Module – 1

Introduction to Geotechnical Earthquake Engineering



Effects of Earthquake

- Devastating effects of earthquakes due to failure of structure







Earthquake never kills, but damage of structures during earthquake due to incorrect or insufficient design and constructions kills

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Effects of Earthquake

- Devastating effects of earthquakes due to **failure of soil beneath**







Structure is safe, but it has settled down by huge amount, due to failure of ground beneath.

Buildings dilapidated because of failure of soil beneath

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Effects of Earthquake

- Devastating effects of earthquakes due to **landslides and rockslides**



Fig. Landslides in Sikkim during 2011 earthquake



Fig. Rockslides in Sikkim at different road streches

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Effects of Earthquake

- **Tsunami**
  - is a series of water waves caused by the displacement of a large volume of a body of water, typically an ocean or a large lake.
  - Tsunami is a Japanese word with the English translation, "harbor wave" ("tsu," means harbor, while "nami," means "wave")





Figures showing disasters due to Tsunami

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Principal Types of Earthquake Damage

Structural

Caused by excessive ground shaking

Strongly influenced by local soil conditions



Principal Types of Earthquake Damage

Structural



Mexico City, 1985
- Low bedrock accelerations
- Strong amplification
- Strong ground surface motions

Principal Types of Earthquake Damage

Structural



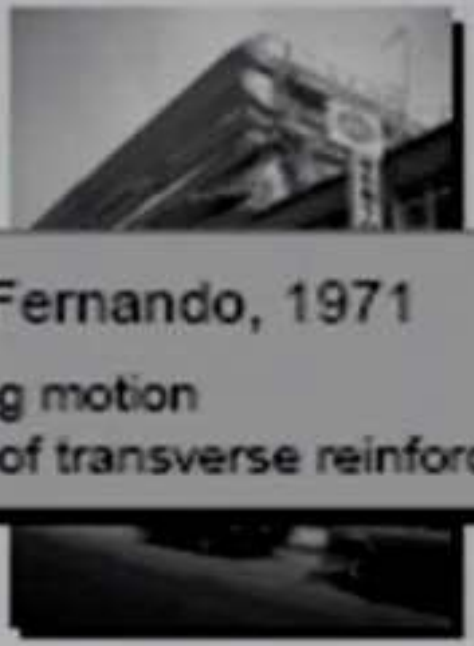


Loma Prieta, 1989

Modest rock accelerations
Strong amplification
Strong ground surface motions

Principal Types of Earthquake Damage

Structural





San Fernando, 1971

Strong motion
Lack of transverse reinforcement

- Ground Shaking: Shakes structures constructed on ground causing them to collapse
- Liquefaction: Conversion of formally stable cohesionless soils to a fluid mass, causing damage to the structures
- Landslides: Triggered by the vibrations
- Retaining structure failure: Damage of anchored wall, sheet pile, other retaining walls and sea walls
- Fire: Indirect result of earthquakes triggered by broken gas and power lines
- Tsunamis: large waves created by the instantaneous displacement of the sea floor during submarine faulting



Damage due to Earthquakes

Earthquakes have varied effects, including changes in geologic features, damage to man-made structures and impact on human and animal life.

Earthquake Damage depends on many factors:

- The size of the Earthquake
- The distance from the focus of the earthquake
- The properties of the materials at the site
- The nature of the structures in the area



Ground Shaking

Frequency of shaking differs for different seismic waves.

High frequency body waves shake low buildings more.

Low frequency surface waves shake high buildings more.

Intensity of shaking also depends on type of subsurface material.

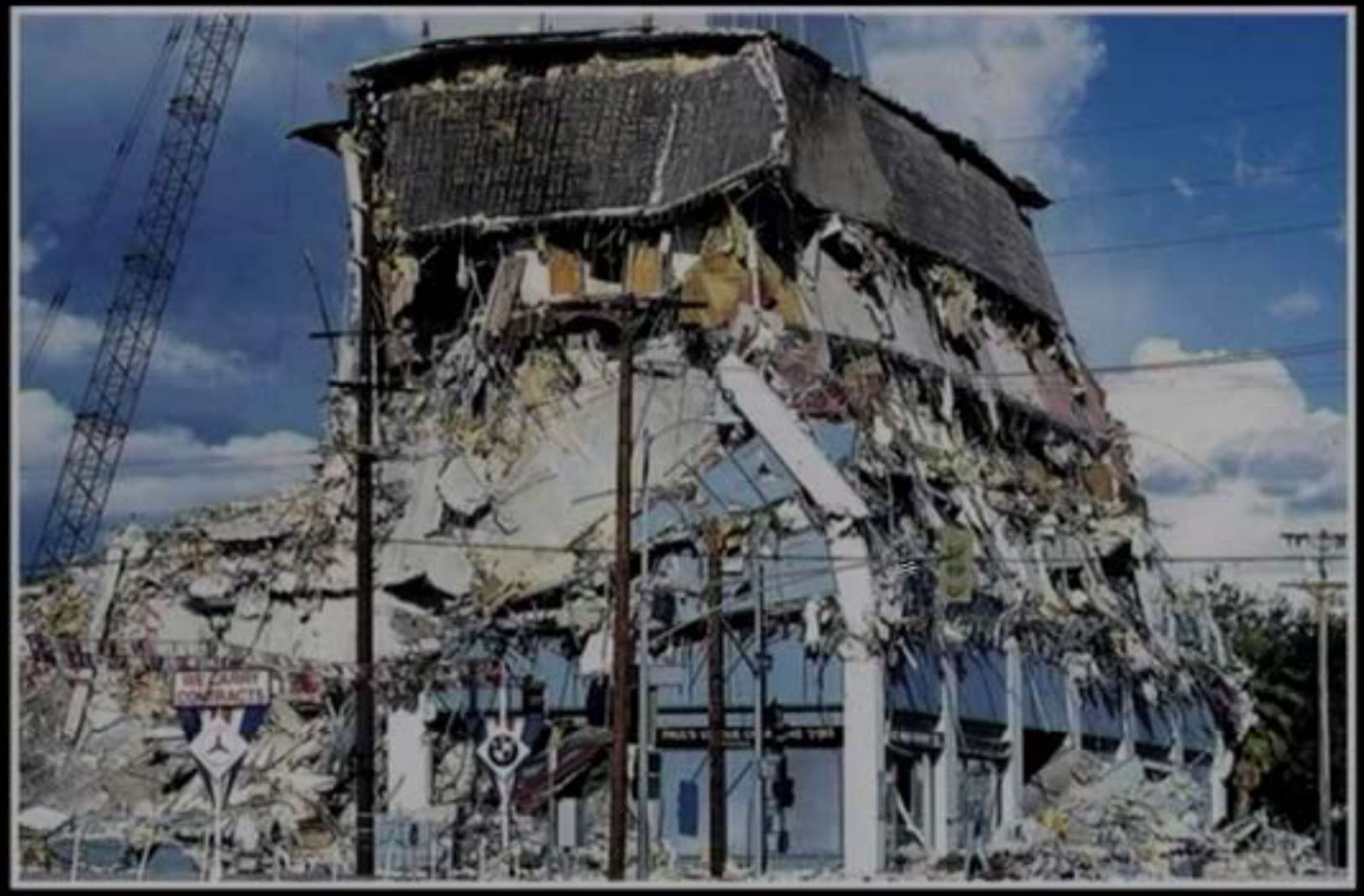
Unconsolidated materials amplify shaking more than rocks do.

Buildings respond differently to shaking depending on construction styles, materials

- Wood -- more flexible, holds up well
- Earthen materials, unreinforced concrete -- very vulnerable to shaking.



Collapse of Buildings



Collapse of Buildings

(Fukui Earthquake, 1948)

June 28th (Mon), 1948
16:13 pm
M7.1, D=0km

Death Toll: 3,769
Injured: 22,203

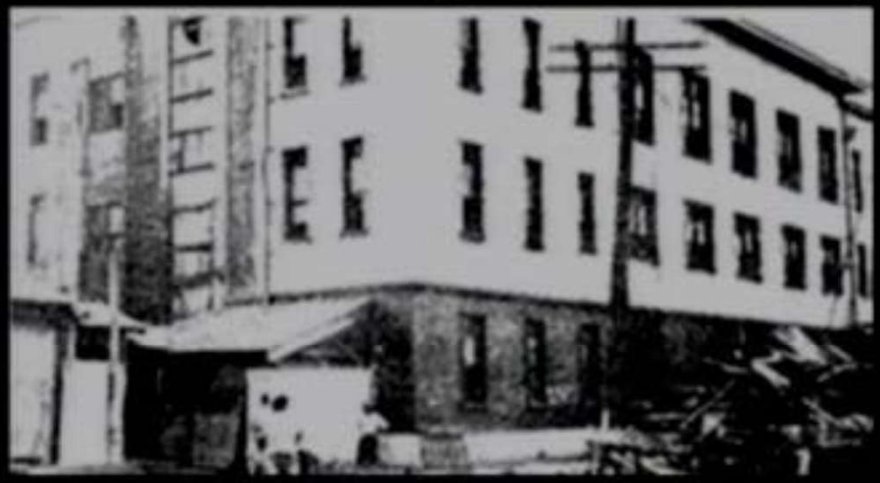
Collapse Ratio of Houses: almost 100% (The Area of South-North 20km by East-West10km of Fukui Plain)

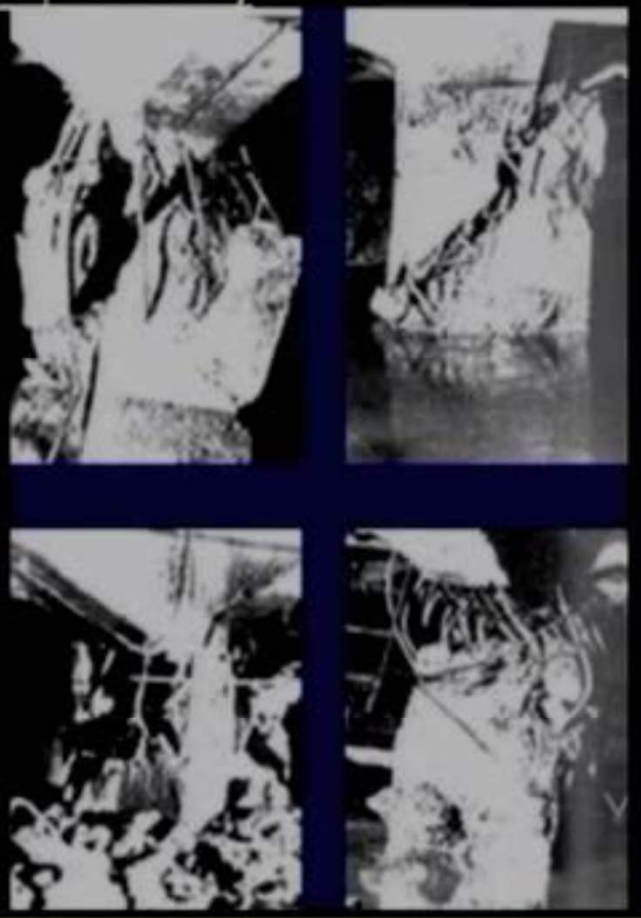


Damage to Pile-Heads of Hokuriku Haiden Building (Shear Cracks)

Collapse of Buildings

(Fukui Earthquake, 1948)





Damage to the Pile Foundations of Hokuriku-Haiden Building caused by the 1948 Fukui Earthquake

Settlements of the First Floor

Cracks at the Column-Heads of the Second Floor and the Floor Slabs of the First Floor

Soft first story/inadequate shear strength



Loma Prieta earthquake damage in San Francisco. The soft first story is due to construction of garages in the first story and resultant reduction in shear strength. (Photo from:)

On October 17, 1989, at 5:04:15 p.m. (P.d.t.), a magnitude 6.9 (moment magnitude; surface-wave magnitude, 7.1)