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Exercise #9: Geometric Nonlinearity/Stable and Unstable equilibrium paths

Problem 1

The steel brace shown in Figure 1 is braced by a steel rod of axial stiffness, k in tension and compression shown in the same figure. The steel brace (and lateral support) can be approximated by the mathematical model shown in Figure 2. By using the Euler method compute the following:

1. The load P versus deformation θ, relationship based on nonlinear and linear theory of buckling (assume no imperfections)
2. The load P versus deformation θ, relationship based on nonlinear and linear theory of buckling (assume imperfections, ε in this case)
3. Compute in a graph the main and secondary equilibrium paths for Questions 1 and 2 and define if the equilibrium path is stable or unstable.
4. In your opinion, are imperfections important to be considered in the analytical solution or not?

Assume in all cases that the steel brace can be assumed as a rigid link

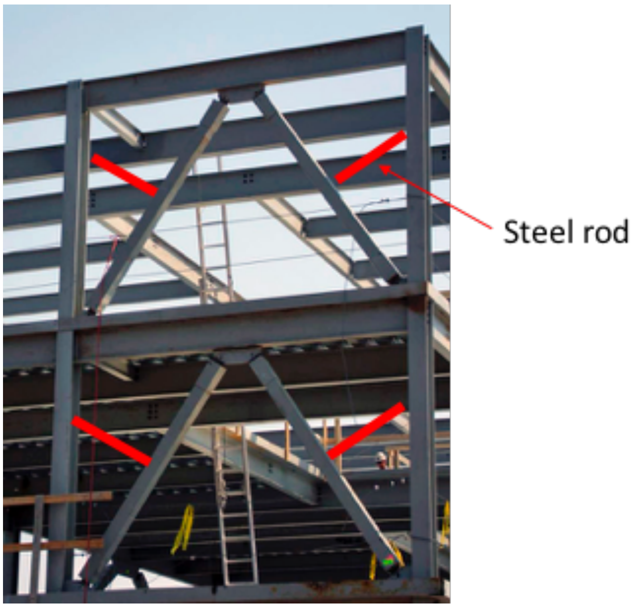

Figure 1. Steel brace and rod

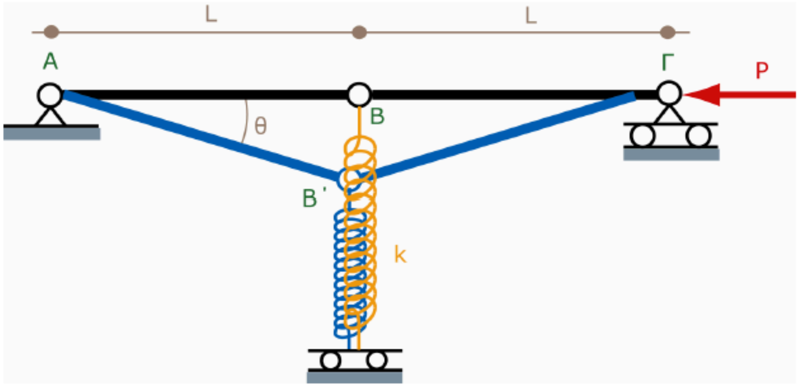

Figure 2. Mathematical representation of the steel brace and rod

Problem 2

The frame shown in Figure 3a consists of two pinned-end columns that are connected by a beam and by diagonal braces. These braces are assumed to be acting in tension only. That is, the brace that is in compression, while the top of the frame moves laterally, will buckle and will not participate in providing stiffness. The steel columns under compression can be represented with av end-restrained subassembly shown in Figure 4. The spring constant is determined by subjecting the frame to a force F and calculating the resultant deflection Δ as shown in Figure 3b. In this case, $\beta = F/\Delta$. Determine the required brace area needed to provide minimum stiffness so that the two columns can support the Euler load.

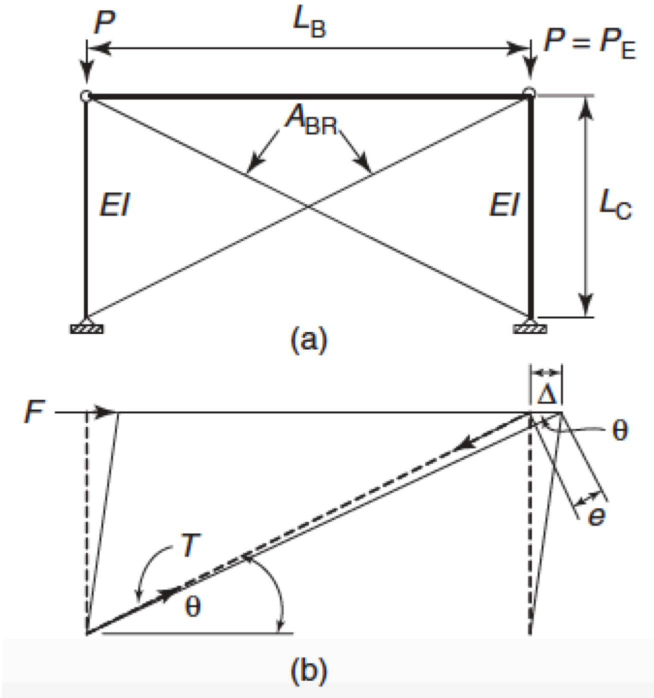

Figure 3. Diagonally braced frame (tension only braces)

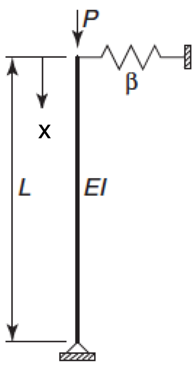

Figure 4. End-restrained subassembly