# Contents

# Grading Tutorials

These tutorials will get you started with adjusting grading settings, creating gradings, and editing gradings to balance cut and fill volumes.

A grading object in AutoCAD Civil 3D, like an alignment or a surface, has its own properties and behaviors.

**Note:**

All drawings used in these tutorials are available in the tutorials drawings folder. If you want to save your work from these tutorials, save the drawings to the My Tutorial Data folder so that you do not overwrite the original drawings.

**Topics in this section**

- **Tutorial: Setting up Grading Standards**
  This tutorial demonstrates how to adjust grading settings, criteria, and styles.

- **Tutorial: Creating Gradings**
  This tutorial demonstrates how to create a feature line and how to grade from the feature line.

- **Tutorial: Editing Gradings**
  This tutorial demonstrates common grading editing tasks, including elevation adjustment and grading criteria editing.

- **Tutorial: Grading from a Complex Building Footprint**
  This tutorial demonstrates how to grade around a building footprint that has relatively complicated geometry and variations in elevation.

- **Tutorial: Using Feature Lines to Modify a Grading**
  This tutorial demonstrates how to use feature lines to control grading around inside corners.

# Tutorial: Setting up Grading Standards

This tutorial demonstrates how to adjust grading settings, criteria, and styles.

Grading settings are used for managing the work environment and specifying the units for grade and slope values.

There are many common grading situations. By defining a *grading criteria* with these settings and saving it, you can easily apply these same criteria to other gradings.

Grading styles control the display of each grading component. You can create different styles to use for different types of gradings. For example, you can create styles to display different colors for cut and fill slopes.

**Topics in this section**

- **Exercise 1: Reviewing Grading Settings**
  In this exercise, you will learn how to use grading settings.
- **Exercise 2: Creating Grading Criteria**
  In this exercise, you will create a grading criteria set for a ditch grading, then create three criteria in the set.
- **Exercise 3: Creating Grading Styles**
  In this exercise, you will create a new grading style and slope pattern.

# Exercise 1: Reviewing Grading Settings

In this exercise, you will learn how to use grading settings.

**Review grading settings**

1. Open *Grading-1.dwg*, which is located in the [tutorials drawings folder](#).
2. In Toolspace, on the Settings tab, right-click Grading ➤ Edit Feature Settings.
3. In the Edit Feature Settings dialog box, expand the General collection.
4. In the Save Command Changes To Settings property, verify that the value is set to Yes.

   This setting saves command settings for reuse. For example, if you create a grading and set the grade to 5%, then 5% is the default value the next time you create a grading.

5. Expand the collections for Grade, Slope, and Grade/Slope (Expand these for each selection)

   Notice the options for unit format and precision. The integer value for precision specifies the number of digits to the right of the decimal place.

6. Click OK to close the menus.

# Exercise 2: Creating Grading Criteria

In this exercise, you will create a grading criteria set for a ditch grading, then create three criteria in the set.

Each grading criteria provides a standard formula for creating a graded slope. Individual criteria values can be locked so that they cannot be changed for individual gradings.
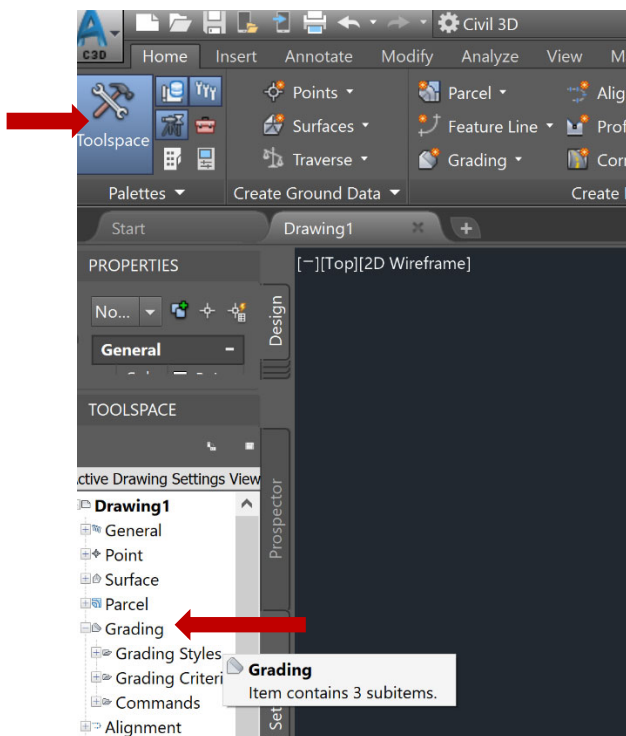
This exercise continues from Exercise Reviewing Grading Settings.

**Create a criteria set**

**Note:**

This exercise uses *Grading-1 Exercise 1.dwg* with the modifications you made in the previous exercise.

1. In Toolspace, on the Settings tab, expand the Grading collection.



2. Expand the Grading Criteria Sets collection.

   The Grading Criteria Sets collection displays the existing grading sets for the drawing. You will create a new grading criteria set then create two new criteria within the new set.

3. Right-click Grading Criteria Sets. Click New.

4. In the Grading Criteria Set Properties dialog box, enter **Ditch Criteria Set** in the Name field, and optionally enter a description.
5. Click OK.

   The new criteria set is displayed in the Grading Criteria Sets collection.
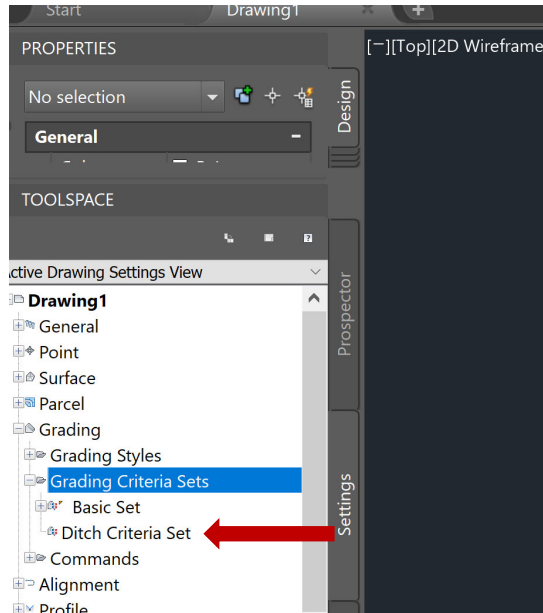


**Create a grading criteria**

1. Right-click **Ditch Criteria Set**. Click New.
2. In the Grading Criteria dialog box, click the Information tab.
3. In the Name field, enter **Distance @ -6%**.

   This criterion creates a grade to a distance of 10 feet at -6% grade.

4. Click the Criteria tab and specify the following parameters:
- Target: **Distance**
- Distance: **10.000'**
- Projection: **Slope**
- Format: **Grade**
- Grade: **-6.000%**

5. For the Grade parameter, click 🔓 to change it to 🔒. When you lock a grade value in the grading criteria, you are not prompted to specify its value each time you use the criteria.

| Parameter | Value | Lock |
|---|---|---|
| **Grading Method** | | |
| Target | Distance | |
| Distance | 10.00' | 🔒 |
| Projection | Slope | |
| **Slope Projection** | | |
| Format | Grade | 🔒 |
| Grade | -6.00% | 🔒 |
| **Conflict Resolution** | | |
| Interior Corner Overlap | Use Average Slope | 🔒 |

6. Click OK.

**Create a second grading criteria**

1. Create a second criteria by repeating the previous procedure. However, use the name **Surface @ 4-1 Slope** and set the following values for the criteria:

- Target: **Surface**
- Projection: **Cut/Fill Slope**
- Search Order: **Cut First**

Set the following values for both the Cut Slope Projection and Fill Slope Projection property groups:

- Format: **Slope**
- Slope: **4:1**

This criterion creates a grade to an existing surface at a 4-to-1 slope. In the next few steps, you will create another grading criteria by copying an existing one.

2. Click OK to close the Grading Criteria dialog box.

**Copy a grading criteria**

1. In the Ditch Criteria Set collection, expand the Set. Right-click the Surface @4-1 Slope criteria. Click Copy.

In the Ditch Criteria Set dialog Information box, change the name to **Relative Elevation @ 3-1 Slope**. When you create criteria set by copying, the new criteria name must be unique within the drawing, regardless of criteria set.

2. On the Criteria Tab, Specify the following parameters:

Target: **Relative Elevation**

Relative Elevation: **-3.0'**

Projection: **Slope**

Format: **Slope**

Slope: **3:1**

These criterion creates a grade to a relative elevation of –3 feet at a 3-to-1 slope.

3. Click **OK** to close the Grading Criteria dialog box.

   *Save this file as Grading-1.dwg Exercise 2 lastname first name.dwg and submit to Canvas*

   To continue this tutorial, continue to Exercise 3: Creating Grading Styles.

# Exercise 3: Creating Grading Styles

In this exercise, you will create a new grading style and slope pattern.

This exercise continues from Exercise Creating Grading Criteria.

**Create a new grading style**

**Note:**

This exercise uses *Grading-1 Exercise 2.dwg* with the modifications you made in the previous exercise.

1. In Toolspace, on the Settings tab, right-click the Grading Styles collection. Click New.
2. In the Grading Style dialog box, click the Information tab. Enter Ditch into the name field. Optionally, enter a description for the style.
3. Click the Display tab and change the color of the Daylight Line to red by clicking its entry in the Color column.

    The Select Color dialog box is displayed, where you can select a color. Select red, then click OK.

4. Click the Slope Patterns tab.
5. Select the Slope Pattern check box. Select the **Basic** style.
6. Click the style drop down list and click Copy Current Selection.
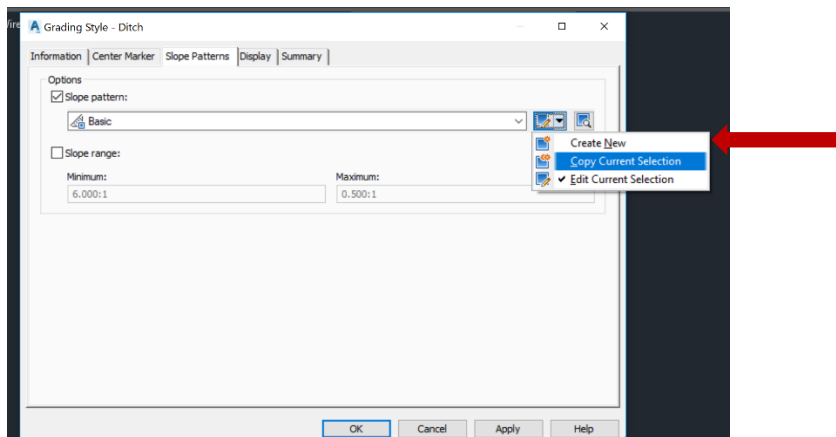


7. In the Slope Pattern Style dialog box, on the Information tab, change the name to **Ditch Slope**.
8. On the Layout tab, in the Component field, select Component 2.

    The parameter table displays values for Component 2, which is the second slope pattern component from the left side. In this case, it is a long line with a tapered line symbol along the top of the slope.

9. In the Slope Line Symbol section, change the Symbol Type to None.
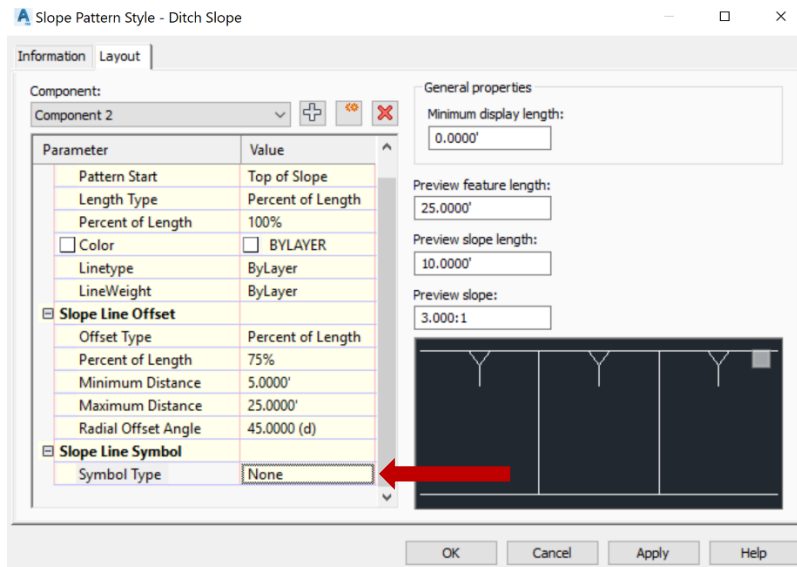


10. Click OK. The new Ditch Slope pattern is selected for the Ditch grading style.

11. To view summary information about the style, click the Summary tab.

12. Click OK.

In Toolspace, on the Settings tab, the Ditch grading style is added to the Grading Styles collection. The Ditch Slope pattern is added to the General ➤ Multipurpose Styles ➤ Slope Pattern Styles collection.

To continue to the next tutorial, go to Creating Gradings.

Save this file as Grading-1.dwg Exercise 3 lastname first name.dwg and submit to Canvas

10

# Tutorial: Creating Gradings

This tutorial demonstrates how to create a feature line and how to grade from the feature line.

You can create gradings from parcel lot lines or *feature lines*. A feature line is a linear object that the grading commands can recognize and use as a baseline. When designing a grading, you must often adjust the elevations along a feature line. You create a feature line by converting existing objects, such as lines or polylines.

In the next two exercises, you will perform the following tasks:

- Create three feature lines.
- Assign elevation values along the feature lines using several methods.
- Create a set of gradings from one of the feature lines.
  **Topics in this section**

- **Exercise 4: Creating Feature Lines**
  In this exercise, you will use two different methods to create feature lines.

- **Exercise 5: Assigning Feature Line Elevations**
  In this exercise, you will assign elevations to the feature lines you created from AutoCAD lines in the previous exercise.

- **Exercise 6: Creating a Grading**
  In this exercise, you will create a set of gradings, called a grading group, that form a runoff on the side of an embankment.

# Exercise 4: Creating Feature Lines

In this exercise, you will use two different methods to create feature lines.

Feature lines can be either drawn with straight and curved feature line segments, or created from existing alignments or AutoCAD lines, arcs, polylines, or 3D polylines.

A feature line can be used as a grading baseline, but not as a target.

This exercise continues from the Setting Up Grading Standards tutorial.

**Create feature lines from AutoCAD objects**

**Note:**

This exercise uses *Grading-1 Exercise 3.dwg* with the modifications you made in the previous tutorial.

1.  Click Home tab ➤ Draw panel ➤ Create Line ╱ . Draw a line from circle A to B to C.
2.  Click Home tab ➤ Create Design panel ➤ Feature Line drop-down ➤ Create Feature Lines From Objects 🖫 .
3.  Click both lines, then right-click and click Enter to end the selection.

    In the Create Feature Lines dialog box, notice that you can assign a name to the feature lines as they are created. Naming significant feature lines can make it easier to assign targets when creating a corridor. For this exercise, you will assign names after the feature lines have been created. Following this workflow enables you to create many feature lines at the same time, but name only the most significant feature lines.

4.  In the Create Feature Lines dialog box, click OK.

    The lines are converted to feature lines and added to Site 1. You will assign elevation values to these feature lines later in this exercise. Next, you will draw a feature line and specify elevations along the line.

**Name the feature lines**

1.  In the drawing, select feature lines AB and BC. Right-click. Click Apply Feature Line Names.
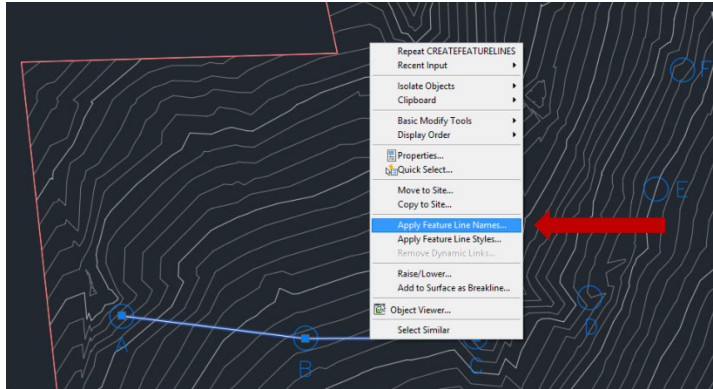
2. In the Apply Feature Line Names dialog box, click ▧ .

3. In the Name Template dialog box, for Property Fields, select Next Counter. Click Insert. Click OK.

4. In the Apply Feature Line Names dialog box, place the cursor at the beginning of the Name field. Enter **ABC**.

   The Name field should contain `ABC <Next Counter]>`.

   Click OK.

5. In Toolspace, on the Prospector tab, expand Sites ➤ Site 1. Select the Feature Lines collection.
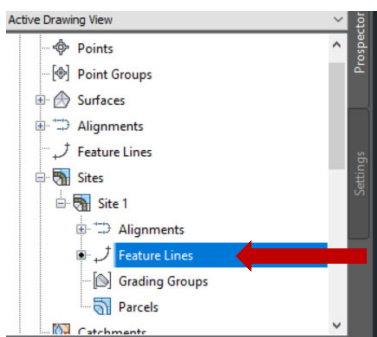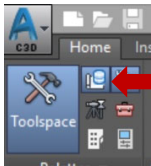




   Notice that the two feature lines and their names are displayed in the Prospector list view. Next, you will draw a feature line and specify elevations along the line.
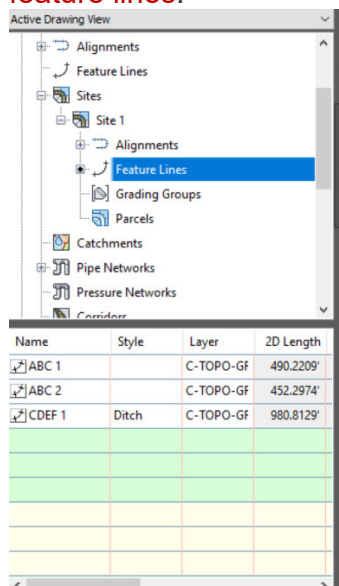
   **Draw a feature line**

1. Home tab ➤ Create Design panel ➤ Click Feature Line drop-down ➤ Create Feature Line ✐ .

2. In the Create Feature Lines dialog box, specify the following parameters:
- Check Name Box: **Selected**
- Name: **CDEF <[Next Counter]>**
- Check Style Check Box: Style: **Ditch**
3. Click OK.
4. In the drawing window, snap to the end of the feature line inside circle C. When prompted, enter **688.00** as the elevation.

   You have entered a known value for the starting elevation. In the following steps, you will use the transition command to defer entering elevation values at intermediate points along the feature line.

5. Stretch the feature line and click inside circle D. When prompted for an elevation, enter **T**.
6. Stretch the feature line and click inside circle E. When prompted for an elevation, press Enter to accept Transition.
7. Stretch the feature line and click inside circle F. When prompted for a transition, enter **SU** to use the elevation of the surface at that point.
8. Note the surface elevation shown at the command line. Press Enter twice to accept the elevation and end the command.
9. In Toolspace, on the Prospector tab, expand Sites ➤ Site 1. Select the Feature Lines collection.

   Notice that the three feature lines you created are displayed in the list view. You can use this box to edit the feature lines' name, style, and layer, and view other properties of all the feature lines.



**Parent topic:** Tutorial: Creating Gradings

*Save this file as Grading-1.dwg Exercise 4 lastname first name.dwg and submit to Canvas*

# Exercise 5: Assigning Feature Line Elevations

In this exercise, you will assign elevations to the feature lines you created from AutoCAD lines in the previous exercise.

This exercise continues from Exercise Creating Feature Lines.

**Edit feature line elevations**

**Note:**

This exercise uses *Grading-1.dwg* with the modifications you made in the previous exercise.

1.  Click Modify tab ➤ Edit Elevations panel ➤ Elevation Editor 📑 .
2.  Select the feature line that stretches from circles C, D, E, to F. Select Panorama Tab.

    In the Panorama View Tab, you see the length of each segment and elevations at each vertex. Notice that as you specified in Exercise Creating Feature Lines, the elevation of the first point is 688.000 and the elevation of the last point matches the elevation of the surface. The elevation values of the two intermediate points are automatically interpolated based on the beginning and end-point values. You can use this table to edit the elevation and grade values.
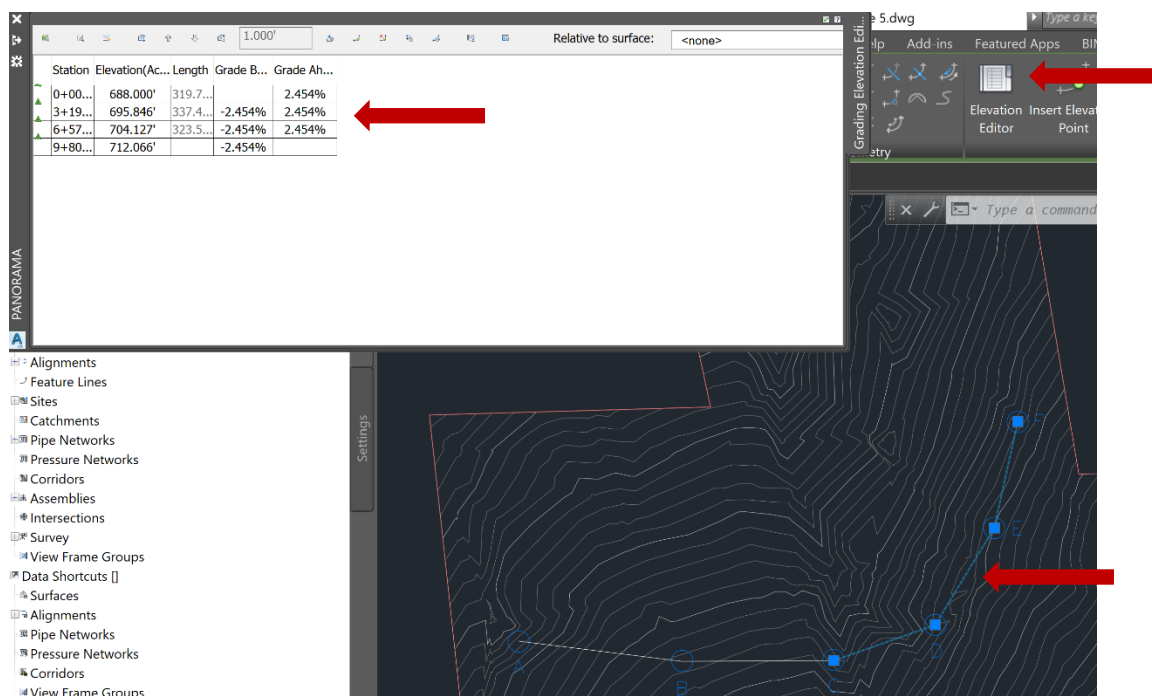
| Station | Elevation(Ac... | Length | Grade B... | Grade Ah... |
|---------|-----------------|--------|------------|-------------|
| 0+00... | 688.000' | 319.7... | | 2.454% |
| 3+19... | 695.846' | 337.4... | -2.454% | 2.454% |
| 6+57... | 704.127' | 323.5... | -2.454% | 2.454% |
| 9+80... | 712.066' | | -2.454% | |

**Now you will assign elevation values to line AB**

3.  Click ⬛, and then click the feature line between circles A and B. The Grading Elevation Editor now displays the elevations along the feature line between circles A and B.
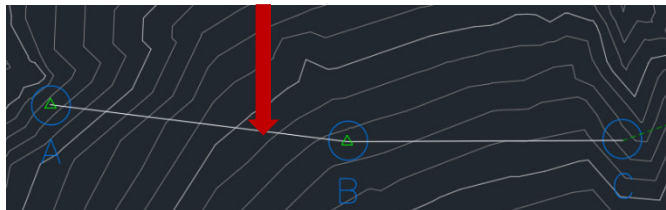




| Station | Elevation(Ac... | Length | Grade B... | Grade Ah... |
|---------|-----------------|--------|------------|-------------|
| 0+00... | 0.000' | 490.2... | | 0.000% |
| 4+90... | 0.000' | | 0.000% | |

4.  Double-click the elevation value for the starting station (0+00.00), and change it to **630.00'**. This value puts it a few feet below the surface. Change the elevation of the end point at station (4+90.00) to **690.00'**.

    In the next few steps, you will insert an elevation point on the feature line.

**Insert an elevation point on a feature line**

1.  In the Grading Elevation Editor, click ⬦ (Insert Elevation Point).

    Select the feature line AB, you see a small circle and a tooltip that shows the station value and elevation of the point as you drag along this line.

Station:3+38.15', Elevation:671.388'

.
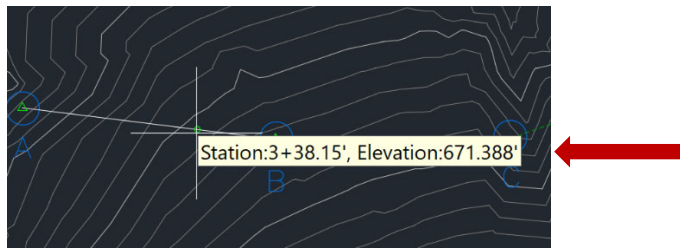
2. Use your mouse to move the point to a new location near the middle of the feature line (Sta. 2+30.00, then click to set this point. You may have to zoom and pan to move this point to this exact location.

3. **OPTIONALLY**, you can use the Elevation Editor and the table in the Panorama View Box to type the exact stationing for this inserted point. Select the Station cell for the inserted point, change the value to 2+30.00 in this cell. The point is added to the table in the Grading Elevation Editor, where you can also edit the station, elevation, grade, and length (distance between points). Once the point has been created, you can also move it at any time using the grips. To do this click feature line AB. Editing grips are displayed for the endpoints and elevation point. You can click the elevation point and slide it along the feature line. You can also click one of the endpoints and move it to a new location. When you do any grip editing, values in the Grading Elevation Editor update.

4. In the Grading Elevation Editor, type the elevation for point at Sta. 2+30.00 to an elevation of 671.277 which is below the surrounding surface.



Z=671.277 (EG)
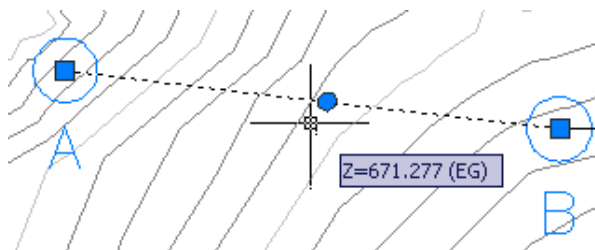
In the next few steps, you will drape feature line BC across the existing ground surface. This command assigns an elevation to each vertex of the feature line.

**Drape a feature line on a surface**

1. If necessary, press Esc once or twice to deselect feature line AB.
2. In the drawing space, select the feature line BC.
3. Click Modify tab ➤ Edit Elevations panel ➤ Elevations From Surface.
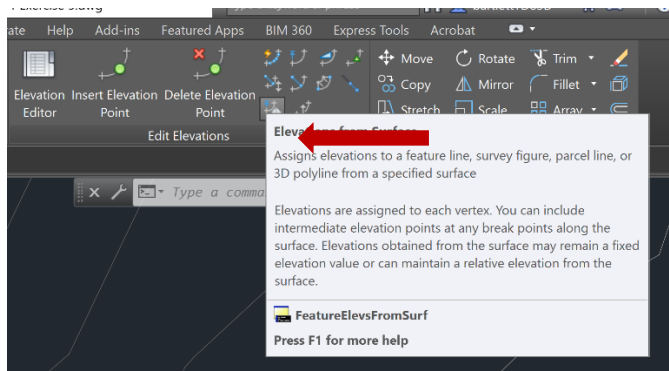
4. In the Set Elevations From Surface dialog box, click OK.

5. Then reselct the line to end the command. The green dots indicate that elevation points have been added wherever the feature line crosses the edge of a triangle in the TIN surface. This means you have draped this feature line over the existing surface to match the existing ground (EG).
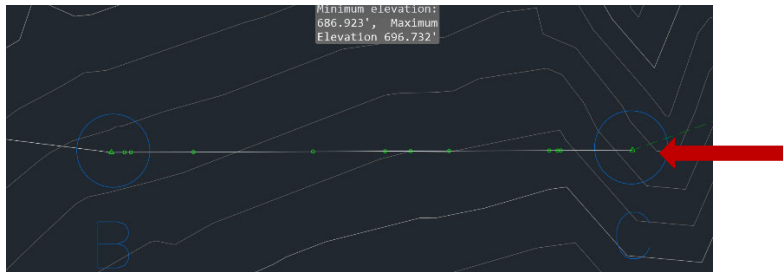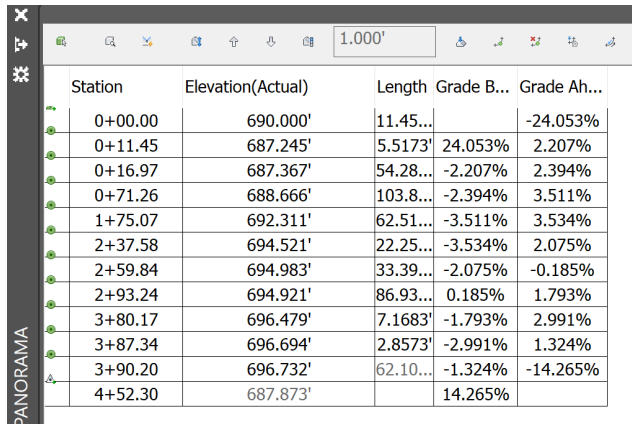


6. If necessary, press Esc once or twice to remove any commands.

7. In the drawing space, select the feature line BC again.
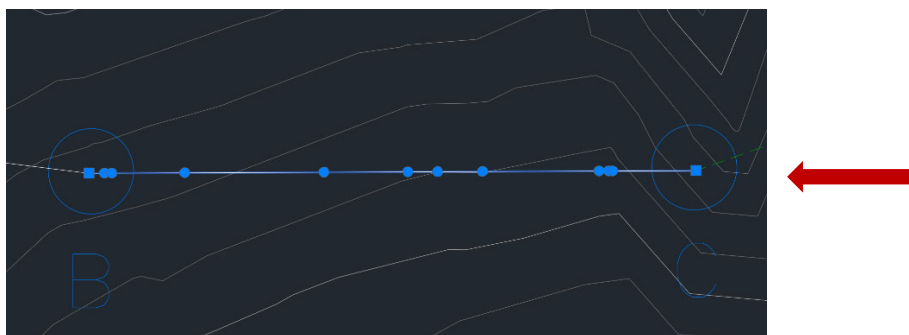


8. Right click and click Elevation Editor. Select Panorama View Tab.

The Elevation Editor displays data for each elevation point along feature line BC, including its elevation, and the distance and grade to the next point. A feature line on the surface like this can be a useful starting point for a grading. **You can use controls along the top of the Grading Elevation Editor to add and delete elevation points, and to adjust their**

18

**elevations.** You can select multiple points within the table for group operations, such as raising or lowering them the same amount, or "flattening" their elevations to the same value.

| Station | Elevation(Actual) | Length | Grade B... | Grade Ah... |
|---------|-------------------|--------|-----------|-------------|
| 0+00.00 | 690.000' | 11.45... | | -24.053% |
| 0+11.45 | 687.245' | 5.5173' | 24.053% | 2.207% |
| 0+16.97 | 687.367' | 54.28... | -2.207% | 2.394% |
| 0+71.26 | 688.666' | 103.8... | -2.394% | 3.511% |
| 1+75.07 | 692.311' | 62.51... | -3.511% | 3.534% |
| 2+37.58 | 694.521' | 22.25... | -3.534% | 2.075% |
| 2+59.84 | 694.983' | 33.39... | -2.075% | -0.185% |
| 2+93.24 | 694.921' | 86.93... | 0.185% | 1.793% |
| 3+80.17 | 696.479' | 7.1683' | -1.793% | 2.991% |
| 3+87.34 | 696.694' | 2.8573' | -2.991% | 1.324% |
| 3+90.20 | 696.732' | 62.10... | -1.324% | -14.265% |
| 4+52.30 | 687.873' | | 14.265% | |

9. Click the drawing space to close the Grading Elevation Editor.

   To continue this tutorial, go to Exercise Creating a Grading.

   **Parent topic:** Tutorial: Creating Gradings

   *Save this file as Grading-1.dwg Exercise 5 lastname first name.dwg and submit to Canvas*

# Exercise 6: Creating a Grading

In this exercise, you will create a set of gradings, called a grading group, that form a runoff on the side of an embankment.

This exercise continues from Exercise Assigning Feature Line Elevations.

**Create a grading group and specify grading creation settings**

**Note:**

This exercise uses *Grading-1.dwg* with the modifications you made in the previous exercise.

1. Click Home tab ➤ Create Design panel ➤ Grading drop-down ➤ Grading Creation Tools 📇 .

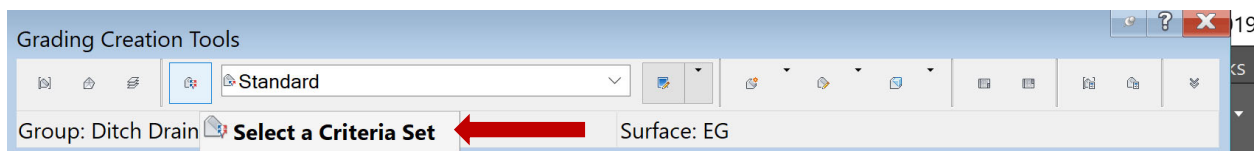2. In the Grading Creation Tools toolbar, click ⬙ Set The Grading Group.
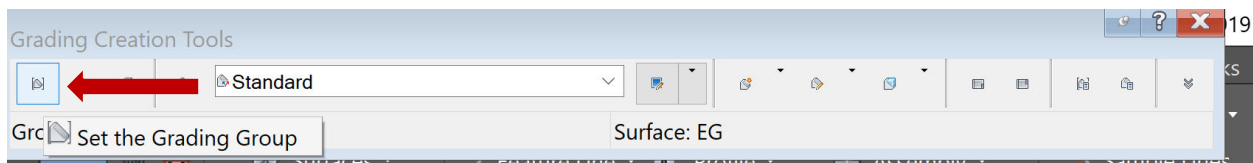


3. In the Create Grading Group dialog box, specify the following parameters:
- Name: **Ditch Drainage**
- Automatic Surface Creation: **Selected**
- Volume Base Surface: **Selected**
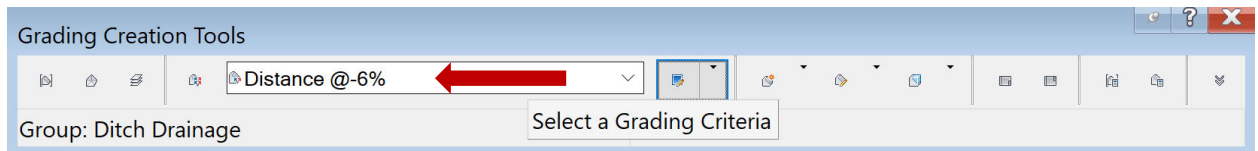4. Click OK.
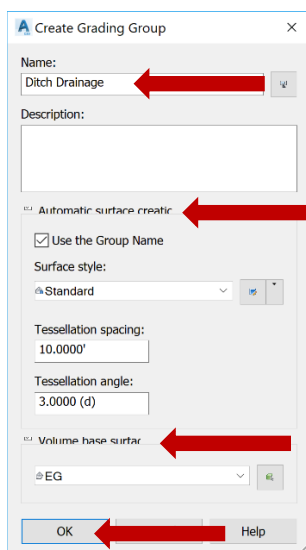
5. In the Create Surface dialog box, click OK.
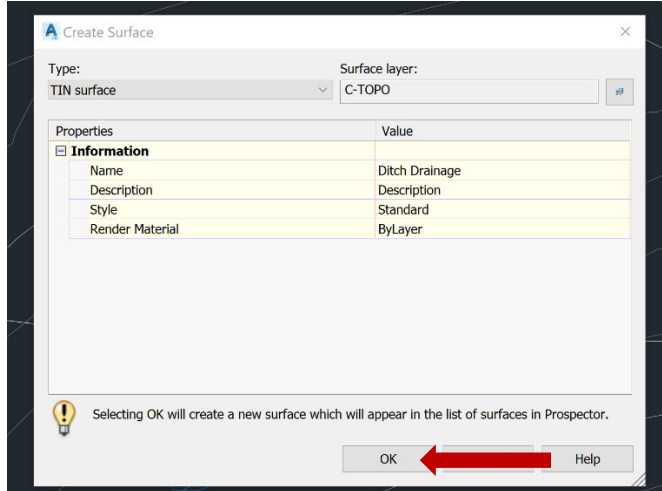


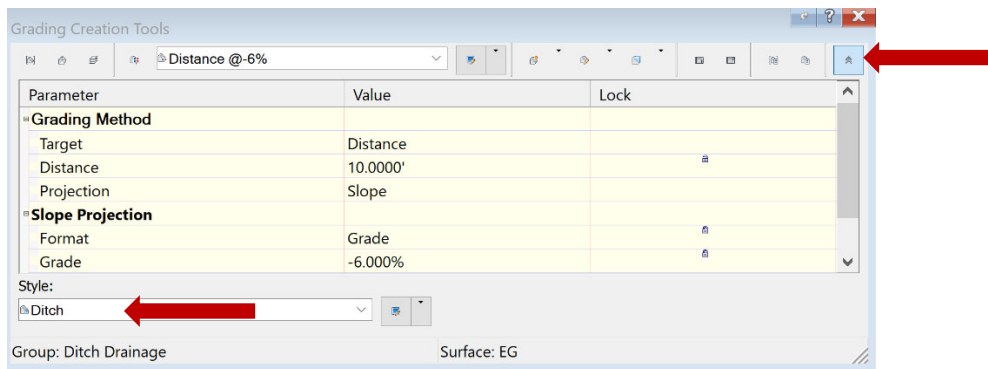6. In the Grading Creation Tools toolbar, click Select a Criteria Set.



7. Select **Ditch Criteria Set** from the list. Click OK.

8. In the Select A Grading Criteria list, ensure that **Distance @ -6%** is selected.



9. Click to expand the Grading Creation Tools toolbar.



10. In the Style list, select **Ditch**.

**Create gradings**

1. Click 🖉Create Grading. In the drawing space, select feature line AB.



2. In response to the command-line prompt, click above the feature line to indicate where to apply the grading.
3. Press Enter (Yes) to apply the grading to the entire length of the feature line.
4. Press Enter to accept the default distance (10 feet).

   The grading is created. Ditch Drainage is added to the grading groups collection in Site 1 on the ToolspaceProspector tab. This grading creates **one side of a ditch**, extending down from the baseline at a 6% grade for a distance of 10 feet.
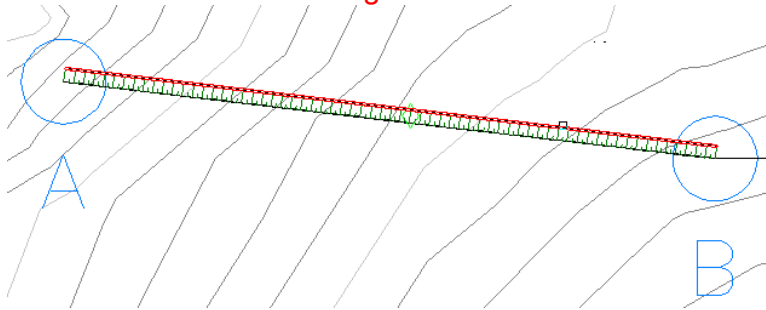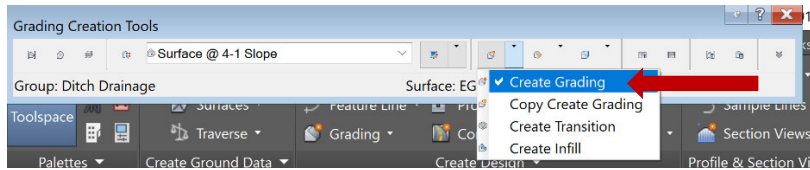


5. Press Esc to end the command.

   In the next few steps, **you will create another grading** from the target line of the first grading to the existing surface.
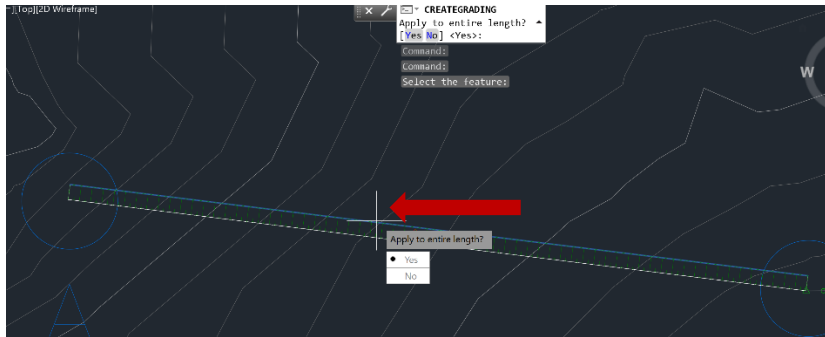
6. Set your display so that feature line AB fills most of the drawing window.
7. Click the Select a Grading Criteria list and click **Surface @ 4-1 Slope.**
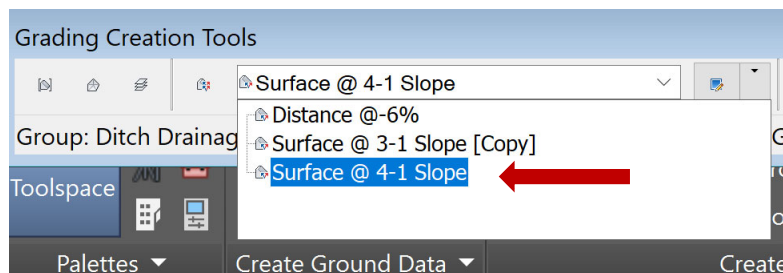


8. Click 🖉Create Grading

9. Select the target line from the first grading that you created.



10. Enter Yes to apply the grading to the entire length of the line.
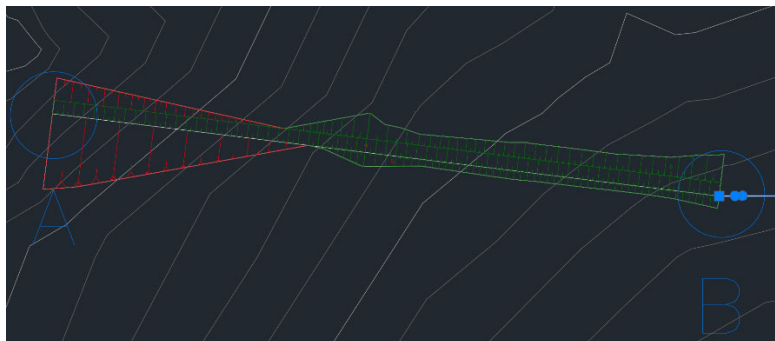11. Press Enter to accept the cut slope (4:1).
12. Press Enter to accept the fill slope (4:1).

    Press Esc to end the command. The grading is created. This grading creates a **4:1 side slope** up from the bottom of the ditch to the surface on the **upper side of the ditch**.
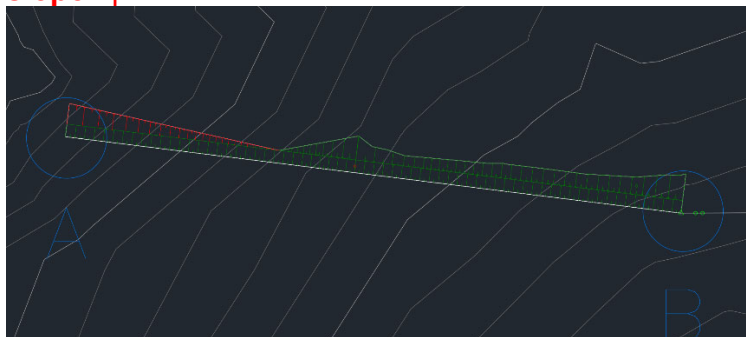


13. Repeat this process to create the 4:1 side slope on the lower side of the ditch.

**Note:**

The Event Viewer might notify you that duplicate points have been ignored. A surface was created from the two gradings, which share a common feature, and therefore share point data. The daylight line of the first grading is the baseline of the second grading. When the surface is created, the data from the points was extracted for each grading. Because the point data is duplicate, the data of one of the two instances of each point is ignored.

To continue to the next tutorial, go to Editing Gradings.

*Save this file as Grading-1.dwg Exercise 6 lastname first name.dwg and submit to Canvas*

# Tutorial: Editing Gradings

This tutorial demonstrates common grading editing tasks, including elevation adjustment and grading criteria editing.

You use the Grading Elevation Editor to edit elevations along a baseline. A baseline is a feature line or lot line that has had a grading applied to it. You can modify the elevations of a lot line unless it is being used as a target for a grading.

You can also insert a PVI (Point of Vertical Intersection) between the start and end stations of the baseline, creating an intermediate elevation point.

**Topics in this section**

- **Exercise 7: Editing the Grading Elevation**
  In this exercise, you will edit the elevation of a grading baseline. The grading adjusts to reflect the elevation change.

- **Exercise 8: Balancing Cut and Fill Volumes**
  In this exercise, you will adjust the elevation of a building pad to balance the cut and fill volumes.

- **Exercise 9: Editing the Grading Criteria**
  In this exercise, you will edit the grading criteria and an associated grading adjusts to reflect the criteria change.

# Exercise 7: Editing the Grading Elevation

In this exercise, you will edit the elevation of a grading baseline. The grading adjusts to reflect the elevation change.

**Edit feature line elevations**

1. Open *Grading-4.dwg*, which is located in the <u>tutorials drawings folder</u>.

   This drawing contains a rectangular building pad graded to the surrounding surface at a 3:1 slope. Where the slope pattern is green, it is a fill slope in which the grading slopes down from the pad to the surface. Where the slope pattern is red, it is a cut slope in which the grading slopes up from the pad.

2. Click Modify tab ➤ Edit Elevations panel ➤ Elevation Editor ▦ .
3. In the drawing, select the baseline for the grading (rectangular line).

   **Note:**

   The surface style for the building pad grading has borders turned off, making it easier to select the baseline. Otherwise, the surface border would be on top of the baseline.

   The Elevation Editor shows the following grading settings for each corner of the feature line in a clockwise direction. The starting point is the upper left corner.

- Station — Distance from the start of the feature line.
- Elevation — Elevation of the current point.
- Length — Distance to the next point.
- Grade Ahead — Grade toward the next point. Adjusting this setting holds the elevation of the current point and adjust the elevation of the next point for the new grade.
- Grade Back — Grade from the previous point. Adjusting this setting affects the elevation of the current point, holding the elevation of the next point for the new grade.

   **Further exploration:** Another way to review and edit the elevations of a feature line is to click Modify tab ➤ Edit Elevations panel ➤ Edit Elevations ⤴ . You can use this command to edit data on the command line.

4. In the Grading Elevation Editor, Shift+click the third and fourth rows to select them.
5. Double-click the elevation value in one of the rows and change it to **730** feet.

   Both of the selected rows' elevation values change to 730 feet. Notice that the shape of the grading and the Grade Ahead and Grade Back values have changed to reflect the elevation change.

**Edit feature line grades**

1. Select the first three rows in the table. Click ⬇Flatten Grade or Elevations.

2. In the Flatten dialog box, select Constant Grade. Click OK.

   The first two points are set to the same grade, and the shape of the grading changes in response to the elevation change. Flattening the grade holds the elevation values of the first and last selected points and modifies elevations of the points in between.

3. Click Show Grade Breaks Only.

   The second station's row is hidden, because there was no difference in grade between it and the previous station.

4. In the first row, change the Grade Ahead value to **-3.000%**.

5. Click Show Grade Breaks Only.

   Notice that the second station's grade has changed to reflect the change you made in step 4.

6. Click ✔ to close the Grading Elevation Editor.

   To continue this tutorial, go to Exercise Adjusting the Cut and Fill Volumes.

   *Save this file as Grading-4.dwg Exercise 7 lastname first name.dwg and submit to Canvas*

# Exercise 8: Balancing Cut and Fill Volumes

In this exercise, you will adjust the elevation of a building pad to balance the cut and fill volumes.

This exercise continues from Exercise Editing the Grading Elevation.

**Balance cut and fill volumes**

**Note:**

This exercise uses *Grading-4.dwg* with the modifications you made in the previous exercise.

1. Click Analyze tab ➤ Volumes And Materials panel ➤ Grading Volume Tools 🔷 .

   On the Grading Volume Tools toolbar, notice that the Group is set to Building Pad, which is the only grading group in the drawing. The fields for Cut, Fill, and Net show that the grading as designed requires the net cutting and removal of a large volume of surface material.

2. Click 🔷Raise the Grading Group to raise the building pad elevation by one foot. Note the changes to cut and fill requirements.

   **Further exploration:** You can also click 🔷Lower the Grading Group and you can change the elevation increment to a value other than 1.0.

3. Click 🔷Automatically Raise/Lower to Balance the Volumes.

4. In the Auto-Balance Volumes dialog box, leave the Required Volume set to 0, or change the value if you wish. Click OK.

   The elevation of the building pad is adjusted to bring the Net amount as close as possible to the set value.

5. Click ⩔ (Expand the Grading Volume Tools). The history of your elevation changes and their effects is displayed.

   To continue this tutorial, go to Exercise Editing the Grading Criteria.

   **Parent topic:** Tutorial: Editing Gradings

   *Save this file as Grading-4.dwg Exercise 8 lastname first name.dwg and submit to Canvas*

# Exercise 9: Editing the Grading Criteria

In this exercise, you will edit a grading criteria and an associated grading adjusts to reflect the criteria change.

You will edit grading criteria attribute values in two ways:

- In the Elevation Editor dialog box. Using this method updates the grading criteria for only the currently selected grading object.
- Directly in the Grading Criteria settings. Using this method will apply the attribute changes to future grading objects created with the criteria. If the attribute value is locked, attribute changes will also be applied to grading objects that currently use the criteria.

This exercise continues from Exercise Adjusting the Cut and Fill Volumes.

This exercise uses the drawing *Grading-3A.dwg*, which contains two grading groups that use the same grading criteria.

**Edit the grading criteria**

1. Open *Grading-3A.dwg*, which is located in the tutorials drawings folder.
2. Click Modify tab ➤ Design panel ➤ Grading 🔷 .
3. Click Grading tab ➤ Modify panel ➤ Grading Editor 🖽 .
4. Click inside the grading that projects from feature line AB.
5. In the Grading Editor Panorama, change the distance value to **5.0000**.

   Notice that grading AB updates to reflect the change. Now, you will make a similar change that will affect all grading groups using the **Distance @ -6%** grading criteria.

6. In Toolspace, on the Settings tab, expand Grading ➤ Grading Criteria Sets ➤ Ditch Criteria Set.
7. Right-click **Distance @ -6%**. Click Edit.
8. In the Grading Criteria dialog box, click the Criteria tab. Change the Distance parameter to **20** and click 🔒 . This locks the attribute value, which will apply it to all grading objects that currently use the Distance @ -6% grading criteria. Leaving the value unlocked applies the value to only grading objects that are created in the future.
9. Click OK.

   The AB and BC grading objects are both updated in the drawing to account for the new criteria value.

   To continue to the next tutorial, go to Grading from a Complex Building Footprint.

   *Save this file as Grading-3A.dwg Exercise 9 lastname first name.dwg and submit to Canvas*

# Optional Tutorial: Grading from a Complex Building Footprint

This tutorial demonstrates how to grade around a building footprint that has relatively complicated geometry and variations in elevation.

The drawing used in this tutorial contains a surface and a building pad that consists of two tiers connected by a small ramp. The elevation of the top portion of the building pad is 402 feet, and the bottom portion is 400 feet.

*Projection* grading, also known as *slope* grading, involves projecting a slope from a feature line to a specified target. Projection grading targets include an intersection with a surface, or a specified distance, elevation, or elevation difference. The ramp that connects the two tiers consists of arcs and inside corners, both of which complicate a grading plan. Simply applying projection grading, which was demonstrated in the Creating a Grading exercise, would result in a grading that overlaps itself.

In this tutorial, you will learn how to create a successful grading solution for similarly complicated scenarios. After you have completed this tutorial, proceed to the Using Feature Lines to Modify a Grading tutorial to learn how to modify the grading solution, using the AutoCAD Civil 3D feature line editing tools.
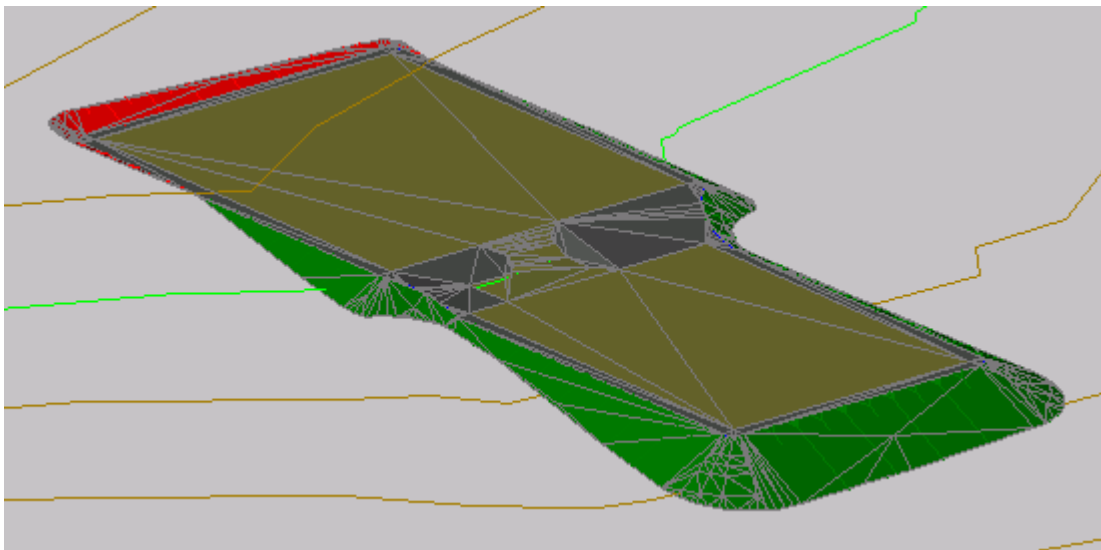


**Topics in this section**

- **Optional Exercise 10: Simplifying a Building Footprint**
  In this exercise, you will use the feature line stepped offset command to generate a simplified footprint from which to grade.

- **Optional Exercise 11: Grading from a Building Footprint to a Surface**
  In this exercise, you will grade from the simplified, offset footprint to the existing ground surface.

- **Optional Exercise 12: Filling Holes in a Grading**
  In this exercise, you will create infill gradings to fill in the open areas inside the grading group.

# Optional Exercise 10: Simplifying a Building Footprint

In this exercise, you will use the feature line stepped offset command to generate a simplified footprint from which to grade.

The drawing you will use in this tutorial displays a building pad in two vertically arranged viewports. In the right viewport, the building pad is shown in plan view. You will design the building pad in the right viewport. In the left viewport, the building pad is displayed in model view. You will use this viewport to see the status of the design as you work.

**Create a stepped offset feature line**

1. Open *Grading-6.dwg,* which is located in the <u>tutorials drawings folder</u>.
2. On the command line, enter **OffsetGapType**. Enter **1** as the value.

   The OffsetGapType variable controls how potential gaps between segments are treated when closed polylines, such as the building pad feature line, are offset. Setting this variable to 1 fills the gaps with filleted arc segments; the radius of each arc segment is equal to the offset distance.

3. Click Home tab ➤ Create Design panel ➤ Feature Line drop-down ➤ Create Feature Line From Stepped Offset ⟳ .
4. On the command line, enter **1.5** as the offset distance.
5. In the right viewport, click the blue feature line representing the building pad when prompted to select a feature line.
6. Click outside the building pad when prompted to specify the side to offset.
7. At the command line, enter **G** to specify a grade value. Enter **-1** as the grade.
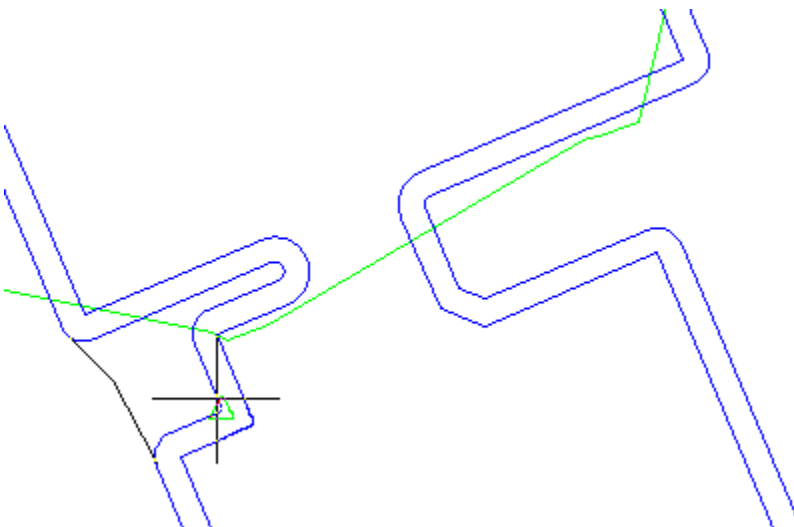8. Press Enter to end the command.

   The stepped offset feature line is displayed. Notice that in the left viewport, on the left side of the ramp, the curve of the stepped offset feature line is not well formed. Because it is an independent feature line, you can use the feature line editing tools to refine the solution.
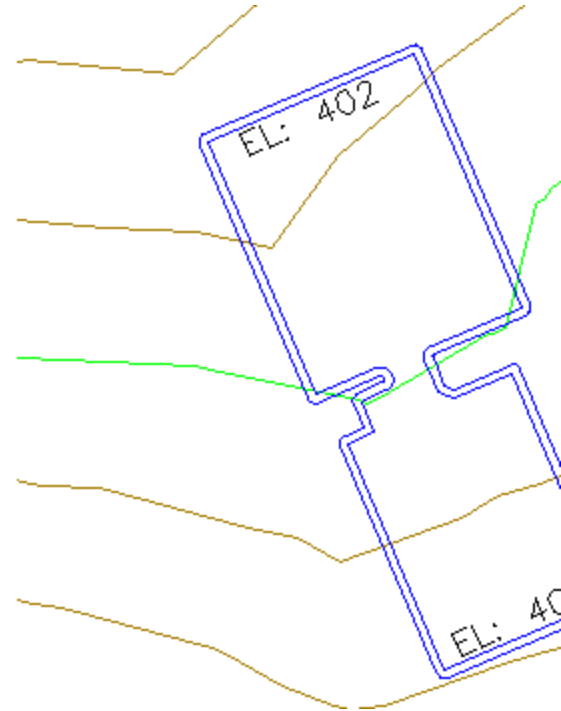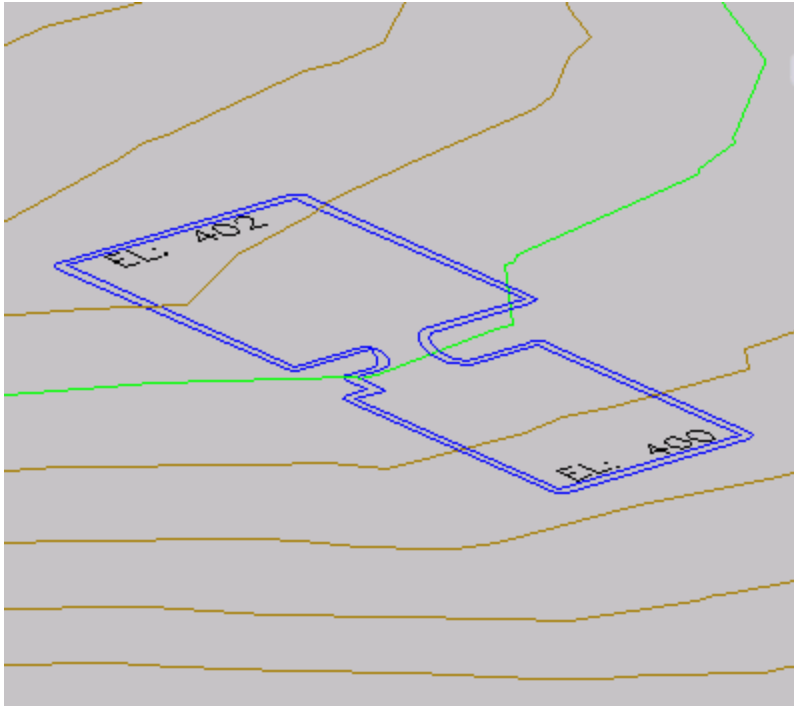
**Add fillets to the feature line**

1. Click Modify tab ➤ Edit Geometry panel ➤ Fillet ⌐.
2. Click the offset feature line when prompted to select an object.
3. On the command line, enter **R** to specify a radius for the fillet. Enter **15.000** as the radius value.
4. On each side of the ramp, click a sharp inside corner of the offset feature line.

   When you move the cursor over the feature line, a green triangle highlights the corners that can be filleted and a preview fillet is displayed. See the following image for an example of a corner to click.

The fillet is applied to the feature line. In the left viewport, notice that the fillet uses the elevations from the existing feature line and smoothly interpolates the elevations along the length of the fillet.
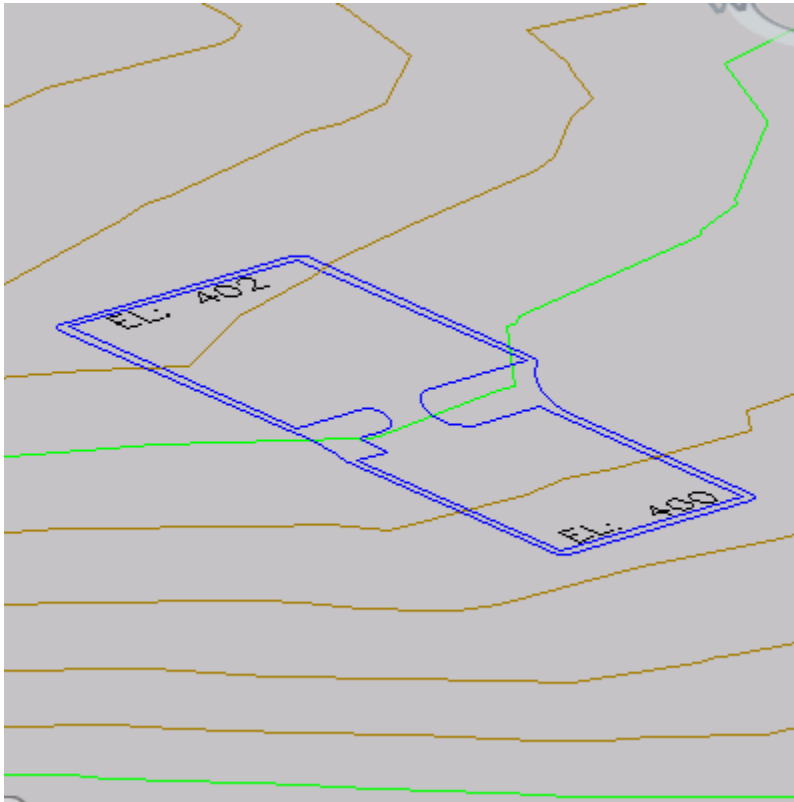


5. Press Enter twice to end the command.

To continue this tutorial, go to Exercise Grading from a Building Footprint to a Surface.

## Optional Exercise 11: Grading from a Building Footprint to a Surface

In this exercise, you will grade from the simplified, offset footprint to the existing ground surface.

The stepped offset feature line has much simpler geometry than the original footprint. The simpler feature line geometry will result in a much simpler grading than one created directly from the original footprint.

This exercise continues from Exercise 1: Simplifying a Building Footprint.

**Create a grading group and specify grading creation settings**

**Note:**

This exercise uses *Grading-6.dwg* with the modifications you made in the previous exercise.

1. Click Home tab ➤ Create Design panel ➤ Grading drop-down ➤ Grading Creation Tools 🖾 .
2. On the Grading Creation Tools toolbar, click 🖾 Set The Grading Group.
3. In the Select Grading Group dialog box, under Site Name, ensure that **Grading - Building Pad** site is selected.
4. Under Group Name, click 🖾 Create A Grading Group.
5. In the Create Grading Group dialog box, for Name, enter **Slope Grading With Feature Lines**.
6. Click OK twice.
7. On the Grading Creation Tools toolbar, click 🖾 Set The Target Surface.
8. In the Select Surface dialog box, ensure that **EG** surface is selected. Click OK.
9. On the Grading Creation Tools toolbar, click 🖾 Select a Criteria Set.
10. In the Select A Criteria Set dialog box, ensure that Basic Set is selected. Click OK.
11. From the Select a Grading Criteria list, select **Grade To Surface** .

**Create a grading**

1. Click 🖾 Create Grading.
2. When prompted to select a feature, click the blue feature line that is offset from the building pad.
3. When prompted to select the grading side, click outside the offset feature line.
4. Press Enter to apply the grading to the entire length of the feature line.
5. Press Enter to accept the default Slope Cut Format.

6. Press Enter to accept the default 2.00:1 Cut Slope.

7. Press Enter to accept the default Slope Fill Format.

8. Press Enter to accept the default 2.00:1 Fill Slope.

9. Press Esc to end the command.

   The stepped offset feature line is graded to the EG surface. Notice that while the cut and fill slopes are shown in red and green, there are still open areas inside the grading group. In the next exercise, you will fill these areas and apply appropriate grading styles.
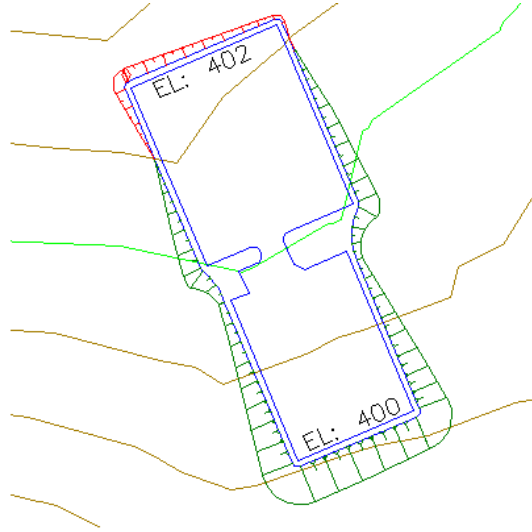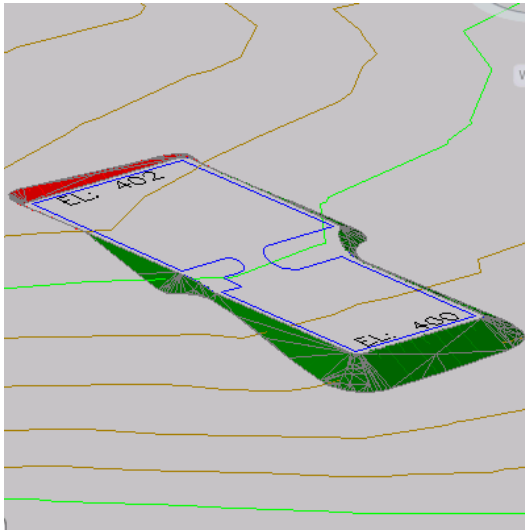


To continue this tutorial, go to Exercise Filling Holes in a Grading.

# Optional Exercise 12: Filling Holes in a Grading

In this exercise, you will create infill gradings to fill in the open areas inside the grading group.

An *infill grading* has no criteria applied to it. Any area bounded by feature lines or lot lines that is not already a grading can be converted to an infill grading. Using infill gradings to fill in holes in a grading group ensures correct contour display and volume calculations.

This exercise continues from Exercise Grading from a Building Footprint to a Surface.

**Create infill gradings**

**Note:**

This exercise uses *Grading-6.dwg* with the modifications you made in the previous exercise.

1. On the Grading Creation Tools toolbar, from the Select A Grading Criteria list, select **Grade To Distance**.

   **Note:**

   Although an infill has no criteria, you select its grading style from an existing criteria.

2. Click ⩔Expand The Toolbar.
3. From the Style list, select **Shoulder**.

   This setting specifies the grading style to apply to the infill.

4. Click 🔷Create Infill.
5. Click in the area between the building footprint and the offset feature line (near the right side of the ramp).

   A diamond is displayed in that area, indicating that an infill has been created. In the left viewport, notice that the infill grading fills the entire area between the two blue feature lines.

6. On the Grading Creation Tools toolbar, from the Style list, select **Pad**.
7. Click inside the building footprint to create an infill using the Pad grading style.
8. Press Enter to end the command.

   In the left viewport, the gray area is the infill grading that represents the shoulder. The gold area is the building pad infill grading. The green and red areas are the grade-to-surface slope grading.
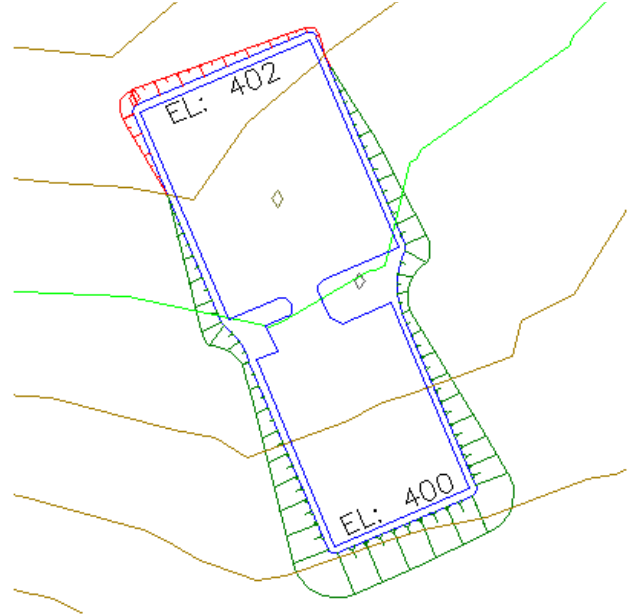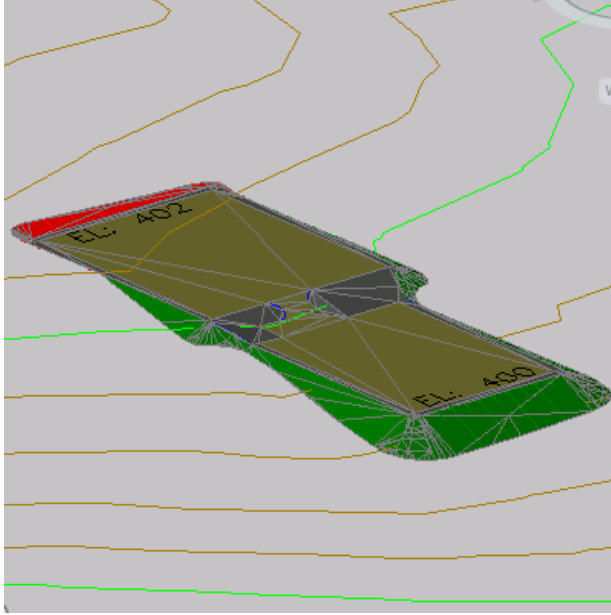
To continue to the next tutorial, go to Using Feature Lines to Modify a Grading.

**Parent topic:** Tutorial: Grading from a Complex Building Footprint

# Optional Tutorial: Using Feature Lines to Modify a Grading

This tutorial demonstrates how to use feature lines to control grading around inside corners.

*Feature line* grading involves creating a set of feature lines to define the graded region as surface breaklines, and then adjusting the elevation of key points to control the shape of the surface. This technique is ideal for wide, fairly flat areas, such as parking lots or building pads. It is also well suited to areas with rapidly changing elevations or slopes where walls would normally be required to grade successfully. You can manually add or remove feature lines and adjust their location in three dimensions to achieve precise slope design. Using this process, you can control water drainage or clean up difficult geometry in areas, such as the intersection of two or more slopes.

**Topics in this section**

- **Exercise 13: Smoothing Feature Line Arcs**
  In this exercise, you will adjust the tessellation of the arcs around the ramp, which will result in a more accurate representation of the ramp.

- **Exercise 14: Adjusting Grading Triangulation with a Feature Line**
  In this exercise, you will use a feature line to break a poorly triangulated grading surface.

- **Exercise 15: Working with Crossing Feature Lines**
  In this exercise, you will learn how feature lines interact when they cross each other at and between vertices

# Optional Exercise 13: Smoothing Feature Line Arcs

In this exercise, you will adjust the tessellation of the arcs around the ramp, which will result in a more accurate representation of the ramp.

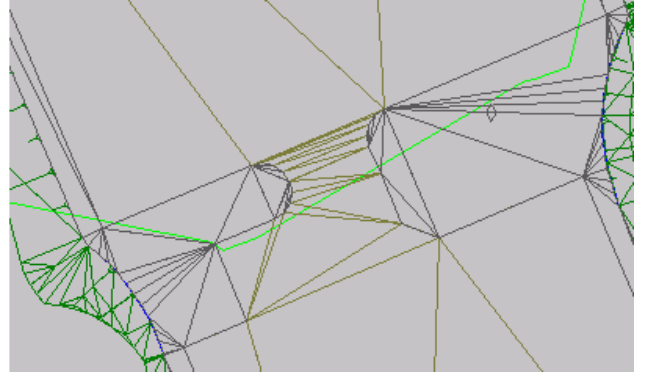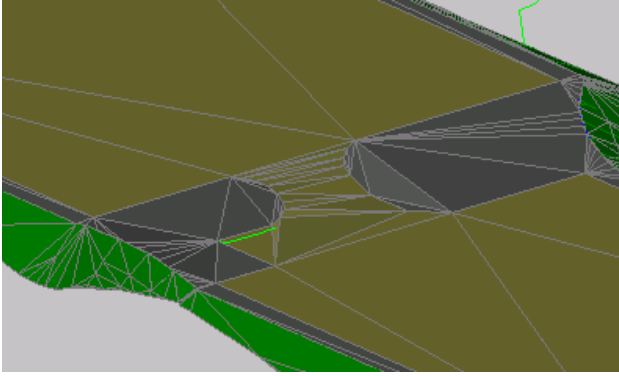**Modify feature line arc tessellation**

**Note:**

This exercise uses *Grading-6.dwg* with the modifications you made in the previous exercise.

1. Click the right viewport to make it active.
2. Click View tab ➤ Views panel ▾ Visual Styles drop-down ➤ 3D Wireframe.

   The grading triangulation is displayed in the 3D Wireframe visual style. It is helpful to observe the triangles as you use the feature line to break the surface.

3. Click Home tab ➤ Create Design panel ➤ Grading drop-down ➤ Grading Creation Tools 🖌 .
4. On the Grading Creation Tools toolbar, click 🖿Grading Group Properties.
5. In the Grading Group Properties dialog box, on the Information tab, select the Automatic Surface Creation check box.
6. In the Create Surface dialog box, click OK.

   To adjust the arc tessellation, a surface must be created from the grading group. This surface is temporary. You will delete it after you have adjusted the arc tessellation.

7. In the Grading Group Properties dialog box, on the Information tab, change the Tessellation Spacing setting to **1.000'**. Click Apply.
8. Clear the Automatic Surface Creation check box. When asked if you want to delete the Slope - Projection Grading surface, click Yes. Click OK.

   Now that you have updated the arc tessellation, you must update the grading infill areas to apply the new setting. The easiest way to update the infill areas is by using the AutoCAD Move command.

9. On the command line, enter **MOVE**.
10. Click the original, interior feature line (the blue building pad). Press Enter.
11. Press Enter again to select the default Displacement selection.
12. Press Enter again to accept the default displacement of <0.0000, 0.0000, 0.0000>.

    In the left viewport, notice that the triangulation of the arcs along the ramp has improved.

To continue this tutorial, go to Exercise Adjusting Grading Triangulation Using a Feature Line.

# Optional Exercise 14: Adjusting Grading Triangulation with a Feature Line

In this exercise, you will use a feature line to break a poorly triangulated grading surface.

The triangles in the area on the right side of the ramp are steeper than desired. These triangles can be corrected by creating a feature line to break the surface in this area.

This exercise continues from Exercise Smoothing Feature Line Arcs.

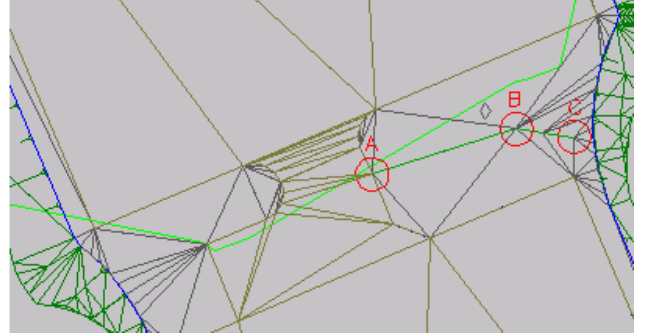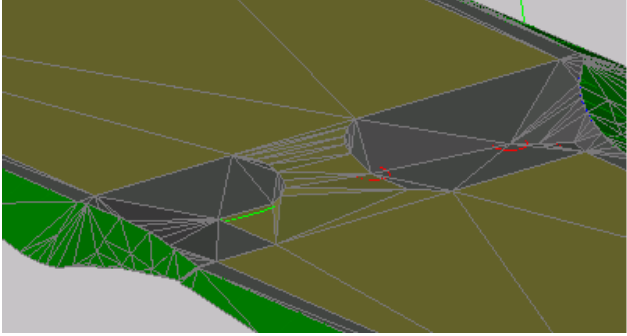**Use a feature line to adjust surface triangulation**

**Note:**

This exercise uses *Grading-6.dwg* with the modifications you made in the previous exercise.

1. Click Home tab ➤ Layers panel ➤ Layer drop-down. Next to the **C-TOPO-FEAT-CROSS** layer, click ⍟.
2. Zoom in to the area to the right of the ramp.

   Notice the polyline between the three circles labeled A, B, and C. You can use the following steps on any polyline. However, this polyline is in a specific location so that you will get the results described in this tutorial.

3. Click Home tab ➤ Create Design panel ➤ Feature Line drop-down ➤ Create Feature Lines From Objects ⍟.
4. Click the polyline between Circles A, B, and C. Press Enter.
5. In the Create Feature Lines dialog box, under Site Name, make sure that **Grading - Building Pad** is selected.
6. Under Conversion Options, make sure that the Erase Existing Entities and Assign Elevations check boxes are selected. Click OK.
7. In the Assign Elevations dialog box, select From Surface. Make sure that the Insert Intermediate Grade Break Points check box is selected. Click OK.

   **Tip:**

   To reduce processing time when working with larger grading groups, clear the Insert Intermediate Grade Break Points check box. This option adds an elevation point at each point at which the feature line crosses a triangle.

   The polyline is converted to a feature line and breaks the triangulation along the right side of the ramp. The new triangulation creates a more gradual slope in the infill area.

To continue this tutorial, go to Exercise Working with Crossing Feature Lines.

# Optional Exercise 15: Working with Crossing Feature Lines

In this exercise, you will learn how feature lines interact when they cross each other at and between vertices.

This exercise continues from Exercise Adjusting Grading Triangulation Using a Feature Line.

**To work with crossing feature lines**

**Note:**

This exercise uses *Grading-6.dwg* with the modifications you made in the previous exercise.

1. In the right viewport, select feature line ABC. Right-click. Click Elevation Editor.

   The Grading Elevation Editor displays a list of the points of intersection (▲ PIs, or horizontal geometry points) and elevation change points (⬤ vertical geometry points) along the feature line.
   Notice that the ▲+ icon is displayed in the first row. This icon indicates that the building pad feature line also has a PI at this point. When two feature lines cross at a common vertex, both vertices must share the same elevation value. The elevation for both feature lines at this point is determined by whichever feature line was most recently edited. In the following illustration, the common vertex is in Circle A.
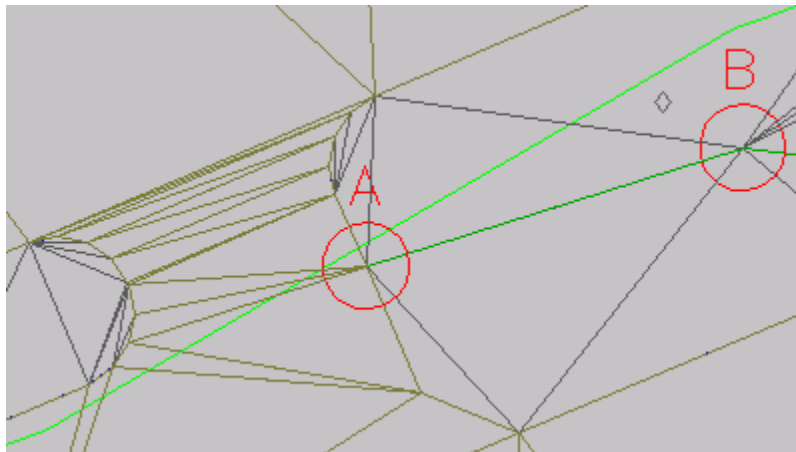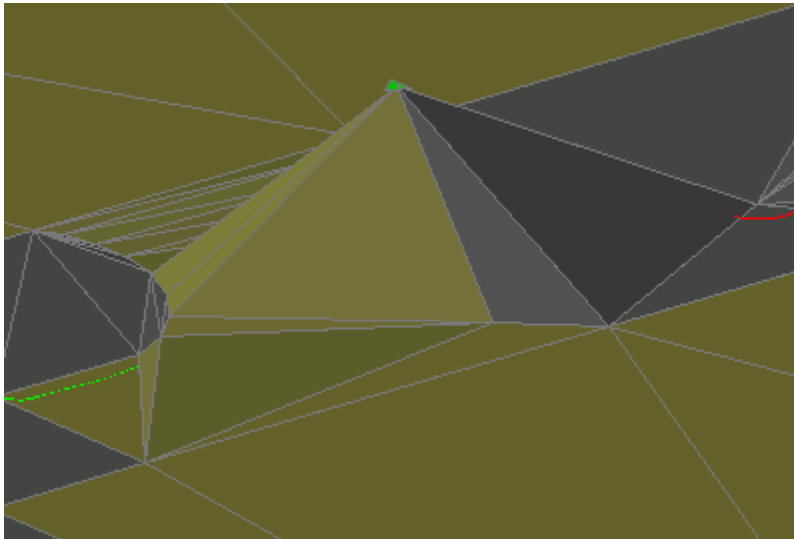


2. In the Grading Elevation Editor click 🔲Unselect All Rows. Click ⬧Flatten Grade Or Elevations.

3. In the Flatten dialog box, select Constant Grade. Click OK.

   Notice that in the Grading Elevation Editor, the Grade Ahead and Grade Back values are updated to a consistent value. When you flatten a feature line, the points between the start elevation and the end elevation are set to the same grade, effectively eliminating the grade breaks. You may flatten either the entire feature line, or a selection of points.

4. In the ⬤ row, in the Elevation column, change the elevation value to **402.00'**.

5. In the Grading Elevation Editor, click 🖱Select A Feature Line, Parcel Line, Or Survey Figure.

6. In the drawing window, click the building pad feature line.

   The elevation points of the building pad are now displayed in the Grading Elevation Editor.

7. Locate the row containing the ⬤ icon.

   Notice that the value in the Elevation column is 402.000', which is the same value you entered for the other feature line in step 4. Change the Elevation value to **405.000'**. In the left viewport, notice that the value you entered for the shared vertex updated the elevation of both feature lines. As you see in the following image, the new common feature line elevation affected the infill gradings of both the ramp and gray infill area. When two feature lines share a vertex, the elevation of both feature lines at that vertex is determined by whichever of the feature lines was most recently edited.



8. In the Grading Elevation Editor, in the ⬤ row, change the Elevation value to **400.00'**.

9. In the right viewport, select feature line ABC. Using the grip inside Circle A, move the beginning point of the feature line toward the lower left of Circle A.

   **Note:**

   You may need to hover over the feature line, and then use Shift+spacebar to select the feature line.

10. Right-click the feature line. Select Elevation Editor.

    In the Grading Elevation Editor, the ⬤ icon indicates the point at which the feature line crosses the building pad. The white triangle indicates a *split point*, which is created when two feature lines cross at a location where neither one has a PI. Much like a ⬤ shared vertex point, a split point acquires the elevation of the feature line that was most recently

edited. If the other feature line has a different elevation, it gets a grade break at the crossing point.
Unlike a shared vertex, there is not an actual point at a split point, so you cannot directly edit the elevation. When you edit one of the feature lines, its grade runs straight through the intersection, forcing the other feature line to break at the split point. You can use the Insert PI command to create a permanent point at that location on one of the feature lines. After you convert a split point to a permanent point, you can edit the elevation of a split point directly, and have better control over that point.

11. Select the grip at the beginning point of the feature line. On the command line, enter **END** to apply an endpoint OSNAP. Snap the feature line to the building pad feature line.

   Notice that an ⊙ elevation change point with an elevation of 402.000' was added in the second row. The change point was added because you changed the elevation of the endpoint (the ▲ shared vertex) of this feature line to 402.000' in step 4. When you changed the elevation of the shared vertex on the building pad feature line to 400.000' in step 8, the grade break point was created. The grade break point ensures that the elevation of this feature line would match the elevation of the building pad.

12. In the Grading Elevation Editor, click ▦. Click ⬦Flatten Grade Or Elevations.

13. In the Flatten dialog box, select Constant Grade. Click OK.

   The grade flattens, and the elevations updates to accommodate the new grade.
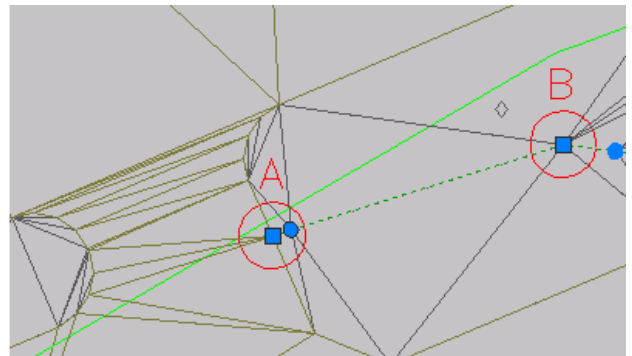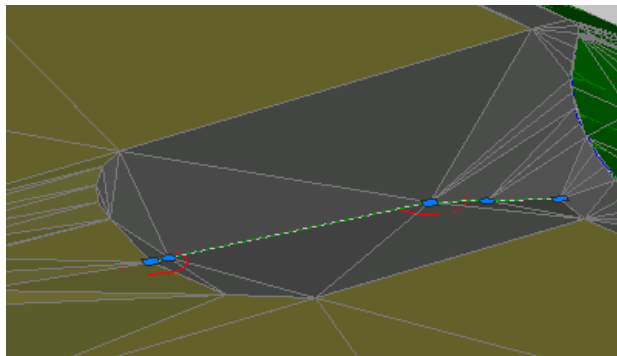


**Parent topic:** <u>Tutorial: Using Feature Lines to Modify a Grading</u>