A LAND USE PLANNER'S HANDBOOK TO DEVELOPING AN EARTHQUAKE RISK REDUCTION STRATEGY

S. Heikkala (I)
M. Greene (II)
P. May (III)
P. Bolton (IV)
M. Wolfe (V)
Presenting Authors: S. Heikkala and P. Bolton

SUMMARY

This paper describes an ongoing project, funded by the National Science Foundation, to develop a decisionmaking framework that local officials can use in determining if and when a locational strategy is appropriate to mitigate their earthquake hazard. This framework will take a decisionmaker through a series of analytical stages, including assessment of information on the seismic hazard in the community, of the physical development context and the range of available planning tools, of the feasibility and costs of each of several applicable planning tools, and finally, of the overall effectiveness of any particular tool. Such an evaluation can facilitate the development and implementation of an appropriate community risk reduction strategy.

INTRODUCTION

This project evolved from the observation that the growing body of literature on land use or locational strategies as a means of reducing earthquake risks emphasized theory, but lacked practical indications of ways to determine whether such approaches were viable. Within the past ten years, land use strategies have come to be considered as mitigation tools (Ref. 1, Ref. 2, Ref. 3). There has been, for example, an attempt in California to link seismic safety and land use planning (Ref. 4, Ref. 2). However, most of this research is methodological and does not devote much attention to assessing the costs of developing and operating such a program, or to determining whether program adoption and implementation will satisfy risk reduction objectives. This project is intended as a careful evaluation of land use strategies for mitigating the earthquake hazard, and as a determination of the viability of such strategies.

(I) Center for Planning and Design, University of Washington, USA

(II) Research Scientist, Battelle HARC, Seattle, Washington, USA

(III) School of Public Affairs, University of Washington, Seattle, Washington, USA

(IV) Research Scientist, Battelle HARC, Seattle, Washington, USA

(V) Professor Emeritus, Dept. of Urban Planning, University of Washington, USA

This project is designed to bridge the gap between two streams of earthquake mitigation evaluation research. On one hand, most of the previous economic research has been based on aggregate levels with broad assumptions about earthquake impacts, but there are few data pertaining to areas smaller than regions. On the other hand, studies of implementation have examined why mitigation programs fail, but not how to put them in place. This project assesses the prospective feasibility of particular earthquake mitigation actions, especially as applied to specific locations.

PROJECT DESIGN

This two-phase project, the first phase of which is now complete, consisted of two distinct parts. The primary component is a decisionmaking framework design--what stages are critical to the process, what planning tools can be considered, what information about the earthquake hazard is necessary, how can cost, feasibility and ultimately effectiveness of the tools be measured and how can the framework be designed so as to be useful in a political decisionmaking environment.

The second component of the first phase is separate but complementary. One team member, who had the opportunity to spend the year in Skopje, Yugoslavia, collected data there on the use of microzonation data in development decisions. Since the devastating earthquake of 1963, Skopje has fully integrated land use-based hazard mitigation strategies into its planning and building process. Skopje's technical experience and approach were examined for applicability to an American setting.

The second phase of the project, now underway, consists of testing the framework in three communities: Bellingham, Washington; Provo, Utah; and Santa Rosa, California. They were chosen because they are all either moderate or high-risk areas; they are medium-sized communities (20,000-100,000 population); and they represent a range of earthquake hazard types (e.g., surface rupture, ground shaking and secondary hazards), information availability, and previous experience in using land use planning tools to reduce earthquake risks.

There will be three products of this project. The primary product will be a handbook that will describe the decisionmaking framework, illustrated by examples from the case studies and other areas. The second will be a technical background report on the theories and assumptions that underlie the study. The third product will be another background report on the use of seismic hazards information in planning in Skopje, Yugoslavia. Because of political and economic differences, it was not considered feasible to use Skopje as a case study in the same sense as American communities; however, Skopje's technical experience with developing and applying microzonation data is certainly relevant.

THE HANDBOOK

The decisionmaking framework has been cast in the form of a handbook that addresses six analytical elements that correspond to those in a normal community planning process: information, planning tools, development

context, implementation feasibility, cost considerations, and effectiveness. The purpose and content of each stage are now briefly described.

The User's Guide

The handbook is prefaced by a User's Guide that describes seven initiatory situations for a decisionmaking effort. For each of seven "starting points," the User's Guide "maps" a different order for proceeding through the analytical stages addressed in the handbook. This flexibility is essential because planning is an iterative process, and different needs often require quite different decisionmaking approaches. For example, one community may know it can implement a special permit process, so its analysis would begin with determining the requirements for implementing that tool. Another community may begin with an assessment of what tools are applicable given existing and available seismic information and then proceed to evaluate implementation feasibility and costs. Figure 1 shows how the User's Guide describes the seven planning situations and the paths through the handbook.

Because the handbook is designed to be entered from any point in the process, each section can stand alone; the information contained within any one does not depend on previous familiarity with the other stages of the process. However, for explanatory purposes here, we will discuss the sections in the order that they are presented in the guide.

Information

This two-part section of the handbook identifies the necessary information for the decisionmaker on physical hazards and risks to the built environment. Three areas are covered. First, the hazards that can result from earthquakes and their implications for community development are identified: surface rupture, ground shaking, liquefaction, landsliding and flooding from tsunamis, seiches, and dam failure. Second, the types of analyses needed to achieve varying degrees of geographic detail--from site-specific to the regional scale--are described. The third area covers the technical expertise required to prepare the information, a range of costs, and basic planning information sources and the range of hazard information that can be derived from their interpretation.

The second part of this section discusses a range of risk assessment techniques that integrate information on the physical hazard with information on the built environment. It describes three types of techniques--risk assessment, microzonation, and land capability analysis--and indicates the expertise needed to develop each. This section informs local officials that they already have some technical information available on their seismic hazard, that information used for other planning purposes is also appropriate to seismic safety, and that certain types of risk analyses and assessments require less information than others, and are therefore potentially less costly and more feasible.

Starting Point	Next Steps				
1. The community has identified one or more planning tools for use in reducing earthquake risks	• Identify information needs for selected tools (Part C--Applicable tools and hazard definition)	• Examine available information and gaps (Part A)	• Assess implementation feasibility (Part D) • Examine physical development context (Part B) • Other considerations (Part E)	• Assess costs (Part F)	• Assess reduced damage potential (Part G)
2. The community wants to use its available information and determine most feasible strategy (or wants to develop optimum strategy)	• Examine available information (Part A) • Examine physical development context (Part B)	• Identify planning tool options (Part C)	• Assess implementation feasibility (Part D) • Other considerations (Part E)	• Assess costs (Part F)	• Assess reduced damage potential (Part G)
3. The community wants a risk reduction strategy that will affect specific target group behaviors (e.g., affect property purchaser's decision)	• Identify planning tool options (Part C--Target groups)	• Identify information needed to put tool in place (Part C) • Examine available information and gaps (Part A)	• Assess implementation feasibility (Part D) • Examine physical development context (Part B) • Other considerations (Part E)	• Assess costs (Part F)	• Assess reduced damage potential (Part G)
4. The community wants to select a strategy that will address a specific development risk	• Identify areas at risk (Part A--Available information on risk assessment) • Examine physical development context (Part B)	• Identify planning tool options (Part C)	• Assess reduced damage potential (Part G)	• Assess implementation feasibility (Part D) • Other considerations (Part E)	• Assess costs (Part F)
5. The community wants to affect the land use development pattern in a specified manner (e.g., direct the location of structures)	• Identify planning tool options (Part C--Application to risk reduction)	• Assess implementation feasibility (Part D) • Identify info needs/gaps (Part A)	• Examine physical development context (Part B) • Other considerations (Part E)	• Assess costs (Part F)	• Assess reduced damage potential (Part G)
6. The community has $\$\underline{x}$ to spend on risk reduction	• Screen costs (Part F)	• Identify areas at risk (Part A) • Examine physical development context (Part B)	• Identify planning tool options (Part C) • Identify information needs and gaps (Part A)	• Assess costs in more detail (Part F) • Assess reduced damage potential (Part G)	• Assess implementation feasibility (Part D) • Other considerations (Part E)
7. The community wants Agency $\underline{y}$ to adopt and apply a set of specified policies/programs	• Identify planning tool options (Part C--Control of implementation)	• Identify information needs and gaps (Part C/A) • Assess implementation feasibility (Part D)	• Examine physical development context (Part B) • Other considerations (Part E)	• Assess costs (Part F)	• Assess reduced damage potential (Part G)

FIGURE 1: USER'S GUIDE TO THE LAND USE PLANNING EARTHQUAKE RISK REDUCTION FRAMEWORK

Planning Tools

Ten planning tools, the means by which a local government institutes a land use risk reduction program, are described, as are ways in which these tools can effect risk reduction, types of data needed to develop and apply the tools, and the procedure for implementation.

The ten land use planning tools are zoning, subdivision ordinance, special use and critical facility permits, sensitive areas ordinance, building code seismic requirements, hazardous building abatement ordinance, lifeline seismic safety requirements, real estate disclosure, tax credit and property acquisition. The applicability of each tool to risk reduction is described in terms of restricting development location, restricting type of use, and setting standards for development, site design and services, different types of construction.

Development Context

The character of local community development can influence the selection of appropriate planning tools for a risk reduction strategy. The intent of this section is to identify environmental factors that are likely to inhibit the implementation of some tools. Considerations planners should make include the portion of the community falling within the hazard area, the amount and type of existing development in the hazard area, the availability of alternative development sites, the community growth rate, and how precisely the hazard area can be defined. For example, building codes are appropriate in a community with few non-conforming existing uses in the hazard area, where the hazard area is moderately to intensively developed where some alternative building sites are available, and where there is only a general definition of hazard area boundaries. However, a planning tool to develop seismically resistant criteria for lifeline location would be most applied in a community with little existing development in the identified hazard area, with alternative development areas available, with a moderate to high growth rate, and with the geographic boundaries of the hazard area well-defined.

Implementation Feasibility

The premise behind the next step is that a determination of implementation likelihood can help structure a strategy that maximizes the fit between the tool and the setting it is applied to (Ref. 5). Implementation feasibility is affected by issues of adoption (what has to be done for a community to officially accept or adopt a strategy); compliance (what affects the willingness of those whose actions are affected--to comply with the strategy in the absence of sanctions and enforcement activity); and enforcement (the activities of governmental entities to secure target group compliance). Measures of implementation feasibility are presented for each of the ten planning tools, including a method for arriving at a summative judgment on the overall feasibility of a particular tool or combination of tools.

Cost Considerations

Measures for assessing the costs of developing an earthquake risk reduction strategy are presented next. For each planning tool, the major quantifiable costs associated with program adoption compliance and enforcement are itemized, and measures are developed for estimating those costs. Also addressed is who bears the cost and when the cost is incurred. A means for making a summary assessment of the program costs is presented. The section also discusses other, non-quantifiable costs that must be involved in the evaluation process.

Effectiveness

To determine the overall impact of a given earthquake risk reduction strategy, information must be assembled on the development context, implementation feasibility, costs, and other community considerations. The handbook postulates that effectiveness can be estimated not as damages averted, but rather as:

Coverage (%) x Maximum Impact (%) x Discount Factor

where coverage is the percentage of the total seismically vulnerable area that would be "covered" by the strategy if it were fully implemented; maximum impact is the maximum reduction in risk exposure assuming full implementation of the planning tool; and where the discount factor reflects how completely and effectively the policy is likely to be implemented, given the expected level of enforcement, sanctions, and incentives. After these variables are operationalized, it will be possible to compare the costs and effectiveness of various risk reduction strategies (e.g., various combinations of hazards information, planning tools and development contexts).

Risk Reduction Strategy

The final section of the handbook brings together the findings of the previous analytical steps. It provides the means to compare qualitatively the attributes of alternative risk reduction strategies so that decisionmakers have a clear sense of the relative appropriateness, cost, feasibility, and effectiveness of one or several earthquake risk reduction strategies.

NEXT STEPS

The results of the testing of the handbook in the three communities will be used to refine the decisionmaking framework. The handbook should assist greatly those communities subject to earthquake hazards that have given little thought to what can be done to reduce their exposure to risk. It represents a first step in providing practical guidance in developing a workable strategy, one that recognizes the physical, political and economic realities in any one community.

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