INTRODUCTION

AutoCAD Civil 3D uses surface breaklines, cogo points, contours, feature lines, and grading objects to create a surface design. There are numerous ways to grade a site, so there are numerous strategies to grade a site, and there are numerous object types to use when grading a site.

When using breaklines, cogo points, and contours, feature lines are the most powerful design tool. Feature lines can be converted lines, arcs, or polylines. The most powerful feature line ability is containing a curve and maintaining elevations along the curve’s length. Feature lines are the basis for grading solutions. Another use for feature lines is as a surface breakline. When processing a feature line as surface data, a mid-ordinate variable samples the changing elevations along the feature line’s curve.

OBJECTIVES

This chapter focuses on the following topics:

- Using Various Grading Tool Types
- Creating Designs Using Points, Feature Lines, and Grading Solutions
- Designing with a Grading Object
- Calculating an Earthworks Volume

OVERVIEW

This textbook’s Chapter 4, Surfaces, introduced basic site design tools (i.e., points, feature lines, breaklines, and 3D polylines). In this chapter, the point routines described assign elevations to points from surfaces, from 3D polylines, or from interpolating elevations between controlling points. Figure 10.1 shows the Interpolation routines from the Create Points toolbar.
Grading routines focus on feature lines and the grading object. A grading object sets blending strategies, matching a design to an existing surface, projecting a surface to a distance using a grade or slope, or projecting a surface to a specific depth using a grade or slope. A grading object does not need to have a surface to which to grade. It can grade for a distance or to an elevation, relative to or absolute from itself. A grading object can automatically create a surface and calculate a volume.

A feature line creates linear shapes that a grading object uses to create a grading solution. Developing key feature lines that later contribute to creating a surface solution is an essential step in developing an overall grading solution.

After grading a site or developing a design surface, the next step is to calculate an earthworks volume. Unit 4 of this chapter describes a design process to create a surface and calculate an earthworks volume.

**Unit 1**
The first unit uses the Create Points toolbar point tools to create a solution from a series of points. The points’ elevations are from a surface or from point grade/slope interpolations.

**Unit 2**
The second unit focuses on the Feature Line, its creation, settings, and modification.

**Unit 3**
The third unit focuses on grading its settings and styles. Whether estimating a stockpile or pond, or designing a pad or parking lot, the grading object presents the user with several opportunities to evaluate different grading scenarios.

**Unit 4**
The fourth unit focuses on designing a second surface with contours, points, and feature lines. After designing the surface, the next step is to calculate the earthwork volume.

**UNIT 1: GRADING WITH POINTS**
Create Points toolbar commands create new points for a surface that represents a grading plan or a proposed site design. Some routines assign point elevations from a surface. Others assign point elevations by interpolating a grade or slope either from
one point or between two controlling points. When you are creating a surface from point data, you may need to add breaklines to correctly triangulate the point data. Instead of using points and breaklines, it may be simpler to use contours, feature lines, and 3D polylines. When you are creating a surface with these three objects, each object type can be a breakline. No matter what object types are used to create the surface, it is necessary to review their effects and resolve any conflicts or crossings.

The Create Points toolbar has three icon stacks that affect grading: Interpolation, Slope/Grade, and Surface.

**INTERPOLATION**

The Interpolation icon stack represents routines that calculate elevations from or between points (see Figure 10.1). Most routines require two points (cogo or selected). Most routines also place points in a direction for a distance at a slope or grade from one point or between two controlling points. To create new points, routines may prompt for one or more of the following values: distance, elevation, grade, offset, and slope.

Why create interpolated points? A wide gap between points along a linear feature, for example, a swale, will allow triangles to cross the swale feature. The crossing triangle legs indicate that the points that represent the swale are not related and those points break the assumed constant slope between the swale points. This triangulation incorrectly interprets the related swale points’ elevations. To control this problem, there are two options: placing additional points between the swale controlling points or placing a breakline between the swale control points. In either case, the purpose is to make the surface create triangles that correctly interpret the swale point data.

**Interpolate**

Interpolate places points between two existing control points. The new points’ elevations are a straight slope calculation of a change in elevation over a distance. The routine places a specified number of points between two controlling points. Each intervening point has a different elevation that reflects a straight slope calculation from the difference in elevation of the controlling points.

**Relative Location/Relative Elevation**

These two routines use a starting and ending point. The new points are interpolated elevations between the starting and ending points’ elevation. The Location routine places points at a distance measured from the first point. The Elevation routine places points along a line from the first to second point, whose elevations are calculated at a constant slope or grade. Both routines have an optional offset. If the elevation or distance is greater than the original distance between two points, the routines continue placing points until they reach their specified distance or elevation.

**Intersection**

This routine places a point at the intersection of two directions and grades or slopes.

**Perpendicular**

This routine places a point perpendicular to an object or direction. The point’s elevation is calculated by the distance and grade/slope perpendicular to the intersection with the object.
**Slope**

The Slope icon stack’s two routines are similar to and less complicated than the point interpolation routines: Slope/Grade - Distance and Slope/Grade - Elevation (see Figure 10.2). The Distance and Elevation routines require only one starting point, and the second point does not need to be an existing point. The new points can include a point that represents the distance end.

![Create Points](image)

**FIGURE 10.2**

**Slope/Grade - Distance**

Slope/Grade - Distance prompts you for a starting point, a direction, a distance, and a slope or grade. It also prompts you for a selected distance and, before proceeding, gives you an opportunity to adjust the distance. The routine then prompts you for the number of intermediate points and whether the farthest distance also has a point.

Command:

Specify start point: _PO (Transparent Command: Point Object)
>> Select point object:
Specify start point: (9655.92 8982.44 681.0)
Elevation <681.000> (Press ENTER)
Specify a point to define the direction of the intermediate points:
(Select a point from the selected point)
Slope (run:rise) or [Grade] <Horizontal>: 5
Slope: (run:rise): 5.00:1
Grade: (percent): 20.00
Distance: (Select a distance from the selected point)

The routine responds with the slope and grade, prompts you for the number of intermediate points, and prompts you to answer if the end point also should receive a point.

Enter the number of intermediate points <0>: 3
Specify an offset <0.000>: (Press ENTER)
Add ending point [Yes/No] <Yes>: (Press ENTER)
Command:
Slope/Grade - Elevation
Slope/Grade - Elevation works much like the Distance routine, except that the primary values are elevations. If the ending elevation over the default distance is not attained, it will continue placing points in the direction until the elevation is achieved. The routine prompts are as follows:

Command:
Specify start point: ' _PO (Transparent Command: Point Object)
>> Select point object:
Resuming CREATEPOINTS command.
Specify start point: (9655.92 8982.44 681.0)
Elevation <681.000'> (Press ENTER)
Specify a point to define the direction of the intermediate points:
(Select a point from the selected point)
Slope (run:rise) or [Grade] <Horizontal>: 7
Slope: (run:rise): 7.00:1
Grade: (percent): 14.29
Ending Elevation: 687.5
Enter the number of intermediate points <0>: 4
Specify an offset <0.000>: (Press ENTER)
Add ending point [Yes/No] <Yes>: (Press ENTER)
Command:

Again, if the elevation in the specified distance (the distance between points 1 and 2) is not attained, the routine continues placing points until the elevation is reached.

SURFACE
Surface point routines require a surface and use the surface’s elevations to assign point elevations (see Figure 10.3). If the surface type is terrain, the points represent surface elevations. If the surface type is volume, the point elevations represent the difference in elevation between the two surfaces at the point’s location.

FIGURE 10.3
Random Points
Random Points creates a point whose elevation is a surface's elevation at the selected coordinates.

On Grid
On Grid places points in a user-defined X and Y spacing. The point elevations are the surface's elevations at the grid intersections.

Along Polyline/Contour
Along Polyline/Contour places cogo points at a specified distance along a polyline or contour. This is a measure type of command.

Polyline/Contour Vertices
Polyline/Contour Vertices places cogo points at each polyline or contour vertex. The point elevations are the surface elevation at the polyline vertex or the contour's elevation.

SUMMARY
- The Create Points toolbar's Surface icon stack creates new points that use surface elevation as the point's elevations.
- Surface icon stack routines create points on a grid, along a polyline or contour, or randomly.
- The Create Points toolbar's Interpolation icon stack uses two points to create new points.
- Interpolates' two points are point objects or points that have been assigned an elevation.
- When using an interpolate point command, the resulting points generally occur between the two control points.
- The Create Points toolbar's Slope icon stack creates new points from a single control point at a slope or grade for a distance, or until a specified distance or elevation has been reached.
- The Interpolation and Slope routines prompt you for an optional offset.

UNIT 2: FEATURE LINES AND GRADING OBJECTS
Civil 3D takes a programmatic approach to solving grading design issues. Traditional grading solves the issue of blending a design to the existing conditions as offsetting and blending contours or elevations. The Civil 3D Grading Object can be a linear or closed object and can daylight to a surface or just grade at a distance or a slope. The end result is a solution that uses the assigned grades and distances. After creating a solution, you may need to calculate a volume or stitch together other grading objects and their solutions into a single solution.

The feature line is fundamental to grading objects. A feature line has many applications and uses. It can be a surface breakline, a corridor string, and a grading object. Feature lines have two ribbon areas (see Figure 10.4). The first location is the Feature Line icon in the Home panel (top of Figure 10.4). Assigning or editing elevations and modifying the feature line are found in the Feature Line panel called from the Modify panel.
A feature line is the only surface breakline that supports arc segments. Because of this, they are ideal for designing curvilinear features such as entrance returns, parking islands, and ponds.

**EDIT DRAWING SETTINGS**
Feature lines have an entry in the Object Layers list and can be assigned a modifier and value.

**FEATURE LINE STYLES**
Feature line styles are found in the Settings, General, Multipurpose Styles branch. Feature Line Styles assign a layer and its properties (see Figure 10.5). Feature lines also use marker styles, which are in the General, Multipurpose Styles branch.
CREATING FEATURE LINES
Feature lines originate from four sources: drawn, converted entities, an alignment, and from a corridor. The four icons on the Feature Lines toolbar’s left create feature lines. Feature line creation commands are also in the Ribbon’s Modify - Corridor panel.

When you create feature lines, a Create Feature Lines dialog box opens. A feature line must belong to a site and can have a style and a layer, can be weeded for redundant data, and can be assigned elevations (see Figure 10.6). When toggling on Assign elevations, a second dialog box opens with elevation assignment options (see Figure 10.7). Elevations can be a user-assigned value, from a grading object, or a surface. Inserting intermediate grade break points produces elevations between control points where the feature line crosses surface triangulation.

FIGURE 10.6
Feature line tools affect 3D polylines, survey figures, and alignment feature lines.

**SITES**
A site is a collection of related objects, parcels, alignments, feature lines, and gradings. All items in a site interact with each other. For example, you want to show a site’s soil types (as parcel polygons) and parcels. If both are in the same site, they interact. If they are in different sites, they do not interact.

**DRAFTING**
To draft a feature line, you start with a site assignment, style, name, and layer. When you select the first feature line point, the command line prompts you for an assignment method: a user-specified elevation or a surface elevation. After you select the second point, you need to select the second point’s elevation assignment method: grade, slope, elevation, difference, surface, or transition.

The method used to create the feature line determines the elevation-assignment options.

**Grade or Slope**
Grade or Slope assigns the just-selected point’s elevation by calculating a grade or slope by the distance between the first and second point. For example, the first point’s elevation is 100, the second point is 100-feet distant, and a 2 percent grade assigns the second point the elevation of 102. A slope of 10:1, 10 feet raises the height 1 foot, which means the second point’s elevation is 110.

**Elevation**
Elevation assigns a user-entered value as the second point’s elevation.

**Difference**
Difference adds a positive or negative value to the first point’s elevation to determine the second point’s elevation. If the first point is 100 and the difference is 8, the second point’s elevation is 108. If the difference is 3.5, the second point’s elevation is 96.5.
Surface
Surface assigns the surface’s elevation to the second vertex.

Transition
Transition starts with the first point and its initial elevation. When you Enter T, and then press ENTER, and you make a series of picks to define transition vertices, no elevation is assigned until you specify an assignment method. This option creates a multi-segment (tangents and/or arcs) that from the first to the last segment has a constant grade or slope, a specific starting and ending elevation, a single elevation difference, or a starting point and ending point with specific surface elevations. When you use the surface option with transitions, the first and last vertices set the starting and ending elevation. The intermediate elevations are a constant grade or slope based on the difference between the first and last elevations.

CONVERTING
When converting an object to a feature line, Create Feature Lines enables an option to assign elevations. There are three elevation-assignment methods. The first method is to enter a single elevation for the entire feature line: the Elevation option. The second method is to assign an elevation from a grading: From Grading. This creates a temporary surface from a selected grading and then assigns the feature its elevations. The third method is from a surface. From surface assigns surface elevations to the feature line. When you assign elevations from a surface, there is an option: Insert intermediate grade break points. This option creates elevation points where the feature line crosses a TIN triangle. See the following discussion about control and elevation points.

CREATE FROM ALIGNMENT
Create from Alignment draws a feature line whose elevations are from the alignment’s vertical profile. This quickly creates a feature line that can be graded to represent other critical road points: edge-of-travelway, gutter, top-face-of-curb, and so on.

CREATE GRADING FEATURE LINE FROM CORRIDOR
From Corridor extracts a feature line from a corridor point code threads and assigns the corridor elevations to the resulting line.

CONTROL POINT
Control points are feature line vertices, for example, a rectangle’s beginning, intermediate, and ending vertex or all vertices on a linear feature line (see Figure 10.8). When reviewing feature line vertices in the Elevation Editor, each vertex in the drawing displays as a green triangle. In the Elevation Editor, when you do not select a vertex, all vertices show a triangle and are affected by using the icons across the editor’s top. When you select a vertex, just that vertex’s triangle is displayed and any changes apply only to the selected vertex (see Figure 10.9). The first icon on the Editor’s right removes the focus from a selected vertex and returns the Editor’s focus to the entire feature line. Between each feature line vertex is a distance with a constant grade or slope.
ELEVATION POINT

Elevation points are not feature line vertices line. Rather, they are a point along the feature line's path, where the elevation changes (see Figure 10.10). This point displays a green circle. This implies a distance and grade or slope between each elevation point and control point.

When converting an object to a feature line and sampling a surface assigning elevations to each vertex, the Insert intermediate grade break points option assigns elevation points to the feature line where the line crosses a TIN triangle (see Figure 10.7).
ELEVATION EDITOR

Elevation Editor assigns and modifies feature line elevations in a Panorama vista (see Figure 10.10). Clicking in a cell puts the cell in edit mode, making the cell’s value available for editing. Elevation and slopes/grades are editable. The Editor’s rightmost icon deselects any selected row(s).

When no cell is selected, using any icon along the Editor’s top affects all entries. When selecting a call, the edits only affect the selected cell’s values.

To remove the focus from a selected cell, click the first icon on the right, and unselect all rows.

Raise/Lower

The Raise/Lower icon assigns an elevation to all feature line points when no entry is selected. When you select an elevation cell and click the icon, the elevation value cell prompts you for an elevation. After you enter a value and press ENTER, the cell is updated.

Raise and Lower Incrementally

Clicking the Raise or Lower incrementally icons changes the selected point’s elevation by the increment set at the Grading Elevation Editor’s top center.

Set Increment

The default increment is 1 foot. Clicking this icon makes the current increment available for editing.

Flatten to Elevation or Grade

Clicking the Flatten to Elevation or Grade icon opens the Flatten dialog box (see Figure 10.11).
If you select Flatten to constant elevation, all points are set to the first point's elevation. Flatten to grade sets the selected points at a constant grade based on the elevation difference between the first and last selected points.

![Flatten dialog box](image)

**FIGURE 10.11**

**Quick Editor**
Quick Editor edits a feature line control or elevation point after you have selected the point in the drawing. The command line prompts you for a new elevation or grade. The new elevations and grades display tooltips and direction arrows.

**Edit Elevation**
Edit Elevation uses the command line to edit each vertex’s elevation or slope, to add new vertices, or to assign elevations from a surface. The command prompts are similar to AutoCAD’s Pedit command.

The Feature Lines toolbar has alternative methods to assign elevations: grade, slope, and elevation difference. First, you select the feature line, and then you select the starting and ending vertices, and set the method to change their elevation.

Set Grade/Slope between points changes elevations by changing elevations or grade/slope between two selected points on a feature line.

Insert High/Low Point places a point elevation between two control points and uses a grade or slope from each point.

Raise/Lower adjusts the entire feature line by a user-specified amount; positive raises and negative lowers.

Elevations from Surface does just that; it assigns elevations from a surface.

**Editing Feature Lines**
The Modify tab’s Edit Elevations and Geometry panels include tools to edit the feature line’s geometry.

**Insert Elevation Point>Delete Elevation Point**
An elevation point is not a control point; it is an elevation along a feature line’s geometry. This point can also represent a surface’s triangle elevation where it intersects a feature line. See the earlier discussion on Converting objects to feature lines using surface elevations. Delete elevation points deletes a feature elevation point.

**Insert PI>Delete PI**
Adds or removes a control point (vertex) from a feature line. After you select the feature line, Insert PI displays a jig that shows the control point pair between which the new control will be placed.
Break/Trim/Join
Break breaks a feature between two selected points. Trim uses a cutting edge and trims a feature line to it. Join joins two or more feature lines into a single feature line. Settings’ Grading, Commands Join Feature sets a fuzzy factor for the command: default value 0.01.

Reverse
Reverse reverses the feature line’s direction. Feature lines that do not travel in the same direction cannot be joined. This is similar to the rule that two alignment segments that do not travel in the same direction cannot be joined.

Fillet
Adds a curve to a feature line. The command previews the curve, using the default radius, and does allow changing the radius.

Edit Radius
Changes a feature line’s curve. After selecting the curve, the Edit Feature Line Curve dialog box opens and prompts you for a new radius (see Figure 10.12).

Fit Curve and Smooth
Fit Curves creates a true curve from tessellated curves. Smooth performs a Bezier curve on a feature line.

Weed
Weed removes redundant feature line vertices (see Figure 10.13). Weeding can be an individual factor or can be combinations of factors: angle, grade, or length. Close point is an additional option. Close point has a 3D distance tolerance and any two points within this distance have one removed. The Weed Vertices dialog box contains the vertices removal parameters. At its bottom, the dialog box reports how many vertices will be removed. The higher the values, the more vertices are weeded. While the values are adjusted, if visible, the removed vertices are highlighted in red and the remaining ones are highlighted in green.
Stepped Offset
Stepped Offset offsets a feature line and, if specified, modifies the elevations. You change all elevations by elevation difference, grade, slope, or specific elevation. The option list includes Variable, which individually adjusts each offset vertices’ elevation by the methods mentioned earlier.

LABELING FEATURE LINES
Feature Line labeling can be similar to labeling a parcel. However, interest in a feature line’s properties includes grade, elevation change, and direction of slope. Each of these labels is dynamic and any change to an elevation on a feature line makes the label change, showing the new grade (see Figure 10.14).
POINTS FROM FEATURE LINES
All appropriate point routines interact with feature lines. For example, measure places points along a feature line at an interval.

FEATURE LINE ANNOTATION
Add Labels adds grade, direction, elevation, and distance labels on feature lines. The labels are dynamic and change their values as the feature changes.

SUMMARY
- Feature lines can be drawn or converted from other AutoCAD and Civil 3D objects and they can represent an alignment’s vertical design or any other corridor point code.
- Each method used to create a feature line has a different method of assigning elevations.
- There are three feature line elevation editors: Elevation Editor …, Quick Elevation Edit, and Edit Elevations.
- Feature lines have control points: a vertex.
- Feature lines have elevation points: an elevation on a feature line segment that is not a vertex.
- The Modify - Feature Line tab edits and annotates a feature line.

UNIT 3: GRADING
Grading assigns feature lines grading criteria. A grading can be a task’s solution, an elevation source, or a method of determining grades. Several settings affect grading and grading criteria.

EDIT DRAWING SETTINGS
When you are working with grading objects, there will be multiple grading groups. It is a good practice to set a Modifier and its value. Edit Drawing Settings’ Object Layers panel sets these values (see Figure 10.15).
EDIT FEATURE SETTINGS

Edit Feature Settings sets default styles for grading and its naming format (see Figure 10.16).
GRADING STYLES
Grading styles affect how a grading object is displayed. A grading style names the style, sets the grading’s center mark and its size, assigns a slope pattern, sets minimum and maximum slope values, and assigns components’ layers and their properties (see Figure 10.17). A grading marker is a grading solution selector.

![Image](72x707 to 444x643)

FIGURE 10.17

GRADING CRITERIA SETS
Grading uses criteria sets. A criteria set is an alias for a grading method’s collection (see Figure 10.18). Grading is a way to determine a solution by a slope or grade by an offset distance, by an elevation (absolute or relative), or by daylighting to a surface.

Grading criteria contains three or four sections: grading method, cut and/or fill slope projection, and conflict resolution. The grading method defines the target (surface, elevation, relative elevation, and distance), default elevation, and projection (cut, fill, both). Slope projection sections set default grades (slopes) and their default value. Conflict resolution defines how to clean up overlapping slope projections (use average slope, hold grade/slope maximum, and hold grade/slope as minimum).
GRADING TOOLS

Grading tools is a toolbar that defines a grading group by setting a target surface and the current criteria, creating grading and infills, editing grading group properties, and calculating volumes (see Figure 10.19). A grading group can have one or more grading objects. The volume utilities allow for an overall or individual volume calculation (see Figure 10.20).
**Grading Group**
Grading groups are a way to organize design areas and grading objects. Grading groups in different sites do not interact.

**EDIT GRADING**
The Grading Editor changes a selected grading object’s parameters. The grading editor lists the grading solution’s parameters and allows for changes to their values (see Figure 10.21).

![Figure 10.21](image)

**SUMMARY**
- Grading objects are excellent for simple grading scenarios.
- Grading objects understand grading solutions' intersections, and if intersections do occur, the resulting solution shows the intersection.
- There are simple grading volume tools.
- A grading group can create a surface.

**UNIT 4: SITE AND BOUNDARY VOLUMES**
Volume calculations are based on the differences in elevations between two surfaces. Surfaces used in a comparison can be any combination of two surface types (TIN or Grid). The Grid and TIN volume methods calculate volumes by different algorithms. Each method is directly dependent on the surface data quality for its results. The better the quality, the better the resulting volume estimate.

**SITE VOLUMES**
Civil 3D uses two methods to calculate earthwork volumes: grid and composite. Prospector dynamically tracks the surface volume status and uses icons to represent surface references (the two comparison surfaces) and checks whether the volume is out of date. If you attempt to delete one of the comparison surfaces, Prospector will
not allow its deletion because a volume surface depends on the comparison surfaces. To delete a dependent surface, you must first delete the volume surface.

**Grid Volume Surface**

A grid volume surface results from sampling elevation differences between two surfaces using a regularly spaced grid (X and Y). The sampling grid can have a rotation that reflects a rotation in one or both surfaces. While sampling the two surfaces, grid checks both surfaces for an elevation at each cell corner. If all four cell corners have elevations, each cell corner is assigned the difference in elevation between the surfaces (see Figure 10.22).

If there are varying cell sizes, then the sampling density varies and possibly changes the resulting volumes. Grid volumes' greatest problem, outside of bad data, is how densely to sample the two surfaces. The first issue of grid density is setting the grid spacing to an interval similar to the surface data spacing. In some cases, the data spacing can vary from 50 feet to as small as one-half foot. Sampling a site with a 20-foot grid is sampling the interpretations between 50-foot spaced data and missing the one-half foot spaced data.

The second issue is that if both surfaces have irregular borders and the grid spacing is too large, the volume surface may not include data around the surfaces' edges. This is because the spacing doesn’t sample the irregular surface border shapes. Grid spacing should sample the greatest amount of intersecting area between surfaces with the fewest number of points. Optimum grid spacing varies based on surface size, shape, and relief. If the volume differences are severe, then you should question the sampling spacing or the surface quality.

The Grid volume method tends to underestimate a volume because the grid does not completely sample the two surfaces to their edges.
**TIN Volume Surface**

Volumes calculated from contour or breakline data limit the design’s effect on the volume. The design usually starts by using the existing ground’s contours as a seed for the design surface. By designing a second surface using Existing Ground’s contours, the undisturbed contours limit volume calculations to the first undisturbed contour beyond the design. This is because the volume between all unchanged contours is 0 (zero).

The TIN volume surface results from the comparison of two surface triangulations (see Figure 10.23). Its elevations are the differences in elevations between two surfaces, and its triangles are a composite of both surfaces’ triangles. This method samples the surface elevation difference at each triangle leg’s end. TIN volume is the most comprehensive volume calculation method, because it samples to the smallest surface’s edge.

**Volumes**

The Analyze panel’s Volumes, Volumes command calculates a TIN volume without creating a volume surface (see Figure 10.24). The volume’s value is the same as creating a TIN volume surface.
BOUNDING VOLUMES

Bounded Volumes calculates a volume for an area defined by a polyline, polygon, or parcel. This method has to have a pre-existing volume surface.

DESIGNING SURFACES

The best methods to moderate volume calculation errors are consistent surface design methodologies, consistent data densities, and an awareness of each volume calculation method’s strengths and weaknesses. What is a good methodology for creating a design and what is the correct density of data are questions open to debate. What a user needs to do is develop a consistent approach to developing a surface and evaluate the calculated volume numbers by mentally figuring the “ball park” value.

Blending a second surface design into the first is best accomplished by starting with 3D polylines or contours from the first surface. This “seed” data is an effective way to create and blend a design surface into the existing conditions. The 3D polylines, feature lines, and contours also aid the process of new surface design. Blending a design into existing contours is straightforward and areas that are undisturbed by the design will produce no volume.

How does one create seed contours from a surface object? First, you apply a style to the surface to display the desired contours. Second, from the Modify - Surface panel, you use the Extract from Surface command to extract as lightweight polylines the major and minor contours. Third, you place the extracted contours on a new layer and start trimming, drafting, grading, and setting control points to define the proposed surface.

SURFACE DESIGN TOOLS

Feature lines are the most powerful Civil 3D design tool. Its commands create feature lines as surface breakline data and grading objects.

Extract Objects from Surface

The Modify, Surface ribbon’s Surface Tools panel’s Extract Objects from Surface routine extracts contours from a surface and creates polylines with elevation. You can use these polylines as contours and you can trim, break, or edit their elevations.

Stepped Offset

The Modify - Feature Line panel’s Edit Geometry icon displays the Stepped Offset icon. This routine offsets lines, survey figures, 3D polylines, or feature lines for a fixed distance. You adjust the offset object’s elevation by specifying a change amount (1, 3, –1, or –3), a grade (25 or –33), or slope (8:1 or –8:1). When you enter a slope, you need only to enter the sign (positive or negative) and the run. When entering a grade, you enter the sign and value, not the percent sign.

Optionally, the Multiple option repeats the offset if you need to make several offsets. In multiple mode, the command assumes the last offset object is the next object to offset.

When you change the offset’s lines elevation, rather than uniformly changing it, you can use the Individual option to adjust each offset line’s vertex elevations.
The following snippet demonstrates how to set the offset distance, change its elevation, and set the multiple option:

Command: Offset layer = Source
Specify offset distance or [Through/Layer]: 8 <Press ENTER>
Select a feature line, survey figure, 3d polyline, or polyline to offset: <Select the object to offset>
Specify side to offset or [Multiple]: m <Press ENTER>
Specify side to offset: <Select the side to offset>
Specify elevation difference or [Grade/Slope] <0.000>: 1 <Press ENTER>
Specify side to offset: <Select the side to offset>
Specify elevation difference or [Grade/Slope] <1.000>: <Press ENTER>

Create Feature Line
Create Feature Line drafts a feature line. A feature line can contain tangent or curve segments. When you assign feature line vertex elevations, the choices are a specific elevation, a slope or grade, a difference in elevation between the previous and current vertex, or a surface elevation.

The following code snippet is from the Create Feature Line command:

Specify the next point or [Arc]: (5292.54 5351.15 732.4)
Distance 220.546', Grade -0.23, Slope -441.09: 1, Elevation 732.400'
Specify grade or [Slope/Elevation/Difference/Surface] <0.00>: e
Specify elevation or [Grade/Slope/Difference/Surface] <732.400>: <Press ENTER>
Specify the next point or [Arc/Length/Undo]:

Insert Elevation Point
Insert Elevation Point adds elevation points to a feature line, but does not add a vertex to the feature line. Elevation points can be user-selected locations or an incremental value (every 10 or 20 units).

Insert High/Low Elevation Point
Insert High/Low Elevation Point creates a new feature line vertex based on intersecting slopes or grades from two adjacent feature line vertices.

Command:
Select a feature line, survey figure, parcel line, or 3d polyline:
Specify the start point: <move cursor to a vertex and select>
Specify the end point: <move cursor to opposite vertex and select>
Start Elevation 732.900', End Elevation 732.750', Distance 206.176'
Specify slope ahead or [Grade]: 50 <press ENTER>
Specify slope back or [Grade]: 50 <press ENTER>
Select a feature line, survey figure, parcel line or 3d polyline: <press ENTER to exit>
Command:

VOLUME REPORT TOOLS
There are no surface Volume Report tools.

CONTOUR DATA
See the discussion on Contour data in Chapter 4, Unit 2.

SUMMARY

- Volume surface elevations are the difference in elevation between two compared surfaces.
- A volume surface property is an earthwork volume.
- Analysis surface styles evaluate a volume surface's data.

This ends the surface design tools and volumes chapter. As mentioned throughout this book, surfaces are fundamental to most projects. If a surface is not correct, this error affects many aspects of a design solution.

Next, you learn to develop pipe networks. The surface also plays a critical role in pipe network design.