# SEMI-RIGID DIAPHRAGMS IN RAM STRUCTURAL SYSTEM V8*i*

Structural Team Screencast 004

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# INTRODUCTION

Hello, and welcome to the **Bentley Structural Team** screencast. I'm *Jason Coleman; a Senior Technical Writer* with Bentley Systems.

Today, I'm going to present to you a new feature in **RAM Structural System V8*i*** called the Semi-rigid diaphragm.

Diaphragms in RAM Frame are classified into four types:

- Rigid – Rigid body behavior distributes load as a function of the relative stiffness of the supporting vertical elements.
- Pseudo-Flexible – Lateral loads are applied by the user.
- Flexible (None) – Loads are shed to supporting elements regardless of their relative stiffness.
- Semi-rigid – New diaphragm type which accounts for diaphragm stiffness.

A semi-rigid diaphragm will be meshed into shell elements and then analyzed along the vertical structure in RAM Frame. The diaphragm behavior and load distribution will be determined by the relative stiffnesses of the diaphragm and the supporting vertical elements.

# EXAMPLE

We will look at the following model to demonstrate the new semi-rigid diaphragm type:

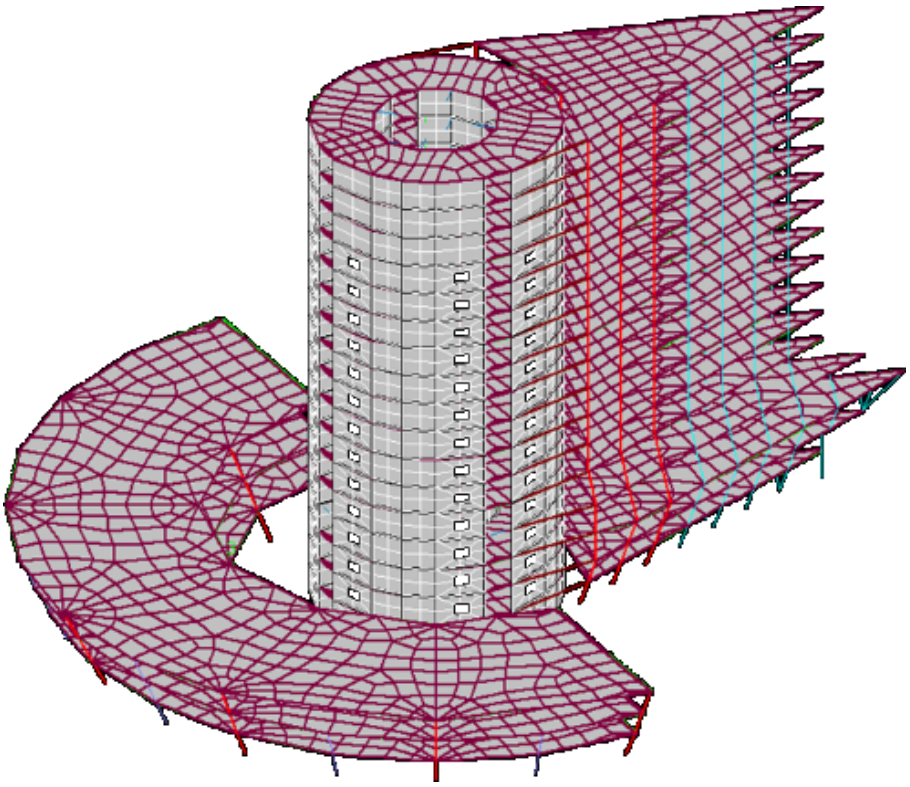

Figure 1: Example structure with semi-rigid diaphragms in RAM Frame.

Here, we see the structure has been opened in RAM Frame and is almost ready for analysis.

First, we must set the General Criteria. Note that a new In-Core solver has been added, called the Sparse solver. As using semi-rigid diaphragms greatly increases the number of degrees of freedom necessary to solve the structure, making use of the Sparse solver will greatly reduce the time required to analyze the structure. With this option selected, click OK.

Next, the Diaphragm Criteria must be specified. Here, for each diaphragm in the structure we can select which of the four types to use. For this example, we wish to analyze all diaphragms as semi-rigid, so we'll just click the All Semi-Rigid button to quickly specify them as such. Upon clicking okay to accept the changes, the program proceeds to mesh the diaphragms automatically. Walls are also

meshed now as this has yet to be done for this model.

Once this process is complete, click Close to dismss the dialog.

There are now two Show Mesh buttons, one for walls and another for diaphragms. Click to display the fully meshed diaphragms. We can view one of the floors in plan to better see the meshing. Now if we display the slab edge, we can see that currently the meshing is bounded by the beam centerline rather than the slab edge. However, we can change this by selecting a different option in the Diaphragm Criteria dialog. The diaphragms are re-meshed and we can now see additional shell elements between the edge beam centerline and the slab edge. Note that this option does add a significant number of additional elements to be analyzed.

Now, we can analyze all the loads on the structure. Note that even with a large number of shell elements, the in-core sparse solver can rapidly analyze the entire structure.

Let’s review the deflected shape of the structure for one of the load cases. Toggle on the Show Mesh for the diaphragms to see their deformed shape as well. However, it is important to remember that these elements loaded in-plane, only. They have no out-of-plane stiffness and loads in that direction are distributed to the supporting vertical elements by means on one-way distribution. The out-of-plane deformations observed in the diaphragms are imposed by the supporting structure.

Let’s take a look at how lateral loads are applied to the semi-rigid diaphragm. First, let’s view the seismic loads on one of the floors. Here, we can see that the mass is calculated and applied at each shell element corner node. This accurately represents the spread mass load across the entire diaphragm. If we toggle off the load view and the display the center of mass, we can see that the center of mass is calculated and applied at each of the corner nodes.

Finally, let's take a closer look at how the mesh is generated with respect to supporting frame and gravity elements. Diaphragm nodes coincide with frame elements, but not necessarily those of gravity elements.

To read more of the technical background on semi-rigid diaphragms, be sure to read the article by Bulent Alemdar and Rakesh Pathak at the Bentley Structural Team blog found at BE Communities.

And for more information on the RAM Structural System, to sign up for training, or to learn about Bentley licensing, be sure to visit Bentley.com.

I'm Jason Coleman and this has been a screencast demonstrating semi-rigid diaphragms in RAM Structural System V8i. Thanks for watching.