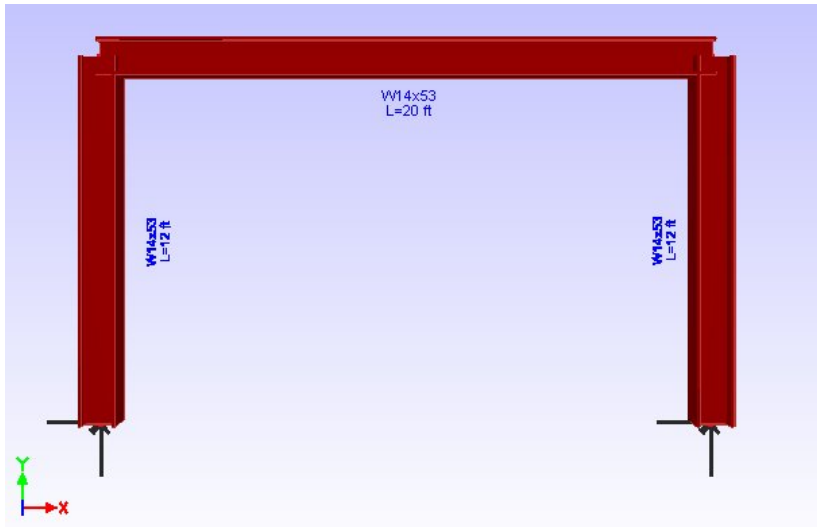


Semi-Rigid Connections

Project Description:

This example will use a simple frame to demonstrate the use of semi-rigid connections.



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 Connections
 Constant Stiffness
 Graphical Results
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 Model

The columns and beams are all W14x53 members. The columns are pin supported at the base. When you are finished creating the model, make a copy of the frame in the X direction, then select both frames and make a copy in the Y direction. When you are finished you should have four frames in a "square" pattern.

Modeling the Structure

Semi-rigid connections essentially allow the joint to act somewhere between a full moment connection and a pinned (simple or truss) connection. Which end of the spectrum depends on the rigidity of the connection and the model used to describe it. VisualAnalysis has three models to describe semi-rigid connection behavior; the constant stiffness model, bilinear stiffness model, and the three parameter power model. All of these models are described in terms of the connection's moment rotation curves. Therefore typical rigidity units are lb-in/radian or in some texts just lb-in. Texts such as those given in the User's Guide (**Help | Contents**) provide formulas and tables for determining appropriate rigidity values based on the type of connection and other parameters. In this tutorial we will simply look at each of the three models and their behaviors using the simple moment frame above. The Semi-Rigid Connection parameters can be found on the Modify Tab of the Project

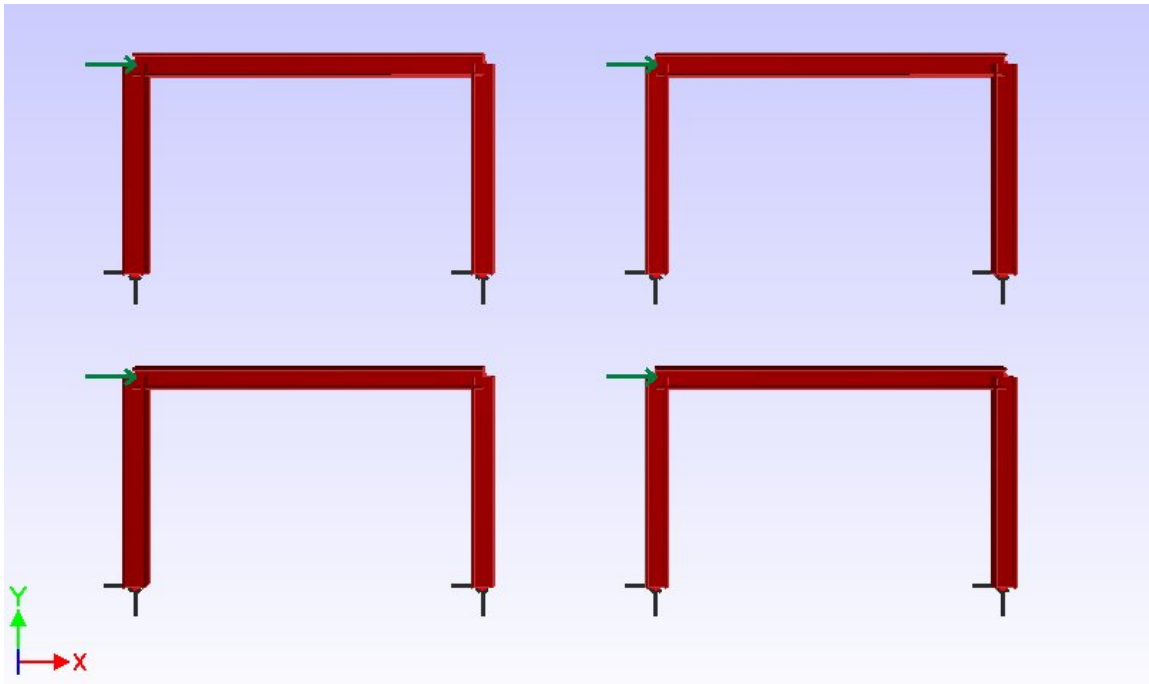
Constant Stiffness Model

Just like it sounds, the constant stiffness model has a linear moment-rotation curve with the slope of the line being the stiffness of the connection. One significant difference between this model and the other two is that this model does not provide any "capping" moment on the behavior. The connection simply follows this stiffness to carry as much moment as the loading induces. We will discuss this more after we have looked at the other two models.

The top left frame will be left as is which should be a normal moment frame (no releases and no semi-rigid connections). **Select** the beam in the top right model and open the "Semi Rigid" menu in the "Modify" tab. For Node 1 Rz, **select** the Constant setting and change the rotational stiffness to 3,490,700 lb-in/deg.

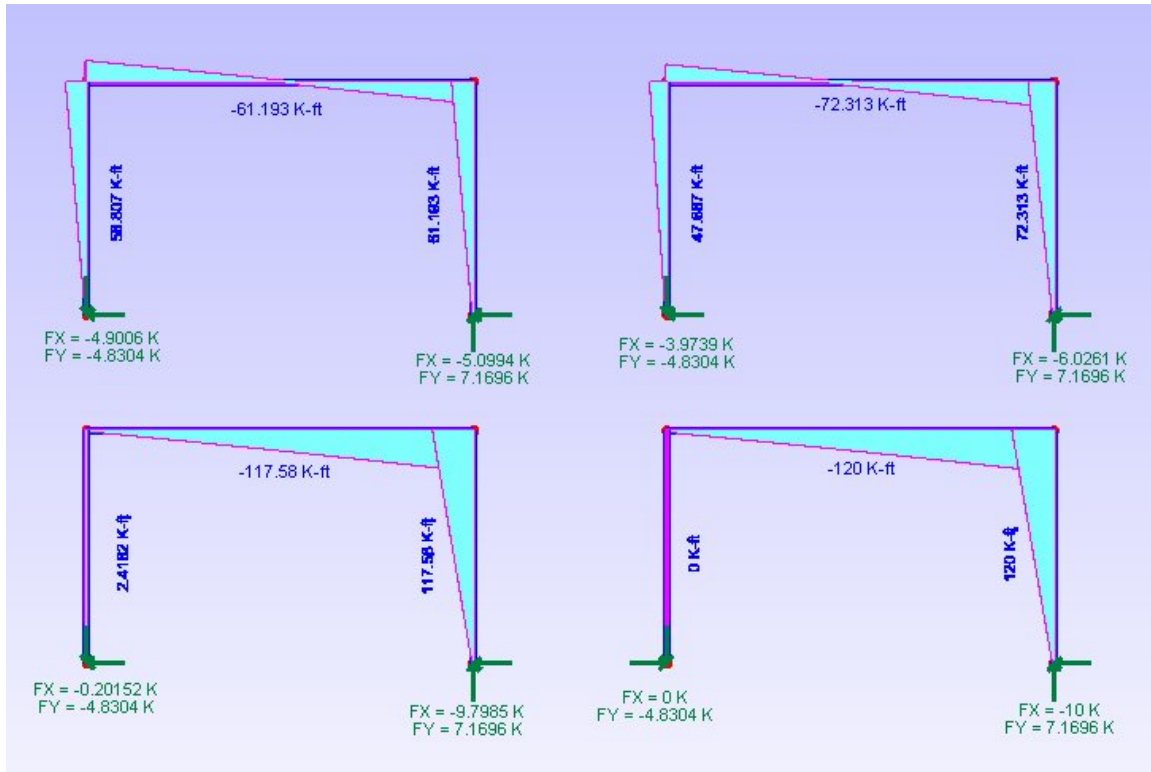
Semi Rigid	
Node 1 Rz	Constant
Stiffness 1	3490700 lb-in/deg
Node 2 Rz	None

Following the same procedure specify a semi-rigid connection using the Constant Stiffness model and rigidity of 34,907 lb-in/rad for the beam in the lower left frame. Lastly, select the beam in the lower right frame and release the strong axis moment at the left node so that it is fully pinned (simply connected).



Four Frames; Top Left Beam Connection Varies from Full Moment to Pinned Connection

After you analyze the models, **click** on the Filter tab of the Project Manager and change the Results to Mz and the Graphics to Diagram. Also, uncheck the Displaced shape box if it is not already. Your Result View should look something like the following.



Four Frames with Mz Moment Diagrams Shown.

Plotting the bending moments really shows the variation in stiffness in the top left joint from a full moment connection to a pinned connection.

	Beam Left End Mz [K-ft]	Beam Right End Mz [K-ft]
Moment Conn. (R = Infinity)	58.8	-61.2
Semi-Rigid (R = 3,490,700)	47.7	-72.3
Semi-Rigid (R = 34,907)	2.4	-117.6
Pinned Connection (R = 0)	0.0	-120.0

As you can see from the table, for a full moment connection the distribution of positive and negative moment at the ends is quite even. But, as the left connection becomes more flexible more moment goes to the right hand connection. This also shows the importance of accurately modeling a connection. If a connection had some flexibility but it was modeled as a moment connection, the right hand connection could be substantially under designed.

Bilinear Stiffness Model

As the name implies, the bilinear stiffness model has two linearly varying "sections" in the moment-rotation curve and therefore takes two rigidity values, and a transition moment. The connection will behave just like the constant stiffness model until it reaches the transition moment, at which time it will use the second rigidity value specified. Note that the second rigidity value can be zero, essentially making the transition moment a "maximum" or "limit" moment. By specifying the transition moment as the plastic moment capacity of the member, you could approximate a plastic analysis procedure. Also note that members would have to be split to model any hinging behavior not occurring at a column connection if you really wanted to approximate a plastic analysis procedure.

Three Parameter Power Model

The three parameter power model takes the bilinear stiffness model further by fitting a curve to describe the moment-rotation curve. This model takes a shape factor, initial rigidity, and an ultimate moment. As shown in the curve in the VisualAnalysis Advanced section of the User's Guide (**Help | Contents**), the shape factor controls the steepness of the curve. For larger values of n , the curve will more closely approximate the two straight lines formed by the initial rigidity and the ultimate moment. Feel free to experiment with this model and the bilinear stiffness model on one of the frames used above.

Reporting

There is only one report specific to semi-rigid connections. The Advanced section of the User's Guide discusses the items available under this report option. General reports such as member internal forces, stresses, displacements, etc., are all available for members with semi-rigid connections as well.