

Natural Disasters

Lecture 14

Ch 3 – Earthquake Geology and Seismology

Text Source Today:

Chapter 3 (p. 65-77)

3.3: Ch. 3 – Earthquake Geology and Seismology

♦ **Richter scale, M_L** , is quick and useful for **moderate-sized EQs** that occur **nearby (i.e., local EQs)**. It does not work well on **distant, large EQs**.

- For example, a Richter scale of 8.3 was assigned to both the 1906 San Francisco EQ and the 1964 Alaska EQ, yet using other scales the San Fran EQ is a **7.8** and the Alaska EQ a **9.2**. The **Alaska EQ** was at least **100 times bigger in terms of energy!**

- **Seismic Moment, M_O** : relies on the amount of **movement** along the fault that generated the EQ; in other words, **M_O** equals the **shear strength of the rocks** times the **fault rupture area** times the **average displacement (slip)** on the fault

♦♦ **Moment Magnitude Scale, M_W** : most accurate measure for **big EQs**; can take **weeks or months** to determine, as time is required to assess all aftershocks to define **the area of the rupture zone**:

$$M_W = 2/3 \log_{10} (M_O) - 6$$

♦ **Largest M_W to date**: (1) **1960 Chile EQ: 9.5**; (2) **2004 Sumatra EQ: 9.2**; (3) 1964 Alaska EQ: 9.2.

- **Large EQs** increase stress on adjacent sections of a fault, resulting in **large aftershocks**, especially in the three days following the **mainshock**.

- If a **big EQ** is followed by an even **bigger EQ** in the same fault zone, then the **first EQ** is reclassified as a **foreshock**.

- **Fault-rupture length** influences EQ magnitudes. A rupture along a fault typically moves 2 to 4 km/sec. (The longer the **rupture**, the lengthier **duration of movement**).

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TABLE 3.4

Rupture Length and Duration

	Magnitude	Rupture Length (km)	Duration (seconds)
1964 Alaska	9.2	1,000	420
1906 San Francisco, CA	7.8	400	110
1992 Landers, CA	7.3	70	24
1983 Borah Peak, ID	7.0	34	9
2001 Nisqually, WA	6.8	20	6
1933 Long Beach, CA	6.4	15	5
2001 Yountville, CA	5.2	4	2

- ◆ Seismic waves die off with **distance traveled**. The **high** frequency seismic waves die out first, at **shorter** distances from the hypocenter, and cause **much damage at short distances** from the epicenter. At **longer** distances away, it is the **low** frequency seismic waves that do most of the **damage**.

- **Ground Motion During EQs:** All seismic waves **radiate outward** from a fault movement, and **interact**, to move the ground **vertically, horizontally and diagonally**.

- ◆ Buildings are designed to handle large **vertical** forces, but it is the **sideways push from the horizontal movements** that is the biggest concern in “earthquake-proofing” construction.

- Building design must also account for **acceleration**, as the different seismic waves arrive and interact. (The acceleration due to gravity of **9.8 m/sec²** is referred to as “**1.0 g**.”)

- Weak buildings can suffer damage at **0.1 g horizontal** accelerations. From **0.1 to 0.2 g**, people can have trouble keeping their footing. **Some EQs have exceeded 1 g!** The **1994 Northridge EQ** had phenomenal accelerations of **1.2 g** vertically and **1.8 g** horizontally!

♦ The **periods** of buildings are determined by their **height** (~0.1 second per story of height) and their **construction materials**.

● A **one-story house** will shake back and forth **quickly** (~0.1 second per cycle), but a **30-story building** sways much **slower**, with a **period** of about **3 seconds per cycle**.

● A building made of flexible **wood or steel** will have a **longer period** than those made of stiff materials, such as **brick or concrete**, which will have a much **shorter period**.

♦ Seismic waves move **faster through hard rocks and slower through softer rocks and sediments**. When seismic waves move from harder rocks into softer rocks, they **slow down** and must increase their **amplitude** to carry the same amount of **energy**.

● Thus, **shaking is stronger** at sites with **softer** sediments where seismic waves move **slower, with greater amplitude**.

♦ When seismic waves of a certain period matches the period of a building, the shaking is **amplified, and resonance** can occur!

♦ **Modified Mercalli Scale of EQ Intensity:** A scale on **what we “feel” and see during an EQ**. Can be used for “real-time” assessment of an EQ and for assessing the magnitudes of historic events before instrument records.

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TABLE 3.6

Comparison of Magnitude, Intensity, and Acceleration

Magnitude	Mercalli Intensity	Acceleration (% g)
2 and less	I–II	Usually not felt by people Less than 0.1–0.19
3	III	Felt indoors by some people 0.2–0.49
4	IV–V	Felt by most people 0.5–1.9
5	VI–VII	Felt by all; building damage 2–9.9
6	VII–VIII	People scared; moderate damage 10–19.9
7	IX–X	Major damage 20–99.9
8 and up	XI–XII	Damage nearly total More than 100 = more than 1 g

- **Mercalli Scale Variables:** **human perception of damage**

- (1) **EQ magnitude:** the **bigger** the EQ, the **more energy** released and more likely **death and damage**.
- (2) **Distance from hypocenter/epicenter:** generally, the **closer** to the hypocenter/epicenter, the **greater the damage**.
- (3) **Foundation materials:** the type of **rock or sediment** making up the ground surface; **P and S waves** can excite **hard** rock that vibrates at **high** frequencies; **surface (L) waves** can amplify shaking in **soft or water-saturated** sediments.
- (4) **Building style:** is of vital importance, as **earthquakes don't kill, buildings do!** High frequency **P and S waves** will have their vibrations amplified by (a) **rigid construction**, such as brick or stone; and, (b) **short buildings**. Low frequency **surface waves** will have their movements increased in **tall buildings**, and especially if built on **soft, water-saturated sand or mud!**
- (5) **Duration of the shaking:** the **longer** the shaking (vertical, horizontal and diagonal) the more likely the **greater** the damage.

- **EQ Mitigation:**

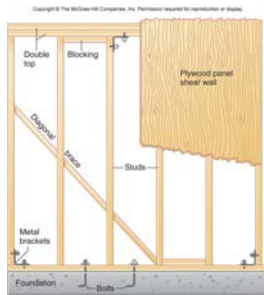
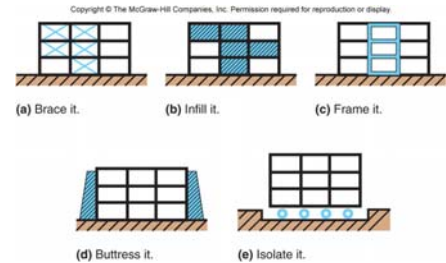
◆ **Building in EQ Country:** to eliminate **resonance**:

- (1) change the **height** of the building; (2) move most of the weight to the **lower floors**; (3) change the **shape** of the building; (4) change the type of **building materials**; (5) change the **degree of attachment** of the building to its **foundation**.

● Retrofitting:

● **Bridges:** additional alternating layers of concrete and steel.

● **Buildings:** brace it, infill it, frame it, buttress it, isolate it. (Fig. 3.34)



● **Houses:** bolt it, bracket it, brace it, block it, panel it.

(Fig. 3.36)

● EQ Safety:

♦ **Before:** (1) Walk into each room of your house and visualize what might fall during strong shaking. Nail them. Brace them. *Velcro* them. Lower them. Remove them; (2) Walk outside and visualize what might fall. Trim them. Chop them. Replace them; (3) Repeat the visits inside and outside and locate **safe spots** for your protection (e.g., under a heavy table, under a strong desk, under a bed). **Drop, cover, and hold on!**

♦ **During:** After preparing your home, program yourself to remain calm and composed during the shaking, which will last only 5-60 seconds. **If you are inside, stay inside; if you are outside, stay outside!**