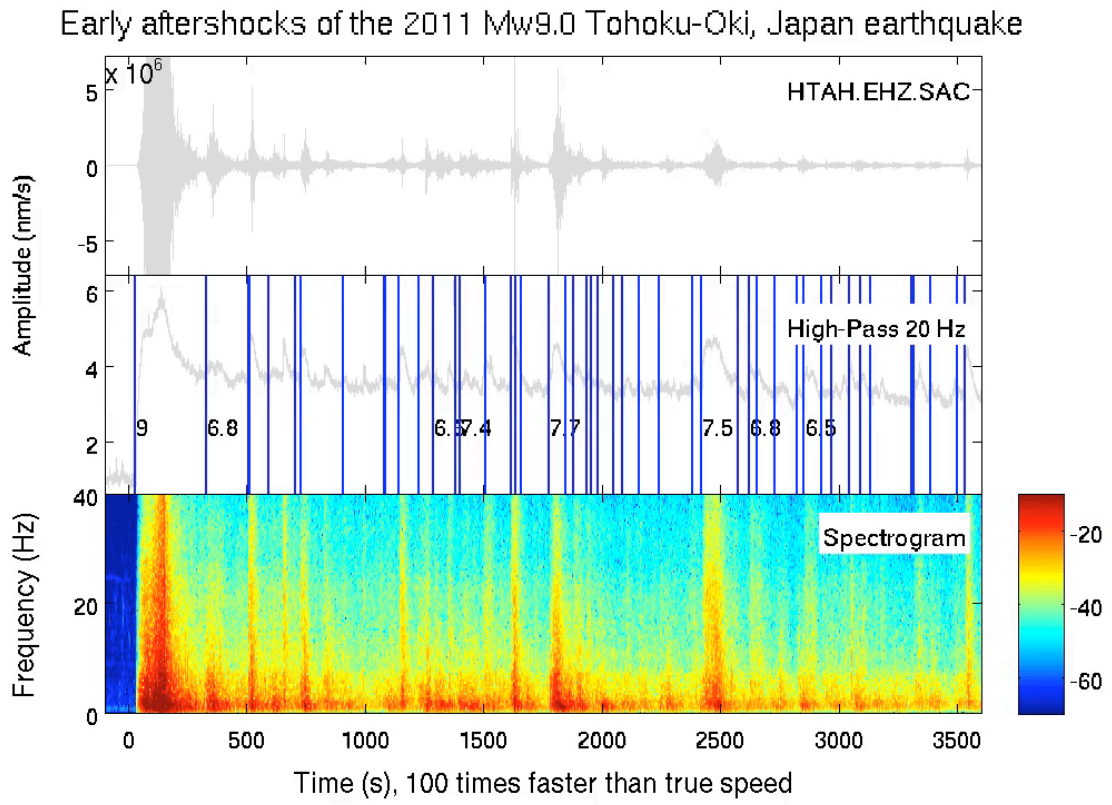
Static triggering

- local
- can last for years



http://geophysics.eas.gatech.edu/people/zpeng/EQ_Music/#part2_3

Dynamic triggering

- large region (sometimes global)
- only while waves are passing (minutes)
- restricted to volcanic or geothermal areas

Dynamic triggering

- large region (sometimes global)
- only while waves are passing (minutes)
- restricted to volcanic or geothermal areas

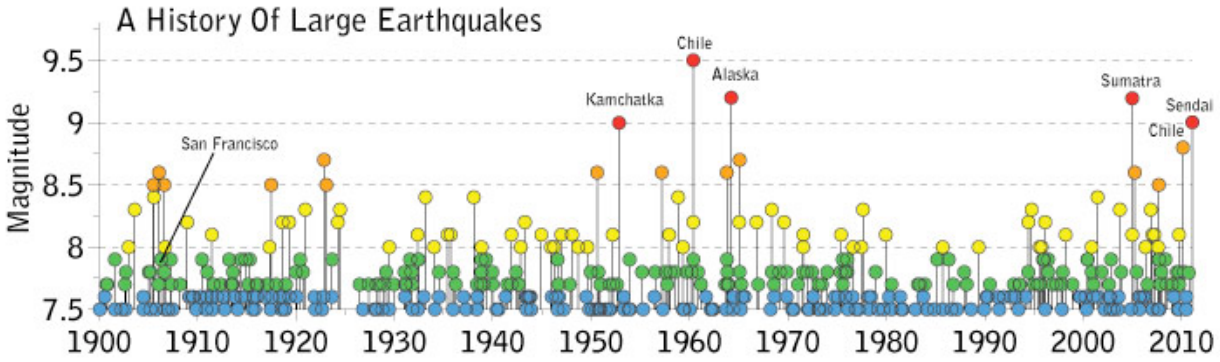
Surface waves from M8.8 earthquake crossing the EarthScope seismometer array

http://www.youtube.com/watch?v=QOJ7XsdoDHg

California geothermal field quakes triggered by Tohoku earthquake

http://geophysics.eas.gatech.edu/people/zpeng/EQ_Music/#part2_3

Occurrence of large earthquakes worldwide: Do great quakes trigger other large quakes worldwide?



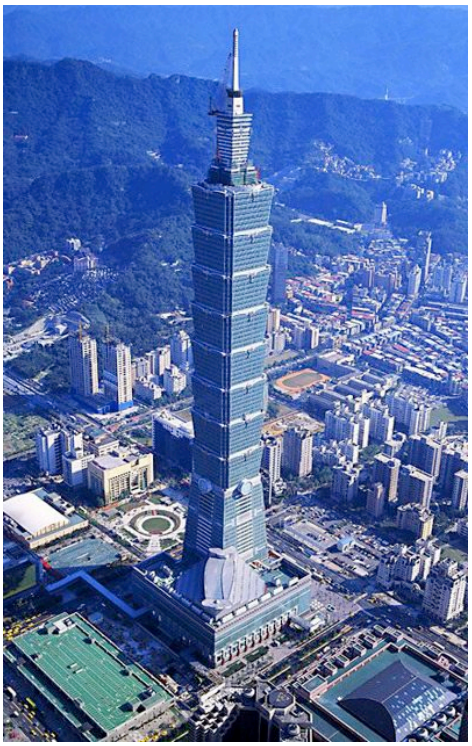
Class exercise: Earthquake triggering by human activity?

Focus is <u>static triggering</u>: we do not make explosions comparable to large earthquakes.

GEOPHYSICAL RESEARCH LETTERS, VOL. 32, L22313, doi:10.1029/2005GL024223, 2005

Seismicity increase after the construction of the world's tallest building: An active blind fault beneath the Taipei 101

Cheng-Horng Lin
Institute of Earth Sciences, Academia Sinica, Taipei, Taiwan



mass = 705,000 metric tons
= 7.05 x 10^8 kg

Force acting on ground = mass x gravitational acceleration = Q = 7.05 x 10^9 kg m/s^2

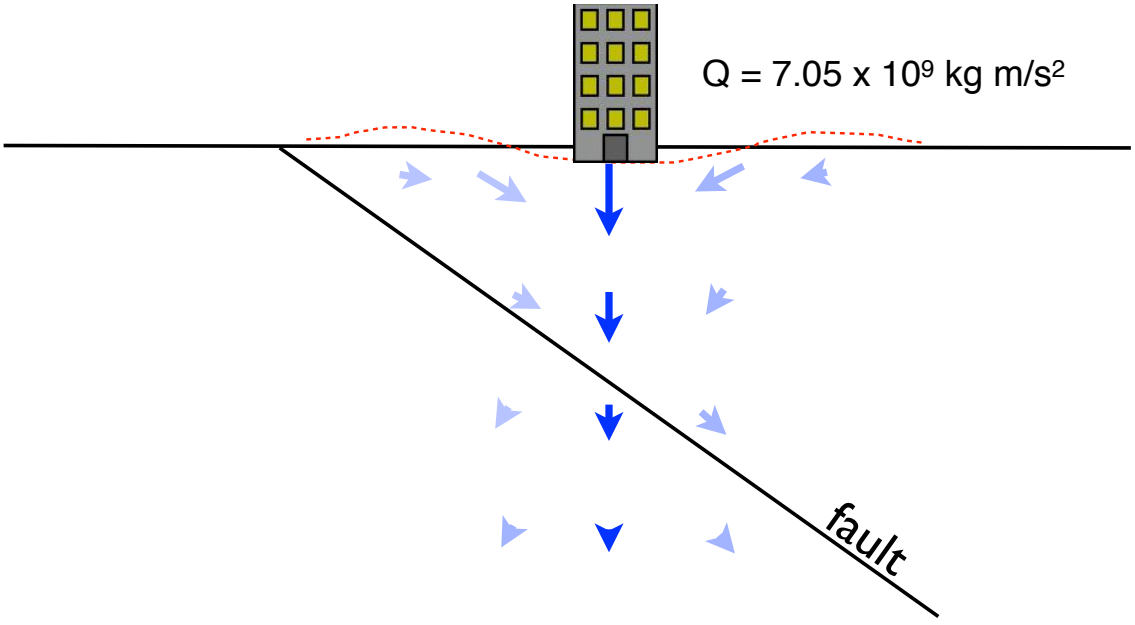
footprint area is 15000 sq m so stress at base is about 0.47 MPa (used by C. Lin...)

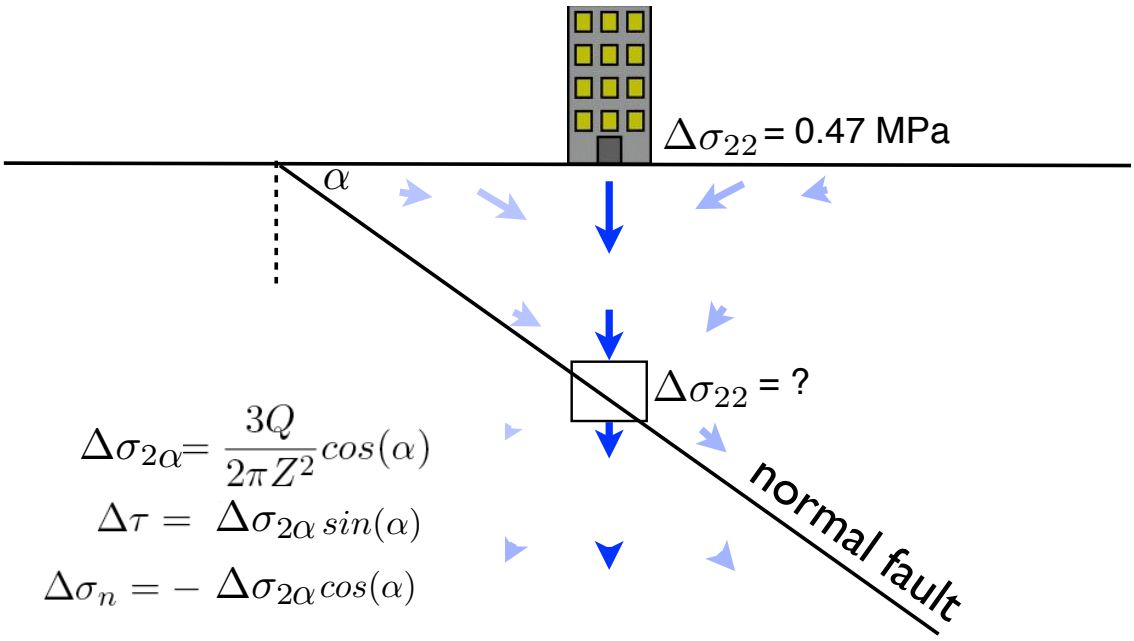
but triggered (??) quake was 10 km deep...

$$\begin{bmatrix} \Delta\sigma_{11} & \Delta\sigma_{12} \\ \Delta\sigma_{21} & \Delta\sigma_{22} \end{bmatrix} \Rightarrow \Delta CFF = \Delta\tau + \mu_s \Delta\sigma_e$$

where

$$(\sigma_e = \sigma_n + P_p)$$





$$\Delta\sigma_{2\alpha} = \frac{3Q}{2\pi Z^2}\cos(\alpha)$$

$$\Delta\tau = \Delta\sigma_{2\alpha}\sin(\alpha)$$

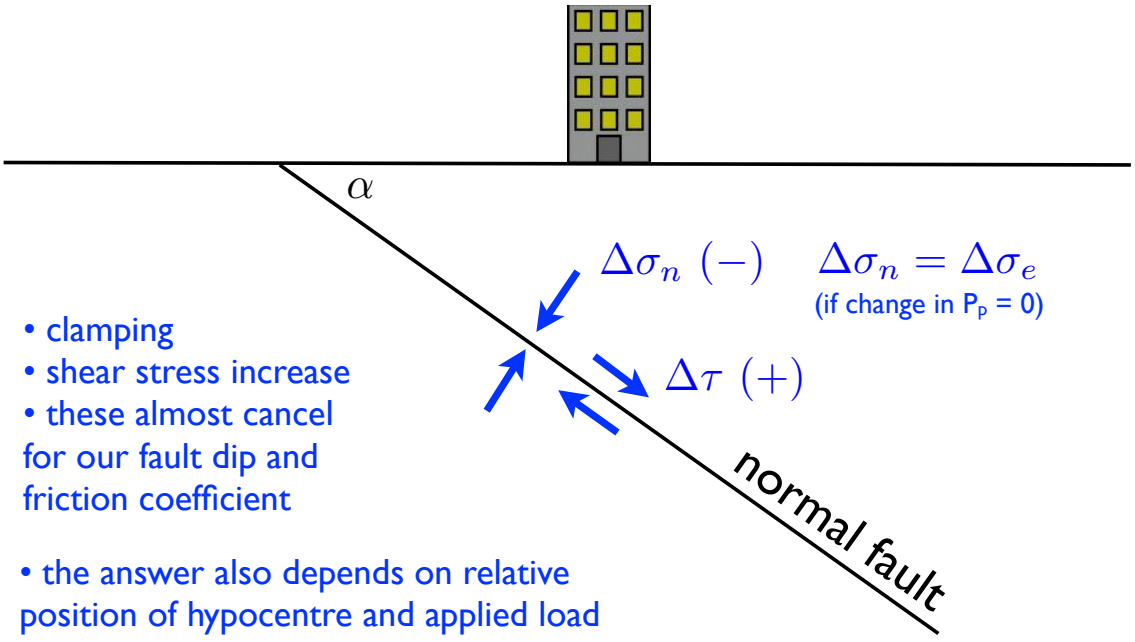
$$\Delta\sigma_n = -\Delta\sigma_{2\alpha}\cos(\alpha)$$

Z = 10 km

Q = 7.05 x 10^9 kg m/s^2

these equations assume z is positive downward, so Q is acting in the +z direction

$$\Delta CFF = \Delta\tau + \mu_s \Delta\sigma_e$$



- clamping
- shear stress increase
- these almost cancel

for our fault dip and friction coefficient

- the answer also depends on relative position of hypocentre and applied load

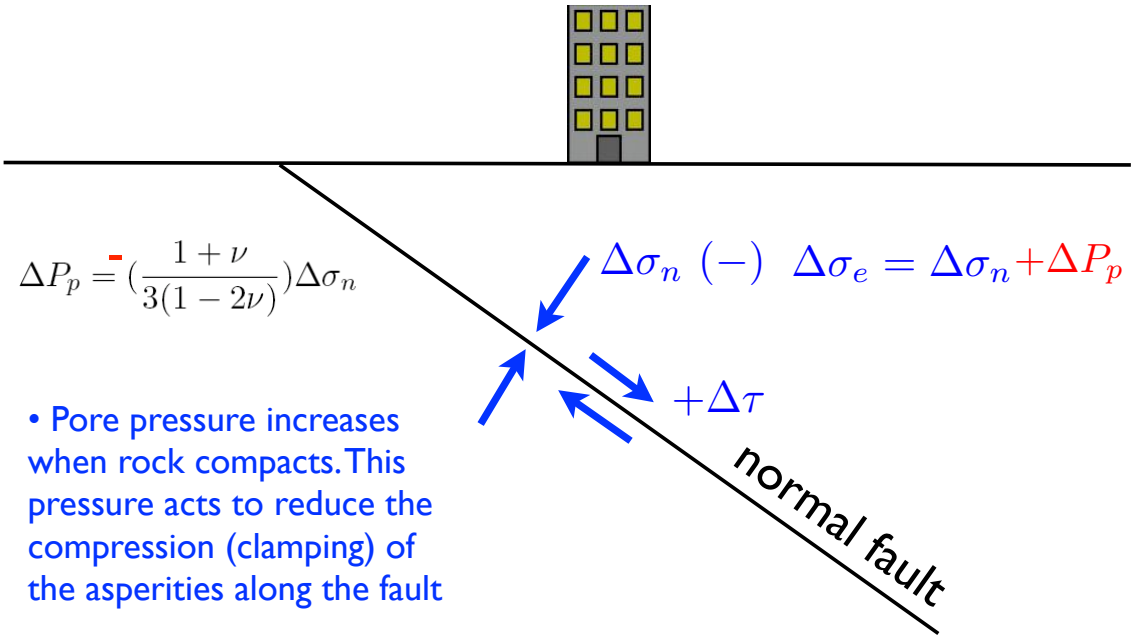
$$\begin{bmatrix} 0 & 0 \\ 0 & \Delta\sigma_{22} \end{bmatrix}$$

(right below building)

$$\Delta CFF = \Delta\tau + \mu_s \Delta\sigma_e$$

where

$$(\sigma_e = \sigma_n + P_p)$$



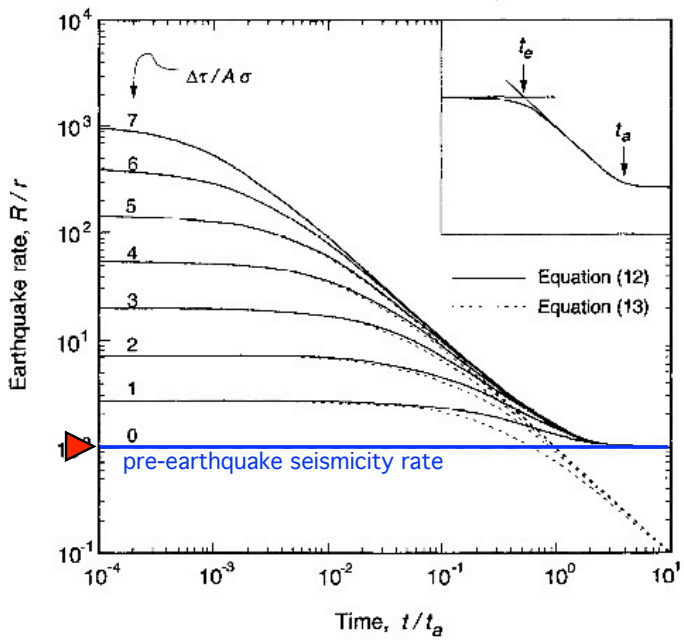
$$\Delta P_p = -(\frac{1+\nu}{3(1-2\nu)})\Delta\sigma_n$$

$\Delta\sigma_n$ $(-)$ $\Delta\sigma_e = \Delta\sigma_n + \Delta P_p$

$+\Delta\tau$

normal fault

• Pore pressure increases when rock compacts. This pressure acts to reduce the compression (clamping) of the asperities along the fault



0.01? 10 MPa?

typical $a\sigma_e$:

1 bar?