Session No. 1

Course Title: Earthquake Hazard and Emergency Management

Session Title: Introduction to earthquake hazards and overview of course and exercises

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Time: 75 minutes

Objectives:

1.1 Define earthquake hazard and emergency management and appreciate the importance of this concept for hazard reduction (and, thus, at the same time appreciate the importance of this course).

1.2 Recognize how big the earthquake problem is and appreciate the high loss potential associated with earthquake disasters.

1.3 Describe the general earthquake threat in the United States.

1.4 Envision what is achievable through successful earthquake hazard management and mitigation.

1.5 Understand the format and requirements of the course and student responsibilities as individuals and members of teams.

Scope:

During this session, the professor introduces her/himself to the class and notes that **trends for disaster losses are rapidly increasing, and earthquake disasters are among the highest threats.** Projected losses are unsustainable, and there must be greater emphasis placed upon mitigation of hazards, as opposed to the traditional approach that places most emphasis on response and recovery. **This course is intended to help create a new generation of emergency managers that are better informed and better prepared to make decisions, obtain relevant information, and better understand how to make effective impacts upon reduction of earthquake hazards.** This goal should be clearly stated at the beginning of the lecture.

As the first lecture in the course, this lecture should begin with a review and discussion of the syllabus and course requirements. To set the tone early on (as this course is designed for much interaction), the instructor is encouraged to immediately get the students directly involved in

class, perhaps by having each student stand and introduce him-or herself to the rest of the class, etc.

The lecture should continue with a discussion of what earthquake hazard management involves and why this course is important. The instructor should point out that, although many lessons and principles learned from the management of other disasters apply to earthquake hazards, many aspects of earthquake hazards are unique, and they must be managed accordingly. **In fact, this is one of the most important issues to convey in the course.**

The lecture should then reinforce the importance of earthquake hazard management and this course by briefly illustrating the magnitude of the earthquake threat and vulnerability in the United States (many more details on these issues are discussed later in the course and are provided here for introduction purposes only). While discussing these events and lessons learned, it is important to stress that the strategy behind this lecture (and entire course, for that matter) is not to attempt to cover all the details associated with earthquakes themselves. The course is not an information repository on earthquakes. Rather, the course is designed to be an interactive experience that will focus on the core issues related to reducing earthquake vulnerability, such as what impact mitigation can have, when management actions are most needed and most effective, what factors lead to reduced vulnerability, and what information and tools are available to best address this mission. Issues associated with the details of earthquakes and their physical characteristics and effects will be covered only to the extent they are necessary for a clear understanding of the nature of this hazard.

Of particular importance are the two earthquake scenarios included at the end of this series of lecture notes. One scenario represents, more or less, a worst case scenario for an earthquake occurring in an urban area of the U.S. (the heavy damages and severe disruptions described for this scenario are probably not far from what would occur in many regions). The second scenario describes a much different set of outcomes where the damages and disruptions from the same event are minimal– in essence this scenario represents what we can achieve with appropriate preparedness and mitigation behavior to reduce vulnerability. The instructor should use these two opposing scenarios to drive home the overall goal of this course. Again, the instructor is highly encouraged to invite class participation in discussing these scenarios, perhaps having the students suggest potential disruptions and unforeseen problems not included in these notes. Finally, although the course is presented in a series of topics and sessions, the course should be regarded as a *continuum* of issues important for earthquake emergency managers. As such, the instructor should strive to explain and reinforce, wherever feasible, how the various topics are interrelated (i.e., how earthquake planning is related to mitigation and how both of these are related to preparedness) and why they are important for earthquake hazard management. Where possible, class discussion is always recommended, even if informal and unplanned. Although the subsequent lectures are developed for presentation primarily in the traditional lecture format, the instructor is encouraged to experiment with various techniques to cover this material (according to the background of the students, makeup of the class, class size, etc.). For instance, in some cases, the instructor may wish to post the lecture notes on the Internet and/or make handouts for the students prior to the lecture, and then use the following lecture period to discuss

the major points of the session. The assigned student reading for this session reinforces the points made in the lecture.

Readings:

Suggested Student Reading:

Course syllabus. A draft syllabus is provided as Handout 1.1.

Mileti, Dennis S. 1999. *Disasters by Design: A Reassessment of Natural Hazards in the United States*. Washington, DC: Joseph Henry Press.

Required Instructor Reading:

Mileti, Dennis S. 1999. *Disasters by Design: A Reassessment of Natural Hazards in the United States*. Washington, DC: Joseph Henry Press.

Additional Suggested Instructor Reading:

EQE, 1994 The January 17, 1994 Northridge, CA Earthquake, An EQE Summary Report, March 1994, (available online at: http://www.eqe.com/publications).

EQE, 1995 The January 17, 1995 Kobe Earthquake, An EQE Summary Report, April, 1995, (available online at: http://www.eqe.com/publications).

EERI, 2003. Earthquake Engineering Research Institute, Securing Society against Catastrophic Earthquake Loss: A Research and Outreach Plan in Earthquake Engineering, Oakland California, (available online at http://www.eeri.org/cds_publications/securing_society.pdf).

National Research Council (NRC), 1992. *The Economic Consequences of a Catastrophic Earthquake: Proceedings of a Forum*, Committee on Earthquake Engineering, Division of Natural Hazard Mitigation, Commission on Engineering and Technical Systems p.100, (available online from http://books.nap.edu/books/0309046394/html/100.html).

National Research Council (NRC), 2003. *Preventing Earthquake Disasters: The Grand Challenge in Earthquake Engineering: A Research Agenda for the Network for Earthquake Engineering Simulation (NEES)*, National Research Council, Washington, DC, National Academies Press,.

Handouts:

1. Handout 1.1: Syllabus: Earthquake Hazard and Emergency Management
2. Handout 1.2: Term Project Assignment
3. Handout 1.3: Homework Assignment

General Requirements:

The instructor's course syllabus and the term project assignment should be distributed to students at the beginning of the class. The homework assignment should be handed out at the end of the session. One week should be allowed for completion of this assignment.

Objective 1.1 Define earthquake hazard and emergency management and appreciate the importance of this concept for hazard reduction (and, thus, at the same time appreciate the importance of this course).

Requirements:

This material should be presented as lecture.

Remarks:

I. What is earthquake hazard management and why is it important? [Significant content adapted from Organization of American States (OAS) (1990)]:

A. Although humans can do little to change the incidence or intensity of most natural phenomena, they have an important role to play in ensuring that natural "hazards" are not converted into "disasters" by their own actions.

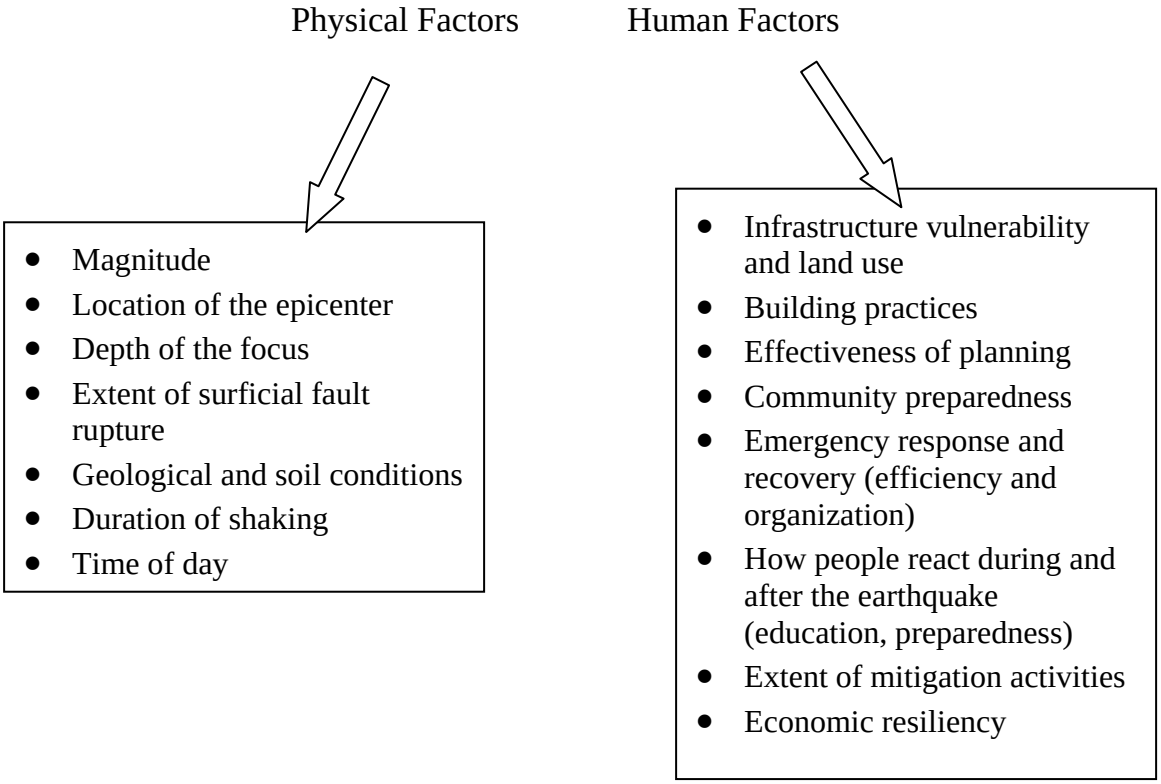
B. It is important to understand that human intervention can increase the frequency and severity of natural hazards. For example, when the toe of a landslide is removed to make room for a structure or development, the earth can move again and bury the development.

C. Human intervention may also cause natural hazards where none existed before. Volcanoes erupt periodically, but it is not until the rich soils formed on their ejecta are occupied by farms and human settlements that they are considered hazardous. Or, since many rivers flow along fault lines, many dams built in the late 19^{th} and early 20^{th} century (before the faults were identified) are now resting on active faults.

D. Understanding the relationship between natural events and social disruptions is key to developing effective vulnerability reduction measures. It should be

recognized that if human activities can cause or aggravate the destructive effects of natural phenomena, they also can eliminate or reduce them!

E. The severity of an earthquake and its impact upon society depend upon the interaction of a number of variables, including physical factors as well as human factors, as shown in the following:
(figure adapted from
http://online.stcharles.ac.uk/courses/geog_leis/geography/alevel/Hazard/managing%20the%20earthquake.doc).



II. It is the management of these interacting factors, many of which involve uncertainty, that form the basis for earthquake hazard management. In fact, one might argue that the whole purpose of hazard management is to deal with uncertainty (and thus probabilities).

A. There has always been a strong focus on studying the physical effects of earthquakes, such as buildings collapsing, but recent research is also focusing more on societal response. Typically, earthquake awareness has been low, and earthquakes have been viewed as "natural" problems that cannot be prevented. However, there is the growing realization that in many ways, earthquakes are societal problems because our actions or inactions largely influence the level of disruption and harm posed by the events.

B. Consider that the earthquake hazards we find today and the seismic processes responsible for them (e.g., the San Andreas Fault) were in place long before we developed populated urban centers with seismically vulnerable structures close to these hazards. Also, deaths in earthquakes frequently are due to falling objects

that are predominantly human-made (collapsing buildings, falling beams and columns, heavy bookcases, etc.). Thus, much of our earthquake vulnerability – loss of human life as well as infrastructure and economic losses – is due to human activity. Thus, in many ways, we actually "design our own disasters." (Meliti, 1999)

C. The purpose of this course is to first recognize the interaction of the many factors that influence vulnerability and learn effective strategies to manage the physical and societal factors in a manner that reduces vulnerability to earthquakes.

D. Successful earthquake hazard management requires a combination of social, technical, political, and social strategies that typically involve:

1. Disaster mitigation
2. Hazard prediction
3. Risk and vulnerability assessment
4. Emergency preparedness
5. Disaster rescue and relief
6. Post-disaster rehabilitation and recovery
7. Education and training activities

Objective 1.2 Recognize how big the earthquake threat is and appreciate the high loss potential associated with earthquake disasters.

Requirements:

This material should be presented as lecture.

Remarks:

I. How big is the earthquake threat in the U.S. and in general?

A. **The Damaging Potential of Earthquakes**. Earthquakes strike suddenly, without warning. Earthquakes can occur at any time of the year and at any time of the day or night. On a yearly basis, 70 to 75 damaging earthquakes occur throughout the world (FEMA, 2004).

B. The losses in major earthquake disasters continue to exceed the social and economic costs created by other disaster events.

C. Estimates of losses from a future earthquake in the United States approach $200 billion (EERI, 2003).

D. For instance, the Northridge Earthquake of January 17, 1994 (magnitude 6.7), struck a modern urban environment generally designed to withstand the forces of earthquakes. And, all things considered, this was a relatively small earthquake on a minor fault (associated with the main San Andreas Fault) and the fringe of Los Angeles— **yet, this was the most expensive single natural disaster in U.S. history! (based on federal expenditures)**

1. Total losses are estimated at $30 billion (EERI, 2003).

2. Although relatively few people (57) were killed in the event, more than 11,800 people received hospital treatment for earthquake-related injuries, while tens of thousands more went unattended. Also, the earthquake occurred during a holiday (Martin Luther King Holiday) in the early morning hours (4:30 AM) which did not fully tax response and recovery efforts in the congested urban environment.

3. Approximately 114,039 structures were damaged by the earthquake.

E. Exactly one year later, Kobe, Japan, a densely populated community less prepared for earthquakes than Northridge, was devastated by the most costly earthquake (magnitude 7.2) ever to occur. Property losses were projected at more than $147 billion. This does not include indirect economic effects from loss of life, business interruption, and loss of production, and at least 5,378 people were killed (EQE, 1994, 1995).

F. A recurrence of the New Madrid Earthquake(s), the largest on record in the contiguous U.S. (magnitude 8+) and postulated with a 4% probability in the next fifty years, has been estimated to have a total loss potential of more than $200 billion (EERI, 2003). Approximately two thirds of this loss will be attributable to interruptions in business operations and the transport of goods across Mid-America (NRC, 2003).

II. A strong damaging earthquake anywhere in the country could have huge economic and social consequences throughout the nation. Indeed, as reported in a report prepared by EERI (2003), recent estimates of earthquake risk in the U.S. alone project current average annual financial loss exposure on the order of $4 billion in building stock alone. Including losses due to damage to infrastructure and indirect losses would give total annualized losses of about $10 billion.

A. The characterization of losses on an annualized basis is misleading because the losses from a strong, damaging earthquake will be sudden and huge (NRC, 2003).

A single large metropolitan earthquake could credibly cause losses in excess of $100 billion to the built and human environment, more than twice that experienced in the 1994 Northridge Earthquake, the most costly domestic earthquake to date (Mileti, 1999). This economic loss is of the same order as that caused by the terrorist attacks of September 11, 2001 on the twin towers of the World Trade Center in New York and on the Pentagon in Virginia.

B. It has been postulated that a repeat of the 1906 San Francisco Earthquake can potentially cause up to $1 trillion in direct and indirect losses affecting cities along the northern coast of California about 100 km south of San Francisco almost north to Eureka (NRC, 1992). Without better preparation, the nation will never be as vulnerable as following a large earthquake in a metropolitan area (Mileti, 1999).

Objective 1.3 Describe the general earthquake threat in the U.S.

Requirements:

This material should be presented as lecture.

Remarks:

I. There are 41 states and territories in the U.S. at moderate to high risk from earthquakes, and they are located in every region of the country (FEMA, 2004).

A. Much of the US is vulnerable to damaging earthquakes. With the continued development of earthquake-prone regions, the potential threat from earthquakes continues to grow.

B. California experiences the most frequent damaging earthquakes; however, Alaska experiences the greatest number of large earthquakes,,most located in uninhabited areas. The largest earthquakes felt in the U.S. were along the New Madrid Fault in Missouri in 1811 to 1812.

C. If a large earthquake were to occur near a major metropolitan area, such as Los Angeles, San Francisco, Salt Lake City, or St. Louis, the potential economic and social consequences would be severe.

D. The vulnerability and lack of preparedness of cities in the eastern US, such as Charleston, SC, Boston, and New York, to even a medium-intensity earthquake could produce even greater losses.

E. The threat is posed, not only to individual structures, but increasingly to the complex lifelines and infrastructure that support them.

F. Since the 1906 San Francisco Earthquake, earthquakes in the U.S. have not occurred directly beneath urbanized regions (the 1989 Loma Prieta Earthquake), have occurred during times of the day that avoided the most severe consequences (the 1994 Northridge Earthquake), or were relatively modest in size (the 1987 Whittier Narrows Earthquake).

G. Eventually a severe earthquake will occur within an urbanized area at a vulnerable time!

H. However, this is not just an urban or regional issue. The geographic interdependence of the American economy guarantees that a large earthquake anywhere in the U.S. will have consequences so severe that they will be borne by the entire nation. These consequences will extend well beyond direct physical losses to the reduced capacity of the national economy to function in the absence of the assets that would be damaged or destroyed.

II. Therefore, it is in the national interest to reduce our vulnerability to future earthquakes.

Objective 1.4 Envision what is achievable through successful earthquake hazard management and mitigation.

Requirements: Note to Instructor

This material should be presented as lecture. The two scenarios below illustrate the importance of preparedness and mitigation. Point out to the students that these concepts will be discussed in detail in Sessions 9 and 10.

Remarks:

I. Scenario 1 – "Business as Usual"

A. Consider the following earthquake scenario as presented in NRC (2003):

1. The earthquake ruptures 40 km of a fault, severing every linear feature across it (gas, water, sewer, fiber optic, oil, roads, telephone, canals, storm lines, electrical, etc.). Buildings collapse, bridges and dams built across the fault line fail catastrophically, etc.

2. If the earthquake is offshore, whether distant or near-shore, it will cause tsunamis that inundate coastal regions. Tsunamis generated by near-shore events cause casualties, destroy facilities not damaged by ground shaking, and impede rescue efforts near the shore.

3. Strong ground shaking causes bridges, buildings, and waterfront structures to collapse; and lifelines (public works and utilities such as electrical power, transportation and water supply, and gas and oil pipelines) to fail, cutting off these services.

4. Fire fighters, police, health care, and emergency management capabilities become ineffective for lack of transportation, power, and operational facilities. This allows fires to spread, losses to multiply, and the injured to die for lack of rescue and access to health care.

5. Economic and social activities are severely reduced for months or years as the damage is cleared, facilities rebuilt, and services restored. Many businesses close forever.

6. The national economy and security are compromised by losses of critical human resources, information, and commercial and manufacturing capabilities in the area affected by the earthquake.

This scenario illustrates the current status quo, "business as usual."

II. Scenario 2 – "A Better Way!" As a counterpoint, the following earthquake disaster reduction scenario is achievable and, in the long term, could presage earthquake prevention.

A. Preventive measures are presented in NRC (2003):

1. Advanced earth science, engineering, and emergency management simulations help assess the earthquake hazard in a given region. They also inform the public and policy makers (public and private) of the earthquake risk in their region and the planning, construction, and response measures available to reduce the risk and prevent a disaster.

2. Public and private decisions are made to implement zoning, construction, and response practices for disaster prevention and increased post-earthquake response capabilities.

3. Selected existing buildings and lifelines are upgraded in a cost-effective manner to minimize casualties, limit damage, and assure needed functionality after an earthquake.

4. New buildings and lifelines are constructed to limit damage and assure needed functionality after an earthquake.

5. Seismological instruments are deployed to warn operators of critical facilities and emergency managers of the occurrence of an earthquake, and

its expected impact on facilities under their control, so that actions such as shutdown of commuter rail systems, and control of power generation and traffic signals can be taken to reduce undesirable consequences. Timely evacuations are conducted for areas exposed to impending dam failure and tsunami inundation. Rapid simulations of expected damage are conducted so that emergency resources can be deployed to the places most needed.

6. Real time damage assessments are conducted so that search and rescue forces can be sent where most needed. Health care is provided for the injured; fires are extinguished while small; alternative routing is developed for utilities and for conduct of commerce and manufacturing; and recovery activities are planned to hasten return to normal economic and social activities.

7. U.S. leadership in earthquake disaster prevention leads to reductions in domestic earthquake losses and provides U.S. leadership in international commerce in earthquake disaster prevention products and services.

This scenario illustrates the long-term vision for what can be achieved through effective hazard management, hard work, and perseverance. **Let us begin here in this course!**

Objective 1.5 Understand the format and requirements of the course and student responsibilities as individuals and members of teams.

Requirements:

This material should be presented as lecture. The homework assignment should be distributed following this objective. One week is sufficient for completion.

Handouts Included:

Handout 1.1: Syllabus: Earthquake Hazard and Emergency Management
Handout 1.2: Term Project Assignment
Handout 1.3: Homework Assignment

Remarks:

I. Course format. [*Handouts 1.1, 1.2, 1.3*]

Class sessions include lectures on the concepts and methods of managing disaster earthquake hazards. Class sessions also will be devoted to work on the assigned exercises as a member of a team.

II. **Course requirements**.

A. Participation in class discussions (15%). Students are expected to have completed reading assignments prior to each session and to actively participate and contribute to class discussions of the reading.

B. Homework and written and oral presentations (20%).

C. Mid-term exam based on the readings and lectures (20%).

D. Final exam based on the remainder of the course readings and lectures (25%).

E. The term project assignment is important and will require considerable time outside of class. Be sure to get started immediately after the assignment is introduced. The exercises are in full detail on your handout. Grades will be based on products produced by each team and the contributions of individual team members to that product, as evaluated by the instructor and individual team members (20 %).

[Distribute Handout 1.3 (homework assignment)]

References Utilized:

EQE, 1994. *The January 17, 1994 Northridge, CA Earthquake, An EQE Summary Report*, March 1994, (available online at: http://www.eqe.com/publications).

EQE, 1995. *The January 17, 1995 Kobe Earthquake, An EQE Summary Report,* April, 1995, (available online at: http://www.eqe.com/publications).

Earthquake Engineering Research Institute (EERI), 2003. *Securing Society Against Catastrophic Earthquake Loss: A Research and Outreach Plan in Earthquake Engineering*, Earthquake Engineering Research Institute, Oakland, California, (available online at http://www.eeri.org/cds_publications/securing_society.pdf).

Federal Emergency Management Agency (FEMA), 2004. Data from FEMA website at: http://www.fema.gov/hazards/earthquakes/quake.shtm.

Mileti, Dennis S. 1999. *Disasters by Design: A Reassessment of Natural Hazards in the United States,* Washington, DC: Joseph Henry Press.

National Research Council (NRC), 2003. *Preventing Earthquake Disasters: The Grand Challenge in Earthquake Engineering: A Research Agenda for the Network for Earthquake Engineering Simulation (NEES),* National Research Council, Washington, DC, National Academies Press.

National Research Council (NRC), 1992. *The Economic Consequences of a Catastrophic Earthquake: Proceedings of a Forum*, Committee on Earthquake Engineering, Division of Natural Hazard Mitigation, Commission on Engineering and Technical Systems, p.100, (available online from http://books.nap.edu/books/0309046394/html/100.html).

Organization of American States (OAS), 1990. *Disaster, Planning and Development: Managing Natural Hazards to Reduce Loss*, Department of Regional Development and Environment Executive Secretariat for Economic and Social Affairs, Organization of American States, Washington, D.C., December, 1990.