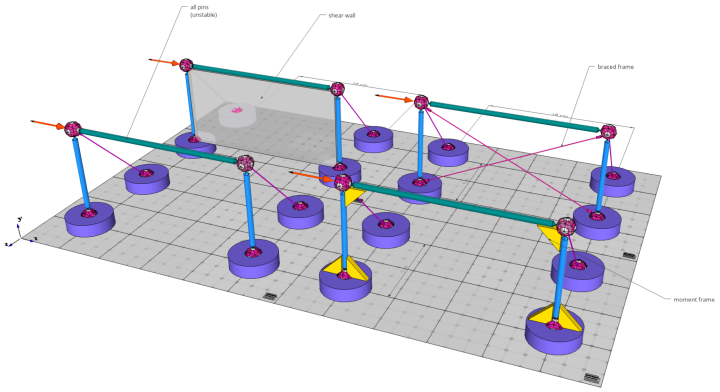
Build + Connect

#07 The Single-Story Diaphragm

How does a diaphragm transfer lateral forces to moment frames and to braced frames?

Part I. Review of lateral systems

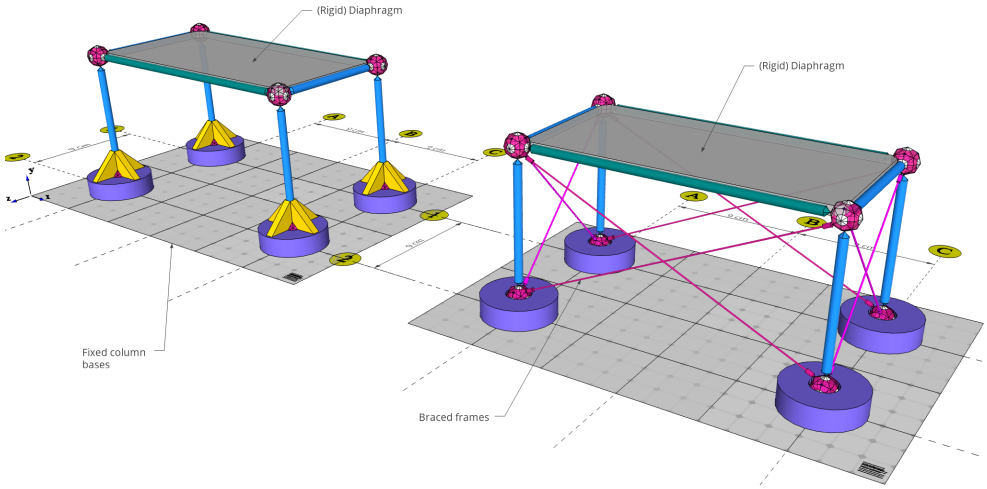
Recall *Build + Connect #05 - Lateral Systems for Buildings.* In that exercise, you compared and contrasted the lateral performance of four frames by loading each frame in-plane. You noted that the stiffest structure was the shear wall, followed by the braced frame, and then the moment frame. The frame composed of pin connections was unstable, forming a collapse mechanism when a lateral load was applied.



Part II. What is a diaphragm, anyway?

Historically, early structural engineers built walls of wood, earth, or brick. Those walls supported wood beams, which in turn supported wood planks that formed floors or roofs. As our technology and materials improved, engineers came to understand that floors and roofs aren't just dead load, but are themselves important structural elements. We began to use the word "diaphragm" for a horizontal plane in a structure that is a structural member in and of itself. The idea that diaphragms (floor assemblies and roof assemblies) are structural elements is relatively new, and researchers are continually searching for better ways to quantify and analyze the behavior of diaphragms.[1] We now classify diaphragms as rigid, flexible, or semi-rigid, depending on their relative stiffness compared to the stiffness of the overall structure.[2]

Go ahead and build the two structures in Build + Connect - 07 - The Single-Story Diaphragm. There are two single-story structures to build: one with braced frames and one with moment connections. In each, the roof plane serves as the structural diaphragm.



[1] Curious and want to learn more? Try: https://www.linkedin.com/pulse/history-diaphragms-allen-adams and https://www.linkedin.com/pulse/types-diaphragms-allen-adams/

[2] The building code provides guidance for determining which diaphragms are rigid vs. flexible.

Part III. Apply loads

Let's simulate a seismic event (an earthquake). Set the model on a table, and then move the baseplate suddenly, so that the structure responds dynamically. Simulate the following ground movements:

- translation in the x-direction
- translation in the z-direction
- a rotation about the y-axis

Part IV. Reflect

Take some time to reflect on what you have learned, considering these prompts.

What types of reactions result from each of the simulated earthquakes?

How do the deformations compare between the two models (one with braced frames and one with moment connections)?

What is the difference between a shear wall and a diaphragm?

Do you think that the diaphragms in the Mola sets are rigid, flexible, or semi-rigid? Explain your reasoning, using your best structural engineering vocabulary. (Feel free to search for more information about types of diaphragms if you'd like to do so.)

Did you have any other unexpected discoveries or connect this exercise to a concept you learned in another class?