



COLORADO

Department of Transportation

Understanding Geometry

Creating & Editing Centerline Geometry Training Dataset

<https://drive.google.com/file/d/139oM4Ga88gePKE80VJK6vTkAUDziEu-H/view?usp=sharing>

Beyond Centerline Geometry Training Dataset

<https://drive.google.com/file/d/139oM4Ga88gePKE80VJK6vTkAUDziEu-H/view?usp=sharing>

Exercise 11 - Understanding Rules and Relationships

Description

This exercise exercises your ability to change the geometry rules that define design intent relationships.

Skills Taught

- Creating Complex Elements
- Reviewing the Civil Model
- Simplify
- Deactivate Reference Rules
- Deactivate Rules
- Activate Rules
- Remove Rules

Creating Complex Elements

At this point we have wonderful, obedient, well-behaved edges of pavement, all defined by individual elements. They are as powerful as they need to be, but they have one shortcoming: individual elements are not particularly good for data management. Designers generally want to work with the length of a road's edge of pavement, not six little subsections.

The *Complex By Element* tool is used to group individual elements into logical, complex (grouped) elements. It's worth noting that the *Complex By Element* tool conveys no new powers upon the elements, which are as powerful as they can be. *Complex By Element* simply groups them together.

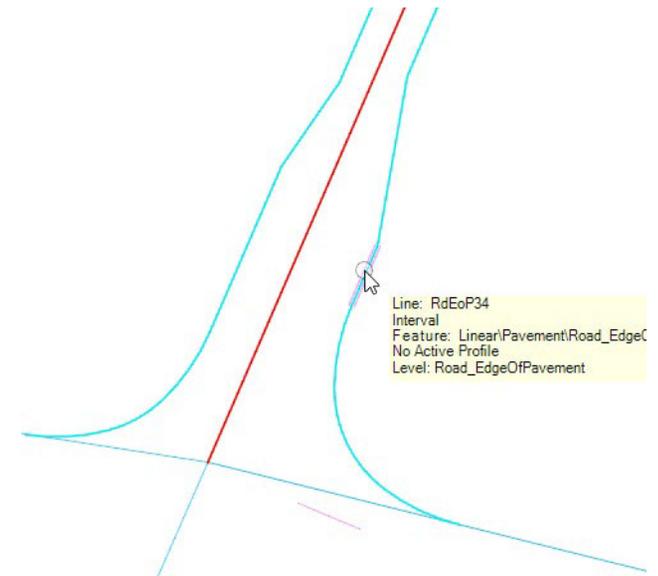
While horizontal work has benefits by Complexing the Geometry, for Profile work it's almost mandatory.

Profiles benefit dramatically from Complexed Horizontal Geometry. Vertical Geometry generally doesn't "stop" because its horizontal path changed from a tangent to a curve.

Complex By Element has two Methods: *Manual* and *Automatic*.

- *Manual* - You click each element in the correct order to add it to the group. Manually selecting which elements to complex together is often required on a complex project and projects with intersecting roadways. We will see why in the following exercises.
- *Automatic* - You click the first element and the software finds the next element and keeps adding elements whose ends are within a specified *Maximum Gap* distance of one another.

Names of the complex elements are important. Rule of Thumb: if it's important enough to complex, it's important enough to name. It only takes a few seconds.

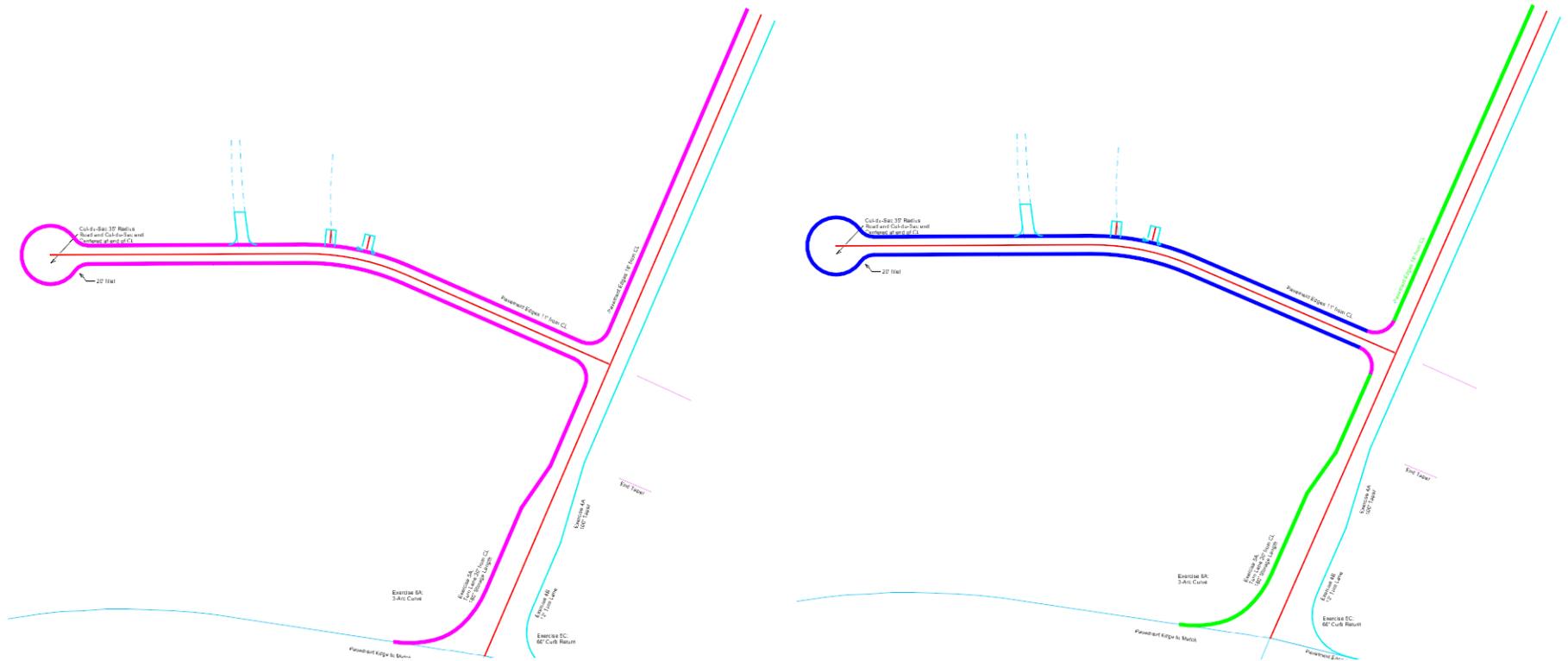


Manually Defining Complex Elements

The task is to group the individual edge of pavement elements along the North-South road.

1. Zoom the drawing so that both the **North-South** and **East-West** roads are visible.

We will use the manual Complex by Element method in this exercise. If the automatic method is used, the complex element would include all connecting elements (including the intersection curb returns, the East-West road, and the cul-de-sac) shown in purple in the left image below. The manual method allows individual element to be selected and grouped. For the North-South road that should be the elements shown in green in the right image.





2. Select *Geometry > Horizontal > Complex Geometry > Complex By Element*.

The *Feature Definition* should read “**Use Active Feature**”. If not, make sure the *Use Active Feature Definition* toggle is set.

Note that the resulting Complex Feature will be assigned the Feature Definition specified here, overriding the Feature Definition of the individual components, which may be different.

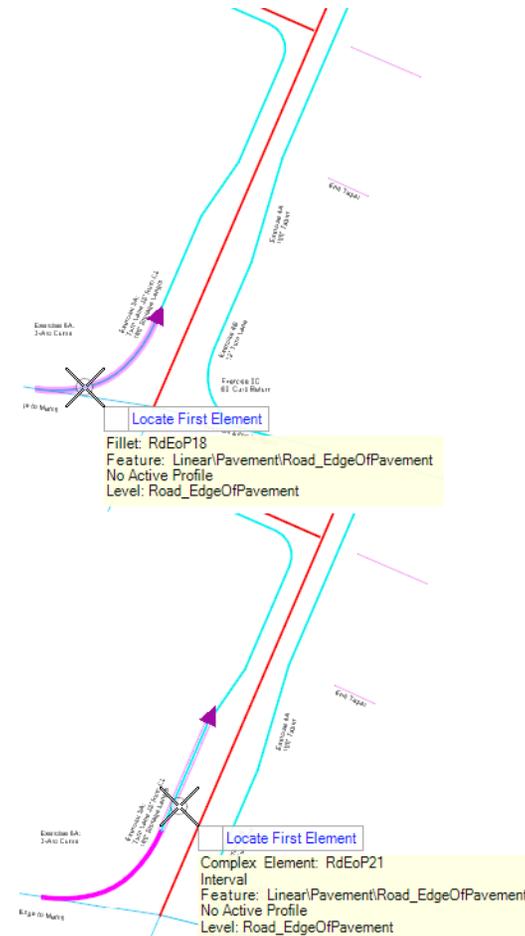
3. Set the *Method* to **Manual**.
4. Set the *Name* to a meaningful name such as: **North-South-Rd_LtEoP**.
5. At the *Locate First Element* prompt, click on the curb return on the southwest corner of North-South road.

Note: The Manual method assumes that the side of element’s midpoint that you pick is the Starting side. Direction is determined from your click. The direction is indicated with an arrow.

OpenRoads trusts that you pick the side you intend: it *will* allow a segment to have a direction opposite of an adjacent segment.

6. Make sure that the direction of the selection arrow is pointing toward the north.
7. At the *Locate Next Element* prompt, click the next pavement edge (the turn lane) for the east side of the North-South road.

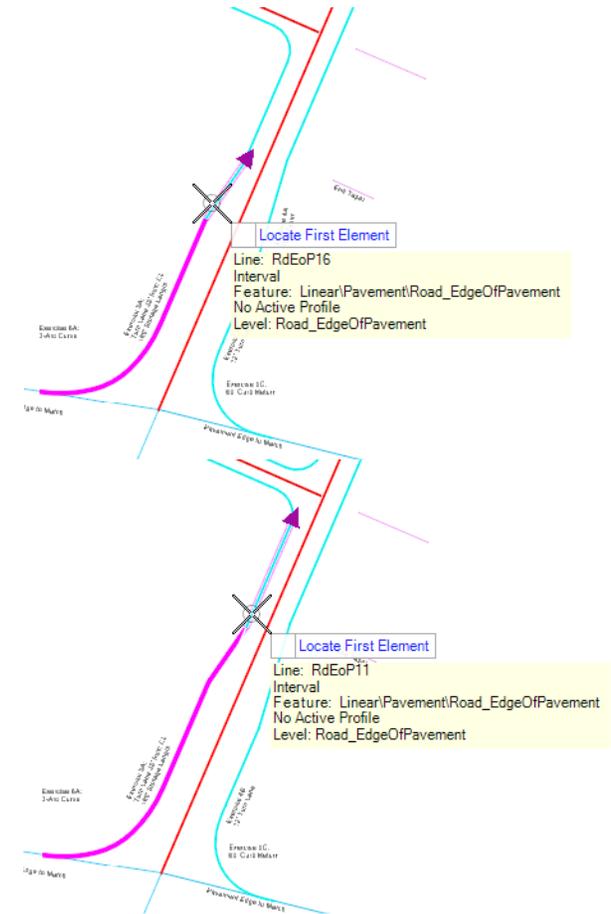
Make sure to pick the element to keep the direction pointed toward the north.



- At the *Locate Next Element* prompt, click the next pavement edge (the taper) for the east side of the North-South road.

Make sure to pick the element to keep the direction pointed in the proper direction.

- At the *Locate Next Element* prompt, click the next pavement edge (the original side of the road) for the east side of the North-South road.
- Make sure to pick the element to keep the direction pointed toward the north.



11. At the *Locate Next Element* prompt, click the next pavement edge (the original side of the road on the NORTH side of the intersection) for the east side of the North-South road.

This time we are selecting a non-adjacent element! Complex elements can have gaps. This allows all of the edge of pavement to be grouped in a single element even though it has a gap at the intersection.

In most modeling situations there would be a match line at the intersection but the match line would be an individual element, not part of the edge of pavement.

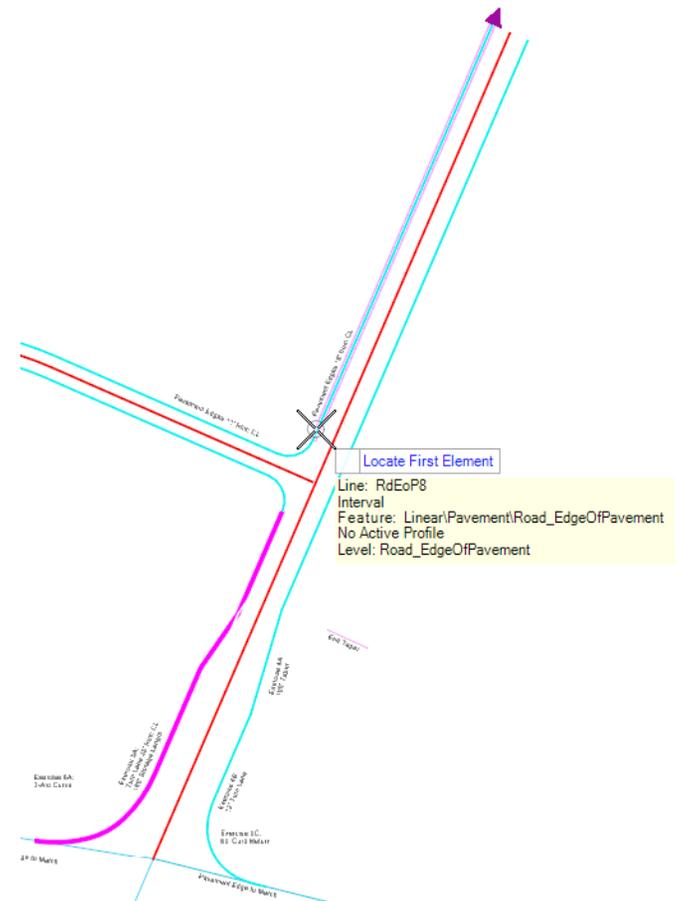
Make sure to pick the element to keep the direction pointed toward the north.

12. After the last element is selected, at the *Locate Next Element* prompts, click away from any element (click nothing). This ends the Complexing and the complex element is created.



13. Select the new complex element and observe the manipulators.

The manipulators are grayed out because they are for a base element that the selected complex element is dependent upon. Right-click to activate the base element.



Automatically Defining Complex Elements



1. Select *Geometry > Horizontal > Complex Geometry > Complex By Element*.

The *Feature Definition* should read “**Use Active Feature**”. If not, make sure the *Use Active Feature Definition* toggle is set and the active Feature Definition is set to **Road_EdgeOfPavement**.

2. Set the *Method* to **Automatic**.
3. Set the *Name* to a meaningful name such as: **North-South-Rd_RtEoP**.

Any elements whose endpoints are closer than the **Maximum Gap** distance will be Complexed. If there are multiple elements within the Maximum Gap, you will be prompted to select the “branch” to connect.

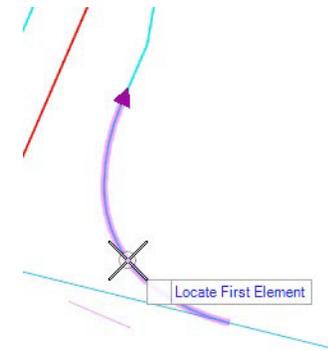
4. At the *Locate First Element* prompt, click on the curb return on the southeast corner of North-South road.

NOTE: The side of element’s midpoint that you pick is the starting side and adjoining elements will be located from the opposite end of the element. Direction is determined from your click. The direction is indicated with an arrow.

OpenRoads will link all the elements within the Maximum Gap limits. It will highlight the elements it will complex.

5. At the *Accept Complex* prompt, left-click to end the complexing and create the complex element.

The four edge of pavement elements on the right side of the road are complexed into a single element.





5. Open the *Home > Primary > Explorer* dialog.
6. Select the **OpenRoads Model** tab.
7. Expand **OpenRoads Model > Linear Geometry**.

This is where OpenRoads linear features are shown grouped by Feature Definition. The Alignment features such as the centerline geometry are in *OpenRoads Model > Alignments*.

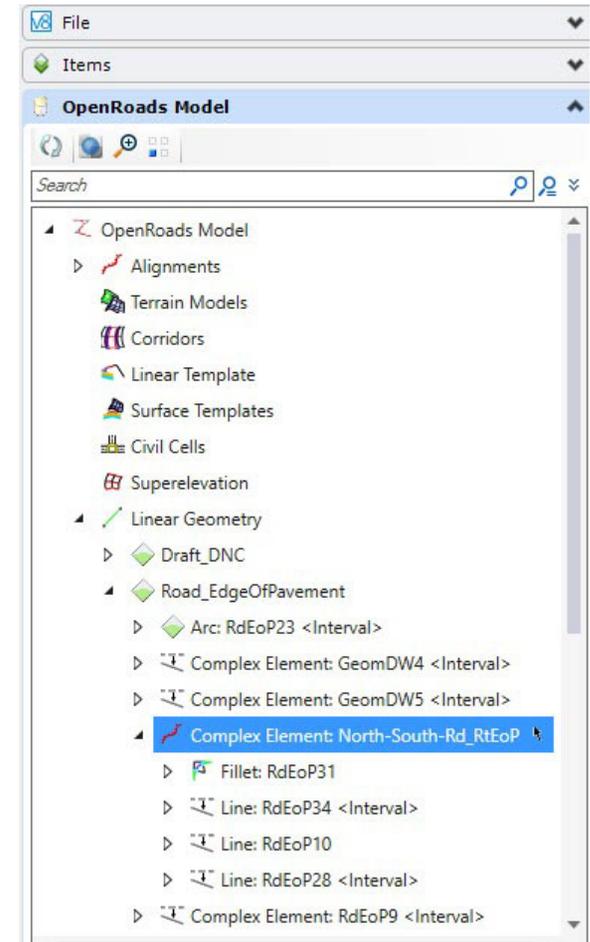
8. Expand the **Road_EdgeOfPavement** header.

All of the simple and complex features that use the *Road_EdgeOfPavement* feature are listed.

9. Expand the **North-South-Rd_RtEoP** Complex Element.
10. Explore the tree structure that defines the ultimate element from all of its dependencies.

Having a basic understanding of this tree structure which illustrates the relationships between geometry elements is beneficial.

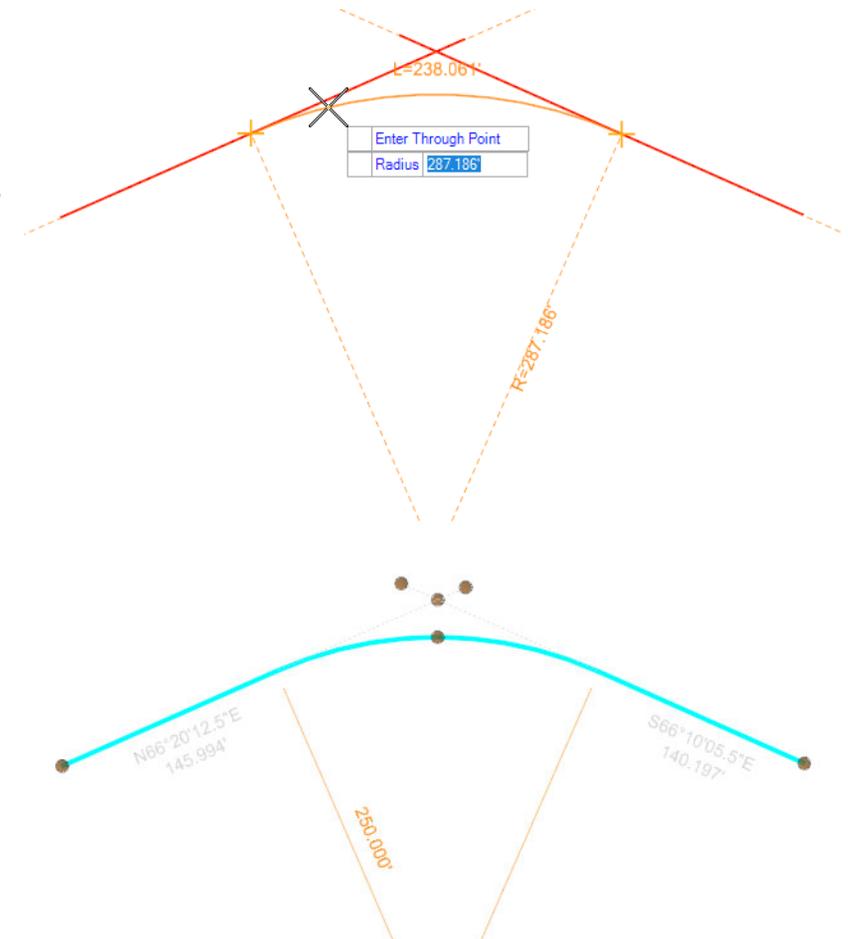
Notice that there are a number of elements with default naming such as RdEoP19. As discussed earlier in the class giving meaningful names to all of these intermediary geometry elements may not be practical. However, the more meaningful naming you can provide the easier it is to understand the geometry when reviewing in the OpenRoads Model and in reports. At a minimum make sure to give your final complex elements meaningful names.



Managing Geometry Rules

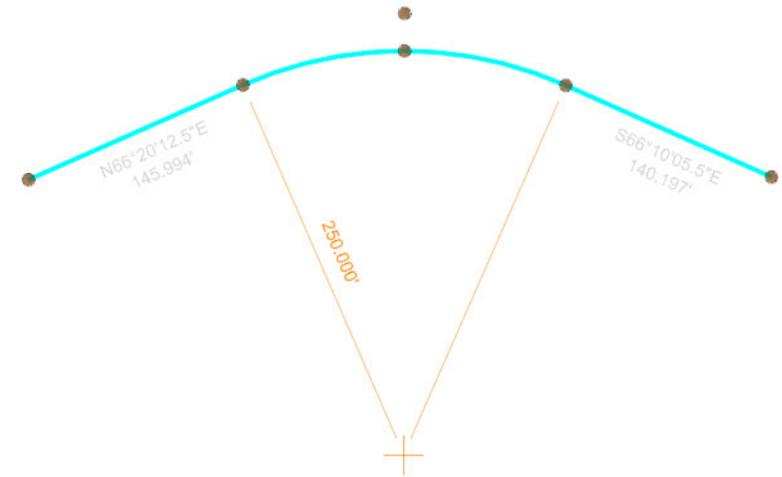
We started the class by saying OpenRoads Remembers, remember? What exactly does it remember? OpenRoads remembers the engineering rules and snaps - the relationships - between elements. Under almost all circumstances OpenRoads remembers everything forever. However, sometimes a perfect memory is not a great thing. Sometimes our needs change and we need to forget some rule here or there, either temporarily or permanently.

1. Zoom to the two crossing lines east of the North-South road.
2. Complete a Line-Arc-Line complex geometry.
 - a. Set the active *Feature Definition* to **Alignment > Geom_Baseline**.
 - b. Select the *Geometry > Horizontal > Arcs > Arc Between Elements > Simple Arc* tool.
 - c. Disable the Radius option.
 - d. Following the prompts, identify the first element, second element, and a point that the arc passes through.
 - e. Use the *Geometry > Horizontal > Arcs > Complex Geometry > Complex by Element* tool to complex the line-arc-line into a single complex element.
3. Review the Complex Element
 - a. Select the line-arc-line element created in the previous step.
 - b. Review the rules.
 - Observe the direction and length of the tangents are not directly editable. These are base elements.
 - Observe the end points of the lines. Recall there are two tangents that crossed one another.
 - c. Move one of the end points and observe how the arc maintains the pass through point.



4. Simplify the complex, multi-element geometry

Simplify is a tool that “liberates” a feature from dependency on another feature or features. It maintains “smart” Civil rules, but they are free-standing geometry rules rather than rules that depend on other elements. A common example is that you may have a ramp with geometry derived from two through lanes. Simplifying the ramp allows you to make intelligent edits not constrained to the through lanes.



a. Select the *Geometry > Common Tools > Simplify Geometry* tool.

b. Select the line-arc-line element.

c. **Right click** (reset) to simplify the element.

d. Set the *Maintain Copy of Base Elements* option to **No**.

e. Select the line-arc-line element to review the rules.

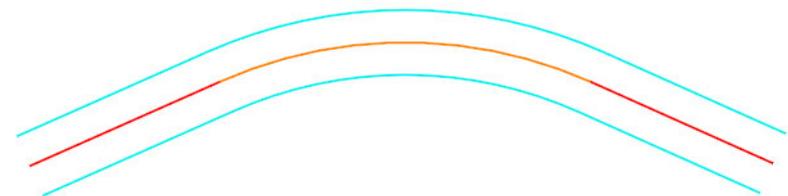
- Observe that the original crossing line elements are no longer part of the element. The geometry has been simplified to its most basic form. There are two tangents with a common point of intersection.
- Move one of the end points and observe that the arc now maintains a fixed radius, not the pass through point. Again, the geometry has been simplified to its most basic form.

5. Define edge of pavements

a. Set the active *Feature Definition* to **Linear > Pavement > Road_EdgeOfPavement**.

b. Use the *Geometry > Horizontal > Offsets and Taper > Single Offset Entire Element* tool to define edges of pavement **20' [6m]** on both sides of the centerline.

c. Select one of the end point of the centerline and verify that the edges of pavement move with the centerline.



6. Deactivate Reference Rules so that an edge of pavement does not update when the element it depends on changes.



a. Select *Geometry > General Tools > Civil Toggles > Deactivate Reference Rules*.

b. Select the southern edge of pavement.

c. **Right click** (reset) to deactivate the rules.

d. Select the southern edge of pavement and notice that the offset manipulators are grayed out because the reference rules (between this element and another reference element) have been disabled.

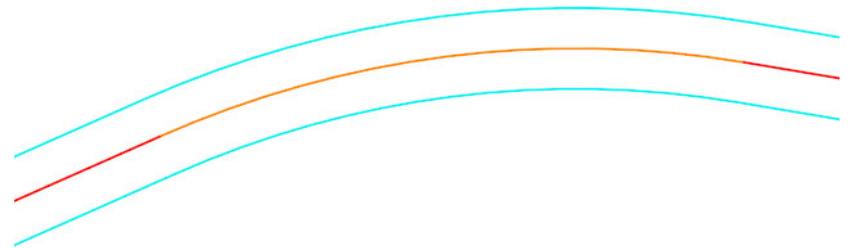
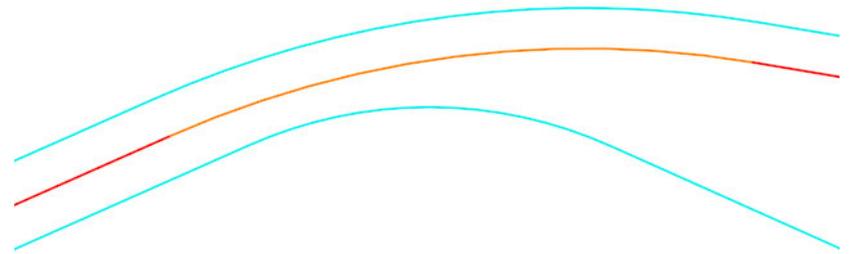
e. Select the centerline and move one of the end point of the centerline to a new location. Notice that the northern edge of pavement follows but the southern does not because its rule to what it references is deactivated.

f. Select *Geometry > General Tools > Civil Toggles > Activate Rules*.

g. Select the southern edge of pavement.

h. **Right click** (reset) to activate the rules.

As soon as the rule is activated the relationship is evaluated and the geometry heals to once again conform to its rules.



7. Deactivating the Rules (not Reference Rules) on an element essentially makes it a read only element that cannot be changed.



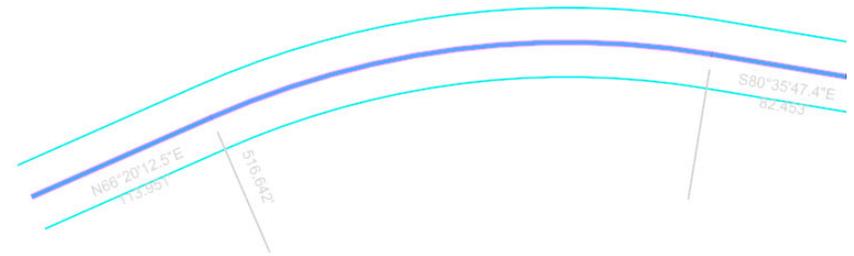
a. Select **Geometry > General Tools > Civil Toggles > Deactivate Rules**.

Notice the icon is a closed lock. Deactivating the rules **locks** the element so that it cannot be updated.

b. Select the centerline.

c. **Right click** (reset) to deactivate the rules.

d. Select the centerline. Notice that the radius text manipulator is grayed out and the element cannot be edited. Also, there are no manipulators to move the geometry.



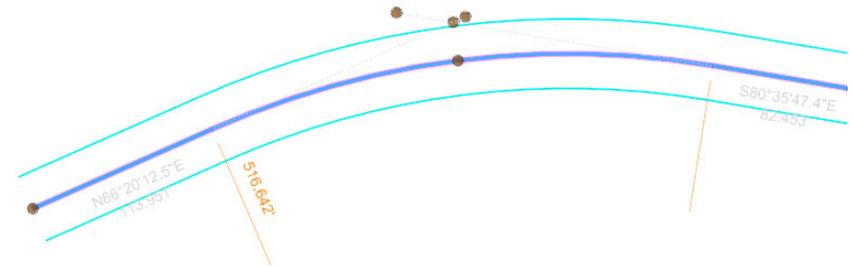
e. Select **Geometry > General Tools > Civil Toggles > Activate Rules**.

Notice the icon is an open lock. Activating the rules **unlocks** the element so that it can be updated.

f. Select the centerline.

g. **Right click** (reset) to activate the rules.

h. Select the centerline. Notice that the radius manipulator is available to edit the element.



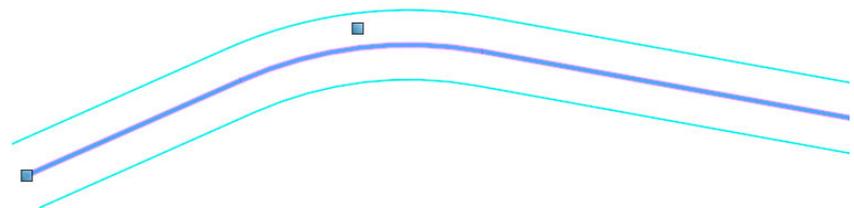
8. Rules can also be completely removed from an element.

a. Select **Geometry > General Tools > Civil Toggles > Remove Rules**.

b. Select the centerline.

c. **Right click** (reset) to remove the rules.

d. Select the centerline. Notice there are no rules. This is essentially a plain cad graphic now. Although it does still have a Feature Definition that defines its appearance and includes it in the OpenRoads model.



TIP: Plain graphics can be assigned rules using the **Geometry > General Tools > Design Elements > Create Civil Rule Feature** tool.



Training Pathway

Roadway ► All Roles ► Fundamental

	Dur. (Min.)	Description	Data set	Video	Work flow	Link Url (Copy & Paste to Browser for best results)
How To's						
Geometry						
Geometry						
General Geometry Overview	2	This video overviews the Geometry tools		X		https://communities.bentley.com/products/road_site_design/w/road_and_site_design_wiki/41450/video-general-geometry-overview
Practical Uses of Civil Accudraw	8	This video shows the practical use of Civil AccuDraw		X		https://communities.bentley.com/products/road_site_design/w/road_and_site_design_wiki/53776/video-practical-uses-of-civil-accudraw
Attach All Profile Views	4	This video describes the "Attach All Profile Views" command available in Profile views or AttachedLongSection views.		X		https://communities.bentley.com/products/road_site_design/w/road_and_site_design_wiki/42706/video-attach-all-profile-views
Create a simple Ramp in OpenRoads Designer	10	This video demonstrates how to create a simple ramp in OpenRoads designer		X		https://communities.bentley.com/products/road_site_design/w/road_and_site_design_wiki/35329/video-create-a-simple-ramp-in-openroads-designer
Create an Event Point List that places points along an Edge of Pavement at the even stations of centerline	3	This message explains how to create an Event Point List that places points along an Edge of Pavement at the even stations of the centerline			X	https://communities.bentley.com/products/road_site_design/w/road_and_site_design_wiki/49157/create-an-event-point-list-that-places-points-along-an-edge-of-pavement-at-the-even-stations-of-centerline
Delete PI in OpenRoads Designer	1	This information shows how to delete a PI (horizontal or vertical) in OpenRoads Designer			X	https://communities.bentley.com/products/road_site_design/w/road_and_site_design_wiki/36805/delete-pi-in-openroads-designer
How can you delete Geometry from OpenRoads Designer?	3	This video shows different ways to delete Civil Alignments			X	https://communities.bentley.com/products/road_site_design/w/road_and_site_design_wiki/36806/how-can-you-delete-geometry-from-openroads-designer
How to add Multiple Station Equations in an Alignment	2	This video demonstrates how to add multiple station equations in an alignment.		X		https://communities.bentley.com/products/road_site_design/w/road_and_site_design_wiki/45433/video-how-to-add-multiple-station-equations-in-an-alignment
How to Correct Complex By Elements Message: "Element not valid for tool"	3	This data set shows when using the Complex By Elements tool to create horizontal geometry			X	https://communities.bentley.com/products/road_site_design/w/road_and_site_design_wiki/36826/how-to-correct-complex-by-elements-message-element-not-valid-for-tool
How to get manipulators to edit the Profile	1	This data set shows how to get manipulators to edit the Profile.			X	https://communities.bentley.com/products/road_site_design/w/road_and_site_design_wiki/47802/openroads-designer-how-to-get-manipulators-to-edit-the-profile
Import native InRoads ALG into OpenRoads Designer CONNECT Edition	2	This video demonstrates how to import native InRoads ALG into OpenRoads Designer CONNECT Edition.		X		https://communities.bentley.com/products/road_site_design/w/road_and_site_design_wiki/51601/import-native-inroads-alg-into-openroads-designer-connect-edition

OpenRoads Designer[Geometry]: Point Abbreviations for Horizontal & Vertical Alignment	5	This data set shows the meaning of the shortcuts for the "horizontal points" and the "vertical points" under Managing Drawing-Annotation		X	https://communities.bentley.com/products/road_site_design/w/road_and_site_design__wiki/50520/wiki-openroads-designer-geometry-point-abbreviations-for-horizontal-vertical-alignment
Plan view display of arcs and spirals in alignment and linear features in OpenRoads Designer	4	This data set shows how to change the display of horizontal alignment curves and spirals in plan view		X	https://communities.bentley.com/products/road_site_design/w/road_and_site_design__wiki/46159/pl-an-view-display-of-arcs-and-spirals-in-alignment-and-linear-features-in-openroads-designer
Tool to copy an alignment parallel to a proposed alignment	4	This data set shows tool in OpenRoads Designer that would copy an alignment parallel to a proposed alignment		X	https://communities.bentley.com/products/road_site_design/w/road_and_site_design__wiki/38988/tool-to-copy-an-alignment-parallel-to-a-proposed-alignment
Unable to solve rule Red Circle with X	1	This data set shows how to correctly remove a red circle X warning "Invalid Element."		X	https://communities.bentley.com/products/road_site_design/w/road_and_site_design__wiki/48464/invalid-element-unable-to-solve-rule-red-circle-with-x
What is the difference between an Alignment and a Linear Feature Definition?	10	This data set shows the difference between an Alignment and a Linear Feature Definition		X	https://communities.bentley.com/products/road_site_design/w/road_and_site_design__wiki/36947/what-is-the-difference-between-an-alignment-and-a-linear-feature-definition
What is the Simplify Geometry tool?	2	This information shows the meaning of Simplify Geometry tool		X	https://communities.bentley.com/products/road_site_design/w/road_and_site_design__wiki/41754/what-is-the-simplify-geometry-tool
Short Video					
Geometry					
Geometry					
Conjunction Junction: Hook Up Individual Elements into a Single Complex Element	2	Conjunction Junction: Hook Up Individual Elements into a Single Complex Element. Complex by Element groups individual geometry into a single chain. It's easier for us humans to manage long clearly-named entities than their individual components. We can use the Manual Method to select each component or let Automatic connect them for you.		X	https://learn.bentley.com/app/VideoPlayer/LinkToIndividualCourse?LearningPathID=113278&CourseId=131830&MediaID=5020092
Create Geometry Using Civil AccuDraw	10	Description: This video shows how to create lines and arcs using Civil AccuDraw and snaps.		X	https://learn.bentley.com/app/VideoPlayer/LinkToIndividualCourse?LearningPathID=113278&CourseId=127071&MediaID=5017494
Curb Returns and Cul-de-Sacs	16	Creating curb returns and cul-de-sacs can be a real challenge: blending straight lines and arcs requires so much calculating. Or does it? With OpenRoads, you can use the Offset tools to make elements meet and mesh correctly. You will learn how to manipulate pavement edges, create a curb return, and create a cul-de-sac.		X	https://learn.bentley.com/app/VideoPlayer/LinkToIndividualCourse?LearningPathID=113278&CourseId=131832&MediaID=5020094
Export Alignment to IFC format	1	This video demonstrates how to create an IFC alignment from an OpenRoads Designer alignment.		X	https://communities.bentley.com/products/road_site_design/w/road_and_site_design__wiki/46138/video-export-alignment-to-ifc-format
Horizontal/Vertical Geometry Creation Example	3	This video demonstrates 3D Presentation of an Alignment.		X	https://communities.bentley.com/products/road_site_design/w/road_and_site_design__wiki/39118/video-horizontal-vertical-geometry-creation-example
How to Display Multiple Terrains in a Profile	1	This video demonstrates how to display multiple terrains in a profile.		X	https://communities.bentley.com/products/road_site_design/w/road_and_site_design__wiki/45432/video-how-to-display-multiple-terrains-in-a-profile

Placing a Driveway	9	Placing a driveway can be simple, or it can get complicated in a hurry. In this video you will learn how to create a smart driveway perpendicular to the road; a driveway that ties into an existing centerline; and a driveway whose new edges match the existing edges.		X	https://learn.bentley.com/app/VideoPlayer/LinkToIndividualCourse?LearningPathID=113278&CourseId=131831&MediaID=5020093
Profile Intersection Point	2	This video demonstrates how to use the Profile Intersection Point command to display points in a profile view for crossing linear elements. Then you can utilize those profile points to create and rule vertical geometry in OpenRoads Designer CONNECT Edition.		X	https://communities.bentley.com/products/road_site_design/w/road_and_site_design_wiki/52759/video-profile-intersection-point
Spiral From Element	2	This video demonstrates how to create a spiral from element.		X	https://communities.bentley.com/products/road_site_design/w/road_and_site_design_wiki/47814/spiral-from-element
Hands On Training - Modules					
Geometry					
Geometry					
Beyond Centerline Geometry	120	Pavement Edges are particularly important: they are required in Plan Sheets and the streamline modeling corridors (a single template can follow edges wherever they meander). In this class you create smart, editable, obedient edges, turn lanes, tapers, and driveways. You will see how OpenRoads Remembers the relationships with which you built the geometry and honors it when the design changes. OpenRoads Remembers your Design Intent	X		https://learn.bentley.com/app/Public/ViewLearningPathDetails?lpId=113539&aftkn=1b61e17e-a3bd-44ccb47d-8f145b3575ef#
Creating and Editing Centerline Geometry	120	In this course, you will learn how to create and edit horizontal and vertical geometry using various tools and techniques. You will be defining the horizontal and vertical geometry for River Rd. You will also learn how to make changes to the River Rd. geometry and how to make changes to the existing geometry for Mountain Highway and Pike Rd.	X		https://learn.bentley.com/app/Public/ViewLearningPathDetails?lpId=110831&aftkn=1b61e17e-a3bd-44ccb47d-8f145b3575ef
QuickStart for Geometry - Road	120	In this course, you will be creating a horizontal and vertical alignment using the geometry tools. You will learn how to create, edit, review and annotate geometric elements. This course will also cover working with existing ground terrain and aerial imagery as well as defining 2D/3D Views	X		https://learn.bentley.com/app/Public/ViewLearningPathDetails?lpId=113539&aftkn=1b61e17e-a3bd-44ccb47d-8f145b3575ef#