Lecture before thanksgiving: **Tue Nov 25th**

**Campus building tour**

Meeting point: **Residence Halls Unit 1 courtyard at 11am**

There will be no regular lecture in Stanley, just the tour.
Preparing for earthquakes:
Building for earthquakes

http://earthquakes.berkeley.edu/eps20

Transamerica building
- completed 1972
- 49 stories
- 260 m (850 ft) high

Loma Prieta
- 100 km away
- shook for >1 minute
- top swayed > 30 cm

How do we know what the motion was?
Recording earthquake shaking

1984, M6.2 Morgan Hill earthquake
- 20 km from West Valley College
- Center of Gymnasium roof swayed more than expected

changes to the Uniform Building Code (in 1991)

...this type of roof now has to be less flexible in new buildings

...but, existing buildings do not have to be modified

Recording earthquake shaking

Loma Prieta: Cypress Viaduct
- Part on land fill over soft mud collapsed
- Part on stronger sand and gravel did not
Learning from earthquakes

Big changes to building codes:


1997 following 1994 Northridge and 1995 Kobe earthquakes

Building for earthquakes

20 years ago, strong motion records were known by name:

El Centro 1940
Parkfield No. 2
Pacoima Dam 1971
...

Strong shaking records
PEER Strong Motion Database

Many more records, but still few earthquakes:

Loma Prieta
Chi-Chi
Kobe
etc

Attenuation relations
National seismic hazard maps

Ground Motion Intensity

1 sec Spectral Acceleration with 2% probability of exceedence in 50 yrs

Tall (400’+) Buildings

In San Francisco:
- 4 under construction
- 10 approved
- 16 proposed (3 are 1200’ high)

Outside the range of building code provisions.
Ground motions - don’t have much data in close to very large earthquakes.
ShakeOut earthquake simulation

M7.8 Scenario Earthquake
Time = 000.0 s

Terrashake simulations

Simulated earthquakes: need to define the fault, slip distribution and earth structure

this is what seismologists are trying to do
Modes of building failure

Soft story/inadequate shear strength

- Apartment buildings collapsing onto weak first story
- Collapse of first story causes damage to rest of the building

Soft story can be at a mid-level wherever there is not continuity in strength
Modes of building failure

Inadequate connection to foundation

Wood-frame house shifted off its foundation in Fillmore. In many cases, damage to older wood-frame houses could be attributed to their not being securely bolted to their foundation or to failure of cripple-stud walls in the crawl space between the foundation and first floor. Photograph by J. W. Doney.

Modes of building failure

Column failure

These crushed columns formerly supported the heavy deck of the I-10 freeway at Venice Boulevard in Los Angeles. Failure of the columns is attributed to the insufficient number and spacing of the horizontal, circular ties reinforcing bars that go through the columns. During vigorous earthquake shaking, the ties failed to confine the concrete and the vertical reinforcing bars in the columns. This freeway was constructed before 1968; newer freeways are designed to withstand stronger earthquake forces. Photograph by Melallet Celik.
**Modes of building failure**

**Column failure**

Northridge

**Modes of building failure**

**Soil failure/liquefaction**

What is the common factor?
EPS20: Earthquakes in your backyard – Prof. Richard Allen

**Modes of building failure**

**Soil failure/liquefaction**

Nigata 1964

**Narrow-base structures**

Kobe
EPS20: Earthquakes in your backyard – Prof. Richard Allen

Modes of building failure
Bending/weak structures

Modes of building failure
Partial wall collapse

This masonry building near downtown Los Angeles was badly damaged during the Northridge earthquake. Poor retrofitting, evidenced by the lack of bolts (left), circular features indicated by the arrows, probably prevented more extensive collapse.

http://earthquakes.berkeley.edu/eps20
Modes of building failure

Fallen objects

What should you be watching for?

When you choose an apartment?
or buy a house?