

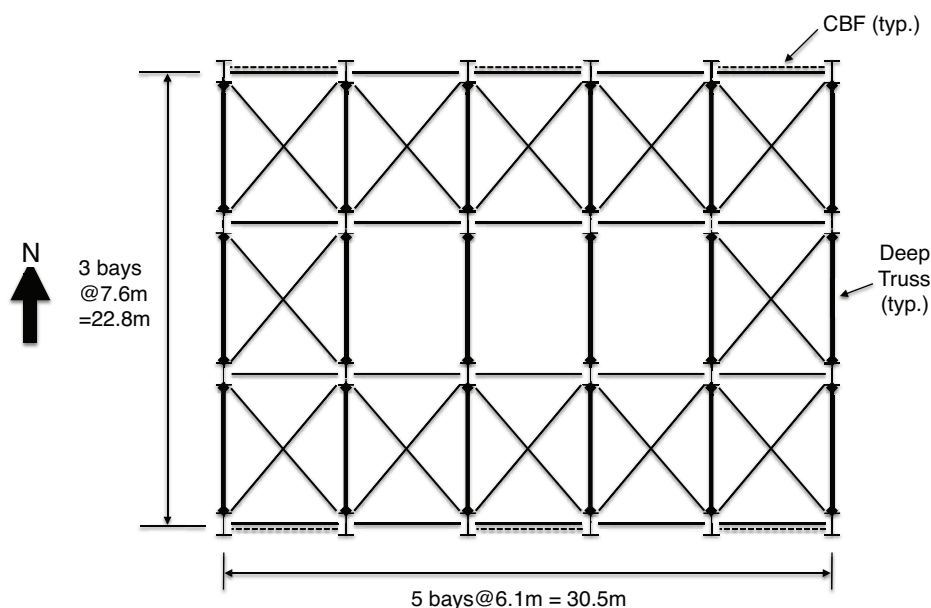
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Exercise #1: Equations of motion and dynamic characteristics

Problem 1

The single-storey steel industrial building shown in Figure 1 can be idealized as a single-degree-of-freedom (SDF) system in each of its principal orthogonal directions. The columns are all I-shaped steel cross-sections ($E = 200GPa$) that are fixed at their base and connected to a roof truss system at the top. The second moments of area of the I-shaped cross sections are $I_x = 34.4 \times 10^{-6} m^4$ and $I_y = 7.64 \times 10^{-6} m^4$. The roof truss has a flexural stiffness that is significantly greater than that of the columns in the direction where the columns bend about their strong axis (assumed as fixed at the base) but has negligible flexural stiffness in the direction where the columns bend about their weak axis (assumed as pinned at the base). In addition, in the two perimeter frames in the east-west (EW) direction, slender X-braces, made of 25-mm-diameter circular steel rods, are installed in three bays (a total of six braces per braced perimeter frame; only the ones in tension contribute to the lateral stiffness). The total dead load acting on the roof of the structure is equal to 1.06kPa while the total dead load acting on the perimeter walls is equal to 0.48kPa.

Compute the natural period of vibration of the building in each one of its principal loading directions (N-S and E-W). List clearly your assumptions.



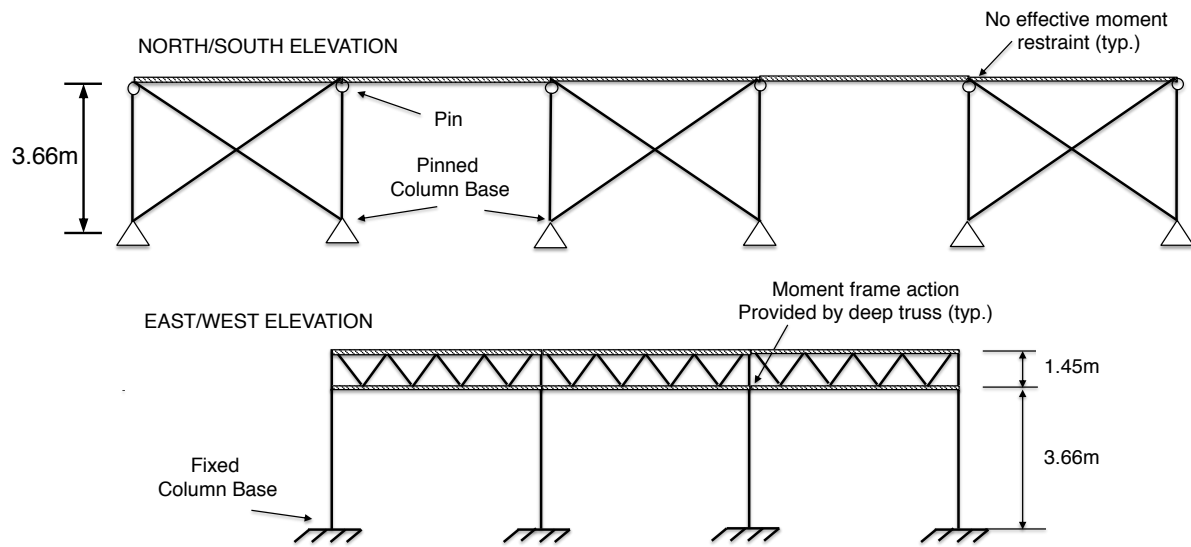


Figure 1. Single-storey industrial building

Problem 2

Compute the elastic stiffness and derive the equation of motion for the frame shown in Figure 2.1. The flexural rigidity of the beam and columns is noted in the figure. The mass lumped at the beam is m ; otherwise, assume the frame to be massless and neglect damping.

1. Assume, $EI_b = \infty$
2. Assume that EI_b is not infinite.

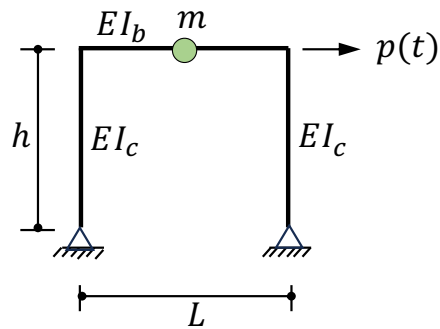


Figure 2. Portal frame

Problem 3

Determine the natural frequency of a weight w suspended from a spring at the midpoint of a simply supported beam. The length of the beam is L , and its flexural rigidity is EI . The spring is k . Assume the beam to be massless.

