Lifeline Mitigation: The Foundation of Good Emergency Management in Earthquake Disasters

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Lifelines and mitigation: perhaps the two most essential elements of community support and emergency management. Lifelines are the “heart” of the community’s functioning—the roads, bridges, dams, water and sewer lines, treatment plants, drainage facilities, electric and gas systems, and communications. Lifelines also include hospitals, emergency shelters, and storage areas for emergency equipment and supplies because in disasters such as earthquakes the resources to respond and care for citizens must be able to function.

Mitigation, by definition, includes measures to avoid, resist, and soften the effects of disaster. Effective mitigation is a great help in emergency preparedness, response, and recovery, while inadequate mitigation can not only hamper efforts in the other three phases, but also create obstacles to meeting public needs during and following emergency events.

Lifeline earthquake mitigation involves five major actions: avoidance, increased seismic design, redundancy, insurance, and augmented preparedness. Of these, the first three probably demand the greatest attention. History is always an essential factor in analyzing the community’s hazard risks, and in no case is it more important than with earthquakes. While earthquakes are not yet generally predictable, considerable information is available regarding hazard areas, fault locations, probable strengths, and other data, all of which should be used by designers, planners, and emergency managers as a focal point in their work.

Certain quakes have become “landmarks” in providing lessons for the future. One example, the 1971 San Fernando disaster, resulted in many changes in mitigation methodology. It is not yet clear whether the earth settlement experience from Alaska in 1964 has sufficiently influenced land planners and developers in other parts of the country to understand and deal with the hazard potential of unstable soil conditions.

Organizations such as the U.S. Geological Survey have been very active in making and reporting special studies helpful in earthquake mitigation. Some of these are national in scope (such as U.S.G.S. Bulletin 1659 on the National Earthquake Hazards Reduction Program), while others focus on specific areas (Professional Paper 941-B on Seismic Safety and Land Use Planning in the San Francisco Bay region). Resources such as these are valuable additions to the library of every professional responsible for earthquake and other hazard identification and mitigation.

The importance of linking land use planning and development with public works mitigation cannot be overemphasized. Not every type of land use can be safely placed in every area, and the juxtaposition of various land uses is critical to avoiding undue earthquakes. There must be a heavy public works participation in general and specific land use planning, and the public works position must be firmly and clearly presented at all stages.

Once the plan is adopted, management of the timing and pattern of development is also critical. Availability of public works facilities must keep pace with development and transitional situations, avoiding access and utility service limitations. Hospital and potential emergency shelter locations must be carefully considered; if these are susceptible to loss of access or utility support as a result of earthquakes, alternate locations should be considered to ensure availability during response and recovery.

Earthquake mitigation also requires careful analysis of the advantages and disadvantages of locational alternatives for important streets, highways, and utility systems. Economics should not necessarily be the prime criteria for design and location decisions if the lower cost options involve unacceptable risk for interruption of lifeline service. (The potential risks from other types of disasters should also enter into decisions to avoid compounding disasters.) Another factor in the equation should be the probable costs of replacement during recovery. Should the lifeline fail completely, rebuilding on a “crash” basis usually costs significantly more.
Increased seismic design includes use of a variety of techniques to permit structures and pipelines to absorb the shock effects of earthquakes and remain serviceable. Particular attention must be paid to facilities subject to total failure. For example, bridge decks must not be capable of dropping off piers or abutments as those supports respond to earth shocks and vibrations. Use of restrainers as part of new construction is simple and low cost, and even retrofitting of existing structures is not too difficult. Junction boxes, tanks, and pump stations should be designed to minimize the possibility of settling or tilting, which would sever their connections or render them inoperable. The connections should be designed to facilitate repair when needed, with consideration of possible limitations in the availability of specialized equipment or services during and following a disaster.

Special care must be taken in the use of “innovative” structural systems. Building codes are minimums in any case and do not cover all types of design and construction in use. Special work may be needed to check and validate unique design proposals before approval for use. A good mitigation rule is “if there isn’t full confidence in the design, don’t let it get built.” Relying on the professional responsibility of the designer is not sufficient. It is better to go through the stress of debating approval of a design than to have a lifetime of regret if the structure does not survive an earthquake.

There are abundant examples of failures of life-line systems because operational elements or control panels shifted or tilted, putting an entire unit out of service. Pump stations, treatment plants, electric switching yards, gas regulator stations, and other critical units of life-line systems must be earthquake-proofed by dealing with their sub-units. Tying equipment down and providing flexibility in connections and piping are examples of items needing full attention to details during design.

Redundancy opportunities occur less frequently than do opportunities for good design, but they do not necessarily represent an unacceptable additional cost. If redundancy can be provided by merely increasing the size of a water or gas pipe, the extra cost is mostly in materials. Redundance in gravity pipeline systems is more difficult to achieve, but such opportunities do exist. It is common to provide for alternate power for pump stations, but this redundancy is only effective for earthquake effects if the motor-generator and fuel tanks are built and installed to resist shocks.

Efforts for good planning and design, and redundancy provision, can be weakened or destroyed if the quality of inspections, testing, and maintenance is overlooked. Good inspection is always important, but it is even more so with respect to life-lines.

There are reasonable limits on the extent of increased design and redundancy which can be built into life-line systems, and system failures will occur. The very nature of life-lines means that service losses must be brief if the community is to recover quickly. Augmented preparedness includes careful storage of both emergency and regular operational supplies and equipment, as well as keeping a good maintenance level. Specialized training of personnel should cover how to effect rapid emergency restoration of life-line facilities.

The role of insurance is to supplement other financial resources which may be available to assist with timely repair and rebuilding of road and utility systems when they fail from earthquake action. Many utilities have reserves available for such work, but there are usually no reserves for repair of roads and bridges. While state and federal emergency relief grants may become available, they may not come quickly enough to get those life-line systems at work again. Because of the expense, it is uncommon for public agencies to secure insurance specifically for earthquake relief, but it is a good idea to consider how earthquakes fit into the agency’s regular insurance or self-insurance program.

Mitigation is the foundation for good emergency management. Sooner or later, every area subject to earthquakes will experience a strong one. Emergency managers and public works professionals in those areas can do no more important community service than to carry out life-line system mitigation as fully as possible.