Session No. 12

Course Title: Earthquake Hazard and Emergency Management

Session Title: Nature of Earthquake Disaster Vulnerability

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Time: 120 minutes.

Objectives:

12.1 Describe the relationship between earthquake hazards, earthquake disasters, and earthquake vulnerability, and identify factors that increase vulnerability in the U.S. and globally.

12.2 Recognize the trend for increasing earthquake disaster vulnerability.

12.3 Describe and discuss keys to reduce earthquake hazard vulnerability.

Scope:

The objective of this session is to encourage the students to stop and reflect on the many important lessons and concepts learned so far in the course and to understand growing vulnerability trends in the U.S. and abroad. So far, important topics have been introduced on the basic mechanisms, effects, principles, strategies, programs, etc. associated with earthquakes. However, similar to what was briefly discussed in Session 6, in many cases, the benefits of this knowledge does not result in hazard reduction. In fact, vulnerabilities to earthquake hazards in many regions of the U.S. and the world are increasing. This section examines this growing trend in more detail and discusses the relationship between earthquake hazards and earthquake disasters (as previously mentioned in Session 1 and other sessions). The concepts presented in this session are important for emergency managers because they address fundamental issues associated specifically with earthquake vulnerability – where the rubber hits the road, per se. This section also provides a more global perspective of the earthquake problem. A classroom assignment, along with a homework assignment, is provided.

Readings:

Suggested Student Readings:

Meliti, D. 1999. *Disasters by Design: A Reassessment of Natural Hazards in the United States* Joseph Henry Press. Chapters 7, 8, and 9, pp. 105-208; 267-288.

Natural Hazards Observer. 1997. Designing *Disasters: Determining Our Future Vulnerability*, Volume XXII, Number 1, September, 1997. Available from: http://www.colorado.edu/hazards/o/septo97/septo97a.htm#Designing

Required instructor reading and resources:

Meliti, D. 1999. *Disasters by Design: A Reassessment of Natural Hazards in the United States* Joseph Henry Press. Chapters 7, 8, and 9, pp. 105-208; 267-288.

Natural Hazards Observer. 1997. *Designing Disasters: Determining Our Future Vulnerability*, Volume XXII, Number 1, September, available from: http://www.colorado.edu/hazards/o/septo97/septo97a.htm#Designing

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

Multidisciplinary Center for Earthquake Engineering Research (MCEER). 2000. Strategic Plan 2000. See: http://mceer.buffalo.edu/aboutMCEER/strategicPlan/.

Handouts:

Handout 12.1 Classroom Discussion Assignment 12.1
Handout 12.2 -Homework Assignment 12.1

Electronic Visuals Included: [*See Session 12 Electronic Visuals.ppt*]

Electronic Visual 12.1	The World's Megacities
Electronic Visual 12.2	Risk Has Outpaced Mitigation – Increased Vulnerability
Electronic Visual 12.3	Trends in earthquake disaster losses
Electronic Visual 12.4	Growing global earthquake vulnerability

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General Requirements:

The instructor should begin by reviewing the definitions of earthquake hazard, disaster, and vulnerability, and discussing key factors responsible for earthquake vulnerability. The instructor should point out that some of these concepts were touched upon previously, such as the discussion on hazard and risk presented in Session 4, and mitigation issues in Session 9. The main purpose of this section is to prompt a discussion of the fundamental factors ("where the rubber hits the road") that combine to produce vulnerability. Although this session could have been placed earlier in the course, the coverage at this point allows a more in-depth, informed

discussion of vulnerability with the students. They should already have a thorough understanding of the basic concepts such as mitigation and preparedness, as well as hazard reduction measures, tools, strategies, and ideals. But, as reemphasized in this session, it typically is the **implementation of the mitigation and hazard reduction measures that are most difficult to achieve**. The large stock of poorly-reinforced, seismically vulnerable buildings in the central and eastern U.S. are a poignant example to discuss; mitigation of these structures would be ghastly in term of costs. More studies are not the most urgent need for reducing the risks associated with these structures; we already know we have a big problem, and this problem is growing in many regions. And as discussed in the homework assignment, Hurricane Andrew (1992) also is an instructive case history to cite and discuss. This event revealed a lot of vulnerability in constructed facilities, particularly residential housing. Many key lessons were learned about steps to be taken to reduce damages (i.e., tie-down straps for roofs, metal garage doors as opposed to wooden, etc.). Stringent inspection and construction procedures were implemented following the disaster. However, vigilance has slowly declined and building standards became more relaxed in this region (due, in part, to pressure from developers and builders) while the population increased. The unfortunate net result is that the region probably is now more vulnerable than it was prior to the 1992 disaster. The concepts and general patterns that combine to create vulnerability from a fundamental standpoint are discussed in this session, with emphasis on real-world bottom line, as opposed to classroom ideals. Lastly, this session also should provide a more global perspective and appreciation of factors that are responsible for increasing global vulnerability.

A class discussion assignment is provided and should be conducted at the end of Objective 12.3. The lecture should take just over one lecture session and the class discussion should take up the balance of the time. The class discussion involves a reading assignment and should be handed out following the first lecture so that students can be prepared for the exercise when they come to the following class. A homework assignment is included and one week should be allowed for its completion. This assignment should be distributed following the session.

Objective 12.1 Describe the relationship between earthquake hazards, earthquake disasters, and earthquake vulnerability; and identify factors that increase vulnerability in the U.S. and globally.

Requirements:

The content should be presented as lecture supplemented with electronic visuals.

Electronic Visuals Included:

Electronic Visual 12.1 The World's Megacities

Remarks:

I. Let's remind ourselves of the terminology that we have used so far in this course:

A. **Hazard** is defined as a rare or extreme event in the natural human environment that adversely affects human life, property, or activity to the extent of causing a disaster (UN, 1992).

B. **Disaster** is defined as a serious disruption of the functioning of society, causing widespread human, material, or environmental losses that exceed the ability of affected society to cope using only its recourse (UN, 1992).

C. **An earthquake disaster** is defined as a catastrophic event resulting in significant loss of life, economic losses. and disruption of community services for an extended period of time (NRC, 2003).

D. We should distinguish **earthquake hazard from earthquake disaster** – the disaster stems from the fact that certain communities are settled in areas susceptible to earthquakes.

1. Remember, the earth's processes are dynamic and have been occurring for millions of years, and we have located our built environment in harm's way.

2. That is, the dynamic **earth is causing the hazard**, whereas **we (by our actions in terms of building practices, locations in seismic areas, etc.) are causing the disaster**.

E. Many disaster losses, rather than stemming from unexpected events, are **the predictable result of interactions among three major systems**:

1. The physical environment, which includes hazardous events.

2. The social and demographic characteristics of the communities that experience them.

3. The buildings, roads, bridges, and other components of the constructed environment.

II. **Earthquake vulnerability essentially is a measure of the effect of the potential hazard upon the disaster. Earthquake vulnerability, in its most general sense, stems from:**

A. **Communities being located in seismic-prone regions.** A number of major urban centers are located in seismically active regions, as discussed in Session 4.

B. **Infrastructure (constructed facilities and lifelines) that is not designed to resist earthquake shaking.**

1. Research findings show that relatively new buildings and infrastructure that are designed and constructed to the current state-of-practice in earthquake engineering perform significantly better than older ones during earthquakes, and that the largest threat to society lies in the seismically vulnerable infrastructure designed and constructed at a time when earthquake-resistant design had not yet matured.

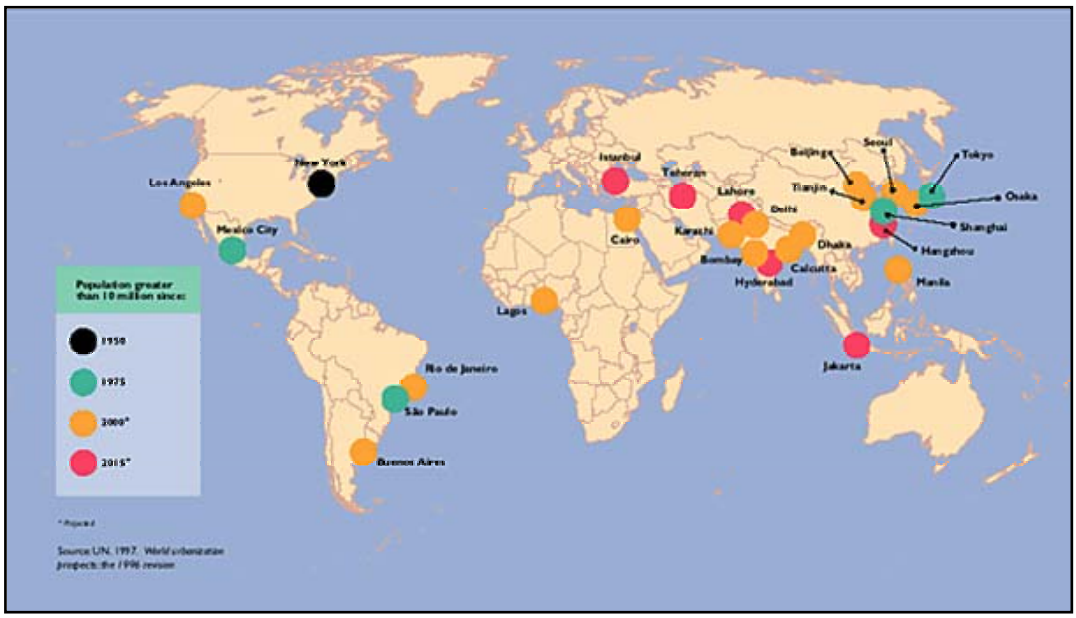
2. Even in high-seismicity regions the majority (say >80%) of existing facilities and lifelines do not have adequate seismic resistance of modern structures EERI (2003).

C. High population concentrations.

1. There is an obvious connection between the increase in losses from a disaster and increases in population. If there are more people and structures in a location where an earthquake strikes, there is likely to be more of an impact.

2. Major population centers, especially those in areas of high seismicity, are highly vulnerable. However, there is a significant risk from a large, rare event in lower seismicity regions.

3. The world's population is becoming increasingly concentrated in rapidly growing large cities-- megacities. Megacities are defined as populations greater than 10 million people. The are currently 15 megacities (see orange circles in visual 12.1) and there will be an additional 6 megacities by 2015-- (red circles) (UN, 1997). Istanbul (Turkey) and Dacca (Bangladesh) are two examples of megacites that have extreme earthquake hazards and grossly inadequate seismic protection. [*Electronic Visual 12.1*]



Visual 12.1 – Map showing world's megacities. Credit: UN (1997)

4. The *Earthquakes and Megacities Initiatives* (EMI) is a non-profit international organization specifically concerned with the reduction of hazard in megacities. see: http://www-megacities.physik.uni-karlsruhe.de/

D. Economic limitations

1. **The most important influence on the impact of most disasters is poverty** (UN, 1992). As studies indicate, **poverty generally makes people more vulnerable to the impact of hazards**. In fact, the average number of victims of natural disasters is 150 times greater and the economic loss (as percent of GNP) is 20 times greater in developing world the world, and recovery is much longer (Bendimerad and Comfort, 2002).

2. In terms of earthquakes, cities and communities in lower economically developed countries are more vulnerable since seismic designs are often too expensive and offer little prospect of reducing the vulnerability of the large numbers of poor people living in squatter settlements and older housing in high densities. Regulation of codes that govern building practices is typically less rigorous as well.

3. It is not possible to rebuild whole cities using seismic design, so people's vulnerability remains high.

a. 70% of the world's hundred largest cities (representing 10% of the world's population) are exposed to significant earthquake hazard (i.e., expected earthquake Modified Mercalli Intensities of VI (strong) at least once every 50 years on average).

b. Some 25% can expect Modified Mercalli Intensities of VIII (destructive) (UN, 2003).

4. The "technological fix" of expensive seismic design provides continued prospects of saving lives during an earthquake, and is particularly important for public buildings and utilities such as hospitals, roads, dams and power stations. However, there are significant drawbacks to this approach.

5. The widening inequality of wealth also makes many people more vulnerable to hazards and less able to recover from them (UN, 2003). For instance, the 1976 Guatemalan earthquake was described by a journalist as a "classquake" since it killed 22,000 people living in unsafe housing in the rural highlands and those in squatter settlements in Guatemala City (UN, 1992). The middle and upper classes were much less affected.

6. Although more economically developed countries, such as Japan and the U.S., are able to introduce stricter building codes that can reduce death rates, the poorer members of these societies remain the most vulnerable to the earthquake hazard.

7. Also, remember that seismic design using current building codes (geared only toward life safety, not limiting damage) simply means the building is less likely to collapse in an earthquake – it does not mean that the structure is not damaged beyond repair. Economic losses remain therefore high and indeed continue to rise.

E. Lack of access to information about earthquake hazards and/or mitigation.

1. Lack of identification of hazards and risks or communication of strategies for mitigation and preparedness allow high vulnerability situations to increase unchecked.

2. In addition to the factors discussed above, hazards vulnerability is not evenly distributed across the communities and societies of the world, in part because vulnerability is also affected by a diverse collection of contextual factors, including:

a. The size and nature of the affected population.

b. The condition of the economy.

c. The values and practices of the culture.

d. The political system.

e. Various aspects of social differentiation.

F. Unsustainable actions:

1. We must acknowledge that how and where we build determine the potential losses we suffer.

2. As paraphrased from Mileti (1999): Some efforts to mitigate damages from hazards only postpone them.

   a. For example, communities below dams or behind levees may avoid losses from most floods. But such communities often have more property to lose if those structures do finally fail (say in an extreme flood event) because additional development occurred that counted on protection. Such a situation contributed to catastrophic damage from the 1993 floods in the Mississippi Basin.

   b. Many of the nation's dams, bridges, and other structures are approaching the end of their designed life, revealing how little thought their backers and builders gave to events 50 years hence.

   c. Similarly, by providing advanced warnings of severe storms, this country may well have encouraged more people to build in fragile coastal areas. Such development, in turn, makes the areas more vulnerable by destroying dunes and other protective natural features. Similar issues exist in term of increasing risk form earthquake hazards.

G. Failure to adopt and implement mitigation measures: Where the rubber hits the road.

1. To date, several strategies have been developed to assess and mitigate known risks, including technological fixes, risk communication, incentives, and sanctions.

2. However, implementation of mitigation strategies has not been performed, partly because of the enormity of the problem in terms of expense. For instance, several studies have clearly shown that the eastern U.S. has very high seismic risk of earthquake, especially due to the large stock of existing unreinforced masonry and inadequately-reinforced concrete structures.

3. However, the real problem is implementation. Who will pay to retrofit these existing structures? Can it be done economically? Can this be cost-justified? What value should be placed on human life? Is the overall problem too enormous?

4. In other words, more research is not needed in many cases to reduce the existing hazards. We know we have big problems. **The bottom line is figuring out a way to apply what we know make the risks lower**—which typically involves addressing the problem of seismically-weak infrastructure. Again, this is "where the rubber hits the road."

Objective 12.2 Recognize the U.S. and global trend of growing earthquake disaster vulnerability.

Requirements:

The content should be presented as lecture supplemented with electronic visuals. The classroom discussion handout should be handed out following this objective and the students reminded to come to class ready to discuss the issues outlined in the assignment.

Electronic Visuals Included:

Electronic Visual 12.2 Risk Has Outpaced Mitigation – Increased Vulnerability
Electronic Visual 12.3 Trends in earthquake disaster losses
Electronic Visual 12.4 Growing global earthquake vulnerability

Handouts Included:

Handout 12.1 Classroom Discussion Assignment 12.1

Remarks:

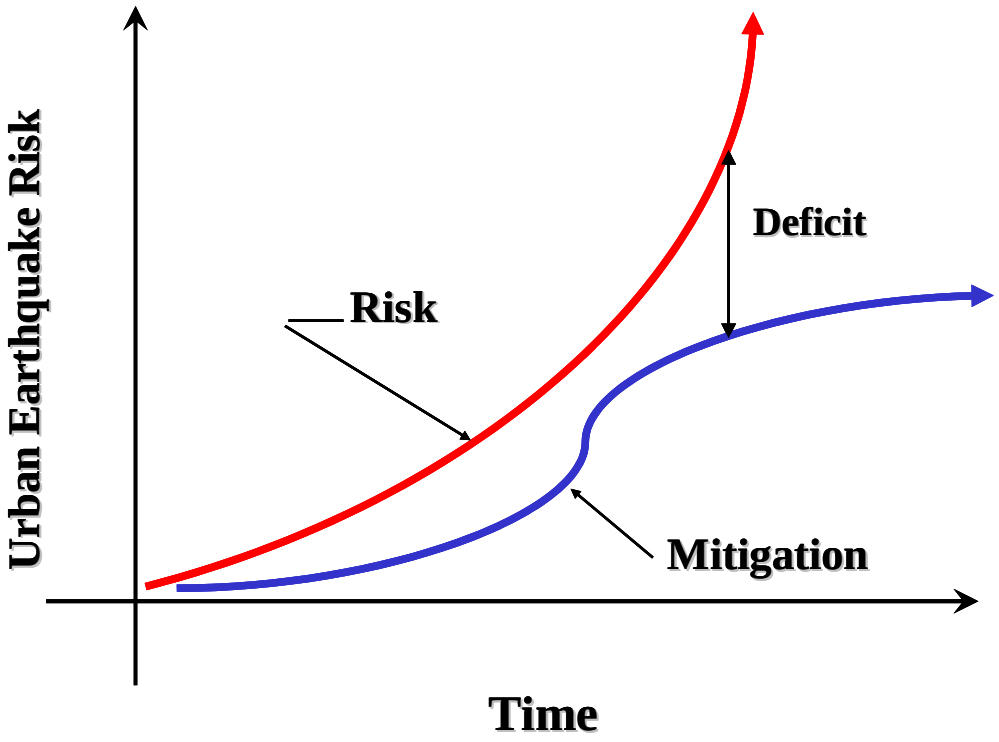
I. Vulnerability to earthquake disasters is increasing in the U.S. and worldwide.

A. Recent and projected changes in the demographic composition and distribution of the U.S. population mean greater exposure to many hazards. The number of people residing in earthquake-prone regions in the U.S., for example, is growing rapidly (EERI, 2003).

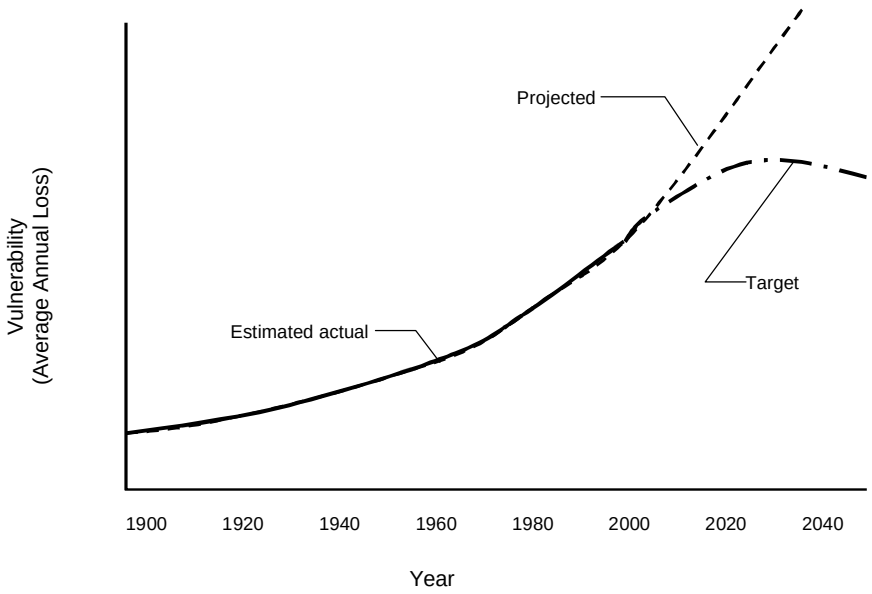
1. The built environment public utilities, transportation systems, communications, and homes and office buildings is growing in density, making the potential losses from earthquakes greater.

2. Earthquakes pose inevitable risks to our growing population. Rising losses in recent urban earthquakes such as Northridge and Kobe [Kobe suffered ~$140 billion in losses (NRC, 2003)] have shown that there is a widening

gap between the increase in urban earthquake risk and our efforts to mitigate that risk—increasing vulnerability. **That is, the threat posed by major earthquakes in most regions has outpaced our ability to mitigate the consequences to acceptable levels.** [*Visuals 12.2, 12.3*]



Visual 12.2 – Qualitative illustration showing how earthquake risk has generally outpaced mitigation. Visual adapted from Bendimerad and Comfort (2002.)



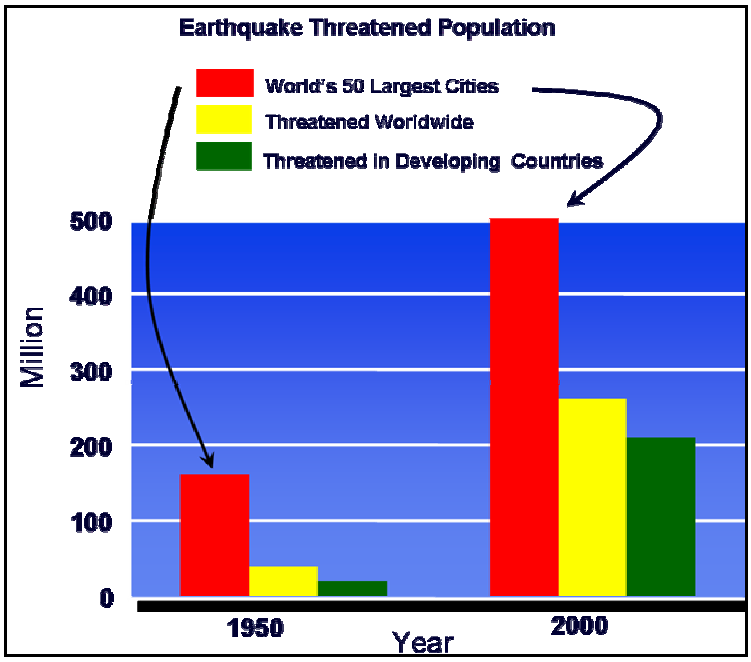
Visual 12.3 – Qualitative illustration of increases in earthquake disaster loss trends and possible results of sustained mitigation actions. Visual adapted from EERI Draft (2003).

3. For instance, at the time of the 1906 San Francisco Earthquake there were only 0.5 million people in the region; today there is more than 5 million, and many structures and lifelines have inadequate protection.

4. Growing losses result partly from the fact that the nation's capital stock is expanding, but they also stem from the fact that all these systems and their interactions are becoming more complex with each passing year (NRC, 2003).

5. As mentioned in Objective 12.1, the world's population is becoming increasingly concentrated in megacities (CDC, 2003). And, many of these cities are located in developing countries that have high earthquake hazards and grossly inadequate seismic protection—**thus global earthquake vulnerability is rapidly growing**. [*Electronic Visual 12.4*]

6. By 2010, 8 out of the 10 largest cities will be in the developing world; and, by 2030, 60% of the world's people will be living in cities, mostly located in the developing world (Bendimerad and Comfort, 2002). Again, **many of these cities are extremely vulnerable to major earthquake damage**.



Visual 12.4 – Bar graphs showing growing earthquake vulnerability of the world's largest cities. Visual adapted from Bendimerad and Comfort (2002) from http://www-megacities.physik.uni-karlsruhe.de/

B. Data from future earthquake scenarios indicate that the consequences of the next major urban U.S. earthquake will be far greater than experienced in the past (EERI, 2003).

1. As discussed earlier, damage from a single large earthquake in the U.S. approach $200 billion (NRC, 2003).

2. In particular, regions outside of California that are seismic-prone are vulnerable due to the presence of large stock of inadequately reinforced concrete and masonry structures.

C. According to Mileti (1999), major U.S. catastrophes in general are growing and will continue to grow, partly because of what was done in the past to reduce risk:

1. As discussed earlier in Objective 12.1 for example, building a dam or levee may protect a community from the small- and medium-sized floods that the structures were designed to handle, but the additional development that occurs because of this protection will mean even greater losses during an extreme flood that causes the dam or levee to fail.

II. Summary of Some Key Causes of High and Growing Vulnerability to Earthquakes (NRC, 2003; Mileti, 1999; EERI, 2003):

A. Limited knowledge of hazards.

B. Limited knowledge of impacts on the built environment.

C. Limited knowledge of societal impacts.

D. Extensive stock of aged infrastructure, and high retrofit costs.

E. Focus of current building codes (only on life safety as opposed to the higher performance standard of limiting damages).

G. Decisions not driven by appropriate consideration of risk, often due to inadequate tools and knowledge to determine risks.

H. Limited response and recovery capabilities.

I. High population increases within or migration to hazardous areas.

J. Interconnectedness of the built and human environment.

K. Development and planning actions that are nonsustainable in nature.

L. Inadequate resources for mitigation actions.

[*Instructor note: distribute Handout 12.1, the Classroom Discussion Assignment]*

Objective 12.3 Describe and discuss keys to reduce earthquake hazard vulnerability

Requirements:

Present as lecture highlighting the important points in the article. The homework assignment should be distributed at the end of this objective.

Handouts Included:

Handout 12.2 Homework Assignment 12.1

Remarks:

I. A discussion of important keys needed for vulnerability reduction is discussed in the following article for the *Natural Hazards Observers* Volume XXII, Number 1, September (1997):

"Needs for Vulnerability Reduction Designing Disasters: Determining Our Future Vulnerability--*an invited comment"* (from Dennis Mileti, Second U.S. Assessment of Research and Applications for Natural Hazards):

II. New Paradigm.

A. The Second U.S. Assessment of Research and Applications for Natural Hazards, a multidisciplinary effort to evaluate and summarize knowledge about natural and technological hazards and disasters from the perspectives of physical, natural, social, behavioral, and engineering sciences, is nearing completion.

1. It is being conducted by staff of the Natural Hazards Center and scores of volunteer hazards researchers and managers.

2. Since 1994, over 100 nationally and internationally recognized experts have worked and debated together to evaluate our nation's relationship to past, present, and future hazards.

B. It is clear to most involved in this effort that natural and related technological disasters are not problems that can be solved in isolation, but symptoms of more basic problems created culturally and based on the ways we view the natural world. We have concluded that it is time for a change in the prevailing thinking about how to cope with these hazards.

C. **How we prepare for disasters today will greatly affect the sustainability of our cities in the future. With every passing year, we are laying the groundwork for increasingly catastrophic natural and technological disasters**.

1. We need a new paradigm of hazard reduction – sustainable hazard mitigation – that embraces the notion of adjusting to the environment, incorporates a global systems perspective, embodies the concept of sustainability, and derives its moral authority from local consensus.

2. In short, the new paradigm must go beyond simply reducing losses to building sustainable local communities throughout the U.S.

D. **Under this new paradigm, actions to reduce losses would only be taken when they are consistent with five principles of sustainability**: **environmental quality, quality of life, disaster resiliency, economic vitality, and inter- and intra-generational equity**. This paradigm cuts across all areas of research and hazard reduction.

III. *Sustainable Hazard Reduction*. To accomplish these goals, we recommend new approaches in several areas:

A. **Sustainable Culture:** We must acknowledge that we are never fully in control of nature and that humans are the cause of disaster losses. We must acknowledge that how and where we build determines the losses we suffer.

1. Developing consensus among divergent stakeholders is the first step. We propose "sustainable hazard mitigation networks" to undertake collaborative problem-solving within appropriate geographical areas, such as metropolitan areas or watersheds.

2. Prototype network projects should be initiated to move us toward more sustainable hazard mitigation.

B. Events, Losses, and Costs: To understand future disaster vulnerability, we must understand where we have been.

1. We conservatively estimate that, in the U.S. between January 1, 1975, and December 31, 1994, natural hazards have killed over 24,000 people (about 23 per week) and injured about 100,000 (about 385 per month).

2. We also estimate that the U.S. sustained about $500 billion in damage during this period, or about one-half billion dollars a week. Of these losses, more than 80% were weather-related, and about 10% were caused by earthquakes and volcanoes. Yet, only 17% of losses were insured.

3. Despite these significant, ongoing losses, there is no systematic reporting method for loss data and no single repository for this information. We need to develop a method that will enable researchers, particularly those in the social sciences, to archive their data in a central repository. We also need to develop standardized measures that can be used across studies and disciplines.

C. The Interactive Structure of Risk: We need to assess – immediately – the interaction among all the facets of the natural world, our population, and our constructed environment to understand better how they shape risk, losses, and their distribution. For example, many scientists believe that global warming will have an adverse effect on the earth's ecosystems, yet, we have very little understanding of the types of climate variability it will cause.

D. Putting Knowledge into Practice: The first Assessment of Research on Natural Hazards, conducted in 1975, emphasized the need for applying hazards-related social science research to disaster prevention and recovery.

1. Since then, **many changes have occurred in the way we approach hazards in this country**, particularly with the new federal emphasis on mitigation and the emergence of an interdisciplinary "hazards community" of researchers and practitioners.

2. However, contrary to the first assessment's recommendations**, little attention has been given to studying ways to enhance the adoption of sound land-use schemes, measuring their social effectiveness,**

understanding why people and organizations make different choices about adjustments, assessing the effectiveness and equity of relief distribution, and evaluating building code enforcement.

E. **Land-Use Management: By planning for and managing land use to accomplish social, ecological, and economic sustainability, communities can also reduce disasters**. This can be accomplished through comprehensive land-use plans and supportive federal and state policies.

F. **Engineering Codes, Standards, Practices, and Control and Protection Works: Any engineering code is only as good as its enforcement; therefore, the issue of building and systems performance in a disaster is not purely a technical one. Until recently, engineers relied on safety factors or made assumptions about uncertainties when estimating how a system would perform**. New methods have brought these uncertainties to the forefront of the planning process. For example, the U.S. Army Corps of Engineers is developing methods and procedures to incorporate risk analysis into their evaluations of proposed flood mitigation measures.

G. **Prediction, Forecast, Warning, and Planning:** As in the past, **our ability to provide timely public warnings must continue to improve in order to reduce the number of injuries and deaths due to disasters.**

1. We must continue to improve our distribution of warnings, and, at the same time, develop a comprehensive national warning strategy that uses efficient and affordable technology.

2. Otherwise, the gap will only increase between state-of-the-art technology and practice.

H. **Disaster Response and Preparedness**: Since the 1975 assessment, a large body of research has been carried out on disaster response and preparedness.

1. We have a much clearer picture of household preparedness, the importance of socioeconomic factors, and the way that information about risk and preparedness can foster appropriate behavior, but our knowledge is far from complete.
2. **We need to learn more about why disaster preparedness has little support and determine ways in which disaster preparedness can serve as a foundation for sustainable development.**

I. **Recovery and Reconstruction: Over the last 20 years, there has been a shift in conceptualizing disaster recovery, moving from thinking of recovery as a linear process that follows specific steps to viewing it as a process of interaction and decision making among groups and institutions**.

1. We believe that **sustainability may be the concept that provides the crucial link between disaster recovery and mitigation.**

2. In particular, planning for recovery has been given minimal attention in the U.S., although in comparison, considerable resources have been devoted to emergency preparedness and response.

J. **Insurance: Although insurance is never an acceptable alternative to loss prevention, it can be an important part of a hazards management program, particularly if it is used to encourage and enforce cost-effective loss-reduction measures.** We suggest a three-faceted approach to its use: improve current estimates of catastrophic risk, use inspections and certifications to verify damage-resistance of buildings, and determine additional ways of raising capital to cover catastrophic losses.

K. **Economics: We need better data to estimate losses due to natural hazards and disasters. In the past, insurance industry loss data has not been shared with researchers**. In addition, we need to understand better how individuals respond to risk and uncertainty through economic means, propose public policies that have appropriate economic incentives, and analyze the effectiveness of public policies by looking at their true economic consequences.

L. **Adoption and Implementation:** To date, several strategies have dominated the adoption of hazards adjustments, including technological fixes, risk communication, incentives, and sanctions. **Reduction of future catastrophic losses will require significantly more sophisticated forms of these and other approaches.**

M. **Looking toward the Future:** Finally, we ask the nation to acknowledge that we will never be totally safe from disasters.

1. We ask that those who are charged with making national and local decisions acknowledge that they are designing the disasters that future generations will experience.

2. And we seek to begin a nationwide conversation that will lead to actions that link hazard mitigation and disaster response to the broader goals of sustainability.

[*Distribute Handout 12.2 Homework Assignment 12.1; one week should be sufficient for completion of this assignment*]

References Utilized:

Bendimerad, F., and L. Comfort. 2002. “Reducing Vulnerability and Improving Sustainability of the World’s Megacities, The EMI Experience,” presentation to the U.S. Agency for

International Development on behalf of the *Earthquakes and Megacities Initiatives*, Washington DC. See: http://www-megacities.physik.uni-karlsruhe.de/.

Center for Disease Control. 2004. *Urban Health and Megacities - An Emerging Global Priorit*y. Available from: http://www.cdc.gov/nceh/globalhealth/.

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