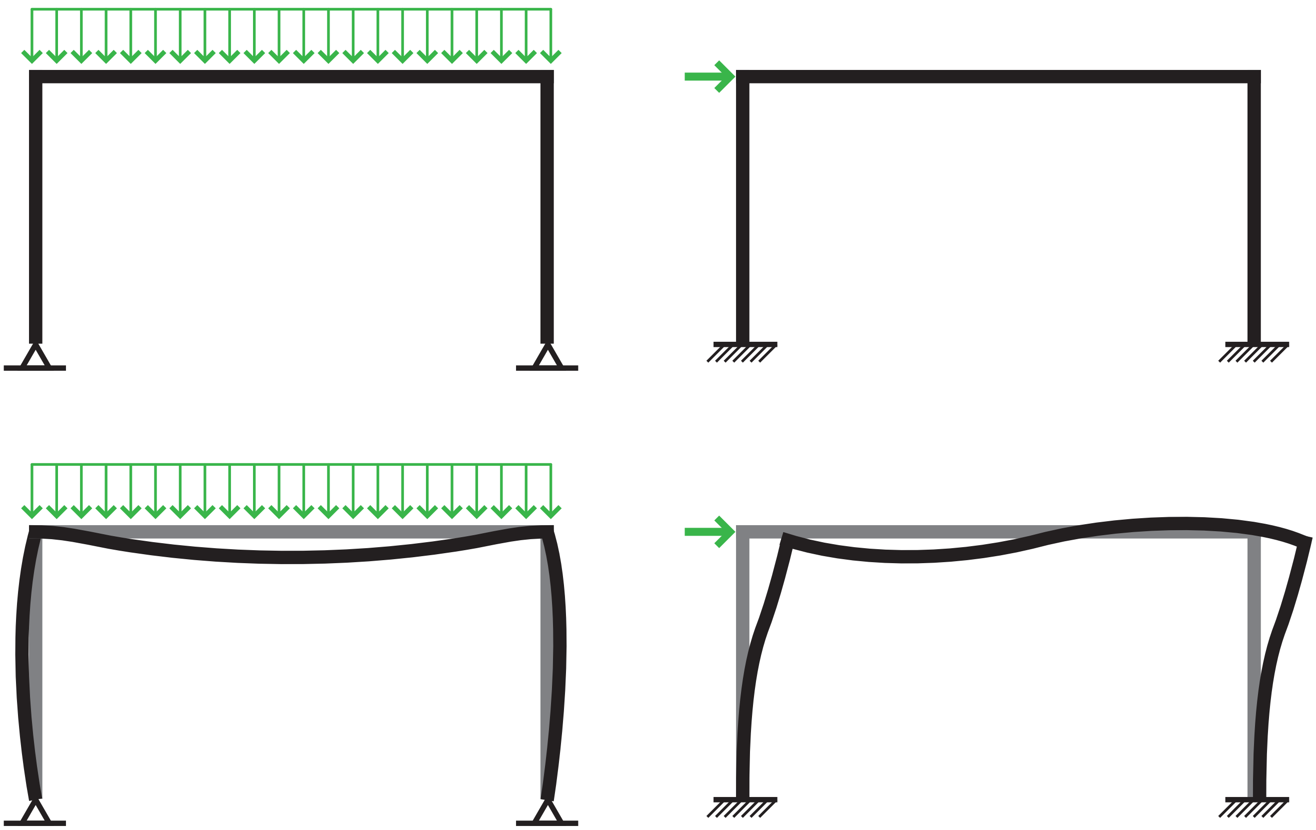
Rigid Frame Calculations
Gravity and Lateral Loads

Consider the following loading scenarios:



Rigid frames are highly interdependent structures, where the presence of a moment connection between beam and column presents an additional complexity to the distribution and resolution of bending moment.

A gravity load or lateral load will attempt to use both the beam and column to resist moments in the structure, and the relative strength and stiffness between the column and beam will determine how much moment is taken up by the columns and how much by the beam.

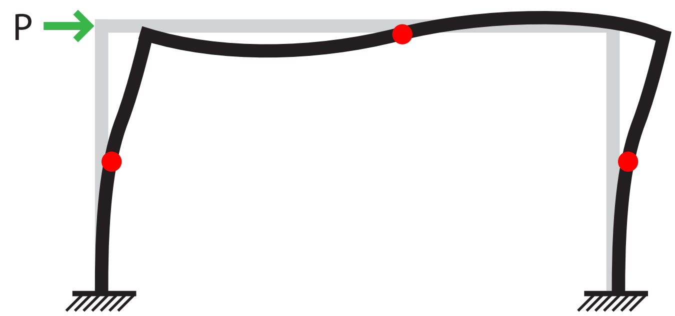
Statics is inadequate to solve this problem, since the material strengths of the beam and column and their section selectiosn form a proiblem too complex for two simple equations ($\Sigma F=0$, $\Sigma M=0$). We can, however, estimate the distribution of moment given a few more indications (knowns) about the internal bending moment in the frame.

Lateral Loading Condition

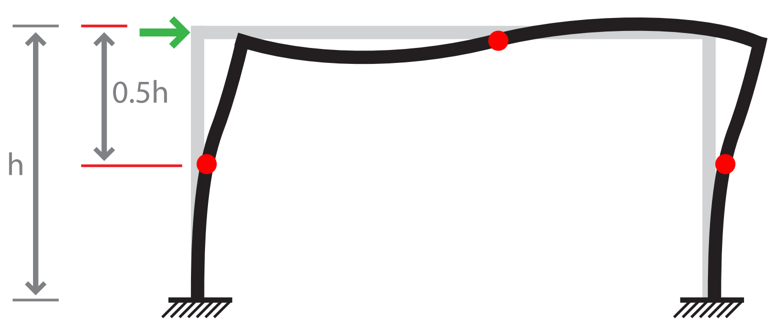
In the lateral loading condition of a rigid frame (seen here moment connections at the base of each column) internal bending moment and shear form in each element to resist the overturning tendency of the force P.

The deformation of the frame itself results in a number of points of inflection, typically one in each member. The locations of these points is a determiner of the relative stiffness of columns and beams.

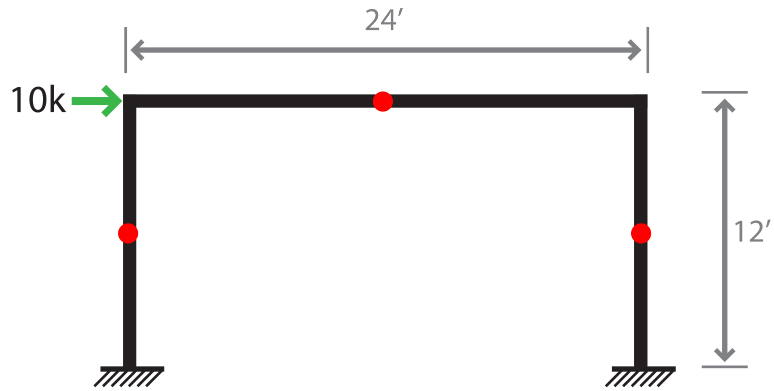
If these points are given, then we have enough information to determine the internal bending, axial, and shear stresses in the frame.



The portal frame method assumes that the inflection points in the beams and columns are in their centers.

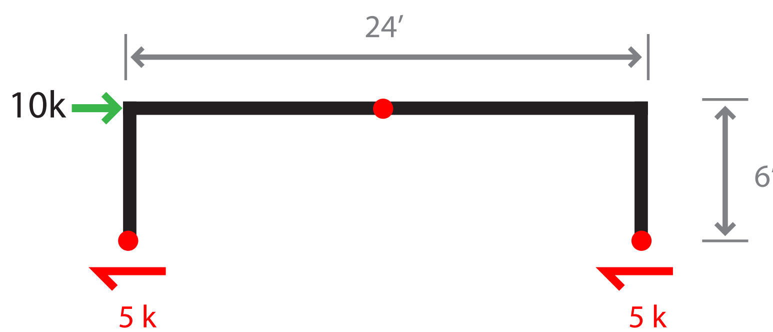


Here is the starting condition.



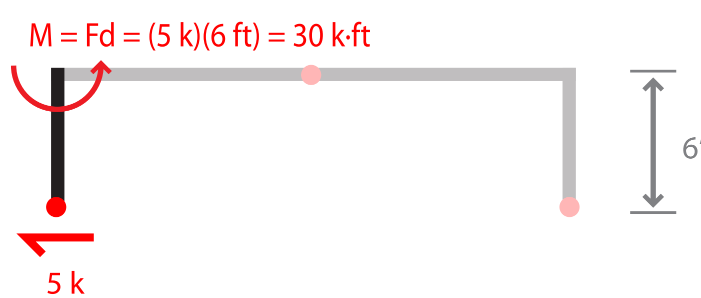
First step is to estimate the internal shear of each column. The portal method assumes:
1) the value of all column shears is calculated at the points of inflection,
2) external columns have the same shear,
3) internal columns all have the same shear,
4) internal columns carry twice as much shear as external columns.

In this example, all we have are two external columns.

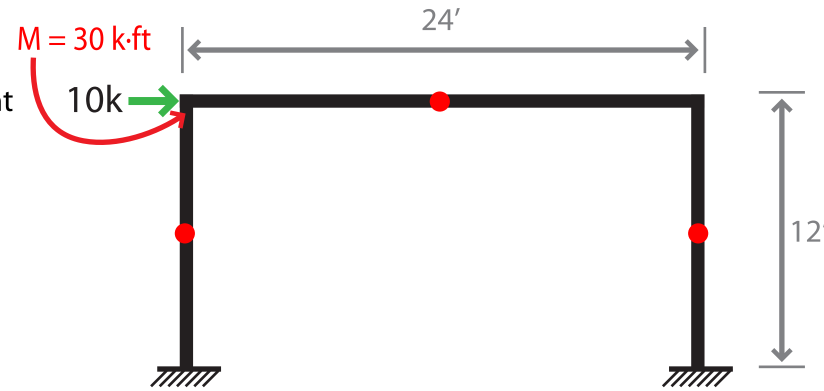


Next, estimate the moment in the columns. All we have to do is imagine the columns separated from the rigid connections and the beam. The internal bending moment is the only force resisting the tendency of the red shear force to turn the column.

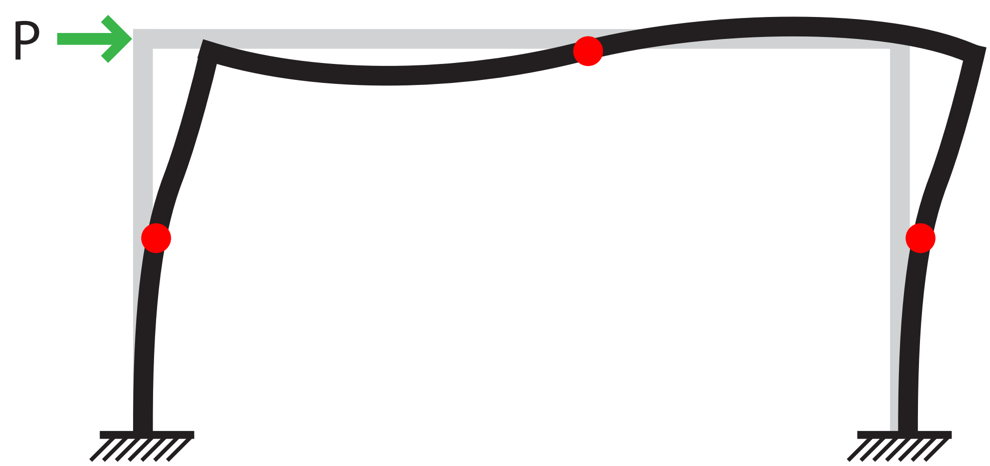
Thus, we can calculate this internal moment by considering it the "equal and opposite" reaction to the moment caused by the shear force.



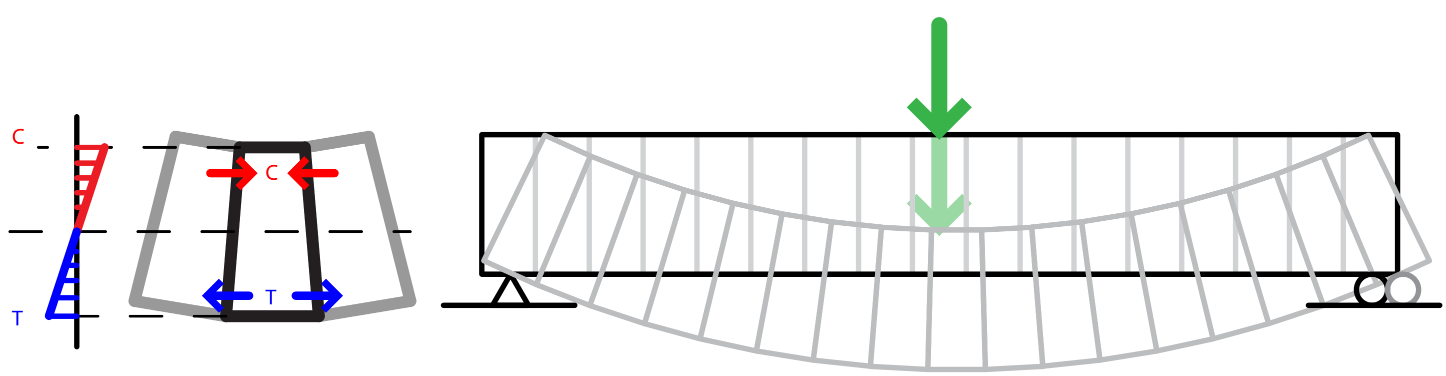
Now we know the internal bending moment inside the column at the rigid connection.

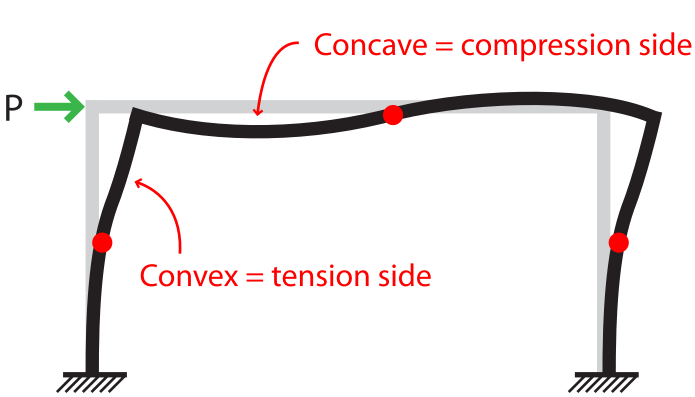


Let’s take a closer look at the deformed shape of our frame. Wherever there is internal bending moment, the beam or column will curve.

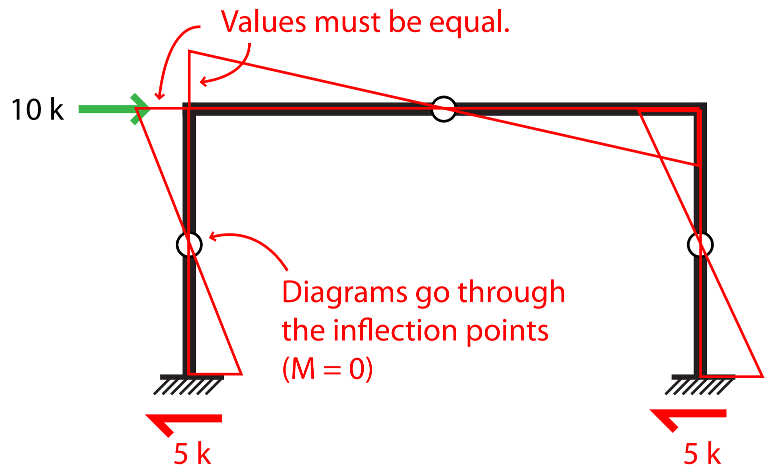


Normally, the curvature for the beam is caused byt he force couple of tension and compression. A gravity load will cause the top part of a beam to compress. This coupled with the tension and lengthening in the bottom will create a curve as parts of the beam are changing shape internally.





Because we can predict how the frame will deform, we can draw moment diagrams on the columns and beams that show the relative magnitude of internal bending stresses that cause these curves.



By convention, we draw the moment diagrams on the compression sides of the beams and columns. We assume the diagrams are linear. Because we know where the inflection points are (points of zero moment), we can draw the line through inflection point where the moment diagrams equal zero (the axis of the diagram goes through the middle of each element).

Continue indicating values for the moment. Because of the equalities in the structure (moment must be equal across the rigid connection, because the beam and columns are torquing against each other), the maximum moment for these diagrams will be the same.

Note that this is only the case for the simple, single frame.