Handout 12.1: Class Discussion Exercise

Earlier in this course we discussed the attached article below which is an excerpt of testimony from Professor Thomas D. O'Rourke, president of EERI. He was testifying before a senate subcommittee on the reauthorization of the National Earthquake Hazards Reduction Program (NEHRP) program. He outlined the vast stock of vulnerable buildings in the central and eastern US. With the background from this article, come to class prepared to discuss the following:

1. What specifically can be done to reduce the "bottom line" for this problem?
2. How can implementation be accomplished? Is the problem too enormous?
3. Would retrofitting be cost-beneficial?
4. Are their more urgent priorities?
5. What value should be place on human life?
6. Would this be necessary ultimately?

Excerpt from testimony of Earthquake Engineering Research Institute (EERI) President Tom O'Rourke before the Subcommittee on Basic Research, U.S. House of Representatives on October 20, 1999. The hearings dealt with lessons learned from the Turkey, Taiwan, and Mexico earthquakes.

The Testimony:

… The two most pervasive images and lessons from both the Turkey and Taiwan earthquakes are 1) thousands of failures of non-ductile concrete buildings, and 2) surface faulting with critical facilities ruptured and unserviceable because they were intersected by severe fault movements. Non-ductile concrete buildings are those built of concrete structurally reinforced with steel, but where the quantity of steel (especially hoop or spiral steel and steel at connections) is too low to strengthen the building against the swaying movement generated during an earthquake. As a consequence, these buildings are prone to catastrophic rupture and fracturing of the concrete, with lethal consequences for the occupants.

Non-ductile concrete structures are a serious problem for the US. Not only do we have a significant inventory of non-ductile concrete buildings in California, but we have a very significant inventory of non-ductile concrete buildings outside California in places like Washington State, the New Madrid area (Missouri, Tennessee, Arkansas adjacent to the Mississippi River), Charleston, SC, and Boston, MA, etc. This places a substantial portion of the US building stock at risk from high impact, low recurrence earthquakes. It also places a considerable number of buildings at risk of catastrophic collapse in high impact, high recurrence earthquake zones. It is not just high occupancy apartment, commercial, and industrial buildings that are at risk. Critical lifelines, such as bridges, are also vulnerable, especially outside California. For example, the elevated reinforced concrete viaduct for Rt. 99 in downtown Seattle is of similar vintage and design as the I 880 Cypress structure that failed in the Loma Prieta earthquake.

Turkey shows us what the lack of vigilance can do, and stimulates renewed efforts at finding effective and equitable measures for high impact, low recurrence areas of the US. We should not think that we are safe because our code adoption and compliance are better than Turkey's. Upwards of 80% of the US building stock in earthquake-vulnerable areas was designed before modern ductile design principles were incorporated in codes. Hence, these buildings may behave similarly to those in Turkey because neither benefits from sufficient steel reinforcement to allow structures to accommodate seismic deformation.

The surface faulting in Turkey, and especially Taiwan, was spectacular and frightening. In Turkey strike slip and normal movement on the Northern Anatolian fault was responsible for highway bridge failure and severe damage at the principal Turkish naval base in Golcuk. Both these are critical facilities, with the naval base being especially critical. Surface faulting at the naval facility intersected and collapsed a military building, killing many high-ranking commanders. In Taiwan, rupture of the Chelungpu fault failed a highway bridge just east of Feng-Yuan and was responsible for over 30 ft of vertical offset at the

Shihkang Dam. The dam failed, and 40% of the raw water supply for Taichung County (several million people) was lost.

In the US, we have tended to forget about surface faulting in part because it was missing from urbanized areas during the Loma Prieta, Whittier, Northridge, and Kobe earthquakes. Although significant surface faulting occurred in the 1979 Imperial Valley and 1992 Landers earthquakes, it was located principally in desert and agricultural areas. Turkey and Taiwan remind us that surface faulting can cause serious destruction and loss of life.

Lessons Learned for Potentially Lethal Structures

There is an urgent need to develop an inventory of buildings in seismically active areas of the US to identify where non-ductile concrete buildings and other vulnerable structures (e.g., unreinforced masonry and open-first-story timber frame apartments) are located. All citizens should have access to knowledge about the buildings they live and/or work in, but this type of inventory is not currently available.

Congress should be asked for a special allocation of funds to identify all high occupancy buildings in near source zones in California and other seismically hazardous areas that represent a serious risk of collapse if subjected to shaking that has been given a fairly high probability of occurrence. Buildings should be identified initially by Rapid Visual Screening, then subjected to a FEMA 178/310 evaluation, oriented towards the collapse condition. In addition, the evaluations should be site specific as far as the nature of ground motion expected, reflecting knowledge of local soil conditions and likelihood of liquefaction. The result would be a definitive list of vulnerable buildings, which might be in the hundreds in each region, but would be manageable.

With a list of potentially lethal buildings, action could shift to states, local jurisdictions, and private owners. Programs might include state bond issues to cover public (school, university, and government) buildings, with perhaps some cost sharing at the federal level. For private buildings there might be grants for engineering design, low interest loans for the work, and other incentives. Financial incentives through federal and state tax credits and insurance premium or deductible reductions should also be explored as inducements either to retrofit or remove seismically unsafe buildings.

This type of program would be a test of the earthquake community's ability to devise and sell real programs rather than give generalized advice. How effective are our evaluation techniques? How effective are the earth sciences people in providing useful site-specific data? How imaginative is the engineering community in devising effective and affordable risk reduction? How effective are our policy experts in developing politically acceptable policies and programs?

The time is right for this specific proposal to Congress rather than continued generalizations about risks, hazards, and earthquake lessons. This proposal is responsive to the lessons of Taiwan and Turkey, and addresses the real threat that thousands of deaths could occur in a US earthquake.

Lessons Learned for Support of Local Communities

Support of FEMA's Project Impact [*note this is no longer a program, 2004*], including increased matching funds, will help to identify potentially lethal buildings by encouraging local communities to work on their natural hazard problems. Project Impact is a program wherein FEMA provides financial assistance to about 120 US communities to develop mitigation practices that focus on reducing losses from several types of natural disasters, including earthquakes. To enhance local community efforts in rehabilitating vulnerable structures, support is needed to implement FEMA Plan 2005[3] to enhance the agency’s Existing Buildings Program. This plan recommends 25 actions to promote the rehabilitation of life-threatening buildings.

Lessons Learned for Active Fault Zones

Although the Alquist-Priolo Act restricts new construction in active fault zones in California, there are many critical facilities grand-fathered into harms way. Schools, reservoirs, hospitals, and the University of California at Berkeley football stadium intersect the Hayward fault in the East Bay. Other critical structures in California are intersected by the Calaveras and San Andreas faults. Similar situations apply in other states. For example, the Seattle and Wasatch faults are mapped through heavily developed areas of Seattle and Salt Lake City, respectively. The recent earthquakes encourage us to revisit our risk assessment, zoning, design, and emergency plans for structures in or near active fault zones.

Reassessment of active fault zones is needed, especially with respect to critical facilities (for example, hospitals, schools, reservoirs, and bridges) that are located on or near active faults. It should be recognized that all the major water supply pipelines from external water sheds for the Los Angeles area cross the San Andreas fault, and a similar situation pertains to the water supply pipelines for San Francisco crossing either the Hayward or San Andreas faults. East of Los Angeles, the San Andreas fault crosses Cajon Pass where many vital lifelines (highway; railroad; natural gas, water, and petroleum pipelines; fiber optic lines, and electric power transmission lines) are collocated in a very narrow pass subject to fault rupture.