

### **Homework Assignment 3.1 (Due in one week)**

Answer the following questions. Note that you may need to (and are expected to) conduct some independent research to complete this assignment. A primary objective is to encounter concepts to which you may not otherwise be exposed. An excellent place to begin research is on the Internet at the URL for the United States Geological Survey at: <http://www.usgs.gov/>. Also, questions related to the national seismic hazard maps can be obtained at: <http://eqhazmaps.usgs.gov/index.html>. See heading “Project Info”, etc.

1. Why is the circum-pacific belt (the boundary of the Pacific plate) called the “Ring of Fire”?
2. Why are the locations of volcanoes closely associated with the locations of earthquakes?
3. Name several major urban centers located along: a.) the Alpide Belt; and b.) the “Ring of Fire”
4. What regions of the US are susceptible to earthquakes large enough to cause damage? (Hint: you may find this information by consulting the following web page: [http://neic.usgs.gov/neis/general/magnitude\\_intensity.html](http://neic.usgs.gov/neis/general/magnitude_intensity.html))
5. What specific types of data were required to develop the U.S. national seismic hazard maps? What are these maps used for?
6. What is a “probabilistic seismic hazard analysis?”
7. What is paleoseismic analysis and how does it relate to the establishment of seismic risk?
8. What is meant by peak ground acceleration and why is this used as a standard for determined relative hazard in many regions?
9. Bonus question: When we refer to hazards such as earthquakes or floods, we often talk about these events in terms of probabilistic return period, such as the “100-year flood’ or the “2,500-year earthquake”. To many, this terminology suggests that that the flood will occur every 100 years, or the earthquake every 2,500 years. Is this true? Explain?

### Homework Assignment 3.1 Answer Key

1. Why is the circum-pacific belt (the boundary of the Pacific plate) called the “Ring of Fire”?

Because 75% of all active volcanoes are located along this boundary.

2. Why are the locations of volcanoes closely associated with the locations of earthquakes?

Volcanoes occur along plate boundaries where the crust is broken, allowing hot magma to escape to the surface. Thus, plate boundaries are the locations where both phenomena occur.

3. Name several major urban centers located along: a.) the Alpide Belt; and b.) the “Ring of Fire”

A: Alpide Belt: East Indies, Northern India the Himalayas, Iran, Turkey, the Balkans, etc.

B: Ring of Fire: Major cities in Japan and California are two primary examples.

4. What regions of the U.S. are susceptible to earthquakes large enough to cause damage?

Basically, all regions (Western, Pacific Northwest, Southeast, Northeast, Midwest) of the U.S. are susceptible to damage from earthquakes. See plot on the web page showing locations:

[http://neic.usgs.gov/neis/general/intensity\\_maps.html](http://neic.usgs.gov/neis/general/intensity_maps.html)

**The above point should be strongly highlighted during the discussion of this answer, as it indicates a major issue that all students in this class should be aware of.**

5. What specific types of data were required to develop the U.S. national seismic hazard maps? What are these maps used for?

a. Input data required for probabilistic seismic hazard maps:

- 1) Catalog of magnitudes of all earthquakes in the region (usually only those above Magnitude 5 are considered).
- 2) Specific locations of all earthquakes in the region.
- 3) Recurrence rates of the earthquakes (how often they occur per unit time).

- 4) Models that predict how the earthquake energy decays with distance from the source (called “attenuation models”).
  - b. Sources of input data:
    - 1) Historical seismicity (including historical written accounts as well as modern seismic monitoring network data)
    - 2) Paleoseismological and geological evidence ⇒ Recent innovation – especially needed in eastern North America and other regions where earthquake mechanisms are poorly understood and the historical record is too short to accurately reflect the true seismic hazard.
6. What is a “probabilistic seismic hazard analysis? And what is it used for”

Probabilistic Seismic Hazard Analysis (PSHA) Summary:

- a. PSHA combines the hazard contribution from all future possible earthquakes of all magnitudes at all possible distances from a given location. The ground motion coming from a particular magnitude and distance is assigned an annual probability equal to the annual probability of occurrence of the causative magnitude and distance.
- b. When all possible earthquakes and magnitudes have been considered, one can find ground motion values that correspond to certain annual rates of being exceeded. These pairs can be plotted to develop maps such as the current USGS maps. On a given seismic hazard map for a given probability of exceedance (PE), locations shaken more frequently will have larger ground motions.
- c. The method assumes a reasonable catalog of data from historical earthquakes and geological information on the recurrence rate of fault ruptures.

This is the basis for the US national seismic hazard maps.

7. What is paleoseismic analysis and how does it relate to the establishment of seismic risk?

Paleoseismic analysis combines the principles of paleontology, geology, and engineering to study ancient evidence that indicates earthquakes have occurred in a region during prehistoric times (prior to historical records). This technique, which includes the study of ancient faults, landslides, and liquefaction features can be used to provide a better and more complete estimate of the seismic hazard

in a region, especially if the historical record is too short or incomplete. This technique became more common and fully developed in the 1980s and has been used in many U.S. areas to confirm or identify hazards previously unrecognized (Charleston, SC, Wabash Valley of the Central U.S., Puget Sound region of the Pacific Northwest).

8. What is meant by peak ground acceleration and why is this used as a standard for determined relative hazard in many regions?

### **What is "acceleration"?**

When you push on the gas pedal in your car, you experience the increase in velocity as a force pushing you back into your seat. Technically, then, acceleration is the rate of increase in velocity, that is, how much the velocity changes in a unit time. Personally, we are most aware of acceleration by the experience of an applied force.

So, consider a car increasing in speed from a stop to 60 miles an hour. 60 miles per hour is 88 feet per second. If the acceleration is uniform (constant) while the car increases speed, we could say that if the car reaches a velocity of 88 feet per second in 8 seconds, the velocity changes by 11 feet per second every second, and thus acceleration is 11 feet per second per second ( $11 \text{ ft./sec}^2$ ). If the acceleration were not uniform, but started off small, achieved a maximum, and then decreased as we approached 60 miles an hour, the largest value of the acceleration would be the "peak" acceleration.

### **What do we mean by "peak" acceleration as a measure of earthquake ground motion?**

A small particle attached to the earth during an earthquake will be moved back and forth rather irregularly. This movement can be described by its changing position as a function of time, or by its changing velocity as a function of time, or by its changing acceleration as a function of time.

Since any one of these descriptions can be obtained from any other, we may choose whichever is most convenient. Acceleration is chosen, because the building codes prescribe how much horizontal force a building should be able to withstand during an earthquake. This force is related to the ground acceleration. The peak acceleration is the maximum acceleration experienced by the particle during the course of the earthquake motion.

9. **Bonus question:** When we refer to hazards such as earthquakes or floods, we often talk about these events in terms of probabilistic return period, such as the "100-year flood" or the "2,500-year earthquake". To many, this terminology

suggests that that the flood will occur every 100 years, or the earthquake every 2,500 years. Is this true? Explain?

No, this thinking is not true. The “100 year flood” actually refers to a **probability**, i.e., that the “100-year flood” is a flood with a 1% probability of being exceeded in any one year. Thus, “100-year flood” should be thought of as a probability of occurrence of 1/100 in any one year, not necessarily the flood that occurs once every 100 years. There is no limit as to how many times the flood will occur in a given time frame, as we have seen that we can sometimes have several 100-year floods in one year (this recently occurred in Virginia in the mid 1990s!).

Similarly, the “2,500 year earthquake” can occur more often than once in 2,500 years, as this expression is again simply referring to an earthquake shaking level with a probability of 2% of being exceeded in 50 years (average building design life). Unfortunately, the common practice of using return periods to express these probabilities can lead to confusion, so perhaps it may be more clear always to use the probabilistic expression directly (i.e., use 2%/50-year event) rather than “2,500 year-event”, etc. Nevertheless, convention has been established and it is important that emergency managers at least have some feel for this concept.