

Lecture 1: Earthquake Hazards

Topics

- Introduction
- Types of Earthquake/Seismic Hazards
- List of Major Historic Earthquakes in the World

Keywords: Earthquake hazards, ground shaking, liquefaction, landslide, Tsunami

Topic 1

Introduction

- The Earth beneath our feet usually feels solid and firm. Yet a million times each year (an average of once every thirty seconds) somewhere around the world the ground shakes and sways. We call this an earthquake.
- Most Earthquakes are too small to be noticed by people; only sensitive scientific instruments record their passage. But hundreds of earthquakes every year are strong enough to change the face of the land and are capable of causing injuries, deaths and property damage.
- Seismic hazards are those associated with earthquakes. The earthquake engineering involves the identification and mitigation of seismic hazards.

Topic 2

Types of Earthquake/Seismic Hazards

<http://web.ics.purdue.edu/~braile/indexlinks/educ.htm>

- **The effect of ground shaking** - The first main earthquake hazard (danger) is the effect of ground shaking. Buildings can be damaged by the shaking itself or by the ground beneath them settling to a different level than it was before the earthquake (subsidence).

When an earthquake occurs seismic waves will generate and it will radiate away from the source and travels rapidly through the earth's crust. When these waves reach on earth's surface, it will produce shaking which will remain for seconds to minutes. The strength and duration of shaking of a particular place depends upon the size and location of the earthquake and the characteristics of the site. All the sites near the source of large earthquake will produce huge damage. In fact, we can consider ground shaking as the most important hazard because all other hazards are occurring due to the ground shaking. Figure 1.1 shows the damage of buildings due to ground shaking



Fig 1.1: Ground storey collapse of a 4-storey building at Bhuj in Gujarat, India.

- **Ground displacement** - The second main earthquake hazard is ground displacement (ground movement) along a fault. If a structure (a building, road, etc.) is built across a fault, the ground displacement during an earthquake could seriously damage or rip apart that structure. Faulting is the surface expression of the differential movement of blocks of the Earth's crust. Faulting can be a simple "mole track" lateral movement, or a major vertical scarp, or may not even be visible. Figure 1.2 shows typical ground displacement due to earthquake



Fig 1.2: Ground displacement

- **Flooding** - An earthquake can rupture (break) dams or levees along a river. The water from the river or the reservoir would then flood the area, damaging buildings and maybe sweeping away or drowning people. The first failure of a

dam due to earthquake reported in the literature is Augusta dam, GA, during the 1886 Charleston, SC earthquake.

- **Fire** - The fourth main earthquake hazard is fire. These fires can be started by broken gas lines and power lines, or tipped over wood or coal stoves. They can be a serious problem, especially if the water lines that feed the fire hydrants are broken, too. For example, after the Great San Francisco Earthquake in 1906, the city burned for three days. Most of the city was destroyed and 250,000 people were left homeless. Figure 3 shows burning of san Francisco due to earthquake.



Fig 1.3: San Francisco burning after the 1906 Earthquake

- **Land slide** – Earthquakes can cause the failure of soil and rock slopes, particularly those that are marginally stable to begin with. The most common type of landslides triggered by seismic events include rock falls, soil slides, and rock slides on relatively steep slopes that are covered with disaggregated soil and rock. The debris from such failures can cut off roads and streams, and it can damage buildings, bridges and other structures. Loss of life due to landslides is a common occurrence. Of special concern are slope failures that progress quickly. A tragic example is the Huascarán Mountain landslide that occurred as a result of the 1970 Peru earthquake. It buried the town of Yungay and part of the town of Ranrahirca, with a loss of life exceeding 18,000. Figure 1.4 shows typical landslide and slope failure due to 2005 Pakistan earthquake



Fig 1.4: Slope failure observed in the regions of Balakot and Muzaffarabad (Pakistan Earthquake 8th Oct. 2005.)

- **Liquefaction** – is the temporary loss of soil strength and fluidization that occurs in certain saturated granular soils due to seismic shaking, represents a significant hazard in coastal areas and other locations with a high water table. The reduction in bearing capacity that accompanies the process of liquefaction can lead to the sinking of buildings, bridges and other heavy structures, often with little or no damage to the structure itself as shown in Figures 1.5 and 1.6 below. Liquefied beds can sometimes be detected by the presence of surface sand boils, formed as mixtures of soil and water squeeze out of ground, with the soil residue deposited nearby.



Fig 1.5: Ground failure due to liquefaction, Loma Prieta earthquake

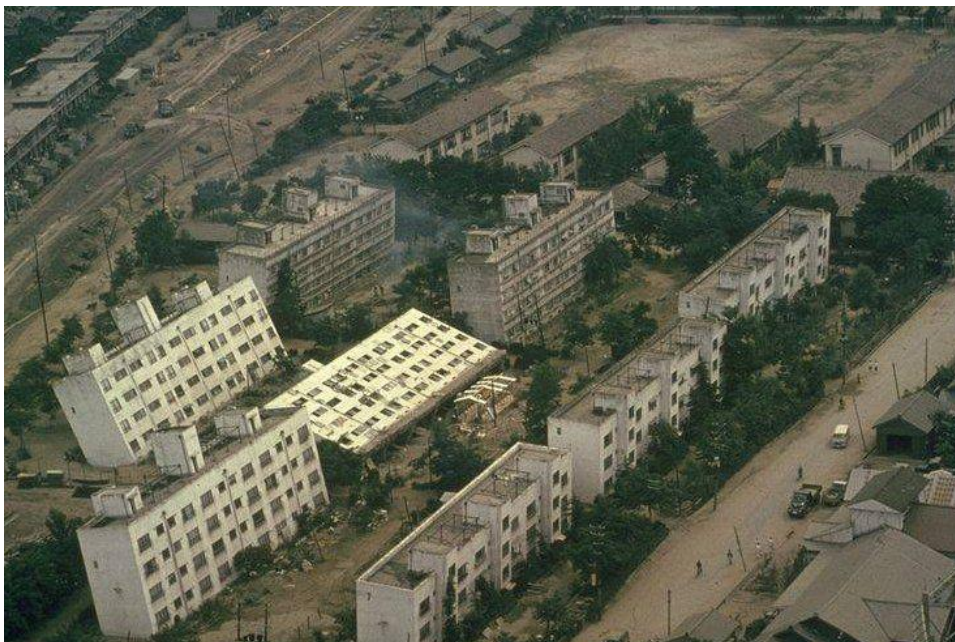


Fig 1.6: Building Collapse due to liquefaction, 1964 Niigata earthquake, Japan

Tsunami - Tsunamis are long period sea waves produced by rapid vertical seafloor movements caused by fault rupture during earthquake. In the open sea, tsunamis travels great distance at high speed but are difficult to detect. They usually have height less than 1 m and wavelength several hundreds of kilometers. As tsunami reaches on shore due to the reduction of depth in the water its speed will decrease and height will increase. In some coastal areas the shape of the seafloor is such that it will amplify the wave producing the vertical wall of water that rushes far inland and cause a huge damage. Figure 1.7 shows Tsunami hazard in famous Marina Beach, Chennai India.



Fig 1.7: Destructions caused due to Tsunami in Marina Beach, Chennai

Topic 3

List of Major Historic Earthquakes in the world

- Earthquakes have been recorded as early as 1177 B.C. in China. In European history, the earliest recorded earthquake occurred in 580 B.C.
- In North America the great earthquakes of 1811-1812 occurred near New Madrid, Missouri.
- The most destructive quake in U.S. history occurred in San Francisco in 1906; it caused the deaths of over 700 people.
- The great Alaskan earthquake of 1964 was twice as powerful, but less destructive due to the low population density of the area struck.
- The Chilean quake of 1960 was the biggest quake ever recorded. It came in at 9.5 on the Richter scale.

- In northern Sumatra, Indonesia earthquake was recorded at 9.1 on the Richter scale in 2004.
- In Kashmir, India quake was recorded at 7.6 killing 79,000 people in 2005.
- Earthquake which occurred in India/Pakistan border recorded at 7.9 on Richter scale killing 20,000 people in 2001.
- In Lisbon, Portugal quake was recorded at 8.6 on the Richter scale which killed 60,000 people in 1755.
- Earthquake which occurred in Kansu, China recorded 8.5 at Richter scale killing 200,000 people in 1920.
- In San Francisco, California earthquake was recorded at 8.3 on the Richter scale in 1906.
- The Kutch (also spelled Kachchh and Cutch) earthquake on June 16, 1819 in the northwestern corner of Peninsular India is considered to be the largest event of Stable Continental Region (SCR). Gutenberg and Richter (1954) assigned $M_L=8.4$, while Johnston and Kanter (1990) reviewed the stable continental earthquakes and assigned $M_W=7.8$ for this event.
- June 12, 1897 earthquake of the Shillong Plateau holds a very prominent place in seismology. The epicenter was reported to be at 25.90°N and 91.80°E (Milne, 1912), and the maximum intensity reached XII on MM scale as rated by Richter (1958).
- A first well documented earthquake is a 1905 Kangra Earthquake, which occurred in the Himachal Pradesh, the epicentre was reported to be at 32°N and 76°E . The initial magnitude was estimated to be $M_L = 8.6$.
- On August 15, 1950 at 19.00 hr. 39 min. (local time) the earthquake of Magnitude $M_S=8.7$ occurred off the northeastern boundary of Assam. The epicentre was reported at 28.5°N and 96.70°E , and maximum intensity to XII on MM scale.

End of Lecture 1 in Earthquake Hazards