

Study Sheet for ESS 202

Plate tectonics

Supercontinents and continental drift

convergent, divergent, transform boundaries

relation to subduction zones, spreading ridges, transform faults

Where are the largest earthquakes?

oceanic vs continental plates. Which type subducts? Thickness? Where are oldest rocks?

about how many tectonic plates, how fast do they move?

lithosphere, asthenosphere

Wadati-Benioff zone. How do we recognize one from seismicity?

Fault types

strike-slip - right-lateral vs left-lateral, vertical fault

dip-slip - dipping fault (that is, not vertical)

normal

reverse (=thrust)

relation to plate tectonic boundaries & plate motions.

nature of San Andreas Fault - boundary between which plates?, slipping how fast (long-term plate motions)? Expect magnitude 7.5 to 8.25 about every 150 yrs on average.

nature of plate boundary near coast of Washington and Oregon

Concepts of elastic rebound, aseismic slip, creep

Seismic waves - what is a wave?

body waves - P & S waves, speed, which type travels faster?

surface waves - speed slower than S, large amplitudes - often most damaging. but don't develop until 100 to 200 km from earthquake

Earthquake location - why does S - P time increase with increasing distance from eq?

how to determine location with S-P times from three or more stations

hypocenter(=focus), epicenter

Modified Mercalli Intensity - strength of shaking at a site. When useful?

Magnitude - measure of size of an earthquake

Richter or local magnitude (M_L) proportional to log of wave amplitude plus correction for distance (why is such a correction needed?). Know how to use Box 8-1

body-wave (m_b) and surface-wave (M_s) magnitudes similar, but use P and surface waves, respectively.

moment magnitude (M_w) proportional to log moment.

Implications of these definitions? E.g., mag 7 a lot bigger than mag 6, etc. Why do we use logarithms to define magnitude?

Seismic Moment = rigidity \times rupture area \times fault slip and rupture area = fault length \times fault width

Distinguish *offset* (same as *slip* or *displacement*) in an earthquake from rupture *length*.

Have a rough idea of possible sizes of offset or slip. E.g., can slip in one earthquake. be several km?

Distribution of sizes of earthquakes - see table in Box 10-3 in book

Earth's Interior

size and composition of major parts of Earth's interior

Mohorovicic discontinuity - what is its significance?

Why do we believe that the mantle is solid and the outer core is liquid?

silicate (rock) mantle convecting slowly (several cm/yr)

liquid iron outer core convecting rapidly (estimate: 0.01 cm/sec)

Where is largest seismic discontinuity in Earth? Core -mantle boundary

Important earthquakes:

1964 Alaska, 1960 Chile, 1989 Loma Prieta (Santa Cruz Mtns.), 1992 Landers, 1994 Northridge, 1995 Kobe, Japan, 1906 San Francisco, 1857 Fort Tejon, 1975 Haicheng, China, 1976 Tangshan, China, 1811-12 New Madrid, Mo., 1886 Charleston, S. Carolina. You should know something about the significance of each of these earthquakes, although different factors may be significant for each one. For example, significant factors could include size of eq, (rough idea of magnitude, length of rupture, amount of displacement), number of people killed, if very large, tectonic setting or if quake is an unusually large but rare *intraplate* event.

California's tectonic history.

General knowledge of the San Andreas Fault system.

What is the “Big One”? (will be different for different regions)

Could California fall into the ocean?

Foreshocks, mainshock, and aftershocks

sizes of great, major (large), and moderate quakes

relative numbers of them

aftershocks map out (occur in) fault area of mainshock

What elements must be specified in an earthquake prediction? time, location, size

Why is it so hard to predict earthquakes?

variability in seismicity patterns - only about half of earthquakes have foreshocks, hard to tell

if foreshock was foreshock until the mainshock

many small events that could grow into larger ones - how to distinguish them?

physical changes (wave velocity, ground uplift, radon, electrical properties) that occur before earthquakes often too small to detect.

unconventional methods (e.g., strange animal behavior) lack a reasonable physical explanation, and have not been verifiable and repeatable.

Volcanoes

where volcanism occurs

1. in overriding plate of subduction zones - “ring of fire” along Pacific Rim, explosive

2. at spreading ridges - mild, but abundant undersea volcanism

3. above hotspots (e.g., Hawaiian island chain)

eruptions can often be predicted

by deformation of volcano as it “fills up” with magma

by acceleration and shallowing of seismic activity

relation to earthquakes: 1) both occur near plate boundaries, most explosive volcanoes and largest earthquakes both associated with convergent boundaries (subduction), 2) volcanic eruptions involve deforming crust and lead to earthquakes, 3) earthquakes could reduce stress in a region and trigger impending volcanic eruptions

Tsunamis - caused by events that uplift or drop down seafloor, displacing large amounts of water, including undersea earthquakes, undersea volcanoes, undersea landslides

travel about 800 km/hr through deep ocean, slow enough that *distant* shores can be warned. Compare to seismic wave speeds.

wave height increases greatly as it approaches the shore

several wavecrests, period of time between wave crests about 15 minutes

avoid beach, if you feel a strong shaking or there is a tsunami warning

Hazards of faults and faulting - don't live in fault zone, difference between ground shaking and ground shift

Hazards of various geological foundations

stronger shaking on soft soil, landfill, waterside sites, cliffs and ridges

liquefaction potential in soft, sandy water-saturated soils (low-lying and flat)

landslide potential on hillsides, steep slopes

1964 Alaska Turnagain landslide - how big, why did it happen?

Consider effect of water and relation to liquefaction, soft soil, landslides

Dangers from dams, water tanks, and neighboring buildings

Principles of earthquake resistance in buildings - lateral bracing to resist shearing forces

Vertical load-bearing elements vs. horizontal diaphragms (walls and floors)

Importance of strong connections between them, steel connectors better than toe-nailing

Shear-strengthening (by plywood sheathing or steel frame bracing) of entire exterior, *cripple wall* (know what it is), areas around large openings, especially important on ground floor.

Weight is building's enemy, (e.g. masonry, chimneys) because it causes greater forces on shaking walls, the higher up the weight the greater the load on lower floors.

Steel and wood best building materials. Why?

Brick walls heavy, with little shear strength, can easily disintegrate - biggest cause of death in earthquakes.

Concept of *soft story* - large openings (garage, windows, doors) reduce shear strength of walls, usually but not always on ground floor.

Glass walls have little shear strength.

Corner buildings experience greater shaking since they are unsupported on two sides.

Apply these principles to:

Wood-frame houses

Brick, concrete, and stone houses

Commercial buildings

How are they reinforced?

Earthquake-safe building design

types of foundations

principles of foundations

attaching house to foundation

problems with

stilts and pilings

split-levels houses and other houses with garages on first floor

chimneys

Minimizing damage from earthquakes

Why strap down your water heater? Where is a good spot to place your bed?

Before an earthquake

make building and contents earthquake-resistant (for example, shear-wall re-inforcement with plywood sheathing, bolt house to foundation)

consider likelihood and effects of next big earthquake (for example, are tsunamis or landslides possible in your area?)

During an earthquake

remain calm

stand in corner or doorway

watch for falling plaster, bricks, light fixtures, etc

stay away from windows and glass

do not rush outside if in store, office, warehouse, *unless* in unreinforced brick or non-ductile concrete building

if you leave a house, watch for collapsing chimneys, fallen electrical wires

remain in open area

After an earthquake

check for injuries

check gas lines, shut off if possibility of damage, put up warning signs, notify neighbors and authorities

check water and electric

wear shoes

do not use telephone or streets unnecessarily

stay away from beaches, if there is possibility of tsunami

stay away from landslide-prone areas

emergency drinking water from water heaters, toilet tanks

be prepared for strong aftershocks, brick buildings are especially susceptible

Seismic hazard in the United States.

Where are the faults in the U.S.?

What is a blind thrust?

Significance for seismic hazard?