Stepping into Variable Height Retaining Walls

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CR 2499 - Mechanically-stabilized earth (MSE) walls are inherently complex shapes; smoothly curving in all 3 dimensions while the structure changes shape. Modeling complex geometry for quantity takeoff, automated machine guidance (AMG), and coordination can be accomplished using Autodesk® AutoCAD® Civil 3D® software with or without the use of Subassembly Composer (SAC). In this advanced class, we create an MSE wall that is based on construction documents. We streamline stepped profile creation, removing a data input bottleneck. We also demonstrate 2 methods for creating MSE wall assemblies and the advantages and disadvantages of using SAC. Moving onto creating the corridor itself, we discuss issues of representing profile steps and how Civil 3D can properly represent necessary detail for MSE walls. After creating the model, we briefly show quantification, visualization, and coordination. All of these steps lead up to exporting the model for AMG to enhance field productivity. At the end of this class a user who knows Civil 3D will be able to easily create a 3D MSE wall. Although this class focuses specifically on MSE walls, these same techniques can be used for any linear structure.

Learning Objectives

At the end of this class, you will be able to:

- Use Microsoft® Excel® and macros to streamline data-heavy profile creation
- Create an MSE wall assembly using standard Civil 3D subassemblies
- Use a custom subassembly created in Subassembly Composer to create a 3D solid MSE wall
- Visualize, coordinate, quantify, and export survey surfaces and line work for an MSE wall

About the Speaker

Eric Cylwik is the virtual construction engineer for Sundt's Heavy Civil division. Before working exclusively for the heavy civil division, Eric focused on adapting BIMs from the office to the field for Sundt's GC & concrete divisions. He now focuses on creating Virtual Design and Construction models that highlight technology's capability to enhance the way construction is performed in the field for horizontal construction. Focusing on infrastructure, he has been able to leverage parametric modeling to create construction-quality bridge, road, and trench models that are used for survey surfaces, machine control, quantity take offs, utility coordination, constructability reviews. Eric has helped Sundt procure almost $1 billion of alternative delivery method projects. Eric graduated from Arizona State University with a Degree in Design Studies with an Emphasis in Digital Visualization. He is also a certified professional in several vertical and horizontal BIM and VDC software.

Using Microsoft Excel to Streamline Data-Heavy Profile Creation

Excel to Civil 3D Formatting Rules:

When exporting a profile to Civil 3D the first column of a spreadsheet is always read as the station, and the second as the elevation of a vertical point of intersection. It is possible to use the third column as a curve length, but that will not be addressed in this class.

	A	B
1	STA	ELEV
2		
3		

Figure 1

Formulas

This course will use formulas to reduce the amount of data entry required by the user. Assuming the top of wall profile elevation is specified every twenty feet a simple excel formula can be used and then replicated to lower cells (see Figure 2). The assumption can also be made that the elevations will be higher than 4,000. In Column B Excel can be instructed to add the ones and tens value of the elevation to 4,000, producing the correct number. This reduces the amount of data that needs to be entered to create the correct profile elevations. Figure 2 below shows the formulas, and figure 3 shows the data output.

	A	B	C
1	1000	=C1+4000	15.89
2	=A1+20	=C2+4000	17.05
3	=A2+20	=C3+4000	18.22

Figure 2

	A	B	C
1	1000	4015.89	15.89
2	1020	4017.05	17.05
3	1040	4018.22	18.22

Figure 3

Records of Profile "Source"

When calculations are required for elevations or stations they can recorded in the spreadsheet. This allows records to be easily kept of how specific elevations or stations were generated, producing an enhanced documentation method for survey calculations. Figure 4 shows the formulas, note Column D row 1. Two values are added together to produce a specific station, but can still be recalled later. Figure 5 shows the data output.

	A	B	C	D
1	1000	=C1+4000	12.06	=7.39+19.68
2	=A1+D1	=C2+4000	12.06	9.84
3	=A2+D2	=C3+4000	12.68	19.68

Figure 4

	A	B	C	D
1	1000	4012.06	12.06	27.07
2	1027.07	4012.06	12.06	9.84
3	1036.91	4012.68	12.68	19.68

Figure 5

Easy to Update

Updating a formula and replicating it is much less time consuming that hand entering an entirely new or different data set. If station is updated along an alignment and it no longer begins at 10+00, but begins at 9+88.25, Excel can easily be updated to subtract that value from the profile.

Less Error Prone

Using color-coded conditionals in Excel it is possible to highlight any erroneous entries that fall outside of the profile range. See Figure 6.

	A	B
1	1000	4012.06
2	1027.05	4012.06
3	1027.07	4012.06
4	1036.89	4012.06
5	1036.91	4012.68
6	1056.57	4012.68
7	1056.59	4013.29
8	1066.41	4013.29
9	1066.43	4013.91
10	1086.09	4013.91
11	1086.11	4014.52
12	1095.93	4014.52
13	1095.95	4015.14
14	1115.61	4015.14
15	1115.63	4015.75
16	1125.45	4015.75
17	1125.47	4016.37
18	1145.13	4016.37
19	1145.15	4016.98

Figure 6

Ability to use Macros, reducing data entry

Export Data to Civil 3D (see sample files)

Create vertical steps between profile points for MSE wall footings. (see sample files)

MSE Wall Assembly Using Stock Subassemblies

MultiLink subassemblies

Quick and excellent tool for creating non-variable shapes as subassemblies in Civil 3D. Very similar to creating a close polyline and converting the closed shape to a subassembly.

LinkVertical Subassembly

Used to offset a subassembly vertically.

LinkWidthAndSlope Subassembly

Normally used to project a specific slope as an offset. This course uses it to convert an absolute elevation difference (the Top Of Wall profile vs. the Bottom Of Wall profile) to a relative difference. Then that value is passed as a parameter to the MSE Panel portion of the subassembly. It tells the MSE panel what height to be.

ShapeTrapezoidal Subassembly

A flexible stock subassembly that has both vertical and horizontal targets. This allows the subassembly to stretch parametrically without breaking it's closed shape. The ShapeTrapezoidal will be used for the MSE Panel shape.

Custom Subassembly for a Retaining Wall in Subassembly Composer

Retaining Wall "H" Value

The "H" Value controls the structural section of the retaining wall. This includes the width and depth of the footing, the presence of a footing toe, as well as the thickness of the wall. This course will demonstrate how to use a constrained input from the user, a constant value of 12 for example, or a variable input that is controlled by a profile height. The variable input will be the most common scenario, but in pre-construction situations that information is not always given.

The H_Target elevation target will read a profile for the current H value, allowing the subassembly to flex based on current conditions

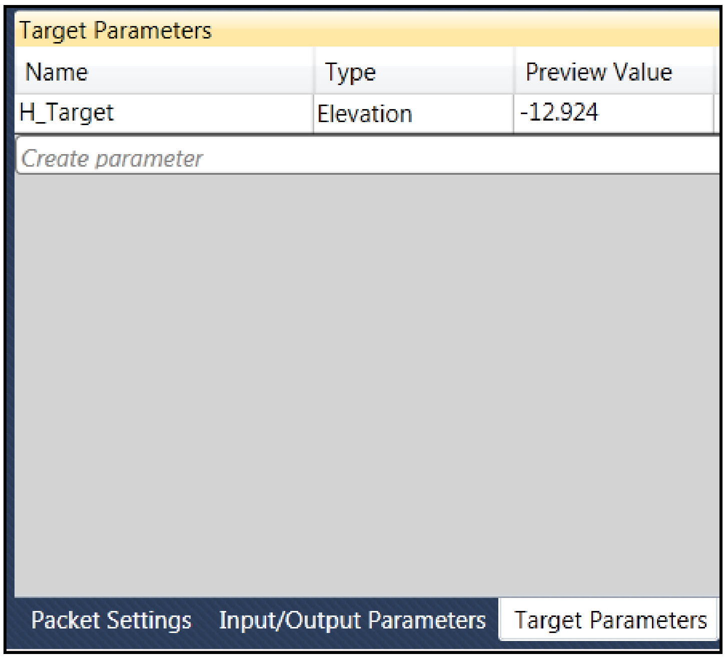

Figure 7

The H_Value input parameter will be a constant input from the user. This will be used when an H_Target value is not present, allowing quick simulations without creating additional profiles.

Geometry Point by Delta Angle and Offset

The delta angle and offset allows a point to be placed vertically based on a target. Using this function one can isolate an elevation target for decision making downstream in a subassembly.

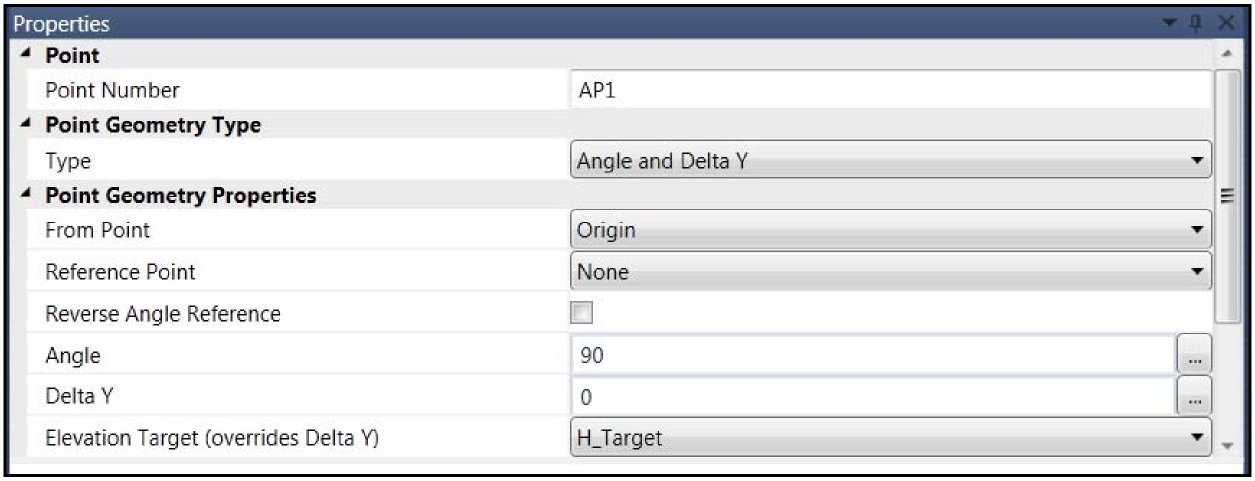

Figure 8

Conditional "IF" statements in Subassembly Composer

Subassembly composer is based on Visual Basic.NET. A user can access many vb.net functions directly within Subassembly composer (SAC). When entering a value for an offset or other parameter an IF statement can be used. See the sample documents for a use case, analyzing the H value of a retaining wall to generate the footing thickness. See Figure 9. It is also possible to use math functions to find absolute values in SAC. See figure 10.

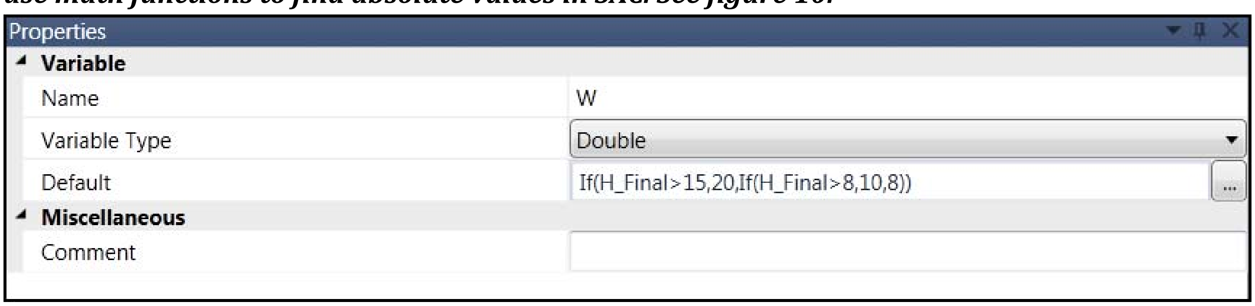

Figure 9

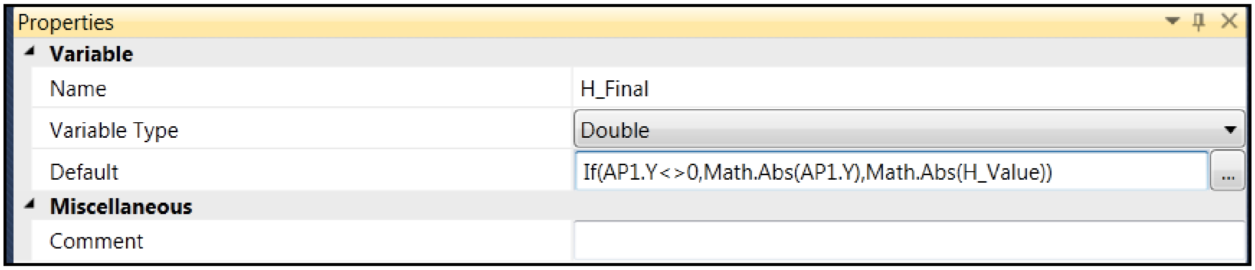
Properties
Variable
Name
H_Final
Variable Type
Double
Default
If(AP1.Y<>0,Math.Abs(AP1.Y),Math.Abs(H_Value))
Miscellaneous
Comment

Figure 10

Export and Use Data from the Model

Quantity Take off

Retaining walls and MSE walls can be very complicated shapes to generate quantities for. As they smoothly curve in all three dimensions a footing size or wall thickness changes and is projected out from the layout line. Beyond calculating the structure itself, measuring from the structure to existing grade can be a challenge in itself. By creating a 3D model the computer is made aware of every variable needed to generate very specific and accurate quantities.

Constructability Review

Construction companies are in the business of managing risk. If a construction executive is not certain of a risk being taken, they will likely add money to the project budget. By creating 3D models for constructability reviews it becomes much easier to communicate complicated construction concerns, sequences, and ideas to those unfamiliar with a project. By reducing the perceived risk of an activity companies can save money and avoid waste.

Clash Detection

As project complexities increase and the duration of design increases it becomes less likely that a specific individual manages the same scope of design on a project. With many designers working on the same project coordination is becoming critical. Using the 3D environment it is possible to have every designer's thoughts "speaking" the same visual language of 3D, without any additional effort necessary.

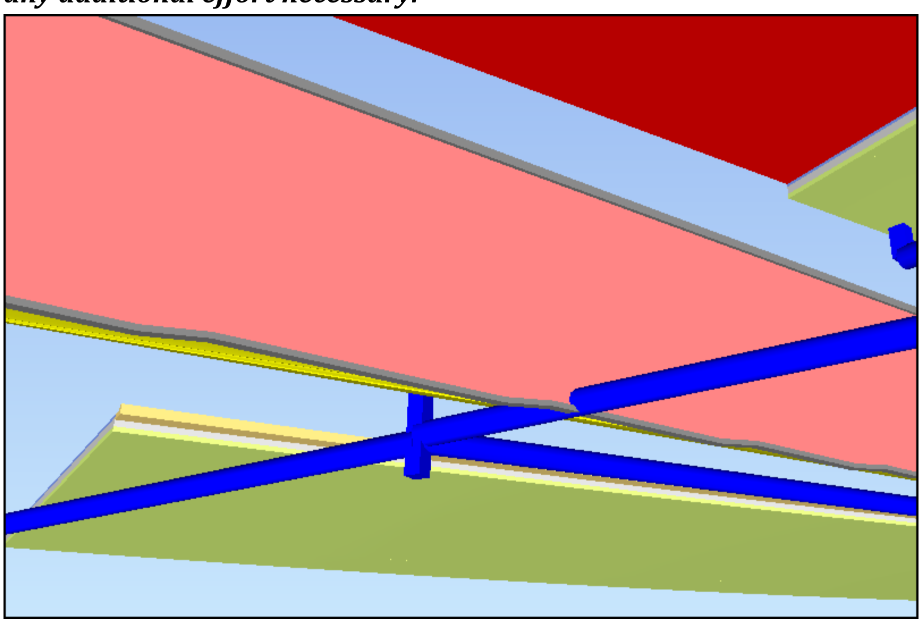

Figure 11

Automated Machine Guidance

All of export from Civil 3D can be survey-grade data, meaning it is ready for construction. By creating surfaces from the corridor in Civil 3D it adds incredible value to the construction process, reducing data reentry and ensuring high levels of accuracy during construction.

This can be accomplished through the surfaces tab of the corridor properties window. After creating the surface it is possible to send it to survey equipment through the LandXML format.

Figure 12