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Grading Optimization: Making Choices that Benefit Automatic Grading

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Learning Objectives

- Learn the roles of zones, lines, and points
- Learn how to encourage drainage in desired directions.
- Learn how to change the objectives to balance volumes.
- Learn how to use the visualization tools to analyze grading progress.

Description

This session will look at Grading Optimization and how it can help users grade sites to optimal slopes or optimal balance. We will look at the importance of zones, and the use of lines and points to provide detail to the automated grading. We will also look at how to encourage desired results, and tools that can identify when results are trending towards undesirable results.

Speaker(s)

Russ Nicloy has been in the civil/infrastructure industry since 1995; 10 years in production drafting and GIS, and 13 years with an Autodesk reseller, providing subject-matter expertise in Civil 3D, InRoads, and Autodesk products. He is a consultant member of the Methods Development team at Wisconsin DOT. His company, MACER Technologies, provides drafting services to the civil/infrastructure industry, with the Autodesk infrastructure collection of products.

The Roles of Zones, Lines, and Points

Different geometry definitions that can be used to encourage overall grading. These definitions can restrict grading at specific parameters, or to a specific geometric location. Since the objective is optimizing a grading result, these definitions let Grading Optimization know what parameters it needs to work within.

Zones

Zones are closed shapes with certain parameters that localize grading. Most zones are similar in that they are assign some sort of slope. Some zones, like Grading Limits, or the more general “Zone,” simply have parameters preset to what that type of zone would normally have. More specialized zones have very specific parameters. The Exclusion Zone prevents grading from occurring within its boundaries.

Zones that are available in Grading Optimization include: Grading Limits, Building Pads, Ponds, Parking Lots, Sidewalk, and user-defined zones.

Lines

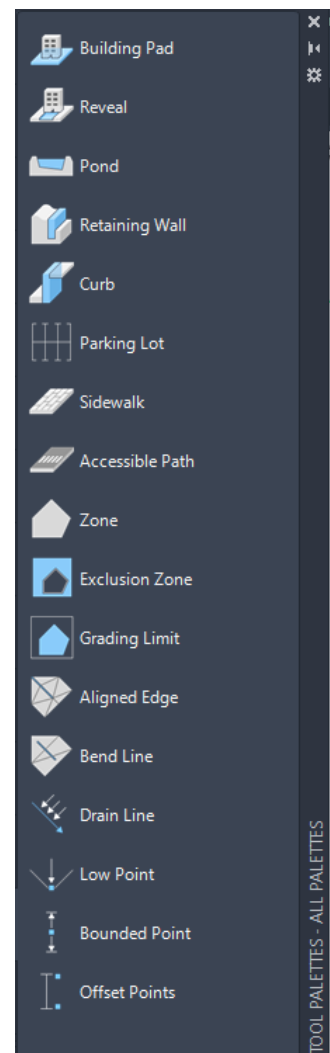
Lines represent open shapes that affect a grading. While some could be closed, the actions they provide work well in un-closed shapes like curbs or retaining walls. Lines are very good at encouraging drainage parameters providing more than just a point to attract drainage.

Lines that are available in Grading Optimization include: Retaining Wall, Curb, Drain Line, Aligned Edge, Bend Line, and Offset Points (which are defined with a line).

Points

Points are very specific locations for drainage. Points can be a general “low point” or could have a specific elevation assigned to it. They could even be assigned a range of elevations so that Grading Optimization has room to optimize the grading functions in relation to the point location. A low point will attract drainage from a large surrounding area. These points do not have to be Civil 3D COGO points. AutoCAD points will also work.

Points that are available in Grading Optimization include: Low Point, and Bounded Point.



The Zones, Lines, and Points available for optimization.

Encouraging Drainage

It is important to keep in mind that you are providing parameters to a computer so that it can find the optimal result. The computer will try to stay within the parameters provided.

Encouraging drainage is the act of letting Grading Optimization know that you are looking for some kind of drainage in a location and in a direction.

Lines that Encourage Drainage

A specific location of definition that encourages grading towards a geometry.

Drainage Lines

Drainage lines attract surface triangle slopes to encourage drainage. The further away the surface triangle it the less attracted it is, and other grading features may influence it away.

If the line is outside a zone it will encourage the zone surface to drain towards the line. If the line is inside the zone the surface triangles will tend to create more of a ditch inside the zone since triangles on either side of the line point back towards it. Some zones have an option to be “Exclusive” which means they ignore drain lines that are outside the zone.

Aligned Edge

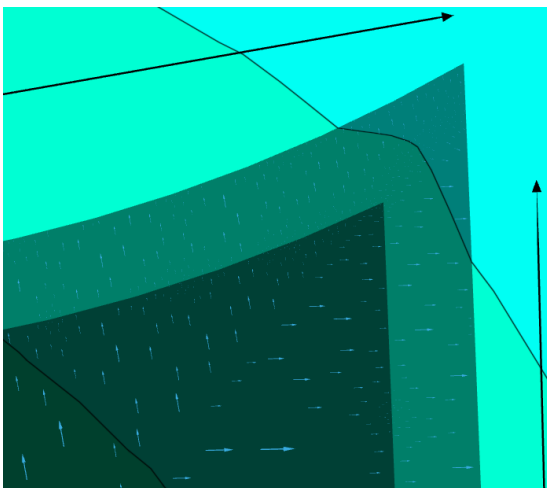
Used when a consistent slope is needed through an area. Aligned Edge lines can be assigned as a breakline which forces triangulation along that location.

Bend Line

Allows any surface triangles that touch it to “relax” (read: ignore parameters).

Offset Points

Despite the name, this is a line tool. You identify two points by drawing a polyline between them. You then provide the elevation difference between those two points.



Hydrology arrows display the effect two drain lines have on this optimization.

Points that Encourage Drainage

Creates a very specific location that is either a low point relative to the rest of the grading or at a specific elevation, or a range of elevations.

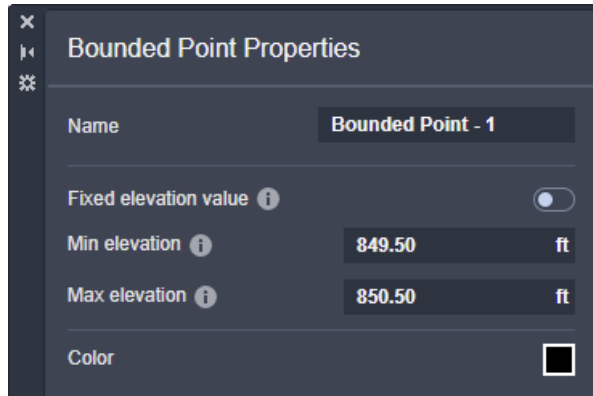
Low Point

Either a Civil 3D COGO point or AutoCAD point object can be placed and will encourage drainage to that location. The elevation of the COGO point or AutoCAD point object does not matter as the Low Point object will just be the low point relative to the rest of the optimization. If you need a specific elevation assigned the Bounded Point should be used.

There is an option to set the low point drainage area to Diamond Shape which can be useful in areas like parking lot drainage.

Bounded Point

The Bounded Point allows for assigning a specific elevation, or a range of elevation, to be respected during optimization. Civil 3D COGO point elevation is respected by this tool but can be changed while assigning the point.



The screenshot shows the 'Bounded Point Properties' dialog box. It has a title bar with standard window controls. The 'Name' field is set to 'Bounded Point - 1'. There is a 'Fixed elevation value' toggle switch which is currently turned off. Below this, the 'Min elevation' is set to '849.50 ft' and the 'Max elevation' is set to '850.50 ft'. At the bottom, there is a 'Color' field with a black color swatch.

Bounded Points allow for specific elevations or a range of elevations to be assigned to the grading as a point.

Balance Volumes or Other Objectives

While all grading is being optimized, Grading Optimization can influence decisions based on weighted factors. Perhaps your project is more interested in balancing cut and fill for the project, but not as interested in how much earthwork there would be. As the grading is being optimized there will be an emphasis on the objectives you choose. These objectives are weighted to better emphasize the proper combination.

Balance Volumes

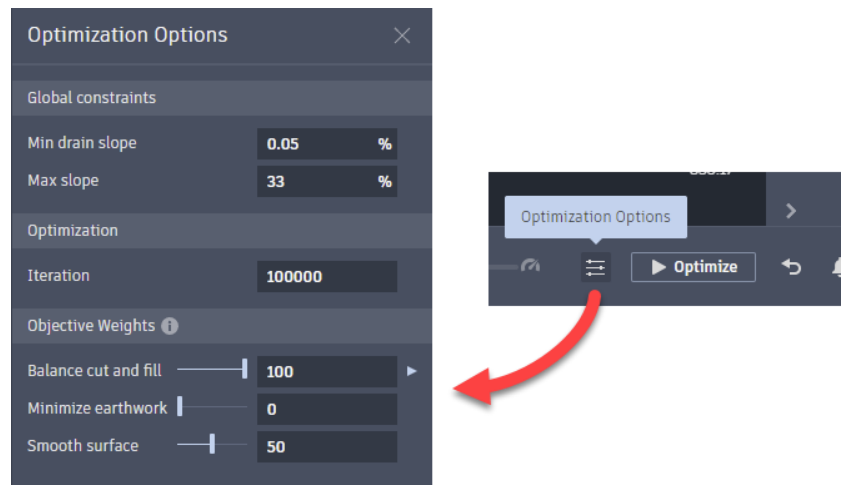
This objective attempts to minimize the difference between cut and fill. You could also assign a net earthwork volume that is acceptable to aim for.

Minimize Earthwork

This objective minimizes the total amount of earthwork, being the sum of cut and fill. Certain design aspects will require cutting or filling, but this objective will try to find options that minimize that.

Smooth Surface

This objective tends to reduce the grade change between surface triangles. This provides a smoother transition over open surface areas.



The Optimization Options are in the lower center of the Optimization window and includes the Objective Weights area.

The Visualization Tools for Supervising the Automatic Grading

The visualization tools are not for making a presentation graphic of the grading project. These tools are available while the grading optimization is running so that you can understand the trends in the possible results. You can switch between options like triangles versus contours, elevation banding versus triangle slopes, and adding drainage flow arrows to each surface triangle.

Visualization Toolbar

The Visualization Toolbar is segmented into several sections; Results, Themes, Topology, and Hydrology. Selecting one of the tools in any of these areas turns off any visual tool that would negate the chosen tool.

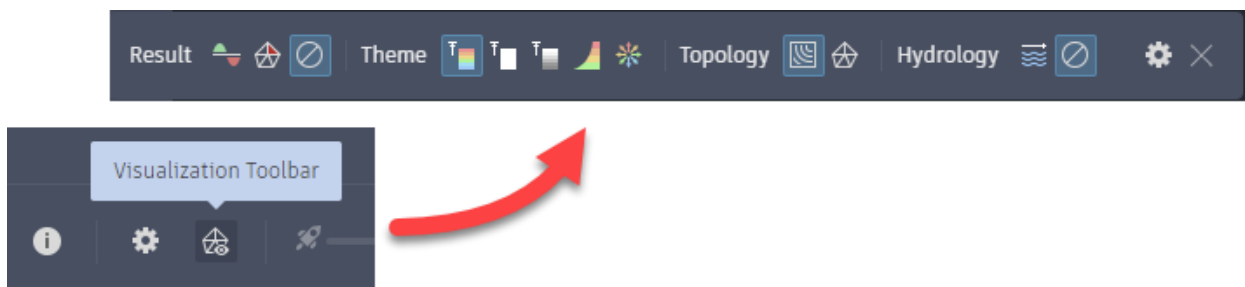
At the start of an optimization the visualization style automatically switches to Violations in the Results area. If you selected the None tool in the Results area the Elevation theme automatically turns on.

Visual Settings

The Visual Settings are available in the gear icon on the visualization Toolbar (there are other gear icons). You can change the contour interval, base elevation, and slope ranges. If you open the Advanced Settings area, you have access to the range definitions of the slope ranges. Whether elevation or slope data, these can help better understand what is happening on the surface.

Vertical Exaggeration Slider

The vertical exaggeration slider appears on the left of the grading optimization window. The window is defaulted to a 1:1 vertical exaggeration, unless you pull that slider up. The slider only affects vertical exaggeration, so details of the surface can be seen more clearly.



The Visualization Toolbar is opened from the icon in the lower left of the Optimization window.

Some Suggestions for Use

This is not an exhaustive list of suggestions, but things you should be aware of when starting out with Grading Optimization. This list is also NOT a list of “right vs wrong.” You will find instances where these suggestions are the opposite of what you may need. These are a good place to start your learning process.

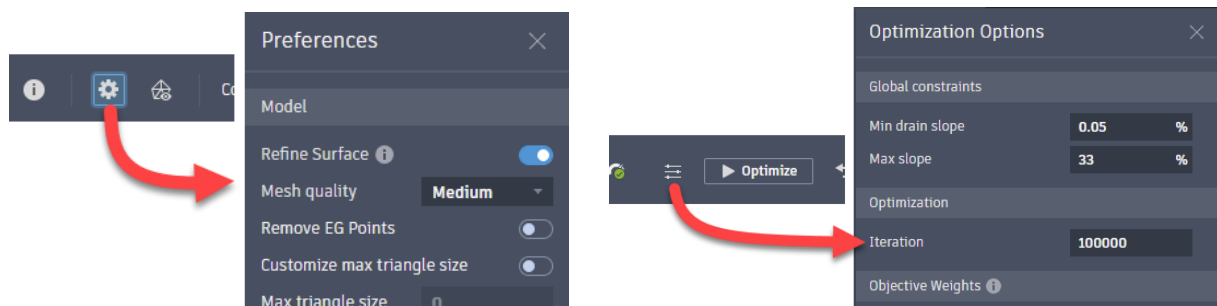
Not for over-constrained projects: Some projects have so many requirements that there is little to no room for optimization. If you are measuring very tight grading areas that have very close tie-ins, you may not benefit from the tools available here.

Limit you limits: The parameters you assign are the outside of the performance envelope. If you have the ability to leave a little more room in the parameters, do so. Remember, you are allowing the tools to find the optimum. If you tell it you are not allowed to go past a certain slope or location, Grading Optimization should be keeping to those limits.

Do grading in phases: You don’t necessarily have to grade the entire project all at once. While that could be useful, it may be beneficial to not need to have every parameter working at the same time. Generally, work from the outside toward the interior of the grading area, thinking in terms of localized additions to the project.

Adjust grading limits (extents) per phase: You do NOT need to stick with the grading limits through the entire project. If the first grading that you optimize is to have a second phase inside of its boundary you can assign a new grading limit inside. If you do this, it is important to turn off the first grading limits, so the new limit is respected. In this way your first grading will stay wherever it falls outside the new grading limit.

Set preferences for speed versus quality: There are settings that you can adjust to speed up the optimization calculations. This can come at the expense of not achieving the higher-quality solution – but perhaps would be “close enough.” If a high-quality surface is required, then plan for a longer optimization run. If you are needing a quick result that is close to what the result *could be* turn the quality options down. Three settings that can make a difference here are: Preference: Refine Surface; Preference: Mesh Quality; Optimization Options: Iterations.



The Preferences and Optimization Options dialogs for adjusting quality versus speed settings.

Before accepting results adjust and try again: If you notice the results are skewing away from your needs, you realize you assigned something incorrectly, or what you were trying just isn't working, you can stop the optimization and start again. Even if the Optimization finished nothing is truly finished until you send the grading to a surface. You can make changes to parameters for zones, lines, or points, turn on/off parameters, return to the drawing file to move geometry around before trying again.