Module 07

RETAINING WALLS Using InRoads

Introduction

The actual design of retaining walls requires specialized experience and knowledge of both structural design as well as input from a geologist. InRoads is used to assist in this design process by providing information to these specialists in the form of horizontal wall location and conceptual geometric wall layout based on the design of the main roadway.

Once this initial 'theoretical' information is created by InRoads, the geologist and structural designer can use it to design the details of the required walls. This finalized wall design information can then circle back into InRoads providing harder values to refine the initial wall conceptual design, and allowing the model to more accurately represent the final condition.

ALERT: The geologist or geotechnical engineer may come back with a different wall type, requiring the roadway designer to create a new component. Regardless, much of the general process included in the module will be the same.

Purpose of this Module

The purpose of this module is to demonstrate modeling a retaining wall that will take into account the excavation area behind the wall and backfill material in addition to wall depth, batter, toe key-in, and work space using the ODOT retaining wall components.

Objectives of this Module

At the end of this module, you will be able to use InRoads to layout project-specific retaining walls that will represent project conditions developed by information provided by the Structural designer and Geologist.

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:

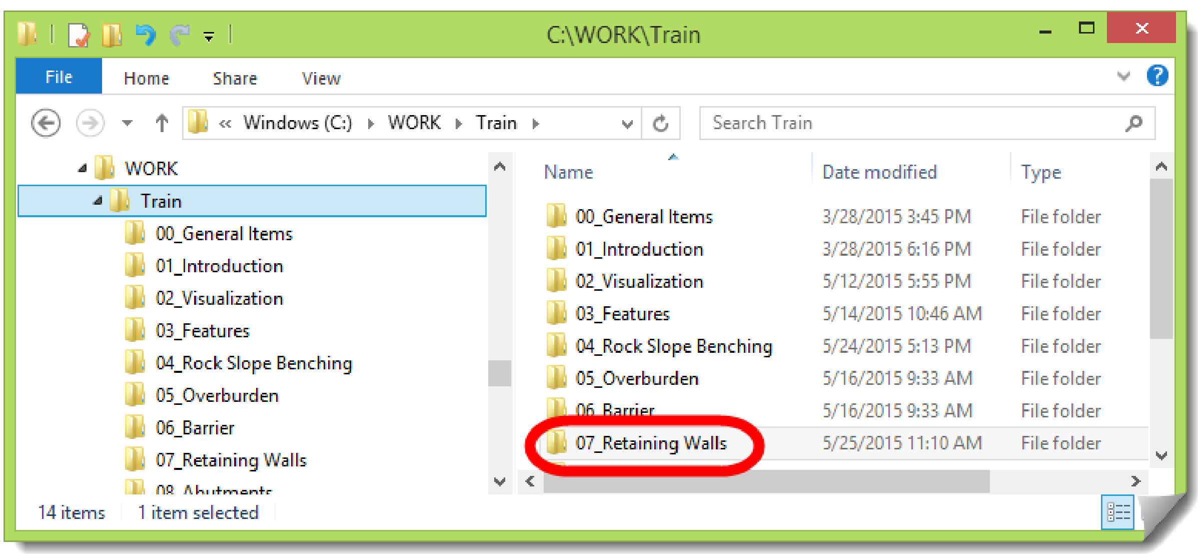
- Module 1 – Introduction to the Training Modules
- Module 2 – Visualization (beneficial, but not mandatory)
- MicroStation Basics
- InRoads Level 1
- InRoads Level 2

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 **`07_Retaining Walls`** 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

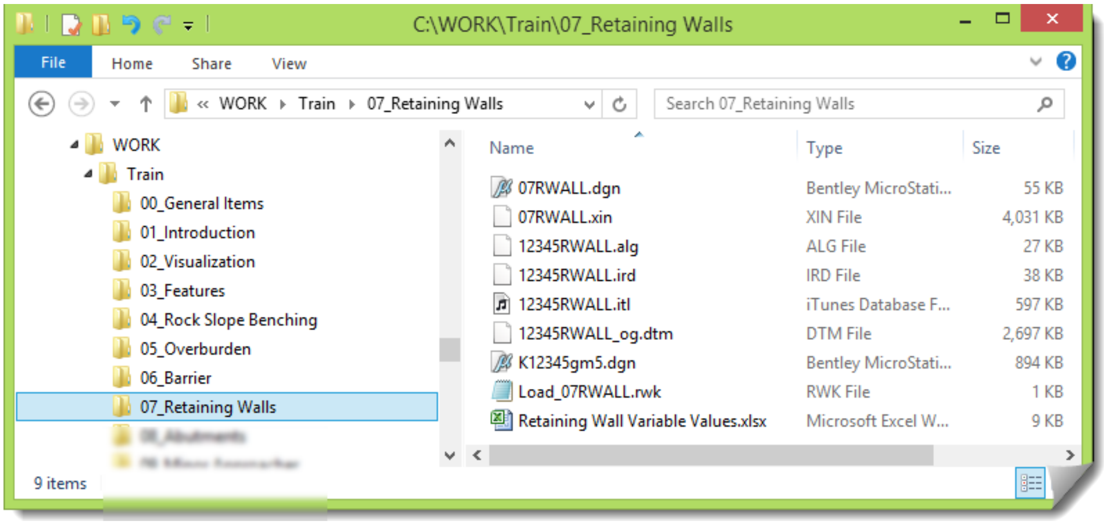
The module folder contains any training files (DGNs, DTMs, ALGs, ITLs, IRDs, XIN and so on) that will be used in the module exercises. DGN or InRoads files starting with **`12345`** are support files, or reference files that are used within the hands-on exercises at some point as directed.

Files starting with **`07RWALL`** will be opened during the launch of the hands-on work and include:

`07RWALL.dgn`, the initial MicroStation file used at the start of the exercises

`07RWALL.xin`, the InRoads configuration file for this work

There will also be an **RWK** file included in the module folder to assist in opening the InRoads files. In this module folder, you should have these files:



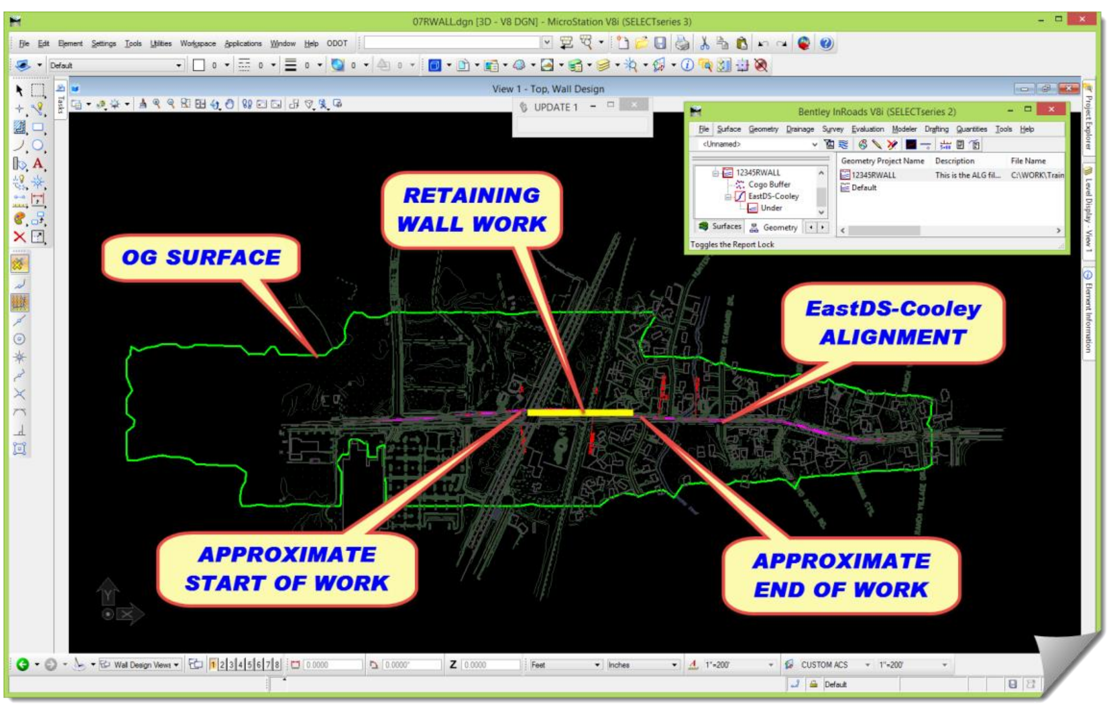
Technical Content of Training:

This module will focus on the application of a very specific composite component built and stored within the InRoads **Template Library**, to be used when the need for retaining walls exists.

Project Orientation

REVIEW WORK AREA

This module will use an OG surface, as well as a centerline alignment called **EastDS-Cooley**. The area of coverage and focus of the work is shown below. This surface and main alignment are already created and will be used as-is within this module.



PREPARE MICROSTATION / INROADS DATA & FILES

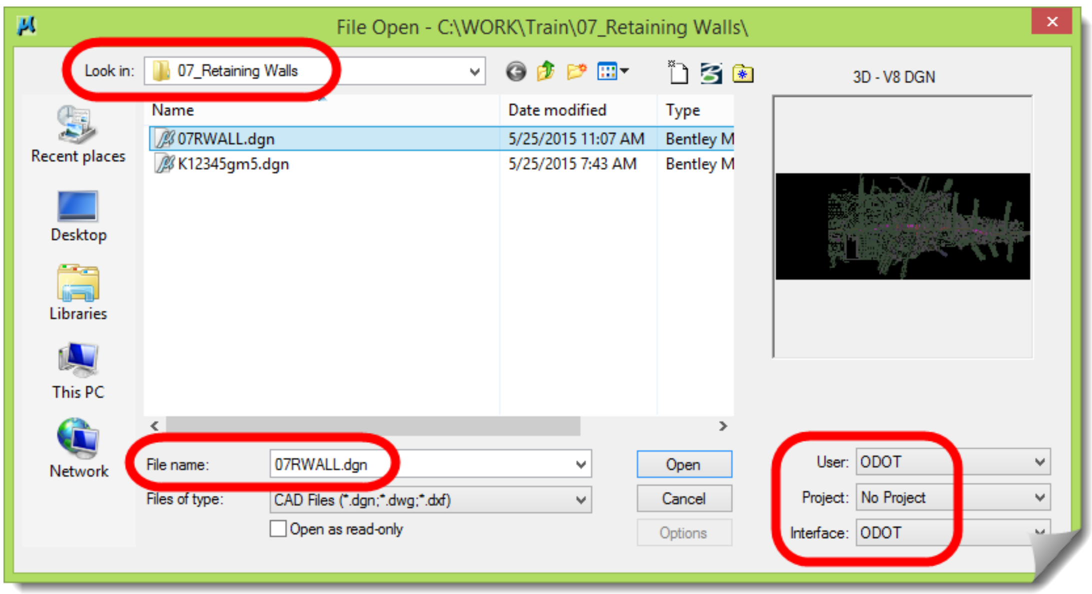
This section will get you into the correct DGN, load the module-specific XIN and other data files.

1) Launch InRoads.

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

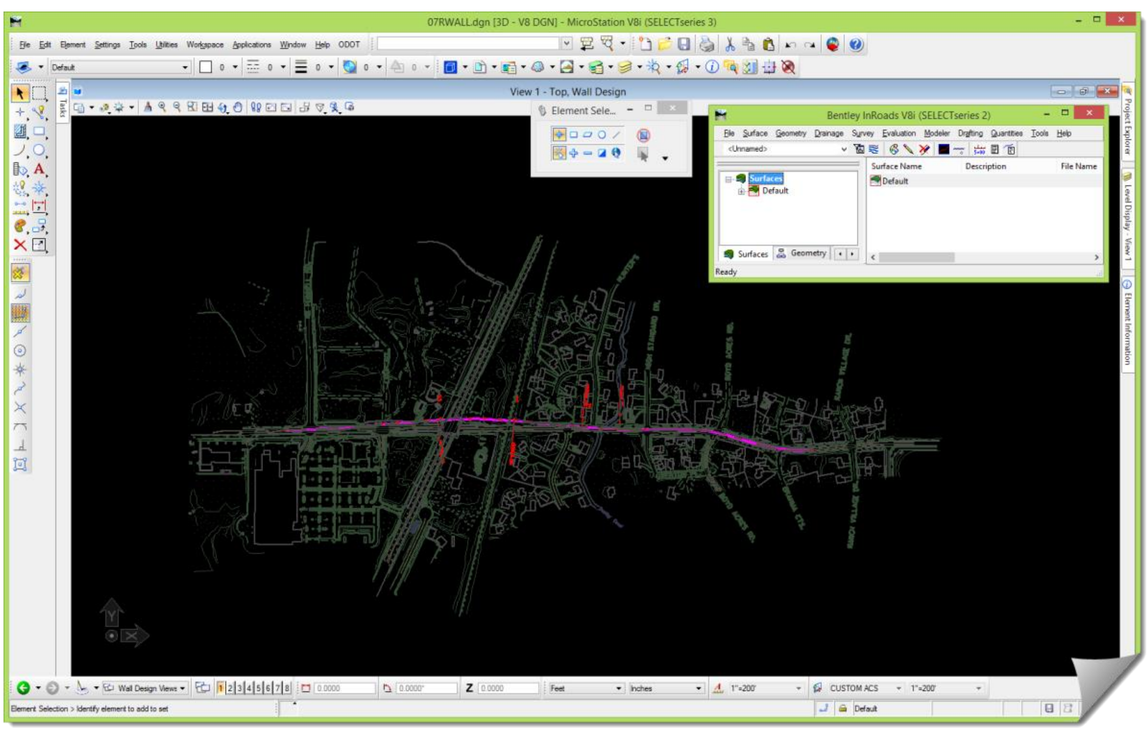
2) When the **MicroStation Manager** opens, set the **User** and **Interface** to **ODOT**.

3) Then browse to the ***C:\WORK\Train\07_Retaining Walls*** folder and select the **07RWALL.dgn** file and **[Open]**.



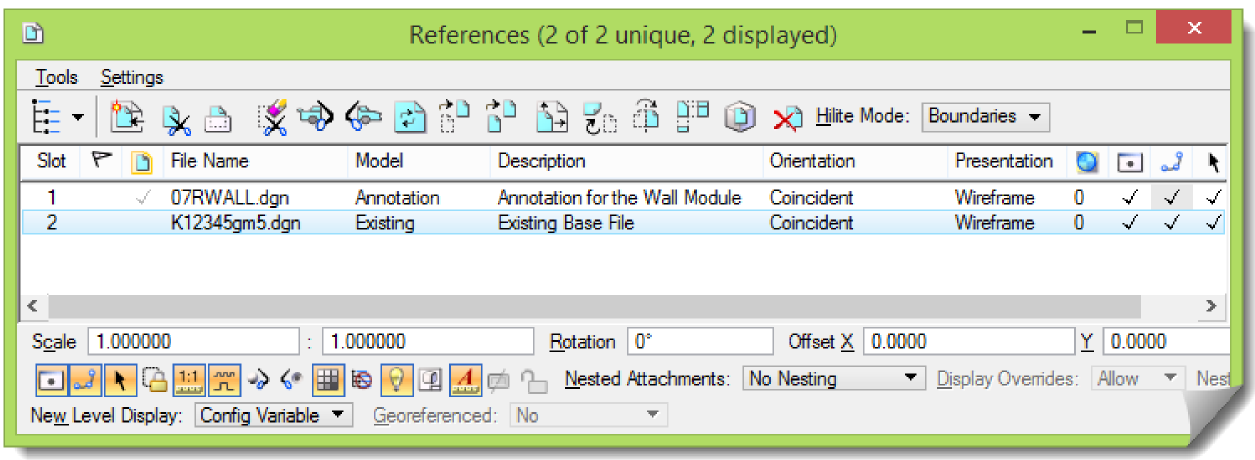
Eventually, MicroStation and then InRoads will open.

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



5) Open Windows **File Explorer** and browse to the **`07_Retaining Walls`** folder.
6) Drag & drop **`Load_07RWALL.rwk`** into the InRoads interface to open the InRoads files.
7) Verify inside InRoads that the following files have been opened:
   - **`07RWALL.xin`**
   - **`12345RWALL_og.dtm`**
   - **`12345RWALL.alg`**
   - **`12345RWALL.itl`**
   - **`12345RWALL.ird`**
8) At this time, feel free to review the project data that was just opened by doing any or all of the following tasks:
   a. View the **PERIMETER**, **CONTOURS** or **TRIANGLES** of the **OG** surface
   b. View the **HORIZONTAL ALIGNMENT** **`EastDS-Cooley`**
   c. View the **STATIONING** of the **HORIZONTAL ALIGNMENT** **`EastDS-Cooley`**
   d. Create a **PROFILE** and view the **VERTICAL ALIGNMENT** called **`Under`**

   At this stage in the module, it's not important that you review the ITL or the IRD in the **CREATE TEMPLATE** or the **ROADWAY DESIGNER**. You will be guided into these files later in the module.
9) Also, review the MicroStation models and reference files 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

This section will focus on discussing a few relevant topics that will set the stage for the upcoming retaining wall modeling, namely:

- Why model retaining walls?
- The overall retaining wall modeling process
- An orientation to the ODOT **TEMPLATE LIBRARY** retaining wall components

Following this discussion, we'll take a closer look at the specific InRoads **TEMPLATE LIBRARY Components** that have been set up for the modeling of retaining walls.

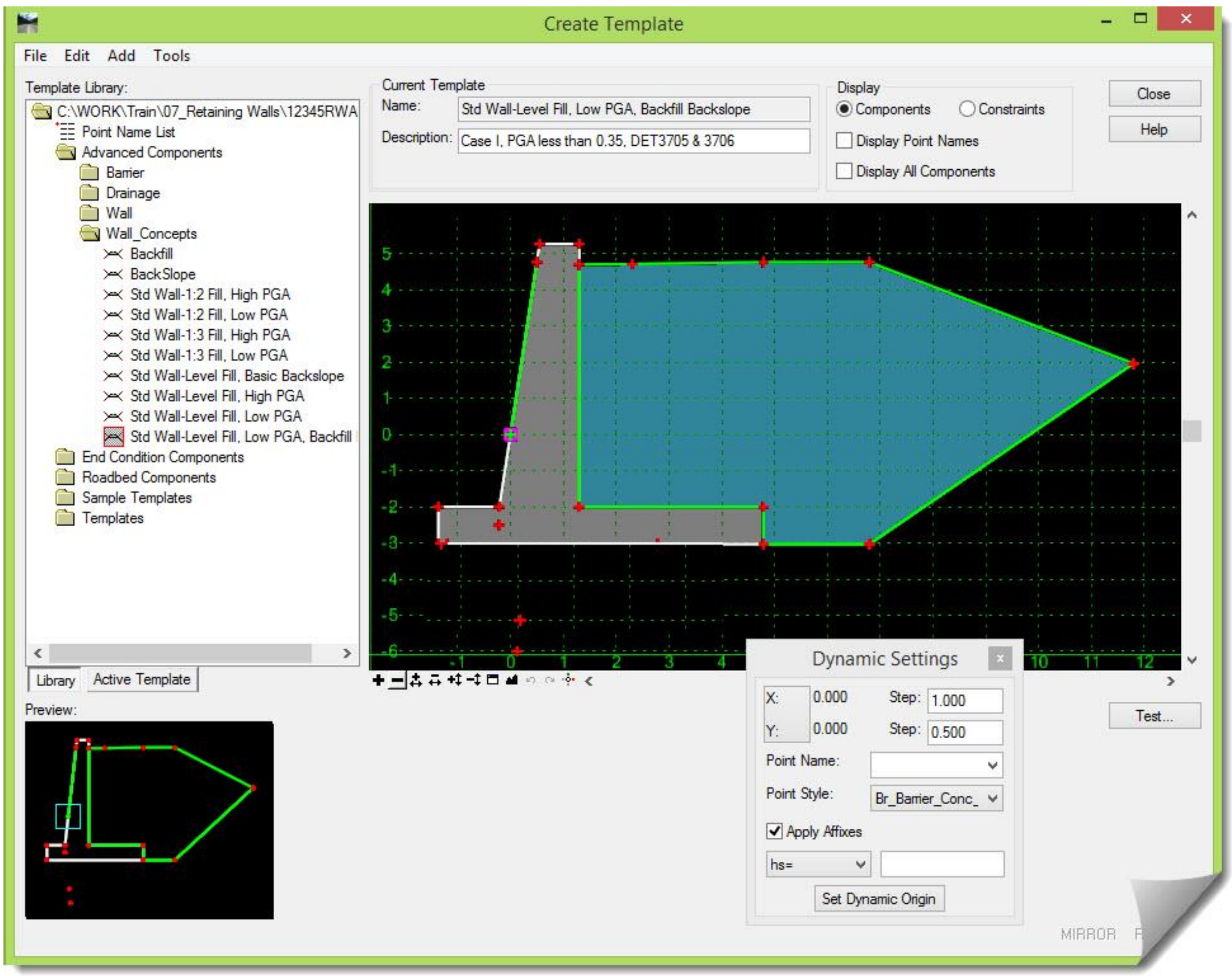
PROCESS OVERVIEW

Things to Consider

Why Model Retaining Walls?

Modeling retaining walls on a project has several benefits:

- Assisting with Right-of-Way development
- Developing excavation estimates of material behind the retaining wall
- Providing useful preliminary information to the structural and geotechnical designers to support the final wall design
- Improved plan, profile and cross section display of final walls



How retaining wall modeling influences each of these areas listed above will be illustrated as you move forward through this module.

The Overall Retaining Wall Modeling Process

First, it should be well understood here that InRoads does not do retaining wall 'design'.

A Structural designer working in concert with a Geotechnical designer is needed to perform the retaining wall design. All that InRoads is doing is providing a mechanism to model the walls in order to develop a preliminary footprint that can be used by a qualified wall designer to design the walls based on the initial conditions.

Beyond that, the acquired wall design parameters can then be used to integrate back into InRoads to refine its modeling output, reflecting the final geometric design.

The modeling process where retaining walls are being considered is not a one-pass workflow, but an iterative one. This iterative process involves the roadway designer taking an initial pass to create a retaining wall concept layout. Resulting information created from this first pass is then provided to the structural and geotechnical designers. They will use this information to develop the final wall design for the project.

The roadway designer will take this information and refine the initial modeling by 'hard coding' the wall layout parameters into the **ROADWAY DESIGNER**. At this point, a new design model will be created that reflects the information provided by the structural and geotechnical designers.

Here is an outline of the overall modeling process and associated roles:

a. ODOT Roadway designer:
   - Lays out the basic roadway template based on project criteria;
   - Assumes a Peak Ground Acceleration (PGA) value based on past local projects, or by input from the geologist or geotechnical designer;
   - Selects the appropriate retaining wall component from the **`Wall_Concept`** folder in the Template Library;
   - Integrates the wall component into their roadway templates where required;
   - Models the area requiring a retaining wall with the default retaining wall component settings, <u>not</u> applying **PARAMETRIC CONSTRAINTS** to the component. (This will develop an estimated wall layout and an excavation backfill catch-point behind the retaining wall);
   - Creates a design surface and provides whatever support information the structural and geotechnical designers need. This can include profiles along the wall with key wall features and existing ground linework projected to the profile. Plan display, as well as cross sectional information, can also be provided based on the needs of the designers.

b. ODOT Structural / Geotechnical Designer:
   - Checks and revises assumptions (including wall type) of Roadway Designer;
   - Takes the information provided by the Roadway designer and determines discrete wall parameters and stationing needed for the final retaining wall design;
   - Provides this information to the Roadway designer when completed.

c. ODOT Roadway designer:
   - Enters the values, provided by the Structural and Geotechnical designers, into the **ROADWAY DESIGNER** as **PARAMETRIC CONSTRAINTS** to refine the earlier concept work;
   - If the wall height requires additional control, retaining wall component modifications will have to be done in order to accommodate any vertical **POINT CONTROLS** used;
   - Outputs a new design surface.

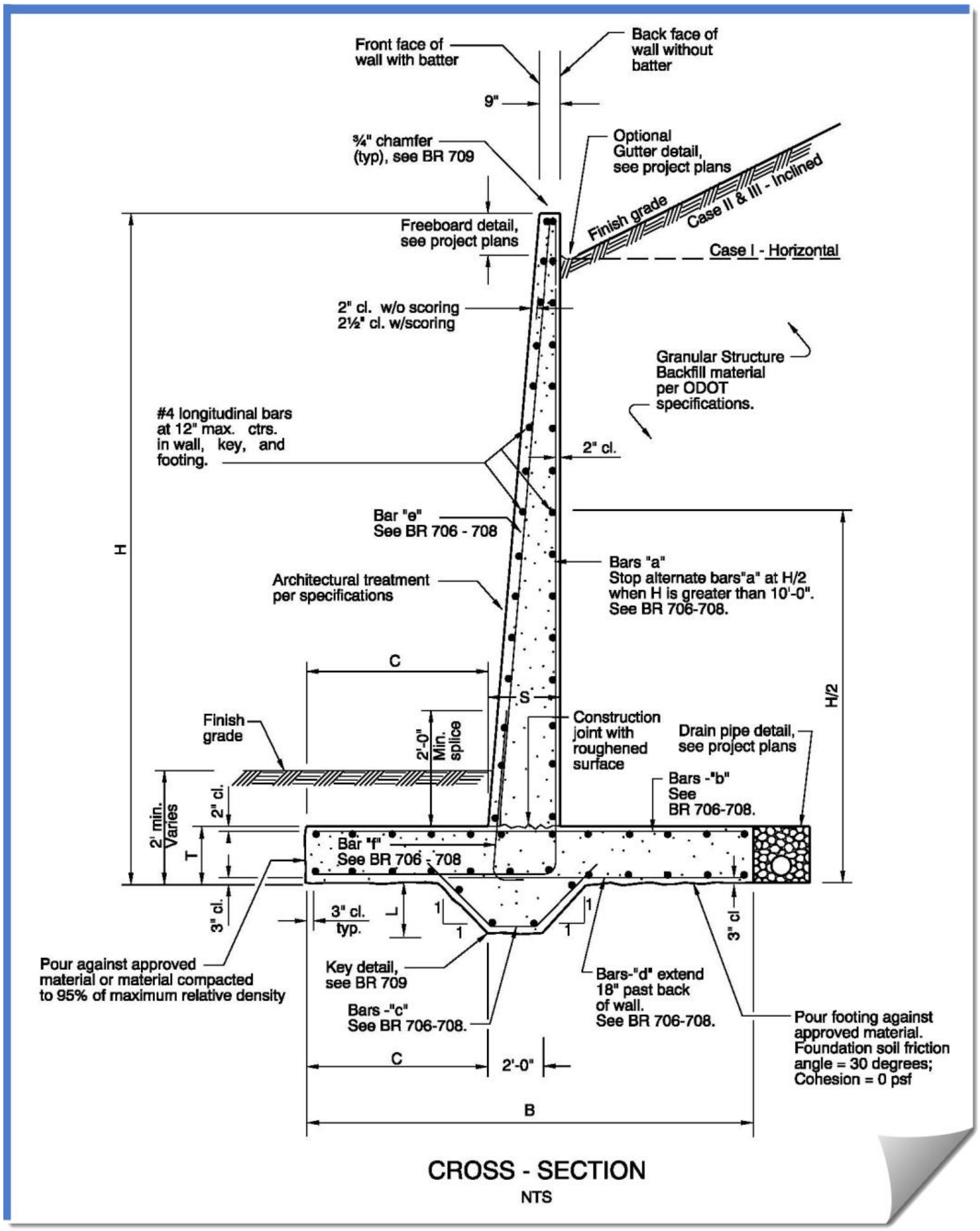
This workflow is illustrated later in the module.

Techniques and Tools

Template Library Retaining Wall Components

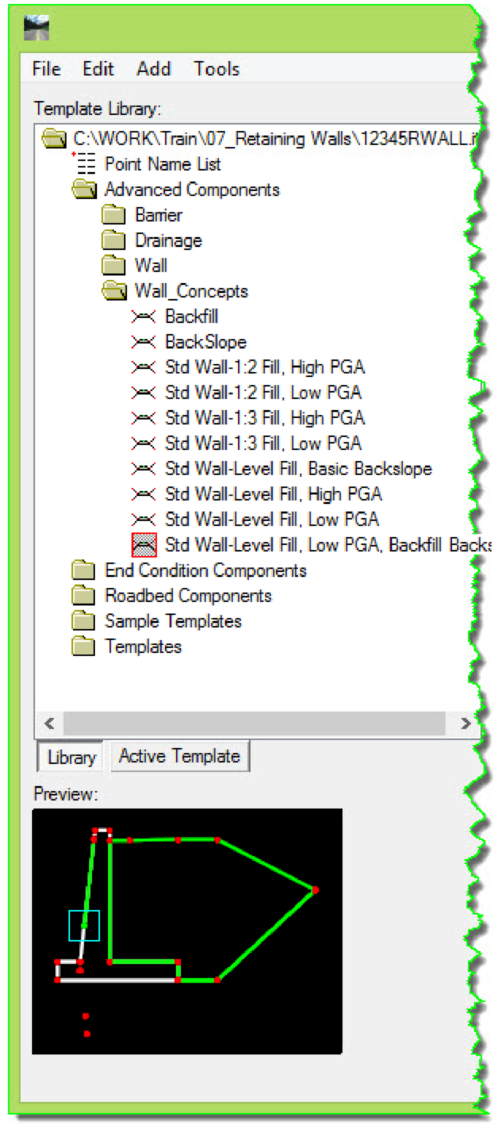
Before moving forward, you may want to re-familiarize yourself with the standard ODOT wall details and associated dimension tables.

The illustration here is from DET3705, and shows the various conditions and variable design parameters that the InRoads components are based on (with the exclusion of the shear key).



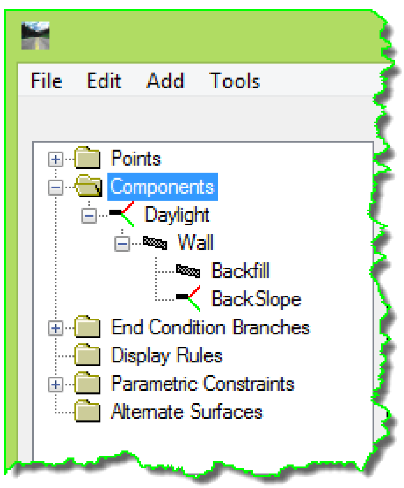
The specific variables to note above are **H**, **B**, **C** and **T**. These are the key variables that drive the structural shape of the retaining walls. These variables are tied to **Parametric Constraints** in the retaining wall components and will be used to modify the wall to reflect the designs produced by the Structural and Geotechnical designers.

Because the components for the retaining wall layout are initially used to develop a first pass concept of the retaining wall condition, they are found in the **`Wall_Concepts`** folder under **`Advanced Components`**. This placement is intended to be a trigger to the user to indicate that these components should not be applied and used 'as-is', but require the full iterative workflow described earlier to be executed if the retaining walls are to be used for anything beyond concept layout.



The retaining wall components are complex components constructed from four separate components where **Parent-Child** relationships exist.

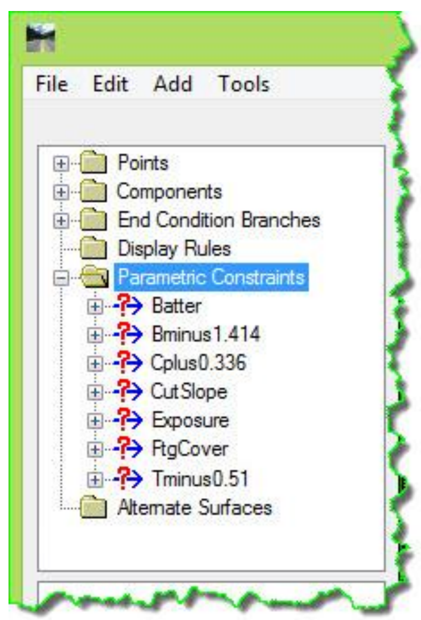
- **Daylight**
- **Wall**
- **Backfill**
- **BackSlope**



In addition to these commonplace component types, the retaining wall components contain three **Null Points** that are used to control various portions of the component layout.

There are also strategically placed **Parametric Constraints** labels throughout the retaining wall component that are used to drive the final wall geometry.

Beyond the areas just mentioned, the most complex aspect to these components is their **Constraint Values**. You will have an opportunity to explore these for yourself shortly.



Practical Application - Hands On Lab Exercises

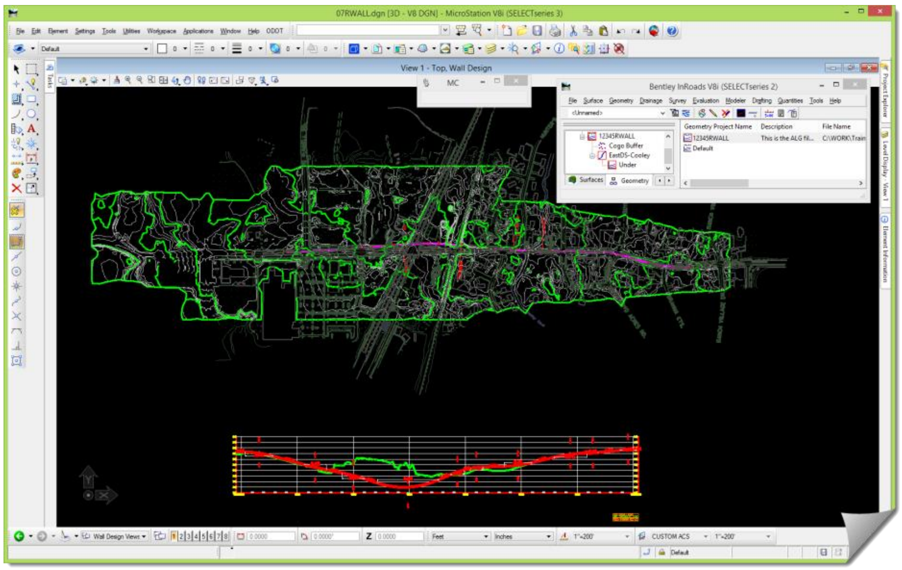
The following hands-on section will initially consist of reviewing a specific retaining wall component that will be used in this module. Following that, this component will be integrated into a roadway section, and used in the **ROADWAY DESIGNER** to create a design surface containing the wall.

UNDERSTANDING THE DETAILS

Review any relevant project data

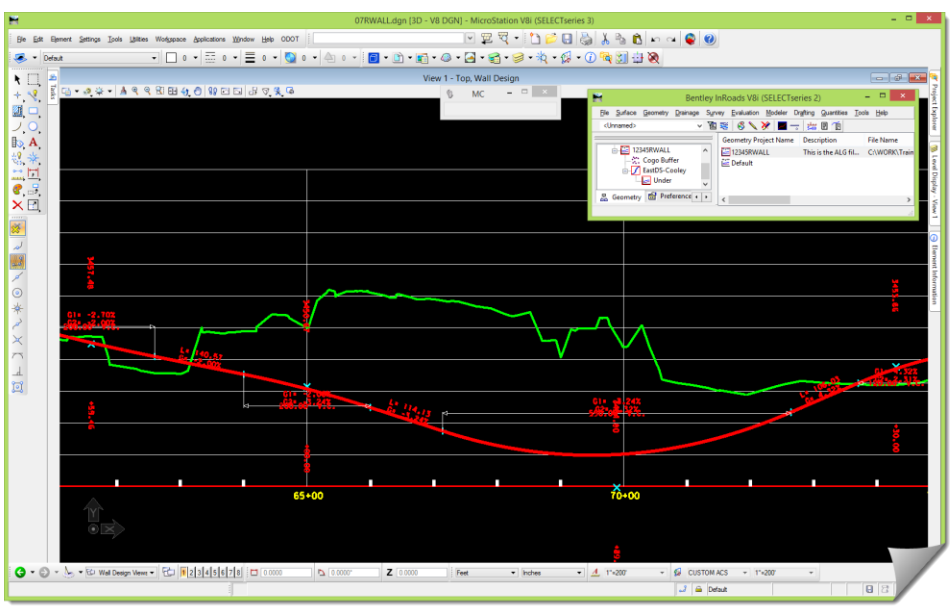
At this point, you should be in the **`07RWALL.dgn`** file and have loaded the InRoads RWK data.

1) If you reviewed the project data earlier, you should be looking at something like this:



If you aren't seeing graphics as shown here, don't worry. The important part is that you understand the surfaces and geometry data that are associated with this module.

2) Taking a closer look at the profile (create one if you haven't already) will show the area that will be the focus of this module and the location of the retaining wall.

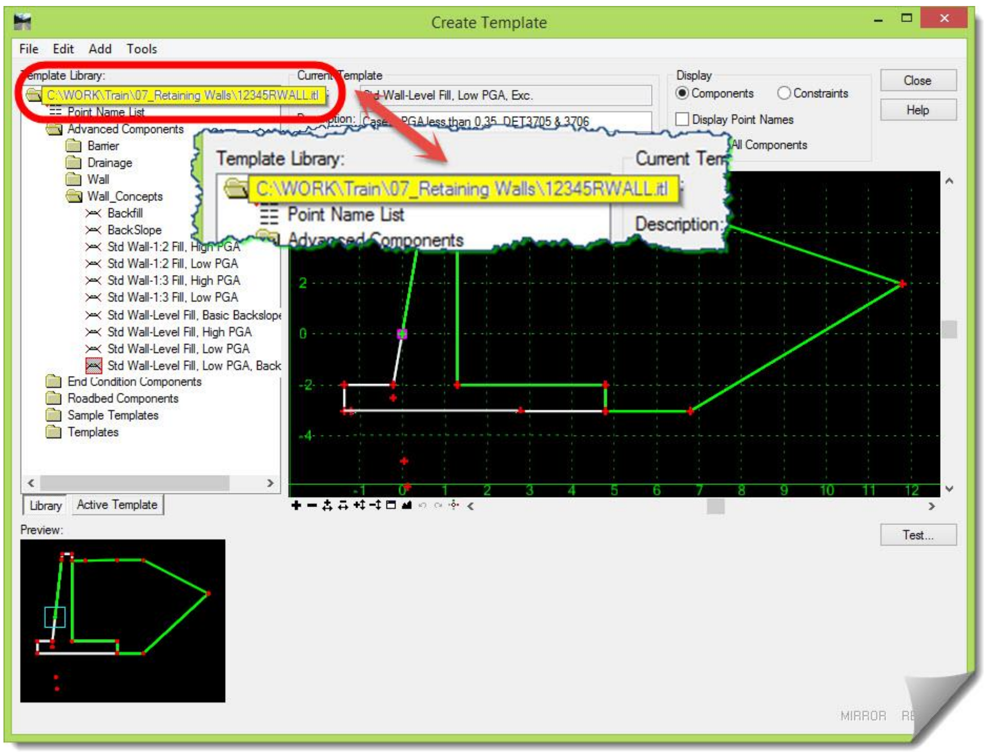


Review relevant InRoads ITL information

Even though the overall workflow for modeling retaining walls goes beyond the wall component itself, it can't be overlooked that an important part of this modeling involves this component and the resultant template used in the **ROADWAY DESIGNER** to create the design surface.

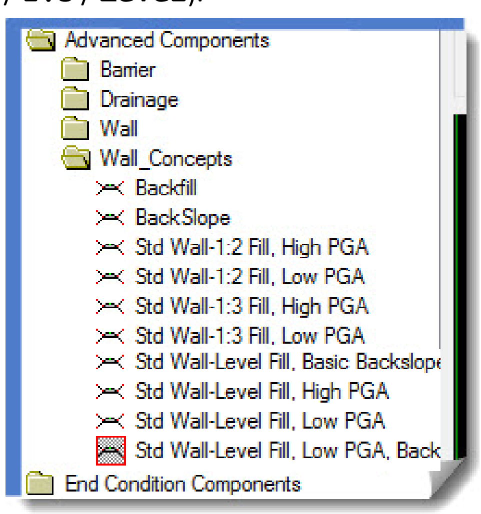
With that in mind, let's take a closer look at this **Component** and give you an opportunity to understand the main component better.

1) Go to the InRoads main menu, open the **CREATE TEMPLATE** tool, and verify that the correct **ITL** is opened by checking the path at the top of the Library window.



2) Now browse and open the **`Wall_Concepts`** folder under **`Advanced Components`**.

You will see a series of wall components with names that reflect a PGA range (**`High`** / **`Low`**) and backslope fill condition (**`1:2`** / **`1:3`** / **`Level`**).

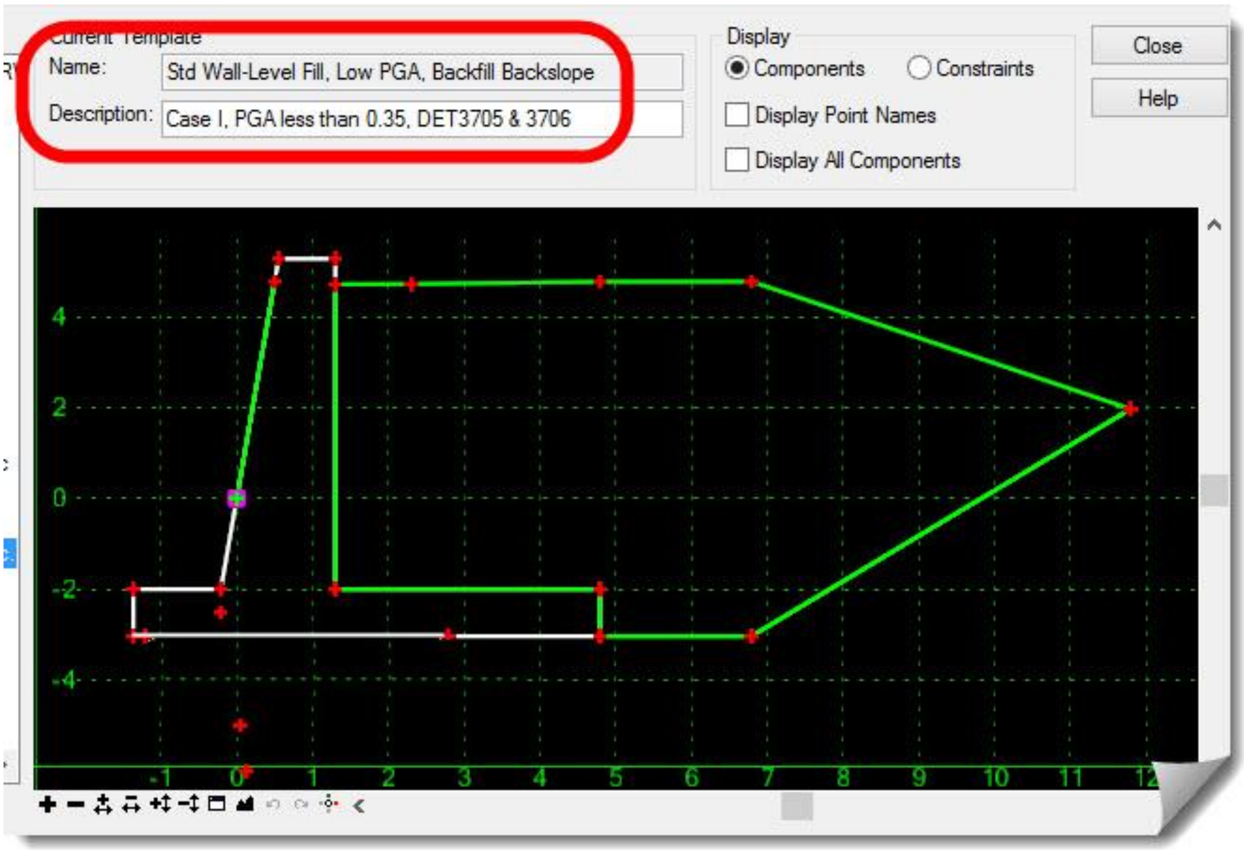


3) Double-click on the **`Std Wall-Level Fill, Low PGA, Backfill Backslope`** component to activate it and put it into editing / review mode.

For clarity, feel free to turn *off* the **Display Point Names** toggle.

4) Notice the **Description**.

This provides additional insight into the layout details used to construct this wall scenario.



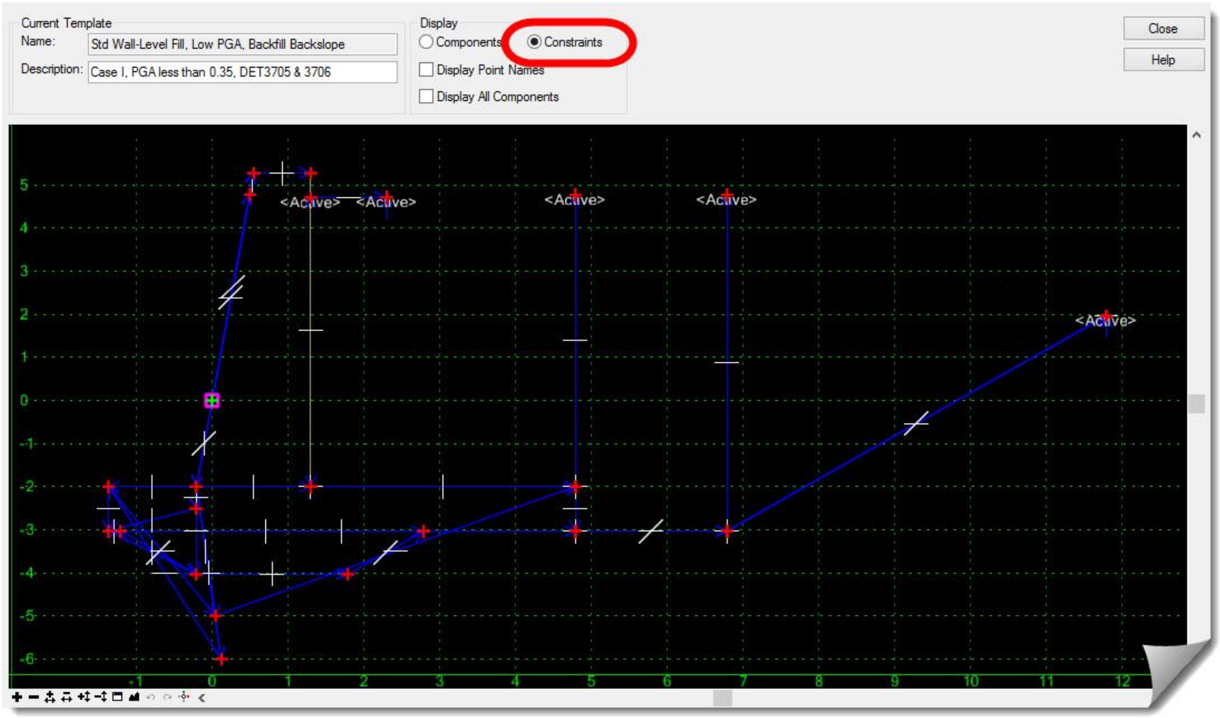
This component will not be edited during its initial use in the concept phase of the layout; however, it will require modification if the wall height is intended to be controlled by a **POINT CONTROL** driven by a **Vertical Alignment**. This will be discussed in more detail later.

Fully understanding the mechanics behind this component requires knowledge of:

- **END CONDITION** (**EC**) branching – combining ECs at a common point to define different alternative solutions
- **PARAMETRIC CONSTRAINTS** – using **Values** to drive the component **Point Constraints**; these are used to drive various portions of the wall discussed earlier and shown in DET3705.
- **Parent Components** – attaching a component to another with a display dependency; used here to tie the **`Wall`** component to the **`Daylight`** EC, and the **`Backfill`** component to the **`Wall`** component.
- **Advanced Point Constraints** – using a **Value Equation** to determine the **Constraint Value** instead of entering a fixed number, as well as defining **Constraint Parent** points to strategically relate point movements to one another
- **Advanced Components** – tying component points to **Null Points**

This is InRoads Level 2 knowledge and will not be covered in this module.

5) To illustrate the constraint complexity, toggle *on* the **Constraint** view under **Display**.



> **ALERT**: These retaining wall components do not require any editing or modification when used to develop the initial concept footprint that will be provided to the Structural and Geotechnical designers. They will however, require specific modifications depending on the final wall design.

6) If you have the level of knowledge and wish to review the construction details, feel free to take some time to review the **`Std Wall-Level Fill, Low PGA, Backfill Backslope`** component. As a suggestion, these areas will provide insight into its structure.

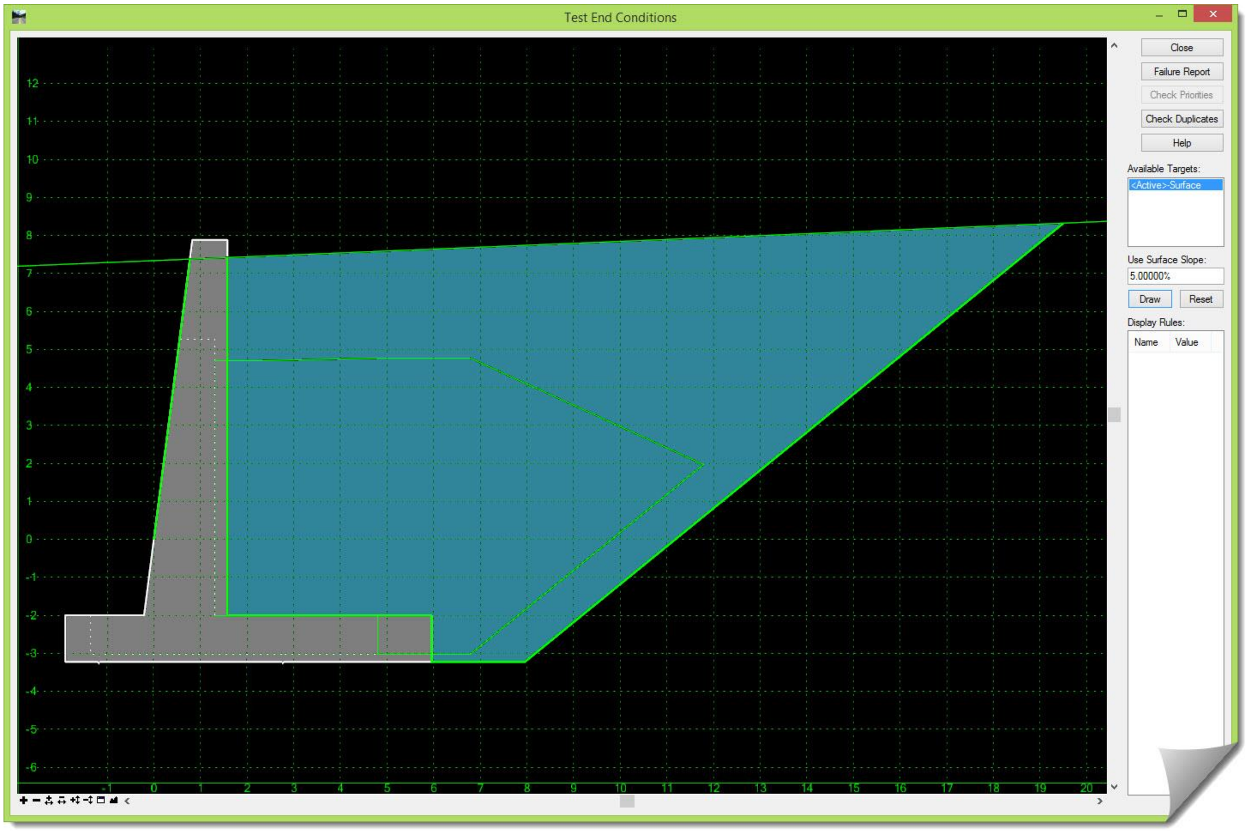
- Review the **ACTIVE TEMPLATE** tab for the following:
  - **Point Names**
  - **Point Constraints**
  - **Components** used (including **Null Points**)
  - **Parent / Child Components**
  - **End Condition** branching
  - **Parametric Constraints**

Before moving on, the last thing that will be done here is to run the standard **Test** of an EC.

7) Make sure **`Std Wall-Level Fill, Low PGA, Backfill Backslope`** is active.

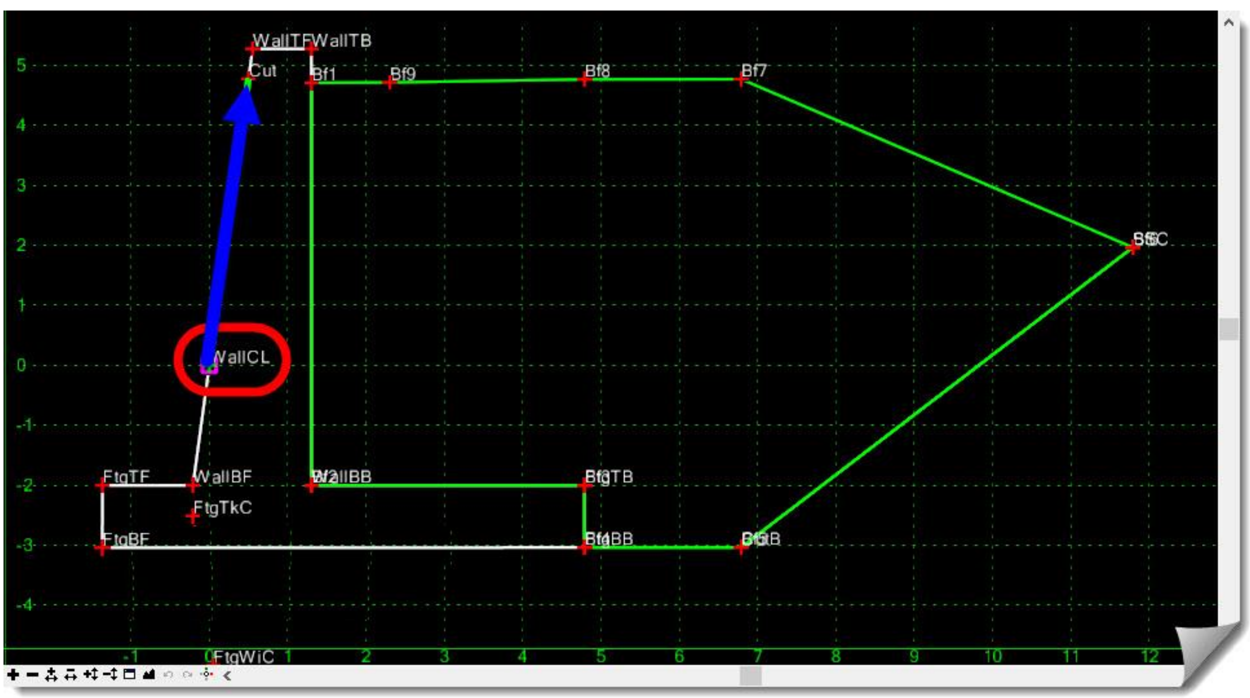
At this stage, you should be aware that these retaining wall components are a composite of **End Conditions** and **Child** components. These **Child** components are <u>not</u> **End Conditions**, but have a **Parent-Child** relationship to them, and doing an EC **Test** will confirm this, i.e. when the EC succeeds the **Child** components also 'succeed'.

8) Click the [**Test…**] button.
9) Click [**Draw**] to simulate a surface condition and notice the results.

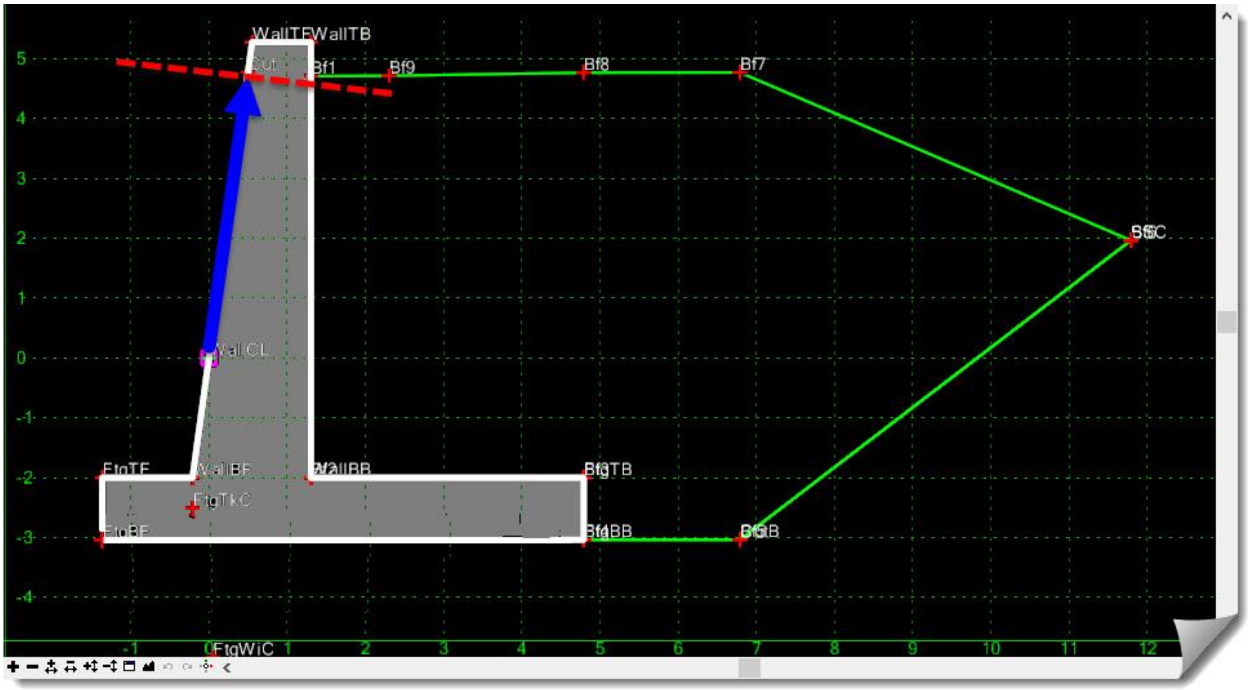


This is what is occurring here:

a. A **`Daylight`** component starting from the **`WallCL`** point is targeting the surface.



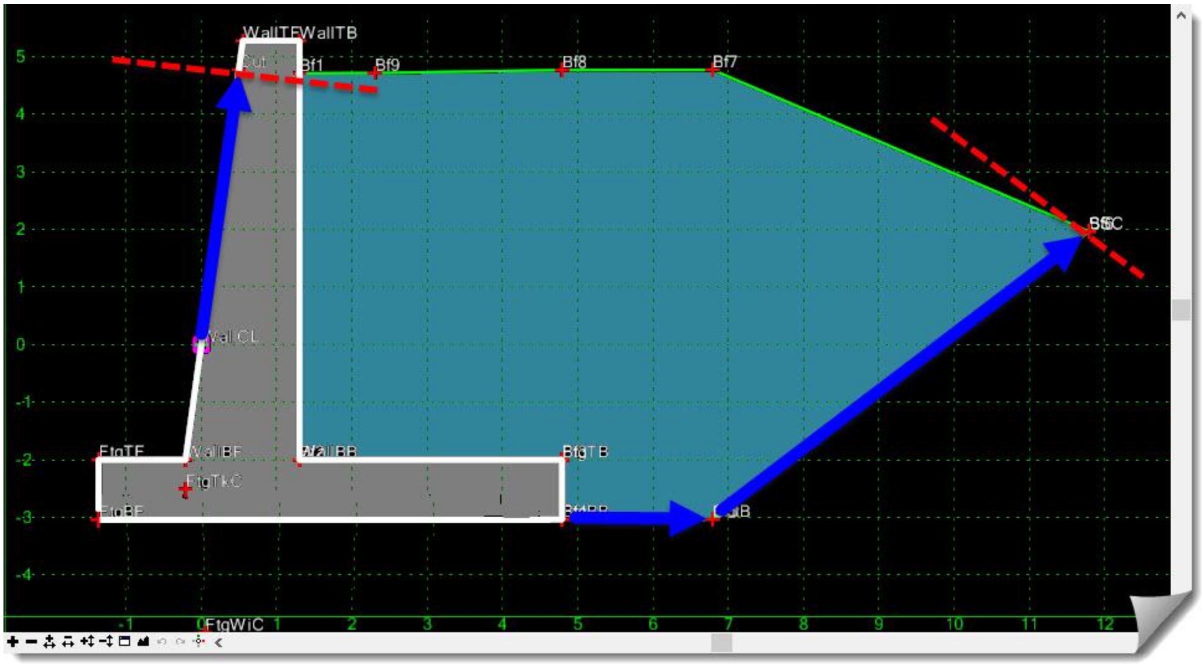
b. When the **`Daylight`** component succeeds, the **Child** component, **`Wall`**, is also drawn.



c. If the **`Wall`** is drawn, the **`BackSlope`** EC is put into play since it is a **Child** of the **`Wall`.**

The final piece of the overall composite wall component is the **`Backfill`**. The points on the **`Backfill`** component are constrained to specific points on the **`Wall`** component, as well as the points on the **`BackSlope`** EC. The upper points on the **`Backfill`** component are constrained to the OG surface (behind the wall) so that it traces along the OG between the back of the wall freeboard and the **`BackSlope`** EC ground intercept.

d. Once the **`Daylight`**, **`Wall`** and **`BackSlope`** are developed, the **`Backfill`** component is constructed.

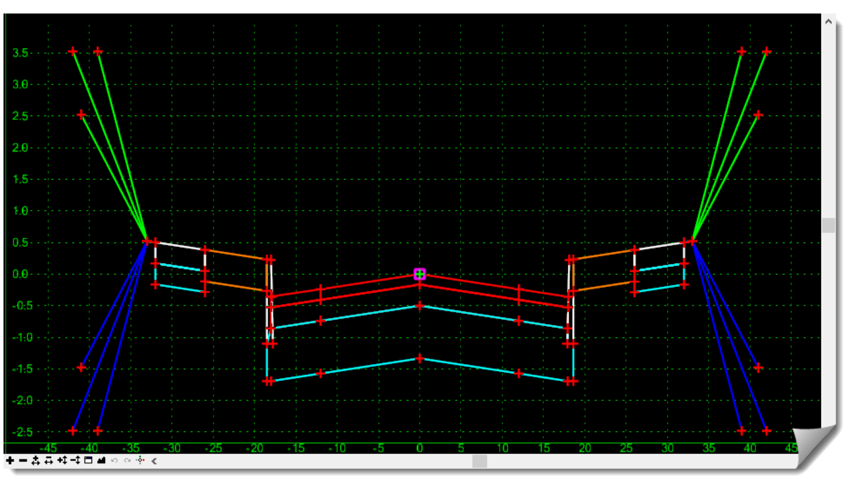


10) [**Close**] this dialog box when you are done.

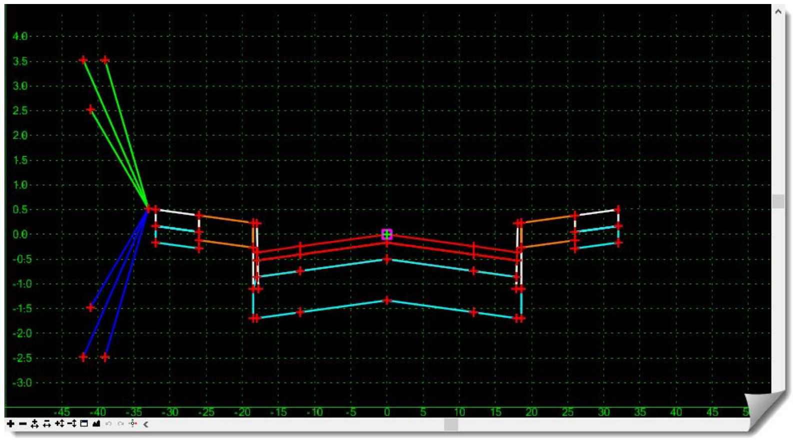
SCENARIO 1 - CONCEPT WALL LAYOUT

This section will cover the first part of the workflow where the wall concepts are created and handed over to the Structural and Geotechnical designers. Here is our starting point:

- The existing surface **`12345RWALL_og`** will be used
- The geometry has already been created
  - Horizontal alignment = **`EastDS-Cooley`**
  - Vertical alignment = **`Under`**
- The basic template has already been created for this project
  - The **`Cooley5-Ln`** template in the **Templates** folder currently exists for modeling without a retaining wall



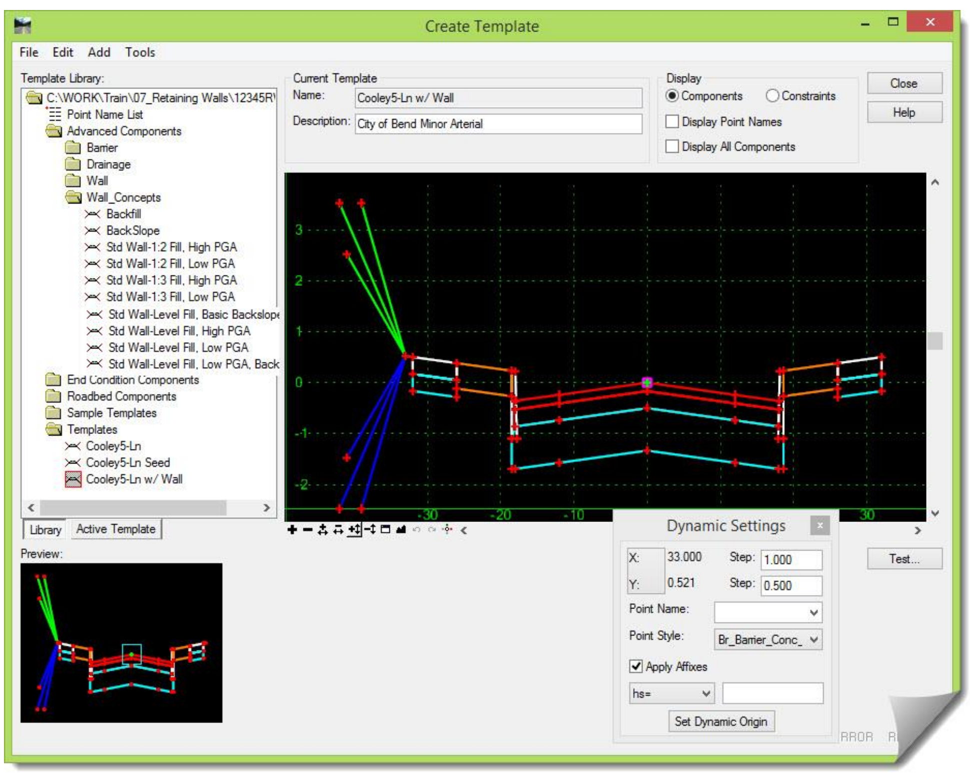
- A **`Cooley5-Ln Seed`** template exists that does not contain any ECs on the right side. This will be used to create the template containing the retaining wall.



- Based on available information and direction from the Geotechnical Designer, we will be using a Case 1 retaining wall with a PGA of less than **0.35**.
  - This corresponds to the **`Std Wall-Level Fill, Low PGA, Backfill Backslope`** wall component.
- A **Corridor** has already been created using the **`Cooley5-Ln`** template in the IRD file.

The first step will be to add the retaining wall component to the template, and then this template will be used in the **Roadway Designer** to develop the initial concept footprint of the retaining wall based on the depth of cut at the wall location.

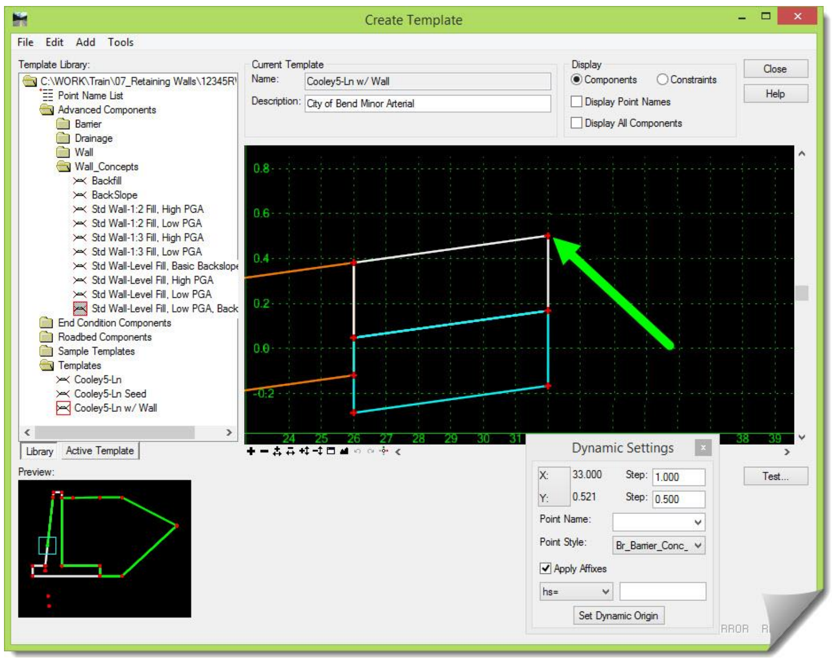
1) Open the **Create Template** tool and browse to the **Templates** folder.
2) [**Copy**] the **`Cooley5-Ln Seed`** and create **`Cooley5-Ln w/ Wall`**.



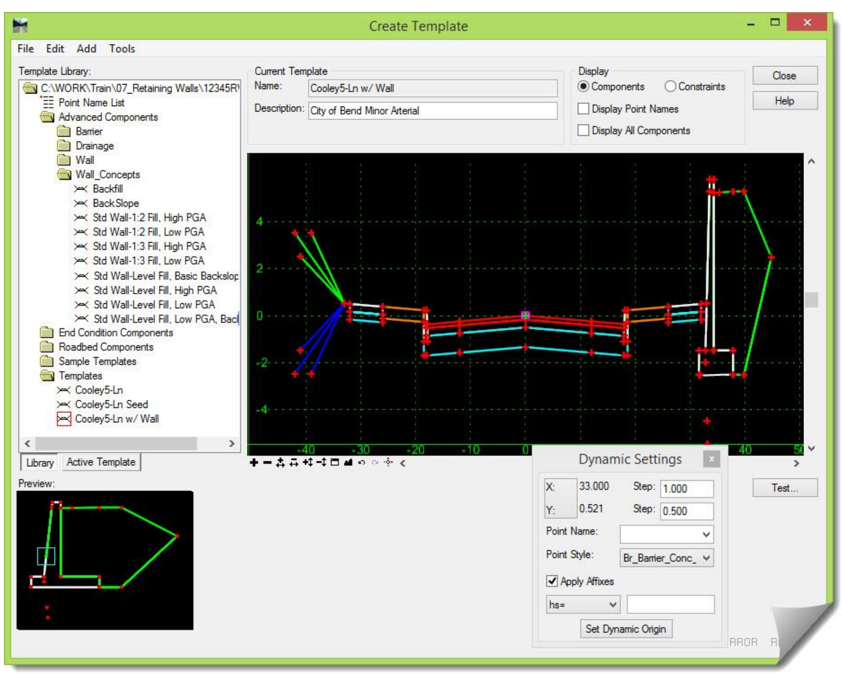
3) Making sure **Apply Affixes** is toggled *on*, drag and drop the retaining wall component onto the right side of the template.

ALERT: Always keep in mind that the primary **PREFERENCE** loaded should be **ODOT**. This **PREFERENCE** should load automatically based on the **PROJECT DEFAULT** settings; however, the user should <u>always</u> ensure that the correct settings are defined.

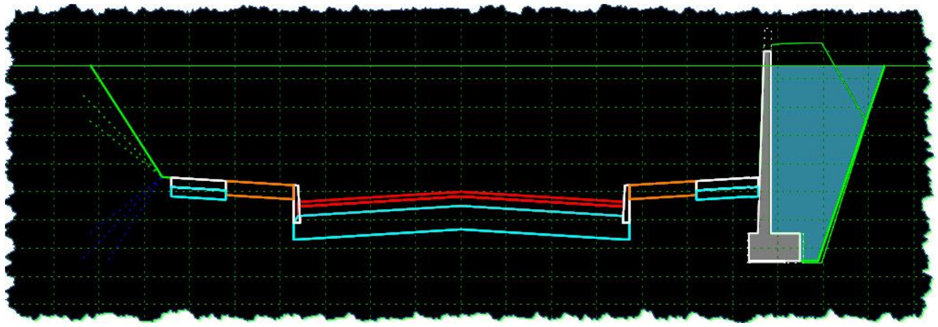
The location of the wall on the template is project-specific. For this example, the wall will be placed on the back of the sidewalk.



It should look like this when it is done:



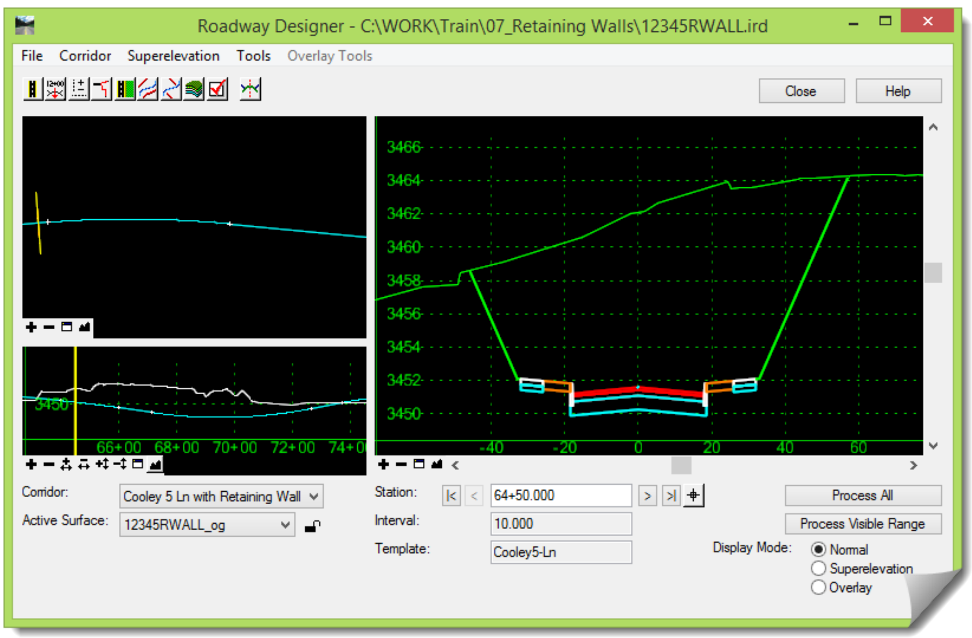
4) Feel free to [**Test…**] it to ensure that it is working properly.



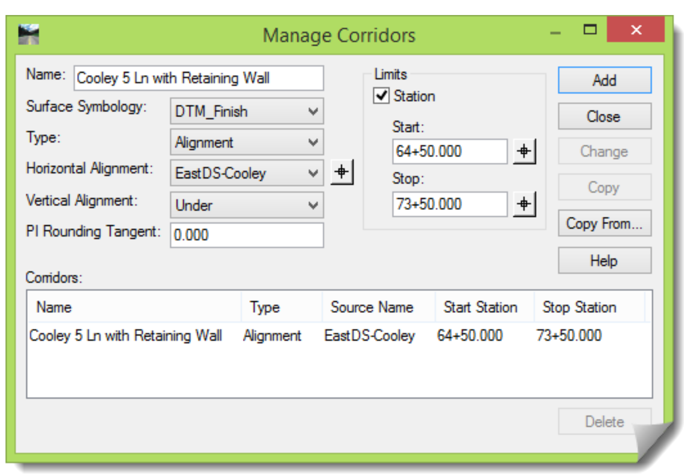
5) [**Save**] the Template Library and then [**Close**] it.

Now an existing corridor will be modified to use this template.

6) Open the **ROADWAY DESIGNER**.

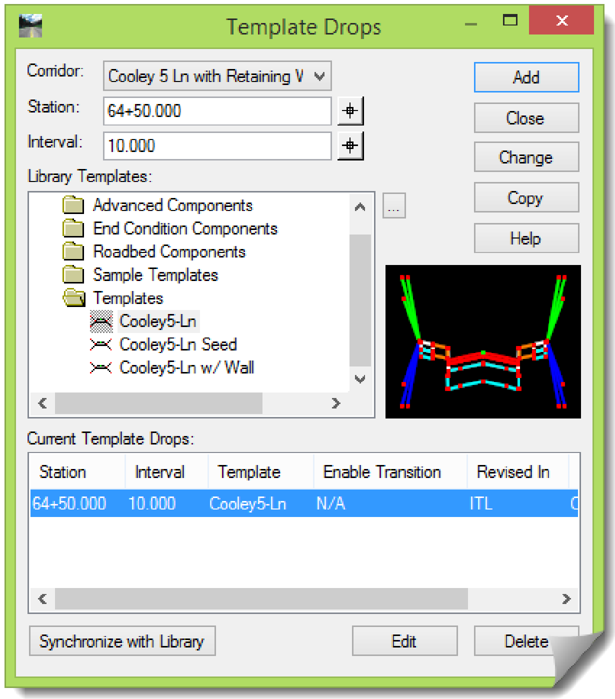


There is an existing corridor using the standard cut / fill slopes already in this IRD. The station range for this corridor is the location where the retaining wall is going to be placed.

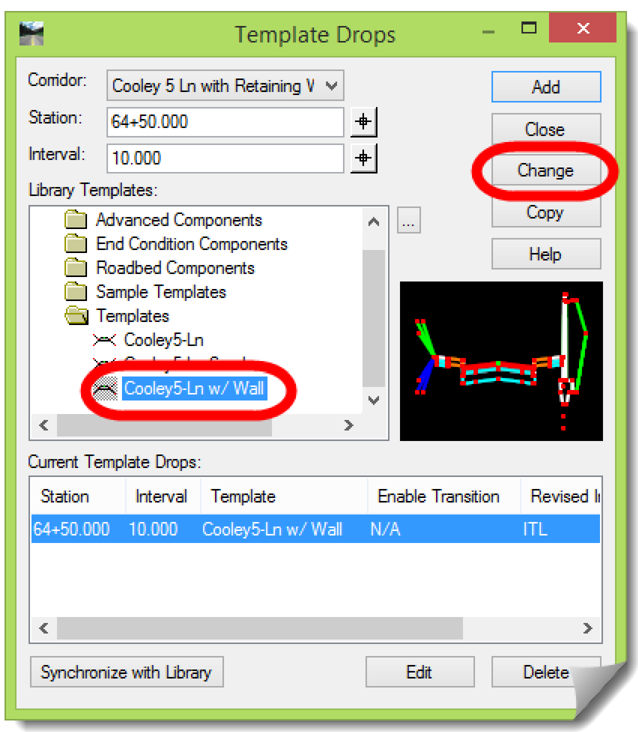


Just for this exercise, we will simply replace the previously used template with the new one just created. On your project, you would be applying strategic template drops that contain the retaining wall component where needed. Other areas of the alignment will likely be modeled using templates that do not contain the retaining wall component.

7) Go to the **Template Drops** dialog box and select the single entry in the **Current Template Drops** list window.



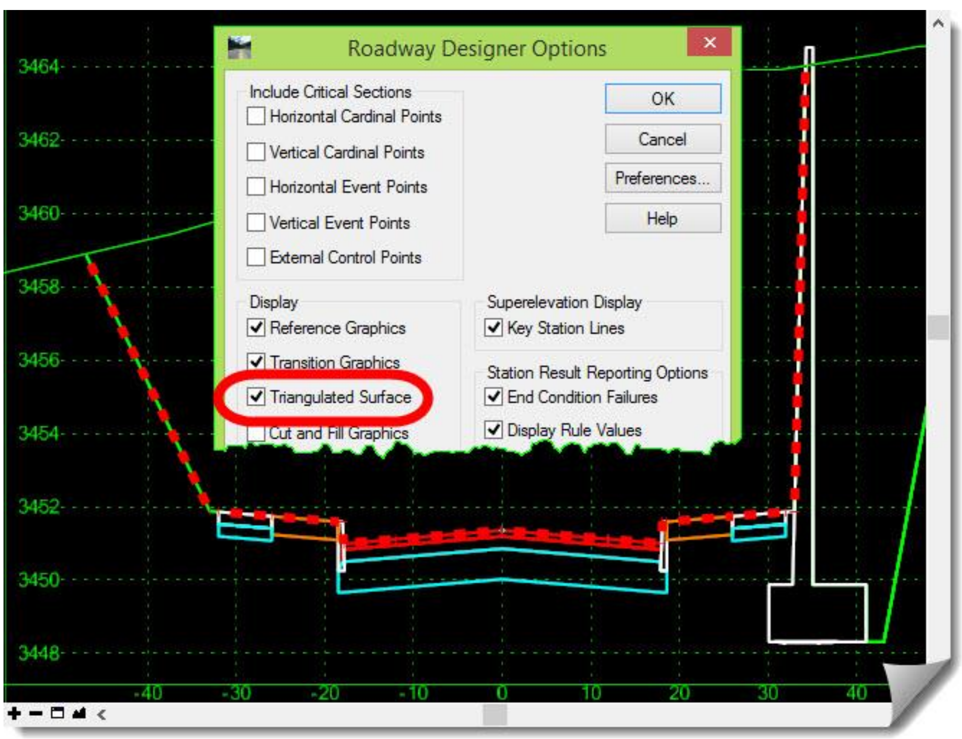
8) Highlight the `Cooley5-Ln w/ Wall` template and click [**Change**].



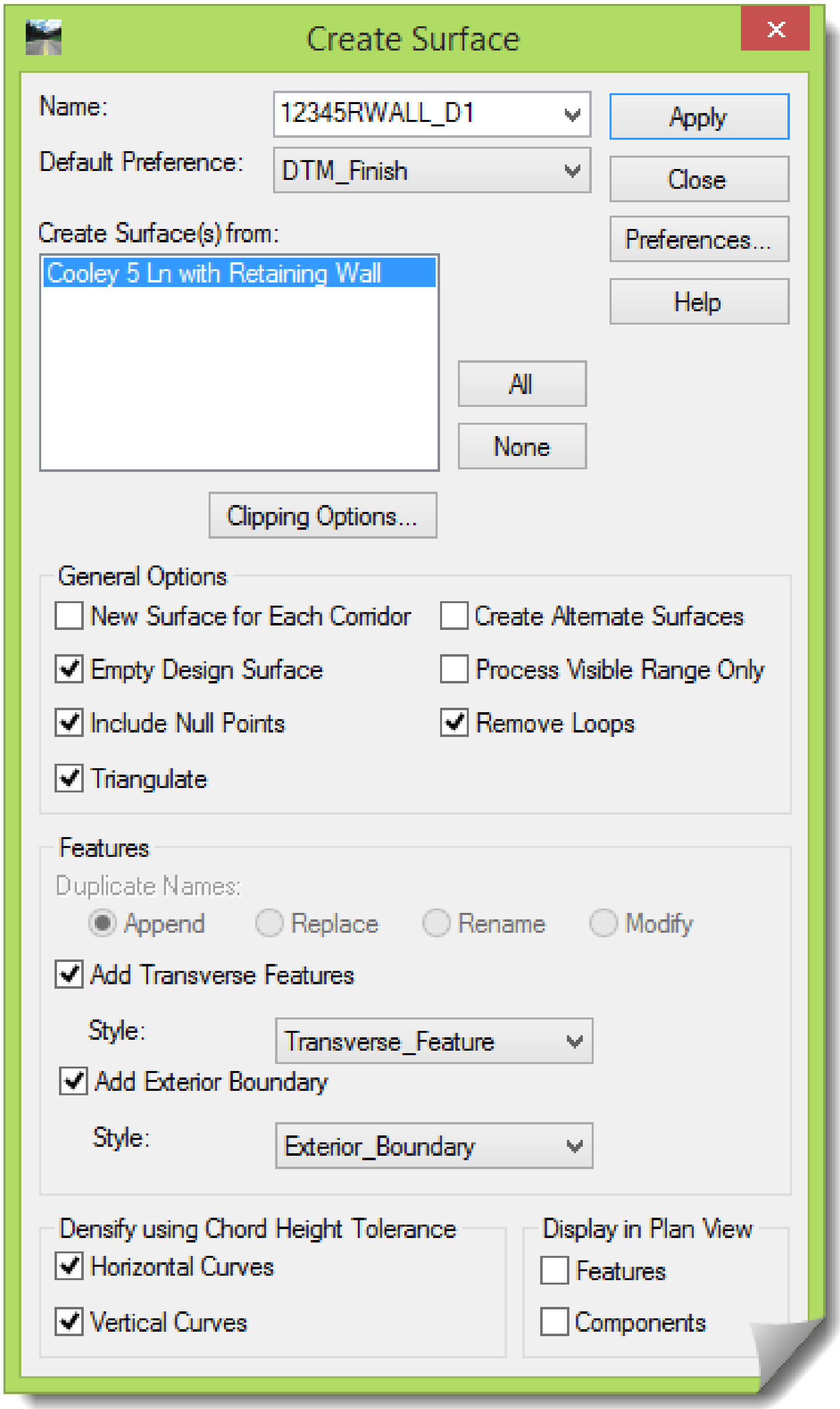
9) [**Close**] the **Template Drops** dialog box and [**Save**] the IRD.

You should be seeing feedback in all three views including the wall in cross section.

10) Turn the **Display** *on* for the **Triangulated Surface** under ***Tools > Options*** to confirm that the surface will be created correctly.



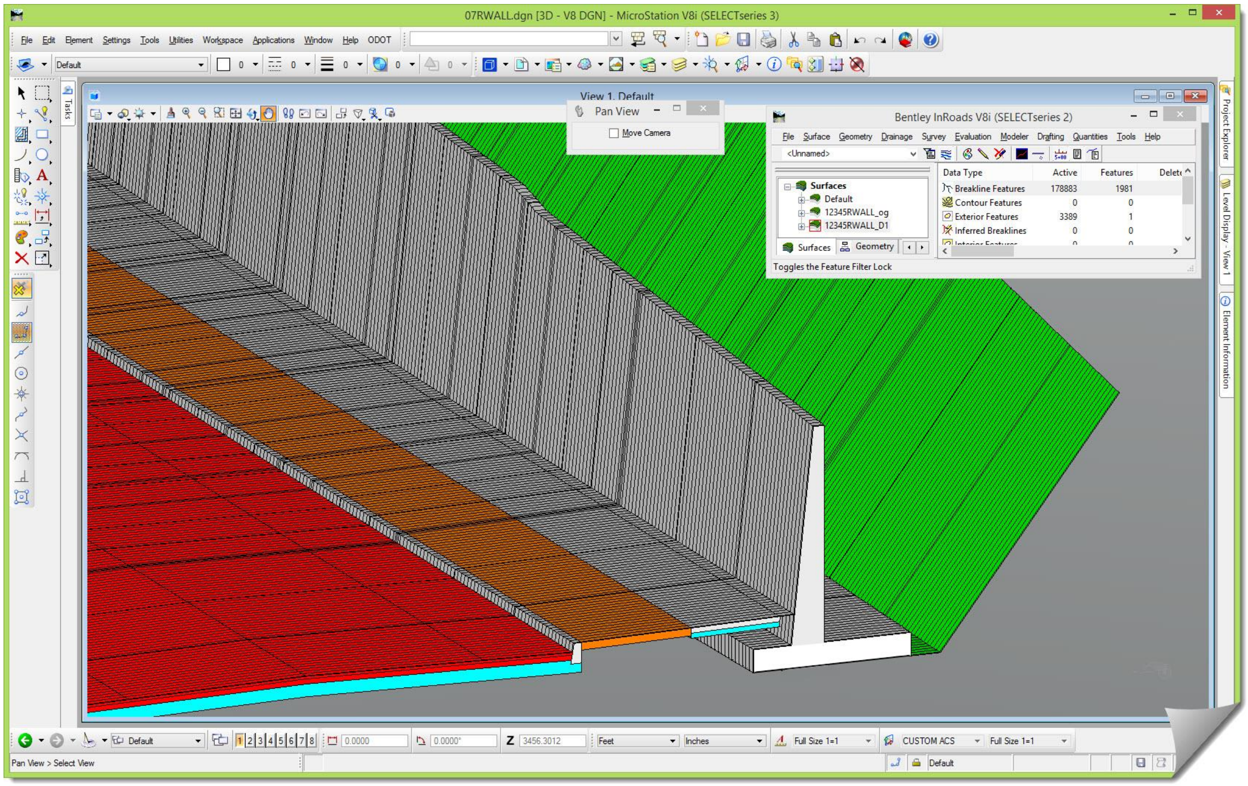
11) Step further along the alignment and verify some of the other section views to make sure that they are reacting properly as well.
12) When you are done with that review, click [**Process All**] to temporarily develop the design model within the **ROADWAY DESIGNER.**
13) Create a surface of this **Corridor** using the settings shown here (or whatever settings you deem are appropriate for your modeling):

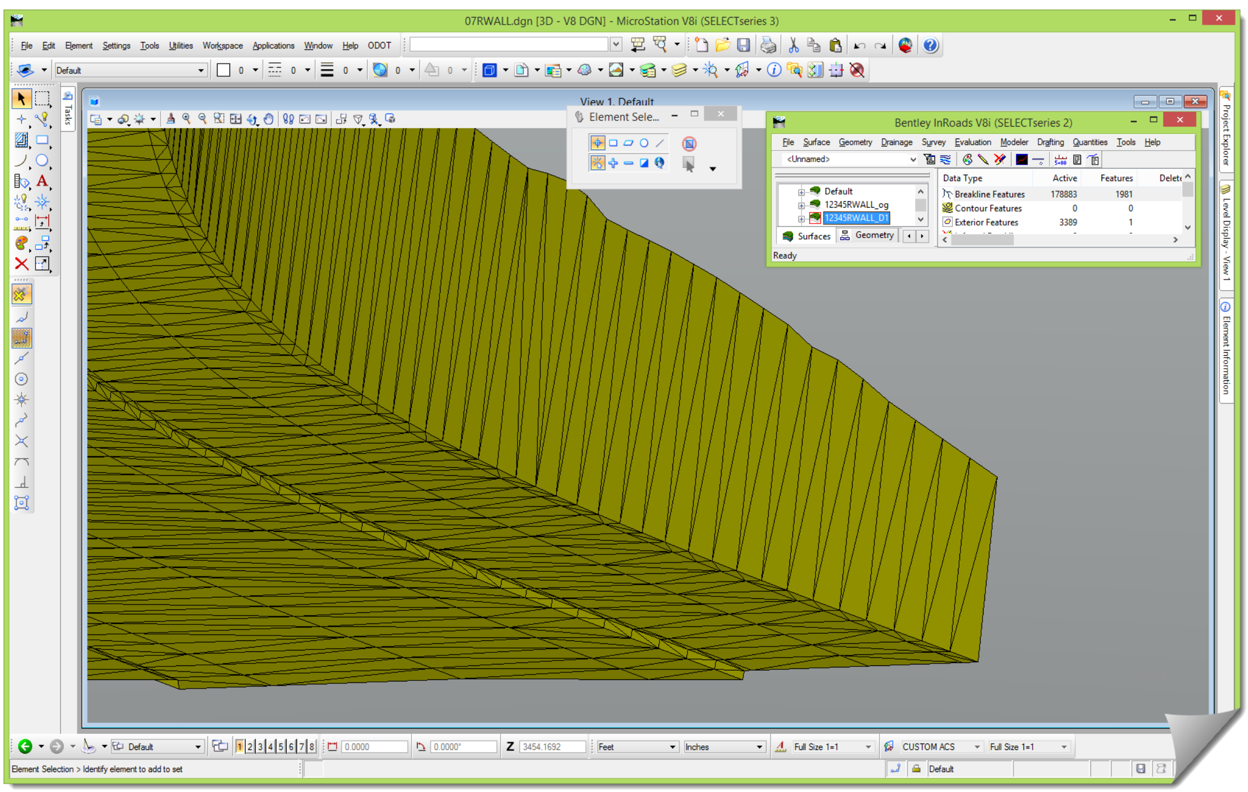


14) [**Close**] the **ROADWAY DESIGNER**, verify the creation of the design surface and then [**Save**] it.

15) Do a review of the surface by viewing the **Triangles**, **Components** or any other aspects of the resulting surface.

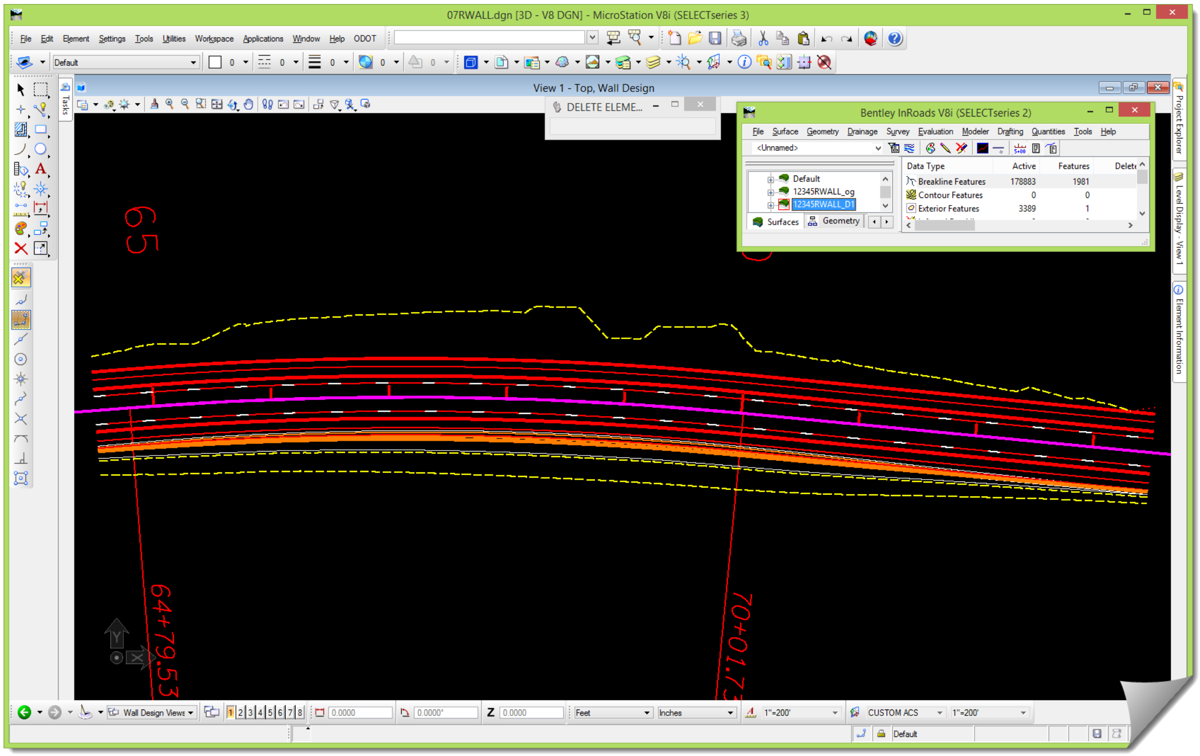
Note the difference in viewing the components versus the surface triangles.



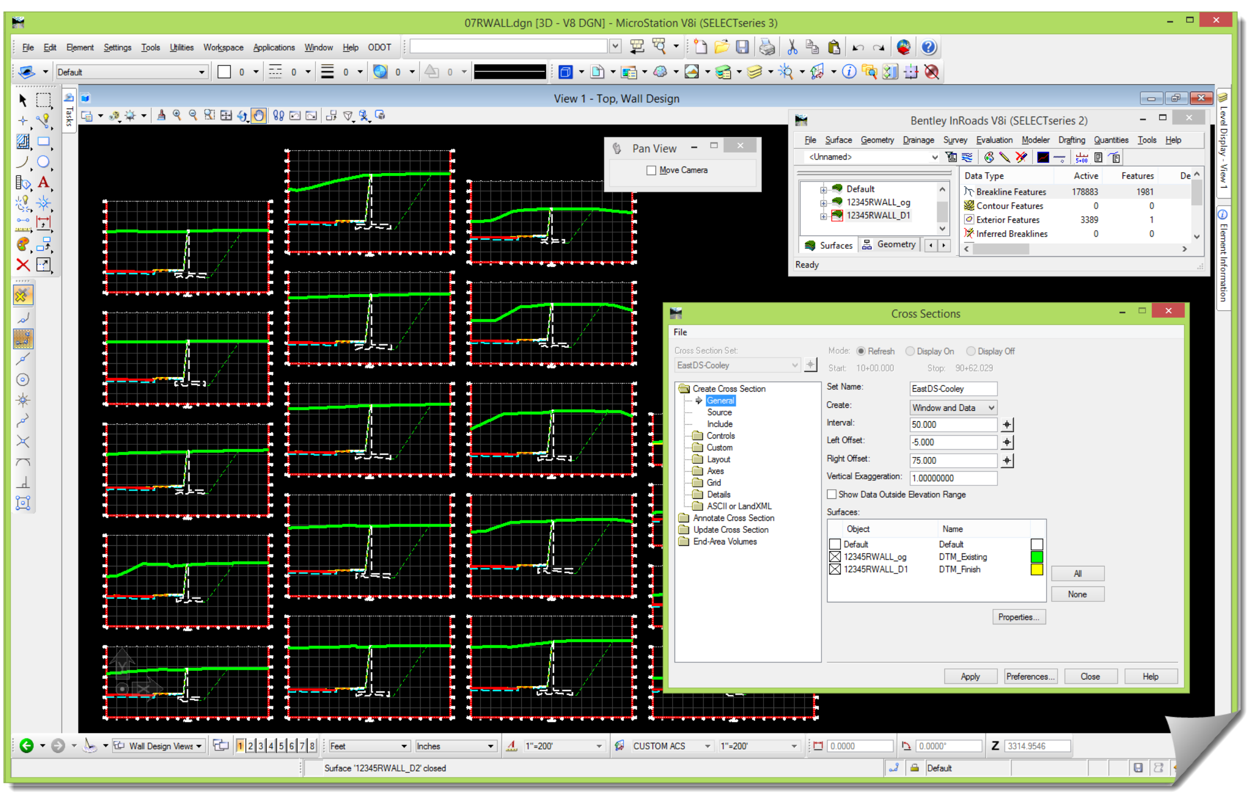


With this surface model, the Roadway designer can supply whatever Plan, Profile or Cross Sectional information the Structural and Geotechnical designers need for their design work.

16) **View Features** in plan.



17) **Create Cross Sections** viewing the surface as well as **Components**.



You can create a profile along the roadway centerline and project the wall features to it, but you may also want to create a profile along the wall itself.

Here is a potential workflow to provide information to the wall designers:

a. **VIEW** a **FEATURE** like **`WallCL_R`** from the design surface that will act as a new path for a profile

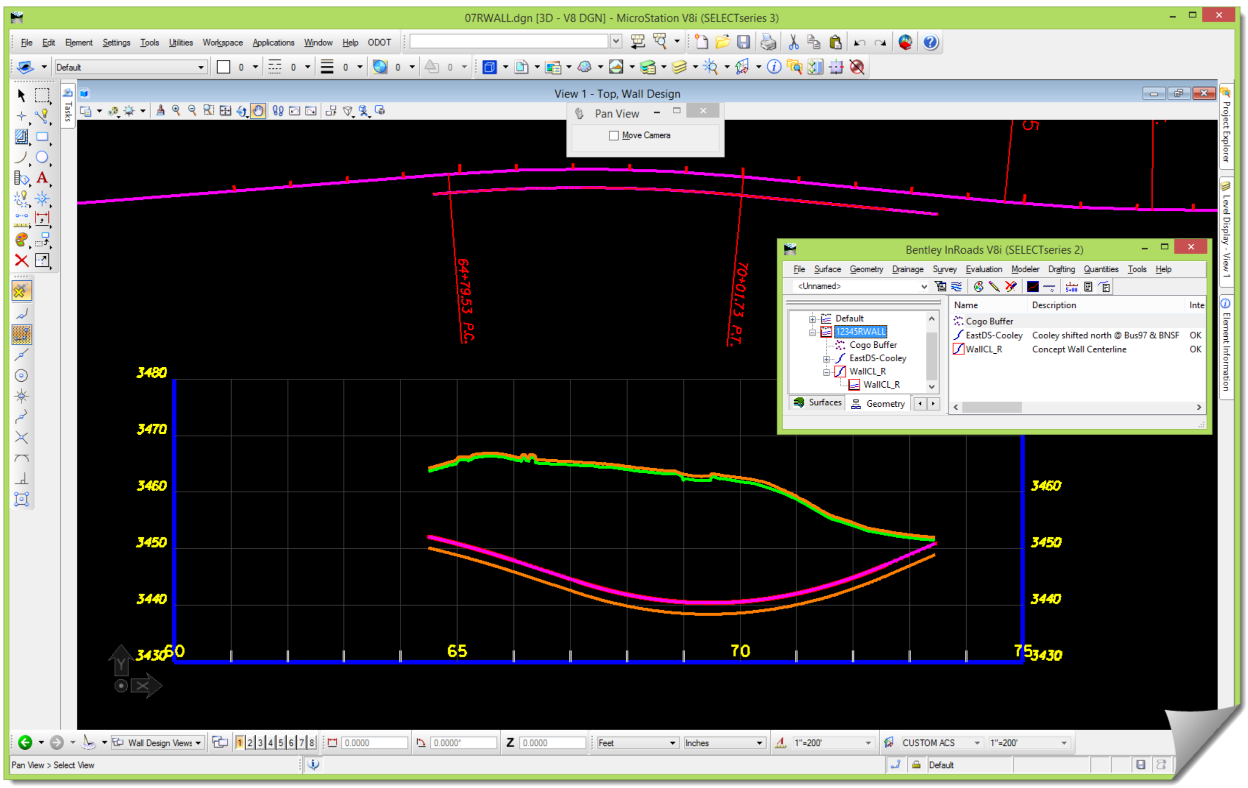
b. Import that **Feature** to a **Horizontal and Vertical** alignment using **IMPORT GEOMETRY FROM GRAPHICS**

c. Reset the beginning station of the imported alignment to sync up with the roadway centerline stationing (in this case it would be **64+50**)

d. **CREATE PROFILE** showing only the OG

e. View the **Vertical Alignment** for **`WallCL_R`** on the profile and annotate it as needed

f. Using the **UPDATE PROFILE** command, **Project Features** onto the profile that show any key locations like the top of wall (**`WallTF_R`**) and / or the top of footing (**`WallBB_R`**)



This information will be very useful for the designers to develop the final wall configuration.

18) Make sure you have saved any information that you've created, because some of it will be used as you step into the next section.

At this point, the initial concept walls have been created and the relevant information has been passed on to the Structural and Geotechnical designers. And for now, as far as the walls go, the Roadway designer is just standing by to supply them with any other information that they need in order to facilitate the final design of the retaining walls.

SCENARIO 2 - FINALIZING THE WALLS

This section will continue moving forward under the premise that the Roadway designer has received the final wall layout details from the Structural and Geotechnical designers.

Depending on the wall designer, you may receive a variety of things; however, the key information that you want is information regarding the main values to define the wall geometrics. These are shown on the earlier diagram and include **H**, **B**, **C**, **T**, **S** and **L**. The **H**, **B**, **C**, and **T** are required for the InRoads **PARAMETRIC CONSTRAINTS**.

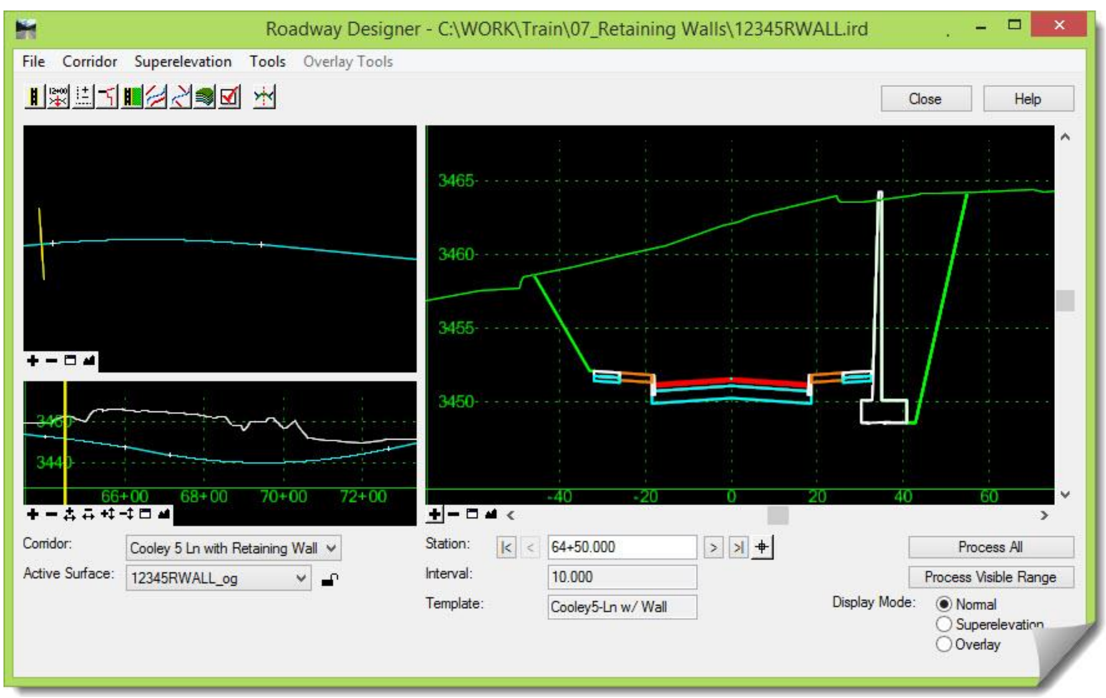
Once you obtain these values, a spreadsheet such as this can help compute the template input:

	A	B	C	D	E
1		**H**	**B**	**C**	**T**
2	**64+50**	12.00	8.00	1.50	1.00
3	**64+80**	14.00	9.00	1.75	1.25
4	**65+15**	16.00	10.50	2.25	1.50
5	**65+65**	18.00	12.00	2.75	1.67
6	**66+45**	20.00	13.50	3.25	1.83
7	**67+40**	22.00	14.75	4.00	2.08
8	**70+55**				
9					
10	*** All values listed in Feet**				
11	**** Values taken directly from DET3705**				
12					

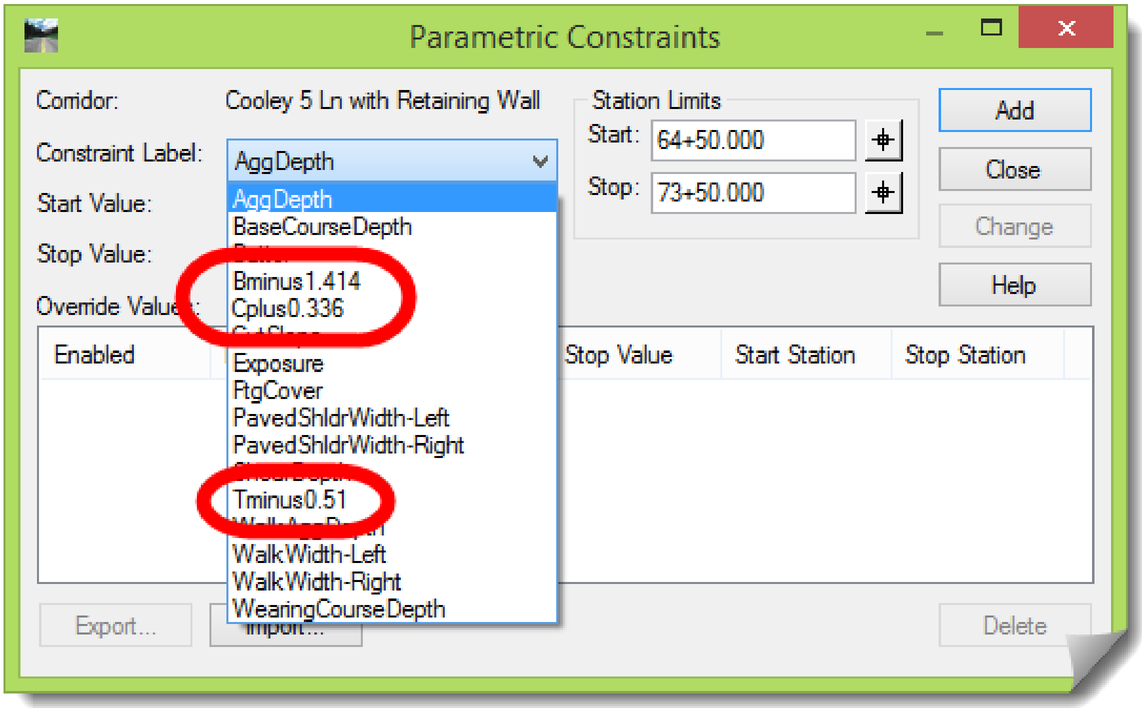
These values will be used to firm up the initial wall concept model that currently exists in the **ROADWAY DESIGNER**.

1) Open the **ROADWAY DESIGNER** and set the **Active Surface** to **`R12345RWALL_og`**.

The **Corridor** should be set to **`Cooley 5Ln with Retaining Wall`** since there is only one.



2) Go to ***Tools > Parametric Constraints*** in the **Roadway Designer** and take a look at the available **Constraint Labels**.



The dimensions that have been provided by the wall designers are **B**, **C** and **T**. These were mentioned earlier, but will be looked at in a little more detail now that a **Start Value** and a **Stop Value** has to be entered for each.

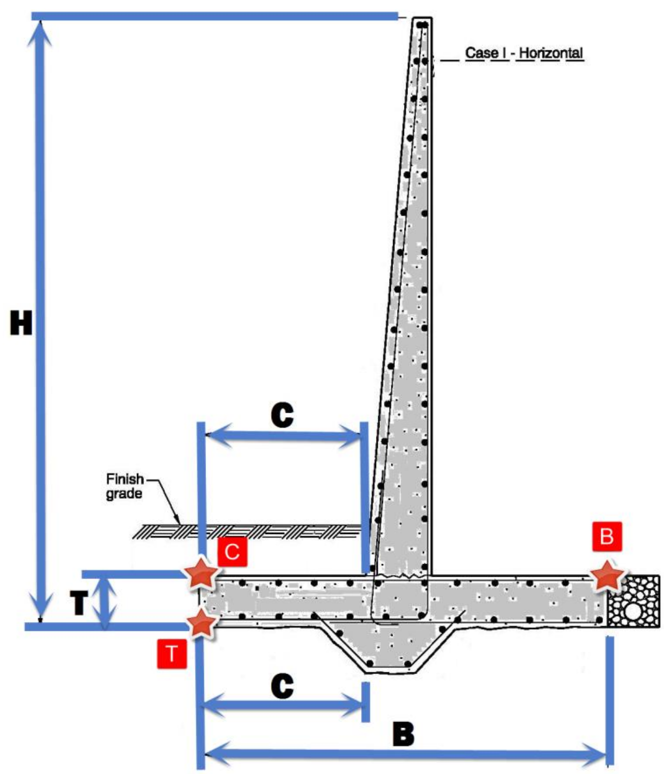
The location of these variables and the point assigned the **Constraint Label** is shown here for reference.

Let's look closer at these **Parametric Constraints** by first noting their names:

- **Bminus1.414**
- **Cplus0.336**
- **Tminus0.51**

These names are an indication of a required **Value** adjustment that needs to be made to each as they are transferred from the wall designer criteria into the InRoads **Roadway Designer**.

The basic reasoning for this **Value** adjustment is due to the construction of the wall component and the way the points are constrained to one another. In the case of these three points, their locations are not relative to any actual wall point, but relative to a 'calculated' **Null Point** position.



These **Null Points** were cited earlier, and if a detailed review of the component was done, it would have been observed that some of the wall points are positioned relative to these **Null Points**.

The exact calculations that were performed to develop these **Parametric Constraint** adjustments won't be covered here, but it's important to understand how to take the wall design values from the designer and enter them into the **ROADWAY DESIGNER**.

These are the baseline design values that will need to be converted to the template's **Values**:

STA	B	C	T
64+50			
	8.00	1.50	1.00
64+80			
	9.00	1.75	1.25
65+15			
	10.50	2.25	1.50
65+65			
	12.00	2.75	1.67
66+45			
	13.50	3.25	1.83
67+40			
	14.75	4.00	2.08
70+55			

The values above need to be adjusted by the number in the name of the **Constraint Label**.

- **Bminus1.414** – The design '**B**' **Value** is **1.414** smaller (or should decrease the relative value)
- **Cplus0.336** – The design '**C**' **Value** is **0.336** greater (or should increase the relative value)
- **Tminus0.51** – The design '**T**' **Value** is **0.51** smaller (or should decrease the relative value)

The last thing to consider in making the value adjustments is the sign of the value in InRoads. The design values are always positive. The template **Value** can be negative, or positive, depending on whether or not that offset is above or below the **Null Point**.

The adjustment is approached this way:

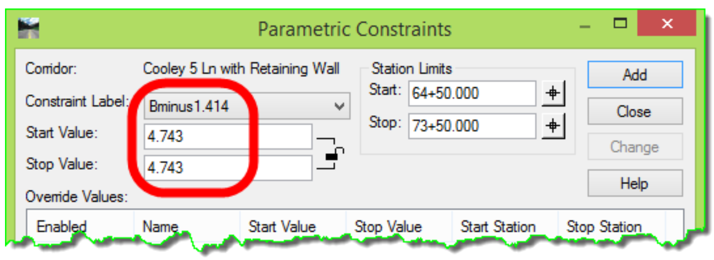
a. Take the design value and change the sign to match the sign of the default **Value**

b. Adjust the 'minus' decrease or 'plus' increase to the signed **Value**

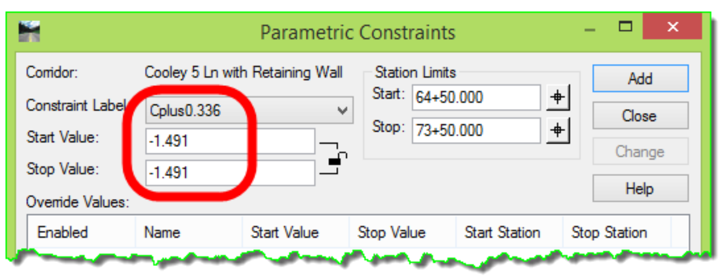
c. Enter this into the **ROADWAY DESIGNER**

The easiest way to determine if the values are negative or positive is to select the **Constraint Label** in the **PARAMETRIC CONSTRAINTS** dialog box. Ignore the actual **Value** and observe the sign.

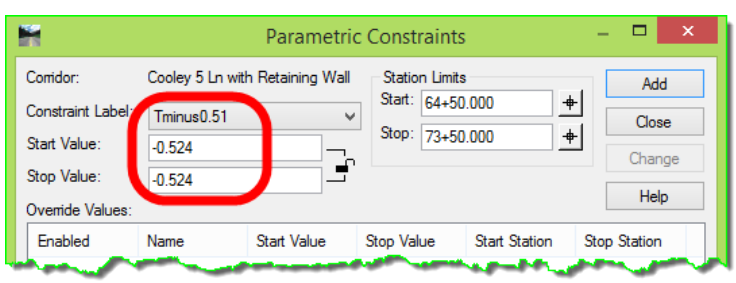
- InRoads '**B**' **Values** are positive, so a design value of `8.000` becomes `6.586` in the **ROADWAY DESIGNER**
  - Take the design value of `8.000`
  - The default **Value** is *positive*, therefore the constraint's **Value** is `+8.000`
  - The constraint's adjusted **Value** is `1.414` less, therefore it's `6.586`



- InRoads '**C**' **Values** are negative, so a design value of `1.50` becomes `-1.836` in the **ROADWAY DESIGNER**
  - Take the design value of `1.500`
  - The default **Value** is *negative*, therefore the constraint's **Value** is `-1.500`
  - The constraint's adjusted **Value** is `0.336` more, therefore it's `-1.836`



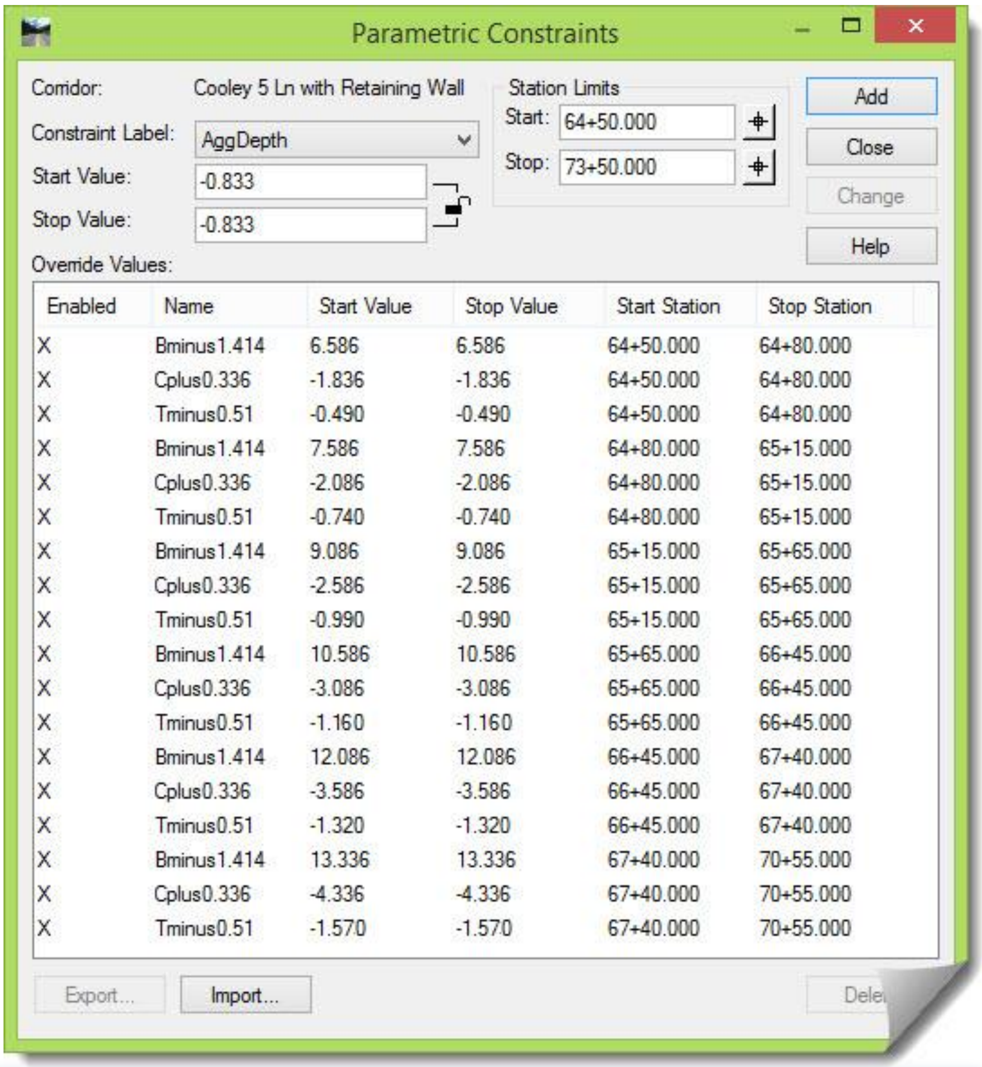
- InRoads '**T**' **Values** are negative, so a design value of `1.00` becomes `-0.490` in the **ROADWAY DESIGNER**
  - Take the design value of `1.000`
  - The default **Value** is *negative*, therefore the constraint's **Value** is `-1.000`
  - The constraint's adjusted **Value** is `0.510` less, therefore it's `-0.490`



Admittedly, this is not necessarily intuitive and may be challenging at first. Regardless, this methodology will allow InRoads to produce a more accurate model of the retaining walls based on actual design values.

3) Convert the wall design values provided earlier into the template equivalents and enter them in the **Parametric Constraints** tool.

It is suggested that you manually work through each of the value adjustments for **B**, **C** and **T**, and compare them to the ones shown below as a check. If something isn't working out correctly, please restudy the last few pages.



Enabled	Name	Start Value	Stop Value	Start Station	Stop Station
X	Bminus1.414	6.586	6.586	64+50.000	64+80.000
X	Cplus0.336	-1.836	-1.836	64+50.000	64+80.000
X	Tminus0.51	-0.490	-0.490	64+50.000	64+80.000
X	Bminus1.414	7.586	7.586	64+80.000	65+15.000
X	Cplus0.336	-2.086	-2.086	64+80.000	65+15.000
X	Tminus0.51	-0.740	-0.740	64+80.000	65+15.000
X	Bminus1.414	9.086	9.086	65+15.000	65+65.000
X	Cplus0.336	-2.586	-2.586	65+15.000	65+65.000
X	Tminus0.51	-0.990	-0.990	65+15.000	65+65.000
X	Bminus1.414	10.586	10.586	65+65.000	66+45.000
X	Cplus0.336	-3.086	-3.086	65+65.000	66+45.000
X	Tminus0.51	-1.160	-1.160	65+65.000	66+45.000
X	Bminus1.414	12.086	12.086	66+45.000	67+40.000
X	Cplus0.336	-3.586	-3.586	66+45.000	67+40.000
X	Tminus0.51	-1.320	-1.320	66+45.000	67+40.000
X	Bminus1.414	13.336	13.336	67+40.000	70+55.000
X	Cplus0.336	-4.336	-4.336	67+40.000	70+55.000
X	Tminus0.51	-1.570	-1.570	67+40.000	70+55.000

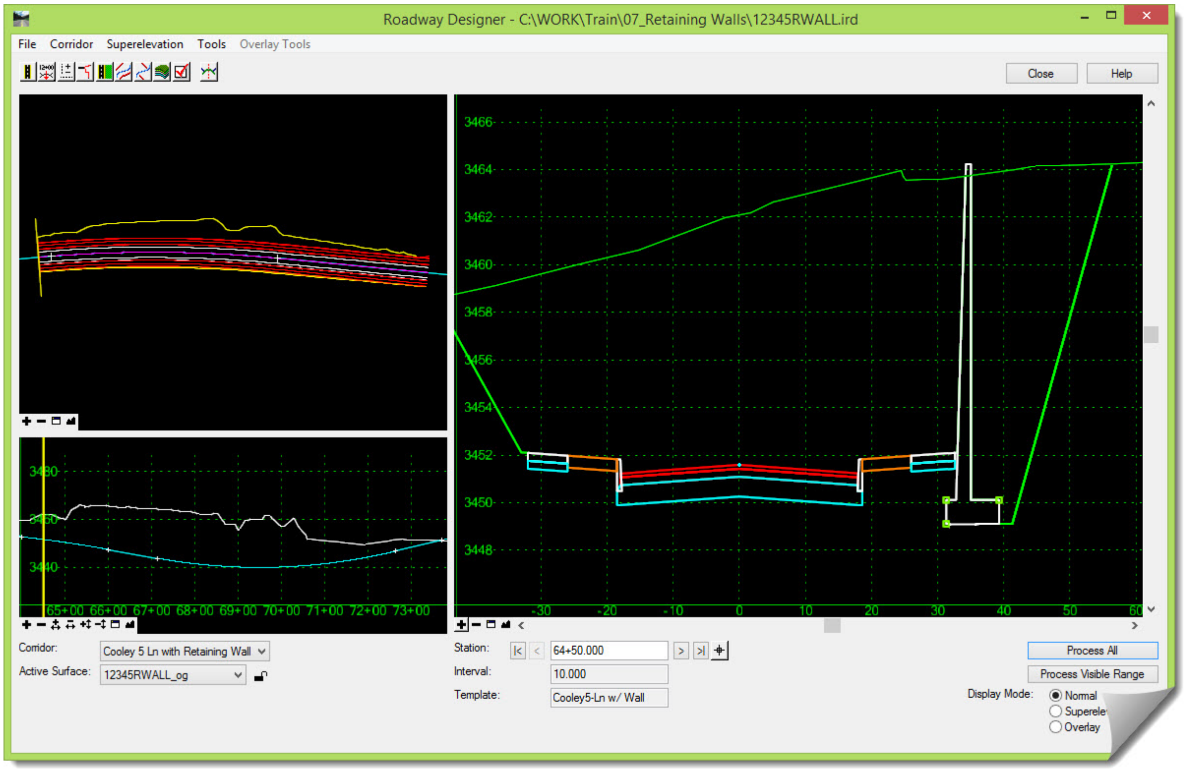
TIP: The structure of this file uses a pipe-delimiter (**|**) and a very specific format. If you are a strong Excel user, you may be able to perform some of these calculations in a spreadsheet, as well as save a file that can be reformatted and imported into InRoads.

Remember, there are actually other **Parametric Constraints** that can influence this wall configuration such as **`Exposure`** and **`CutSlope`**. If the wall designers do not provide these values, they are assumed to be the same as the default **Values** used during the initial wall component construction.

4) [**Close**] the **Parametric Constraints** dialog box when this is complete.

5) Select [**Process All**] to generate an updated corridor.

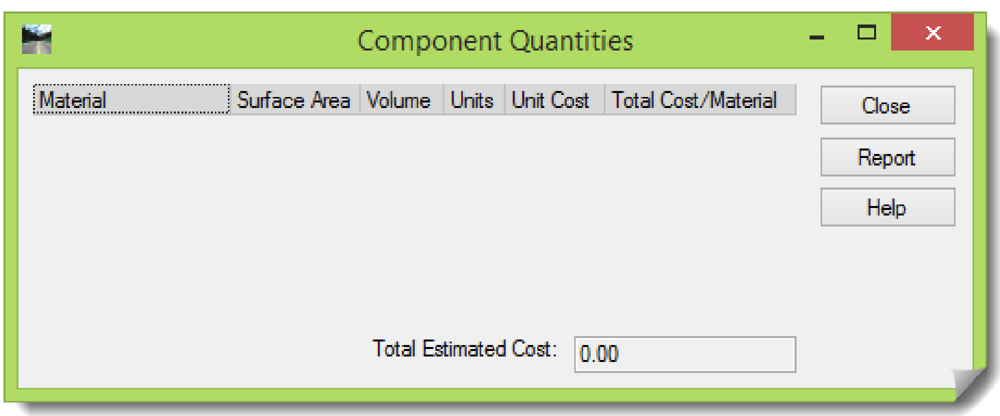
You should now see an improved design-driven retaining wall with the **Parametric Constraint** indicators in the **Roadway Designer**.



6) If you haven't already done so, [**Save**] the **Roadway Designer**.

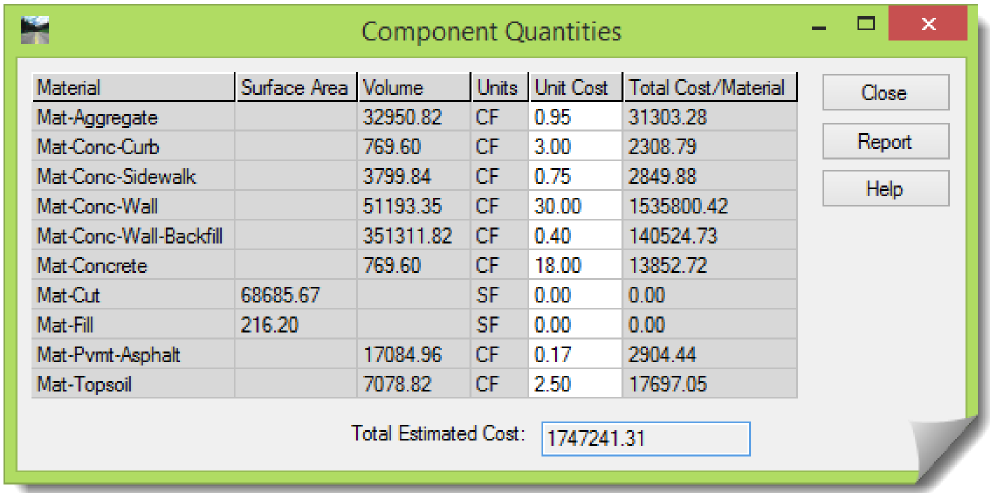
One of the benefits of developing closed components for modeling is the quantity take-off functionality built into InRoads. A version of this capability exists within the **Roadway Designer**, and can be found under **Tools**.

7) Go to **Tools** and open the **Component Quantities**.



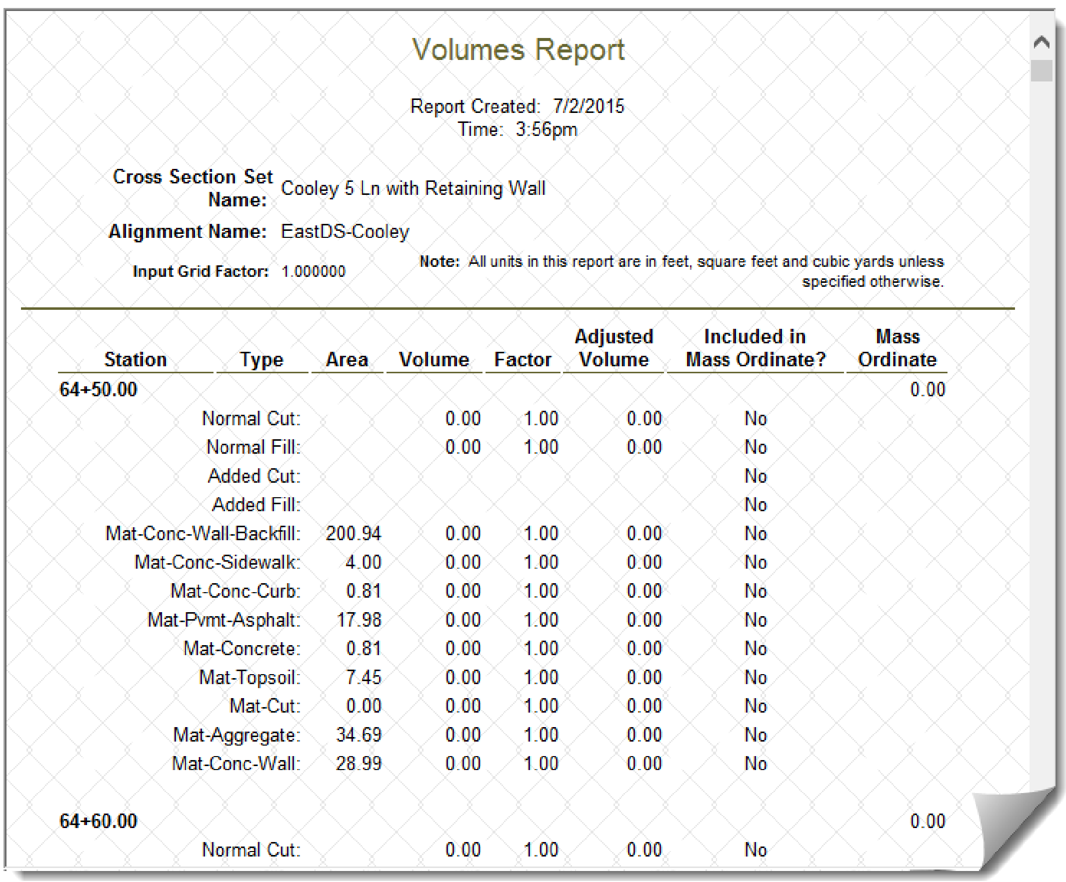
Initially this dialog box is void of information, and is populated by moving the yellow slider bar in the **Roadway Designer** plan view window or by stepping through the sections in the Cross Section Display using the **Station < >** arrow buttons.

8) Slide the yellow bar in the Plan view window along the corridor path and note the activity inside the **Component Quantities** dialog box.



Material	Surface Area	Volume	Units	Unit Cost	Total Cost/Material
Mat-Aggregate		32950.82	CF	0.95	31303.28
Mat-Conc-Curb		769.60	CF	3.00	2308.79
Mat-Conc-Sidewalk		3799.84	CF	0.75	2849.88
Mat-Conc-Wall		51193.35	CF	30.00	1535800.42
Mat-Conc-Wall-Backfill		351311.82	CF	0.40	140524.73
Mat-Concrete		769.60	CF	18.00	13852.72
Mat-Cut	68685.67		SF	0.00	0.00
Mat-Fill	216.20		SF	0.00	0.00
Mat-Pvmt-Asphalt		17084.96	CF	0.17	2904.44
Mat-Topsoil		7078.82	CF	2.50	17697.05

9) Click the [**Report**] button to open the assigned XML style sheet.



Station	Type	Area	Volume	Factor	Adjusted Volume	Included in Mass Ordinate?	Mass Ordinate
64+50.00							0.00
	Normal Cut:		0.00	1.00	0.00	No	
	Normal Fill:		0.00	1.00	0.00	No	
	Added Cut:					No	
	Added Fill:					No	
	Mat-Conc-Wall-Backfill:	200.94	0.00	1.00	0.00	No	
	Mat-Conc-Sidewalk:	4.00	0.00	1.00	0.00	No	
	Mat-Conc-Curb:	0.81	0.00	1.00	0.00	No	
	Mat-Pvmt-Asphalt:	17.98	0.00	1.00	0.00	No	
	Mat-Concrete:	0.81	0.00	1.00	0.00	No	
	Mat-Topsoil:	7.45	0.00	1.00	0.00	No	
	Mat-Cut:	0.00	0.00	1.00	0.00	No	
	Mat-Aggregate:	34.69	0.00	1.00	0.00	No	
	Mat-Conc-Wall:	28.99	0.00	1.00	0.00	No	
64+60.00							0.00
	Normal Cut:		0.00	1.00	0.00	No	

10) To conclude this section you can:

- Create the design surface
- Review the resulting design surface in MicroStation
- Create Cross Sections for an additional review of the design surface

SCENARIO 3 - WALL HEIGHT POINT CONTROL

One more scenario will be mentioned here and presented as a workflow.

It is likely, in the course of designing the retaining wall, that the Structural or Geotechnical designer will choose to establish the height of the wall.

In the modeling so far, the height of the wall was completely determined by the Exposure value and the **`Daylight` End Condition** that starts at the **`WallCL`** point on the retaining wall component, and where that EC successfully intercepted its target – the OG surface.

In the case where the wall height is provided by the wall designer, a few modifications have to be made to the wall component.

Here is the workflow should this be the case (feel free to open the **Create Template** tool and walk through the steps related to the template):

a. Initial wall concept is done as usual and given to the Structural and Geotechnical designers.

b. They return with a top of wall design.

c. Create a "Design" Top of Wall vertical alignment as directed / determined / created by the Geologist or Structural designer.

d. Make a copy of the template containing the retaining wall.

e. Modify the retaining wall component by removing the **Parent-Child** relationship between the Wall and Daylight components. This was required for the concept work, but is no longer needed since the daylight condition will be overridden by the provided top of wall design.

f. Delete the **Daylight** component, and place a vertical constraint on the **WallTF** point, tying it to **WallCL.** This properly constrains the top of wall face.

   A new component could be created that already contains this condition; however, it is relatively simple to remove the unnecessary component and re-constrain the top of wall.

g. Update the **Roadway Designer** with this revised template.

h. Add a **Vertical Point Control** to the **WallTF** point, using the newly created vertical alignment as the control.

i. Create the new design surface.

Including the wall in the Surface

Lastly, if there is a desire to include the wall in the surface triangulation it will be necessary to edit the features after the design surface is created. This is needed in order to develop the triangulation since the wall component is, by default, excluded from triangulation.

This is done in the **Feature Properties** by turning off the "**Exclude From Triangulation**" toggle. This would be done to the **WallTF** feature and the others on the top of the wall, down to the wall backfill in the finished surface (**`WallTB`** and **`Bf1`**).

FINAL NOTE

ALERT: Remember, the geologist or geotechnical engineer may come back with a different wall type, requiring the roadway designer to create a new component. Regardless, much of the general process included in the module will be the same.

Conclusion

Congratulations, you have completed the Retaining Wall module and should be another step closer to building 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.