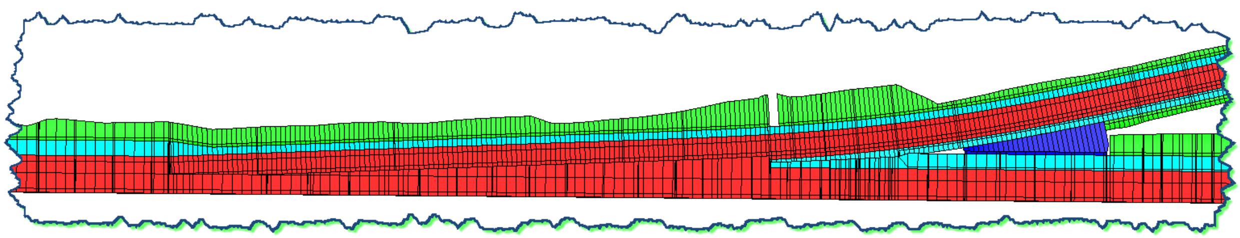


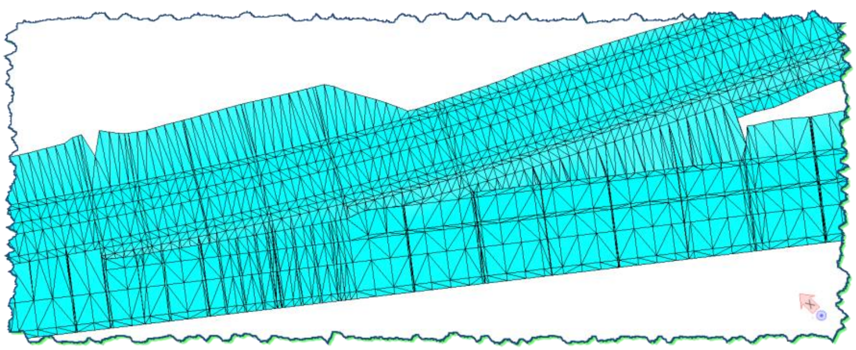
Other areas of this model may also require some additional editing, but as this is done also keep in mind the specifics of the overall drainage patterns of the grading leading into the gore.

The general technique is to view the triangles of the surface, scan for any triangulation issues, find the offending breakline and edit the breakline to remove the problem found. The features should also be viewed to check for issues not readily apparent from the triangulation.

9) [**Save**] the new design surface along with any other InRoads data.







CLEAN UP DISCUSSION

The process described in this module is the general approach to gore modeling. This however, is not the definitive cookbook for every gore-modeling scenario. Because of the wide range of project-related variables, there will always be unique aspects that will have to be addressed on a case-by-case basis. These include:

- Key Station locations
- End Condition Exception locations
- Point Control locations
- Parametric Constraint locations

Beyond the uniqueness of the items above, there will be varying levels of clean up and model refinement. This may occur in the following transitional areas:

- Where the normal ECs end and the 'controlled' ECs begin
- Where the 'controlled' ECs end and the End Condition Exceptions begin
- Where the subgrades change from a typical state to a 'controlled' state
- Where the ramp modeling abuts to the main road corridor

The areas identified above might require post-modeling feature edits, Point Control modifications, additional transition modeling, or even the addition of new Parametric Constraints to improve the modeling 'smoothness'.

One specific area of clean up that deserves special mention is the mainline shoulder at the paved gore. Since a Point Control was applied to connect **TL1_R** of the mainline to **TL1_L** of the ramp, the shoulder cross slope abruptly changes. Some ways to address this are editing the Superelevation Control of the shoulder to transition the cross slope leading up to the paved gore; revising the limits of the Superelevation Point Control for the shoulder through the transition area combined with adding a Parametric Label and Parametric Constraint to vary the cross slope; or revising the ramp profile so that the cross slopes match. Another option, of course, is to simply break the cross slope at the **EP** points instead. In situations where there is less flexibility to alter the profile and cross slope of the mainline or ramp due to project constraints, additional features or alignments may be needed to control the grade breaks through the paved gore.

Other Specific Modeling Items

Here are a few other steps that you can consider to further refine the modeling described in this module in the area leading up to the gore:

- When creating the temporary D2 corridor to generate the **SG_PtCntrl** feature, use a template drop interval of 1' instead of 5' to create a "tighter" feature
- Trim the **Dch_R** feature at **57+10** instead of **57+35** after seeing where the **SG_PtCntrl** feature ends (and add a **KEY STATION** for the corresponding mainline station)
- Edit the **SG_PtCntrl** feature to remove the discontinuity and eliminate the "jog" near the paved gore (draw a guide line to assist with snapping vertices to new locations)
  - The **SG_PtCntrl** feature is only used to control the horizontal location of the template points so the vertical location is not critical
  - If vertical control is also desired to define the ditch development starting at the paved gore, edit the elevations of the relevant vertices and update the **POINT CONTROLS** accordingly

- Trim the **SG_PtCntrl** feature at **59+32**
- Join the **Dch_R** feature to the **SG_PtCntrl** feature to create a single new control **Dch_R** feature
- Display **SGSh_R** from the **Temporary-L-NB-Line** surface and see where it intersects the new **Dch_R** feature
    - Use this station for the mainline Point Control start limits on the **SGSh_R** and **ERk_R** points and the **END CONDITION EXCEPTION**

ALTERNATE MODELING APPROACHES

There are alternative modeling approaches that can also be done. The "Completed Files" folder provided with the training files contains several InRoads files that demonstrate the items discussed below. You are encouraged to review them and try incorporating them as a supplemental exercise.

One alternative technique is adding a short alignment extension of the ramp horizontal and vertical, combined with PI rounding, to eliminate the need for post-modeling surface edits where the two corridors meet at the end of the ramp. This technique entails lengthening the ramp alignment parallel to the mainline so that it models a short piece of the acceleration lane. The length needed for this extension is dependent on the PI rounding value chosen. This technique creates a cleaner joint between the ramp corridor and the main road corridor by ensuring that the edges of the two corridors are nearly parallel. Currently these two models come together at a two and half-degree angle, creating overlapping features.

Another alternative modeling technique is adding template drops at strategic locations to introduce new point names for the same template point. As InRoads wants to automatically connect points with the same name, this can lead to triangulation issues when the feature location suddenly changes. At the end of the ramp corridor, the **EP_R** point of the mainline suddenly moves outward with the template drop for the acceleration lane and creates "crossing" breaklines. By purposely renaming the **EP_R** point with a new template drop at the start of the paved gore, this is avoided. Triangulation problems can also occur when a feature, such as **SGSh**, suddenly goes from being triangulated on the surface to running underneath the FG surface. In this case, a strategic template drop to rename the **SGSh** point is introduced at the location this occurs so that the triangulated **SGSh** feature is "broken" and will not be mistakenly triangulated as it moves underneath the FG surface.

Conclusion

Congratulations, you have completed the Gore design module and have gained yet another specific skill that can be used toward the development of a more complete design model with InRoads.

We leave you with our encouraging final thought – Do these modules with an attitude of application. Study them with the viewpoint that you are going to apply these new skills on your current or future project. Look into and beyond the exercise steps and motivate yourself to momentarily pause and consider past, present and future projects and how this information could be put into practice.