McGill University
Department of Civil Engineering and Applied Mechanics
CIVE 603 – Structural Dynamics

Instructor: Sarven Akcelyan, PhD
Macdonald Engineering Bld., Room 275, e-mail: sarven.akcelyan@mcgill.ca

Homework #5 (Total Points 100/100)
Individual Assignment
Due Date, April 3rd 2018 by 4:00pm

Note: In addition to hard-copy submission, please submit your MATLAB/SAP2000 files and soft-copy of your assignment through mycourses.

Problem 1 (30 points)
For the three-story shear building shown below determine the following:

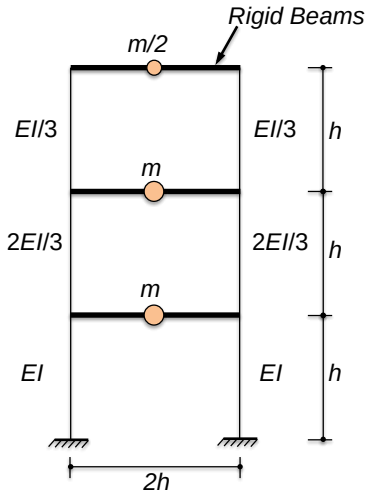


Figure 1. Shear building

1. The natural frequencies and modes; express the frequencies in terms of m, EI, and h. Sketch the modes and identify the associated natural frequencies.
2. Verify that the modes satisfy the Orthogonality properties.
3. Normalize each mode so that the generalized modal mass M_n has unit value. Sketch these normalized modes. Compare these modes with those obtained in Part 1 and comment on the differences.

Problem 2 (30 points)
Determine the free vibration response of the three-story shear building discussed in Problem 1 if it is displaced as shown in Figures 2a, 2b, 2c below and released (i.e., free vibration). Plot floor displacements versus t/T_1 and comment on the relative contributions of the three vibration modes

to the response that was produced by each of the three initial displacements shown in Figures 2a, 2b and 2c. Neglect damping.

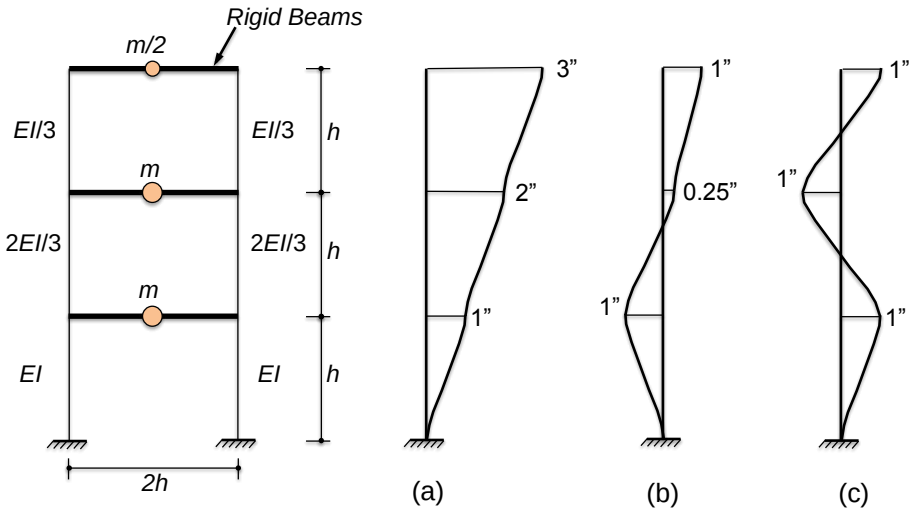
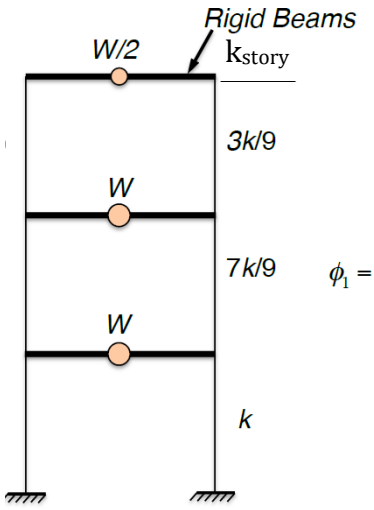


Figure 2. Deformed shapes for free vibration

Problem 3 (40 points)

The properties of a three-story shear building are given in the figure below. These include the floor weights, story stiffnesses, natural vibration frequencies, and modes.

1) Model the shear building in SAP2000 to verify the modal properties. Assume a story height h=12ft and a bay width L=28ft. Report the natural periods and frequencies of vibrations, mode shapes and their eigenvectors from SAP2000.
2) Derive a Rayleigh damping matrix [**c**] such that the damping ratio is 5% for the first and third modes. Compute the damping ratio for the second mode.
3) Compute the generalized modal mass [**M**] and modal stiffness [**K**] and modal damping [**C**] matrices.



W = 100 *kips*, k = 168 *kips/in.*

ω_n=12.01, 25.47, 38.90 rad/sec

$$\phi_1 = \begin{Bmatrix} 0.6375 \\ 1.2750 \\ 1.9125 \end{Bmatrix}, \phi_2 = \begin{Bmatrix} 0.9827 \\ 0.9829 \\ -1.9642 \end{Bmatrix}, \phi_3 = \begin{Bmatrix} 1.5778 \\ -1.1270 \\ 0.4508 \end{Bmatrix}$$

Figure 3. Shear building and its dynamic properties