LECTURE #7: Earthquake Disasters: Mitigation & Tsunami Science

Date: 7 Feb 2021

I. Exam I

- Feb 17th – one week from today's class
- details:
    - covers material from weeks 1 – 4 *(everything up to/including the beginning of tsunamis)*
        - *that is everything to the end of today's lecture (not next Monday's lecture)*

    - ~ 50 multiple choice questions including a few based on pictures, the recitation, and the video
    - 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*
- we will go over some example questions at the start of today's class

II. Video Homework

- "The Day the Earth Shook"
    - comparison of the January 17th earthquakes in Northridge, CA (1994) and Kobe, Japan (1995)
    - take notes – there will be a few exam questions on it!

III. EQ's *(continued)*: *Hazard Intensity*

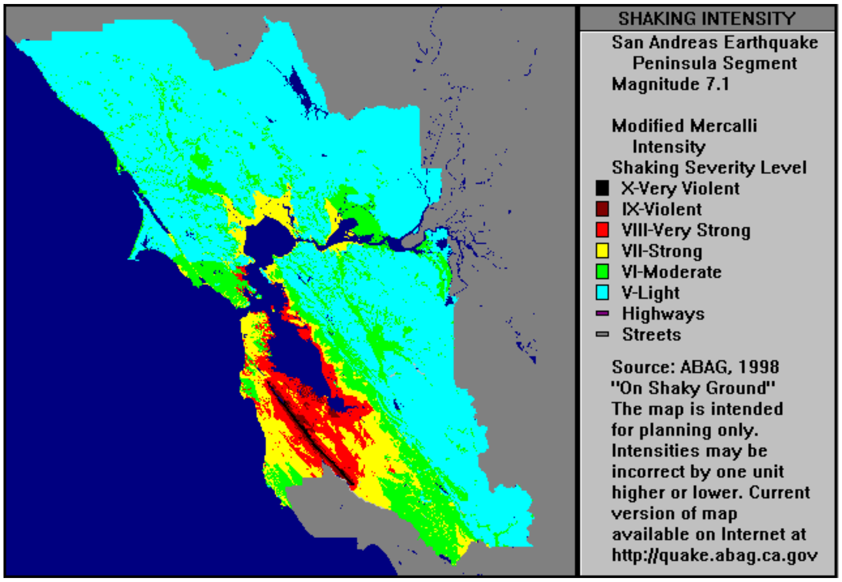
- function of the magnitude
    - other critical factors are equally important and include
        - duration of shaking
        - surface geology
        - quality of the structures
            - integrity
            - density
            - utilities

        - 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

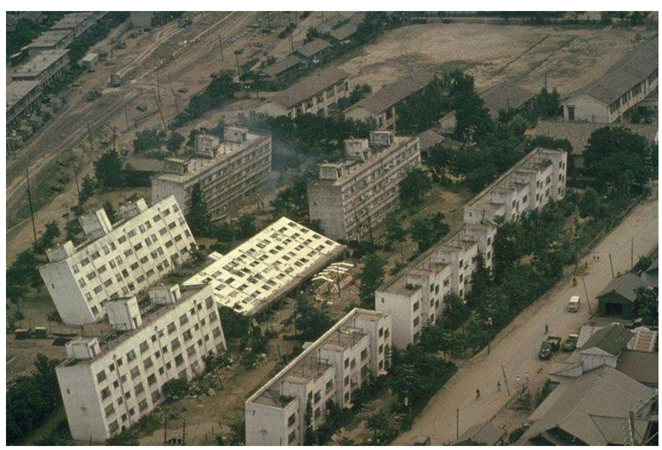
    - mitigation through hazard maps
        - providing shaking hazard information
        - show the areas with the strongest expected shaking
        - suggest ways to mitigate shaking damage



- surface geology:
    - 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 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's are caused by building/structural failures
  - examples:
    - <u>brickwork:</u> fails at a high rate due to the weakness of the mortar:

    - <u>wood-frame:</u> more flexible and can withstand low-moderate ground motion, but easily destroyed
    - <u>heavy roofed structures:</u> very unstable and easily fail, trapping people underneath
    - <u>buildings with large open spaces:</u> 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 *(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

IV. *new topic:* Tsunamis

- awareness
  - 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, for example, 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 of the seafloor along the fault trace: 25m

- a tsunami is NOT a "tidal wave"
  - it is not a wind-driven

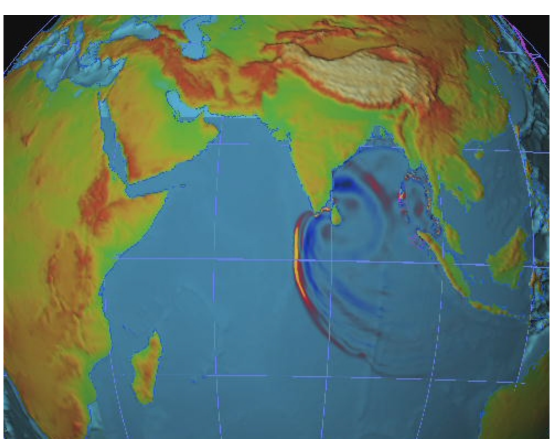
- caused by a major transfer of energy into the ocean water
  - disturbance on the sea floor (volcano, EQ, landslide, or even meteorite impact)
    - example: movement along a trust fault, for example, can create an upward motion of the water → produces surface movement (swells)
    - this is what happened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

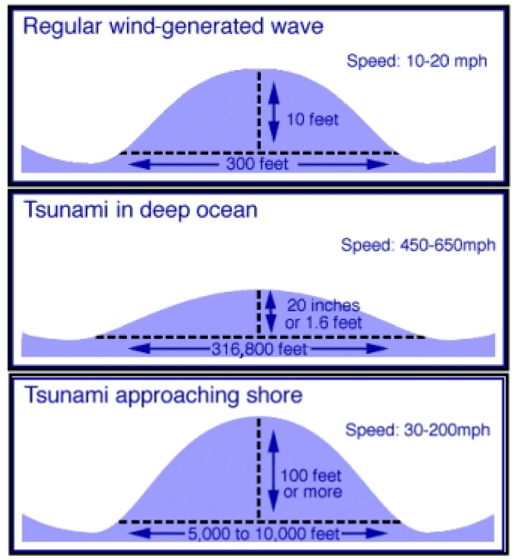
V. Characteristics:

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



Model of 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
    - ~ 10's up to 100 km's
  - 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 airplane!



VI. Next Class:

- 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*