LECTURE #8: Earthquake Disasters: Mitigation & Tsunami Science

Date: 5 Feb 2025

I. Exam I

- Feb 10th – next Monday
  - covers material from weeks 1 – 5 *(everything up to/including today's class)*
  - ~ 50 multiple choice questions including a few based on pictures, the videos, in the news slides
  - never leave blanks/skip questions – better to guess if you are unsure
- please be on time
  - if you are more than 10 minutes late or you **will not** be given the test
- you **must** have: *Peoplesoft number, #2 pencil, eraser, photo ID*
- here are example questions, which we will go over at the start of lecture:

1. During the last half of the 20th century, hurricanes, tsunami, and _____ account for the majority of deaths from natural disasters.
   A. volcanic eruptions B. floods C. landslides D. earthquakes

2. In general, the larger and more energetic the disaster, the shorter the return period between such events.
   A. true B. false

3. The heat that transformed the Earth early in its history came primarily from all but which of the following?
   A. impact energy B. gravitational energy
   C. magnetic energy D. decay of radioactive elements

4. The compressional movement at subduction zones and continent-continent collisions generate the largest tectonic earthquakes affecting the widest areas.
   A. true B. false

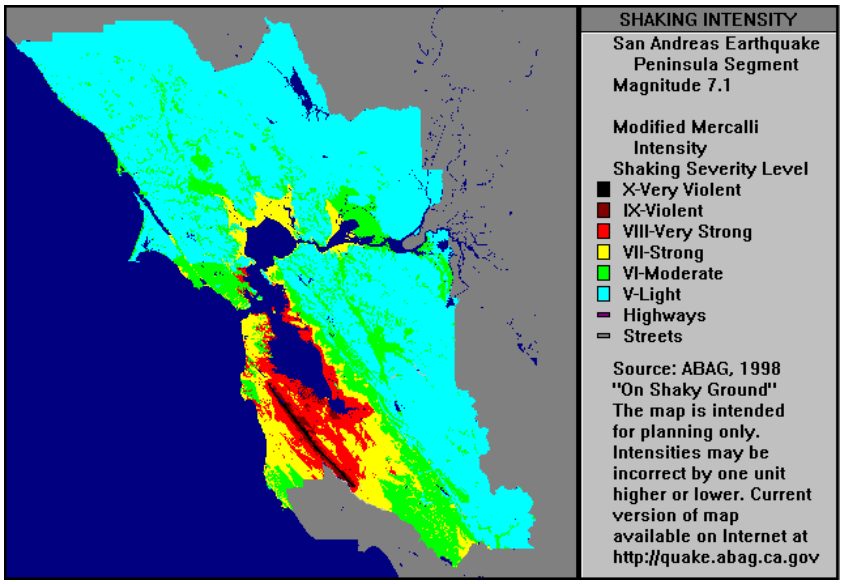
II. EQs: *Hazard Intensity*

- function of the magnitude *(energy released)*
  - other critical factors are equally important and include
    - duration of shaking
    - rock/soil types at/near the surface
    - quality of the structures
      - integrity/strength
      - density
      - utilities

        - human population
            - density
            - time of day *(at work, home, on the highways?)*

- duration of shaking
    - longer ground shaking causes more damage to buildings
    - potentially results in:
        - more people injured or killed
        - evacuation of homes and businesses
        - segments of the economy that suffer
        - hazardous materials can be released

    - mitigation through hazard maps
        - providing shaking hazard information
        - show the areas with the strongest expected shaking
        - suggest ways to mitigate shaking damage

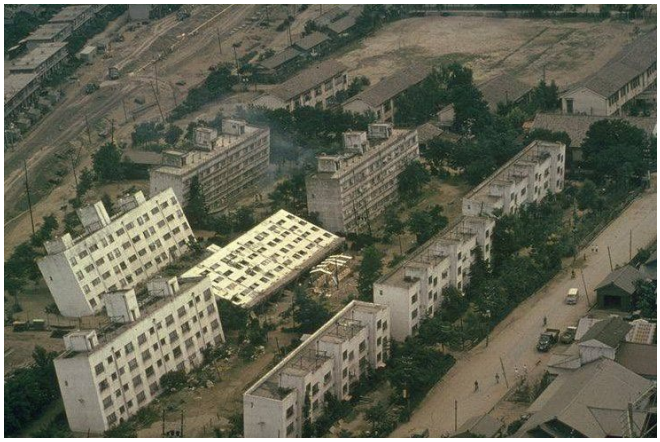


- rock/soil types at/near the surface:
    - contributor to higher amounts of ground shaking
        - transmits surface waves and can amplify them

    - has a LARGE effect on amount of shaking & building damage
        - buildings on bedrock always suffer far less damage than those built on soft sediment, soils, and/or weakened rock
        - sediment compresses more and tends to subside and/or amplify the ground motion

    - EQ induced landslides:
        - vibrations from EQ an act as a trigger for landslides in steep areas
        - we will cover landslides more in later lectures

- *liquefaction:* the process of ground water flow toward the surface due to seismic waves
  - the flow keeps soil particles from touching
  - creates a flowing soil/water mixture (similar to quicksand)
    - surface expression includes sand boils, dikes, and ridges



building damage from liquefaction

- structural integrity:
  - critical in preventing high death rates following a large earthquake
  - a vast majority of the fatalities from EQ are caused by building/structural failures *(key point in the video homework)*
  - examples:
    - brickwork: fails at a high rate due to the weakness of the mortar

    - wood-frame: more flexible and can withstand low-moderate ground motion, but easily destroyed
    - heavy-roofed structures: very unstable and easily fail, trapping people underneath
    - buildings with large open spaces: have weak floors which promote "pancaking" failure
      - example: parking garages, hotel lobbies, etc.

- integrity of utilities:
  - failure of underground pipelines (gas, water, electrical) due to ground acceleration
  - in modern cities, problems arise due to post-EQ fires

        - can impact other facilities: nuclear power facilities, chemical plants, etc.
        - can cause a large increase in EQ-related damage and deaths due to these fires, explosions, and electrocutions
        - failure of water lines also hinders fire-fighting efforts
        - example: over 30% of the city of San Francisco was destroyed due to fire after the 1906 EQ

- population/building density, time of day *(aka, the people factor)*
    - as the density of people and buildings increase, so does the hazard risks
    - if more people are out on the roads, walking on the sidewalks or at work in buildings, there are more chances for injury

- mitigation efforts
    - structural reinforcements
        - buildings, concrete columns, single-family home construction

I. Tsunamis *(new topic)*

- awareness of the disaster
    - South Asian (Dec. 26, 2004) and Japan (Mar. 11, 2011) tsunamis
        - these received mass media coverage around the world
        - first major tsunamis in the recent past
        - last large one was in the Indian Ocean in 1883
            - caused by the eruption of Krakatau Volcano
            - 36,000 deaths

        - the 2004 tsunami: killed ~230,000 people in 14 countries
            - ~ 150,000 in Indonesia alone

        - caused by the 3rd largest EQ ever recorded (M ~ 9.1)
            - hypocenter: 30km below seafloor
            - vertical offset (thrust fault) of the seafloor along the fault trace: 25m

- a tsunami is NOT a “tidal wave”
    - nothing to do with the tides, nor is it a wind-driven wave

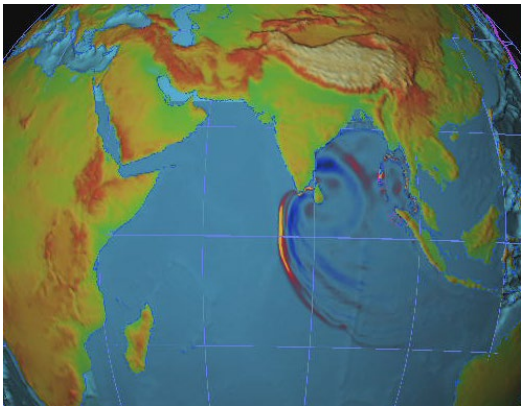
- caused by a major transfer of energy into the ocean water
    - disturbance on the sea floor (volcano, EQ, landslide, or even meteorite impact)
        - <u>example:</u> movement along a trust fault, for example, can create an upward motion of the water → produces surface movement (swells)
        - this is what happened in Indonesia and Japan

- can strike almost any coastal area and cause severe damage
    - much more common in the Pacific Ocean

- deaths:
    - 1600-1900: ~321,000
    - 1900-2000: ~150,000
    - 2000-present: ~230,000 *(2004 tsunami)* + ~19,000 *(2011 tsunami)* + ~1500 *(2018 tsunami)* = **~250,000**

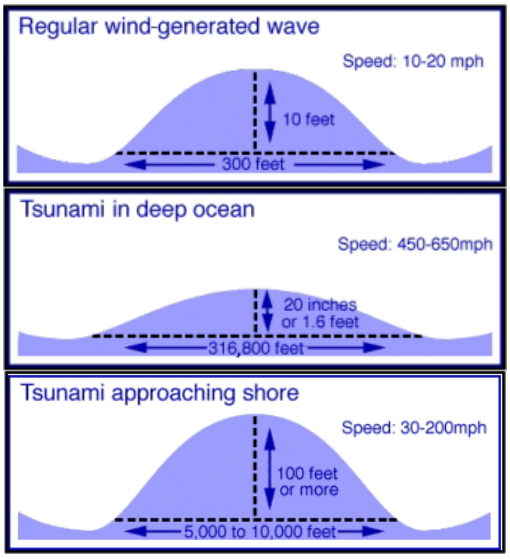
II. Tsunami Characteristics:

- disturbance of the water column
- propagation of energy away from source in all directions
  - reflection and refraction of waves at coastlines



Video modeling the distribution of waves following the 2004 tsunami *(red/yellow colors are wave peak heights and dark blue are the wave troughs)*

- energy is distributed over the entire water column
  - wavelength is much longer than wind waves
    - ~ 10s up to 100 kilometers
  - wave height is much smaller in <u>deep water</u>
    - 0.5 - 1.0 meters
    - generally, not felt in the open ocean in boats
  - speed can exceed 500 mph in the deep ocean
    - as fast as a jet aircraft!



III. Next Class:

- we will finish the notes on tsunamis looking at monitoring and mitigation

- also, please review old news and social media accounts of the 2011 Japan EQ and tsunami
  - *we will discuss those events since the disaster was so well covered by first person accounts and cell phone videos*