APPLICATIONS OF EARTHQUAKE HAZARD MAPS TO LAND-USE AND EMERGENCY PLANNING

EXAMPLES FROM THE PORTLAND AREA

O. Gerald Uba
Metro, Portland, Oregon

OVERVIEW

The extent to which we understand "below ground" (geological) and "above ground" (buildings and infrastructures) seismic risks is a key issue in developing appropriate earthquake mitigation and preparedness techniques, and policies that could minimize the effects of a major disaster event such as an earthquake. Cooperation among the urban and emergency management planners, developers, and owners of public and private structures is also vital for developing effective earthquake mitigation, preparedness, response and recovery strategies. Natural disasters, such as earthquakes, do not usually occur within the geographical boundaries of a local community or a service area of single utility agency. Costs associated with recovering from a major natural disaster are usually borne by more than the local community. Hence, rigorous disaster planning, such as seismic risk identification on a regional basis, and cooperative, integrated and comprehensive regional emergency planning can spread today's scarce disaster management funds across many jurisdictions.

The Oregon Department of Geology and Mineral Industries (DOGAMI) and Metro1 embarked on the Regional Earthquake Hazard Identification Project to develop and provide an earthquake hazards data file system, based on a geographic information system (GIS) linking data concerning geology, buildings, lifeline systems and critical facilities, and capable of generating estimates of property damage and loss. This data file system will support all phases of earthquake disaster planning in the Portland metropolitan area. Metro's mission includes bridging the gap between information technology and policy decision-making at the regional emergency management level. The agency’s effort is directed at: a) developing hazard data file systems with tools that can support earthquake mitigation, preparedness, response and recovery planning and real-time response; b) estimating possible property damage and loss; c) developing model land-use mitigation regulations that local governments can adopt and implement; d) assisting in the development of a regional emergency management plan and system; and e) involving public and private sector organizations in determining how to develop, maintain, and share the hazard data file systems.

In 1993, Metro collaborated with local governments in the Portland metropolitan area to form the Regional Emergency Management Group (REMG) for the Portland area through an intergovernmental agreement. The group is made of up of two bodies, the Regional Emergency Management Policy Advisory Committee (REMPAC) and Regional Emergency Management Technical Committee (REMTEC). The REMG has become the catalyst for initiating, developing and implementing disaster mitigation, preparedness, response and recovery strategies and plans in the region. Table 1 illustrates the issues and process that made the formation of REMG possible.

METHODS OF HAZARD IDENTIFICATION

Geologic hazards data for liquefaction, ground shaking amplification and slope instability were collected by the DOGAMI in the area described by the Portland 7½ minute U.S.G.S. quadrangle map. The methods of collecting and mapping these hazards are described in other reports (Mabey et al., 1993) and (Mabey and Madin, 1993).

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1 Metro is the only directly elected regional government in the United States. About 1 million people live within Metro's boundaries. The geographic area of Metro is 1194 square kilometers (461 square miles) and includes 24 cities in the urban portion of three counties and 151 special districts. Metro's primary responsibilities include urban growth management, transportation, zoo and recreational facilities management, and green spaces and solid waste planning management.
Table 1. Formation of the Portland area regional emergency management group.

**MAJOR ISSUES**

1. Some emergency management issues are better dealt with at the regional level (and can be determined by separating local issues from those that are regional in scope).
2. There is no clear legal authority for coordinating emergency management planning at the regional level.
3. There is no organ of local government in the region to provide policy decision-making that would enhance disaster preparedness.
4. It is not known if the emergency management plans of local governments including the Red Cross are compatible and consistent.

**PROCESS**

1. Emergency managers in the four-county area around Portland recognized the major issue and expressed interest and willingness to find solutions to them.
2. Emergency managers developed a work plan that summarized existing emergency management programs and responsibilities in the region. The work plan also identified funding sources and defined the broader emergency management issues that are regional in scope, developed broader regional goals and proposed how a regional emergency management program could be developed, including the formation of the Regional Emergency Policy Advisory Committee and the Regional Emergency Technical Committee.
3. The work plan was used by emergency managers to educate elected officials and others of the need for developing a coordinated regional emergency management program and policy-making body.
4. Governing bodies of represented jurisdictions used resolutions (or ordinances) to: a) accept and recognize the work plan as the basis to formally address common policy issues faced in regional disasters by emergency management organizations in the Portland area, and b) signed an intergovernmental agreement that committed them to participate in the formation of the advisory committee to develop a regional plan and system.
5. The formal inaugural meeting of the new Regional Emergency Management Group (REMG) was held; the REMG is made up of the Regional Emergency Management Policy Advisory Committee (REMPAC) and Regional Emergency Management Technical Committee (REMTEC).
6. An annual work plan was developed with time line and project leaders for developing the regional emergency management elements identified earlier. This task includes identification of key policy recommendations for REMPAC to consider for adoption. Examples of policy actions include adoption of a regional emergency operation center and a regional process for activating the emergency broadcast system.

Metro's effort in hazard identification is devoted to assessment of buildings, lifeline systems and critical facilities, in the region for potential hazards. The assessment of buildings entails rapid visual screening of buildings, including specified critical facilities to identify those buildings that might pose potentially serious risk of loss of life and injury and severe disruption of community services in the event of a major earthquake.

Through the joint efforts of Metro, City of Portland Bureau of Buildings and Portland State University Civil Engineering Department, over 9000 nonresidential (commercial) buildings were assessed. Public and private utilities, the City of Portland, Multnomah County, hospitals and the Portland School District were very cooperative in collecting and mapping the major components of lifeline systems and critical facilities in the Portland quadrangle. Data have been collected for the following systems and critical facilities: electric power, sewer and storm drainage, telecommunications, bridges, water, hazardous materials storage, hospitals, ambulance, fire stations, police stations, schools and dams in the region.

The buildings, lifeline system and critical facilities data were integrated into Metro's GIS-based Regional Land Information System (RLIS). Maps displaying the geographic distribution of these structures were overlaid on geo-
logic hazard maps and used for vulnerability analysis (Figure 1).

**APPLICATION OF EARTHQUAKE HAZARD DATA FILES (AND MAPS) TO LAND-USE PLANNING**

To obtain suggestions concerning how the earthquake hazard data files and maps may be used, a workshop was organized in January 1993 that brought together about 250 emergency planners, engineers, land-use planners, elected officials, citizens, and insurance and banking representatives. The workshop provided the following land-use related mitigation questions and answers concerning the uses of the hazard data files and maps.

**Land-use Planning Questions**

- Should all current comprehensive land-use plans be re-evaluated?
- Can the geologic hazards maps actually be used for zoning?
- How do you deal with properties at the boundaries of the geologic hazard zones?
- Is the Oregon statewide land-use planning Goal 7 (Areas Subject to Natural Disaster and Natural Hazards) adequate to cause any impact on the utilization of the geologic hazard maps?
- Should site-specific studies be required of land developers in the higher hazard areas?

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**Figure 1. Residential buildings by structure and type and relative earthquake hazards.**
Land-use Planning Answers

- Maps based on the individual geologic hazard should be utilized to guide land-use policy for that specific hazard, not a combined hazard map.
- Overlay maps with the floodplain map to get the overall picture of land-use hazards.
- Treat the maps as advisory only, because they are not adequate to mandate land-use actions and zoning. More information is needed.
- Use these hazard maps in the permitting process.
- Limit critical facilities such as hazardous facilities, schools and hospitals in the high hazard areas.
- Maps should be used to guide future development, especially of lifelines.

The above issues provided the guidelines used by Metro to initiate regional land-use planning efforts to mitigate seismic hazards in the Portland area. Subsequently, Metro and a land-use consulting firm based in California (Spangle Associates, 1996) worked with an advisory committee made up of land-use planners, building officials, developers and other interested partners to develop model land-use regulations for mitigating seismic hazards. The project purpose was to define the options for applying the earthquake hazards data files and maps directly to land development decisions in the Portland region. Development of regulations that could be used to mitigate seismic risks requires the correlation of geotechnical information (ground motion amplification, liquefaction susceptibility, and lateral spread displacement and dynamic slope instability) with existing land-use and building types.

Defining these correlations has helped to establish a reasonable procedure for justifying why and how earthquake hazard maps should be included in the range of factors considered by land-use. The fundamental concept that guided the team is as follows:

seismic hazard + land-use = risk

In other words, the risk of damage from an earthquake depends on the presence of land subject to failure from an earthquake and vulnerable land-use patterns (land plus its infrastructure, buildings, building content and function). Risk can be reduced by avoiding or modifying the land subject to failure by constructing buildings and facilities to withstand the effects of earthquakes, or by proscribing the development of a vulnerable land-use pattern.

The intent of this is to develop model regulations that are clear and flexible and that local governments can adopt and incorporate into land-use policies. Major features of these regulations include provisions and guidelines for action, such as adoption of the hazard maps as accepted maps of earthquake hazards for a local government, adoption of earthquake performance objectives and acceptable risk levels and matrices correlating land-uses to hazard zones, and refinement of hazard maps by property owners as required by a local community.

The issue of how local governments should be encouraged to use the model regulations and which agency should enforce the regulations will be explored by the advisory committee. Currently, there are very limited tools for enforcing any seismic safety regulation. One of the 19 goals of the Oregon statewide land-use planning laws (Goal 7) is to keep developments away from areas of natural disaster and hazards, or allow developments only with appropriate safeguards. The Oregon Land Conservation and Development Commission (LCDC) expect local governments to accommodate this goal as information on natural hazards (such as the earthquake hazard maps) becomes available. Periodic review of local governmental “Comprehensive Land-use Plans” by LCDC, to ensure that local plans include new information such as earthquake hazards and population changes, could be an opportunity to enforce land-use regulations for mitigating earthquake risks.

APPLICATION OF EARTHQUAKE HAZARD DATA FILES (AND MAPS) TO EMERGENCY MANAGEMENT

Another project initiated by Metro and DOGAMI (1993) is the use of the hazard data file systems to estimate property damage and loss from possible future earthquakes. A pilot study was conducted in a 60-square block area of Portland that includes 441 parcels of land with 185 buildings, railroad tracks and lifeline systems. The pilot study assessed building damage.
and casualties as a result of a hypothetical moderate earthquake. The study found that damage would equal approximately 12 percent of the total building value. It also provided an indication of the variations in expected loss by structural types of buildings, potential liability issues, and areas requiring greater emergency response priority following an earthquake. Damage and loss assessments will be evaluated throughout the region, at the county level, as additional data are collected.

Damage and loss estimation methodology could be used to support many aspects of emergency management planning and implementation. The methodology and results could be used to forecast demand on health care facilities, estimate shelter demand and amount of debris that will be generated, based on expected damage in buildings and infrastructure. The results could also be used to determine potential debris disposal and recycling sites, locate emergency transportation routes and potential utility outages. The data analysis could also support emergency resource allocation planning activities such as the pre-planned dispatch of building inspectors to areas where high damage and failure of facilities are likely to occur.

Disaster response planning (such as earthquake exercises and response drills) could also be guided by the maps. During the disaster recovery period, some of the major issues that communities have to deal with include tightening of existing ordinances and stricter enforcement of existing laws. The hazard data files can be used to evaluate the extent of likely disaster damage and suggest how existing ordinances should be modified.

CONCLUDING REMARKS

The success or failure of applying an earthquake hazard information system and map within a defined region may be dependent on factors such as the authority or responsibility of agencies supplying and using the information, information distribution techniques, status and structure of existing emergency management partnerships, potential for new partnerships, structure of existing land-use and emergency planning programs, and funding. However, the experience in the Portland area suggests that the following elements are also crucial: a) well

known source of information and maps; b) availability of staff involved in the development of the maps to speak at public forums; c) ensuring equitable distribution of information and maps among all jurisdictions and agencies in the region; d) recognition of a lead agency that is responsible for articulating map application methods; and e) directing advisory committee efforts to develop a regionally balanced, cost-effective, technologically feasible, and publicly acceptable regional earthquake mitigation and emergency management system.

REFERENCES:


