AutoCAD Civil 3D 2010
Education Curriculum Instructor Guide
Unit 2: Create Ground Data

Autodesk

Lesson

3

Surfaces

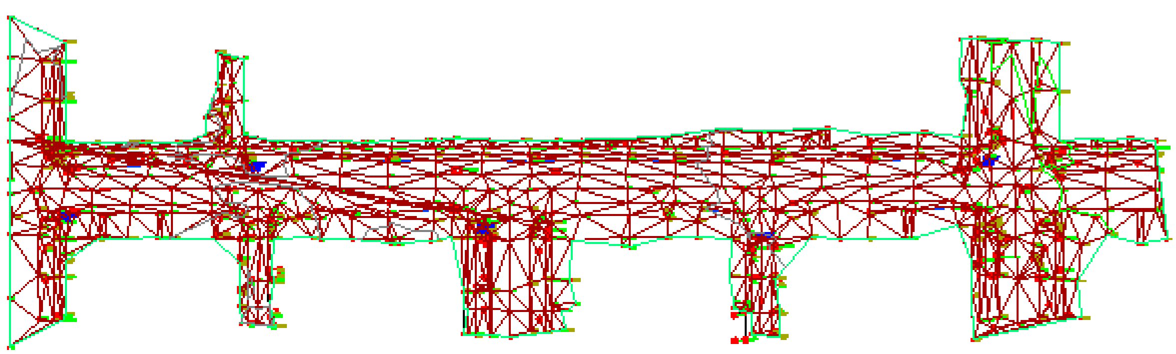
Overview

In this lesson, students learn how to work with surfaces in AutoCAD® Civil 3D® software. Surfaces are three-dimensional objects used to represent both existing and proposed terrain conditions.

The display of a surface is controlled with a surface style. Surfaces can be displayed with different components including contours, triangles, and points. Surfaces can also be annotated with contour elevations, spot elevations, and slopes. Engineers usually display existing terrain surfaces on their plans with contours.

During the design process, engineers regularly work with existing terrain surfaces. These surfaces are used to check the interaction between the proposed design and the existing terrain.

Engineers also create surfaces representing proposed conditions during the design process. These surfaces are used to help visualize the design, calculate material quantities, and to generate data required for construction staking.



Objectives

After completing this lesson, students will be able to:

- Describe surfaces.
- Describe how breaklines are used for surface modeling.
- Create a surface from points and breaklines.
- Create and apply surface styles.
- Apply contour, slope and spot elevation labels to a surface.
- Export a surface to Google Earth.

Exercises

The following exercises are provided in a step-by-step format in this lesson:

1. Create a Surface
2. Modify Surface Properties
3. Edit a Surface
4. Create Surface Styles
5. Assign a Contour Style and Apply Surface Labels
6. Export a Surface to Google Earth

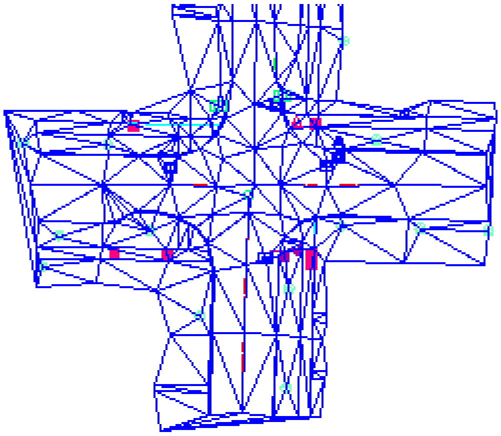
Introduction to Surfaces

Surfaces are the basic building blocks in Civil 3D. You use surface objects to create a three-dimensional representation of existing and proposed project data.

A Triangulated Irregular Network, or TIN, is a surface model consisting of data points (vertices) connected by 3D lines (TIN lines) to form three-dimensional irregularly shaped triangular faces. These triangular faces are collectively called a TIN. TINs are used to model existing ground surfaces, proposed surfaces, subsurfaces (like bedrock), and water surfaces.

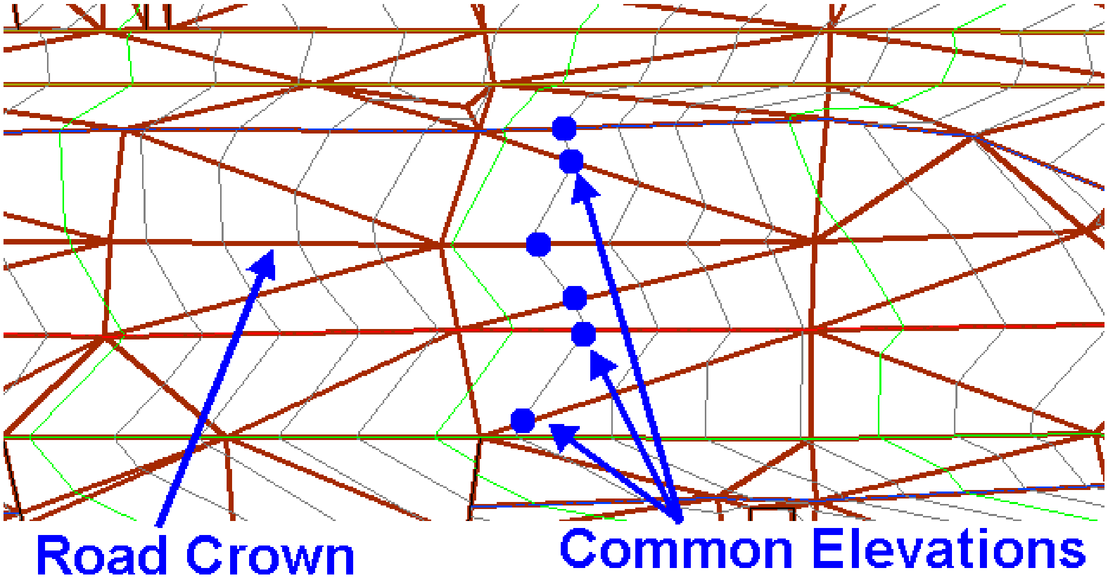
By connecting surface points with a network of triangulation lines, you create a dynamic, continuous representation of a surface. Using this network, you can interpolate the elevation of any location on the surface, not just locations that are defined by a point. The TIN models a continuous surface that you can use to display contours and elevation data, and create surface profiles and targets for slope daylighting.

A surface representing an existing intersection is shown in the following illustration:



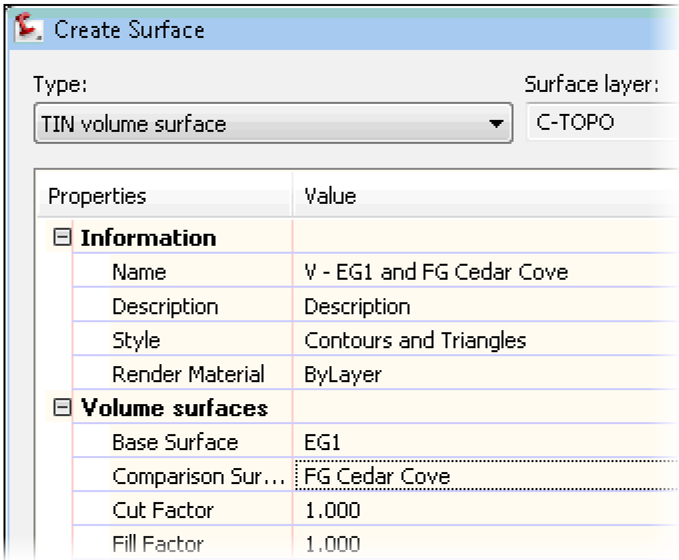
When you use a surface to create an existing ground profile for an alignment, or an existing ground cross section, the data points for the profile (station and elevation) and the data points for the cross section (station and offset) are generated where the alignment or cross section sample line interest the triangulation lines. Furthermore, contours are generated by connecting the points on the triangulations lines that have the same elevations. It is therefore very important to ensure that the triangulation lines are generated in the correct locations and connect to the correct points. You can read more about this topic in the section on breaklines.

In the following illustration, note how the triangulation lines provide the “shape” for the contours. Also notice how the contours connect common elevations on the TIN lines.



You can create two types of surfaces. Regular surfaces are used to model existing and proposed terrain. You use volume surfaces to calculate site volumes by referencing an existing and a proposed surface.

The following illustration shows the Civil 3D interface for creating a TIN volume surface:



When you create surfaces, you should keep the following important points in mind:

- When creating surfaces from point data, points that do not represent the topography should be excluded from the surface model to ensure the accuracy of the surface. Examples of points to exclude include manhole inverts, hydrant tops, and raised manhole lids. You can use the exclusion criteria in a point group to exclude certain points from the surface model.

- If the surface contains terrain breaks, breaklines must be defined to accurately represent the terrain breaks on the surface.

Examples of Surfaces

Surfaces can be used to model both existing and proposed conditions.

You use surfaces that represent existing conditions to:

- Display base mapping contours.

- Generate surface profiles for alignments.

- Generate surface sections.

- Calculate volumes when compared against a proposed surface.
- Calculate grading limits for corridors and grading objects.

You use surfaces that represent proposed conditions to:

- Display proposed contours.
- Calculate volumes when compared against an existing surface.
- Generate construction staking data.
- Label design spot elevations and grades.

About Breaklines

Breaklines are required for most surface modeling tasks. Surface triangulation lines follow along the defined breaklines. It is important that triangulation lines follow the terrain breaks in order to accurately model the terrain.

When you define a breakline, the surface lines follow the breakline instead of interpolating an elevation for the location using the closest points. Breaklines increase the accuracy of the surface because they interpolate elevations between two consecutive points along a distinctive terrain break. Adding a breakline improves the three-dimensional representation of linear features on the surface.

Types of Breaklines

The two most common types of breaklines defined in AutoCAD Civil 3D are proximity breaklines and standard breaklines. You choose the breakline type based on the type of polyline, 2D or 3D, being defined as a breakline.

Proximity Breaklines

Proximity breaklines are defined from 2D polylines. Elevations and locations of breakline vertices are determined by physically relocating each vertex of the 2D polyline to the nearest point used to create the surface, and assigning the northing, easting, and elevation of that point to the vertex.

Proximity breaklines are most often used when the polylines are created by snapping to the nodes of the points. This functionality is very useful when you want to use 2D polyline base plan entities (pavement edge, crown, ditch bottom, and so on) as breaklines.

Standard Breaklines

Standard breaklines are defined from 3D polylines. The northing, easting, and elevations of the polyline vertices are used to define the points along the breakline.

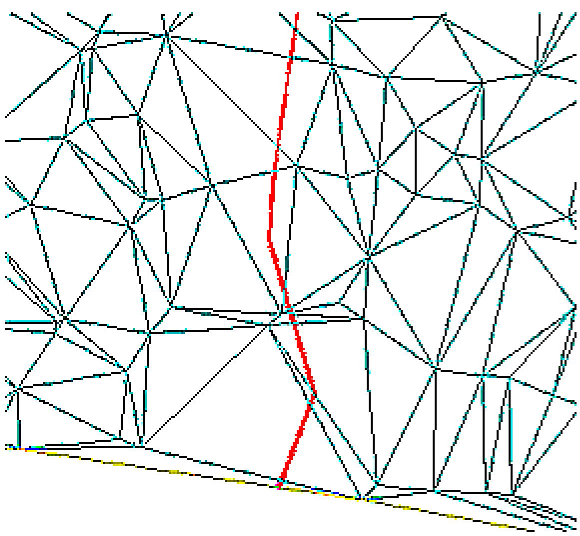
Breaklines are listed on the Prospector tab of the Toolspace windows by expanding Surface, Surface Name, Definition, and Breaklines.

Breakline Example

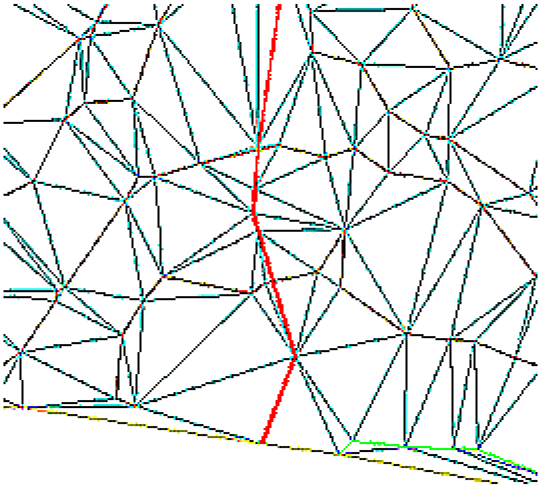
Suppose that your surface data includes a line of points representing a ridge or swale, but the points are far apart in places. As a result, there might be triangles that cross the line, reducing the precision of the surface. When this happens, you can create a breakline that represents the feature more accurately.

In another example, you define breaklines to represent the distinct terrain breaks along an existing roadway, such as crown of road, edge of pavement, gutterline, or sidewalk. Because these are breaklines, the surface triangulation lines are forced along them. This means that you can always interpolate an elevation between two consecutive points along a distinct terrain break.

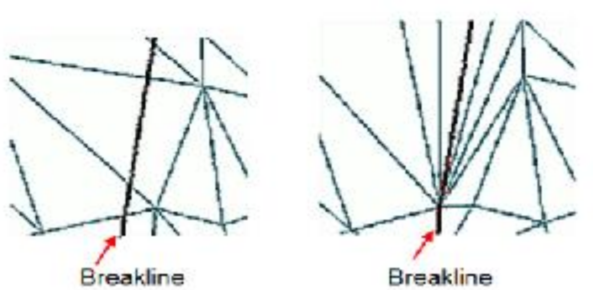
In the following illustration, the 3D polyline represents the course of a stream. Triangles cross the stream at various points.



When you use the 3D polyline to create a standard breakline, the elevations at each of the line's vertices are added to the surface. When you rebuild the surface, no triangles cross the breakline.



Notice how the polyline crosses the triangles that describe the surface in the illustration on the left. The illustration on the right shows the same polyline made into a breakline. Notice how the surface triangles follow the breakline, increasing the accuracy of elevation calculations at this part of the surface.



Surface Properties

You modify Surface Properties to assign a surface style, change the surface definition parameters, specify surface analysis parameters, and to review surface statistics. You can also perform other useful functions such as setting the maximum triangle length and resolving crossing breaklines.

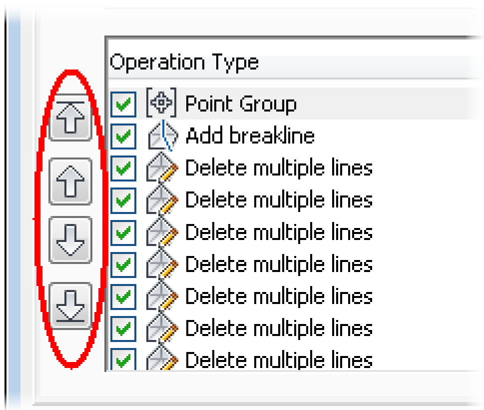
When you modify the properties of a surface, you can:

- Provide a name and description.
- Assign a surface style.
- Lock or unlock a surface.

- Specify the maximum triangle length for a surface.
- Resolve crossing breaklines.
- Specify analysis parameters.
- Review surface statistics.

When you modify the surface properties, you can also change the order in which certain operations were performed on a surface, by using the Operation Type list.

The Operation Type list displays all of the data addition and editing operations made to a surface, in the order in which they were performed. It also shows the parameters for each operation.

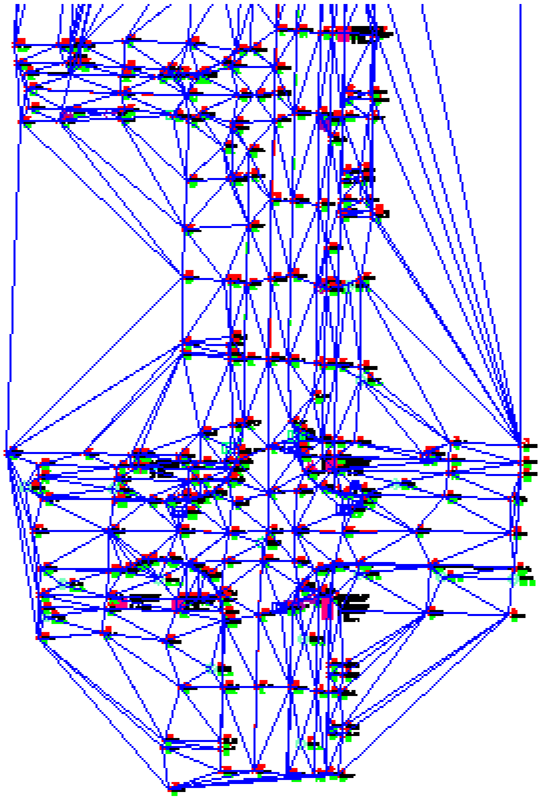


When you create and edit a surface, you can perform many different types of operations to add data and edit surfaces. The order and inclusion of these operations could produce undesired results. The Operation Type list makes it easy to track the operations you perform on a surface, undo or redo the operations, and change the order in which operations are executed.

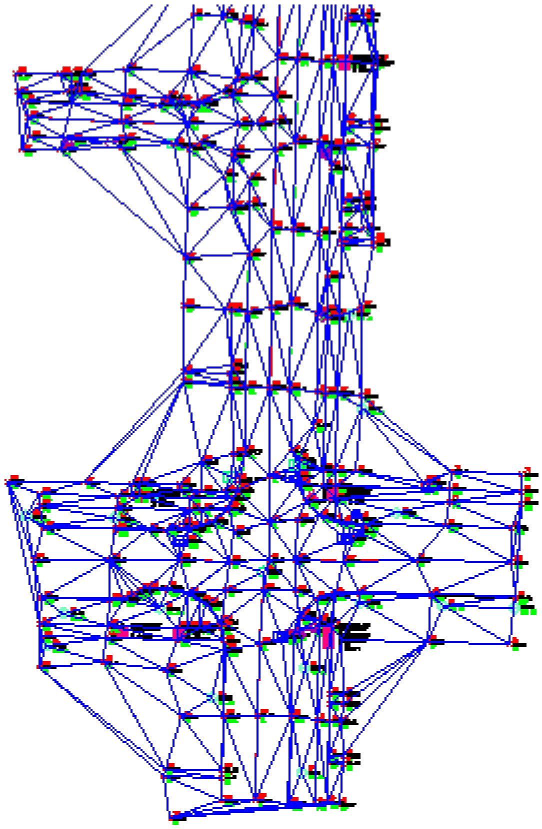
Maximum Triangle Length

When you modify the surface properties you can establish the maximum triangle length. This is a very quick way to delete the unwanted long triangulation lines that appear around the surface perimeter.

This first illustration shows a surface without the maximum triangle length set.



This following illustration shows the surface with the maximum triangle length set to 75' (20 m).



Crossing Breaklines

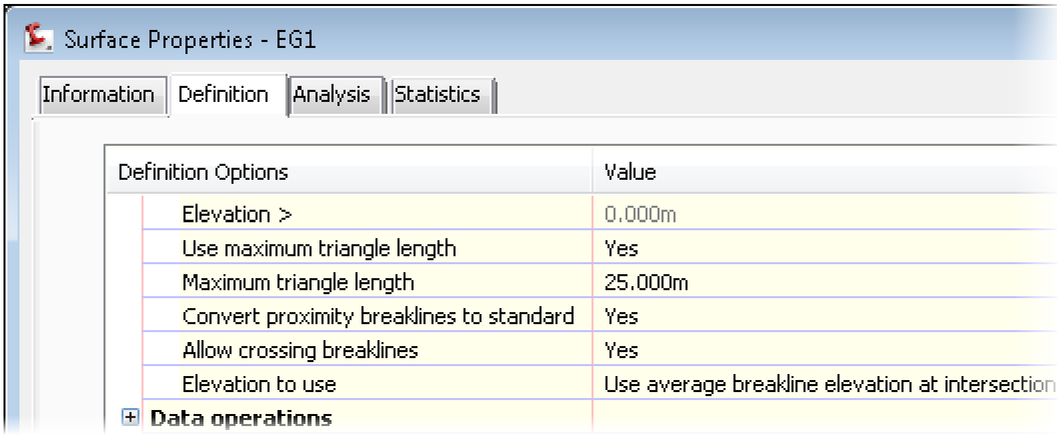
You can resolve issues with crossing breaklines when you modify the properties of a surface.

By definition, triangulation lines are forced along breaklines. Furthermore, triangulation lines cannot cross each other. Therefore, when breaklines cross, an error is generated. If a resolution to the breakline is not assigned, the second breakline created will be ignored.

You can resolve crossing breaklines using any of the following methods:

- Use the first breakline elevation at and the intersection.
- Use the last breakline elevation at the intersection.
- Use the average breakline elevation at the intersection.

The most common solution for crossing breaklines is to enable the Use Average Breakline Elevation at the Intersection option. You enable this option in the Surface Properties dialog box, shown in the following illustration.



Editing Surface Triangles

You can edit surface triangles to achieve greater precision in your terrain model. You can delete triangles or change the orientation of their edges. An edit operation list is maintained so that you can view different versions of the surface as you edit. The more common edits involve deleting triangles and swapping triangle edges.

Keep the following important points in mind when editing surface triangles:

- To keep surface editing to a minimum, create a surface from quality data. Always use breaklines and remove data that does not accurately represent the terrain.

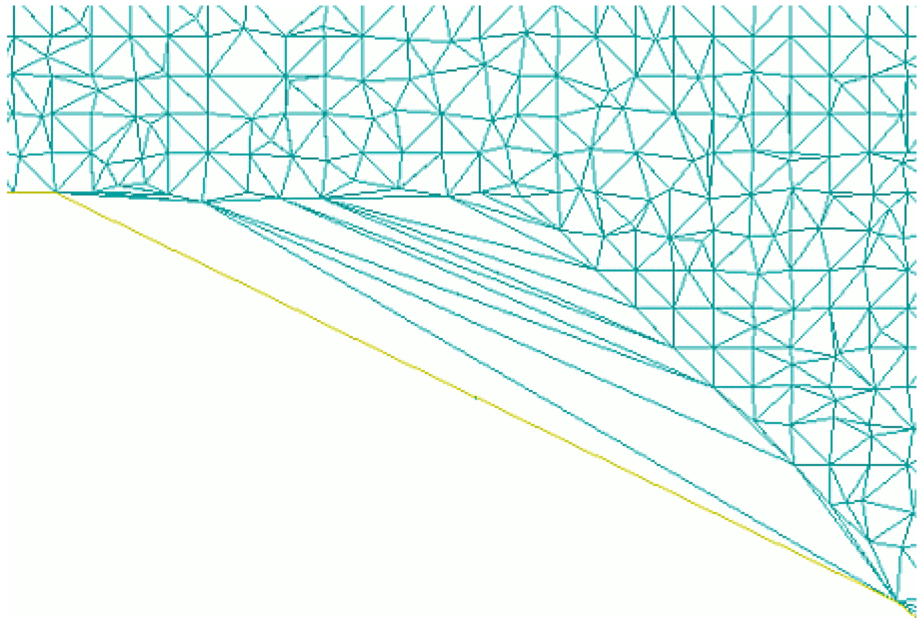
- When you edit a surface, it is useful to assign a style that displays both triangles and contours. This style enables you to see the effects of editing triangulation lines on the contours.

- Best practices in breakline creation are breaklines that do not cross. In some instances, however, you may be provided with breaklines from another source that may cross each other in some locations. In these cases, it is necessary to resolve the crossing breaklines so that you create an accurate surface.

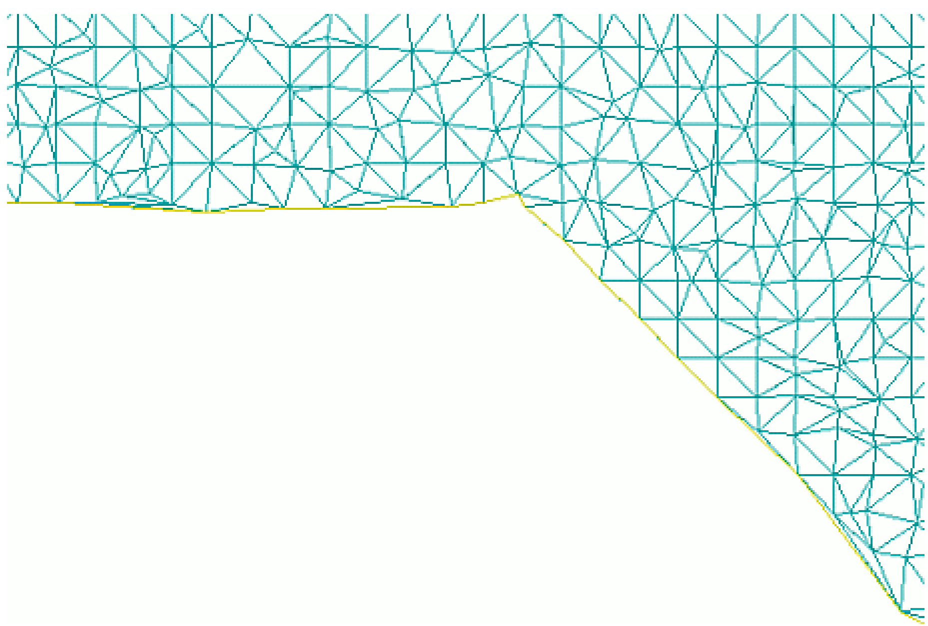
Deleting Triangles

In some cases, triangles are created in areas where there is not enough point data to accurately represent the surface shape and elevation. As part of your review of the surface data, you can identify the superfluous triangles and delete them from the surface.

The following illustration shows a section of a surface that was created by importing point data from a text file without defining a boundary. The long triangulation lines located at the surface boundary are created by joining two distant points. The point data in this area is too scarce to include it in the surface. To refine the surface, you can create a boundary that excludes the problem area, or you can delete the triangles.



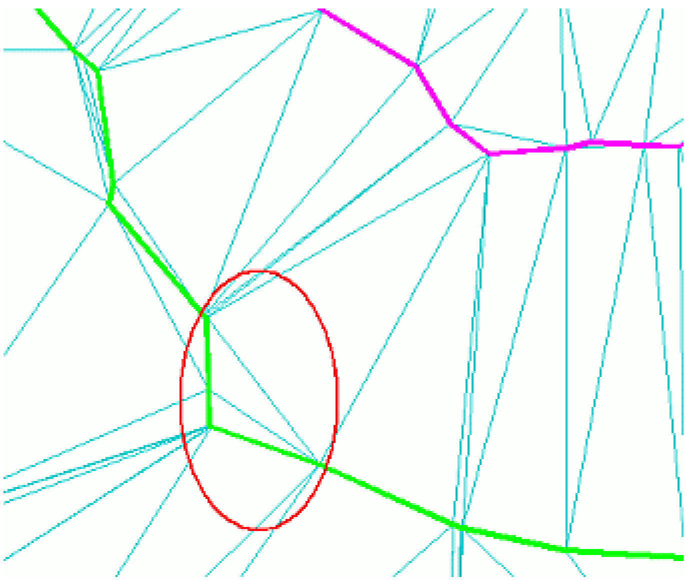
The following illustration shows the same area of the surface after you delete the triangles. The surface border now coincides with the limit of the point data.



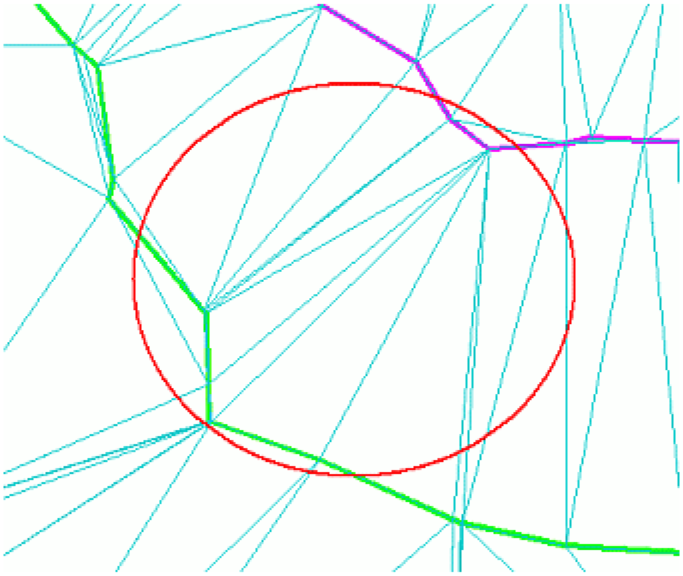
Swapping Triangle Edges

Often you are provided with contour or polyline data to create a surface. After you import the contours, a surface is created that consists of a network of triangles based on the X, Y, Z coordinates of the contour vertices. Sometimes, the surface triangles are oriented incorrectly, producing a flat surface rather than a three-dimensional one. You can configure Civil 3D to automatically check for these flat locations. Alternatively, you can change the direction of the triangle lines using the Swap Edge command.

The following illustration shows a detail view of a surface created from contours. In the circled area, the generated triangles connect points on a contour, rather than connecting points between contours. This location on the surface appears as though there was no change in the elevation, showing a flat surface.



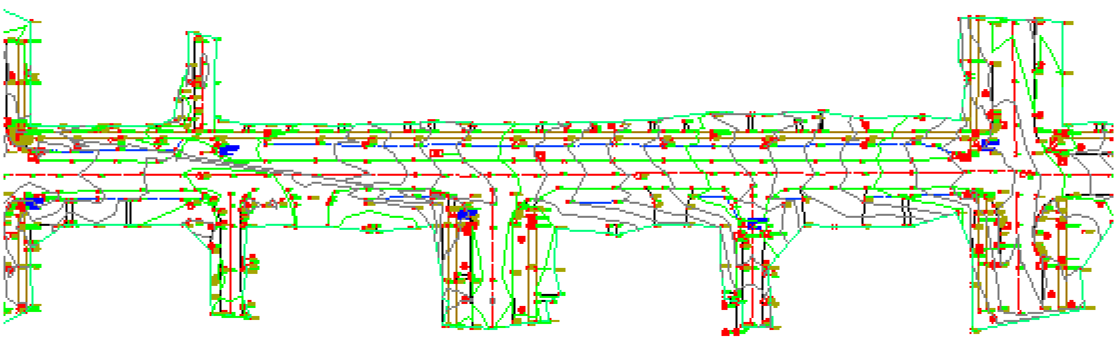
With the Swap Edge command, you can change the direction of triangle lines to improve the accuracy of the surface. In the following illustration, two triangle edges that connected the same contour were edited. In the original version of the surface, the contours were oriented from upper left to lower right. In the current version, they are oriented from lower left to upper right.



Surface Styles

You create and assign surface styles based on how you want to display the surface. For example, if you need to edit a surface, you assign a surface style that shows both triangulation lines and contours. If you want to display a surface as part of a background map, you assign a surface style that displays only contours. You can even assign a surface style that suppresses the display of the surface entirely. With model-based design, design objects can serve as the final drafted objects that you would display on contract drawings.

The following illustration shows a surface that uses a surface style to display contours.



You can create surface styles to display any combination of the following surface components:

- Points
- Triangles

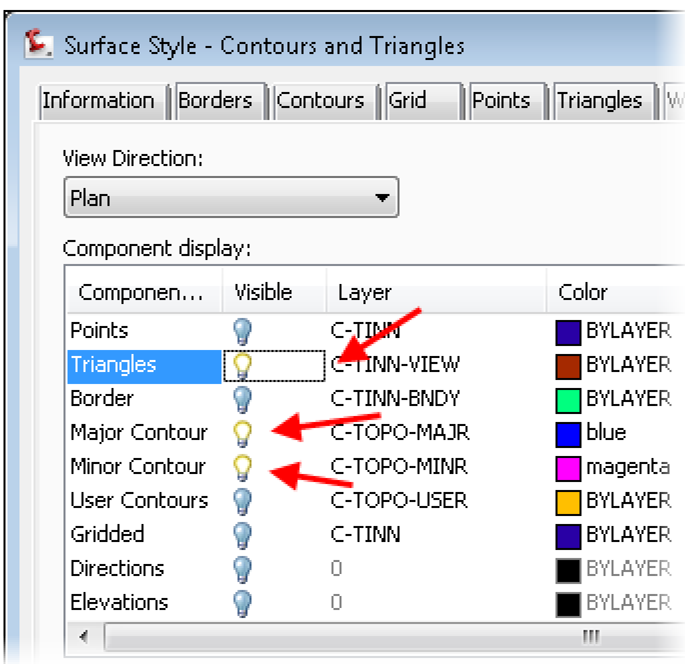
- Borders
- Contours (major, minor, and user)
- Grids
- Analysis (directions, elevations, slopes, slope arrows, and watersheds)

You can also create surface styles that suppress the display of all surface components. This type of style is named as a No Display style and is an alternative to turning off the surface layer.

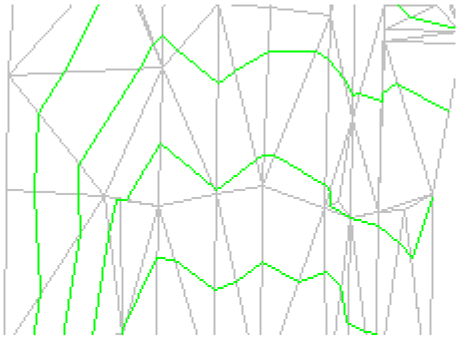
Example of a Surface Style

A surface style that displays contours and triangles is useful for editing a surface. When you edit a surface, you manipulate the triangulation lines. If the contours are also visible, you can immediately see the effects of the edits on the contours.

The following illustration shows the Surface Style dialog box for a style that displays the Triangle, Major Contour, and Minor Contour components.



A surface using the Contours and Triangles surface style is shown in the following illustration.



Key Terms

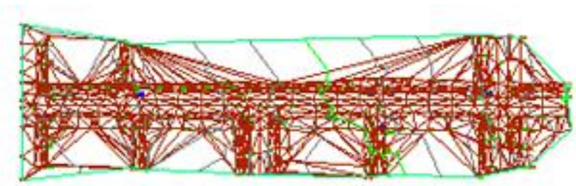
DTM	Digital Terrain Model. A digital terrain model is another name for a surface.
TIN	Triangulated Irregular Network. AutoCAD Civil 3D uses a TIN to represent surface models. A TIN is created by connecting points with closest proximity, forming a series of interconnected triangular surfaces.
Breakline	Breaklines represent distinct terrain breaks and are critical to produce a more accurate terrain model. Examples of breaklines include road crowns, gutters, top of bank, bottom of bank, ditch edges, stream edges, and sidewalk edges. When creating surfaces, breaklines must be defined. Triangulation lines cannot cross over breaklines. Triangulation lines are forced to “break” the terrain and run along the length of defined breaklines to match the terrain “break.”
Proximity Breakline	A proximity breakline is defined from 2D polylines. Proximity breaklines assign elevations by physically relocating the polyline vertices to the nearest surface data point, and assigning that elevation to the breakline. 2D polylines created with vertices at the point node locations do not relocate, because the nearest surface data point is at the location where the vertex was created. The 2D polyline still remains a 2D polyline; however, the 3D information is transferred to the breakline definition.
Contour	A contour line connects points of constant elevation. Contour lines are created by connecting locations on triangulation lines that have the same elevation.
Boundary	The boundary of a surface controls the extent of triangulation that can occur. A well-defined boundary can stop unintended interpolation

	between distant points.
Surface Style	The surface style controls the display of the surface. Surface styles can be used to display surfaces as triangles, points, contours, borders or grids. You can also create surface styles to suppress the display of a surface. This functionality is especially useful when working with large surfaces.
Naming Template	Naming templates are used in AutoCAD Civil 3D to automatically assign names to newly created objects. Naming templates are useful when large amounts of civil engineering data are being created. They help organize the data in the drawing. Users can override the names automatically assigned with naming templates.
Invalid DTM Points	Invalid DTM points are excluded from point groups used to create surface models. These points do not represent true surface elevations. Typical examples include sewer inverts and tops of fire hydrants.
Google Earth	Google Earth is a popular geospatial application made by Google. Google Earth enables you to view aerial photographs and other data anywhere on the surface of the earth. You can download Google Earth by visiting earth.google.com.

Exercise 1: Create a Surface

In this exercise, students create a surface from points and breaklines. A point group for surface modeling already exists in the drawing.

This point group excludes the points that are not suitable for surface modeling such as tops of fire hydrants and survey monument data. Breaklines are created using the proximity breakline definition method.



For this exercise open …*I_Surfaces-EX1.dwg (M_Surfaces-EX1.dwg).*

Exercise 2: Modify Surface Properties

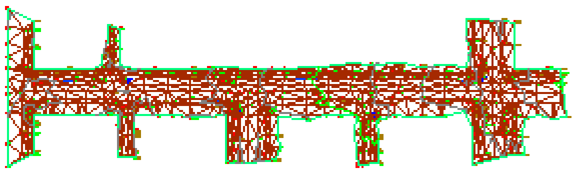
In this exercise, students modify the properties of the surface to:

- Change the surface style.
- Manage crossing breaklines.
- Change surface definition parameters.
- Review surface statistics.

For this exercise, open …*I_Surfaces-EX2.dwg (M_Surfaces-EX2.dwg).*

Exercise 3: Edit a Surface

In this exercise, students edit a surface to ensure that the triangulation lines correctly represent the topography you are modeling. Students add a line, delete a line, and swap an



edge on a surface.

For this exercise open *…\I_Surfaces-EX3.dwg (M_Surfaces-EX3.dwg).*

Exercise 4: Create Surface Styles

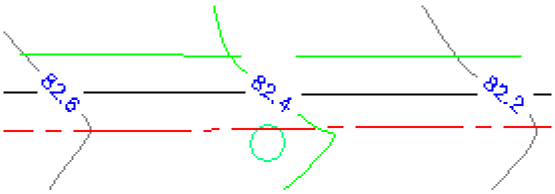
In this exercise, students modify, create, and apply surface styles. A surface is a singular object in Civil 3D. A surface style controls the display of a surface. Surface styles can be used to display the surface as points, triangles, borders, contours, and grids.

For this exercise open *…\I_Surfaces-EX4.dwg (M_Surfaces-EX4.dwg).*

The surface in the drawing is displayed using the Contours and Triangles surface style. Note that not many contours are visible. The contour interval is too big. Students begin by modifying the Contours and Triangles surface style to decrease the contour interval.

Exercise 5: Apply Surface Labels

In this exercise, students learn how to apply contour labels, spot elevation labels, and slope labels to a surface. Surface labels automatically update if the surface changes.



For this exercise open *…\I_Surfaces-EX5.dwg (M_Surfaces-EX5.dwg).*

Exercise 6: Export Surface to Google Earth

For this exercise, students must open the drawing provided.

This exercise requires that Google Earth is installed on your computer, and also requires an Internet connection. If Google Earth is not installed, students can download it at the following location:

http://earth.google.com/

With Civil 3D, you can work within defined coordinate zones on the surface of the earth. The dataset students have been working with in this lesson is located in Vancouver, British Columbia.

In this exercise, students export the surface and drawing data to a Google Earth KMZ (keyhole markup zipped) file. Students then open the file and view the drawing data in Google Earth.

For this exercise, open *M_Surfaces-EX6.dwg.*

Begin by reviewing the coordinate zone.

Assessment

Challenge Exercise

Instructors provide a master or challenge exercise for students to do based on this lesson.

Questions

1. What does the acronym TIN stand for?
2. Why would a surveyor exclude some points from a surface model? Offer some examples of these types of points.
3. Explain why breaklines are necessary for surface modeling.
4. Why would an engineer modify the properties of a surface?
5. Explain when an engineer would use a no display, triangles, and contours surface style.
6. What are the most common types of surface edits?
7. What is Google Earth and why is it useful?

Answers

1. TIN stands for Triangulated Irregular Network. Civil 3D uses a TIN to represent surface models in AutoCAD Civil 3D.
2. A surveyor would exclude points from a surface model that do not reflect the true topography. These points are referred to as Invalid DTM points. Examples include sewer inverts, tops of fire hydrants, and subsurface valves.
3. Breaklines are used to represent distinct terrain breaks. Examples of breaklines include road crowns, gutters, top of bank, bottom of bank, stream edges, and creek edges. When creating surfaces, it is important to define breaklines to make sure the surface is accurate. Triangulation lines are forced along breaklines.
4. Modifying surface properties enables you to change the style assigned to the surface, specify the maximum triangle length to be used, allow for crossing breaklines, and to review surface statistics.
5. A no display style is used to suppress the display of a surface. No display styles make the drawing more manageable when working with larger surfaces. A triangles style is useful for surface editing. A contours surface style is used for presentation on final engineering drawings.
6. The most common types of surface edits include deleting lines, adding lines, and swapping edges.

7. Google Earth is a geospatial software application made available by Google. Google Earth is useful because 1) you can export Civil 3D data to Google Earth, and 2) you can import Google Earth images and surface data to Civil 3D.

Lesson Summary

In this lesson, students learned how to work with surfaces in AutoCAD Civil 3D. Students started by creating a few surface styles. The default surface style was set and the surface naming template defined. Next, the surface was created using point group data and breaklines. The point group excludes invalid DTM points, and proximity breaklines were used. Students then modified the surface properties and edited the surface using the Delete Line, Add Line, and Swap Edges commands. Once the surface was created, students annotated the surface with contour labels, spot elevations, and slope labels. The lesson ended with an exercise that taught students how to export data from Civil 3D and publish it to Google Earth.