EARTHQUAKE INDUCED PHENOMENA

Landslides

Sumatran earthquake induced landslide (2009), which has destroyed three villages
Source: http://www.theguardian.com/world/2009/oct/04/indonesia-natural-disasters

Buildings aren't the only thing to fail under the stresses of seismic waves. The unstable regions of hillsides or mountains also fail due to earthquakes[1]. Landslides occur on a regular basis throughout the world as part of the ongoing evolution of landscapes. At any given point of time, slopes exist in states ranging from very stable to marginally stable. When an earthquake occurs, the effects of earthquake induced ground shaking is often sufficient to cause failure of slopes that were marginally to moderately stable before the earthquake[2].

Huge landslide caused by Sikkim earthquake 2011, India
Source:http://www.thehindu.com/sci-tech/science/us-scientists-testing-earthquake-early-warning/article2470320.ece

In many earthquakes, landslides have been responsible for as much or more damage than all other seismic hazards combined. In the 1964 Alaska earthquake, for example, an estimated 56% of the total cost of damage was caused by earthquake-induced landslides. It was found that

more than half of all deaths in large (M>6.9) earthquakes in Japan between 1964 and 1980 were caused by landslides. The 1920 Haiyuan earthquake (M=8.5) in the Ningxia Province of China produced hundreds of large landslides that caused more than 100,000 deaths[2]. In 1970 an earthquake off the coast of Peru produced a landslide than began 128 meters away from the earthquake. The slide was large (witnesses estimated it's height at about 30 meters), traveled at more than one-hundred miles per hour and plowed through part of one village and annihilated another, killing more than 18,000 people[1].

Liquefaction

Liquefaction occurs when vibrations or water pressure within a mass of soil cause the soil particles to lose contact with one another. As a result, the soil behaves like a liquid, has an inability to support weight and can flow down in very gentle slopes[3]. It is frequently seen during, and even minutes after, earthquakes[4]. Liquefaction and related phenomena have been responsible for tremendous amounts of damage in historical earthquakes around the world[5].

Liquefaction caused from earthquake in Christchurch, New Zealand (2011)
Source: http://planetark.org/enviro-news/item/61352

Liquefaction induced bearing capacity failure during an earthquake (1999) in Adpazari, Turkey
Source:http://www.geerassociation.org/GEER_Post%20EQ%20Reports/Duzce_1999/Adapazari.htm

Because liquefaction only occurs in saturated soil, its effects are most commonly observed in low-lying areas near bodies of water such as rivers, lakes, bays, and oceans. The effects of liquefaction may include major sliding of soil toward the body slumping and of water, as in he case of the 1957 Lake Merced slide shown above, or more

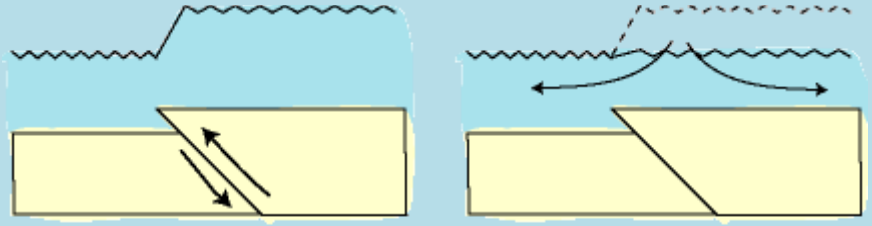
modest movements that produce tension cracks such as those on the banks of the Motagua River following the 1976 Guatemala Earthquake.

Tsunamis

The name tsunami is derived from the Japanese words ‘tsu’ meaning harbor and ‘nami’ meaning wave[6, 7 and 8]. Tsunami is a set of ocean waves caused by any large, abrupt disturbance of the sea-surface[8]. The most common cause of tsunami is an undersea earthquake that results in a sudden rise or fall of a section of the earth’s crust under or near the ocean[6]. Typically tsunamis are generated by earthquakes that occur along subduction zones. A subduction zone is an area on the earth where two tectonic plates meet and move towards one another, with one sliding underneath the other down into the earth at rates typically measured in centimeters per year.

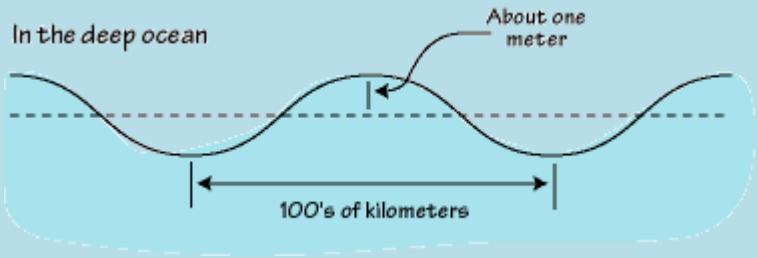
Tsunami Initiation[9]

A sudden offset changes the elevation of the ocean and initiates a water wave that travels outward from the region of sea-floor disruption. Tsunamis can travel all the way across the ocean and large earthquakes in Alaska and Chile have generated waves that caused damage and deaths in regions as far away as California, Hawaii and Japan.



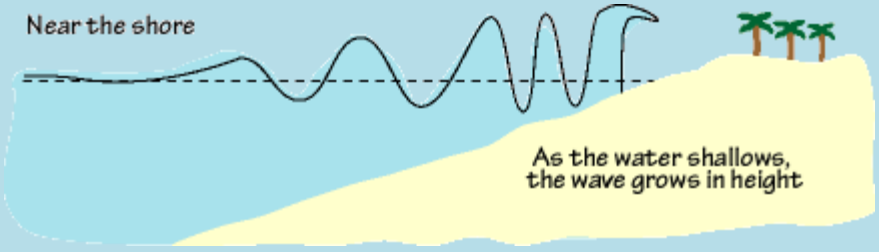
Tsunamis are initiated by a sudden displacement of the ocean, commonly caused by vertical deformation of the ocean floor during earthquakes. Other causes such as deformation by landslides and volcanic processes also generate tsunamis.

The speed of this wave depends on the ocean depth and is typically about as fast as a commercial passenger jet (about 0.2 km/s or 712 km/hr). This is relatively slow compared to seismic waves, so we are often alerted to the dangers of the tsunami by the shaking before the wave arrives. The trouble is that the time to react is not very long in regions close to the earthquake that caused the tsunami.



In deep water tsunamis are not large and pose no danger. They are very broad with horizontal wavelengths of hundreds of kilometers and surface heights much much smaller, about one meter.

Tsunamis pose no threat in the deep ocean because they are only a meter or so high in deep water. But as the wave approaches the shore and the water shallows, all the energy that was distributed throughout the ocean depth becomes concentrated in the shallow water and the wave height increases.



When a tsunami approaches the shore, the water depth decreases, the front of the wave slows down, the wave grows dramatically, and surges on land.

Typical heights for large tsunamis are on the order of 10s of meters and a few have approached 90 meters (about 300 feet). These waves are typically more devastating to the coastal region than the shaking of the earthquake that caused the tsunami.

Even the more common tsunamis of about 10-20 meters can "wipe clean" coastal communities.

Deadly tsunamis occur about every one to two years and they have at times killed thousands of people. In 1992-93 three large tsunamis occurred: one in Japan, Indonesia, and Nicaragua. All struck at night and devastated the local communities.

References

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[2] http://dod.nic.in/manual.pdf
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