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

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Homework #6 (Total Points 100/100)
Group assignment: max. 2 students
Due Date, April 12th 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 (40 points)

The three-story shear building given in HW#5/Problem 3 is subjected to the Canoga Park record from the Northridge 1994 earthquake in California (check HW#3 for the file). By using the uncoupled modal response history analysis approach that was shown in class, determine the following:

Part A (25 points)

1. Determine the equivalent SDF system responses $D_n(t)$ and $A_n(t)$ for each one of the three modes of the frame using a numerical time-stepping method that you developed in HW#3. Assume 5% damping ratio for all the modes.
2. For each natural mode calculate as a function of time the following response quantities:
    a. The roof displacement
    b. The story drift ratios
    c. The story shears, and
    d. The base overturning moment
3. At each instant of time combine the modal contributions to each of the response quantities to obtain the total response and plot it; determine the peak value of the total responses.
4. Compare the peak values of the total responses with response spectrum analysis (RSA) for the same ground motion.

Part B (15 points)

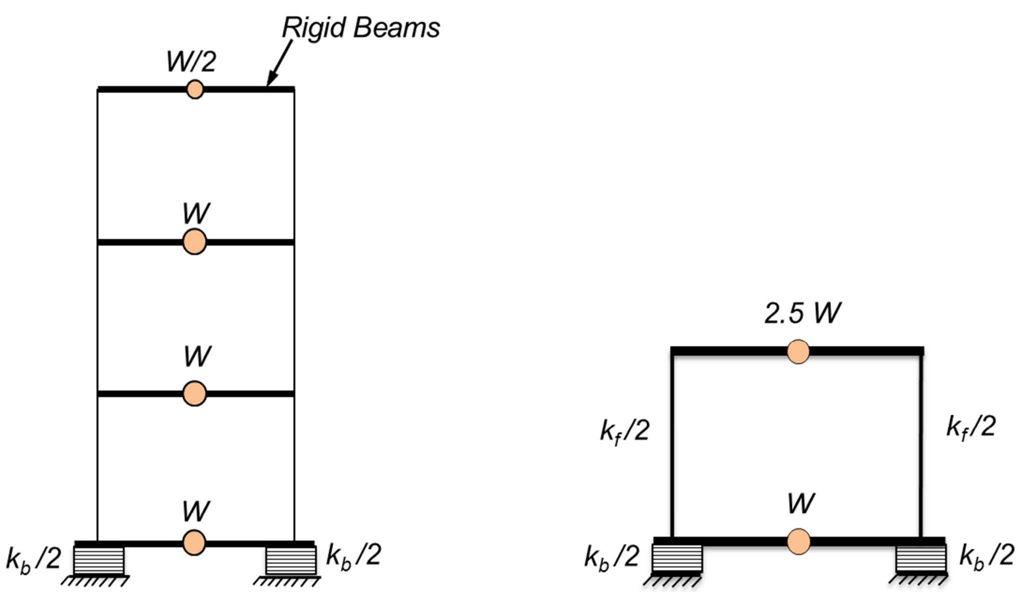
You are to use SAP2000 to analyze the three-story shear frame in Part A under the Canoga Park record from the Northridge 1994 earthquake in California. Conduct an uncoupled modal response history analysis with SAP2000 and compare your answers with Part A. In case that you have to plot quantities compare them in the same figure.

Problem 2 (60 points)

The three-story shear building is to be isolated with laminated-rubber bearings as illustrated in Figure 1a.

Part A (35 points)

1. For preliminary design, the building is simplified as a 2-DOF base-isolated frame as shown in Figure 1b (i.e. ω_f = 12.01 rad/sec, m_f=250 kips/g, m_b=100 kips/g). Assume 5% damping ratio for all the modes.
    a. Compute the fixed-based stiffness k_f of the single story frame.
    b. Determine the isolation period T_b and stiffness k_b of isolation bearings such that the base isolated structure will have a fundamental period T_1=2.0 sec.
    c. Obtain the vibration period of the second mode.
    d. Draw the mode shapes of equivalent 2-DOF base-isolated frame.
    e. Obtain the peak shear force of the first story, peak roof and isolation displacements based on response spectrum analysis (RSA) with the SRSS rule for the Canoga Park record.
2. Utilize the rigid-frame approximation. Obtain the peak shear force of the first story and peak isolation displacement and compare the results with the outcomes obtained in 1e).



a) b)

Figure 1. Base-isolated shear building and its 2-DOF representation.

Part B (25 points)

You are to use SAP2000 to analyze the three-story base-isolated shear building shown in Figure 1a with laminated-rubber bearings designed in Part A.

1. Report the vibration periods of each mode and compare them with Part B of Problem 1.
2. Conduct an uncoupled modal response history analysis of the three-story base isolated structure subjected to the Canoga Park record. Assume 5% damping ratio for all the vibration modes.
    a. Plot the response histories of displacement at the roof and the isolator layer, shear force of the first story and absolute floor acceleration at the roof. Compare these response quantities with the fixed base frame obtained from Part B of Problem 1. Explain the benefits of base isolation compared to the conventional design.
    b. Obtain the peak shear force of the first story, peak roof and isolation displacement and compare your answers with Part A of Problem 2.