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Exercise #1 – Statics, deflections, periods of vibration and drift verifications

Problem #1: Review on statics and deflection calculations

Compute the deflection at the top of the two 2-storey frames shown in Figure 1. Assume that the point of inflection in the second story columns is at mid-height, even though this assumption is not always valid.

The following properties should be considered:

- All columns: $I_c = 1.66x10^9 mm^4$,
- All beams: $I_b = 1.25x10^9 mm^4$,
- $E = 30{,}000 MPa$.

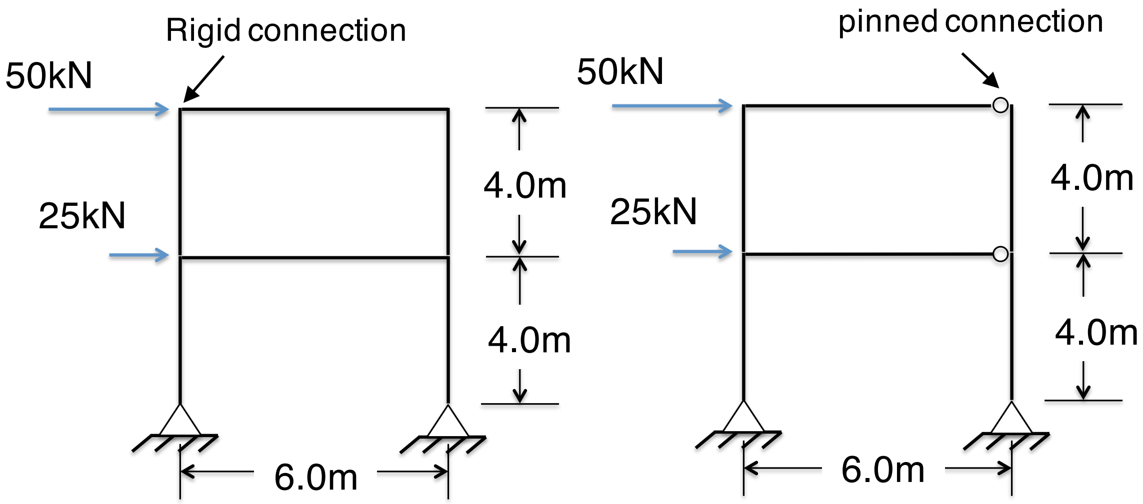

Figure 1. Two-storey frames

Problem #2: Lateral stiffness, natural period and seismic action computations

The one-storey steel industrial building is located at a high seismicity zone that is characterized by the pseudo-acceleration response spectrum shown in Figure 2-1 and its simplification, which is shown with the red solid line. The building, which is shown in Figure 2-2, 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 moments of inertia of the I-shaped cross sections are as follows, $I_y = 34.4x10^{-6}m^4$ and $I_y = 7.64x10^{-6}m^4$. 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 are bending 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 $0.48kPa$.

1. Compute the natural period of vibration of the building in each one of its principal loading directions (N-S and E-W). Clearly list your assumptions (because depending on those, the expected period may vary). In any case, $T_1 \leq 0.4sec$.

2. Compute the expected base shear for seismic loading in both horizontal directions for the pseudo-acceleration response spectrum given in Figure 2-1.

3. Does the building meet a drift limit of 1% in both loading directions?

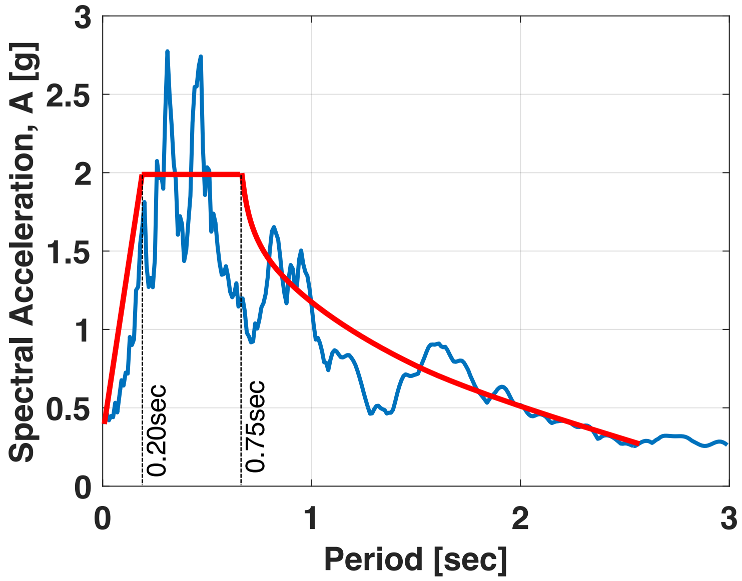

Figure 2-1. Pseudo-acceleration response spectrum

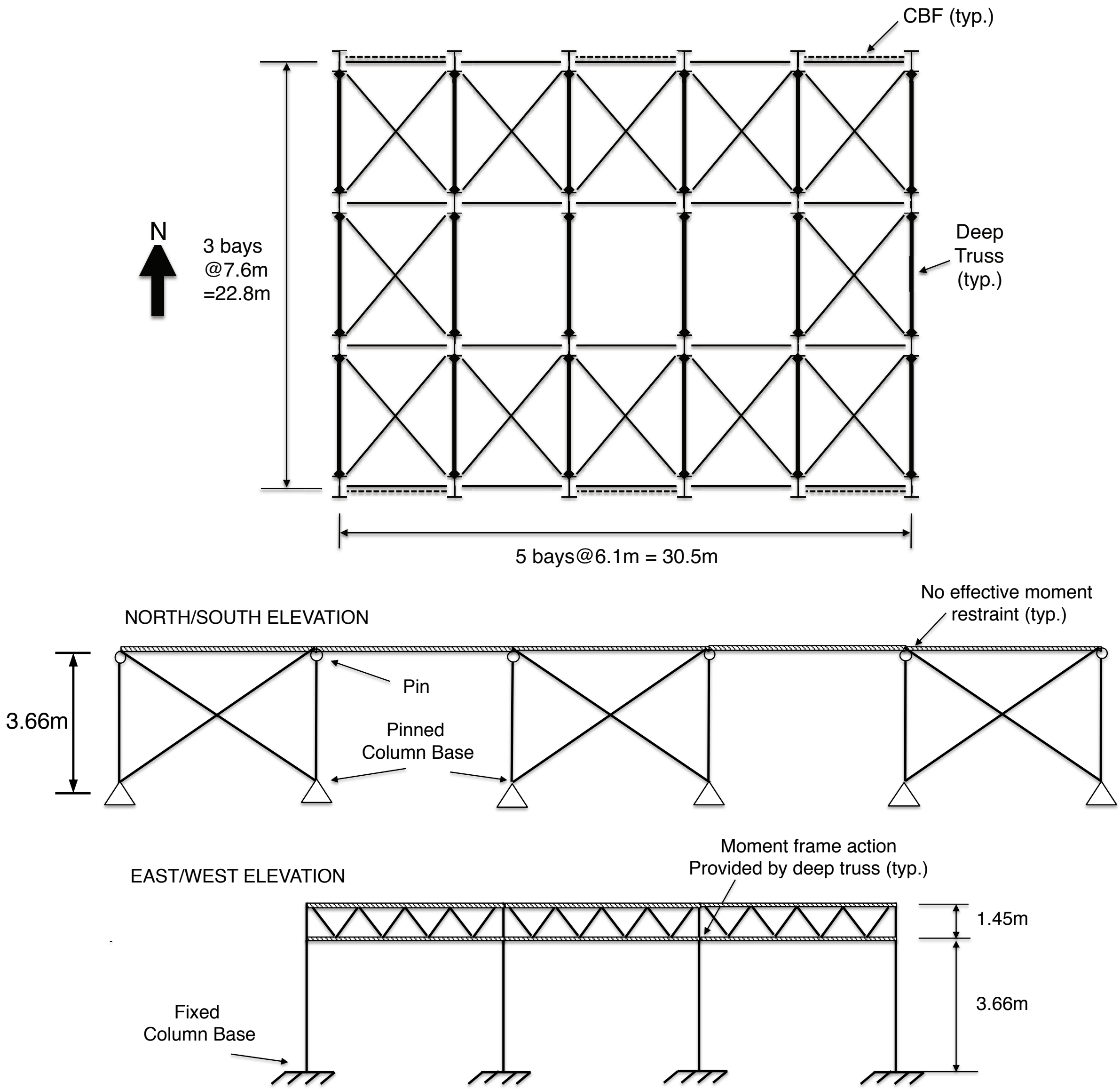

Figure 2-2. Single-storey industrial building; plan view and elevations