Seismic design of structures-Intro

Question: What is the significance of this subject and why it is necessary for Engineers to make their structures safe against earthquakes.

The answer is given in the next slides.

Seismic design of structures-Intro

- The latest techniques available now can predict how much is the maximum Earthquake can occur at a specific fault in terms of Richter scale.
- Based on this we can determine the peak ground accelerations which are the basis of our design.

Seismic design of structures-Intro

Earthquakes

- Most earthquakes occur due to the movement of faults. Faults slowly build up stresses that are suddenly released during an earthquake.
- We measure the size of earthquakes using moment magnitude as defined in Equation 2.1:

$$M = \left(\frac{2}{3}\right)[\log(M_0) - 16.05] \tag{2.1}$$

where M_0 is the seismic moment as defined in Equation 2.2:

$$M_0 = GAD \quad \text{(in dyne cm)} \tag{2.2}$$

Seismic design of structures-Intro

Earthquakes

1 dyne/cm^2 = 0.1 N/m^2

- where G is the shear modulus of the rock (dyne/cm^2), A is the area of the fault (cm^2), and D is the amount of slip or movement of the fault (cm).
- The largest-magnitude earthquake that can occur on a particular fault is the product of the fault length times its depth (A), the average slip rate times the recurrence interval of the earthquake (D), and the hardness of the rock (G).

Maximum slip

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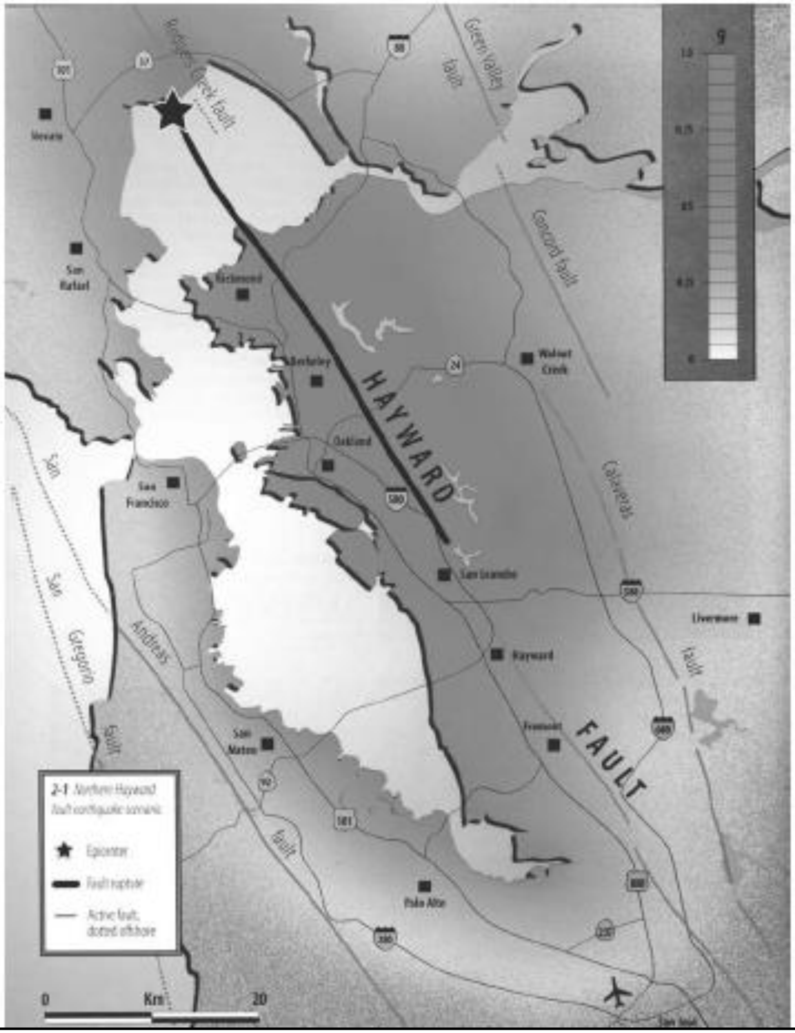

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Earthquakes

- For instance the northern half of the Hayward Fault (in the San Francisco Bay Area) has an annual slip rate of 9 mm/year (Figure 2.1).
- It has an earthquake recurrence interval of 200 years.
- It is 50 km long and 14 km deep. G is taken as 3 x 10^{11} dyne/cm^2.

$$M_0 = (0.9 \times 200)(5 \times 10^6)(1.4 \times 10^6)(3 \times 10^{11}) = 3.78 \times 10^{26}$$

$$M = (2/3)[\log 3.78 \times 10^{26} - 16.05] = 7.01$$

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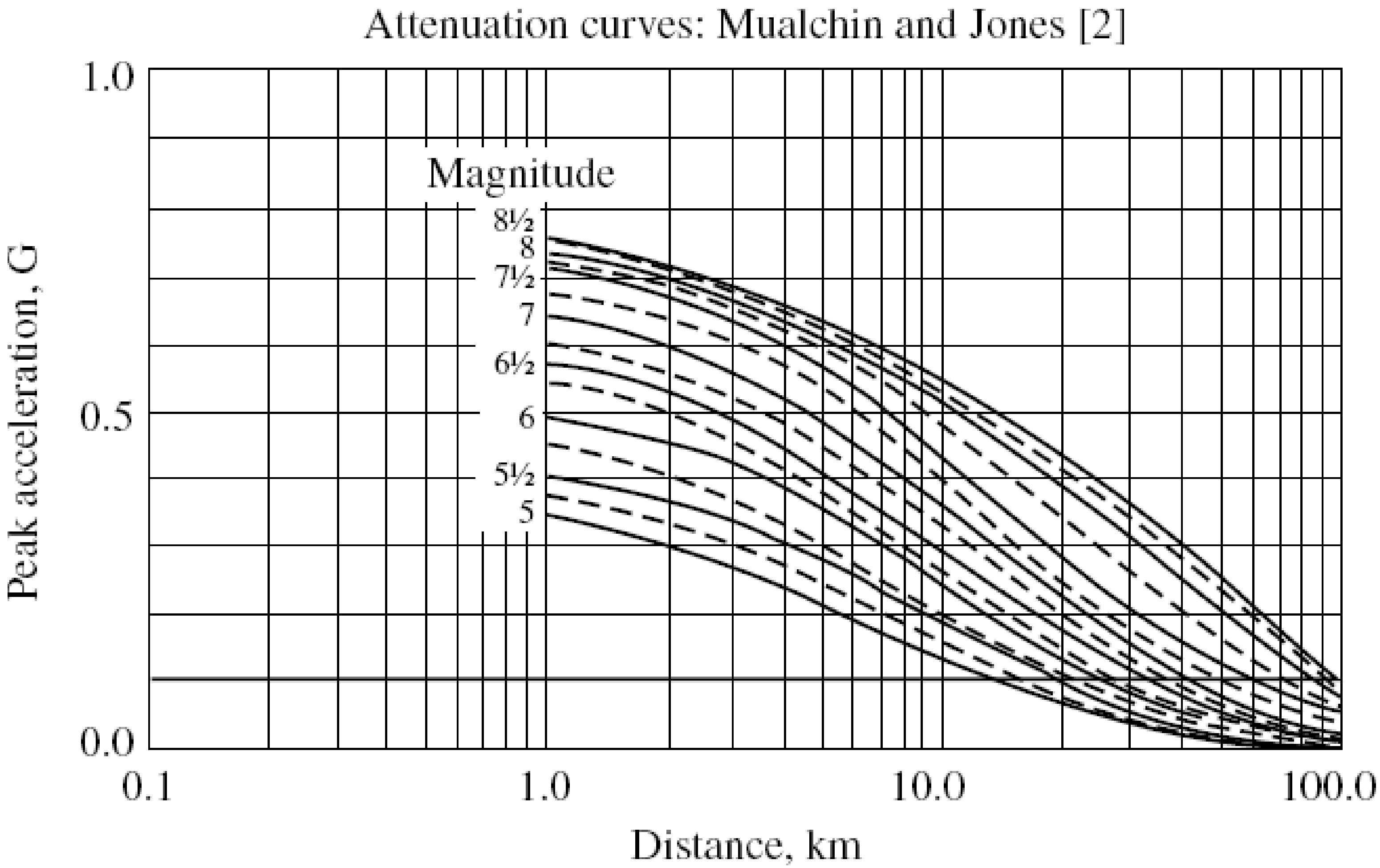

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Earthquakes

- Therefore, about a magnitude 7.0 earthquake is the maximum event that can occur on the northern section of the Hayward Fault.
- Since G is a constant, the average slip is usually a few meters, the depth of the crust is fairly constant, the size of the earthquake is usually controlled by the length of the fault.

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Earthquakes

- Magnitude is not particularly revealing to the structural engineer.
- Engineers design structures for the peak accelerations and displacements at the site.
- After every earthquake, seismologists assemble the recordings of acceleration versus distance to create attenuation curves that relate the peak ground acceleration (PGA) to the magnitude of earthquakes with distance from the fault rupture.

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Earthquakes

- All of the data available on active faults is assembled to create a seismic hazard map.
- The map has contour lines that provide the peak acceleration based on attenuation curves that provide the reduction in acceleration due to the distance from a fault.
- The map is based on deterministic derived earthquakes or on earthquakes with the same return period.

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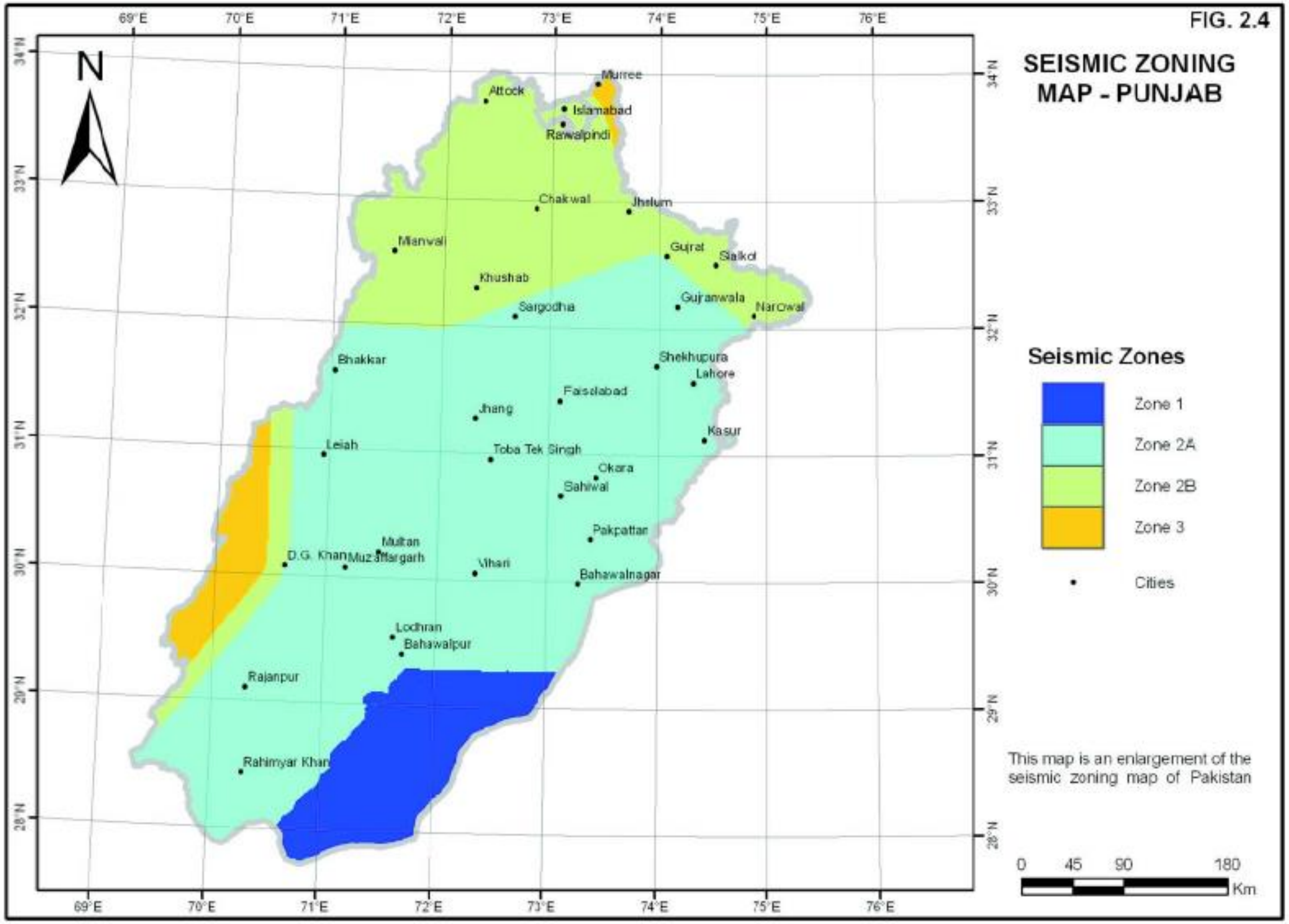

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- Building are situated on ground
- Earthquake shakes the ground and with the movement of the ground buildings also shake.
- Engineer's duty is to ensure the movement of structures during earthquakes within specified limits or there shall not be any damage/controlled damage in the structure during an earthquake.

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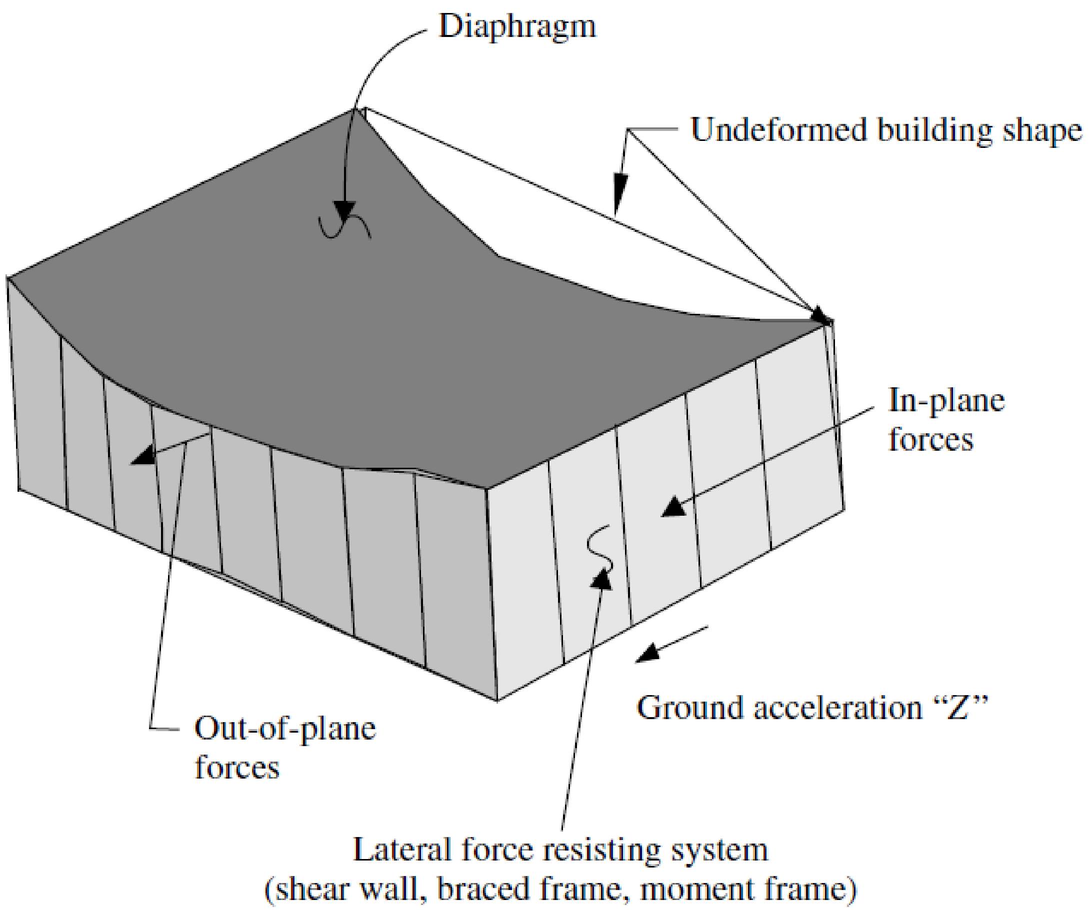

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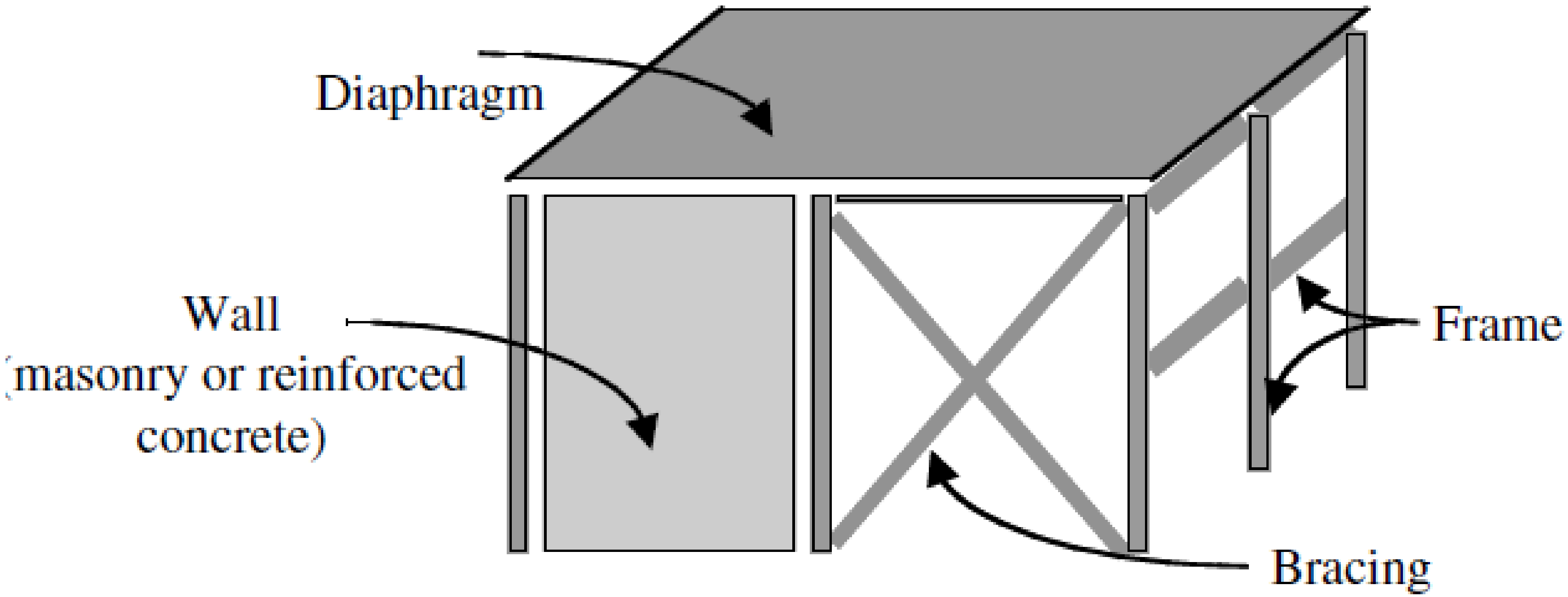

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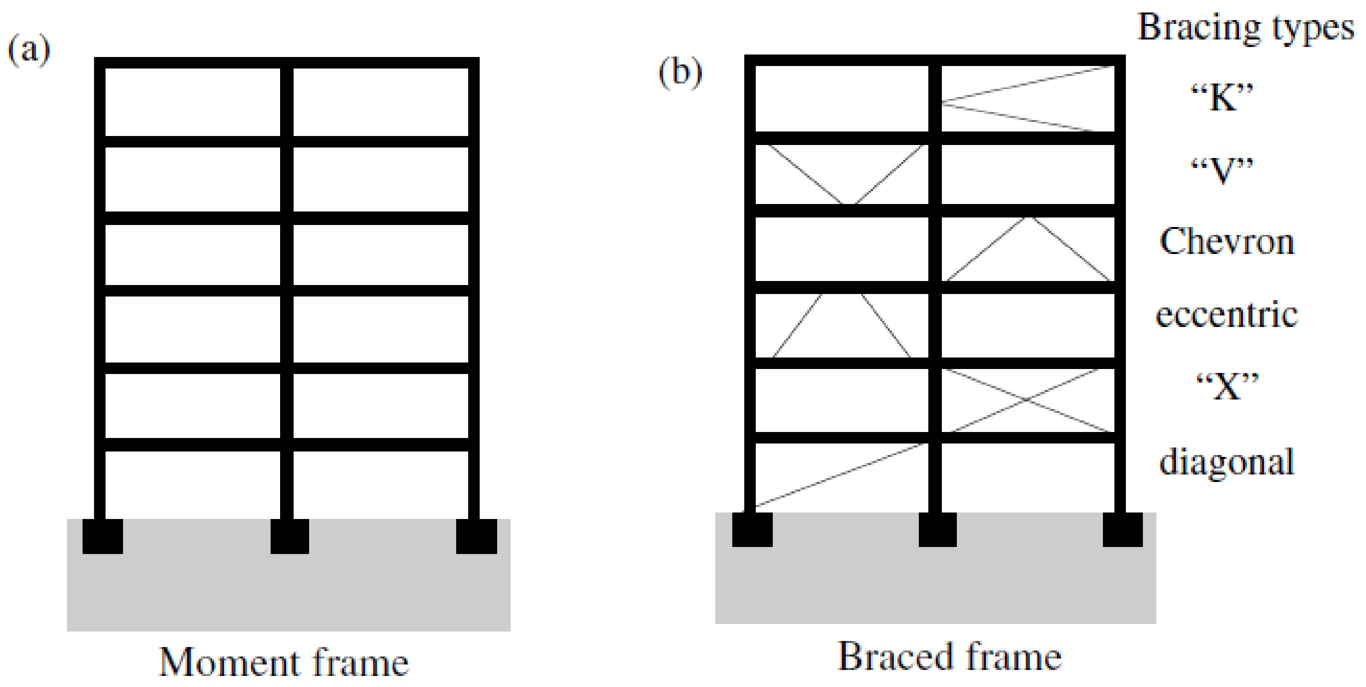

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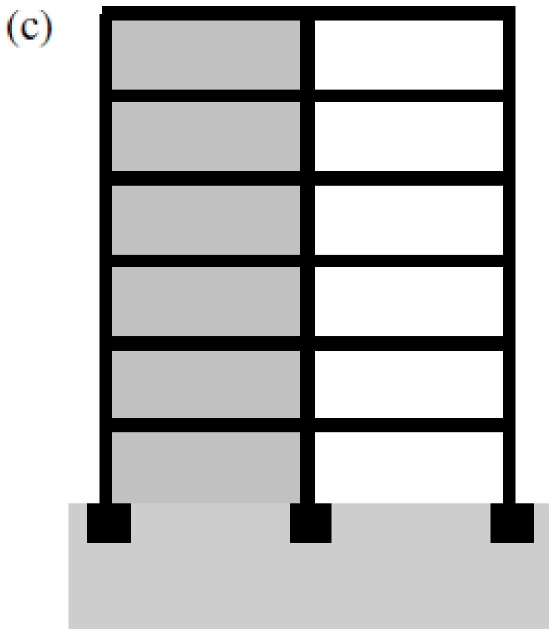
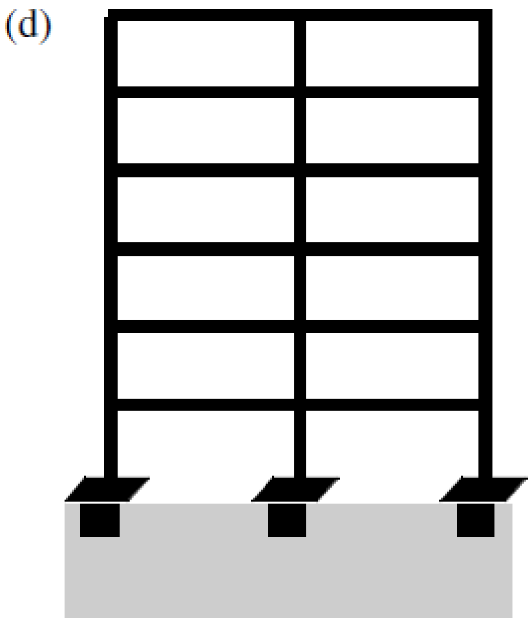


Shear wall



Base isolation

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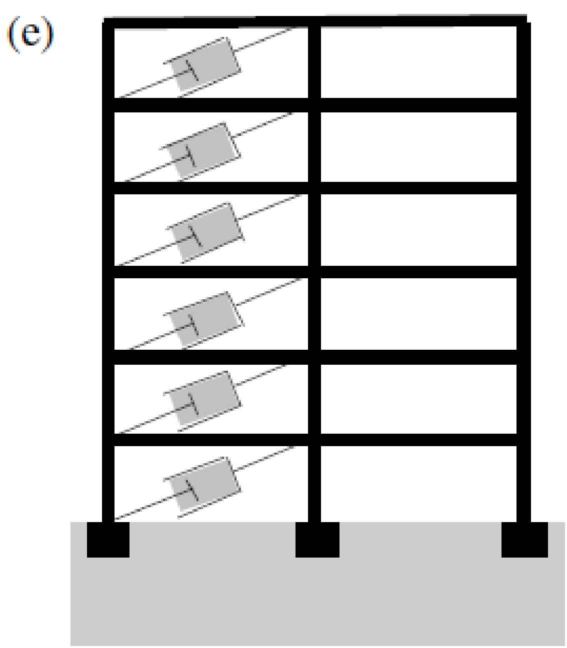
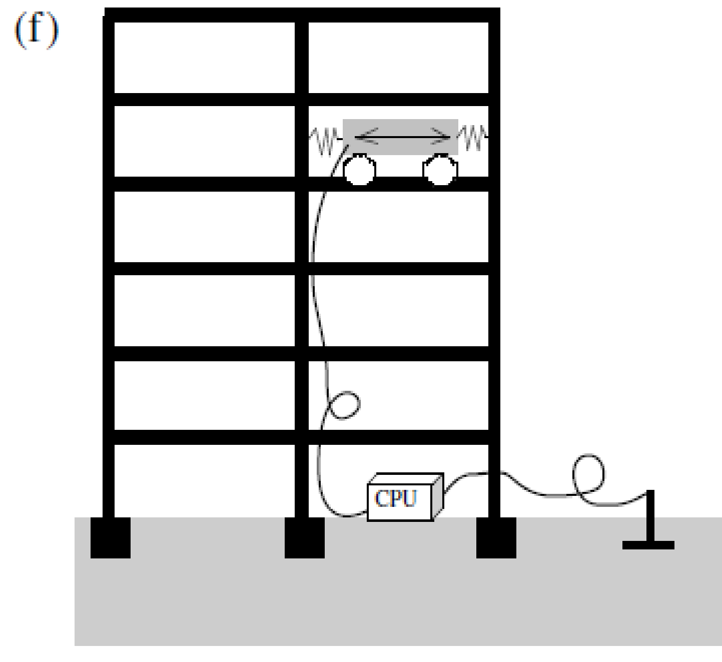


Damped frame



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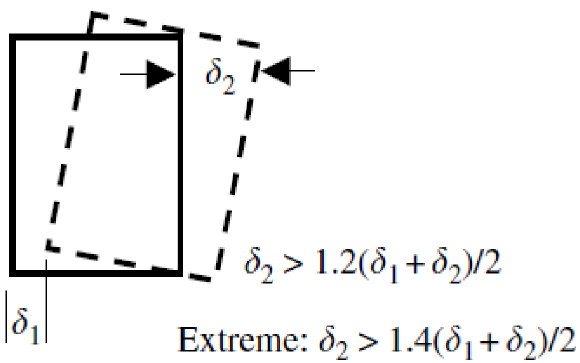
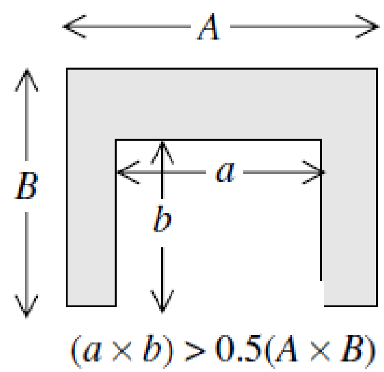
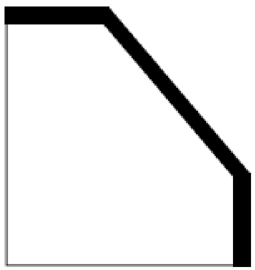
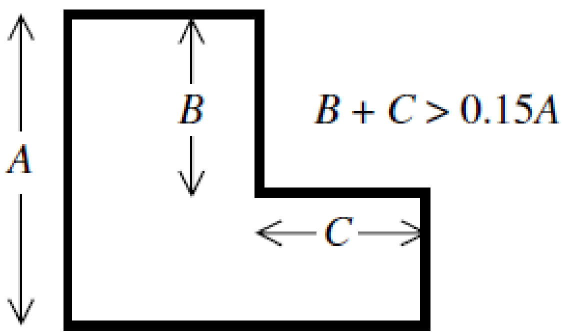
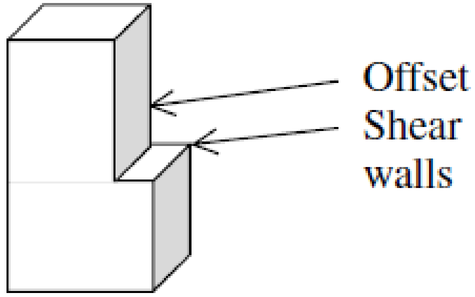
Not only height but also the horizontal and vertical configuration of the building controls its performance during an earthquake.











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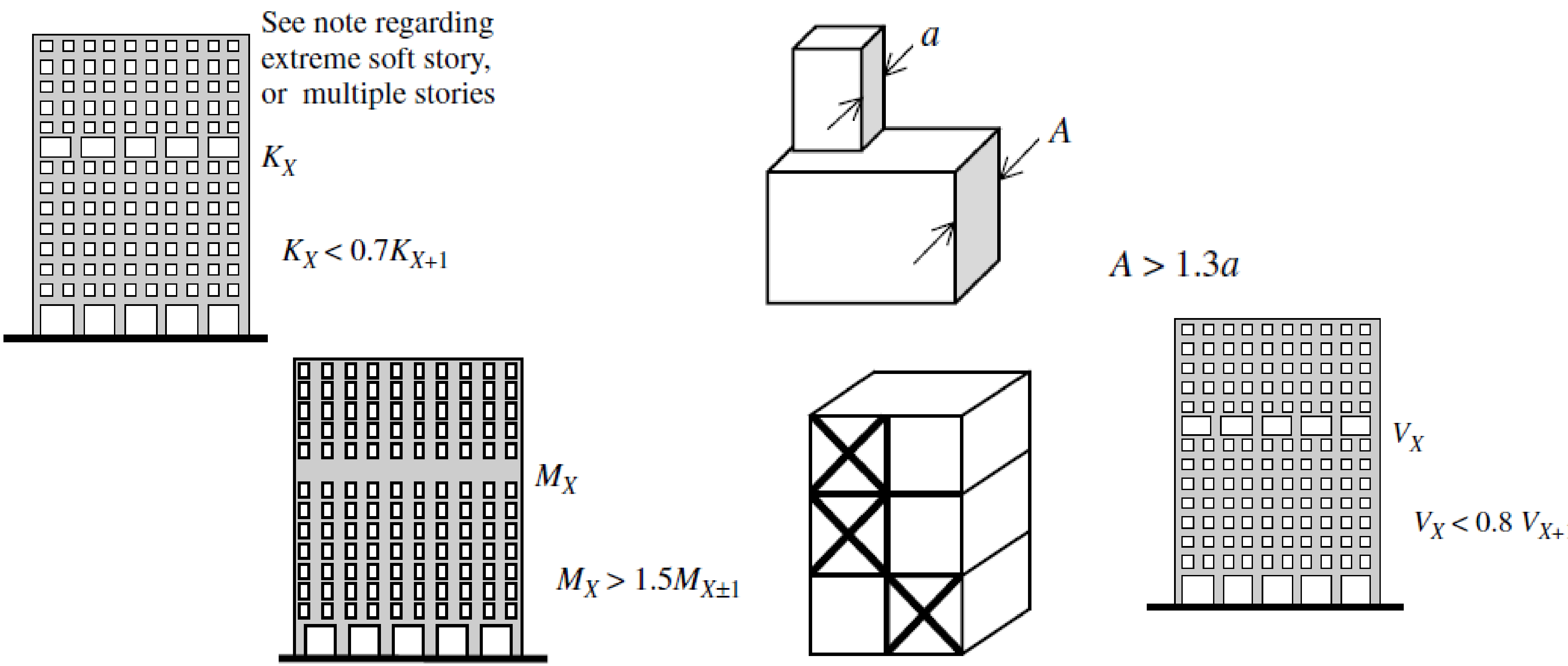
Not only height but also the horizontal and vertical configuration of the building controls its performance during an earthquake.



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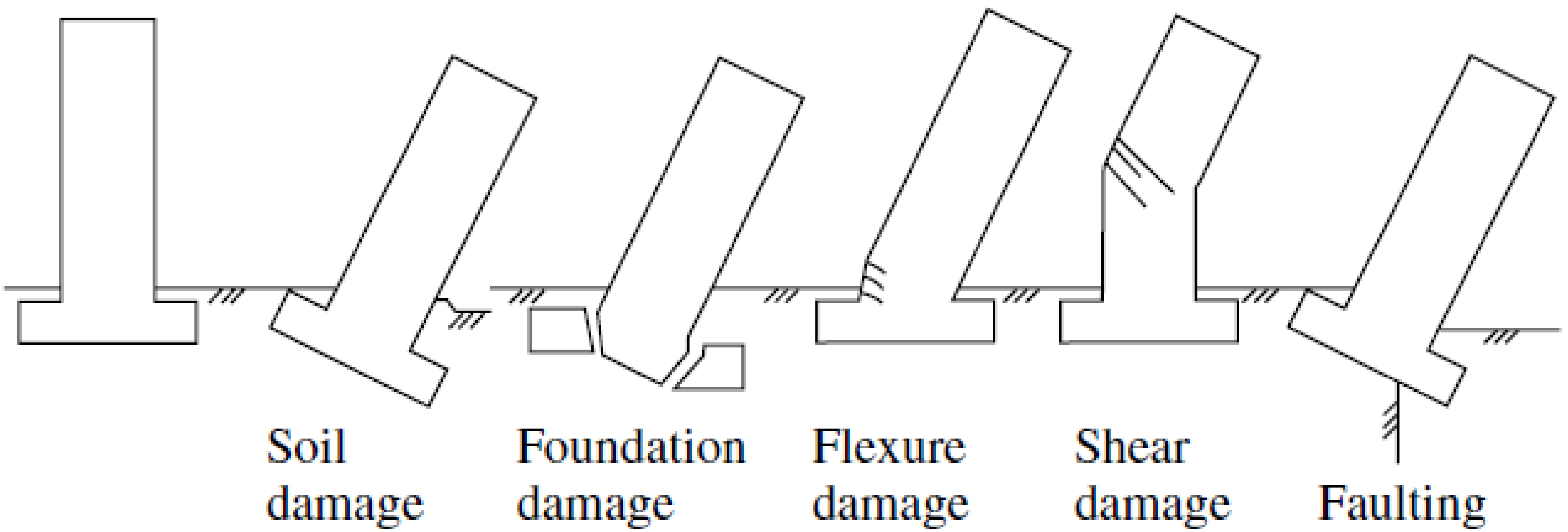
DAMAGES TO FOUNDATIONS IN EARTHQUAKES



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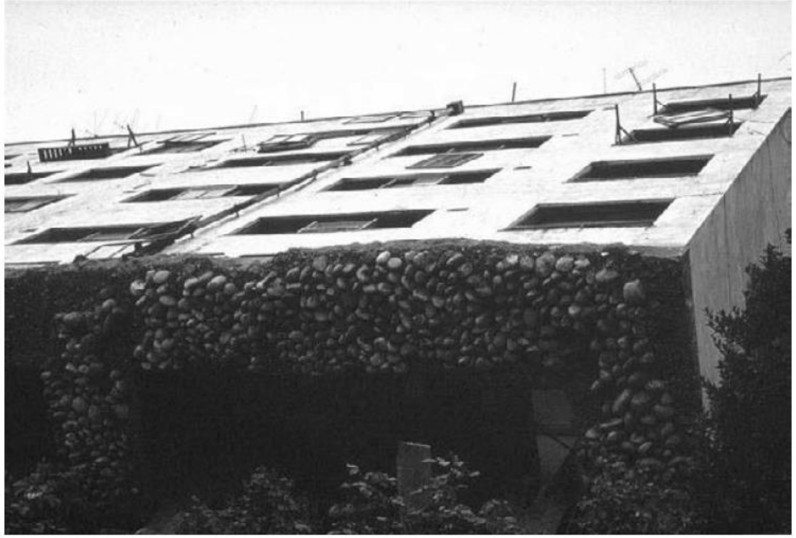
DAMAGES DUE TO SOIL FAILURE IN EARTHQUAKES

LIQUEFACTION OF SOIL FAILURE



LIQUEFACTION OF SOIL FAILURE

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DAMAGES DUE TO SOIL FAILURE IN EARTHQUAKES

BEARING CAPACITY FAILURE

LIQUEFACTION OF SOIL FAILURE

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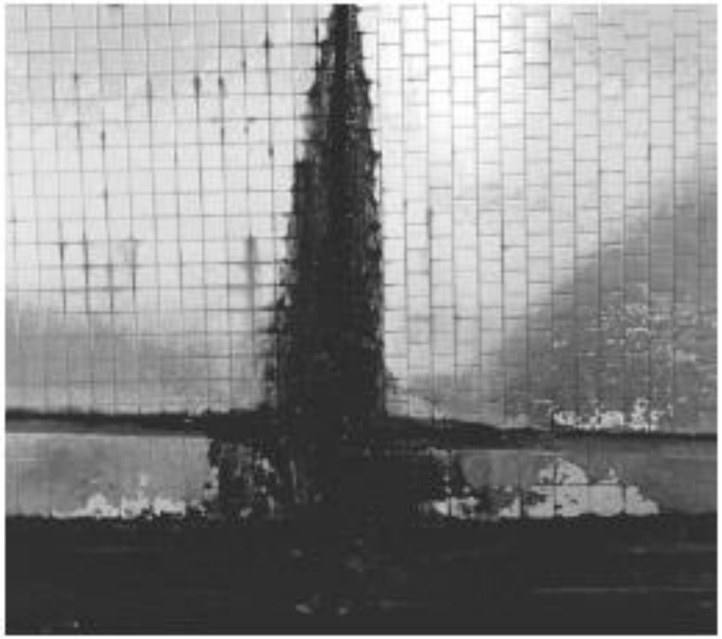
DAMAGES DUE TO SOIL FAILURE IN EARTHQUAKES

LIQUEFACTION OF SOIL FAILURE



LIQUEFACTION OF SOIL FAILURE

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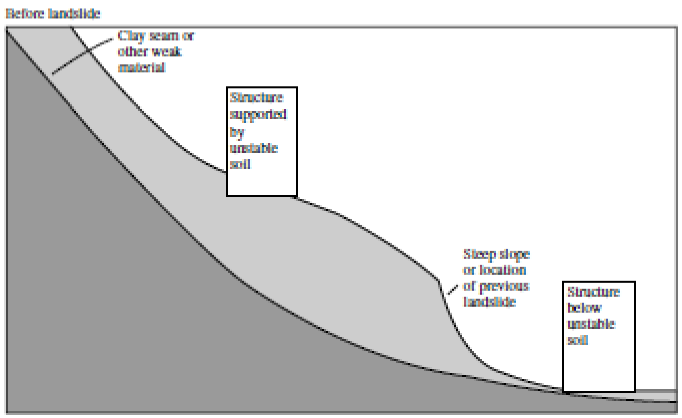
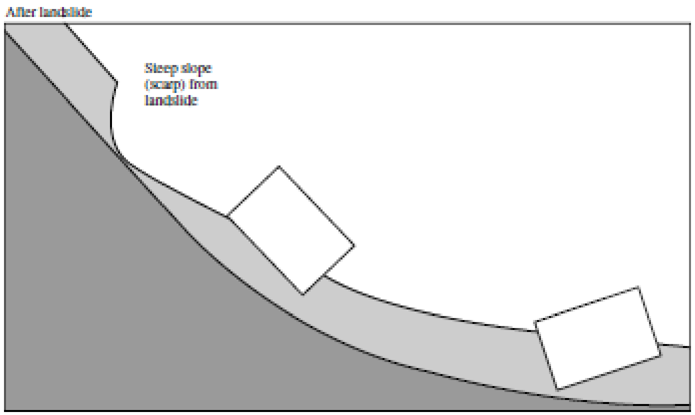
DAMAGES DUE TO SOIL FAILURE IN EARTHQUAKES





BEFORE LANDSLIDE

AFTER LAND SLIDE

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DAMAGES DUE TO SOIL FAILURE IN EARTHQUAKES

RETAINING WALL FAILURE

RETAINING WALL FAILURE

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FOUNDATION STRUCTURAL FAILURE

DAM FAILURE

PILE FAILURE

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FOUNDATION STRUCTURAL FAILURE

PILES POPPING DECK SLAB

FOUNDATION JOINT FAILURE

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FOUNDATION STRUCTURAL FAILURE

FAILURE DUE TO MATCHING TIME PERIODS

MASONARY BLOCK FAILURE

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FOUNDATION STRUCTURAL FAILURE

PILE FAILURE AT FOUNDATION JOINT

FOUNDATION JOINT FAILURE

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SUPER STRUCTURE STRUCTURAL FAILURE

SOFT STORY FAILURE

SOFT STORY AT 3RD FLOOR

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SUPER STRUCTURE STRUCTURAL FAILURE

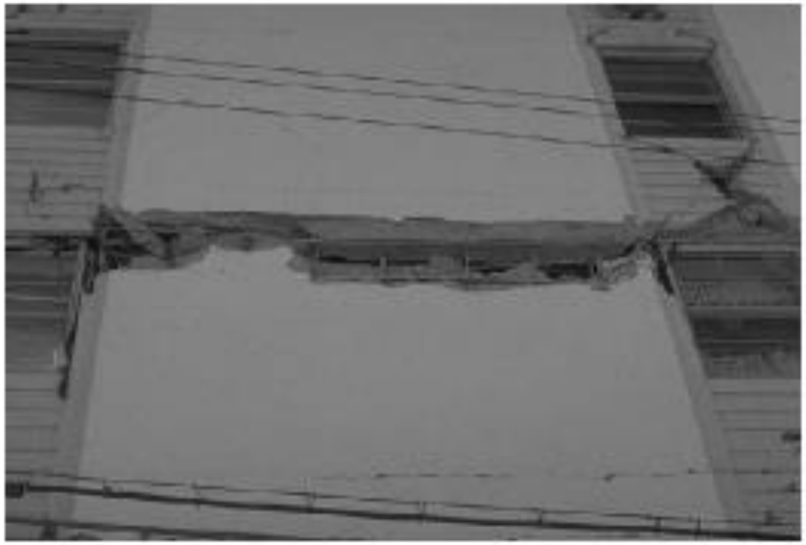
FAILURE

FAILURE

Seismic design of structures-Intro

SUPER STRUCTURE STRUCTURAL FAILURE

PLASTIC HINGE FORMATION



SHEAR WALL FAILURE

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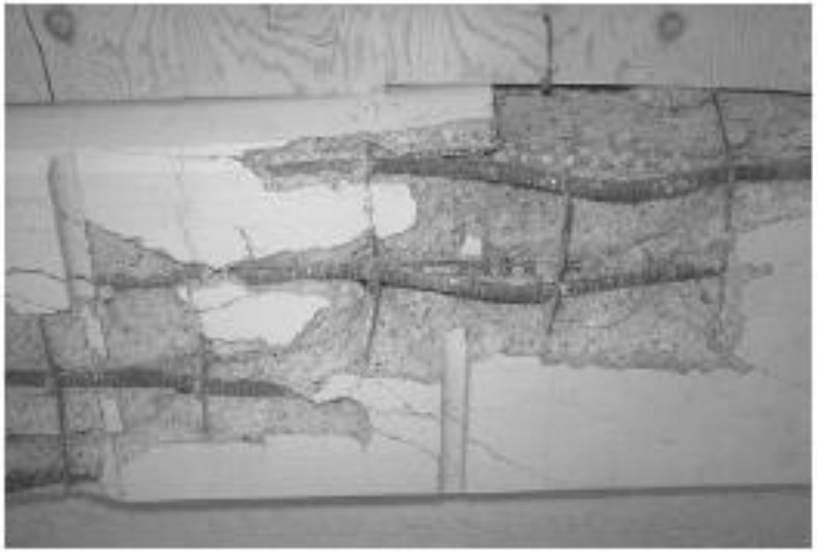
SUPER STRUCTURE STRUCTURAL FAILURE



SHEAR WALL FAILURE

STEEL COLUMN BUCKLING

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SUPER STRUCTURE STRUCTURAL FAILURE

PAN CAKE FAILURE

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SECONDARY FAILURE DURING EARTHQUAKES

SOIL WASHED OUT DUE TO BROKEN PIPES UNDER GROUND

BUILDING RESTING ON SIDE OF FLYOVER

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- I hope the answer to the significance of the of the subject is explained.
- Being Engineer, it is our duty to control these failures in buildings by using the appropriate guidelines of the code.
- For a successful seismic design of structure, includes both design and construction.