

# Concrete Bridge Design – Conception to Fabrication

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## Learning Objectives

- Learn how to rapidly produce workable concrete bridge designs in InfraWorks
- Learn how to refine the bridge model with your own custom parametric content with Inventor, and apply them in InfraWorks
- Learn how to confirm suitability of the chosen girder system with the production of structural calculations
- Learn how to use Revit to model and schedule 3D reinforcement and produce structural drawings

## Description

This class will cover concrete bridge modeling in the context of a wider transportation project. The class will explore fast conceptual bridge modeling in InfraWorks software, and workflows to Structural Bridge Design software, Inventor software, and Revit software. You will learn how to rapidly model concrete bridges in InfraWorks and use the “built-in” analysis tools to assess the suitability of the chosen girder system against recognized design standards. You will learn how to use Structural Bridge Design to examine and refine the design and to carry out more-detailed analysis and design checks. You will learn how to use Inventor to refine the InfraWorks bridge model by creating custom parametric bridge components for use in InfraWorks, and you’ll see how to configure them to act as native parts. You will also learn how to transfer the refined bridge model to Revit, where you will add 3D reinforcement using new rebar tools and finally produce drawings and rebar scheduling ready for fabrication.

## Speaker(s)

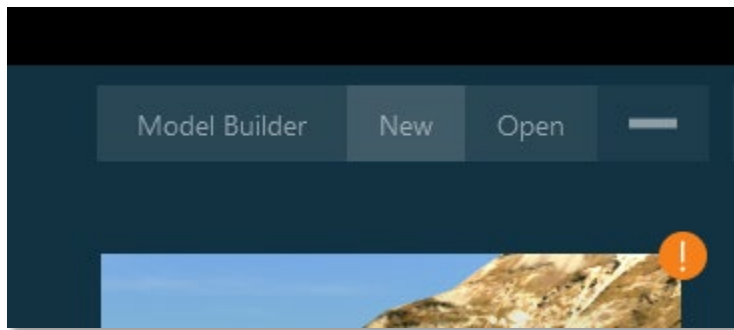
Andrew Manze has worked in the civil and structural engineering industry for over 30 years, functioning both in industry and in the specialist construction software sector. After training as a structural engineer in the United Kingdom in the late 1980s and working on a variety of unusual and novel international projects, Manze focused on supporting customers with a local structural engineering software firm. Manze then moved on to business development in the 3D modeling and structural-analysis software market, and he also spent many years bringing advanced structural-fabrication technology to the European and Commonwealth of Independent States (CIS) regions. In later years, Manze concentrated on the bridge analysis and design market, getting involved with the rollout of the Eurocodes within engineering consultants in Europe, before joining Autodesk, Inc., in 2013 to support bridge technology in InfraWorks software.

## The InfraWorks Model

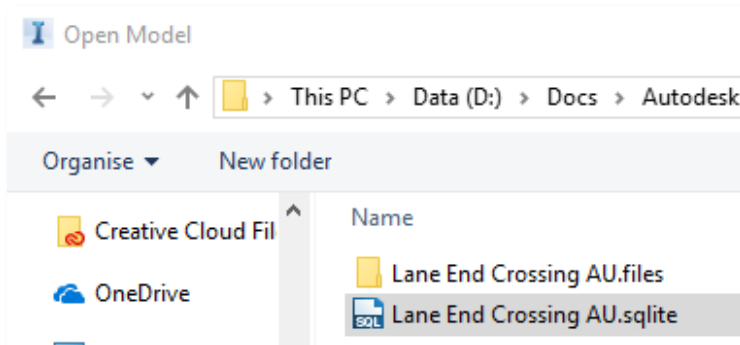
1. Launch the InfraWorks software by double clicking the InfraWorks icon



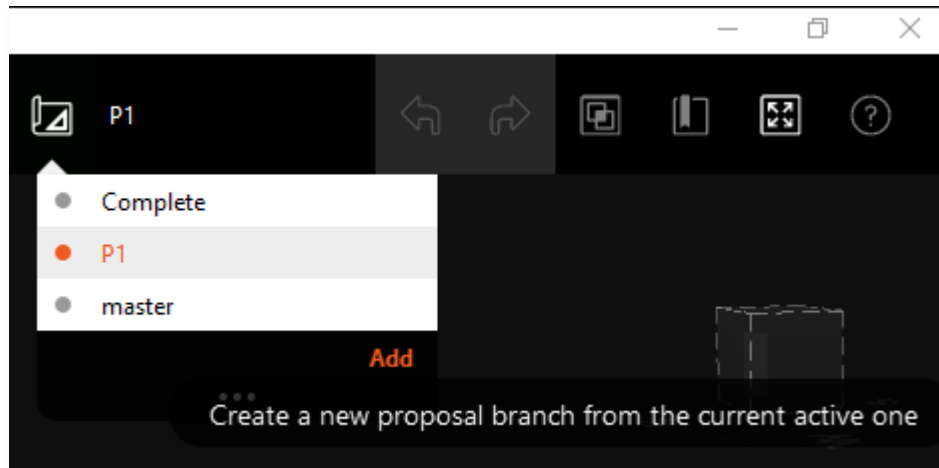
2. Sign-in if necessary, check for Metric units in Application Options and then click the **Open** model button



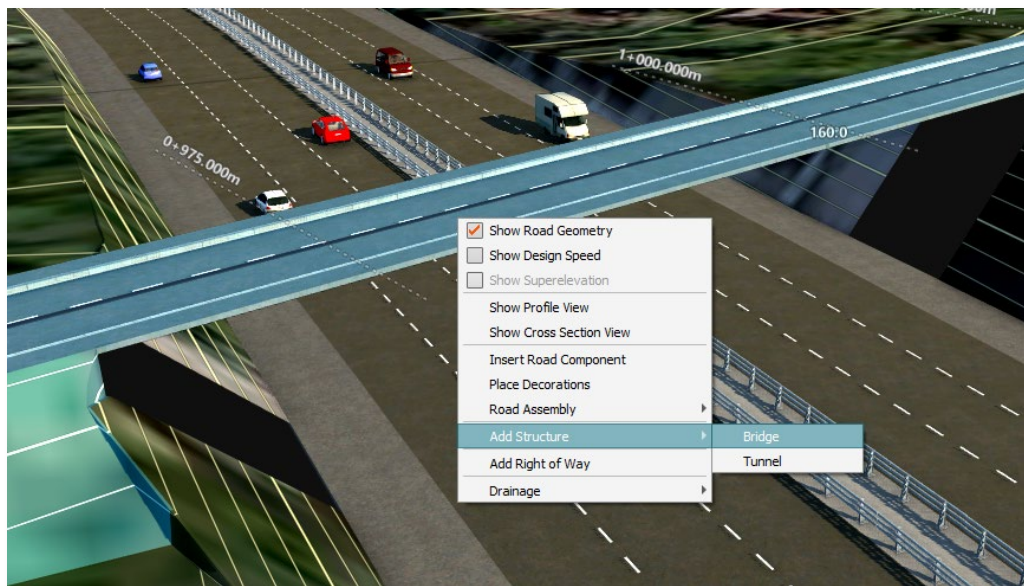
3. Navigate to the model location and open the model



4. **Add** a new proposal and call it '**Proposal1**'



5. Manipulate the model to a workable view, select the overpass road, right click on it and select **Add Structure > Bridge**



6. Enter the following data;

- a. Start Station: 961.5
- b. Length: 58

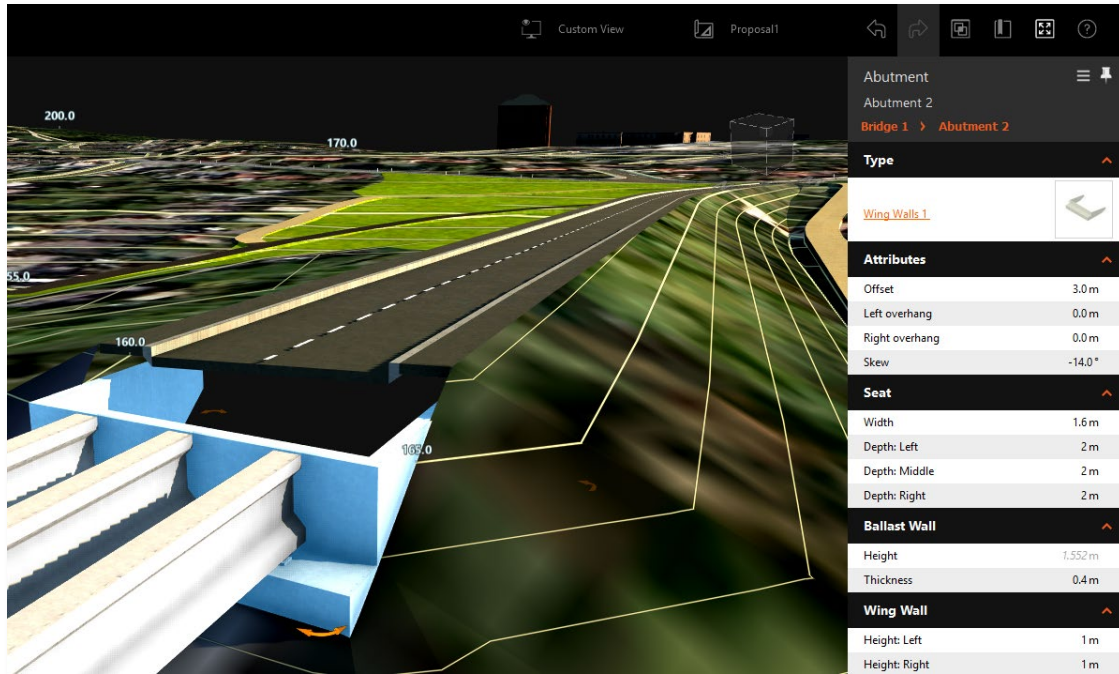


and then hit **Return**, the resulting structure will be as below;

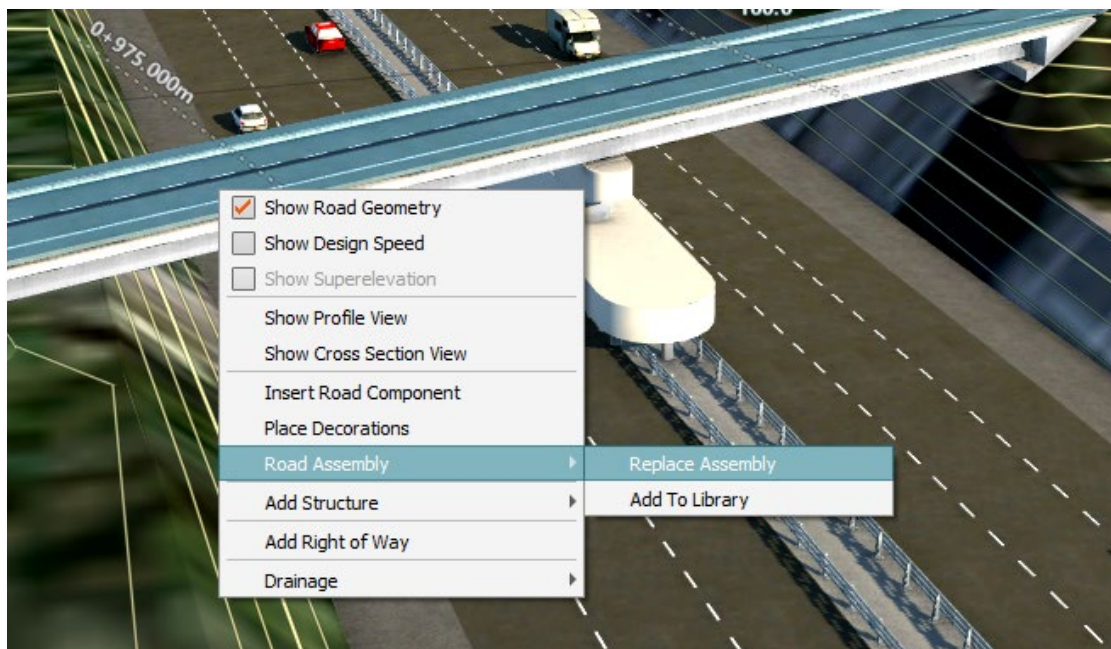


7. Select one of the abutments and enter the following data
- a. Offset: 3
- b. Skew: -14

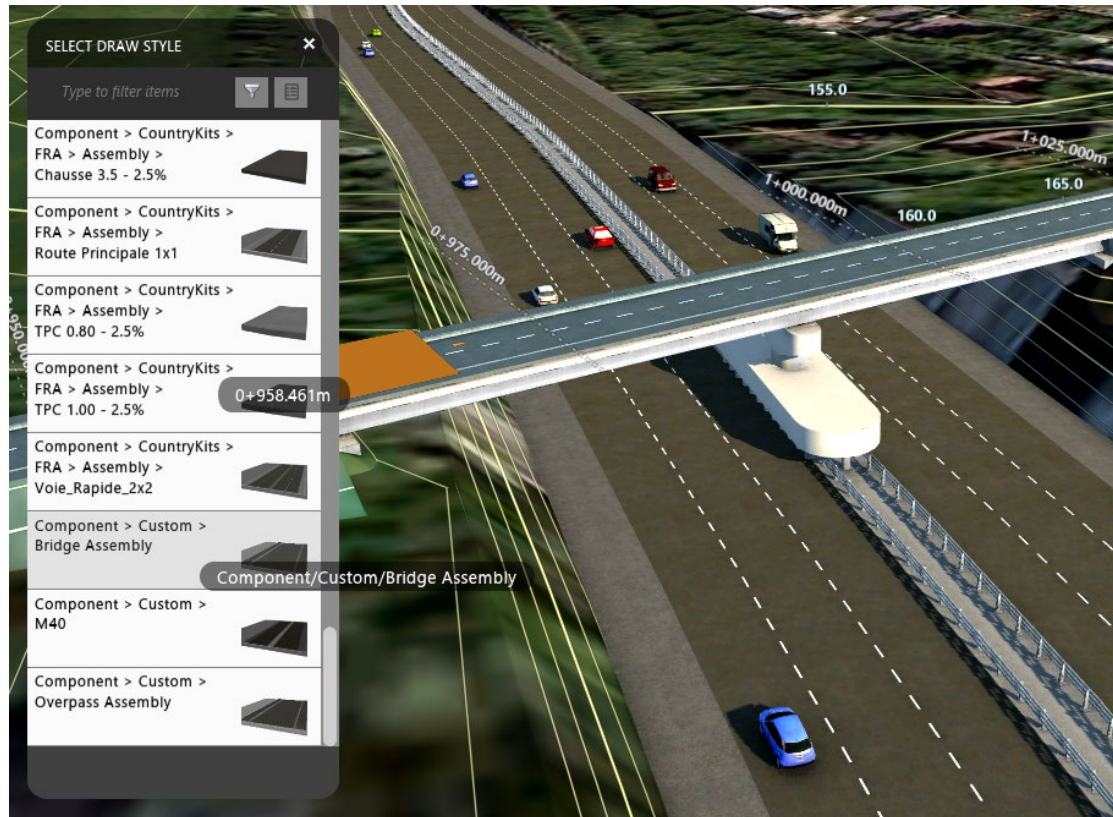




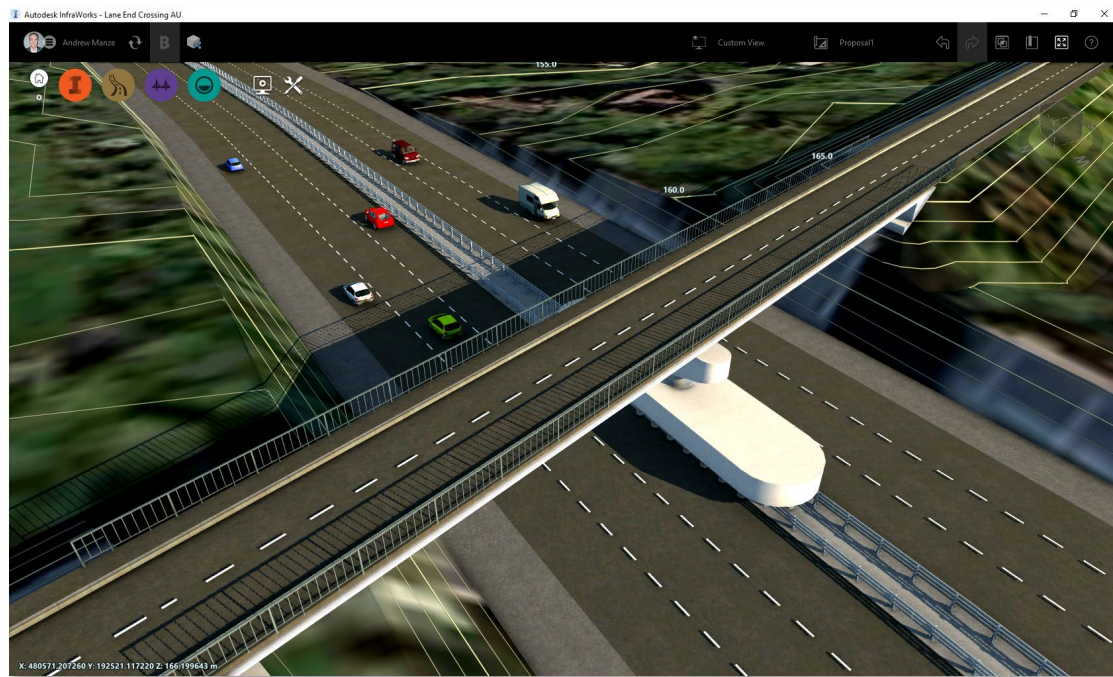
8. Repeat for the other abutment.
9. Select the central pier and change the Skew to -14.
10. Deselect the bridge by pressing Esc and then select the road, right click and select Road Assembly > Replace Assembly



11. Choose the 'Bridge Assembly' option from the list



12. Then, using the grips, stretch out the orange/blue rectangle to cover the extent of where you feel the handrailing would start and finish, then press **Return**.



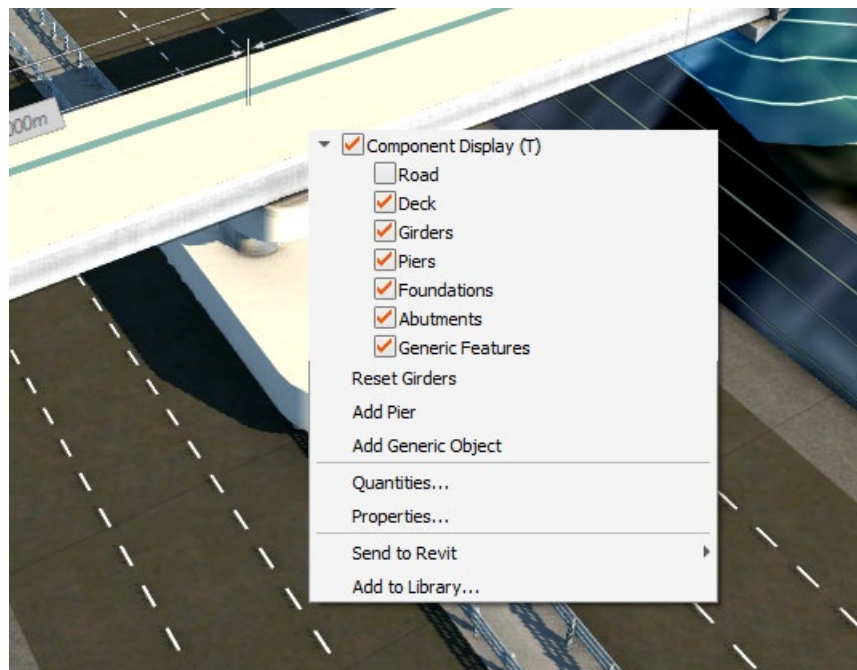


13. Select the bridge once more, then select one of the girder groups, change the number of girders to 5.

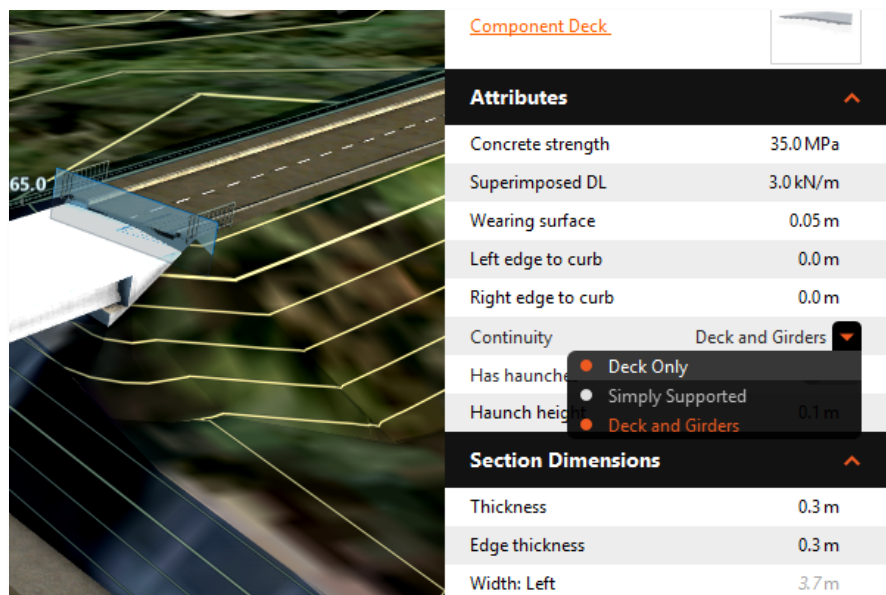


14. Right click on the group and select **Apply To... > All Girder Groups**.

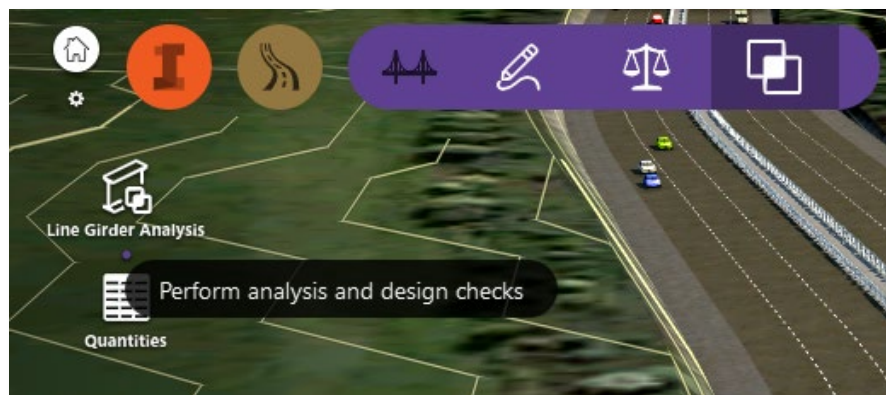
15. Right click on the bridge and select **Component Display** and check **Deck**.



16. Select the deck and change the **Continuity** value to **Deck Only**.



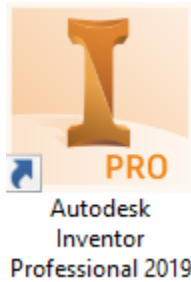
17. Next from the Bridges menu select Line Girder Analysis



18. Click **Start Analysis** in the Line Girder Analysis panel.

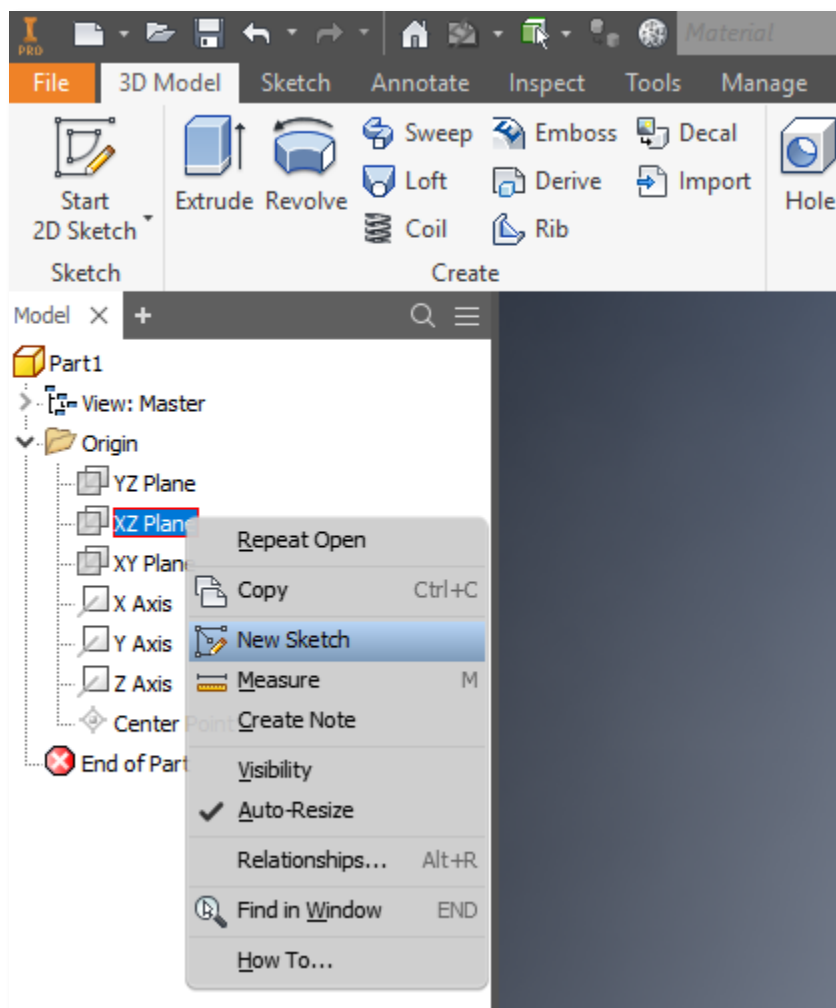


19. Start Inventor

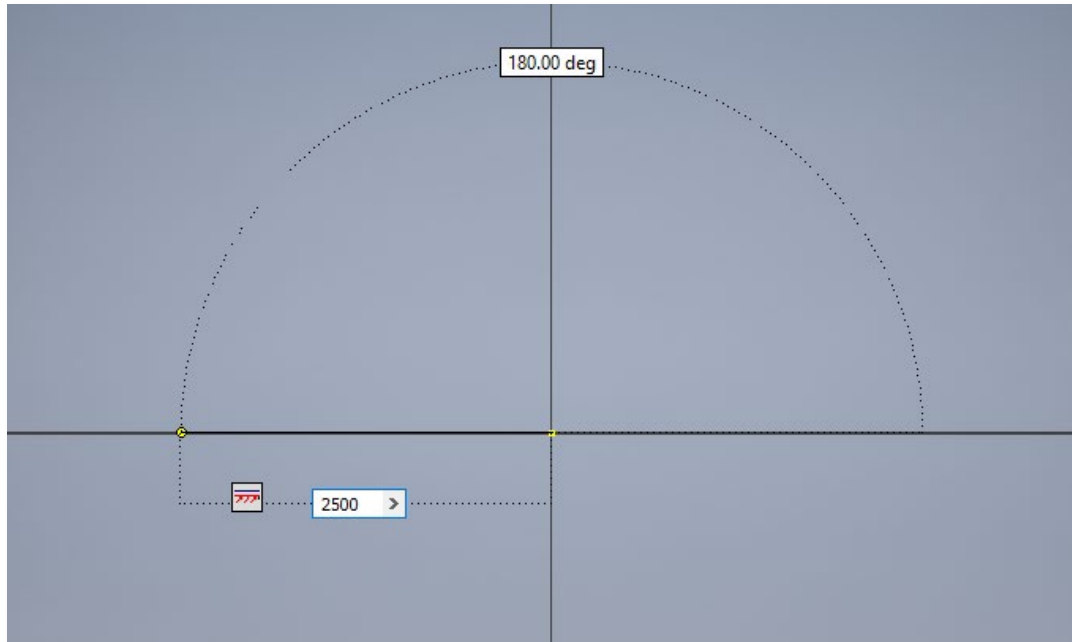


20. Click the **New** button and select then **Standard (mm).ipt** template.

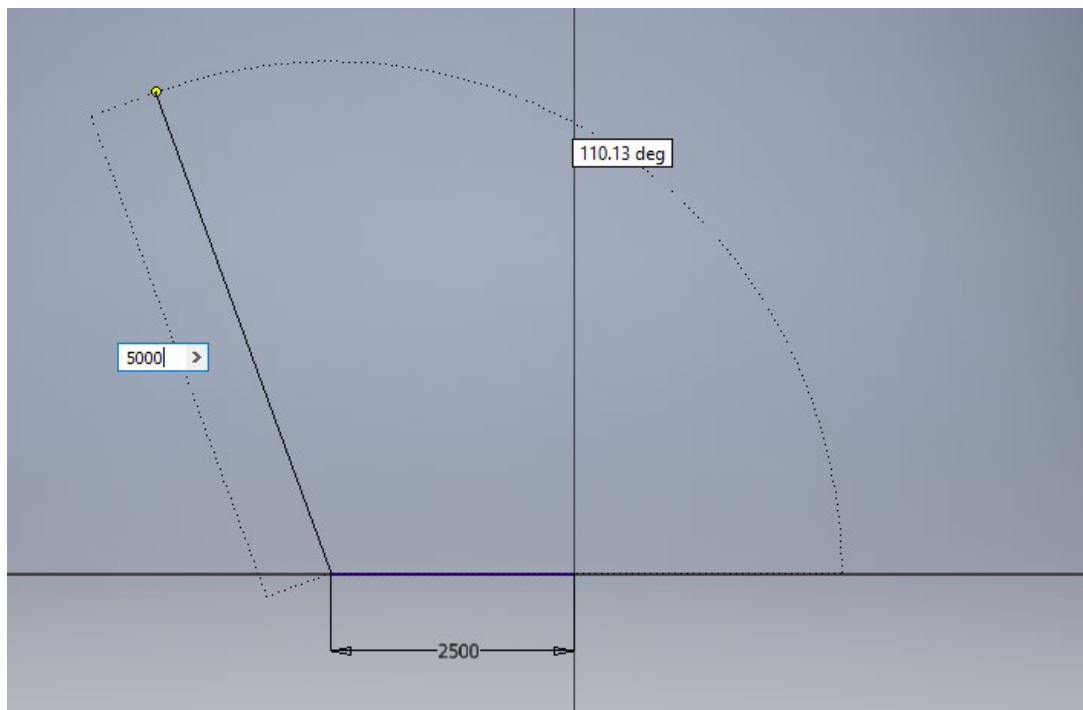
21. From the model browser click on **Origin**, right click on **XZ Plane** the select **New Sketch**.



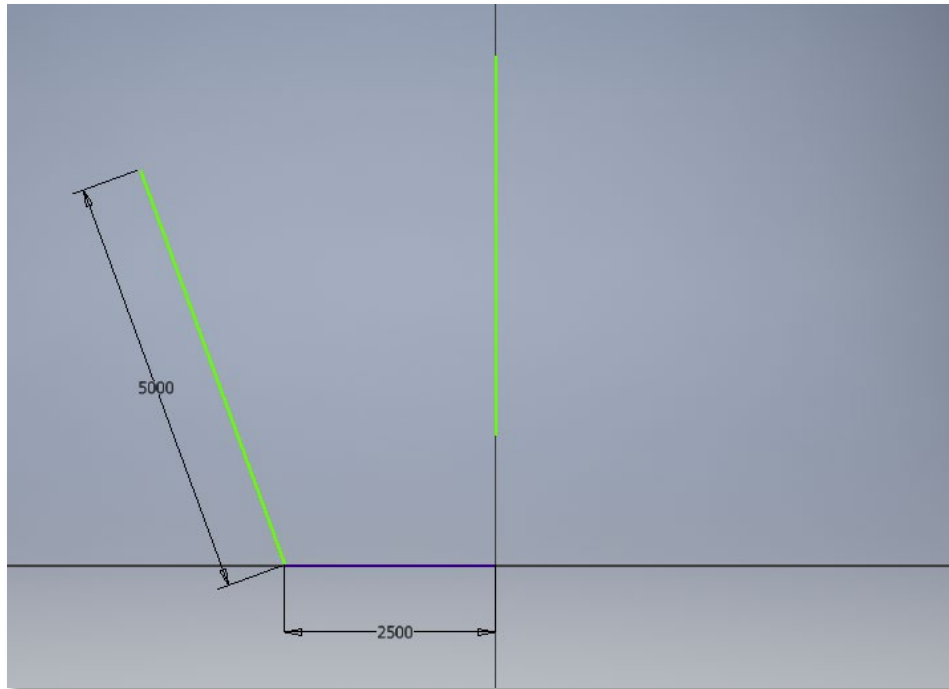
22. Select the line tool and starting from the Origin draw a line 2500 long ensuring that the line is parallel to the x axis.



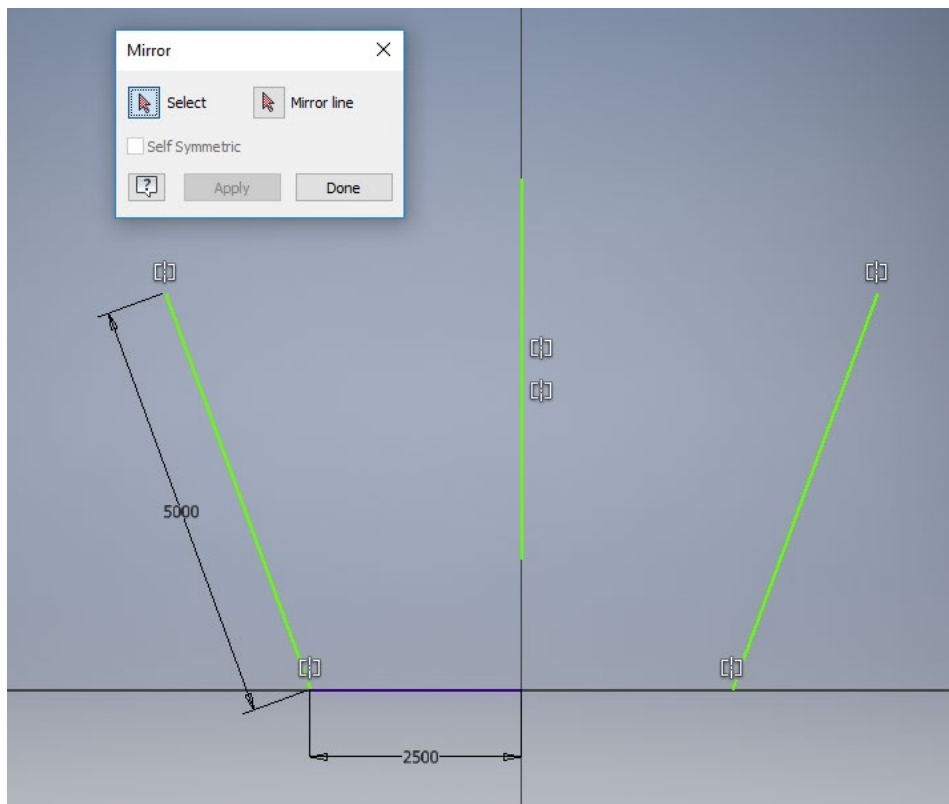
23. Next draw a line at the rough angle shown with a length of 5000 (you can type the number in the field)



24. The draw a temporary line down the centre for mirroring.

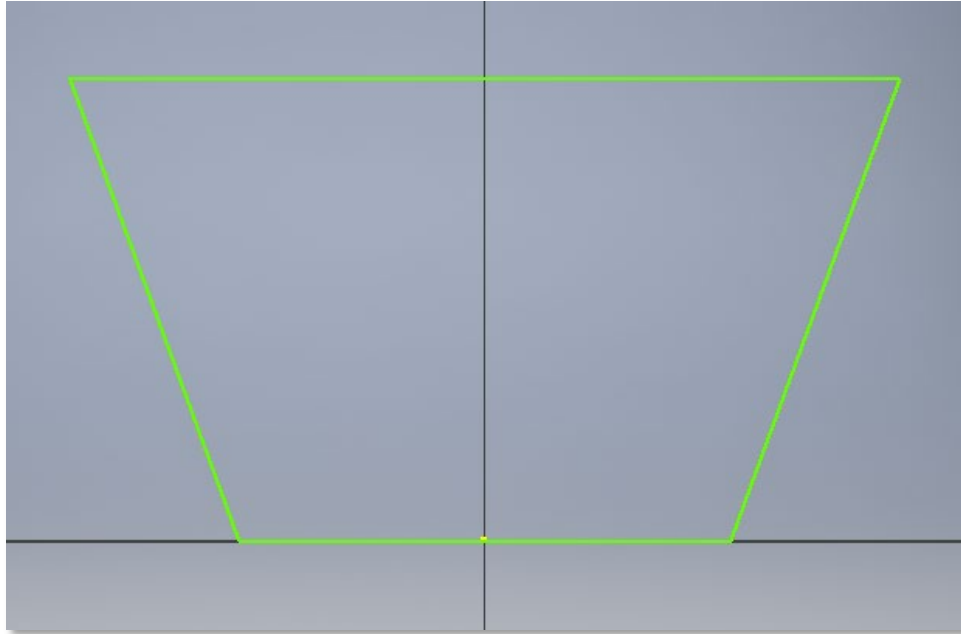


25. Use the mirror tool from the toolbar to mirror the sloping line to the other side of the Z axis.

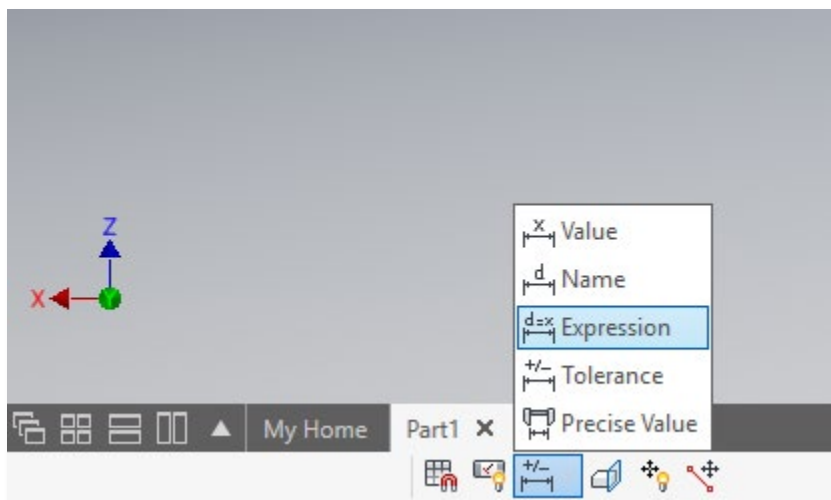




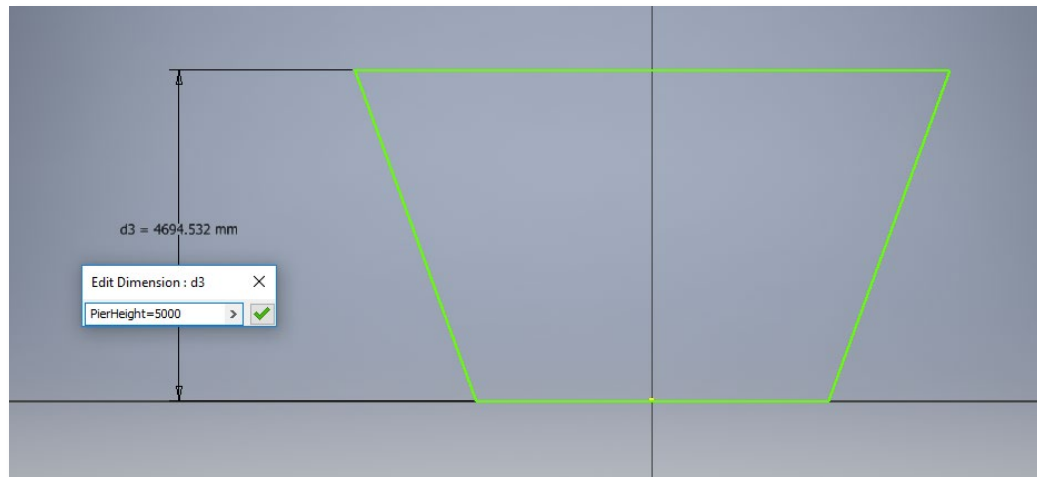
26. Now delete the mirror line, the very first 2500 long line and all the dimensions by selecting them and pressing delete.
27. To complete the drawing, we now need to draw a line between the tops of the sloping lines and the bottom of the sloping lines.



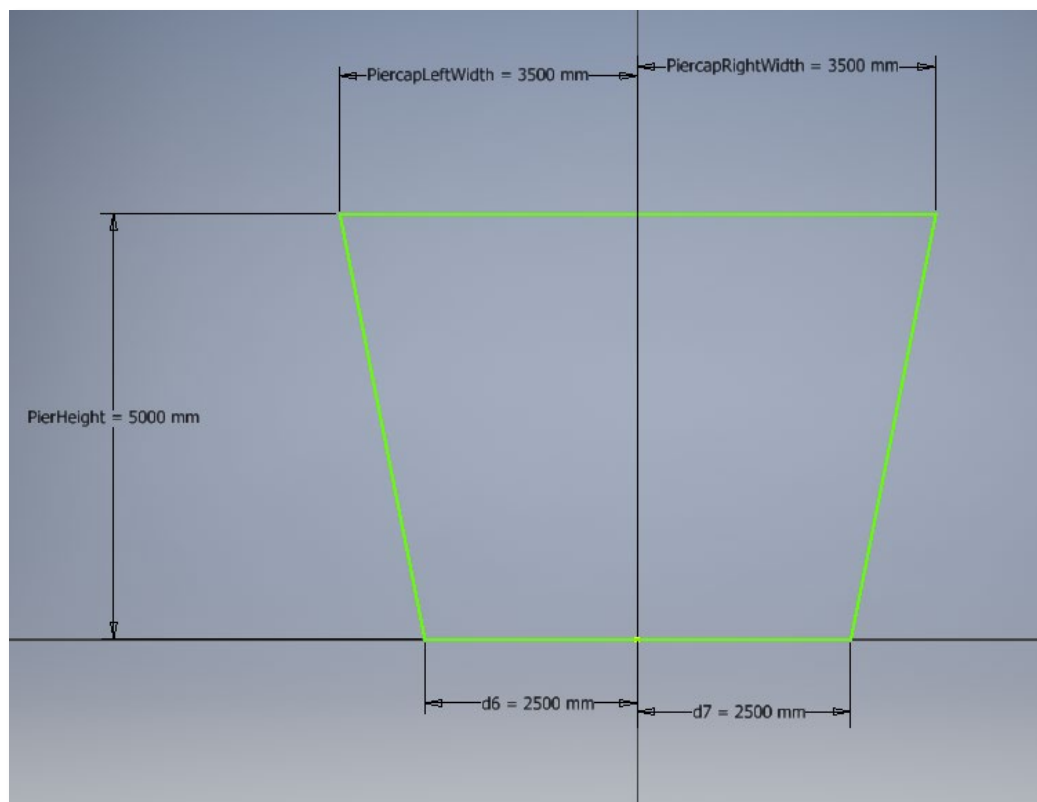
28. Click on the **dimension style button** and select **Expression**.



29. Use the Dimension tool to add a dimension to the height of the pier with parameter name as shown (capitalisation is important) Ensure that the dimension line runs from top of the pier top corner to the origin.

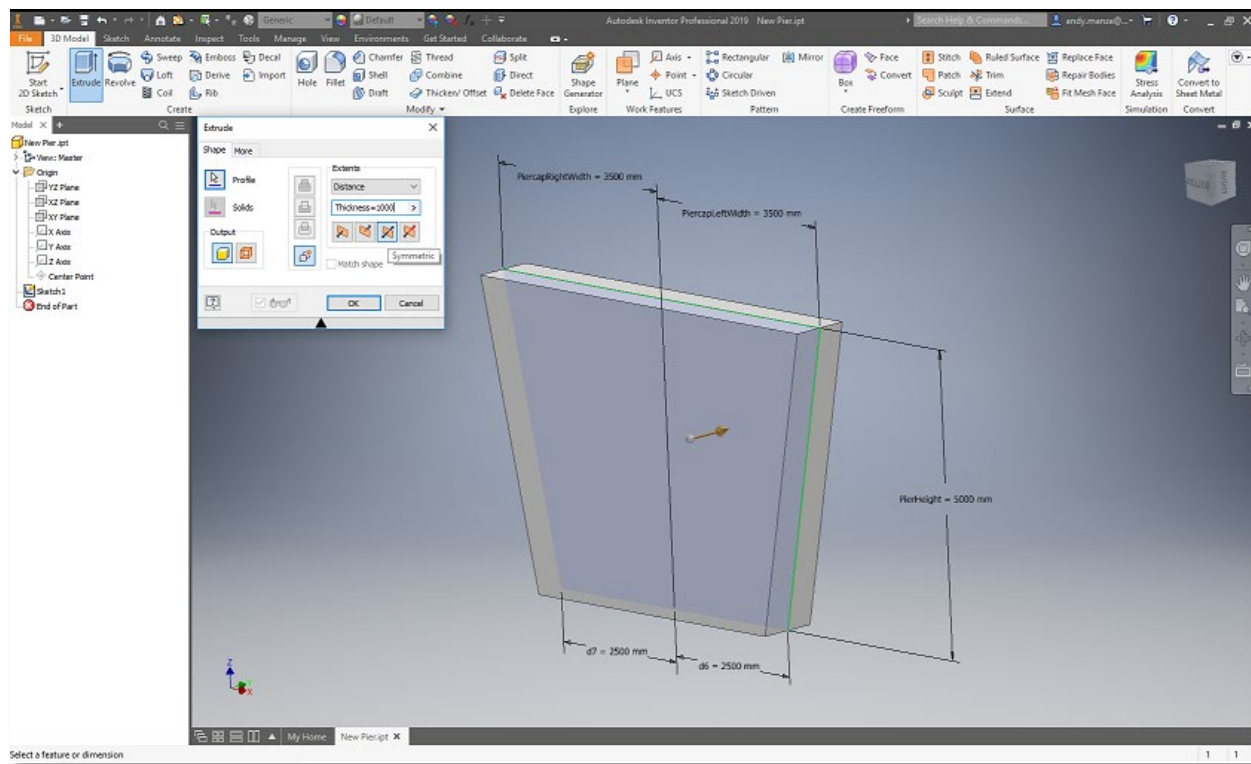


30. Then add dimensions to define the width of the pier including parameters as shown;



31. Click **Finish Sketch** at the end of the toolbar.
32. Rotate the view to show the z axis uppermost.

33. Use the **Extrude** tool on the toolbar to create a 1000mm symmetrical extrusion with parameter name '**Thickness**'.



34. Click on the **Manage** tab and select **Parameters**

35. Tick all checkboxes for Key and Export

Parameters

Parameter Name	Consumed by	Unit/Type	Equation	Nominal Value	Tol.	Model Value	Key	Export	Comment
Model Parameters									
PierHeight	Sketch1	mm	5000 mm	5000.000000	Blue	5000.000000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
PiercapLeftWidth	Sketch1	mm	3500 mm	3500.000000	Yellow	3500.000000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
PiercapRightWi	Sketch1	mm	3500 mm	3500.000000	Yellow	3500.000000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
d6	Sketch1	mm	2500 mm	2500.000000	Yellow	2500.000000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
d7	Sketch1	mm	2500 mm	2500.000000	Yellow	2500.000000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
Thickness	Extrusion1	mm	1000 mm	1000.000000	Yellow	1000.000000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
d9	Extrusion1	deg	0.0 deg	0.000000	Yellow	0.000000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
User Parameters									

$E = mc^2$   $P + \rho \times \frac{1}{2} v^2 = C$   $E = mc^2$   $P + \rho \times \frac{1}{2} v^2 = C$   $E = mc^2$   $P +$

$\nabla \times E = -\frac{\partial B}{\partial t}$   $\Delta S > 0$   $\nabla \times E = -\frac{\partial B}{\partial t}$   $\Delta S > 0$   $\nabla \times E = -\frac{\partial B}{\partial t}$

Add Numeric Update Purge Unused

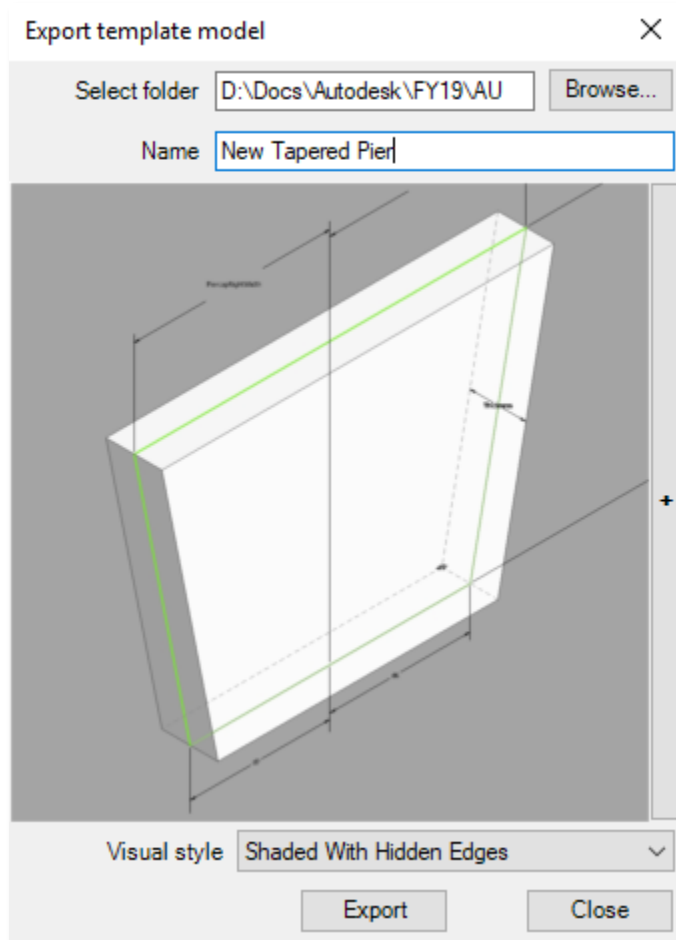
Link ☒ Immediate Update

Reset Tolerance + -

<< Less Done

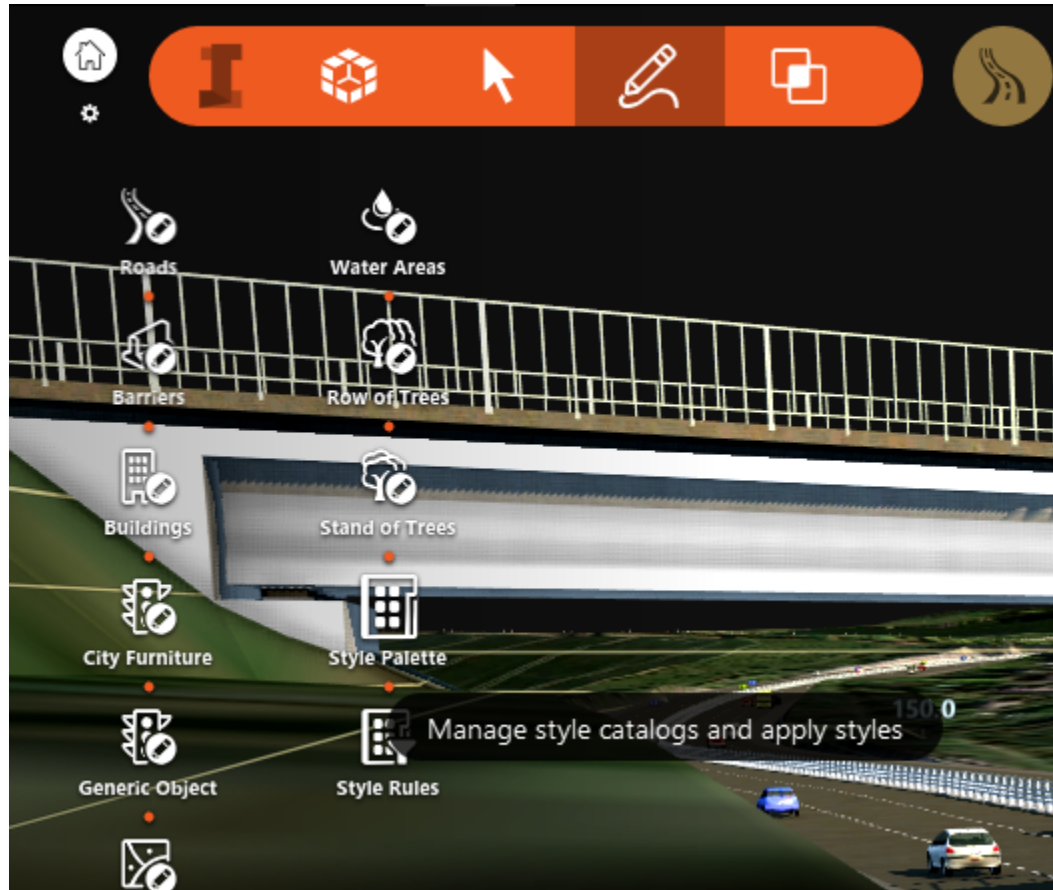


36. Then click on the **Environments** tab and select **Infrastructure Part Shape Utilities** then **Export Template**.
37. Under **Select Folder**, select a suitable file location, perhaps the Desktop and give the file a name, click **Export**.



38. Close the dialogue box and click **Finish Infrastructure**.
39. Go back to InfraWorks

40. Open the Style Palette



41. Select the **Parametric Models** tab and navigate to **Bridge > Piers**

42. Hit the Plus icon at the bottom of the Style Palette.



43. Load the new Inventor file previously created into the **Define New Parametric Models** dialogue.

**Define New Parametric Models**

Model URI:

**Model Details** | Part Sizes | UI Appearance

Name:

Description:

Units:

Domain:

Component type:

Parametric parts have certain parameters that are required in order for them to be used in InfraWorks. These must be marked as 'Key' when exported from Inventor. See the list of required parameters below, or the [help docs](#) for more information.


PierHeight ✓  
PiercapLeftWidth ✓  
PiercapRightWidth ✓

**Repair Model**

☐ Invert Up Axis ☐ Flip Y and Z

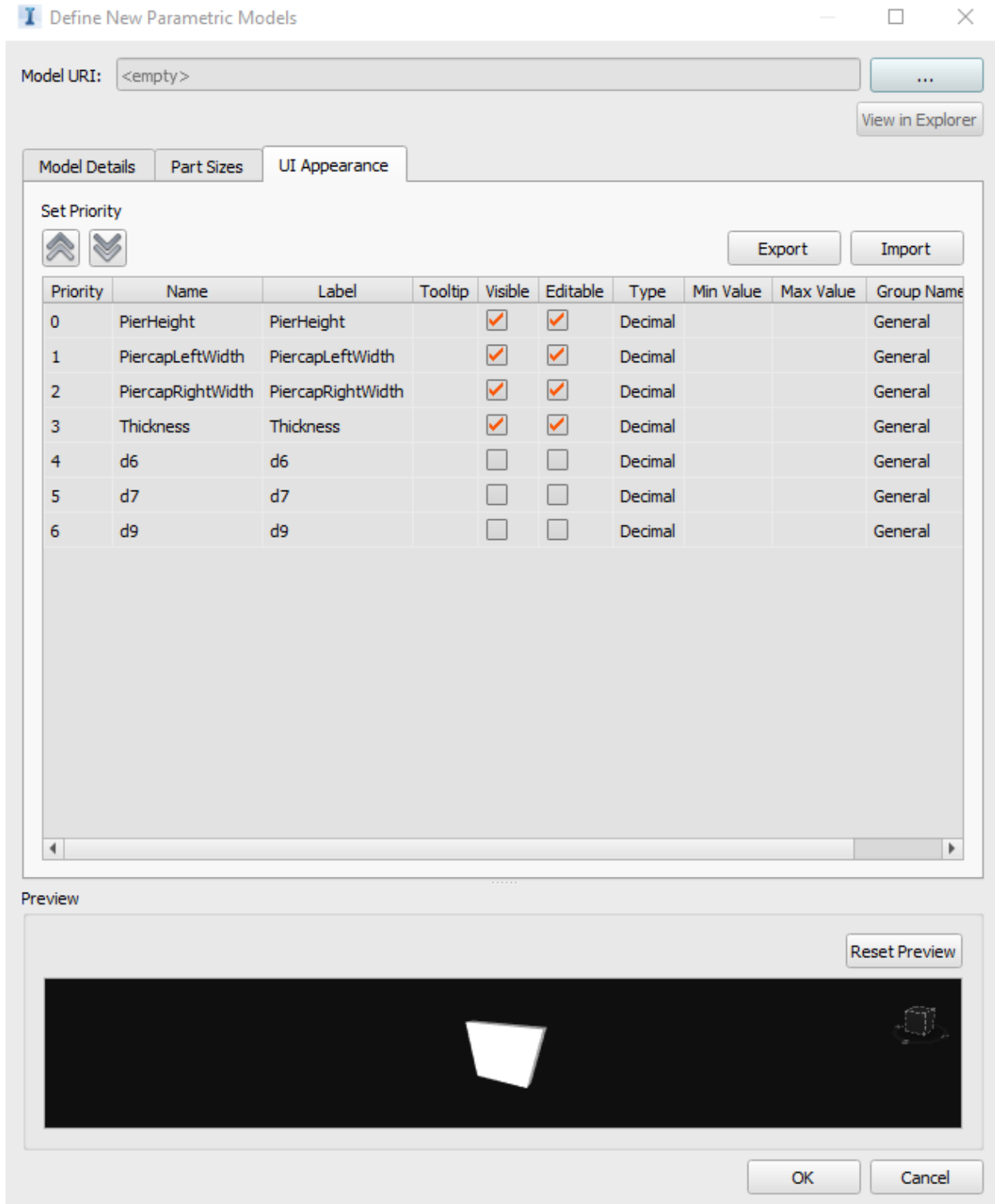
	X	Y	Z
Translation	0.00000000	0.00000000	0.00000000
Rotation	0.000 °	0.000 °	0.000 °

**Preview**





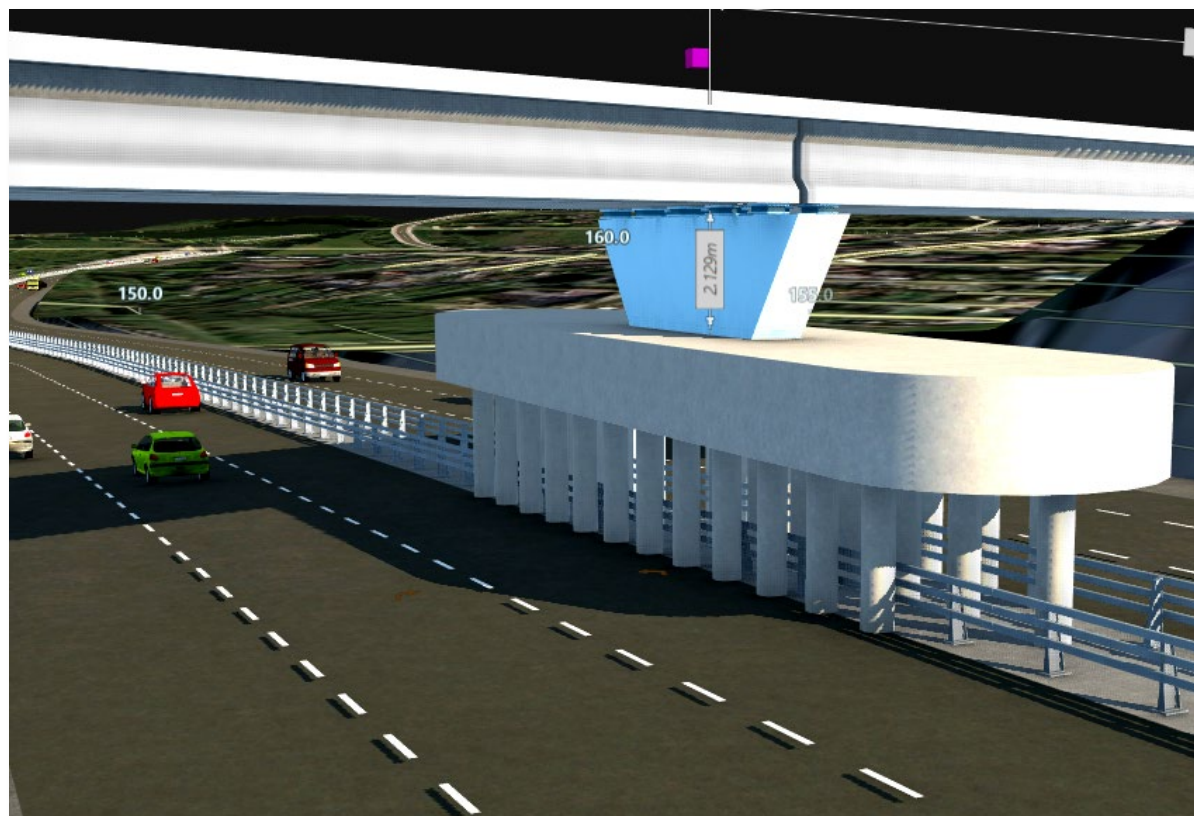
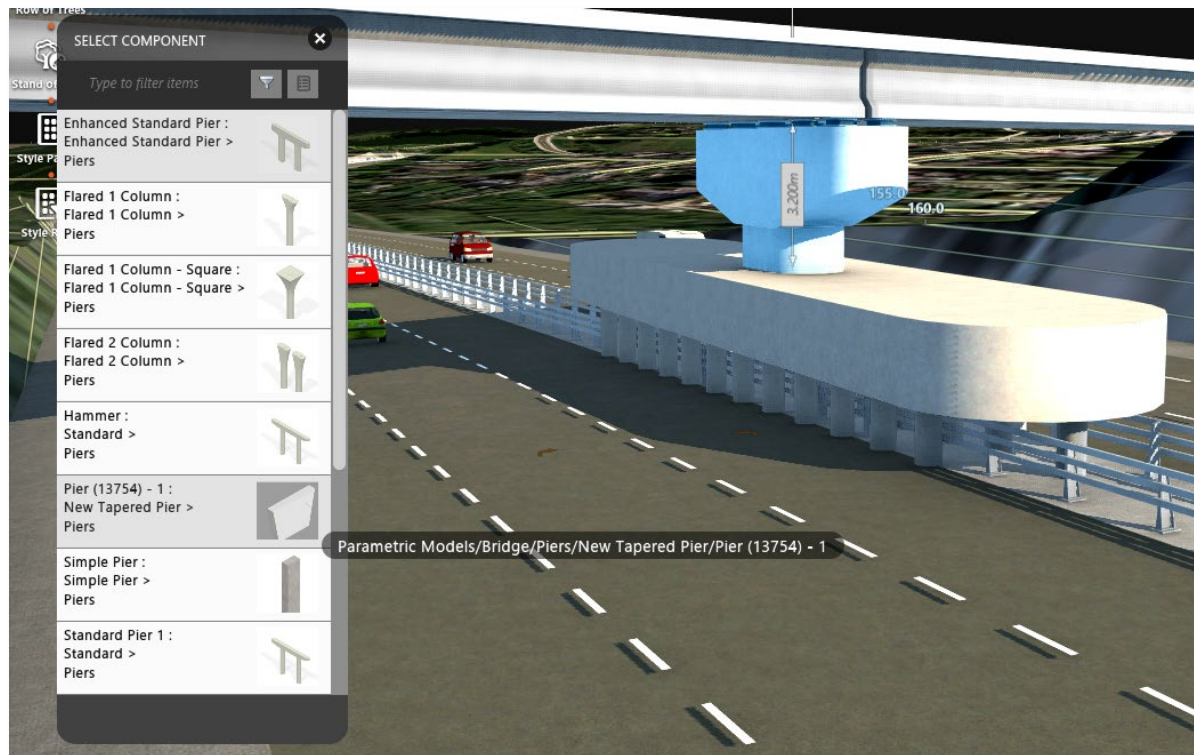
44. Under the **UI Appearance** tab untick **Visible** and **Editable** for the unnamed parameters.



45. Click OK and accept the default name in the **Style Palette** and close it.

46. Select the central pier and click on the **Type** hyperlink in the stack on the right hand side.

47. Double click on the New Pier that has been newly created.

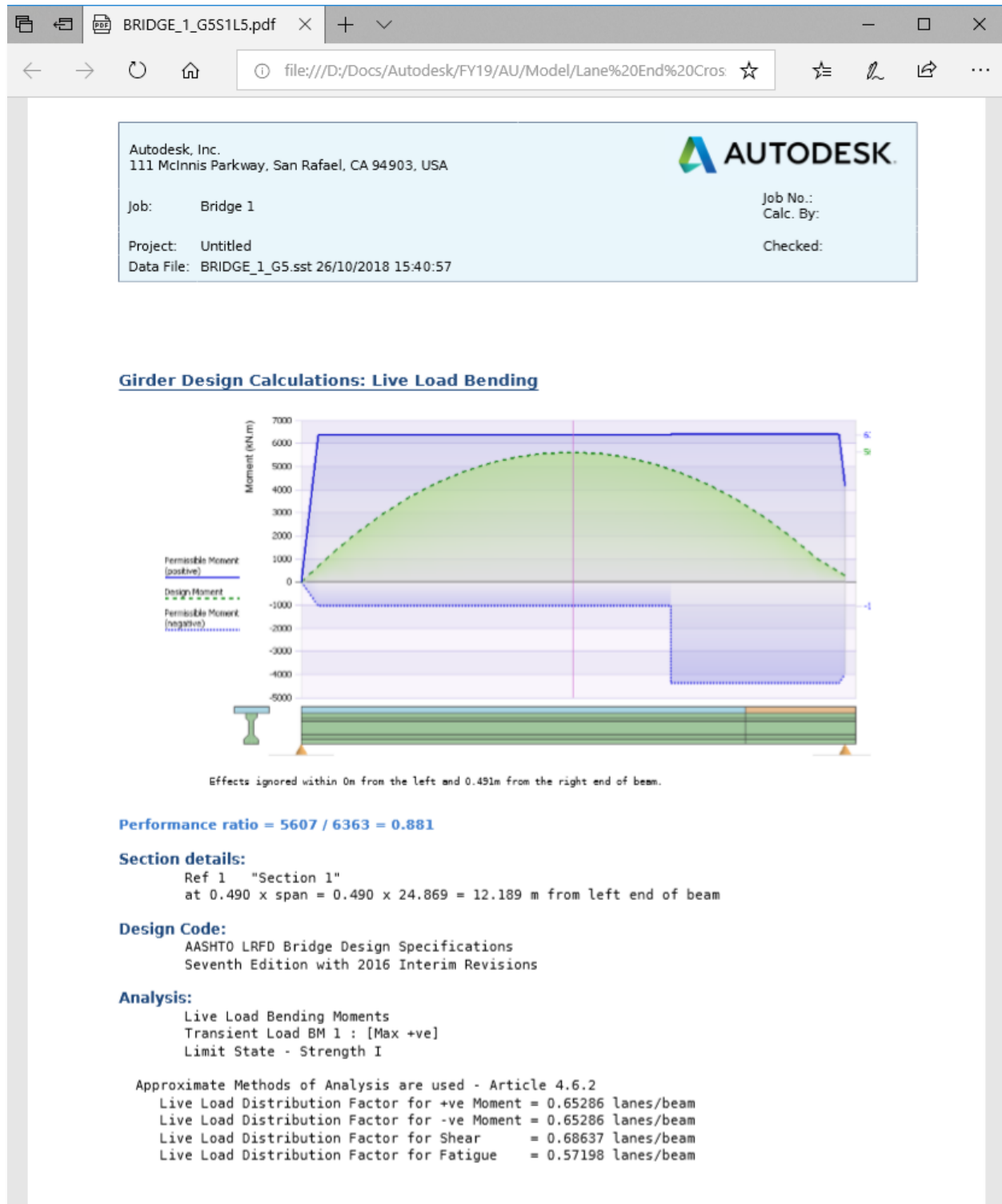


48. Select the piled foundation and amend the values below;
- a. **Height above ground: -5.0**
  - b. **Size based on pile count : On**
  - c. **Count: Transverse row: 5**
  - d. **Pile length: 10**
49. Select the new pier and change the **Thickness** to 1.75m. The model is now complete.



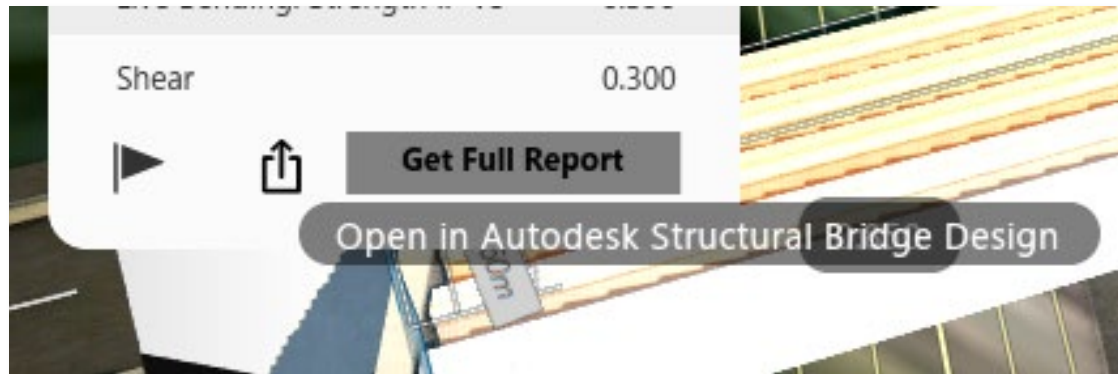
50. Check the analysis results by going back to the Line Girder Analysis icon and selecting the bridge.
51. Click on one of the girders and select **Get Full Report** from the Line Girder Analysis panel and completing purchase (Free).

52. Click on the hyperlink for **Girder Design Summary** and then **Live Load Bending – Strength 1**.

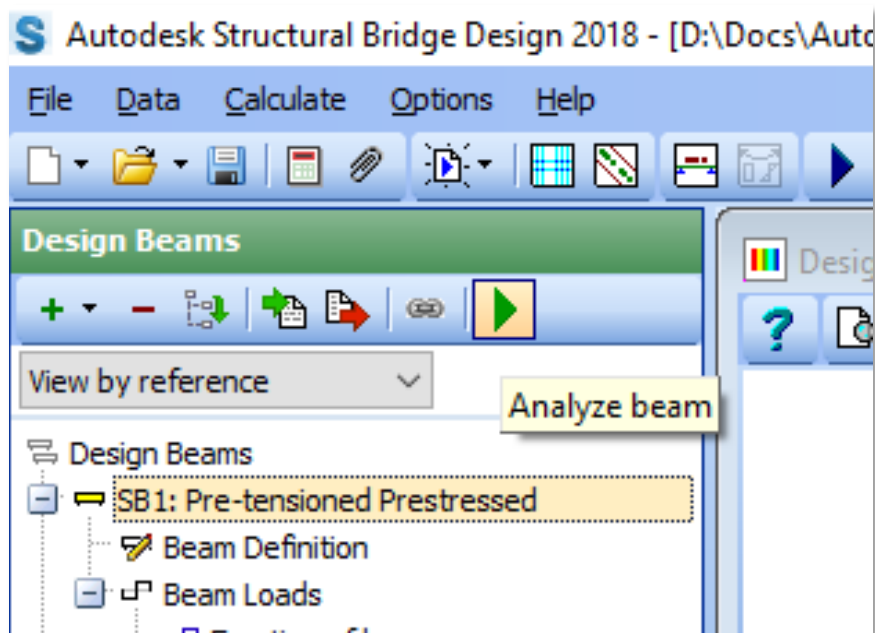




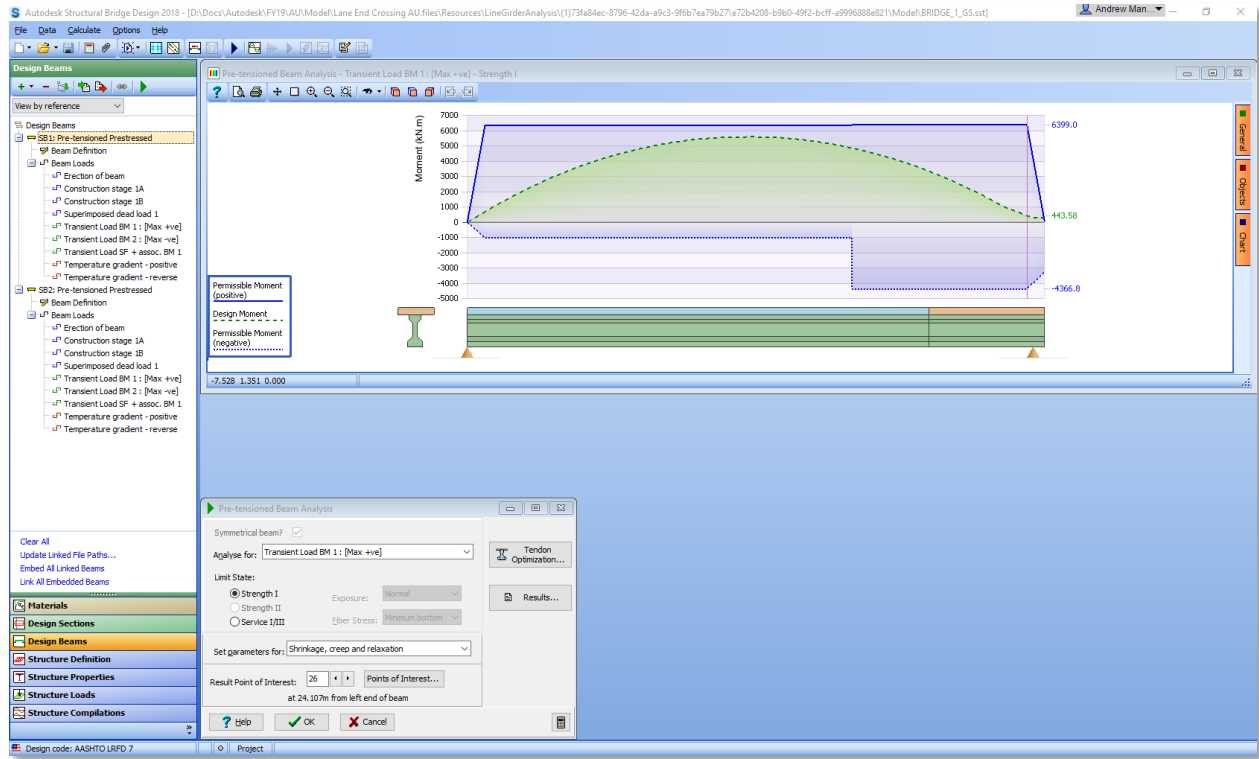
53. Open the girder in Structural Bridge Design by clicking on the icon in the Line Girder Analysis panel



54. Close the open windows and select the Design Beams tab.  
55. Select the first design beam **SB1: Pretensioned Prestressed**  
56. Click the 'play' button to run the design checks.

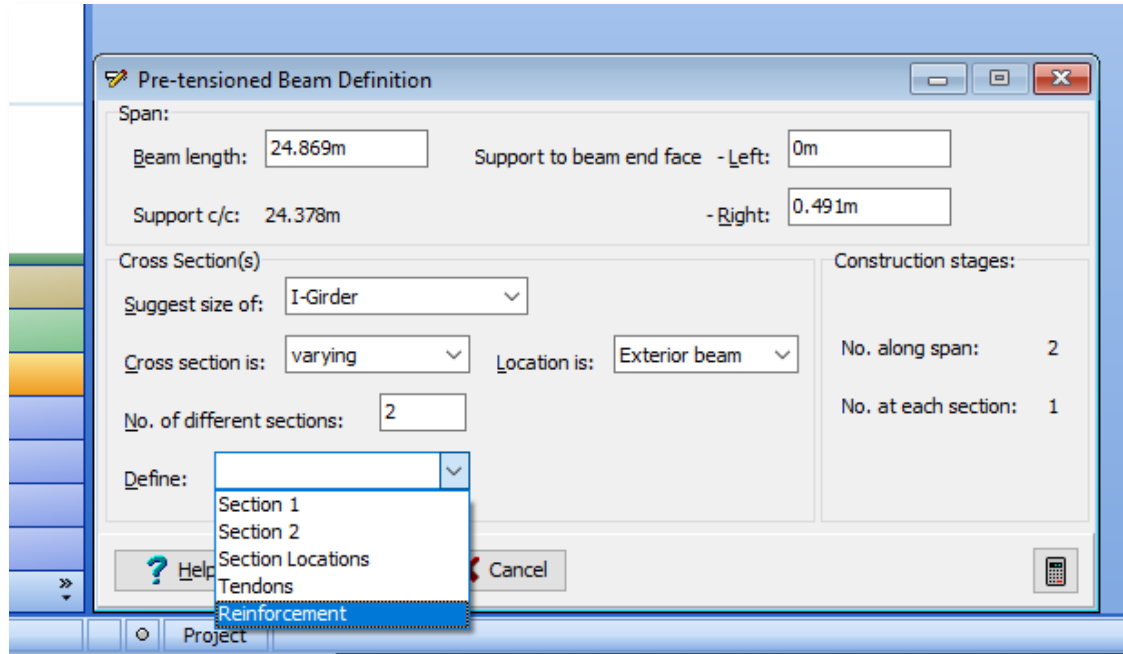


57. In the beam analysis panel select **Transient Load BM1 : [Max +ve]** and choose **Strength 1**.

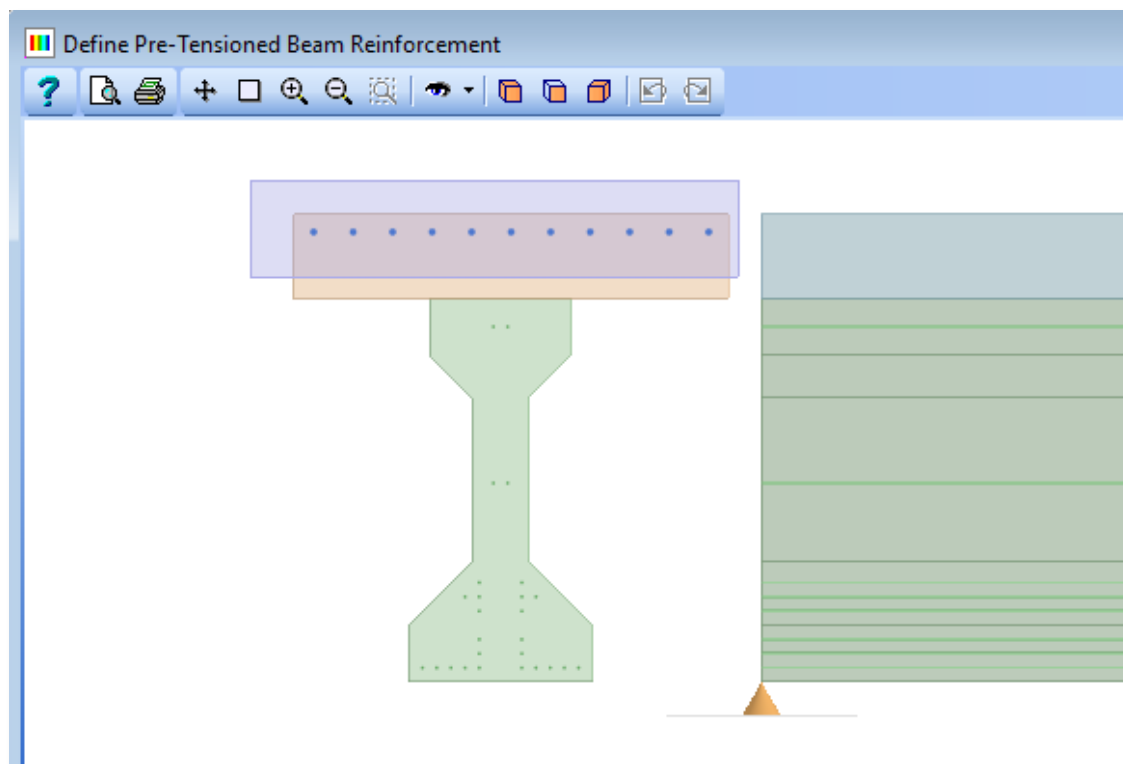


58. Note the Permissible negative moment jump in capacity, then close the dialogue.  
59. Click on Beam Definition in the tree.

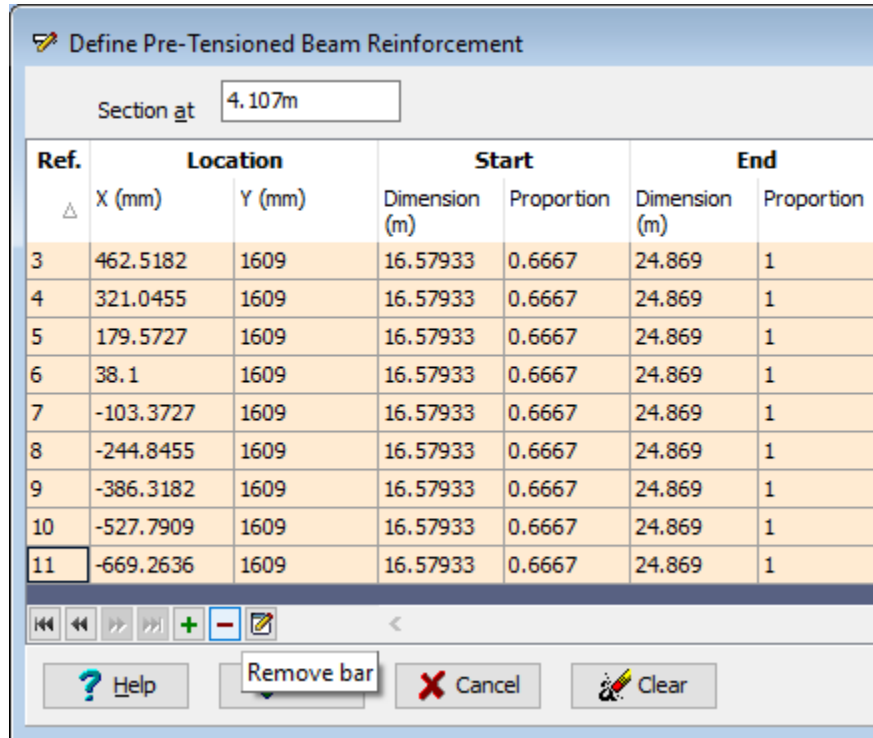
60. Choose Reinforcement from the drop-down menu in the definition dialogue.



61. Draw a box to select all the slab reinforcement.



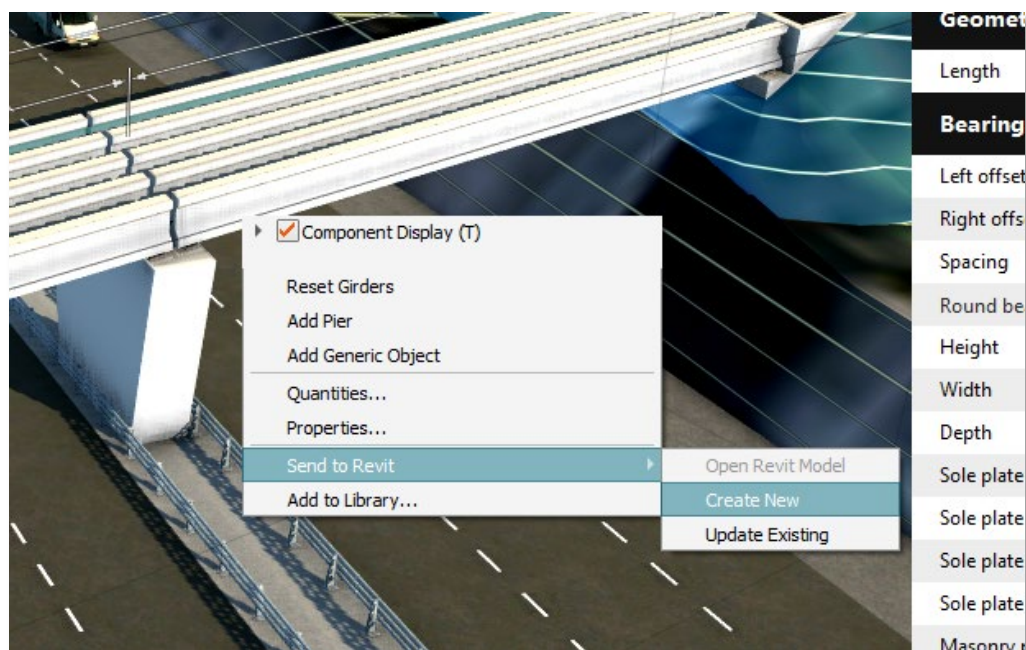
62. Click the **Delete Bar** button then click OK and close the beam definition dialogue.



63. Click on the green 'play' button again and notice the reduction on permissible negative moment capacity.

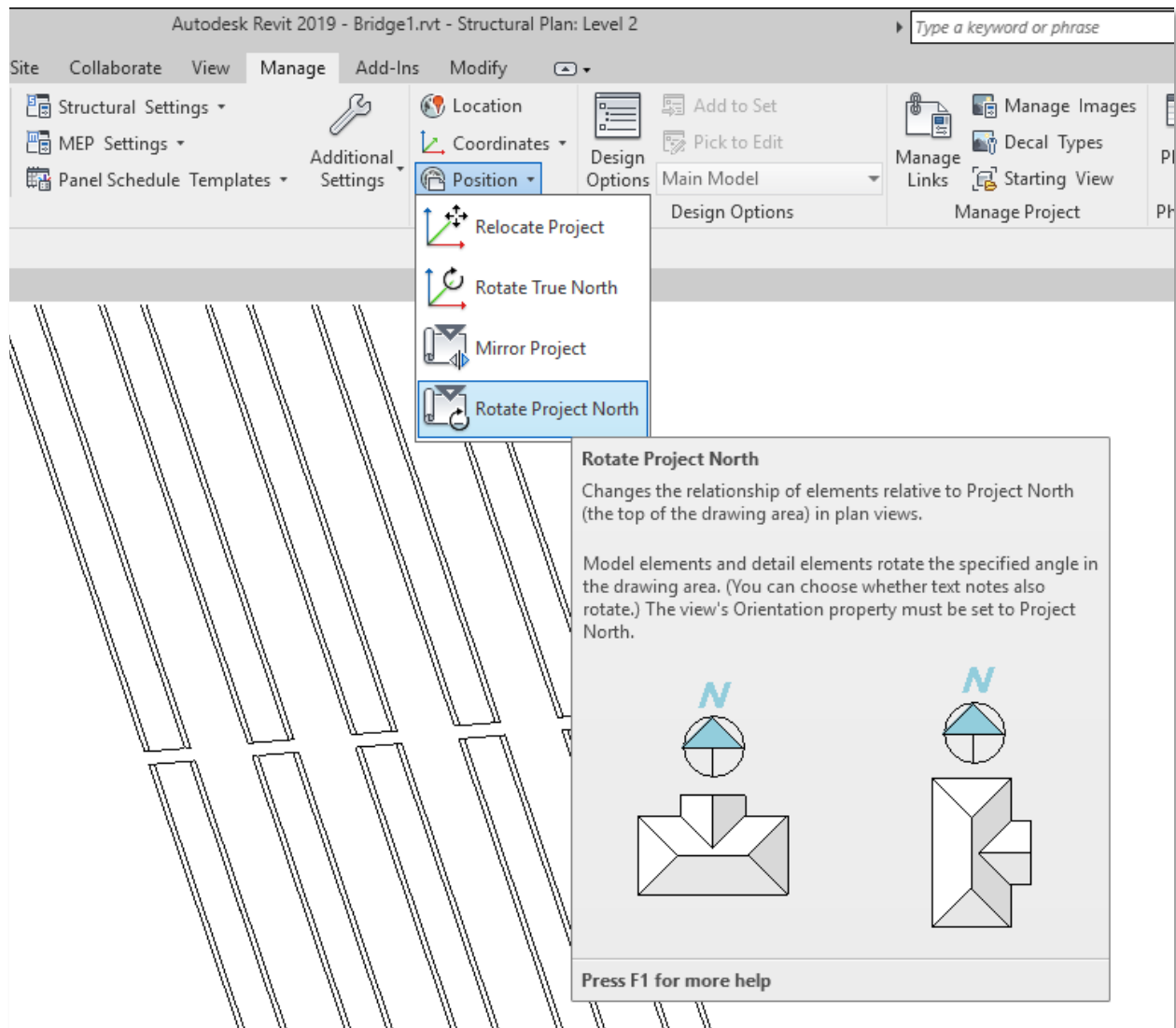
64. Go back to InfraWorks.

65. Select the bridge, right click and select **Send to Revit > Create New** and click **Create**.





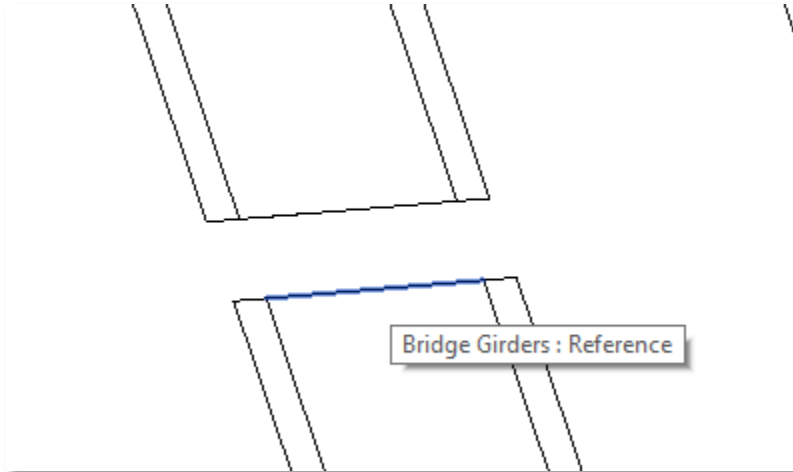
66. In Revit hover over one of the road components, right click and select **Hide in View > Category**.
67. Repeat with the bridge deck element but choose **Elements** instead.
68. Under the **Manage** tab choose **Position > Rotate Project North**.



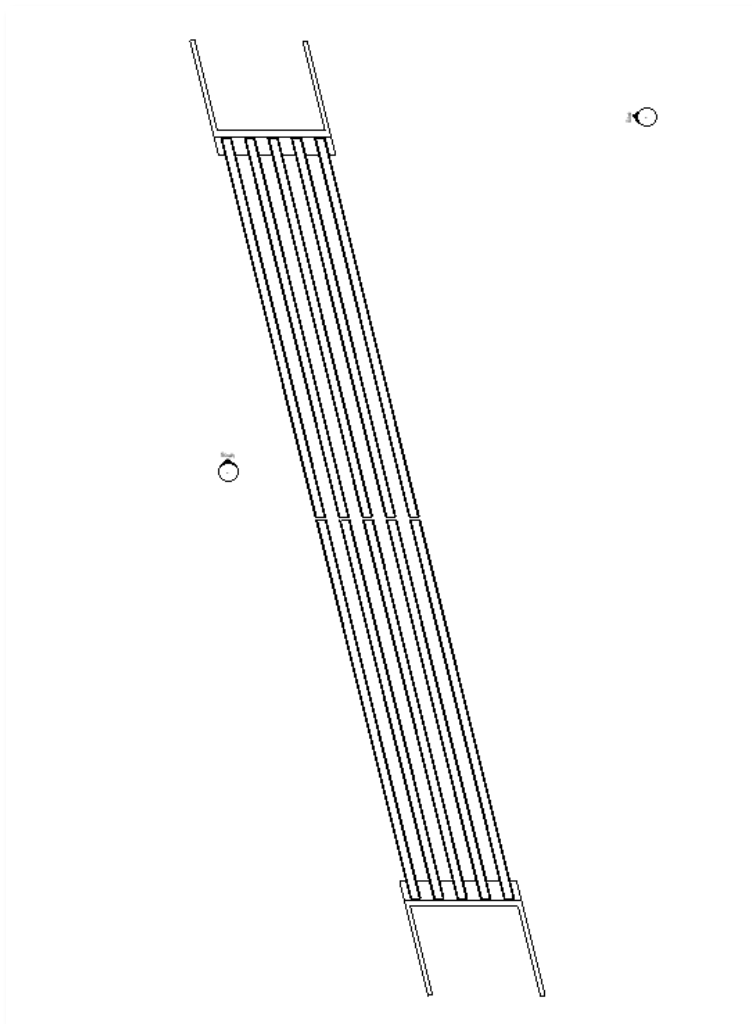
69. Choose Align selected line or plane.

➔ **Align selected line or plane**  
Align the selected line or plane along either the North/South or East/West orientation, whichever is closest.

70. Then click on one of the lines representing the end of a girder.



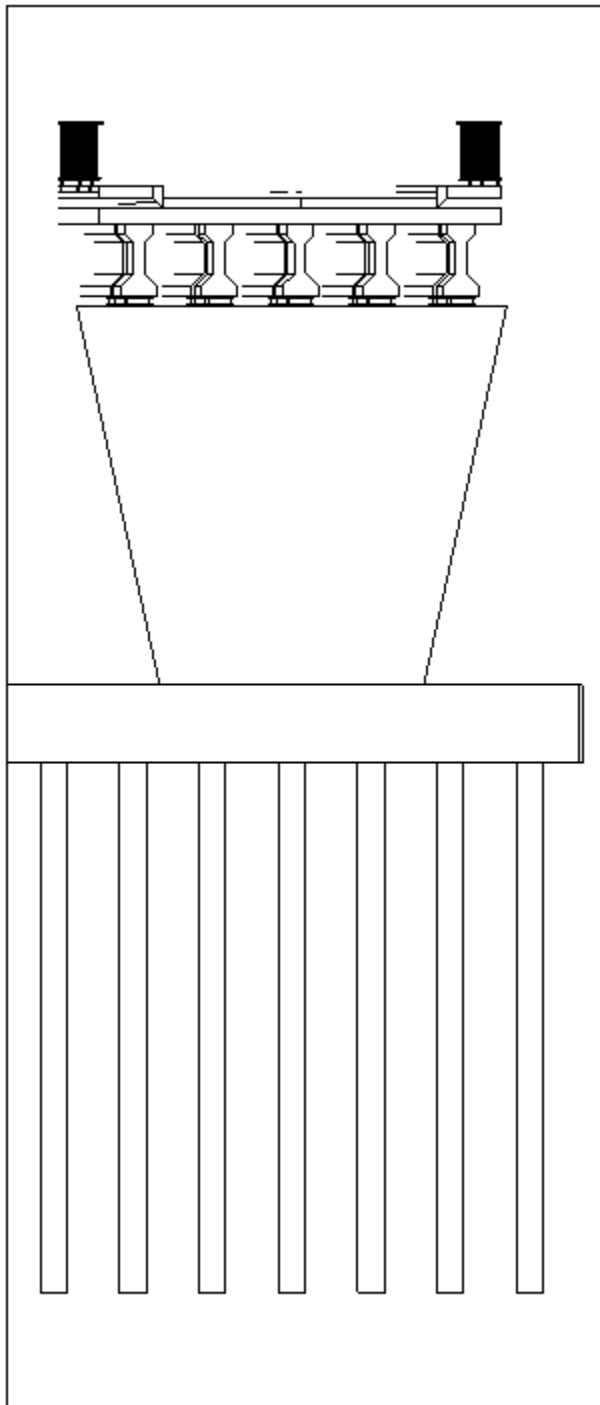
71. Click OK and zoom back out. The model should now be oriented as shown.



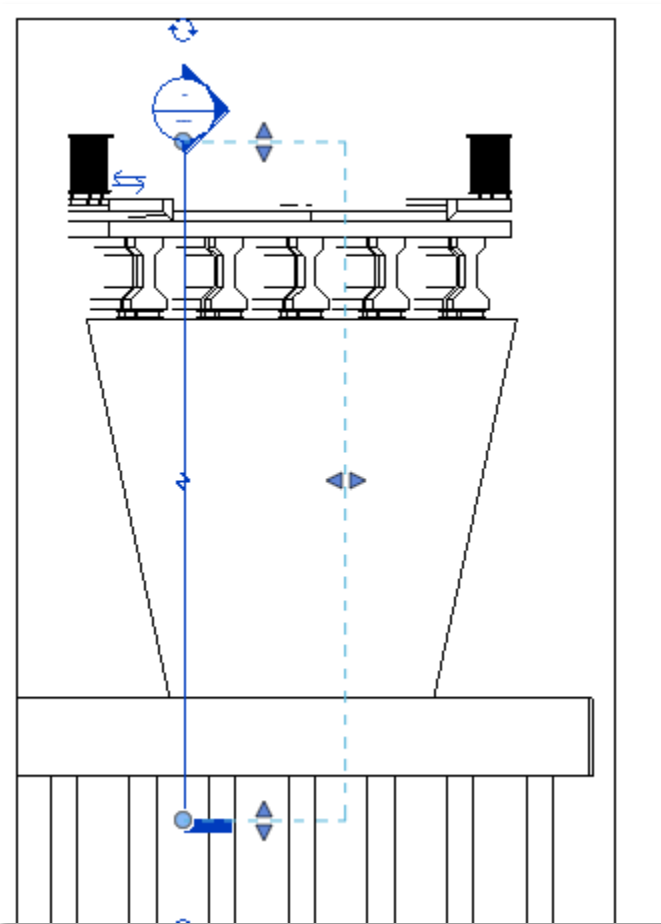


The diagram shows a closed kinematic chain. On the left, a rotating arm is pivoted to a fixed frame (indicated by a ground symbol). The arm has a vertical slot that guides a slider block. The slider block is connected to a horizontal link that is pivoted to another fixed frame (also indicated by a ground symbol). The slider block and the horizontal link are connected by a revolute joint. The slider block has a vertical guide surface that fits into the slot of the rotating arm. The horizontal link has a vertical guide surface that fits into the slot of the fixed frame. The slider block and the horizontal link are connected by a revolute joint. The slider block has a vertical guide surface that fits into the slot of the rotating arm. The horizontal link has a vertical guide surface that fits into the slot of the fixed frame. The slider block and the horizontal link are connected by a revolute joint.

74. Deselect the section tool and then double click on the blue section marker to be taken to the new view.



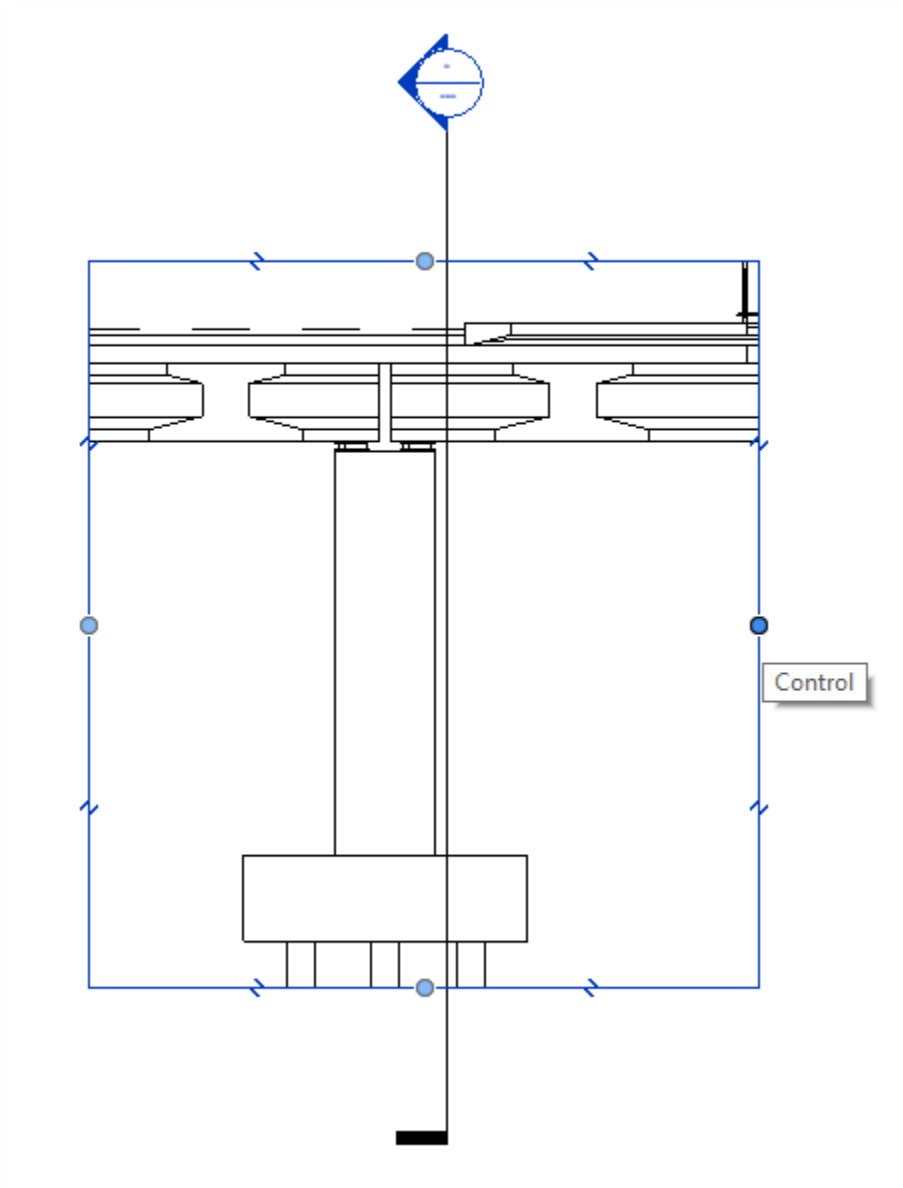
75. Use the same tool to draw a vertical section through this view.



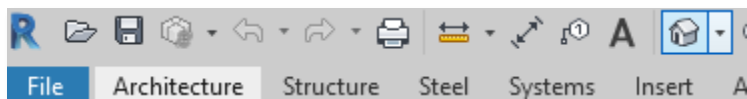
76. Go to the new view by double clicking on the section marker as before.



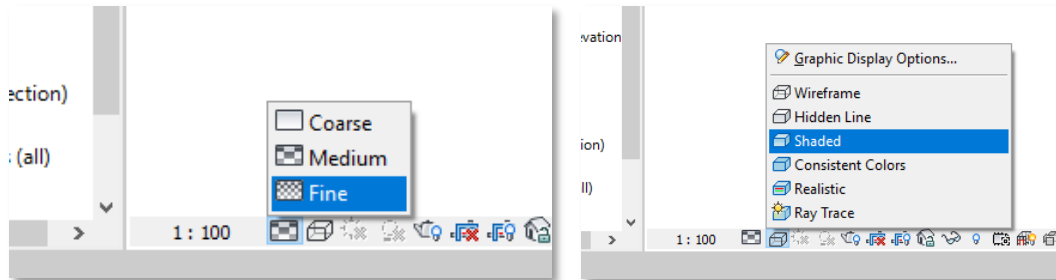
77. Click on the 'crop regions' and use the grips to reduce the size of the cropped view.



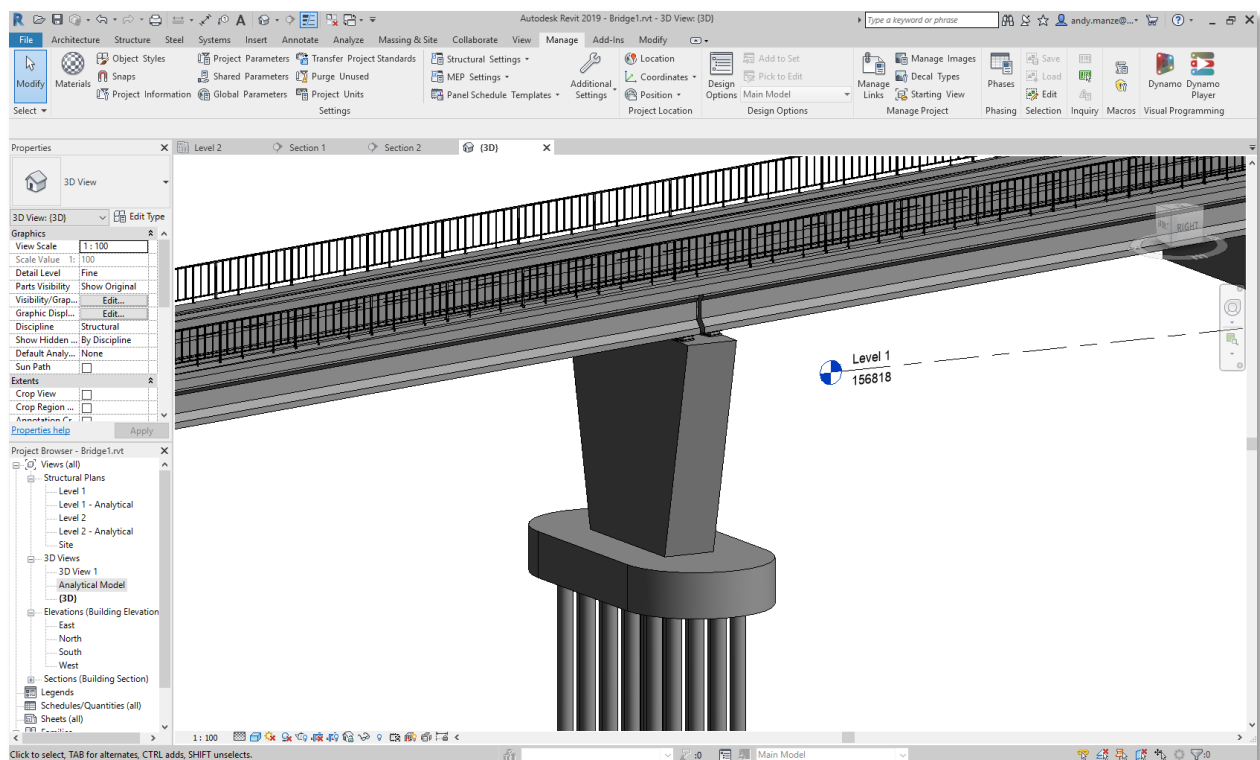
78. In Revit click on the 3d View to create the view.



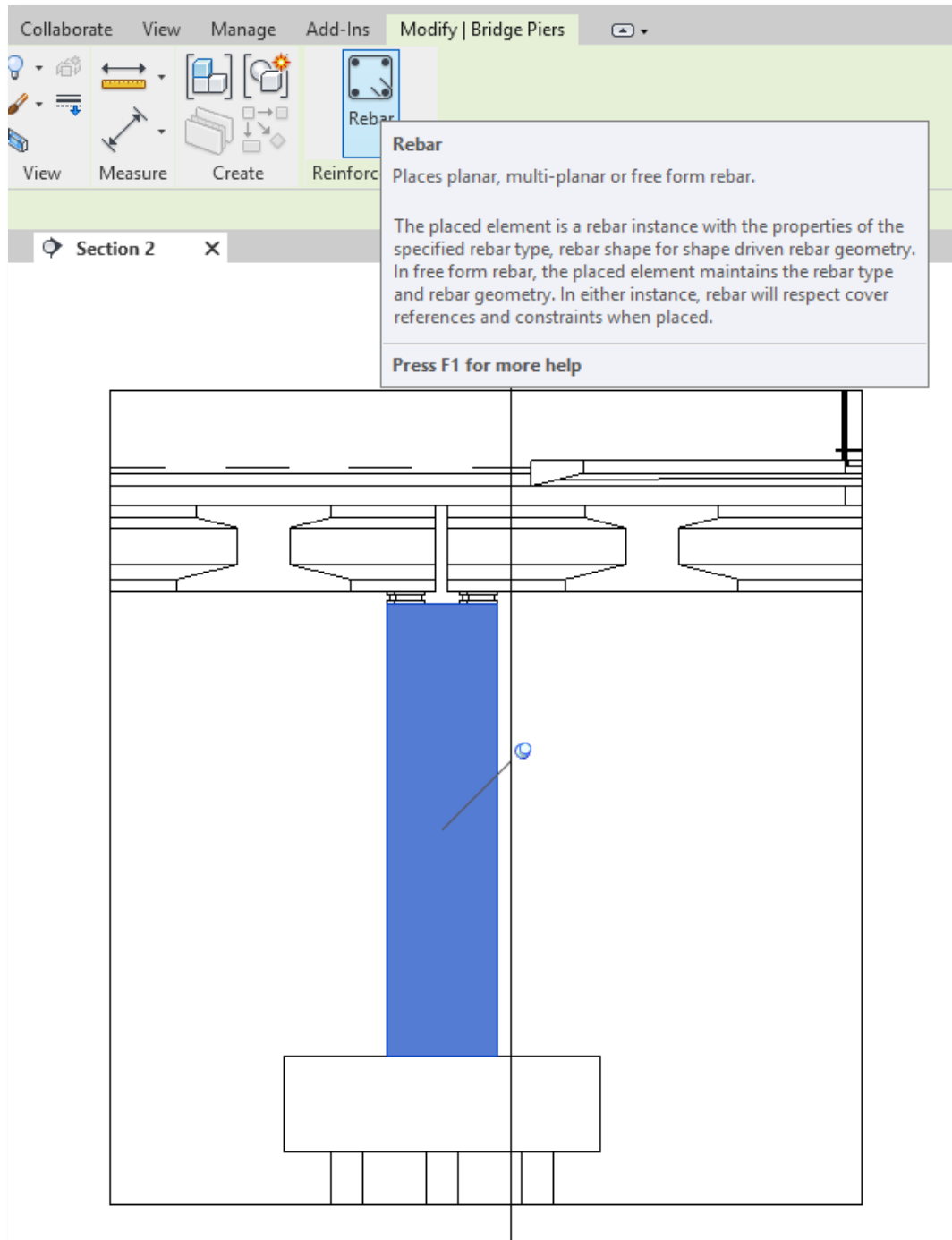
79. Change the appearance of the view by changing **Detail Level** to **Fine** and **Visual Style** to **Shaded**.



80. The view should look like this;

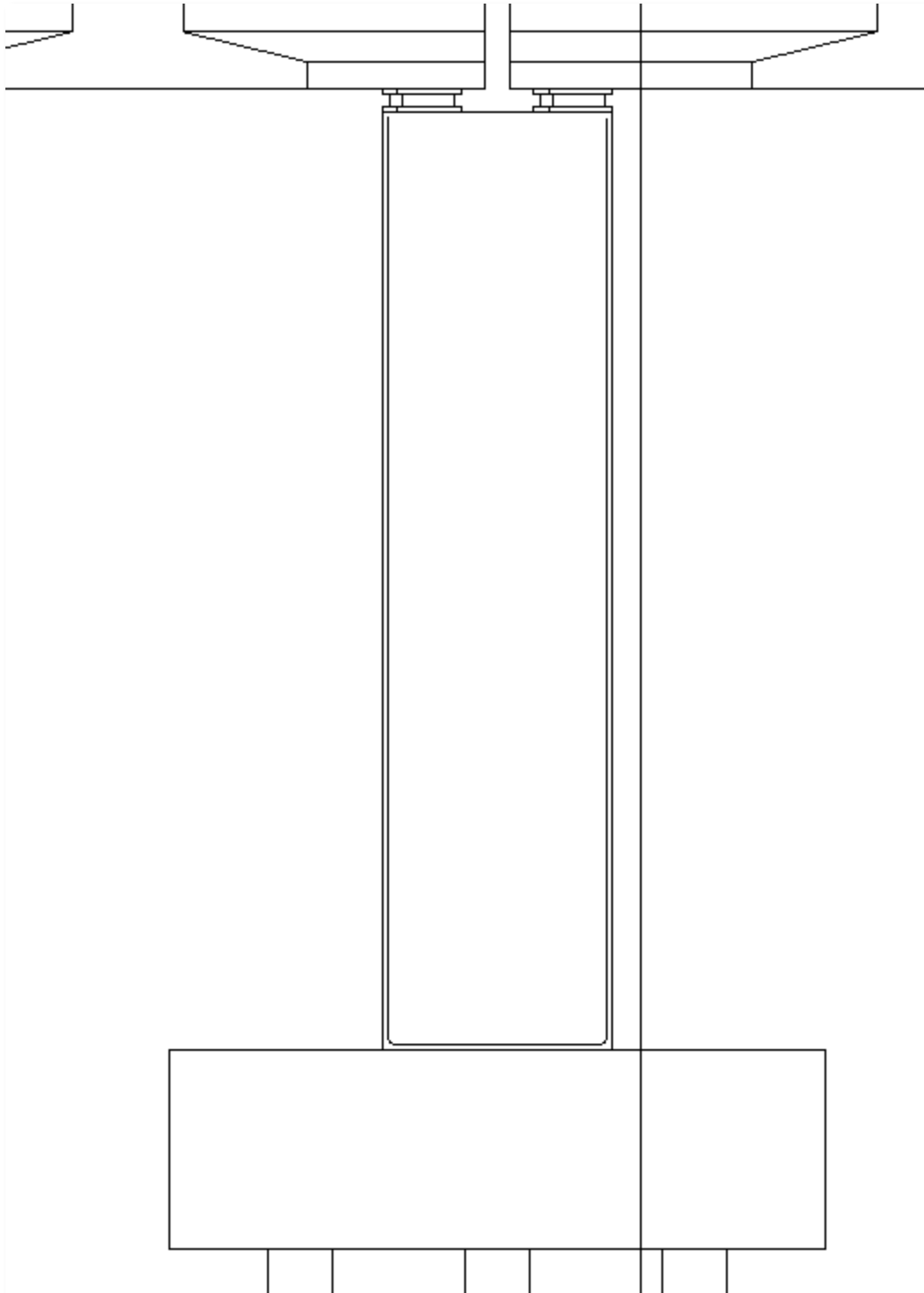


81. To add rebar switch to Section 2 and click on the pier, which should highlight in blue. Then select Rebar from the ribbon.

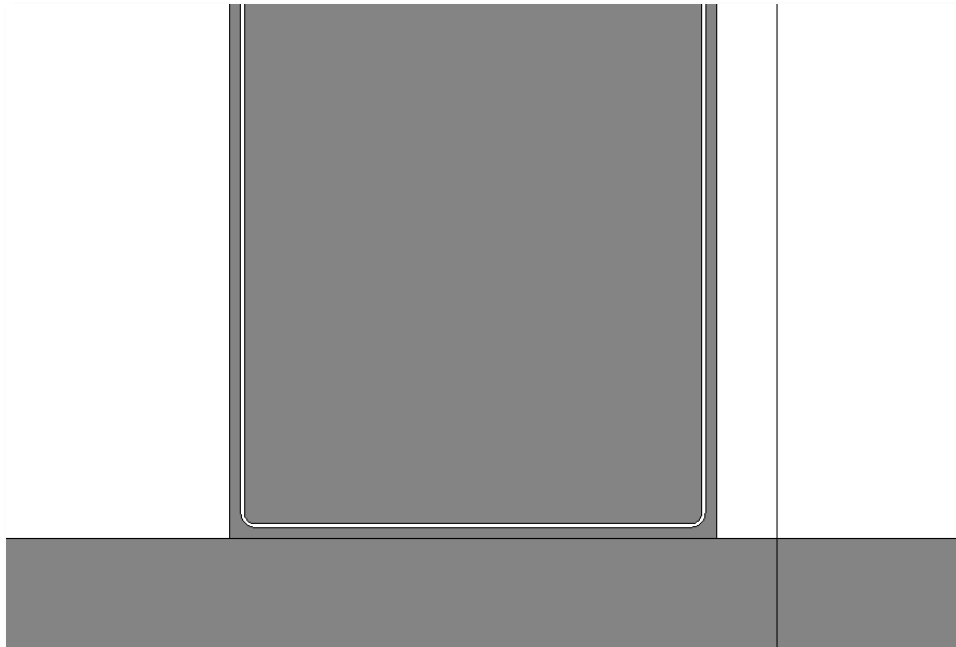


82. Click OK, then select shape code **M\_17** from the shape codes menu, then carefully click inside the pier making sure that the central leg of the bar is against the bottom of the pier, the spacebar will change the orientation of the bar. Then press **Esc**.

83. You should see something like this;

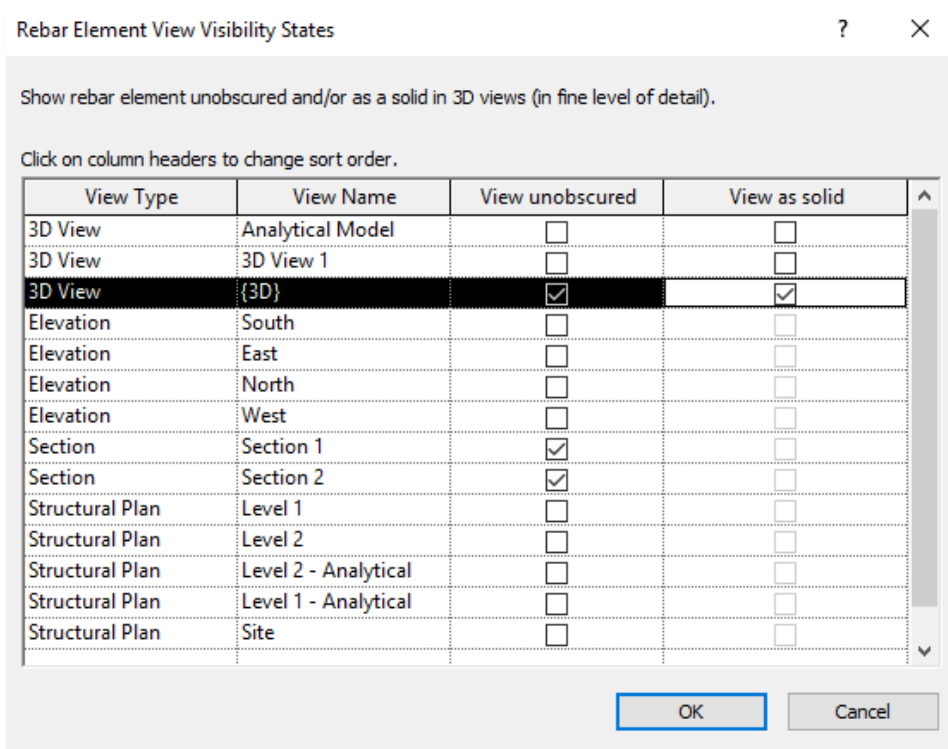


84. For the current view change the Detail Level to Fine and the Visual Style to Shaded. The view should then look like this.



85. Select the bar then open the View Visibility States in the Properties Panel..you may have to scroll down.

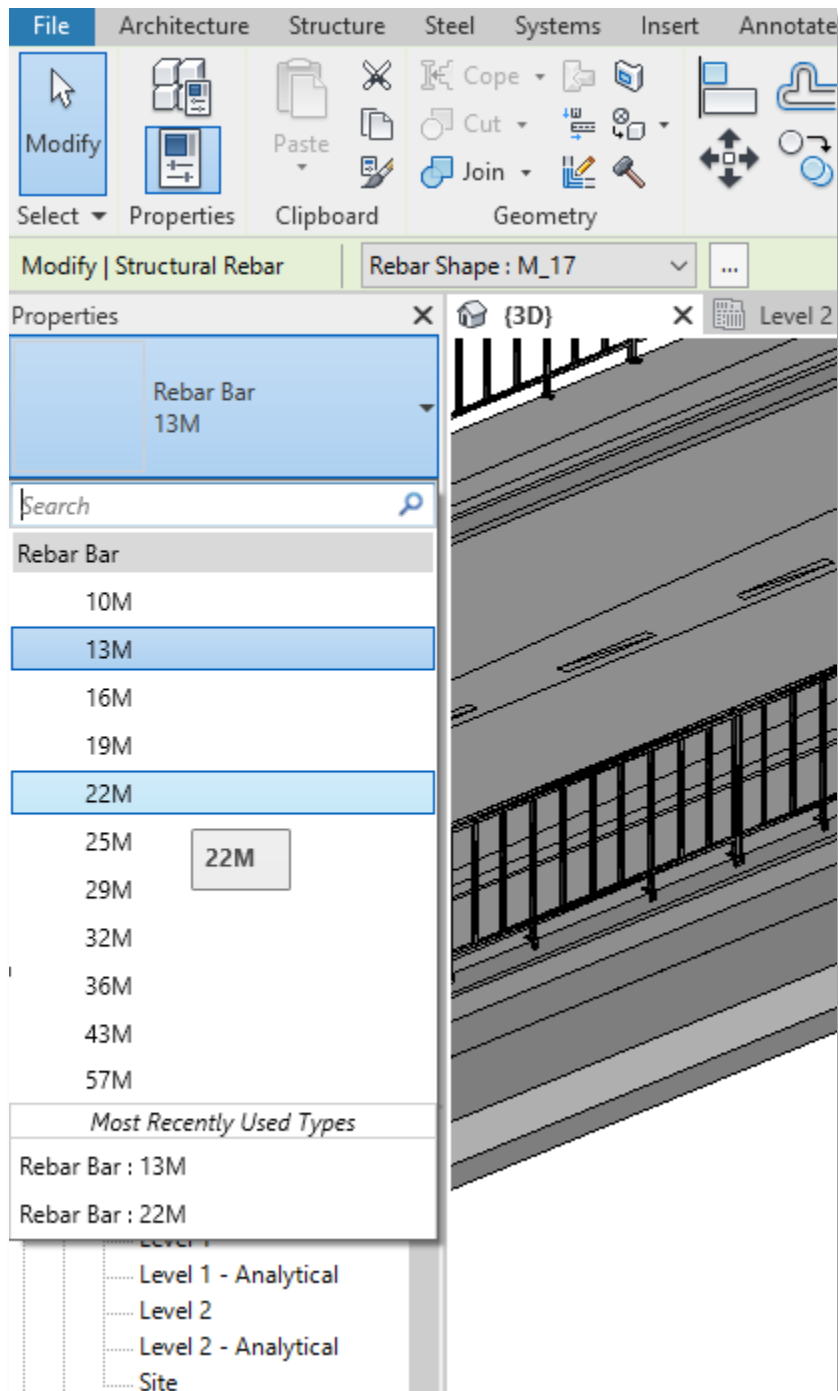
86. Tick both **View Unobscured** and **View as solid** for 3d View {3D}.



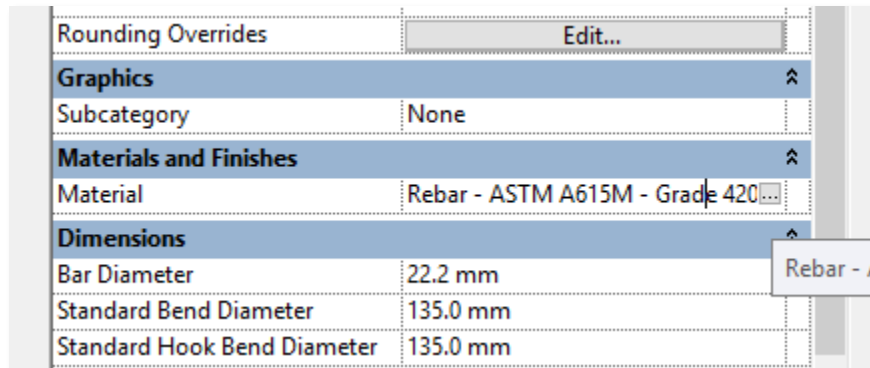


87. Switch to the 3d view to see the bar.

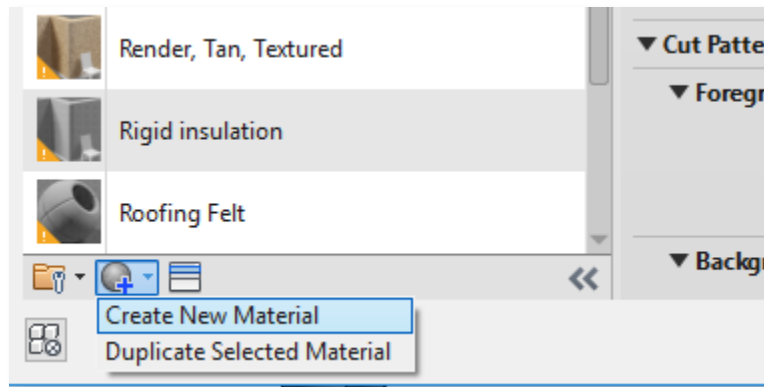
88. Change the bar diameter by click on type selector and clicking on 22M.



89. To change the bar colour click on **Edit Type** in the Properties Panel, then click on the Material selector.



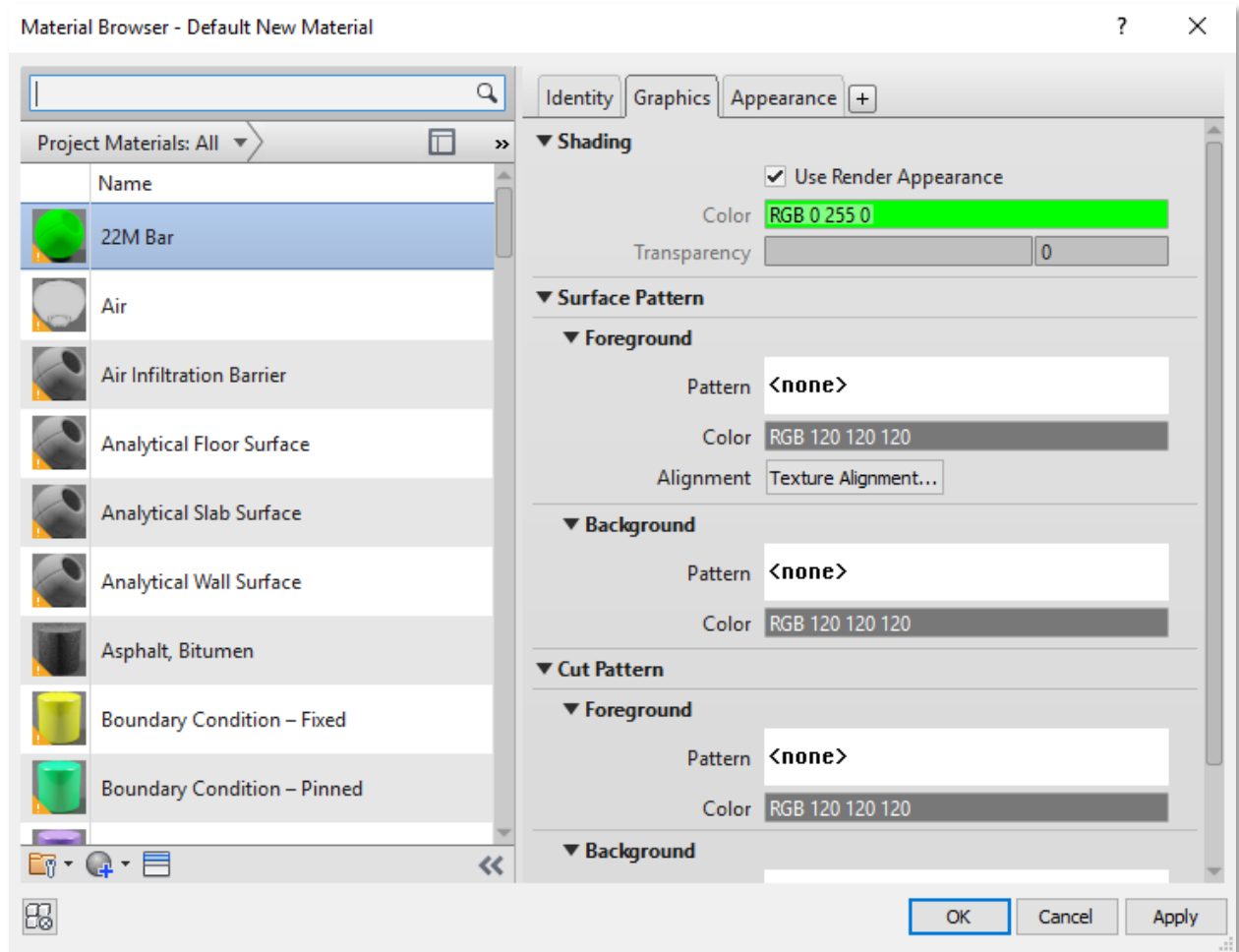
90. At the bottom of the Material Browser click on **Create New Material**.



91. Right click on the **New Default Material** created and rename to **22M Bar**.

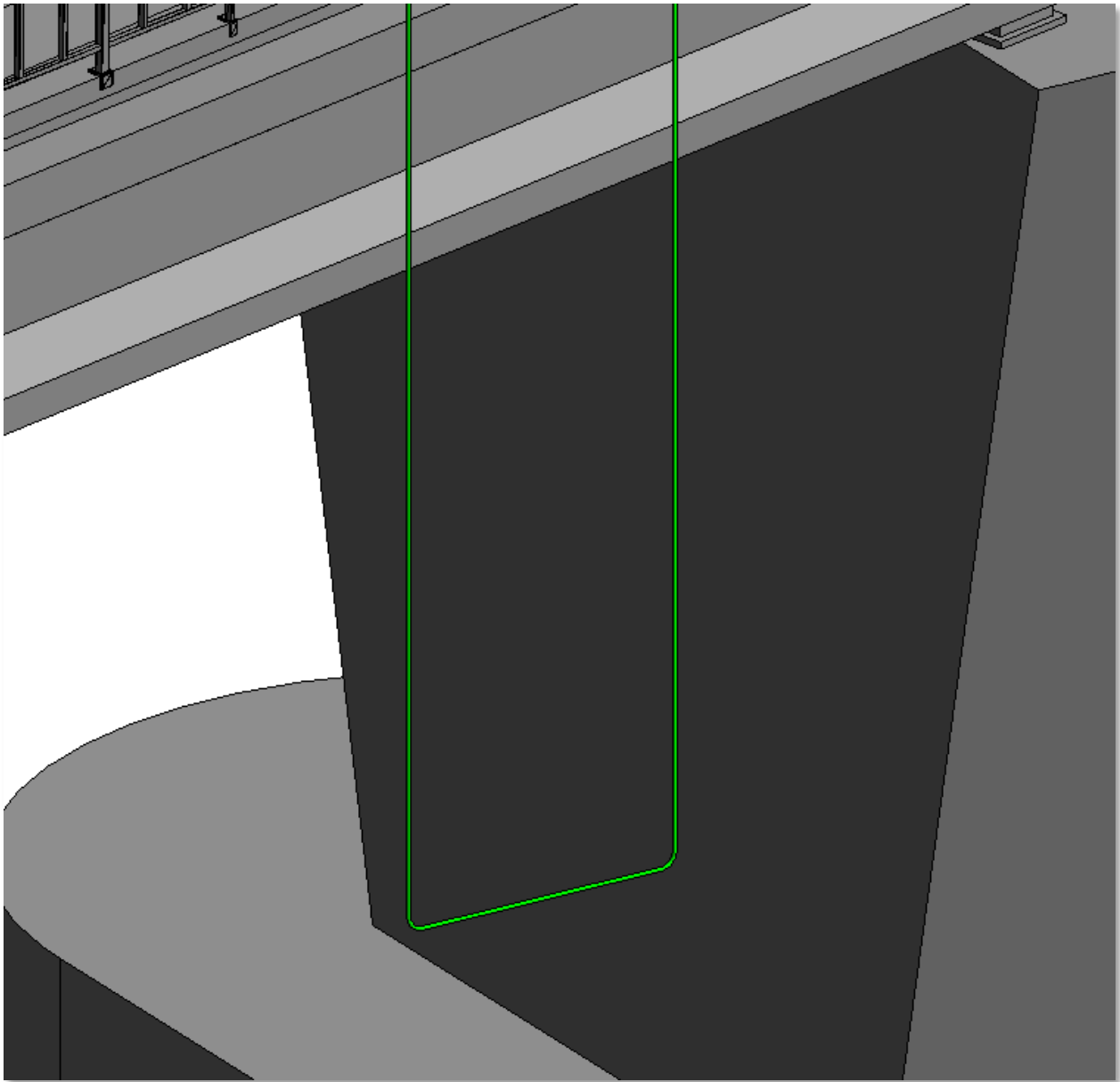
92. With the 22M Bar material selected go to the **Appearance** tab and select an appropriate colour.

93. Then go to the **Graphics** tab and check the **Use Render Appearance** box.

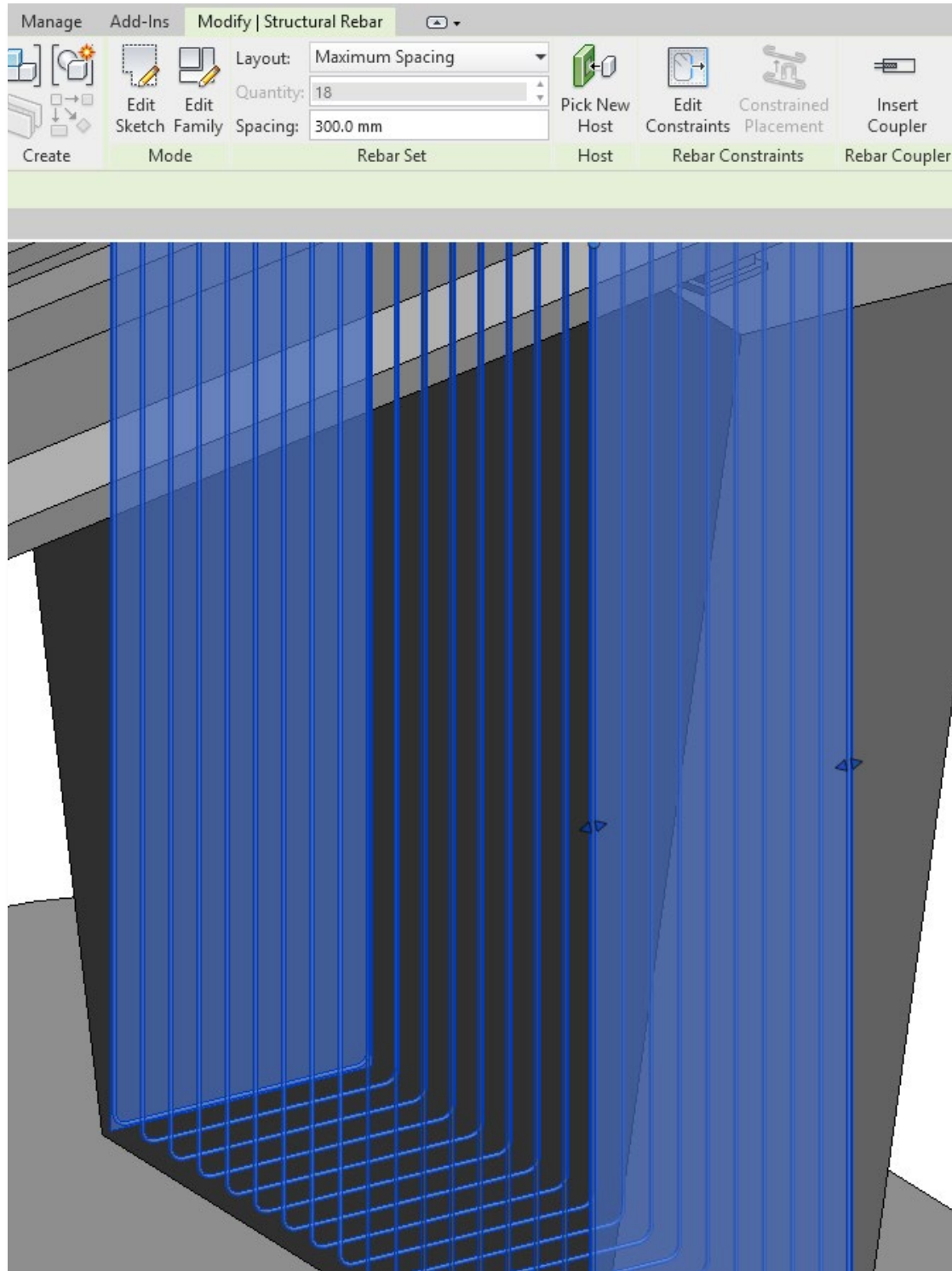


94. Click Apply and OK, then Apply and OK.

95. By deselecting the bar, you will see the new bar with the new material.

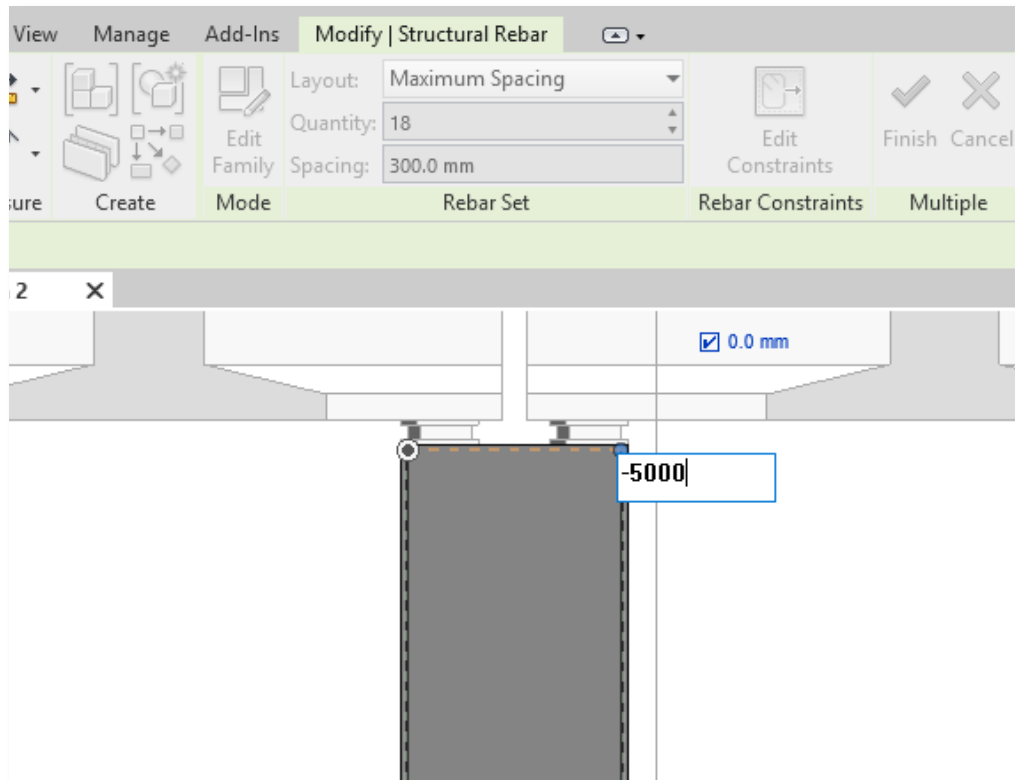


96. Select the bar again and then change **Layout** to **Maximum Spacing** and **300mm**.

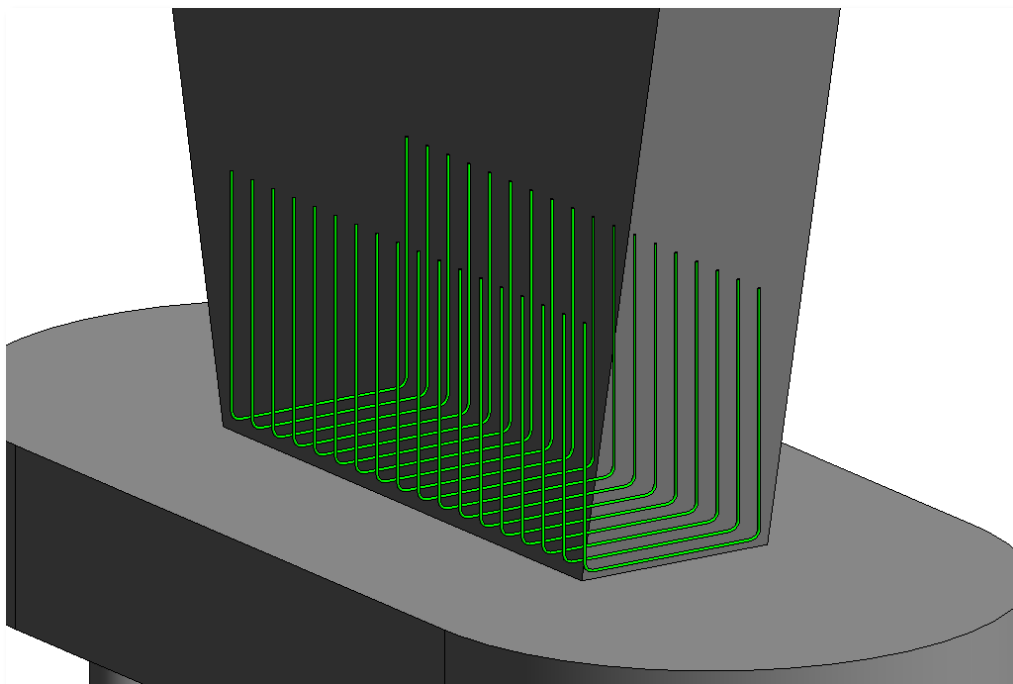


97. Go back to Section 2. Select **Edit Constraints** from the ribbon.

98. Click on the top right blue dot and then enter the value **-5000** to reduce the length of the leg.

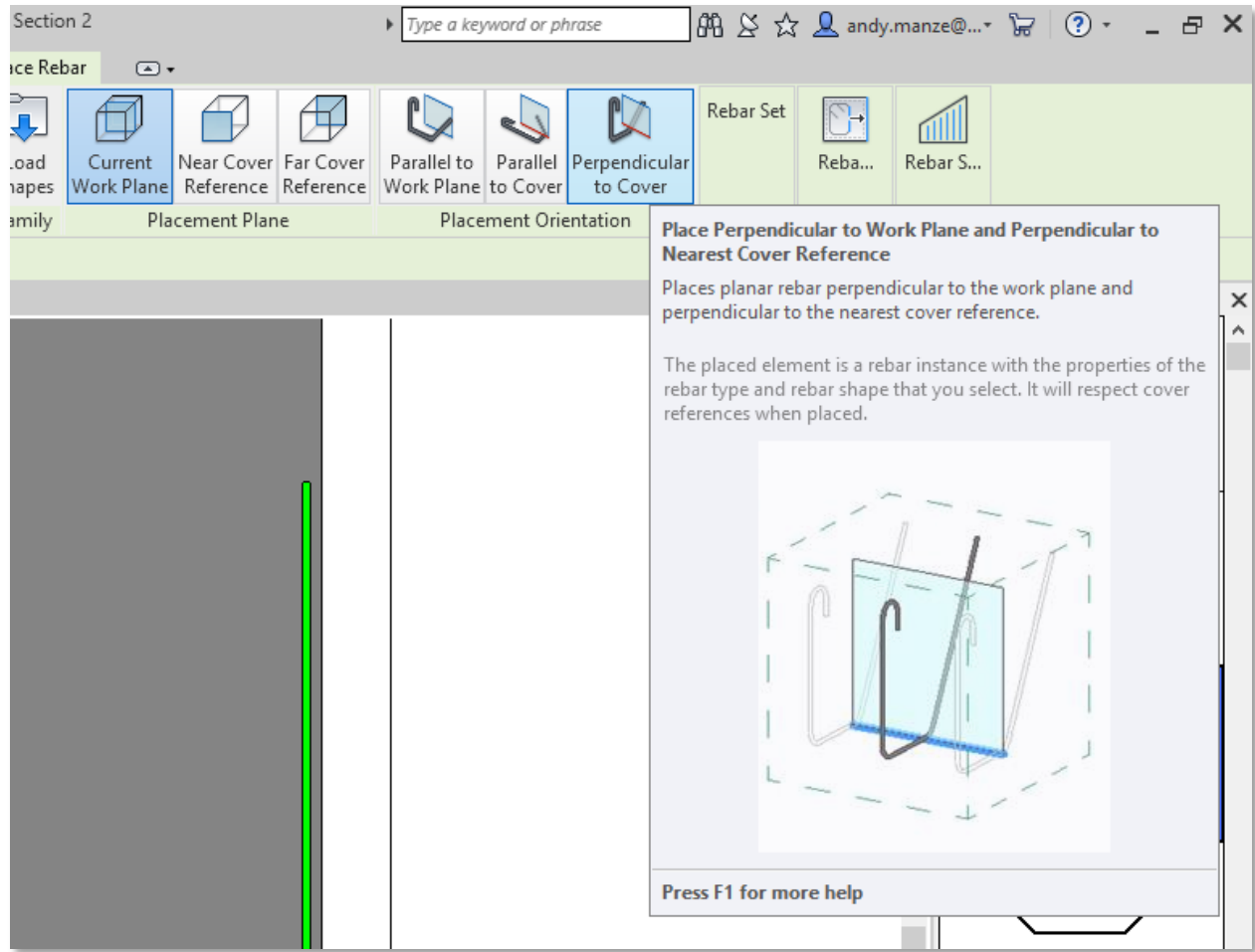


99. Repeat for the opposite leg, then click Finish in the ribbon. You can then deselect and see the effect in the 3d view.

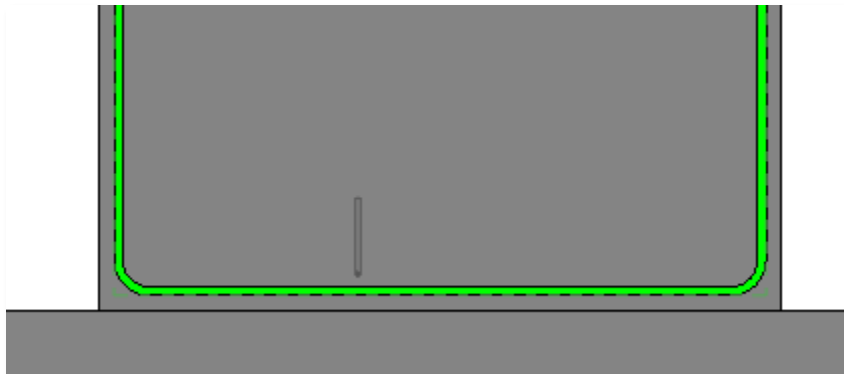




100. Go back to Section 2, select the pier again, choose Rebar and select shape M\_02.  
101. Change the **Placement Orientation** to **Perpendicular to Cover** in the ribbon.

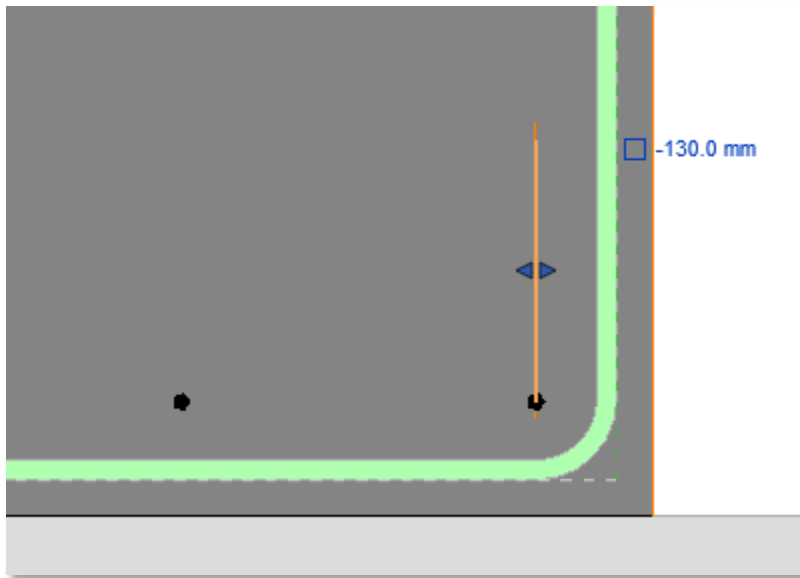


102. Place a bar close to the central leg of the existing bar.

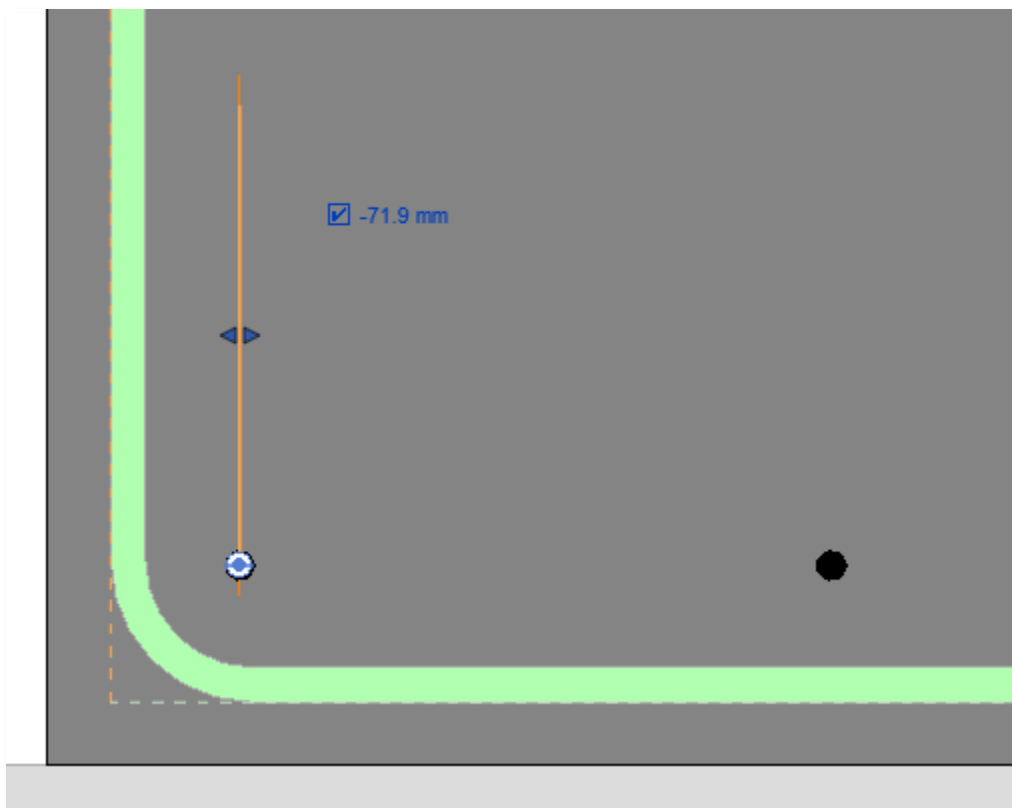


103. Change the bar to **19M** and change the colour as before if desired.

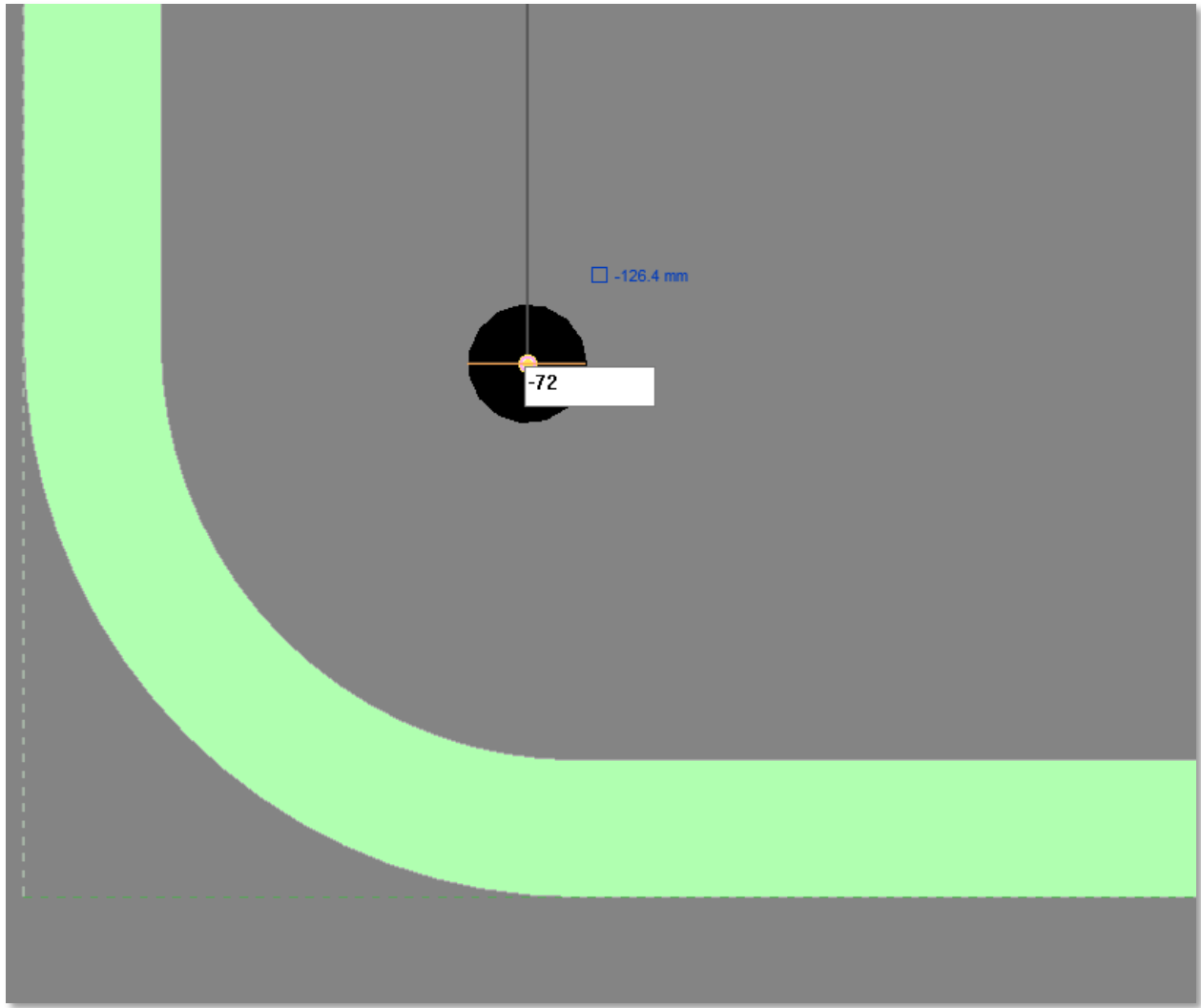
104. Change the **Layout** to **Maximum Spacing** and **Spacing** to **450mm**.  
105. Select Edit Constraints again, click on the right most bar and use the grips to drag it to the left to position it.



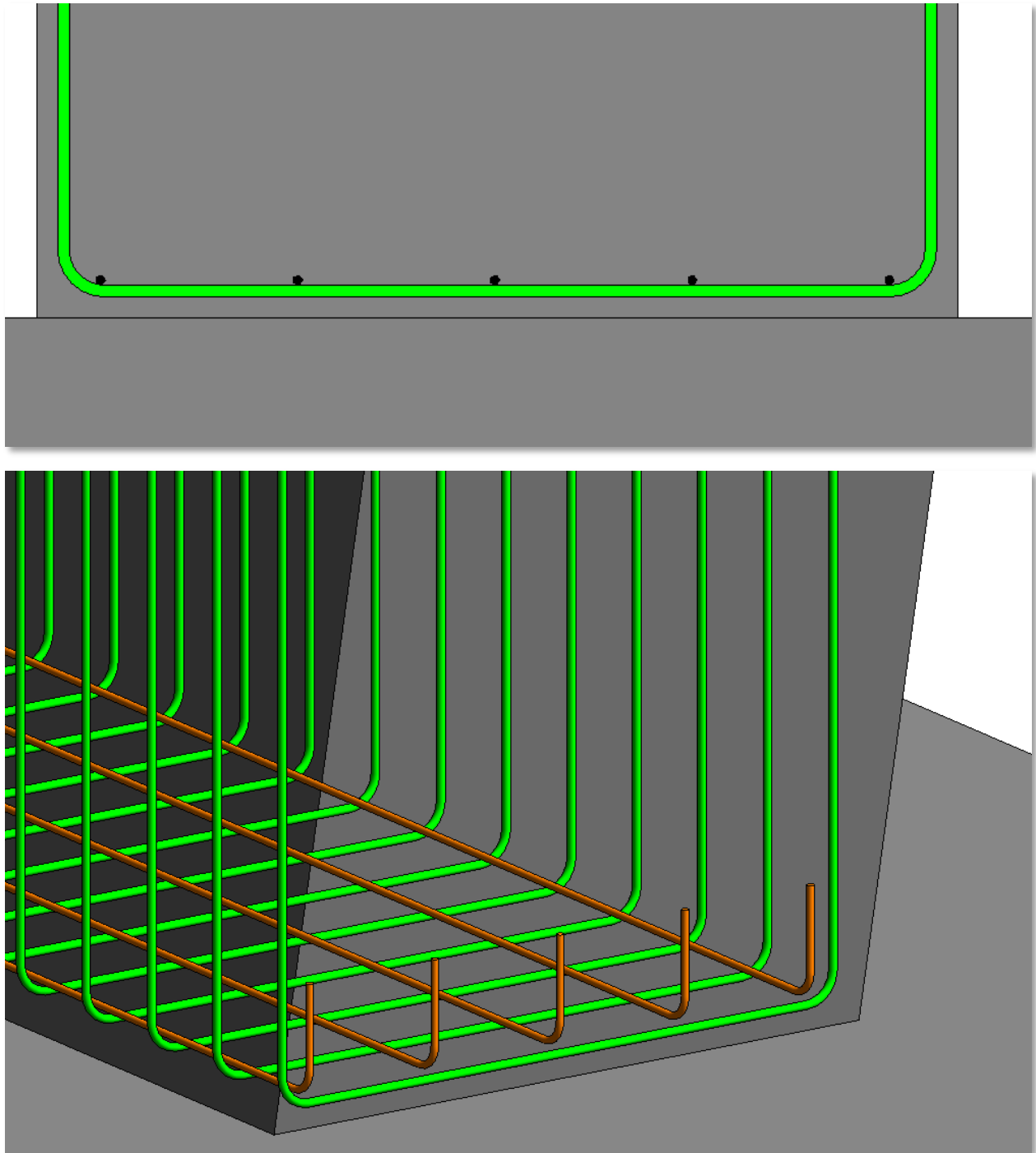
106. Click on the left most bar constraint and this time type a value of -72.



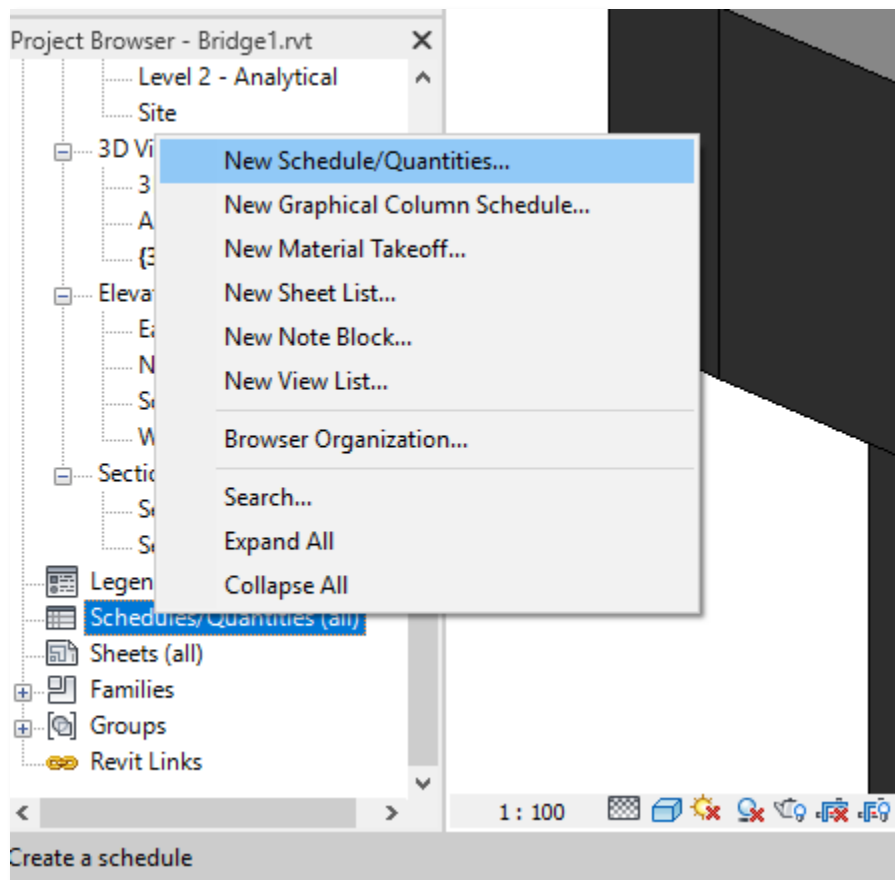
107. Now select the horizontal line within the bar constraint and change the value to -72.



108. Then click Finish in the ribbon. Change Visibility States as before and the bar arrangement should look like this.

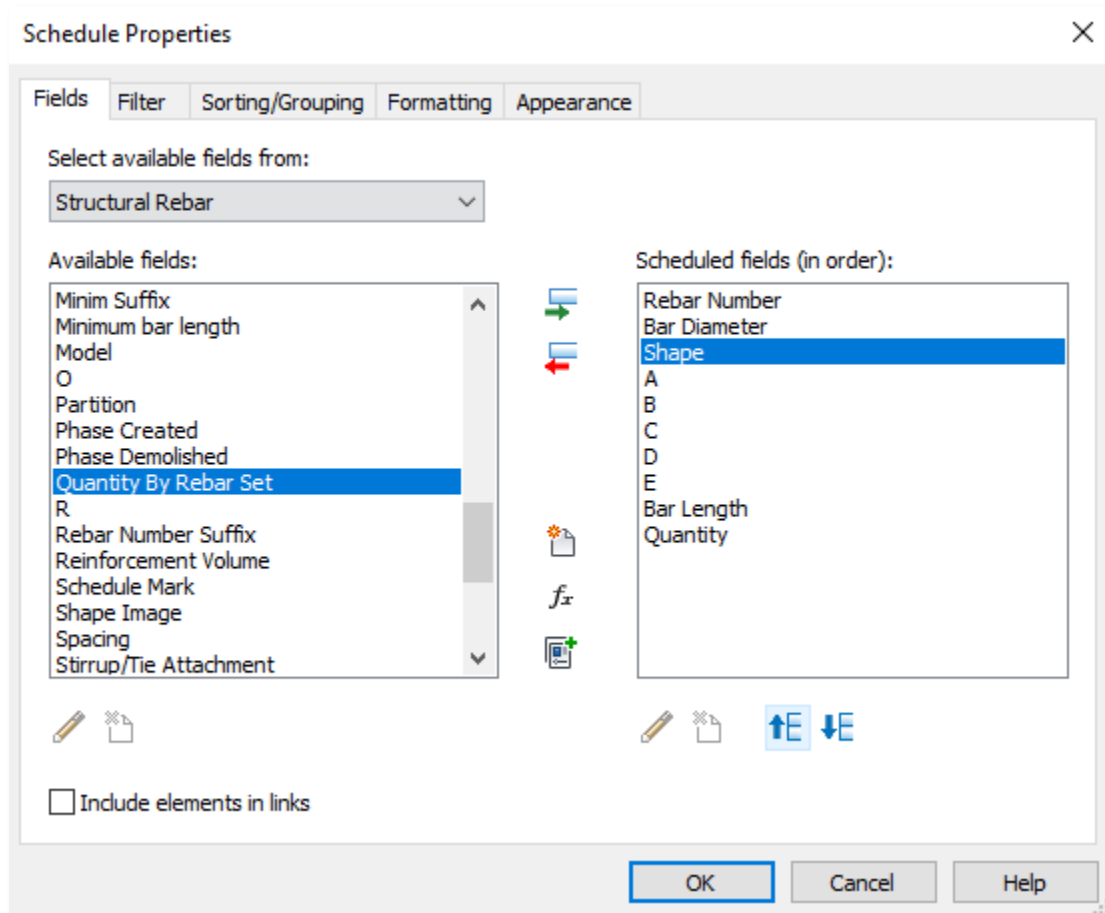


109. To schedule the bars right click on Schedules/Quantities in the Project Browser and choose New Schedule/Quantities...



110. Locate Structural Rebar in the list, highlight it and then click OK.

111. Move the required fields from the left-hand list to the right and reorder them as shown;

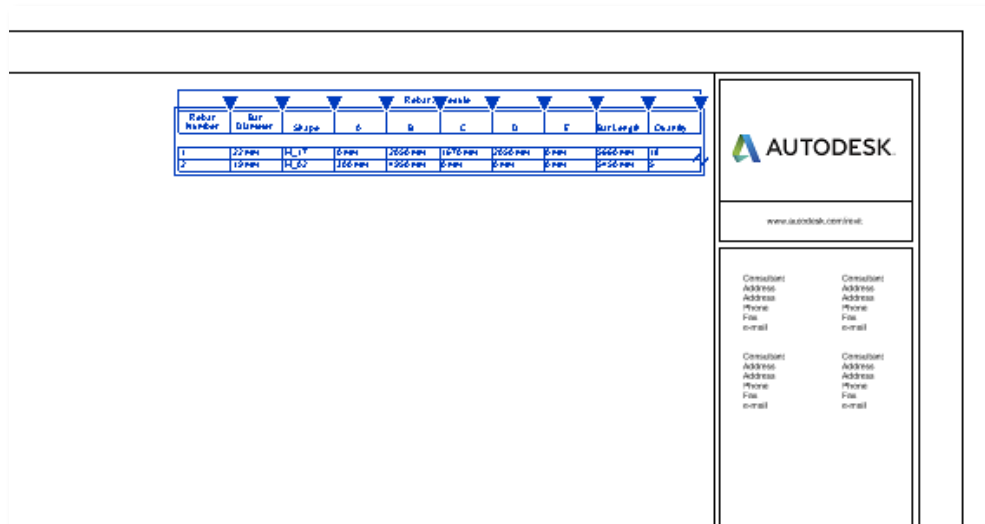


112. Click on OK to reveal the schedule table.

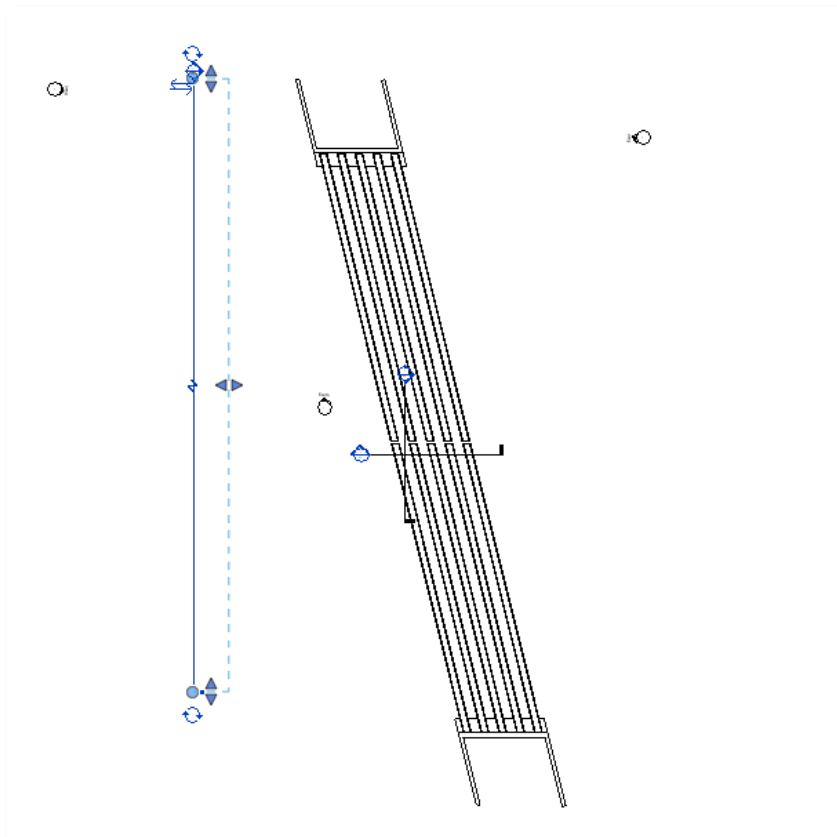
<Rebar Schedule>									
A	B	C	D	E	F	G	H	I	J
Rebar Number	Bar Diameter	Shape	A	B	C	D	E	Bar Length	Quantity
1	22 mm	M_17	0 mm	2050 mm	1670 mm	2050 mm	0 mm	5660 mm	18
2	19 mm	M_02	300 mm	4950 mm	0 mm	0 mm	0 mm	5450 mm	5

113. Right click on **Sheets** in the Project Browser and select **A1 metric** and click **OK**.

114. Expand the Schedules tree in the Project Browser and drag the Rebar Schedule onto the sheet and position.

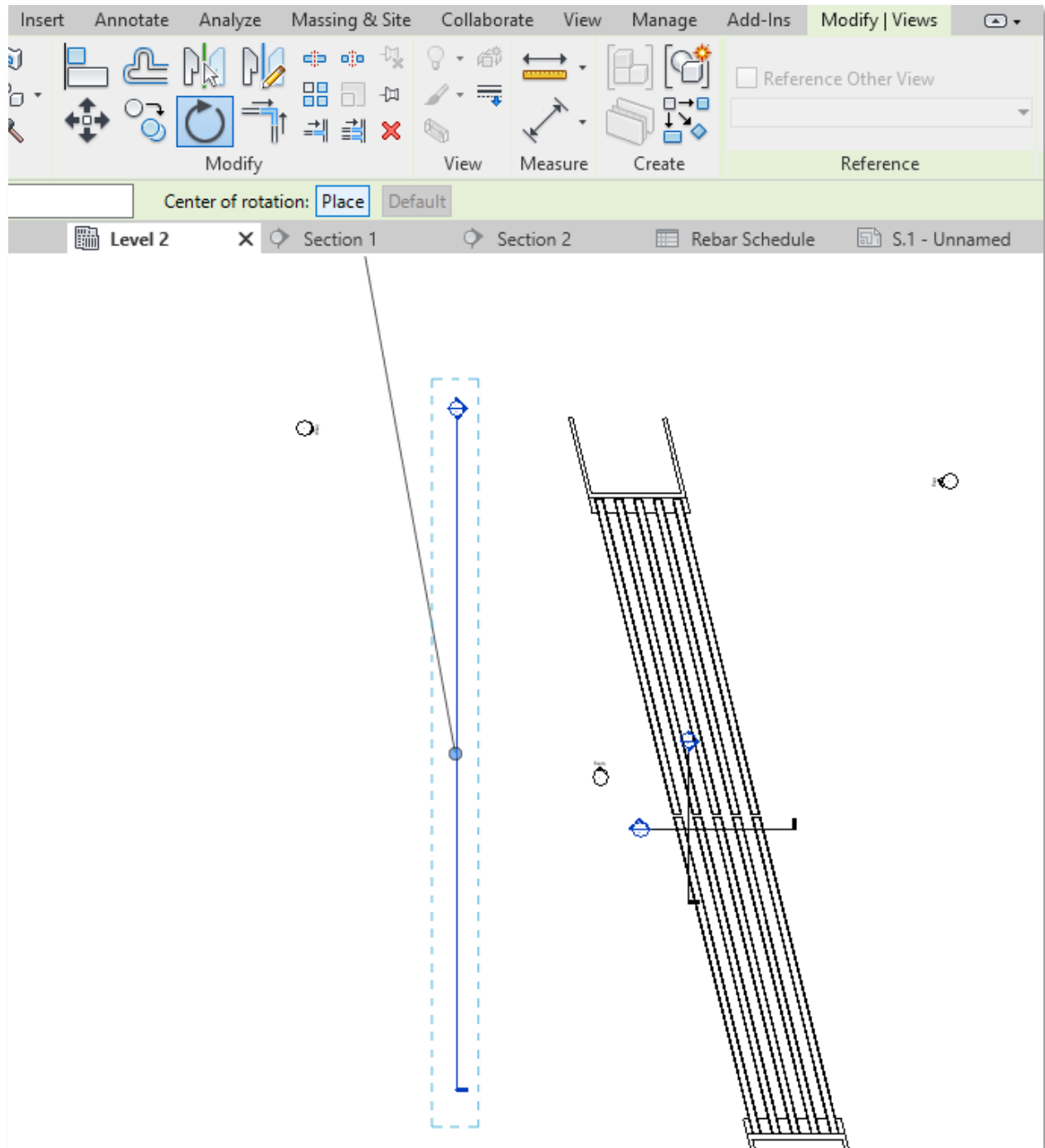


115. Go back to Level 2 view.
116. Select the Section tool and create a new vertical section.

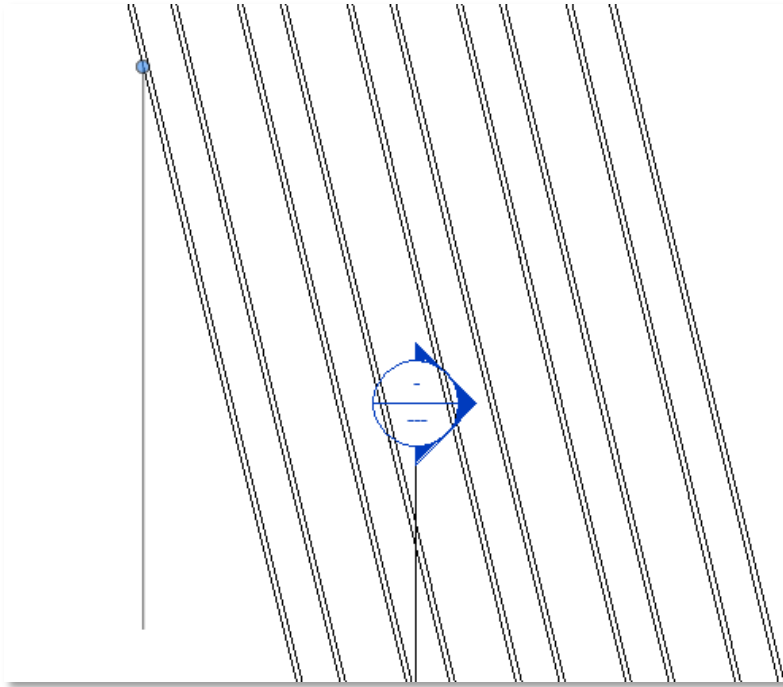




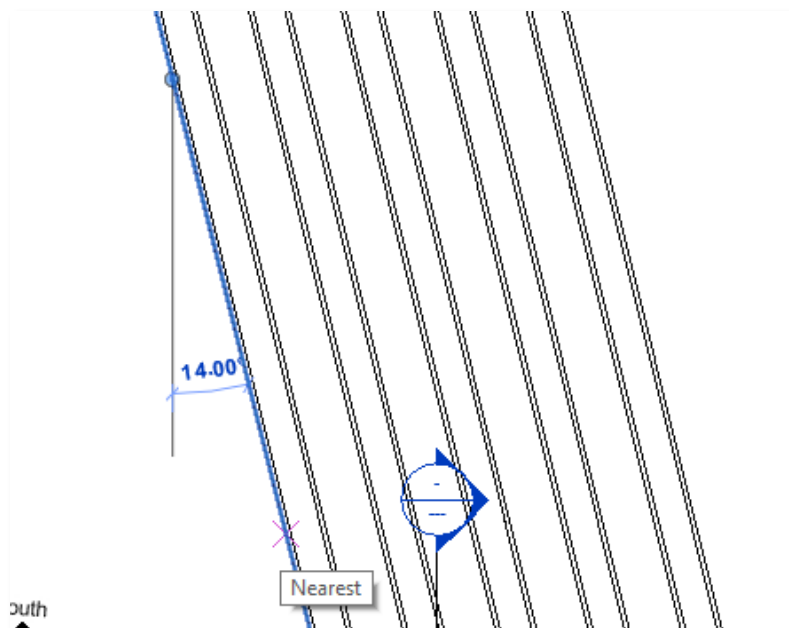
117. Then from the Modify area select Rotate and the choose Place for Centre of rotation.



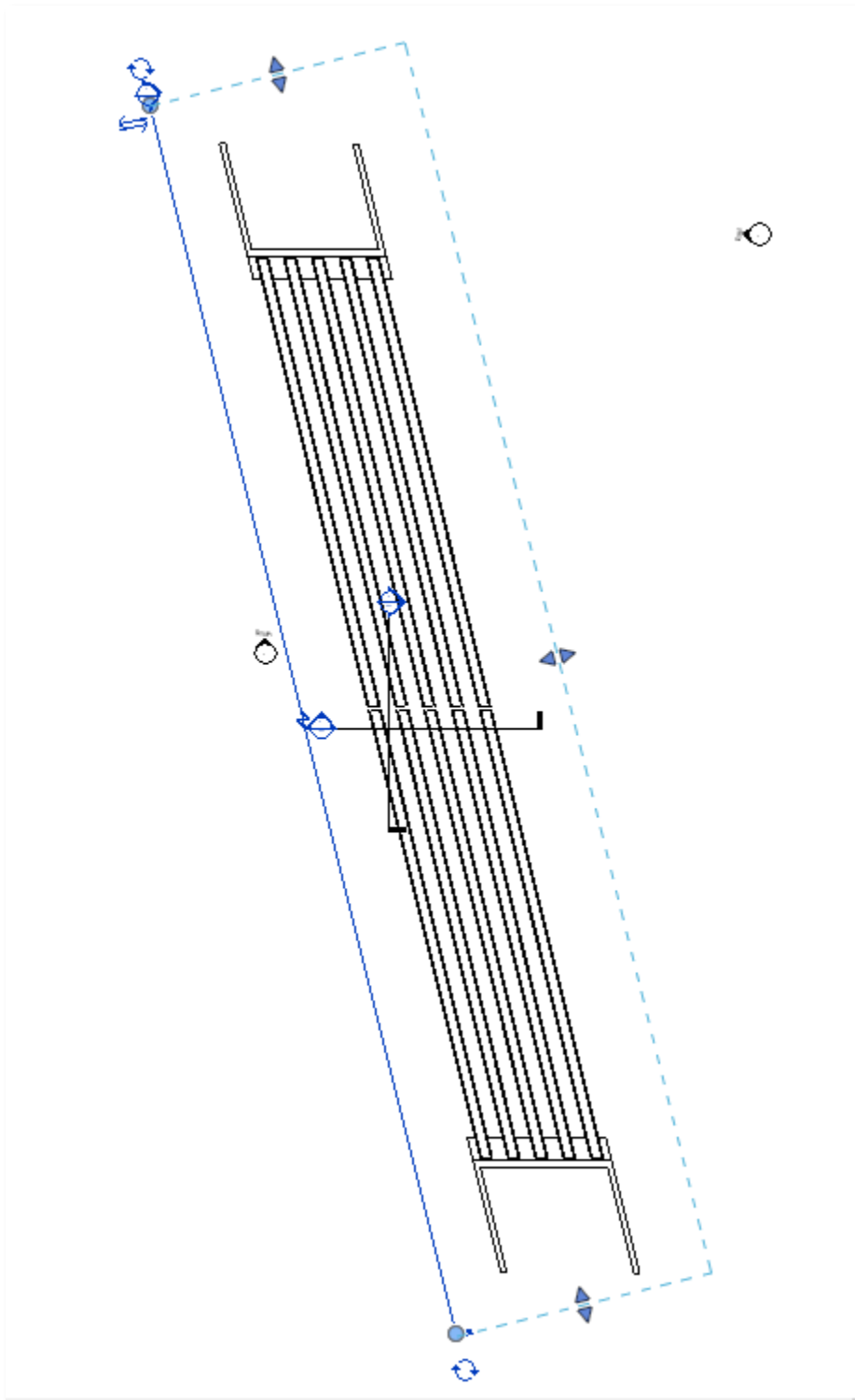
118. Place the centre of rotation on one of the girder edges, then drag vertically down and click.



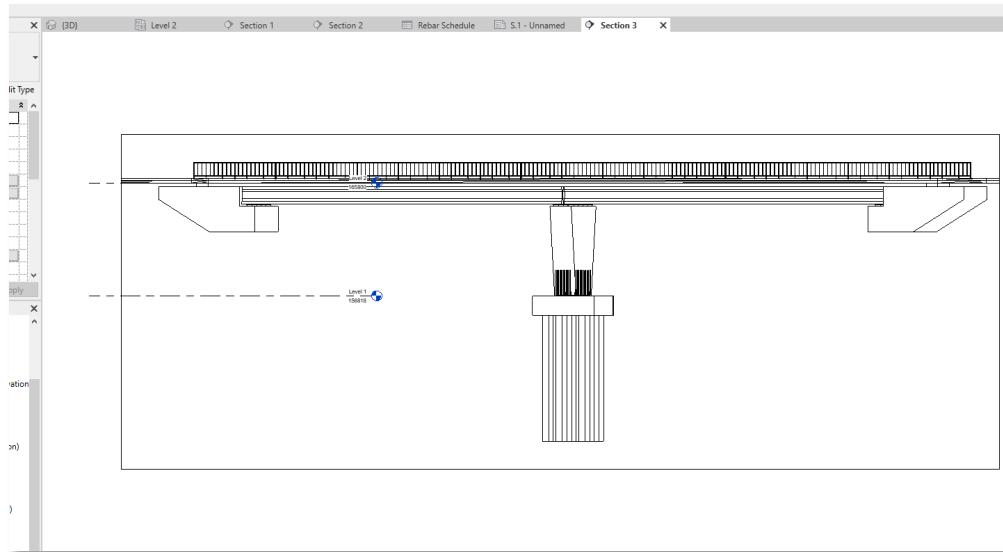
119. Then select the edge again, as shown, to rotate the view.



120. Drag the view into place and use the grips to change the coverage so as to replicate the view below;

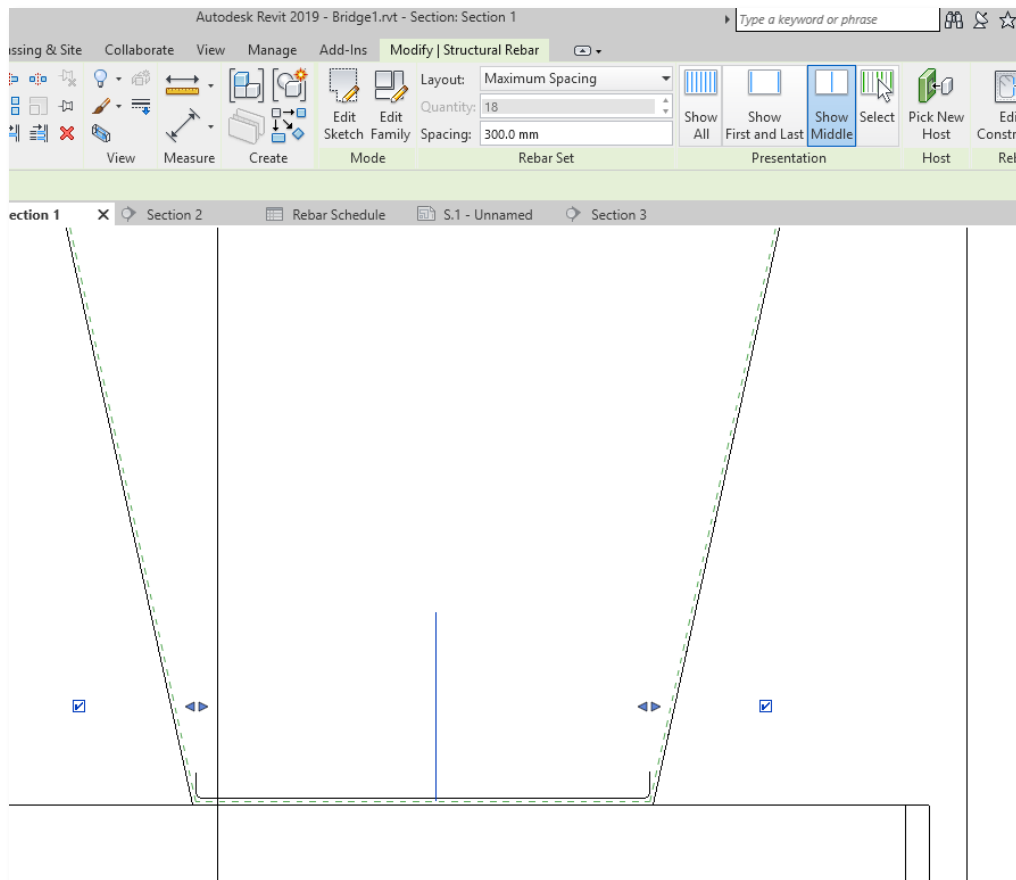


121. Deselect the view tool then double click the section marker to go to the created view.

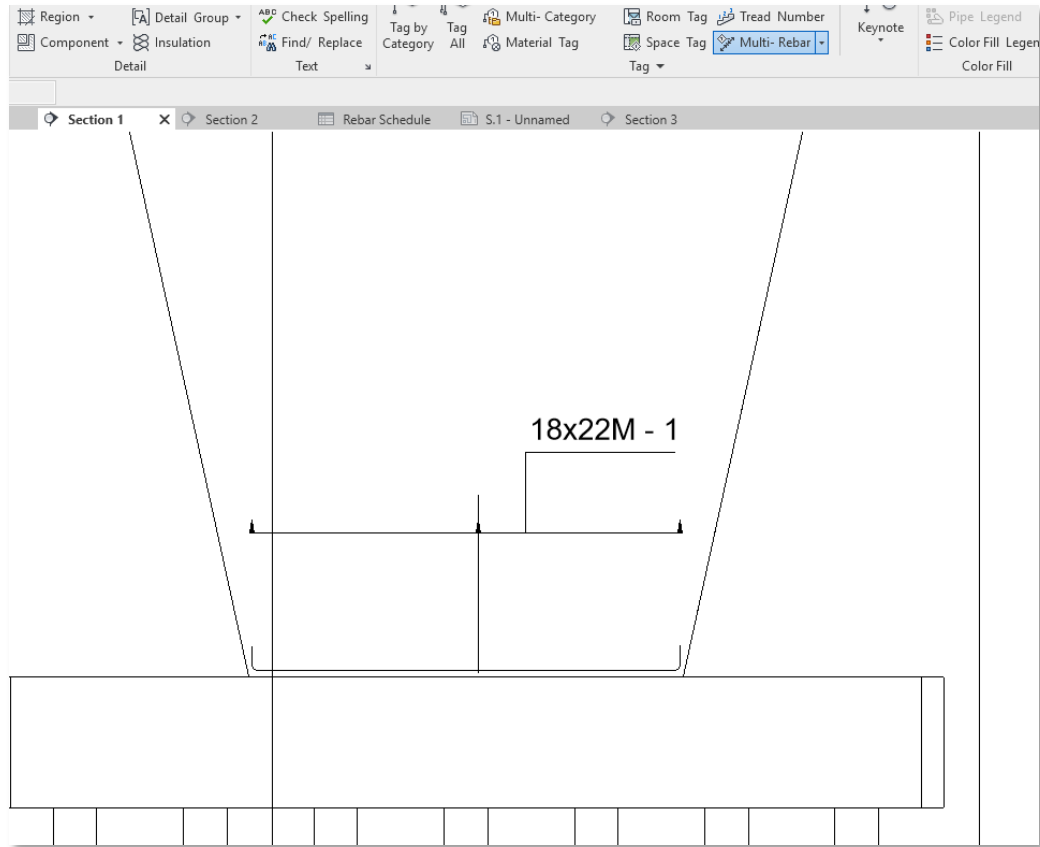


122. Go back to Section 1.

123. Click on the U bars and select Show Middle from the presentation area of the ribbon.

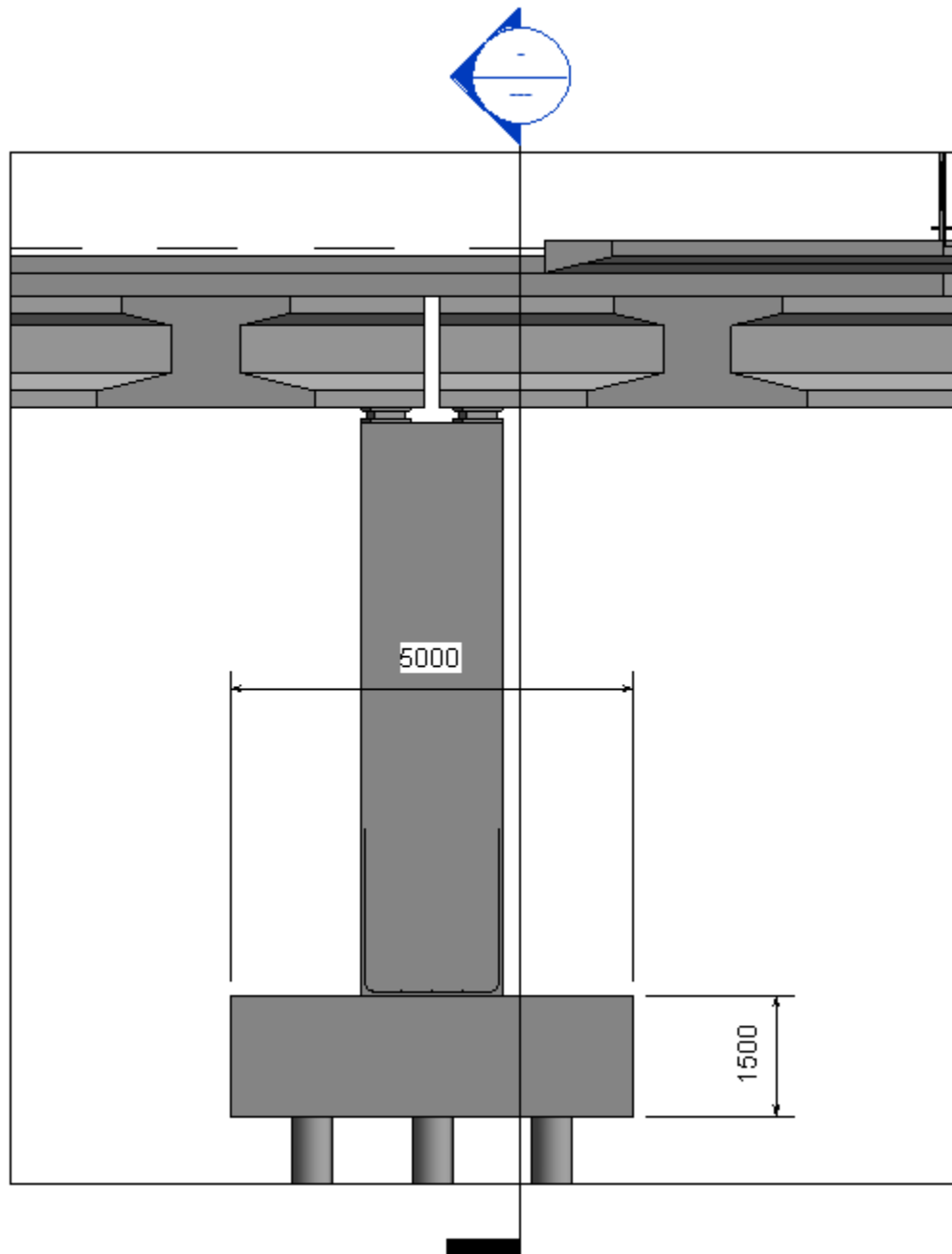


124. From the Annotate tab on the ribbon select Multi-Rebar and then Aligned Multi-rebar annotation.
125. Click on the single U bar and drag the annotation to a convenient location.

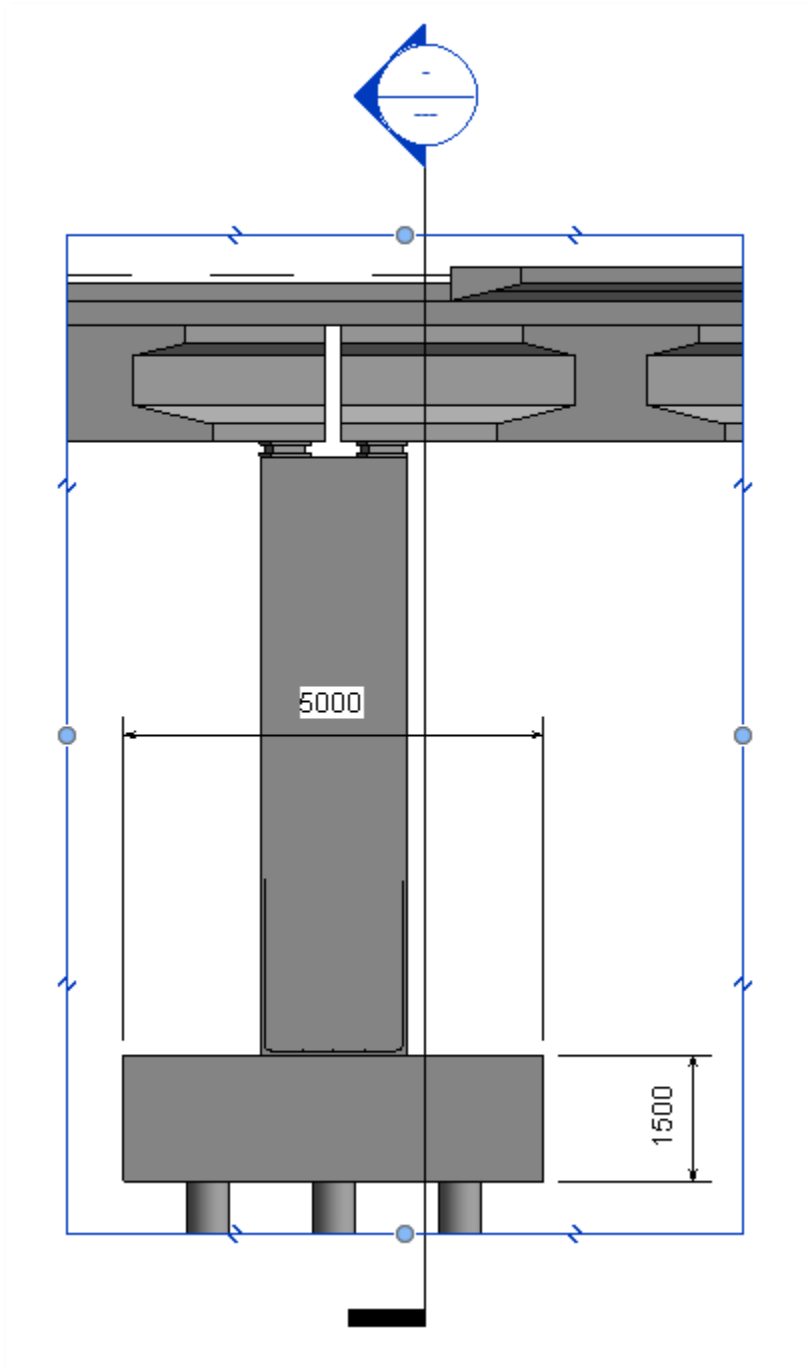


126. Go to Section 2.
127. Click on Linear from the Annotate > Dimension tab on the ribbon.

128. Click on the corners of the foundation to generate dimensions and click to position them.

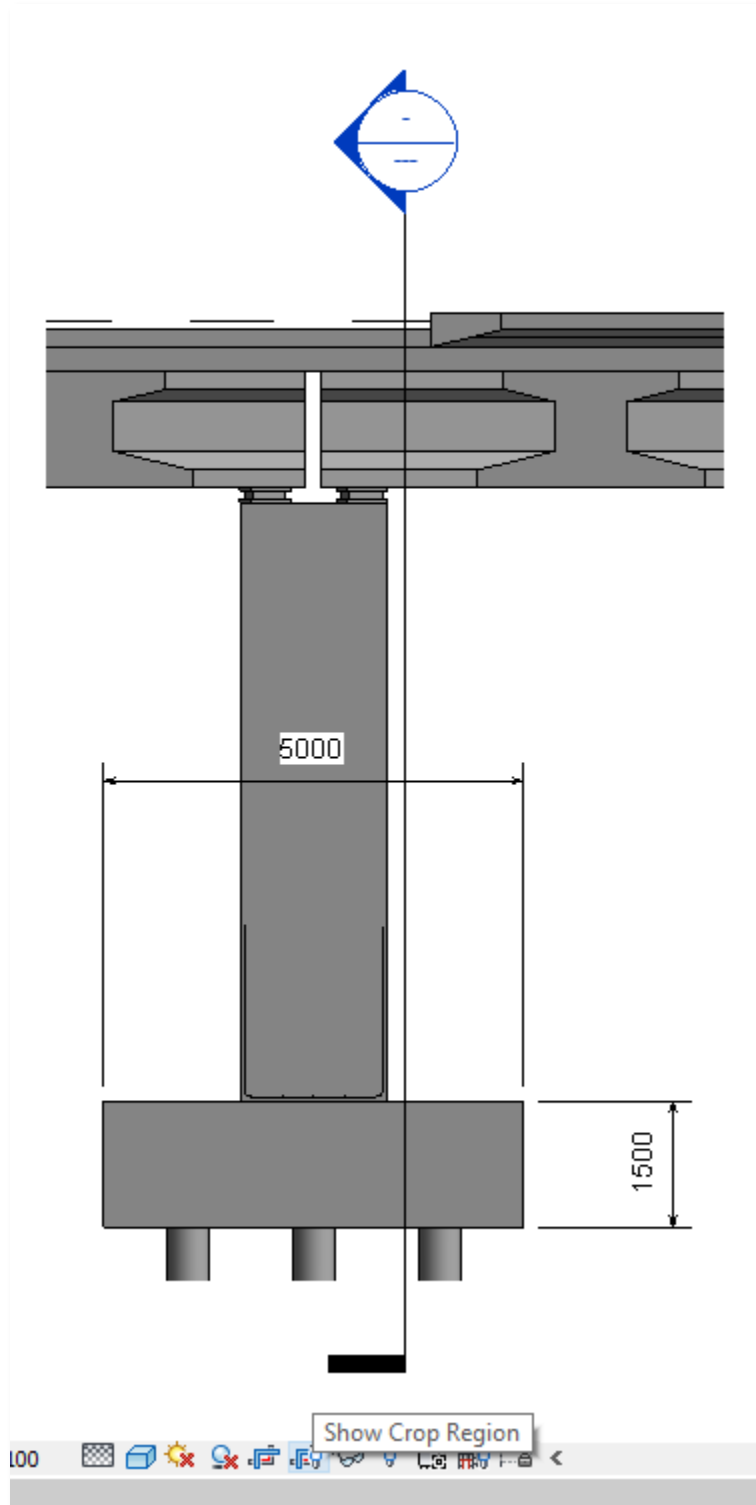


129. Click on the outer rectangle and use the grips to position the Crop appropriately.

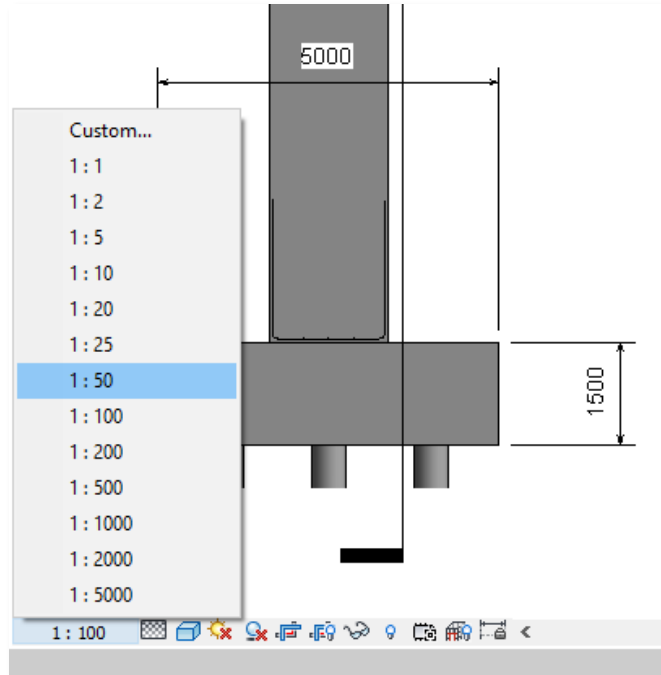




130. Hide the crop region.



131. Change the scale to 1:50.



132. Switch to the sheet view and drag the Section 2 onto the sheet and position it.

