FACULTE ENVIRONNEMENT NATUREL, ARCHITECTURAL ET CONSTRUIT ENAC
INSTITUT D'INGÉNIERIE CIVILE IIC
Laboratoire des Structures Métalliques Résilientes RESSLab

Téléphone : +41 21 693 24 27
Fax : +41 21 693 28 68
E-mail : dimitrios.lignos@epfl.ch
Site web : http://resslab.epfl.ch
Address: EPFL ENAC IIC RESSLAB
GC B3 485, Station 18,
CH-1015, Lausanne

Exercise #7: Frame stability

Problem 1

The 7-storey moment resisting frame shown in Figure 1 is subjected to a concentrated load at the top.

Q1: Prove that for the concentrated load, the resulting drift in a single storey, i, is given by,

$$\delta_i = \frac{V_i \cdot h_i^2}{12 \cdot E} \cdot \left(\frac{1}{G} + \frac{1}{C}\right)_i$$

In which, $C_i = \sum_{j=1}^{N} \left(\frac{I_c}{h}\right)_{i,j}$ and $G_i = \sum_{k=1}^{N-1} \left(\frac{I_g}{L}\right)_{i,k}$.

Q2: Assume that the inflection point of the columns in the first storey is located at $3/4h_1$ (not at mid-height). Prove that for the concentrated load, the drift of the first storey may be estimated as follows,

$$\delta_1 = \frac{V_1 \cdot h_1^2}{12 \cdot E} \cdot \left(\frac{3}{8 \cdot G} + \frac{7}{4 \cdot C}\right)_1$$

Q3: What is the minimum moment of inertia of the girders I_g of the moment resisting frame to satisfy a lateral drift ratio limit $\delta_i/h_i = 0.02$ at all stories? Assume that in all cases, the girders control the relative deformations, therefore, $\psi \cong 1$ (>>0.5). Assume that all members are made of steel ($E = 200GPa$).

I_g: moment of inertia of girders

I_c: moment of inertia of columns

$I_g = 1.5 \cdot I_c$

$F_7 = 1000kN$

$h_1 = h_i = 3.5m$

$L = 8m$

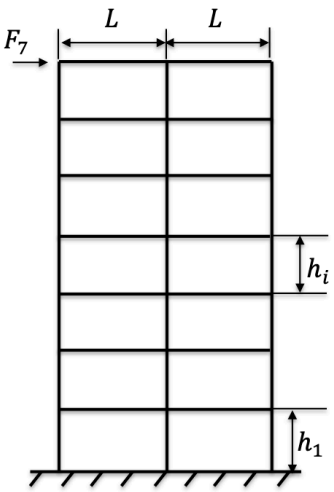

Figure 1. Moment resisting frame with rigid connections and concentrated lateral load

Problem 2

The 7-storey moment resisting frame shown in Figure 2 is subjected to a uniform wind load of F_i per storey, i.

Q1: Prove that for the uniform wind load, the resulting drift in a single storey, i, is given by,

$$\delta_i = \frac{h_i^2}{24E} \cdot \left[\frac{(V_i + V_{i+1})}{G_i} + \frac{2 \cdot V_i}{C_i}\right]$$

In which, $C_i = \sum_{j=1}^{N} \left(\frac{I_c}{h}\right)_{i,j}$, $G_i = \sum_{k=1}^{N-1} \left(\frac{I_g}{L}\right)_{i,k}$, V_i and V_{i+1} are the storey shears in storeys i and $i+1$, respectively.

Q2: Assume that the inflection point of the columns in the first storey is located at $3/4h_1$ (not at mid-height). Prove that for the uniform wind load, the drift of the first storey may be estimated as follows,

$$\delta_1 = \frac{h_1^2}{48E} \cdot \left[\frac{(V_1 + 2 \cdot V_2)}{2G_1} + \frac{7 \cdot V_1}{C_1}\right]$$

Q3: What is the minimum moment of inertia of the girders I_g of the moment resisting frame to satisfy a lateral drift ratio limit $\delta_i/h_i = 0.02$ at all stories? Assume that in all cases, the girders control the relative deformations, therefore, $\psi \cong 1$ (>>0.5). Assume that all members are made of steel ($E = 200GPa$).

I_g: moment of inertia of girders

I_c: moment of inertia of columns

$I_g = 1.5 \cdot I_c$

$F_1 = F_i = F_7 = \frac{1000}{7} kN$

$h_1 = h_i = 3.5m$

$L = 8m$

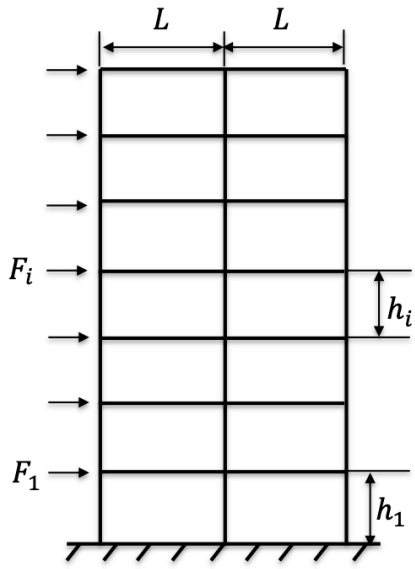

Figure 2. Moment resisting frame with rigid connections