# Engineering Mechanics: Dynamics
# CIEG311 - Fall 2001
# Project #4: Seismic Rehabilitation of an Existing Structure

Your engineering firm has just received word that it won the bid on a seismic rehabiltation project in southern California. The president of the firm is delighted to have won the bid because the firm has been trying to land a seismic rehab project for some time. None the less, he is a bit apprehensive because this is the first seismic job the company has ever done. You ashore him, however, that your group of talented, enthusiastic and knowledgeable structural engineers can handle the job.

The existing building is 40 years old. It is a one story, steel frame structure, which measures 20 ft by 80 ft by 14 ft high. The lateral load resisting system consists of five moment frames, spaced at 20 ft in the longitudinal (long) direction. The columns of the frames are W12x366 members and are clamped at the base. The columns are aligned so that the strong axis of bending is in the longitudinal direction. The roof girders/beams are deep truss members. The built-up roof consists of a metal deck, insulation, bituminous weathering surface and gravel: the total dead load of the roof is estimated to be 25 lb/ft$^2$, which includes the weight of the girders. The exterior façade of the building is lightweight corrugated steel, which can be neglected. A sketch of the building is shown in figure 1.

Because of a change in use, the building needs to be seismically upgraded and strengthened. *The goal of the upgrade is to reduce the maximum lateral deformation and maximum base shear (that is, the horizontal reaction at the foundation) that the building is likely to experience during an earthquake.* To do this, your team has decided to conduct preliminary designs for two different rehabilitation options:

1. add a diagonal brace (W12x152) to the frame
2. convert the columns from clamped, to pinned at the base.

The rehabilitation alternatives are shown in figure 1. For this phase of the project you have to consider the response in the transverse (short) direction only.

For a structure subjected to a very high intensity, short duration earthquake, a very crude approximate analysis of the response could be obtained from a simple undamped, free vibration analysis. In this case the formulation for the response of a Single-Degree-Of-Freedom system would be given by

$$m\ddot{x} + kx = 0$$
$$x(0) = 0, \quad \dot{x}(0) = \alpha A_g$$

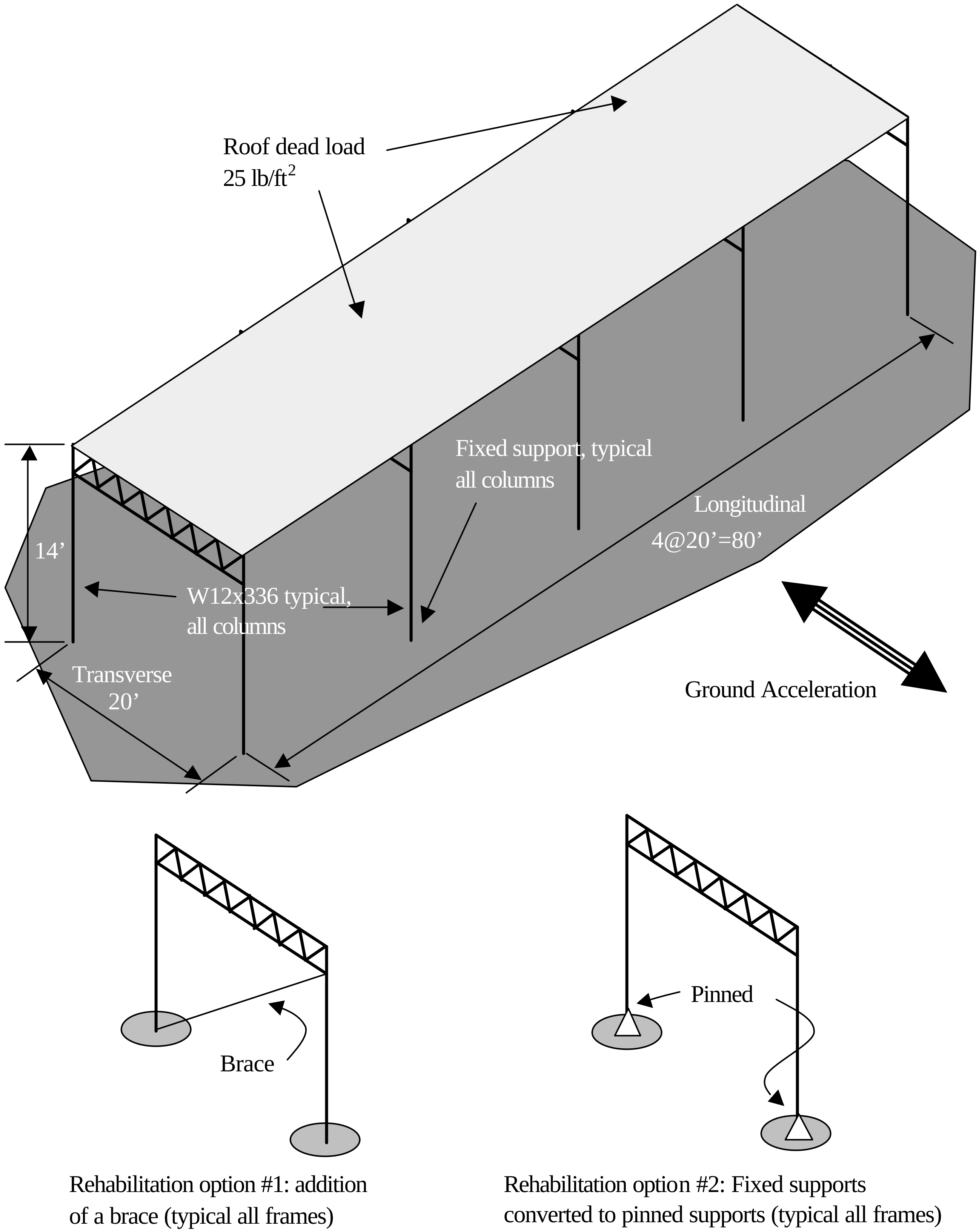
in which $m$ is the mass, $k$ is the stiffness, $A_g$ is the peak ground acceleration and $\alpha$=0.025 is a parameter (with dimensions of seconds) that depends on the characteristics of the earthquake ground motion. To determine the peak ground acceleration, the engineers will turn to something call a Design Response Spectrum, which is shown in figure 2. The response spectrum plots maximum ground acceleration ($A_g$) versus natural period of the structure ($T_n$). It shows that in effect, the maximum force exerted on the structure is a function of the structures natural period.

Your job is to conduct an analysis of the existing building and of the two rehabilitation alternatives, and to make a recommendation on the rehabilitation scheme you think would be most effective, based on the maximum deformation and base shear. You will need to calculate the natural frequency of each design, you can do this using STAAD. You should, however, double check that the STAAD results agree with hand calculations for at least the original building design.

****** NOTE ******

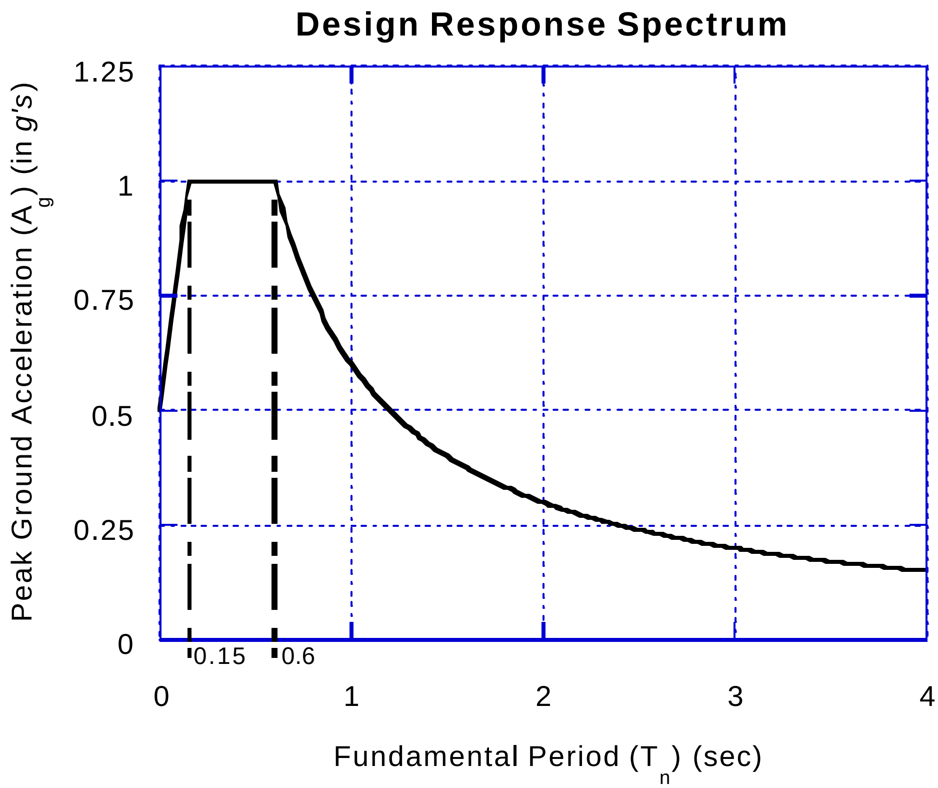
This project does not require a formal report. Analysis and calculations can be done as if this were just another homework assignment. What is required is a brief write-up on the results, including which rehabilitation option your group would recommend and why.

Also, each member of the group is to turn in a separate, concise, detailed statement of exactly what work they did on the project.



Roof dead load
25 lb/ft2
Fixed support, typical
all columns
Longitudinal
4@20'=80'
14'
W12x336 typical,
all columns
Transverse
20'
Ground Acceleration
Brace
Pinned
Rehabilitation option #1: addition
of a brace (typical all frames)
Rehabilitation option #2: Fixed supports
converted to pinned supports (typical all frames)


Figure 1.



Design Response Spectrum
Peak Ground Acceleration (A_g) (in g's)
1.25
1
0.75
0.5
0.25
0
0.15
0.6
0
1
2
3
4
Fundamental Period (T_n) (sec)


Figure 2.