Lesson 1

Roadway Alignments

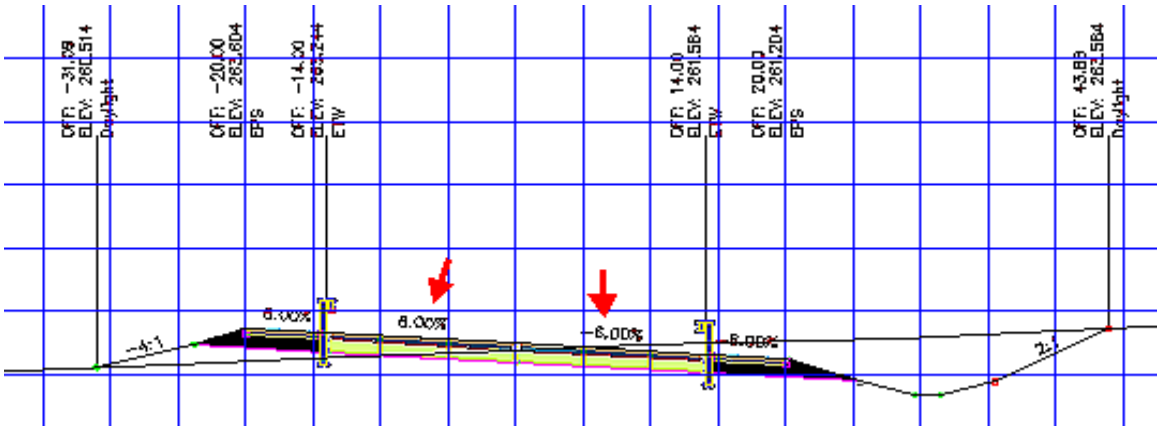
Overview

In this lesson, students learn how to work with alignments specifically intended for transportation projects. These are typically more advanced designs than those used for subdivision design. Alignments are frequently criteria-based and may include superelevation and offset alignments.

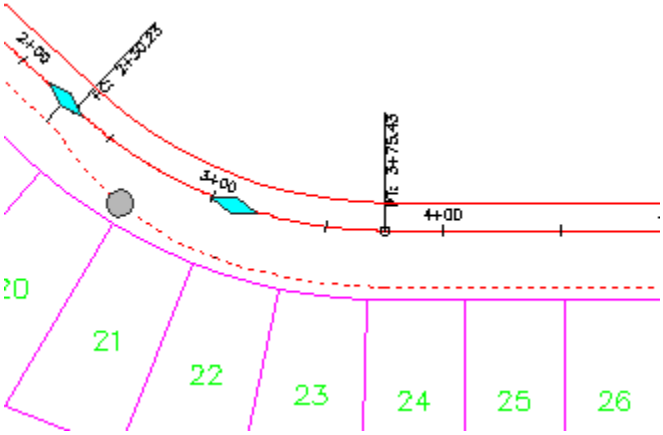
When engineers plan and design transportation facilities for both new construction and road reconstruction projects, they must create and then edit the alignments used to control the design of the road. You create tangent, curve, and spiral alignment components with layout tools, and you can edit alignments both graphically and in a table. When you edit alignment data in a table, the graphical display of the geometry and associated annotation is automatically updated. When you edit alignment data graphically, curves maintain tangency to the lines. When you edit alignment geometry, surface profile data also automatically updates. The following illustration shows two intersecting alignments:

Superelevation is the purposeful canting of road or railway cross sections within spiral and curve alignment components. The intent is to counteract centrifugal forces to allow for higher design speeds and safer passage through alignment spirals and curves. To calculate superelevation values for an alignment, you modify alignment properties to assign a design speed. The superelevation values are referenced from a rate table in a design criteria file. Each curve is a superelevation region, and for each superelevation region, you can assign independent superelevation properties. You can also apply the superelevation properties of one superelevation region to the other superelevation regions in the alignment.

When you use alignment design criteria and superelevation, you associate standard imperial and metric superelevation tables with the alignment to calculate minimum curve radii and superelevation critical values for assigned design speeds. The superelevation values assigned to an alignment are referenced when you create the corridor model for the transportation facility.



Offset alignments are directly related to the centerline alignment. When you change the geometry of the centerline alignment, the geometry of the offset alignment automatically recalculates based on the offset parameters.



Objectives

After completing this lesson, students will be able to:

- Describe alignments and their properties.
- Create alignments using objects.
- Describe alignment tag labels.
- Label alignments and create a table.
- Explain criteria-based design.
- Create alignments using layout tools.
- Calculate and apply superelevation to a horizontal alignment.
- Create offset alignments and widenings.

Exercises

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

1. Create an Alignment Using Objects
2. Label an Alignment
3. Create an Alignment Using Layout Tools
4. Edit an Alignment
5. Apply Superelevation
6. Create Offset Alignments and Widenings

About Alignments

An alignment is a series of coordinates, lines, curves, or spirals used to represent linear features such as the centerline of a road, edges of pavement, sidewalks, and rights-of-way. Creating and defining the alignment is one of the first steps in a transportation design project. The alignment controls the horizontal location of a transportation corridor model. The alignment serves as the controlling geometry for the layout and construction of the road.

Detailing the particular geometric points of alignments is critical in order for the design engineer to provide clear communication of the engineering data for the client, reviewers, and contractors. Alignment labels and styles are effective tools for providing this communication.

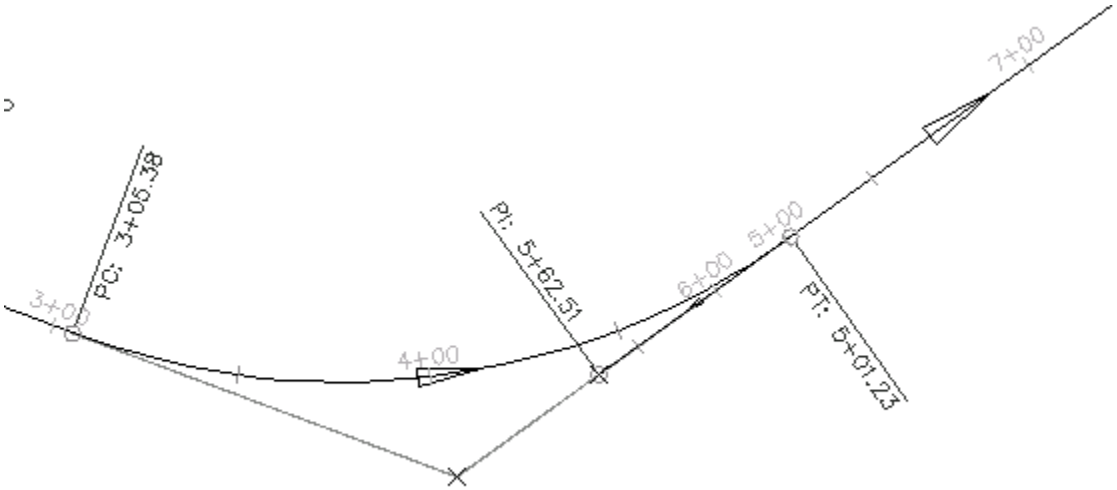
Alignments are the first of the three primary design planes to be laid out and used by the designer. Profiles and cross sections provide the other two design planes necessary for a full three-dimensional description and modeling of proposed roadways.

Alignment Subentities

Alignments are created and displayed with subentities. The alignment components are lines, curves, spirals, arrows, line extensions, and curve extensions. Alignment lines, curves, and spirals can be either fixed, floating, or free. Fixed, floating, and free entities are summarized in the following table.

Term	Description
Fixed Entities	Alignment lines, curves, and spirals can be fixed entities. Fixed entities have a fixed position and are not necessarily tangent to another entity for the definition of its geometry.
Floating Entities	Alignment lines, curves, and spirals can be floating entities. When a floating entity is created, it is tangent to one other alignment entity for the definition of its geometry.
Free Entities	Alignment lines, curves, and spirals can be free entities. When a free entity is created, it is tangent to two other alignment entities for the definition of its geometry.

An alignment segment with a generated curve is shown in the following illustration.



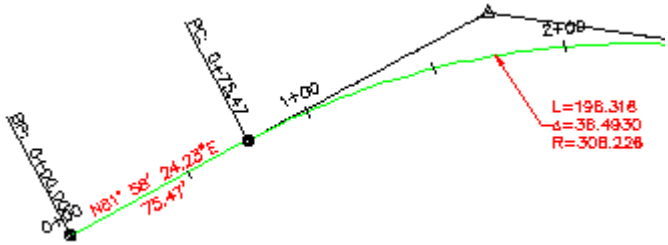
Keep the following guidelines in mind when you create alignments:

- When you create an alignment from a polyline with no curves, or from lines, you can automatically add curves between the tangents.
- You can assign a value to the starting station of the alignment, which is the start point of the polyline, line, or arc. Alignment station reference points and base stationing values can be adjusted later.
- Alignments can either be independent or included in a site. Use alignments in a site if you want them to interact with other objects in the site, or if you want to use sites to organize the alignments.

Labeling Alignments

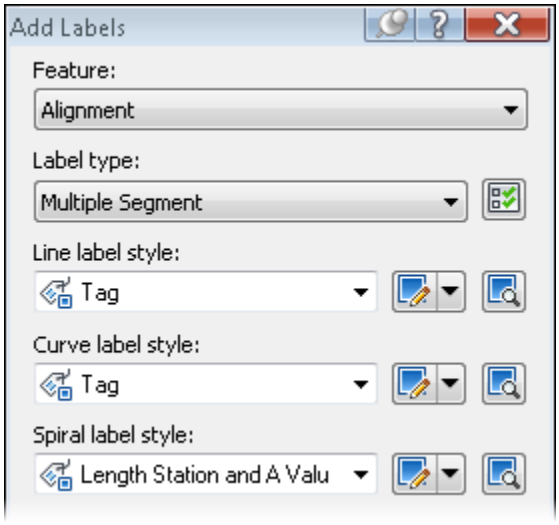
Horizontal alignments are made up of segments, which are lines, arcs, or spirals. There are a number of powerful labeling tools in AutoCAD® Civil 3D® software for labeling horizontal alignment geometry, either on the alignment itself or in a table. When you edit or change an alignment, associated labels and tables automatically update to reflect the new alignment geometry.

The following illustration shows alignment geometry with segment labels.



When plans become difficult to read because of too many geometry alignment labels, you can create tag labels for the alignment segments and show the geometry in a corresponding table. After adding tag labels, you create an alignment table that references the tags. You can create a line, curve, spiral, or segmental table that shows the geometry for the entire alignment. The table can be dynamic. When you edit the horizontal alignment or change the station reference point, the data in the table automatically updates to reflect the new geometry.

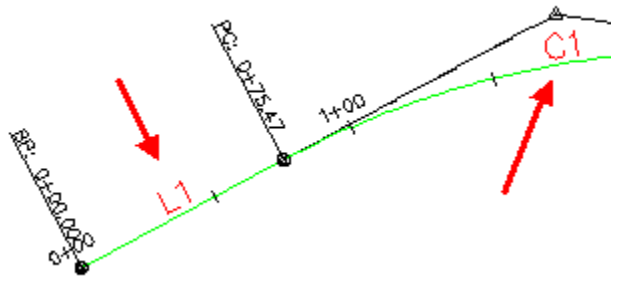
To create tag labels, you select a tag label style from the Add Labels dialog box as shown.



Definition of Alignment Tag Labels

There are a number of different label types that you can add to a horizontal alignment. To label alignment geometry, you can either label single segments or multiple segments. The multiple segment option enables you to label all segments for the entire alignment. When you choose the label type, you can then specify the corresponding label style.

An alignment with tag labels is shown in the following illustration.



The table in the following illustration displays segment numbers (tag label) and its associated details.

Huckleberry Hill				
Number	Radius	Length	Line/Chord Direction	A Value
L2		101.87	S81° 32' 01.01"E	
L3		156.94	S69° 41' 15.00"E	
L1		75.47	N81° 58' 24.23"E	
C1	308.23	196.32	N80° 13' 11.61"E	
C2	373.38	77.20	S75° 36' 38.00"E	

Keep the following guidelines in mind when labeling alignments:

- Use the Alignment command settings to specify default label styles for alignment labeling.
- Use tag labels and tables to simplify the appearance of a drawing. Note that when you create a table for an alignment that already has labels, the labels are automatically converted to tag labels.

Editing Alignments

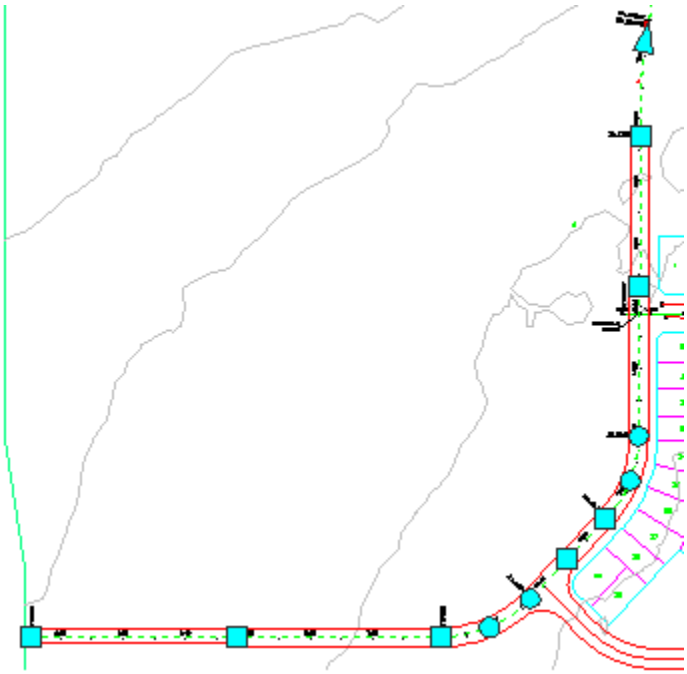
You can edit an alignment by grip editing or by changing the layout parameters in a table shown in specialized windows.

Editing with Grips

When you select an alignment, graphical editing grips are displayed. The square grips are used to edit tangents, the circular grips are used to edit curves, and the triangle grips are used to edit the PI location. As you make changes, an alignment retains its tangency rules at curves, and all alignment labels are dynamically updated. The shapes of the grips displayed depend on whether or not the alignment entities are fixed, floating, or free. You can edit the location of tangents and resize curves and spirals.

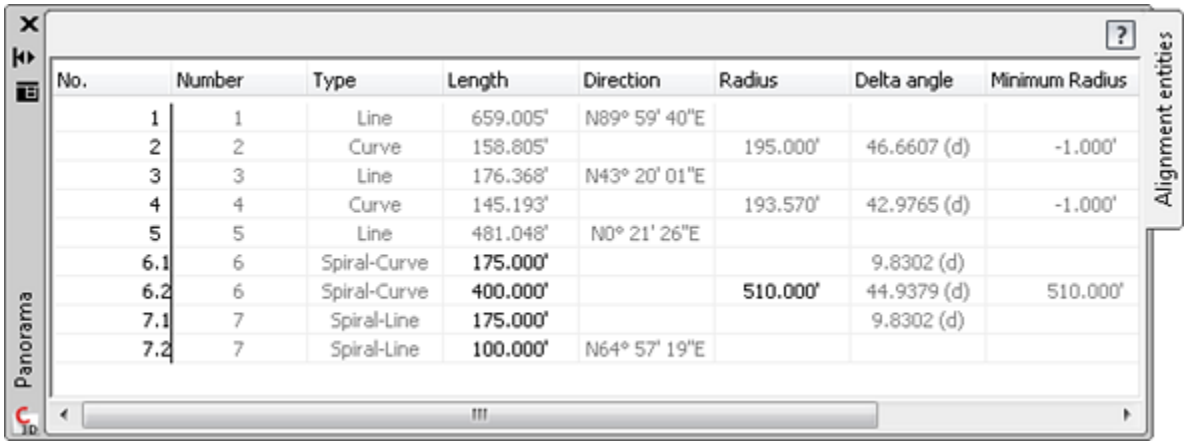
Grip Type	Description
Circular grip	Changes the parameter of a curve. You can change the radius by moving a center point, pass-through point, or the tangency point of an attached curve. This grip is used only on curves and circles and always affects the radius of the curve.
Square grip	Moves an unconstrained pass-through point on a line, a curve, or a center point of a circle. On a curve or a circle, moving this grip does not affect the radius of the entity that the grip belongs to. However, it may affect the radius of another attached entity.
Triangular grip	Changes where two tangent points meet. This grip is always oriented with the top point up, toward the *Y* axis of the world coordinate system.

The following illustration shows that when you select an alignment, blue editing grips appear at the curve ends, midpoints, and points of intersection (PIs). By using these grips, you can move alignment features directly and reshape a line or curve using visual cues. Use this method of editing when precision is not important.



Editing Alignments in Tables

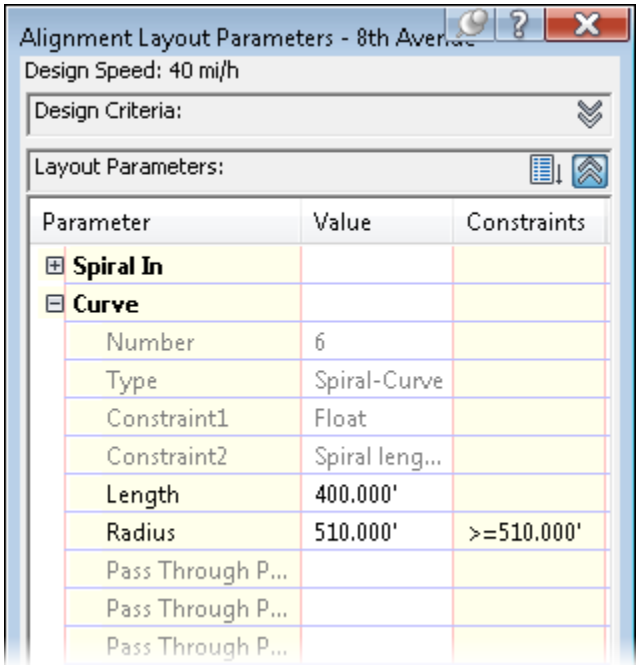
When you edit alignment data in a table, you modify values to change tangent bearings, curve radii, and spiral geometry parameters. The alignment object in the drawing and associated annotation automatically updates. The alignment segments are numbered according to both their position in the alignment and their order of creation. Each row of the table shows design data about a specific alignment entity.



No.	Number	Type	Length	Direction	Radius	Delta angle	Minimum Radius
1	1	Line	659.005'	N89° 59' 40"E			
2	2	Curve	158.805'		195.000'	46.6607 (d)	-1.000'
3	3	Line	176.368'	N43° 20' 01"E			
4	4	Curve	145.193'		193.570'	42.9765 (d)	-1.000'
5	5	Line	481.048'	N0° 21' 26"E			
6.1	6	Spiral-Curve	175.000'			9.8302 (d)	
6.2	6	Spiral-Curve	400.000'		510.000'	44.9379 (d)	510.000'
7.1	7	Spiral-Line	175.000'			9.8302 (d)	
7.2	7	Spiral-Line	100.000'	N64° 57' 19"E			

The design data for an entity that you select in the Alignment Entities window is displayed in the Alignment Layout Parameters window. This simplifies review and editing tasks. You use the Alignment Layout Parameters window for precise alignment editing such as when your

design calculations and reference tables provide numeric values for minimum curve radius, length, or spiral A values.



About Criteria-Based Design

Criteria-based design is an option available to the engineer when creating a new alignment or editing an existing one. It enables the engineer to verify that a design meets the local agency's design standards. When this option is used, the alignment is checked against the minimum values specified in a design criteria file, which is XML based. The file contains all the local agency's minimum design values for such parameters as the minimum curve radius, superelevation attainment method, and the spiral transition length for a wide range of design speeds.

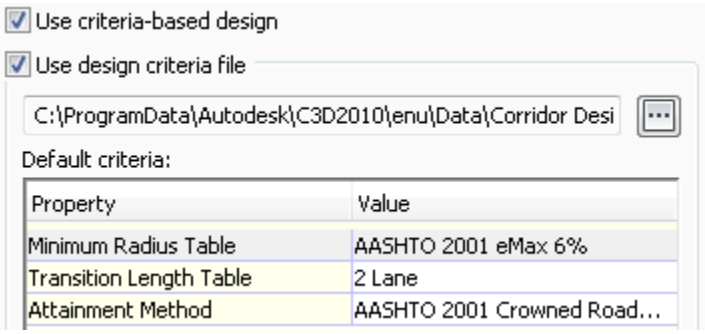
If this option is used when laying out a new alignment, the appropriate minimum values are displayed on the command line for acceptance. If you apply these design criteria to an existing alignment, then the entire alignment is checked against the design values. In either case, whether the design criteria is applied during alignment layout or applied to an existing alignment after the fact, any segment of the alignment that does not meet the minimum values specified in the design file is flagged with a warning symbol. This warning symbol provides a tooltip with information about the standard that was violated and what the standard value should be.

Parameters

The following table provides a description of the terms and options available to the engineer when applying criteria-based design to alignments. Only the horizontal component of an alignment is described here. The vertical component is discussed in a later lesson.

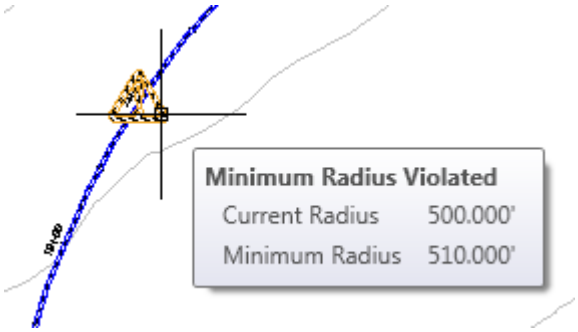
Term	Definition
Criteria-Based Design	This option enables the use of criteria-based design to be applied to the current alignment
Design Criteria File	This option enables you to specify the location of the XML file that contains all of the local agency's design standards controlling the minimum horizontal and vertical design parameters.
Default Criteria	This list displays the major design categories and their values, which will be used in the layout process. These categories are contained in the design criteria file and include the minimum radius table, the transition length table, and the superelevation attainment method for horizontal layout, as well as the minimum K table used in vertical layout.
Design Checks	This option allows for the use of design checks against the current alignment. A design check is a user-defined expression used to verify that an entity meets the minimum design standards that were established for the alignment or profile object. Design checks can be defined for different entity types such as lines, curves, and spirals. A design check must be saved in a design check set to be applied to an alignment or profile.

The design criteria file and some criteria values are as shown.



If the design parameters for a subentity violate the minimum values established in the design criteria file, a warning marker displays on the subentity in the drawing window. The display of the warning symbol is controlled by the object's style (profile or alignment).

The following illustration shows a Design Check Marker warning that shows that minimum radius violation has occurred, and that the radius should be a minimum of 60 m for the given design speed.



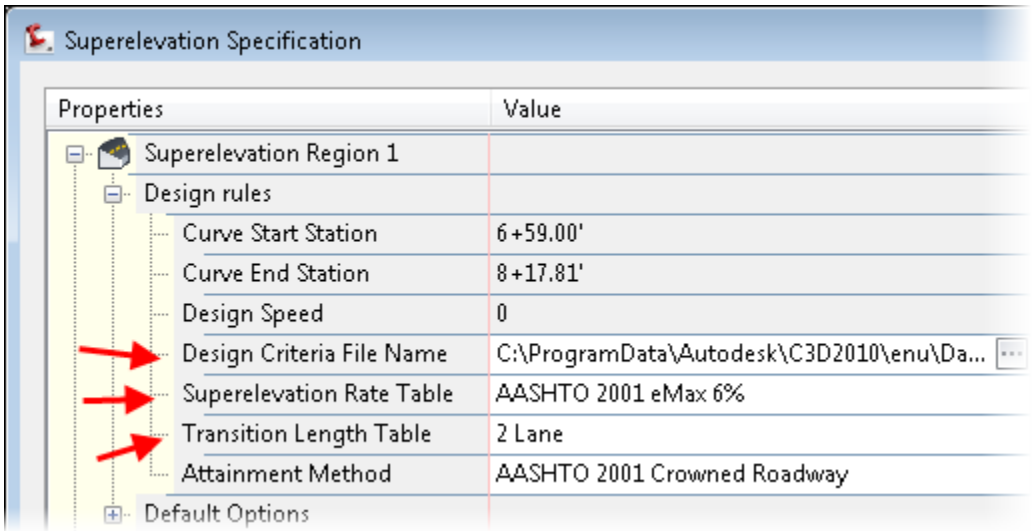
About Superelevation

Superelevation is the purposeful banking of a roadway to provide for smooth and safe travel around a curved section of road at the design speed. The purpose of superelevation is to counteract the centripetal and frictional forces experienced by a vehicle as it moves along this curved path.

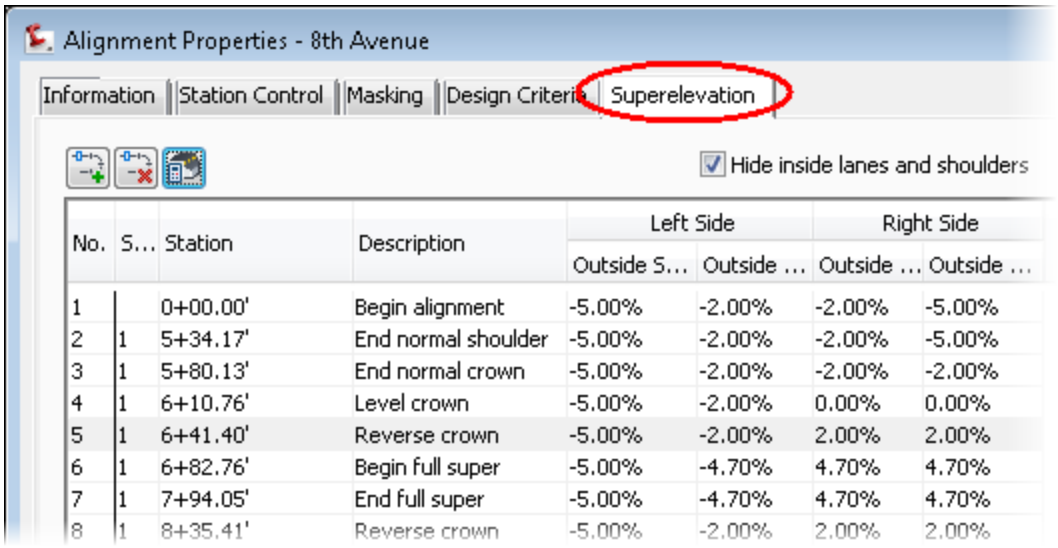
Superelevation is calculated for an alignment when you assign a design speed, a design criteria file, a rate table, and a transition length table. You can assign different design speeds at different locations along the alignment.

Design criteria files are available for both imperial and metric units. The rate table indicates the superelevation rate, or the maximum section cross fall. The transition length table is used to assess the length it takes to achieve full superelevation, and the locations of the critical superelevation points.

The image shows the superelevation specifications for a superelevation region on an alignment. Notice the design criteria file, superelevation rate table, and the transition length table assignment.

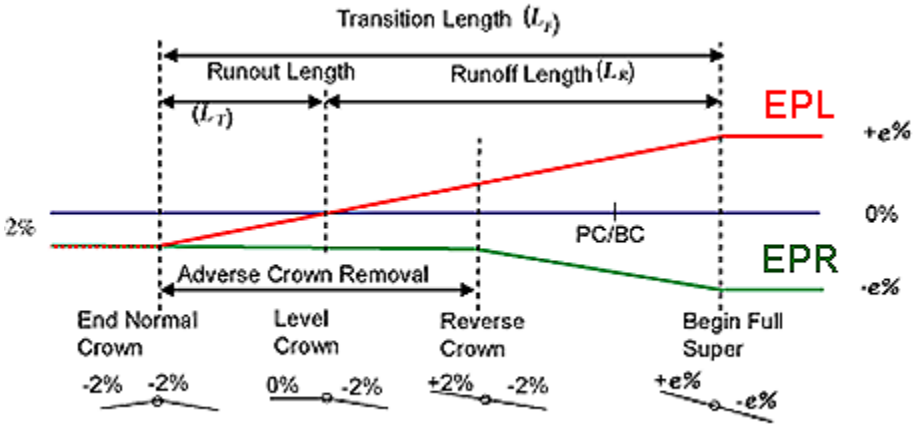


Superelevation is defined and applied in the Alignment Properties dialog box as shown. To calculate superelevation, you need to specify the design speed, the minimum radius table, and the superelevation attainment method. The following image shows the calculated superelevation critical points for an alignment.

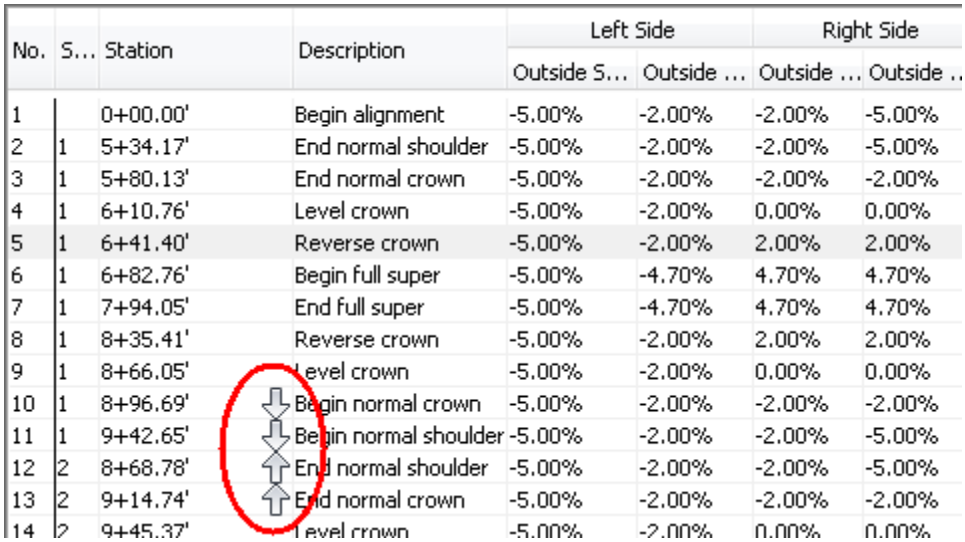


No.	S...	Station	Description	Left Side		Right Side	
				Outside S...	Outside ...	Outside ...	Outside ...
1		0+00.00'	Begin alignment	-5.00%	-2.00%	-2.00%	-5.00%
2	1	5+34.17'	End normal shoulder	-5.00%	-2.00%	-2.00%	-5.00%
3	1	5+80.13'	End normal crown	-5.00%	-2.00%	-2.00%	-2.00%
4	1	6+10.76'	Level crown	-5.00%	-2.00%	0.00%	0.00%
5	1	6+41.40'	Reverse crown	-5.00%	-2.00%	2.00%	2.00%
6	1	6+82.76'	Begin full super	-5.00%	-4.70%	4.70%	4.70%
7	1	7+94.05'	End full super	-5.00%	-4.70%	4.70%	4.70%
8	1	8+35.41'	Reverse crown	-5.00%	-2.00%	2.00%	2.00%

The following image shows how superelevation is attained for a clockwise-direction curve on a crowned roadway. To achieve the superelevation, the left edge of pavement rises and the right edge of pavement drops.



The following image shows an example of an alignment where the superelevation stations overlap. You can manually adjust the superelevation by adding, removing, and changing the location of superelevation critical points.



No.	S...	Station	Description	Left Side		Right Side	
				Outside S...	Outside ...	Outside ...	Outside ..
1		0+00.00'	Begin alignment	-5.00%	-2.00%	-2.00%	-5.00%
2	1	5+34.17'	End normal shoulder	-5.00%	-2.00%	-2.00%	-5.00%
3	1	5+80.13'	End normal crown	-5.00%	-2.00%	-2.00%	-2.00%
4	1	6+10.76'	Level crown	-5.00%	-2.00%	0.00%	0.00%
5	1	6+41.40'	Reverse crown	-5.00%	-2.00%	2.00%	2.00%
6	1	6+82.76'	Begin full super	-5.00%	-4.70%	4.70%	4.70%
7	1	7+94.05'	End full super	-5.00%	-4.70%	4.70%	4.70%
8	1	8+35.41'	Reverse crown	-5.00%	-2.00%	2.00%	2.00%
9	1	8+66.05'	Level crown	-5.00%	-2.00%	0.00%	0.00%
10	1	8+96.69'	Begin normal crown	-5.00%	-2.00%	-2.00%	-2.00%
11	1	9+42.65'	Begin normal shoulder	-5.00%	-2.00%	-2.00%	-5.00%
12	2	8+68.78'	End normal shoulder	-5.00%	-2.00%	-2.00%	-5.00%
13	2	9+14.74'	End normal crown	-5.00%	-2.00%	-2.00%	-2.00%
14	2	9+45.37'	Level crown	-5.00%	-2.00%	0.00%	0.00%

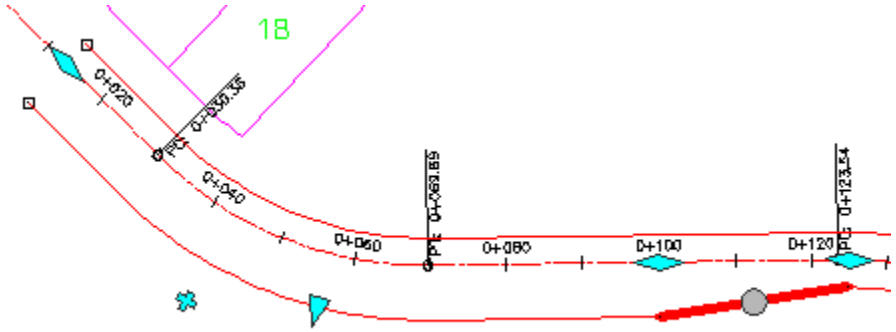
Keep the following guidelines in mind when calculating superelevation for an alignment:

- When assigning superelevation to an alignment, be sure to leave enough tangent between reverse curves to adequately generate sufficient run-out and runoff.
- After you apply superelevation to an alignment, you can modify the location of critical superelevation points when you modify the alignment properties.
- If the consecutive curves on an alignment are close together, there may not be sufficient tangent length to transition the superelevation out of one curve and into the next curve. In these instances you can manually adjust the superelevation by adding, removing, and changing the location of superelevation critical points.

About Offset Alignments

An offset alignment is a dynamic alignment created at an offset distance from another alignment, such as a road edge offset from a centerline alignment. Offset alignments run parallel to the centerline alignment and are defined to model features such as pavement edges, gutter lines, and sidewalks.

The geometry of offset alignments is based on the geometry of the centerline alignments. When you edit the geometry of the centerline alignment, the offset alignment will automatically update to follow the geometry of the centerline alignment at a specified offset value.

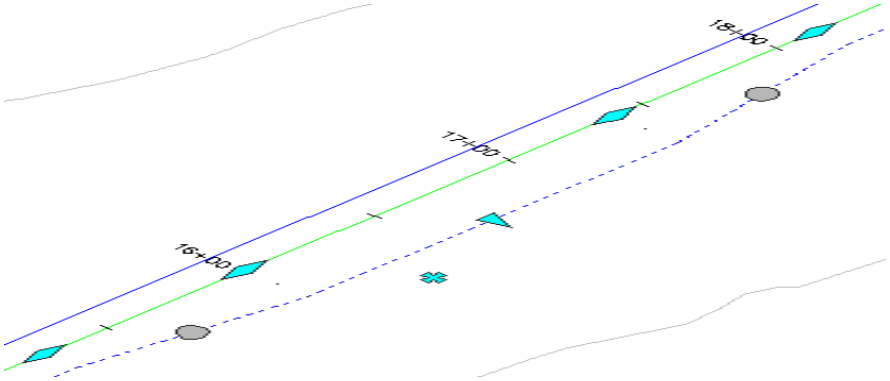


Widenings

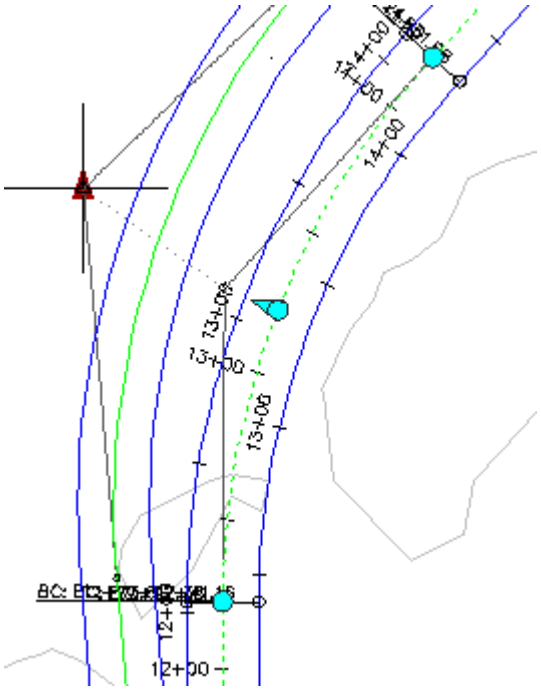
Widenings expand the width of a roadway for a specified length to accommodate a feature such as a turn lane or bus bay. The widening usually includes a transition region at one or both ends. The Create Widening command simplifies the creation of roadway features such as turn lanes, acceleration lanes, deceleration lanes, and bus bays.

When you create a widening, you can either create a new offset alignment or modify an existing offset alignment.

If the alignment is an offset, it is widened by the value you specified and the widening parameters are added to the properties. If you add a widening to an alignment that is not an offset, the command creates a new dynamic offset alignment. You can edit the widening by using grips or modifying the values in a table.



An engineer is planning a two-lane road with parallel lanes located 12' from the left and right sides of the centerline. To accomplish this you would create two offset alignments.

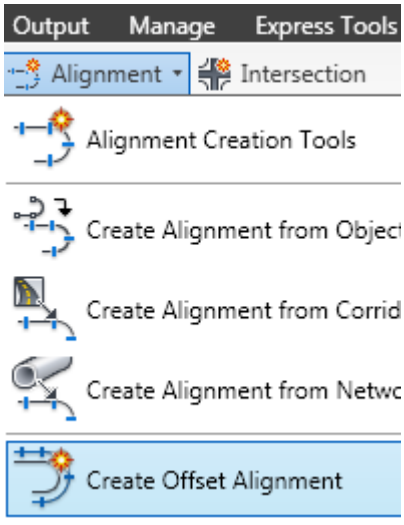


Creating Offset Alignments

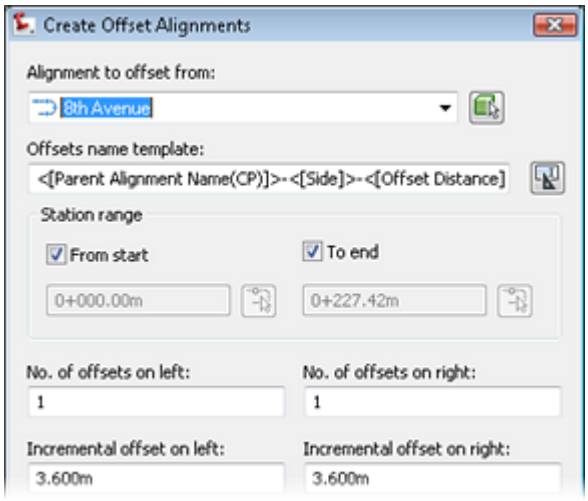
To create an offset alignment, you select a centerline alignment (alignment to offset from), specify the starting and ending station of the offset alignment relative to the centerline alignment, and specify the offset distances on the left and right sides. To create multiple offsets, specify how many you want to create for each side.

The following steps show how you create an offset alignment:

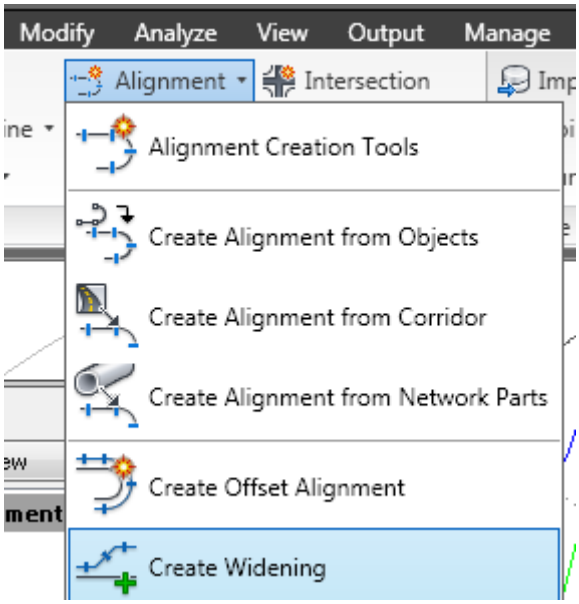
1. Launch the Create Offset Alignment command. Select alignment location.



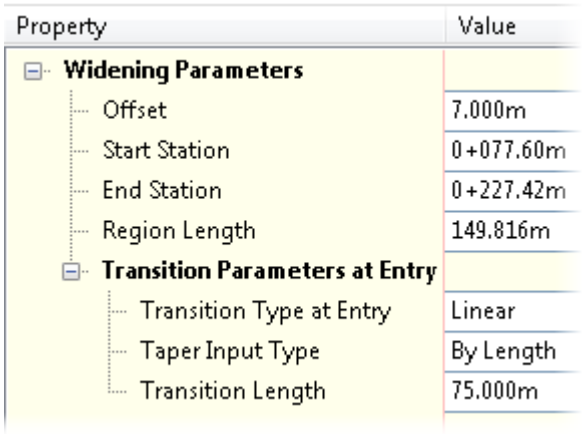
2. Configure offset alignment parameters.



3. Add a widening as required. Enter start station. Enter end station. Enter widening width.



4. Edit widening and transition parameters.



Key Points About Widenings

- For each widening, specify the entry transition length, widening length, and exit transition length.
- Specify default transition lengths in the command settings for the Add Widening command.
- Curb return alignments in intersections can be edited to add widenings at one or both ends. This type of widening forms a turn lane at the entry to a curb return or a merge lane at the exit from a curb return.
- Offset and widening geometry parameters can be modified after they have been created.

Key Terms

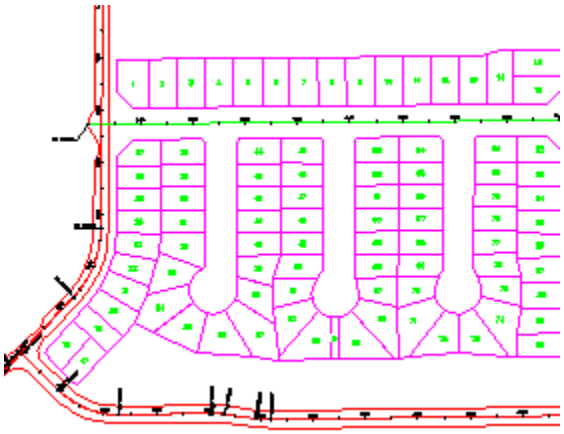
Alignment	An alignment is a linear feature in the horizontal plane. An alignment is typically used for features such as road centerlines, pavement edges, and drainage lines.
Point of Curvature (PC)	The PC is the transition point on the alignment from a tangent to a curve in the direction of increasing stationing. The PC is sometimes referred to as the beginning of curve.
Point of Intersection (PI)	The PI is the point where two tangents that are connected by a curve intersect. The tangents form the approaching and departing directions from the curve. The PI is not on the horizontal alignment, but is a key geometric point necessary to define the curve geometry.
Point of Tangency (PT)	The PT is the transition point on the alignment from a curve to a tangent in the direction of increasing stationing. The PT is sometimes referred to as the end of curve.
Tangent	A tangent is a straight line section of roadway.
Curve	In alignments for road design, a curve is based on horizontal circle geometry defined by a radius, an inscribed angle, and a length.
Tags	Tags, or tag labels, are a shorthand method of labeling lines or curves. A line tag label is normally L1, L2, and so on; and a curve tag label is C1, C2, and so on. Tags reduce the amount of text directly around an alignment, making the drawing more readable. After you label an alignment with tag labels, you create a table that associates alignment geometry and coordinate data with the individual tags.

Label Sets	A label set is a collection of alignment station and geometry label styles for an alignment. When you create an alignment, you apply a label set as opposed to selecting individual label styles.
Station	Stationing is a form of linear referencing of distance along an alignment. A station is a value of distance from the start point added to the starting station value. The base value for imperial stationing is 100 feet, designated as 1+00. The base value for metric stationing is 1000 meters, designated 1+000.
Station Reference Point	The station reference point is the point on the alignment about which stationing is based. When you first create an alignment, the station reference point is the beginning of the alignment.
Offset	An offset is a perpendicular distance from an alignment.
Station-Offset	A station-offset is a method for identifying the location of a point based on the alignment station and the perpendicular offset that matches the position.
Superelevation	The banking of a roadway to provide for smooth and safe travel around a curved section of road at the design speed.
Offset Alignment	An offset alignment is a dynamic alignment created at an offset distance from another alignment, such as a road edge offset from a centerline alignment. Offset alignments run parallel to the centerline alignment and are defined to model features such as pavement edges, gutter lines, and sidewalks.
Widening	Widenings expand the width of a roadway for a specified length to accommodate a feature such as a turn lane or bus bay. The widening usually includes a transition region at one or both ends.

Exercise 1: Create an Alignment Using Objects

In this exercise, students create alignments using polylines.

The completed drawing is as shown.

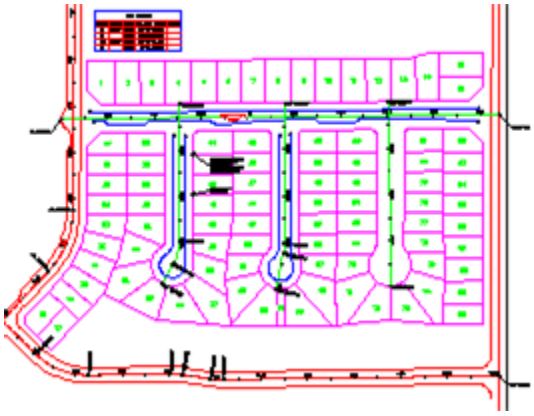


For this exercise, open …*I_Alignments-EX1.dwg (M_Alignments-EX1.dwg).*

Exercise 2: Label Alignments

In this exercise, students create alignment tag labels and an alignment table.

The completed drawing is as shown.



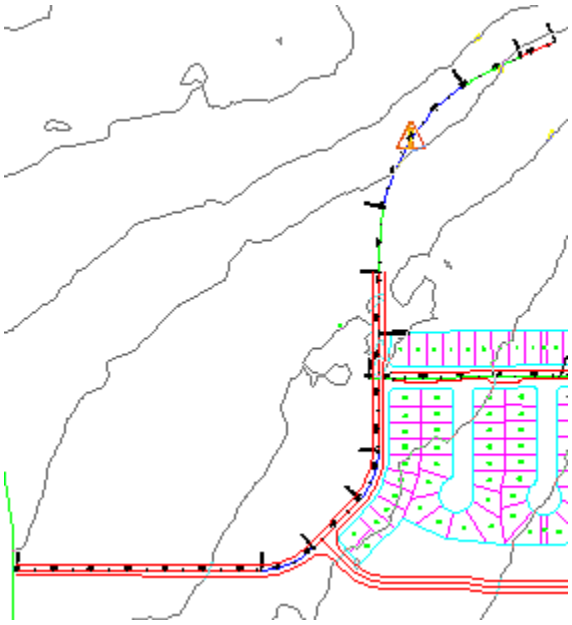
For this exercise, open …*I_Alignments-EX2.dwg (M_Alignments-EX2.dwg).*

First, students review the labels.

Exercise 3: Create an Alignment Using Layout Tools

In this exercise, students create an alignment using the Alignment Layout Tools toolbar.

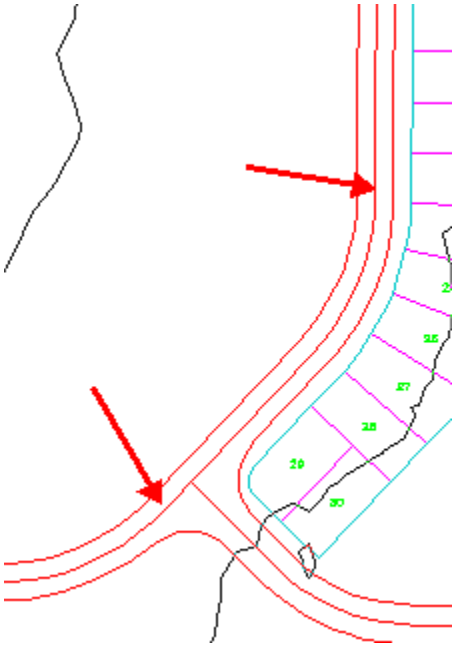
At the end of this exercise, the drawing displays as shown.



For this exercise, open *…\I_Alignments-EX3.dwg (M_Alignments-EX3.dwg).*

First, students review the labels.

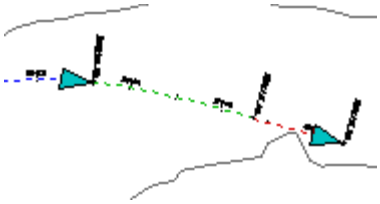
In the drawing area, notice the collector road alignment along the west side of the proposed subdivision. The south part of the centerline alignment has been designed and is represented with AutoCAD tangents and arcs.



Exercise 4: Edit an Alignment

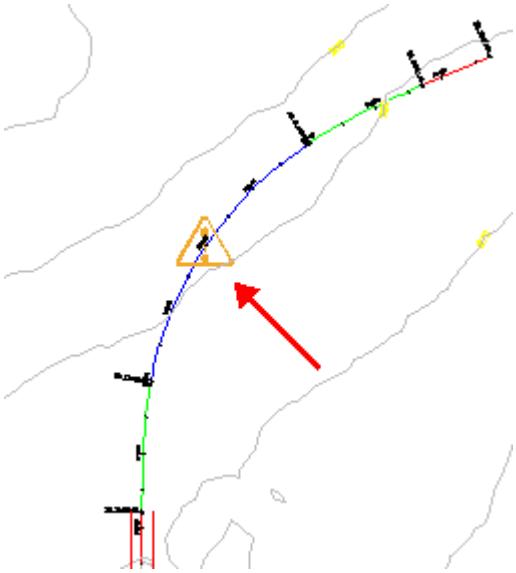
In this exercise, students edit an alignment using two different methods.

The completed drawing is as shown.



For this exercise, open *…\I_Alignments-EX4.dwg (M_Alignments-EX4.dwg).*

Students begin by editing the alignment data in a table to correct violations to the assigned design criteria. Notice the design criteria warning symbol component at the north end of the alignment. .



The path for the design criteria file referenced by the alignment in this drawing is based on Windows Vista.

If students are using Windows XP, proceed to step 1. If students are using Windows Vista, proceed to step 2.

Exercise 5: Apply Superelevation

In this exercise, students calculate and apply superelevation to an alignment.

For this exercise, open *…\I_Alignments-EX5.dwg (M_Alignments-EX5.dwg).*

The path for the design criteria file referenced by the alignment in this drawing is based on using Windows Vista. If students are not using Windows Vista, then proceed to the next step. Otherwise skip the next step and continue to step 2.

Exercise 6: Create Offset Alignments and Widenings

In this exercise, students create an offset alignment and a widening on an alignment. Students also hide the display of an alignment by applying an alignment mask.

The completed drawing is as shown.

For this exercise, open *…\I_Alignments-EX6.dwg (M_Alignments-EX6.dwg).*

Create Offset Alignments

First, students create offset alignments for the 8th Avenue alignment.

Assessment

Challenge Exercise

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

Questions

1. Do alignments need to be included in a site?
2. How do you modify the appearance of an alignment linetype in the drawing area?
3. What is a label set?
4. What type of alignment label would you use to label a fire hydrant location that is off to the side of the road?
5. Explain how superelevation is calculated for a horizontal alignment.
6. Are offset alignments linked to centerline alignments?
7. What is a widening?

Answers

1. No. Alignments can either be independent or included in a site. Use alignments in a site if you want them to interact with other objects in the site, or if you want to use sites to organize the alignments.

1. The appearance of the line is controlled by the alignment style. You can either right-click the alignment in Prospector, click Properties, and select a different object style; or you can create your own style in the Settings tab and then set it to be current using the Alignment properties.
2. A label set is a collection of label style settings for an alignment that defines the types of markers and styles used for labeling.
3. You use a Station-Offset Fixed Point label.
4. The engineer determines the design speeds of an alignment for different locations along the alignment. Superelevation tables that are included with AutoCAD Civil 3D reference the assigned design speeds and are used to calculate the superelevation points along the alignment.
5. Yes. The geometry of offset alignments is based on the geometry of the centerline alignments. When you edit the geometry of the centerline alignment, the offset alignment will automatically update to follow the geometry of the centerline alignment at a specified offset value.
6. Widenings expand the width of a roadway for a specified length to accommodate a feature such as a turn lane or bus bay. The widening usually includes a transition region at one or both ends.

Lesson Summary

In this lesson, students learned how to work with alignments. Alignments were created using existing polylines. Alignment styles were created and modified to alter the appearance of the important alignment points. Labels of various types were created and a label set was explained. Tags were used for alignment segments and an alignment table with line and curve segment tags was created.

Criteria-based design concepts were discussed and students created an alignment using layout tools. Students edited the alignment using graphic and table-based tools. Students applied superelevation to a curve and created an offset alignment, using an alignment mask to hide a section of it.