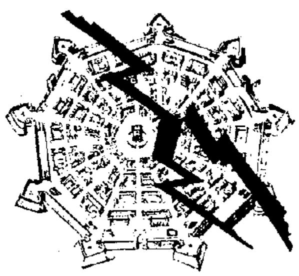

URBAN SCALE VULNERABILITY

Proceedings of the
U.S.-Italy Colloquium on
Urban Design and
Earthquake Hazard Mitigation

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Myer R. Wolfe, Project Director
Susan G. Heikkala, Editor

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Any opinions, findings, conclusions
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Introduction and Summary

The concept of "urban scale vulnerability" calls for the examination of earthquake hazard mitigation from a new perspective. Rather than focussing solely on engineering and building performance, it requires an understanding of the behavior of the entire urban system and the interaction of its various components in response to an earthquake. This then becomes the basis for physical design and public policy interventions in the urban environment to develop more resilient cities and better methods of hazard mitigation. An international colloquium was held in Rome, Italy to define the parameters of this new concept and formulate a research agenda. To set the stage for the presentation of the colloquium findings, it is important to first describe the shortcomings of current approaches to earthquake hazard mitigation and how this provides direction for a holistic approach, as well as to summarize the events leading up to the colloquium, the structure and organization of the meeting, and finally, the themes that served as points of departure for the week's discussion.

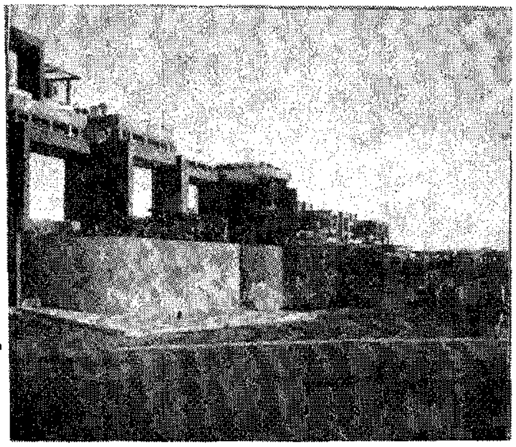
The Problem

Numerous cities and regions around the globe are acknowledged as candidates for devastating earthquake disasters. In choosing to act on this knowledge, threatened areas have generally pursued some combination of the following three approaches: (1) preparation to mitigate the effects of the disaster, (2) preparation to cope with the emergency itself, and (3) advance preparation for reconstruction and recovery. For those jurisdictions that have adopted mitigation measures, the most direct approach to minimizing potential losses has been to increase structural safety by adopting seismic resistant building codes. Currently, building codes represent the great majority of earthquake mitigation techniques in effect.[1] However, the scope of preventation concerns has expanded to consider siting new buildings and critical facilities in fault zones. Now, some states in the U.S., as well as other countries, use land use planning approaches to delineate hazardous areas, and then develop regulations to restrict development or reconstruction within them.[2]

The second type of approach, emergency relief programs, more often than not are developed as special governmental tasks that are concerned with providing immediate relief, medical care, food, and shelter in the event of a disaster. Long range recovery planning is usually initiated at the time of the disaster, not before.[3] But once the earthquake has occurred, the existing governmental bodies are faced with competing demands to restore pre-quake conditions as quickly as possible, yet at the same time avoid reproducing former hazardous conditions or creating new ones. Given the variety of activities and divided responsibilities, coordination is usually lacking. In fact, there is a growing sense that current mitigation strategies treat only symptoms and ignore the roots of a larger problem.

Recent experience with international earthquake disasters yields clues to the gaps in current approaches to mitigation and recovery:

- In Italy's Campania-Basilicata region, rubble-filled, narrow streets blocked escape, rescue and recovery efforts after the November, 1980 quake. Some towns were temporarily isolated by the closure of their sole transportation route. In other villages, structurally sound buildings were toppled by the



Residential quarter in post-earthquake Tuscania

collapse of adjacent, unsound structures.[4]

- In Naples, where 150,000 people were left homeless following the quake, Italians working with the recovery teams observed: "Social unrest among the large number of poor and unemployed persons is rapidly getting out of hand".[5]
- Tuscania, formerly a small agricultural town north of Rome with an historic center dating from Etruscan times, was severely damaged by a quake in 1971. The combination of programs to provide temporary housing in segregated residential enclaves and to accurately restore the historic core has led to changes in the town's rural character. The now "gentrifying" town center is becoming a weekend retreat for wealthy Romans and Florentines, while older residents living in the exclusively residential zones on the outskirts of town claim the diversity and urban vitality that formerly characterized the town has been lost.[6]
- In addition to destroying 53,000 housing units, the 1972 Managua, Nicaragua earthquake destroyed all hospitals and most of the city's retail and office space. Their economy was temporarily crippled.[7]
- In Skopje, Yugoslavia, rapid recovery from the disasterous 1963 quake was aided by the fact that water and utility lines had not been severely damaged.[8]
- In Romania, activity returned to normal relatively quickly following the 1977 earthquake, in part due to the existence of an highly centralized and paternalistic decision-making system that immediately intervened in the recovery process, defined priorities and distributed resources accordingly.[9]

The list could easily go on; however, these illustrations do point out that independent structural modifications or stop-gap relief programs fail to address the panoply of physical, social, political, and economic issues that significantly affect the ability to mitigate or recover from an earthquake disaster. Cities are still vulnerable.

Shortcomings of these past fragmentary approaches to hazard mitigation led to the conclusion that the entire urban system must be examined for a better understanding of the nature of urban vulnerability. This knowledge would then guide the structuring of interventions so that cities can more effectively avoid and/or cope with disasters. It is an issue of problem conceptualization. A more complete assessment of the urban earthquake hazard must address:

(1) The physical vulnerability of regional and urban systems. How does the regional and urban fabric—the interrelationships of buildings, life-line systems, and urban activities—respond to and affect risk?

(2) The social vulnerability of the population and government systems. What are the socio-cultural and political effects of an earthquake and subsequent community recovery efforts?

(3) The economic vulnerability of the urban system. How does an earthquake impact urban and regional economic activities—business, offices, industry—and are there mechanisms to restore them to functioning levels while minimizing undesirable spin-offs?

Pursuing this line of investigation does not discount the need for engineering or other technological advances. On the contrary, it assumes the full integration of technical knowledge and research as a guide to both the formulation of research inquiry and the development of potential physical solutions.

To further explore the concept of urban scale vulnerability, the University of Washington, aided by a grant from the National Science Foundation, and the University of Rome, supported by their counterpart agency CNR (Consiglio Nazionale delle Recherche), organized a cooperative research colloquium in Rome, Italy in October of 1981. Bringing together American and Italian architects, planners, social scientists and earthquake engineers, it initiated the debate on urban scale vulnerability to earthquake hazards, building upon the knowledge of earthquake engineering and expanding its applicability to the environmental design disciplines. As such, the colloquium was not designed as a research project; rather it was to serve as a meeting ground where the identification of research topics of mutual interest and concern would emerge.

BACKGROUND

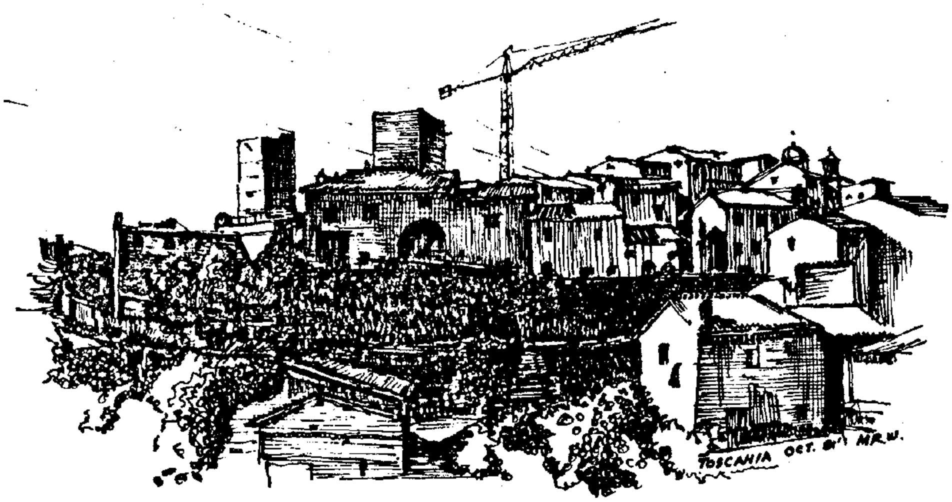
The germ of the idea for the colloquium dates from 1978. At that time, the College of Architecture and Urban Planning of the University of Washington and the Instituto di Architettura e Edilizia Tecnica Urbanistica of the University of Rome had joined forces in a study seminar to examine the comparative issues of preservation and restoration of historic urban centers. There, some discussion focussed on the complications induced by natural disasters, a particularly severe problem in Italy. Given the absence of extensive consideration of urban design in existing hazard mitigation programs and the severity of the risk, several seminar participants committed themselves to pursue some of these problems through another binational seminar. Thus began a year or more of communication between the two countries to secure funding and make arrangements for the conference.

Related meetings provided additional impetus for the Rome event. Also in 1978, the NATO Committee for Challenges to Modern Society (CCMS) Pilot Study on Seismology and Earthquake Loss Reduction commenced, involving faculty at the University of Rome. This strengthened their resolve to continue to work in the area of hazard mitigation.

Furthermore, other design professionals began to probe into the issue of city design and susceptability to earthquake damage. Prior to the Rome colloquium in 1979, a joint U.S.-Japan seminar on urban design and seismic safety was held in Tokyo, Japan. This seminar began with the premise that rapid urbanization generates higher risks of severe earthquake damage in cities, and that in view of the complexities of the urban fabric, technological advances in earthquake engineering were insufficient to cope with the consequences. Thus it attempted to both clarify the parameters of a new research area concerning urban design and seismic safety and identify joint research topics.

Finally, a sister conference on the "Social and Economic Aspects of Earthquakes and Planning to Mitigate Their Impacts" held at Lake Bled, Yugoslavia in July 1981, addressed additional planning implications of hazard mitigation. Several members of both the American and Italian teams participated in Yugoslavia.

The Rome colloquium can be seen as a logical extension of these past efforts: first, it extends the geographic scope to include other hazardous regions of the world, and second, it expands the substantive scope to consider urban design in relation to other disciplines—engineering, sociology, planning, and design—for a better understanding of the nature of urban scale vulnerability. An implicit assumption was the importance of integrating planning and/or programming for reduced hazard vulner-



Tuscania *Sketch by Myer R. Wolfe*

ability within the overall community planning and development process. Without explicitly and continually balancing risk reduction against other community objectives, it is probable that the strategy to cope with disasters would continue to be developed in isolation, implemented in only a piecemeal fashion and thus affect only discrete portions of a community, failing ultimately to reduce urban vulnerability.

THE STRUCTURE

Participation. The colloquium convened in Rome from October 12 to October 16, 1981. The participants, selected because of their expertise in seismic problems and/or the areas of engineering, social science, or design, represented a true interdisciplinary panel. The American group contained urban designers, architects, planners, planner/geologists, a social scientist, a lawyer, and engineers. The Italian team was similarly diverse, consisting of architect/designers, an economist, a statistician, a lawyer, a local official, planners, structural engineers, and a civil engineer. The group size was kept small to maintain an informal atmosphere since the meeting was conceived more as a binational brainstorming session rather than a conference.

Program. The program was structured in three parts, as illustrated in Figure 1. The first phase, a preparatory stage, was handled separately in the United States and Italy. During this time three theme papers, designed to provide the basis for discussion, were written and distributed. One American and one Italian paper were prepared on each topic, covering the essential aspects of the emerging concept of urban scale vulnerability.

The second phase was the "in situ" seminar, designed to create a climate conducive to structured exchange and discussion. Three sessions during the week consisted of a synopsis and expansion of the individual papers, followed by open discussion identifying areas of comparison and researchable issues. The final day was reserved for a full day of discussion, synthesizing the work of the previous three days and developing the research agenda. One other day during the week was set aside for a field trip to Tuscania—a small town heavily damaged by an earthquake in 1971 and still in the process of rebuilding. The break from long meetings provided an invaluable opportunity to see first-hand some of the actual dimensions of urban scale vulnerability in Italy. Observation and discussions with local officials and residents strengthened the conclusions emerging from the meetings in Rome.

The Colloquium proceeded more or less according to schedule, with the addition of several informal presentations of work related to assesing structural damage and recovery from the Campania-Basilicata region and microzonation efforts in both Sant' Angelo dei Lombardi

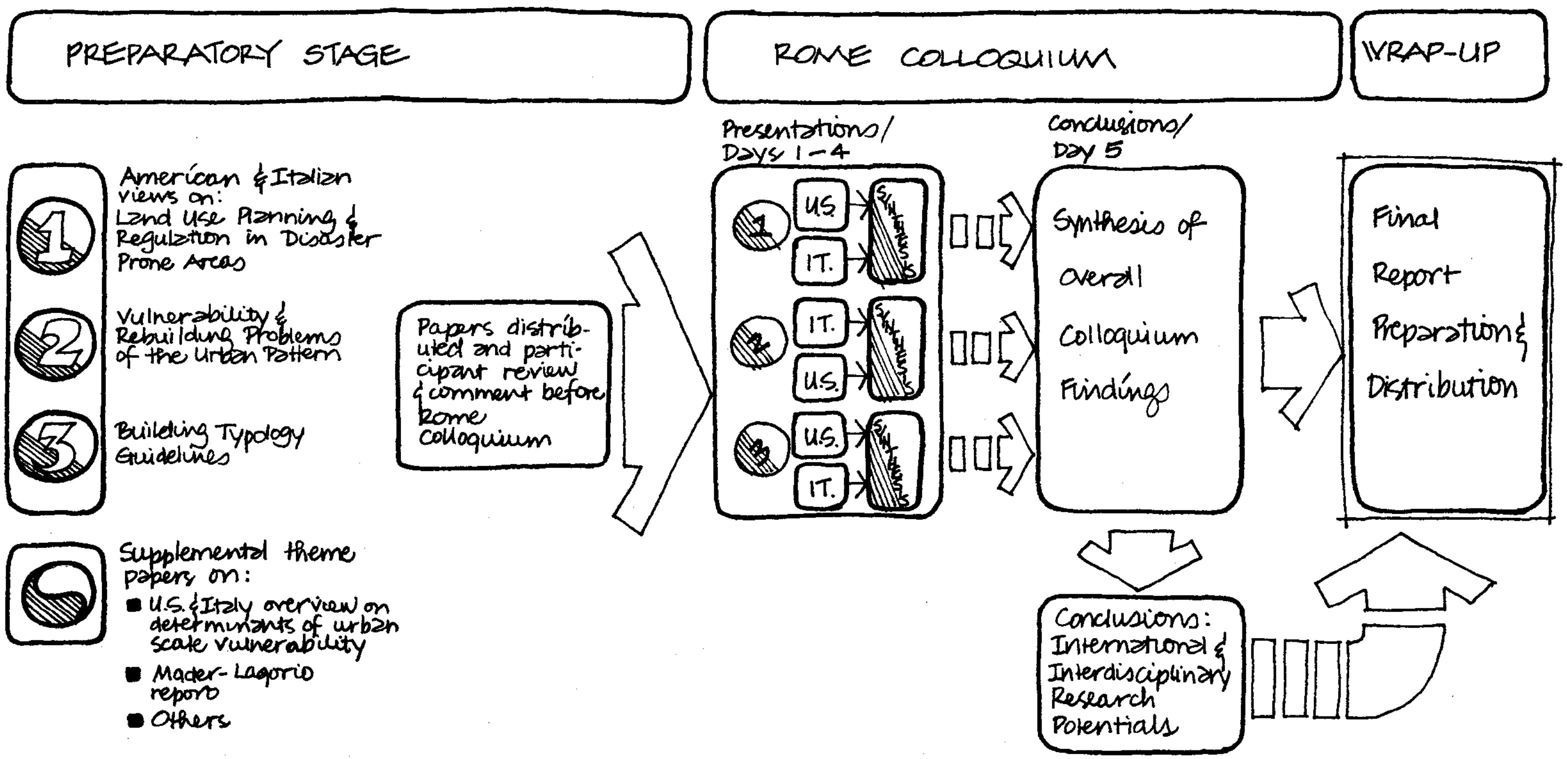


Figure 1. U.S./Italy Urban Scale Vulnerability Colloquium. Procedural Flow.

(Italy) and California.

The third stage consists of the follow-up preparation of the proceedings, consolidating the papers, discussion summaries, and research recommendations in a monograph form, and is the purpose of this document.

Some Initial Premises. For its primary emphasis, the colloquium was to examine and refine the concept of urban scale vulnerability, expanding it to encompass not just structural safety or life-line concerns, but also the broader urban context. A subsequent step was to identify urban scale hazards which could then be the subject of physical development or policy actions aimed at minimizing exposure to risk or better equipping a community to handle reconstruction. Beyond safety, cost or feasibility issues there would be an attempt to recognize and analyze the relationship of public policy actions and private development decisions in the three dimensional environment to achieving the goal of earthquake risk reduction. The physical outcomes of public and private policy decisions were to be examined in this interrelated context.

Interdisciplinary collaboration and cross-cultural exchange were felt to be two essential ingredients for the full exploration of urban scale vulnerability and to achieve the stated goods. Thus, a triumvirate group of engineers, social scientists and planner/designers who are generally insulated from one another, was assembled to help bridge a common communication gap and to identify areas of additional information needs and exchange.

The binational perspective was also deemed important. Both the U.S. and Italy (and other neighboring European countries) contain highly active seismic regions as well as urban or historic town centers potentially exposed to severe risk. However, experience in preparing for and recovering from earthquakes is not equally distributed. For example, by American standards, the State of California is advanced in developing planning approaches to hazard mitigation, while parts of Italy and Yugoslavia have had more recent experience in recovering from devastating earthquakes. Each stands to gain from the other's experience.

But the fact that earthquakes are common to both countries is just a prerequisite. It would then be possible to create an abstract model, or prototype, of the general scene or designated study regions so that the relevant similarities and differences between the respective cases can be isolated and meaningful comparisons or lessons can be drawn. Economic, political and cultural factors and town age and morphology may all have a bearing on urban scale vulnerability and thus would be variables examined through a model.

Within this framework, the goals of the colloquium were threefold:

(1) Define the area of urban scale vulnerability and the role of environmental design disciplines in reducing earthquake risks.

(2) Generate research ideas to advance the understanding of the field and promote effective hazard mitigation.

(3) Identify areas for future cross-cultural research and exchange.

THREE THEMES

As a means of more systematically exploring the nature of urban scale vulnerability, three themes were selected to be the topics of American and Italian papers and the discussion sessions in Rome: (1) the relationship of land use planning and regulation to hazard mitigation, (2) the definition of physical vulnerability of the urban pattern at both regional and community scales, (3) the identification of building typology guidelines. Each is described more fully below:

(1) The examination of land use planning and regulation in disaster prone urban areas was to focus on formal and informal political decisionmaking systems and how they do or do not integrate considerations of urban morphology and vulnerability to disasters. Questions asked included how does the historical and present form of government impact policies, regulations, and appropriations for hazard mitigation? Beyond written policies, how does the political system actually respond to the issue of hazard mitigation in the face of competing political and economic priorities? How does the institutional response vary with respect to the magnitude and/or scale of the disaster?

(2) Defining the vulnerability of the urban pattern was to be a principal task of the colloquium, considering "urban scale" in both macro and micro terms. This called for an examination of context; or where, when, and how the disaster takes place given the constraints, possibilities and probabilities of the preventative or re-

medial actions that may be marshalled to cope with it. Comparative discussions were to cover: (1) land use density and intensity patterns, (2) nodes and focal points of urban activities, and (3) the lines of transportation and communication accessibility. In addition, systems of interaction, points of clustering and focussing, and fields of "traffic" generation were to be considered. The dynamics of development and/or redevelopment as they are shaped by economic interventions and socio/political factors were to be investigated at both the macro and micro levels.

(3) In addition to investigating the vulnerability of the overall urban pattern, there must continue to be an examination of the vulnerability of building types. An inventory of the urban fabric, an assessment of volumetric aspects of the extent and character of building groups, the classification and evaluation of existing buildings, and the development of methods for documentation and assessment should lead to the creation of building typology guidelines to be applied to renovation, reconstruction and new development. Within the framework of macro analyses of an urban area, micro assessments could follow. Here, ideas of adaptive use, emphasizing the cultural differences inherent in past building practices while incorporating new design determinants generated by changing community development trends (due to energy conservation, historic preservation, etc.) could be considered.

Format of the Report

The remainder of this report documents the colloquium findings, including the research agenda. Papers presented at the colloquium, the list of participants and other related material are all contained in the Appendices.

NOTES

[1]See the paper by Tridib Banerjee, "Earthquakes, Urban Scale Vulnerability and City Design: Some Observations" in Appendix C.

[2]See the articles by Christopher Arnold and Marcy Li Wang, cited in Appendix F.

[3]See "The Proceedings of the Workshop on the Effect of Building Codes on the Rehabilitation of Older Buildings. July 13-15, 1982. Pike Place Market, Seattle." Edited by Padraic Burke, cited in Appendix F.

[4]The idea for "floating zones" is now being developed by David Brower for application in areas with high hurricane risks.

Issues of Urban Scale Vulnerability

In the exploration of earthquake hazard mitigation from an environmental design perspective, leading academicians in the fields of seismic engineering, architecture, planning and the social sciences verified the colloquium's original premise: city design can significantly influence community resilience to earthquakes. Indeed, it is possible to explicitly design cities to minimize seismic risk, provided that knowledge of seismic engineering is supplemented by knowledge of how buildings, groupings of buildings, and life-line systems behave when subject to seismic stress. This knowledge must then be applied in the development and use of appropriate planning and design standards.

The colloquium not only demonstrated that urban scale vulnerability is a physical or environmental design issue, but it also showed that social and economic concerns are additional aspects encompassed by the concept of vulnerability. These, too, should be addressed in the development of hazard mitigation and reconstruction programs. The similarities and differences between Italian and American communities affect the re-establishment of economic productivity and social networks following an earthquake. In fact, engineers participating in Rome stressed that planners and designers must augment engineers' understanding of structural performance by defining human behavioral parameters relevant to the functioning of urban systems and networks. Thus the problems surrounding earthquake safety, which have previously been viewed as issues of structural safety or emergency relief, were acknowledged to be part of a broader issue of urban scale vulnerability.

For empirical evidence of urban vulnerability, George Mader cited three recent catastrophic earthquakes — Campania/Basilicata, Anchorage and Tangshan. By extracting environmental design and planning problems caused by the earthquakes in these instances, both the breadth of the problem of urban vulnerability and the international commonalities were apparent. (See Figure 2.) What remains is the development of a more precise definition of the concept and techniques to be used in city planning and engineering practice.

By the end of the week, the group concluded there are eight key aspects of urban scale vulnerability:

1. Regional Vulnerability
2. Urban Vulnerability
3. Building Vulnerability
4. Historic District Vulnerability and Reconstruction
5. Vulnerability Reduction
6. Post-Disaster Response and Recovery
7. Scientific Information Flow
8. Planning and Implementation Techniques

Several of these are definitional in nature, hence one of the main conclusions of the colloquium was that the concept is clear, but an operational definition is needed. Some of the other aspects address questions of vulnerability not covered by traditional hazard mitigation programs, such as information transfer or the incorporation of hazard concerns in the political process. In the opinion of colloquium participants, these are the questions which should guide initial research in the area of urban scale vulnerability. The following paragraphs describe the scope of each of the themes. The last chapter then lists the specific research questions related to them.

Figure 2. Urban Scale Problems of Three Selected Earthquakes

	Campania/ Basilicata Italy (1980)	Anchorage Alaska (1964)	Tangshan, China (1976)
1. Unstable ground	✓	✓	✓
2. Damage to historic districts or structures	✓		✓
3. Damage caused by the interaction of structures	✓		
4. Damage to critical facilities	✓	✓	
5. Disruption or blockage of access routes or life-line systems	✓	✓	✓
6. Critical need for temporary housing	✓		✓
7. Short and long term social and economic dislocation	✓	✓	✓
8. Requirements for new housing	✓	✓	✓
9. Need for relocation of cities or city sectors	✓	✓	✓
10. Government involvement in reconstruction	✓	✓	✓

1. Regional Vulnerability. The concept of urban scale vulnerability requires that the city be viewed as an integrated system, where changes or damages to one part have ramifications for the operations of the whole. Following the same logic, the urban structure should first be analyzed as one component of the surrounding region because the region conditions both the urban economy and political structure, and it also influences city form.

An earthquake causes a crisis in the regional order that has, in the past, been studied primarily by seismologists and other scientists who have confined their examination to intrinsic characteristics of the phenomena: the physical environment and mechanisms of geologic change; a description of the frequency, duration, and intensity of the shock/s; and the extent and severity of damage. But an earthquake can have far-reaching effects on the regional system, and thus it is necessary to expand the analysis to cover other interrelated aspects of seismic disaster and recovery, such as:

- regional ecology
- physical distribution and configuration of settlements — their populations and their characteristics of size, history, development density, scale, morphology, and resiliency and rate of change
- regional life-line systems
- regional economic activities and local specializations
- social or cultural group characteristics
- societal norms and values
- governing or regulatory organizations and institutions that are responsible for managing growth, the economy and/or various service systems

On the one hand, physical variables will influence the extent and type of damage and community disruption in the event of an earthquake, and therefore, the type of programs and length of time required for recovery. On the other hand, economic, political and social variables will have an important bearing upon the type and extent of economic or social dislocation, the appropriate organization to effectively cope with the impacts of such a disaster, the relative weight to accord recovery priorities throughout the region, and the design and content of the recovery programs themselves.

Previously, the methods and models used by earthquake specialists have not acknowledged these interdependencies, resulting in little communication between the different disciplines. New avenues of research should aim to verify the possibilities of integrating these variables in technical approaches and models as well as the planning process.

Political considerations are equally important because the regional scale is the level where political units should first be organized to undertake and implement earthquake hazard mitigation actions. An understanding of regional hazards or vulnerability should influence the political decisionmaking apparatus to allocate resources for structuring appropriate interventions in the built environment. However, two countervailing problems must be addressed by those concerned with earthquake mitigation:

(a) the tendency for governments to focus almost exclusively on immediate regional administration and/or management problems, and

(b) the limited amount of financial resources potentially available for earthquake hazard mitigation programs.

2. Urban Vulnerability. The term "vulnerability" as currently applied to urban earthquake hazards is inadequate for planning purposes because it lacks an operational definition useful for planners and decisionmakers working in an urban milieu. The attention given to the sensationalistic earthquake event and the immediate aftermath overlooks the critical secondary effects on the community and its residents and the ability to resume or restore "normal" community functioning. Perhaps even more importantly, it overlooks the interactions of natural physical phenomena; urban form elements; and social, political, and economic systems. Thus, in terms of substantive content, urban vulnerability is parallel to the regional scale, but the scope and level of detail will be much more refined and narrowly focused.

The primary task is to develop a more precise definition of urban scale vulnerability, one which identifies reliable and replicable measures that can be used in classifying and ranking aspects of community vulnerability. As already stated, both physical and functional attributes must be included. A set of physical measures should address the hazards associated with the established range of building configurations, spaces, and life-lines and associated human activities. Functional measures should address the operating characteristics of the entire urban system—its economic base, political structure and processes, and social characteristics—and its ability to absorb and/or recover from a natural disaster. What are the effects of varying disaster intensities on the "recoverability" of the local economic base? How can the existing social organization guide reconstruction activities so that they are successful in restoring community social stability?

Then, interactions between elements must be examined. For example, how does the response of different prototypical urban forms vary when located in areas characterized by differing geologic conditions? Or, how are specific economic activities affected by failures of life-line systems? How does the organization of the political system affect mitigation and recovery programs? With answers to questions such as these, it should be possible to construct an interactive model of a functioning urban system which can be used to determine with some accuracy how systems will respond in crisis and thereby guide community decision-making.

Falling short of modelling the entire urban system, developing and applying vulnerability indicators may be a realistic alternative planning approach for cities with limited data bases, planning skills, or financial resources.[1] A preliminary list of indicators of place vulnerability might include those related to the physical environment—system redundancy, restorability, serviceability, evacuation potential, hazard potential—and those related to the human and social environment—trauma potential, occupancy, coping potential, and critical resident populations. A third category of indicators could be added concerning the functional environment, or the community's ability to restore normal economic and political operations.

In addition to defining urban vulnerability, there is also a need for a more precise definition of "acceptable risk", a discussion which should proceed simultaneously with development of the vulnerability concept. Finally, there is the issue of equity, or who bears the responsibility for vulnerability and loss, and who benefits—the public that is affected or the public-at-large?

3. Building Vulnerability. The emerging concept of urban scale vulnerability requires that cities be evaluated as an entire system at risk; similarly, the subject of building vulnerability requires that examination go beyond the structural safety or soundness of individual buildings. Pursuing this line of thinking, some researchers are investigating the hazards char-

Photo by George Mader

Old hill towns constructed primarily of unreinforced rock, rubble and mixed masonry - like Laviano - were almost completely destroyed by seismic shaking in the 1980 Campania-Basilicata earthquake

Photo by George Mader

The collapse of older, unreinforced masonry structures often brought down neighboring attached buildings in a characteristic domino effect

acteristic of specific building forms and alignments, including those that are popularized during the ascendence of various architecture styles.[2] They examine construction materials, decorative detailing, and the articulation of spaces and built volumes to determine the effects on building safety.

From the standpoint of urban scale vulnerability, this work can be expanded to look at how building groupings react under seismic stress, considering variables such as site specific geologic conditions; building age, construction methods, and materials; topography; and the relationship of a building to adjacent buildings, open spaces, and road systems. Research in this area should examine both the hazards associated with the existing building stock as well as develop requirements dealing with new construction.

4. Historic District Vulnerability and Reconstruction. As a common policy goal for communities in both the U.S. and Italy, historic preservation presents special problems for earthquake hazard mitigation. Seattle's Pioneer Square district or the Italian hilltowns were all constructed prior to the advent of seismic resistant building codes and today these buildings pose severe risks to human life and property. The 1980 Campania-Basilicata earthquake demolished many old hilltowns in Italy, destroying an irreplacable architectural/planning heritage and causing the loss of many lives as well. Numerous problems confront hazard reduction in these areas. One remedial and mitigation approach is seismic retrofitting of older buildings, which is currently the subject of another NSF-funded project at the University of Washington.[3] Despite the benefits of risk reduction, development costs are high and often prohibitive. In some economically marginal districts, these programs can speed up the process of "gentrification", driving out low-income tenants or small businesses. In other cases, retrofitting can destroy the historic character the program is trying to preserve. The parapets on the nineteenth century Victorian buildings in San Francisco were targeted for removal by an ordinance to increase seismic safety, but the ordinance has not been enforced because it would alter an essential aspect of the city's physical character and was not politically acceptable. Instead, it was preferable to retain the risk.

Reconstruction in earthquake damaged historic centers faces similar dilemmas: how can safety be enhanced while preserving a town's character? This problem is more difficult when the town form itself—with narrow, convoluted street networks, numerous unreinforced buildings, limited accessibility, a mix of old and new construction—is counter to the emerging tenets of seismic resistant design.

5. Vulnerability Reduction. Hazard mitigation programs regulate new development in risk-prone areas and reconstruction in those areas struck by disaster in order to avoid creating or exacerbating hazardous conditions. Mitigation programs may also attempt to reduce existing vulnerability. For existing buildings, this can be accomplished through programs of seismic retrofitting (including structurally reinforcing or strengthening the building; removing decorative, but dangerous, elements such as parapets or cornices) or modifying structural use. In addition, vulnerability reduction programs could be applied to lifeline systems through the selective reinforcement or modification of roads; communication systems; or sewer, water, or power lines. It may also entail "planned redundancy" for critical segments of the infrastructure system, such as designing alternative routes to the community hospital.

Often the urban areas with the highest risks also contain the most socially and economically vulnerable residents and businesses; consequently, the costs of vulnerability reduction programs are likely to be significant, and their distribution must be an issue of public concern.

6. Post-Disaster Response and Recovery. Community upheaval, changes in social patterns, economic disruption, and redevelopment using unfamiliar urban forms are among those earthquake impacts making post-disaster reconstruction a major concern. The negative impacts of a catastrophe can be compounded by actions taken in the short term. In some instances, temporary housing consisting of prefabricated units set in an austere, camp-like setting has become the permanent solution when political or funding bottlenecks blocked implementation of long range reconstruction plans. Although they fulfill critical housing needs immediately after the disaster, the siting of some of these compounds in prime redevelopment areas has at times frustrated reconstruction design options.

Problems such as these demand more well conceived temporary relocation schemes; but on the other hand, better short-term relief programs may only increase the chances that permanent programs are put off altogether. Difficulties such as these require that post-


Photo by George Mader

Temporary housing in one of the towns damaged in the 1980 Campania-Basilicata earthquake disaster reconstruction become a pre-earthquake concern. What is needed for a city to respond quickly and effectively? Should the local government be primed to handle the event with a pre-programmed response plan? Or, given knowledge of existing hazards, and vulnerabilities, can some reconstruction needs be accommodated by the preparation of an advance reconstruction plan?

In addition, the more intangible attributes of a community—the way people live and use the community and the changes induced by an earthquake—are crucial considerations. Longitudinal and comparative case studies of past reconstruction efforts would provide valuable insights on changes needed in the reconstruction process.

7. Scientific Information Flow. Contributing to the lack of a clear definition of vulnerability is the lack of interdisciplinary communication and research. Planners and designers require access to a scientific information base translated into an applied form, first as a means of understanding the nature of local seismic risk and second, to incorporate this knowledge in the policies, decisions and actions affecting the built environment.

One reason that hazards have not received extensive planning attention is that practitioners lack adequate information on the nature of the risks within their jurisdictions. Most cities and regions in the U.S., Italy, and elsewhere do not have sufficiently detailed geologic data sources upon which to base extensive intervention in the development process. However, detailed geologic data may be beyond the reach of local resources. In this case, planners require techniques or other approaches for developing reasonably reliable hazard indicators related to surface faulting, ground shaking, ground failure, tectonic deformation and tsunamis and seiches that can be used in the development of land use and hazard mitigation programs. The United States Geological Survey (U.S.G.S.) currently devotes some effort to developing and disseminating this kind of information, but more work is needed.

Scientists and engineers require the articulation of the social and physical factors that have implications for structural or life-line engineering solutions to risk situations. At the present time, planners and engineers use different data bases which are not developed to the same level of sophistication. The result is, today, "hard" engineering solutions tend to "drive" policy actions. Interdisciplinary exchange is necessary to identify methods to refine current decisionmaking processes.

8. Planning and Implementation Techniques. Understanding the nature of local risks is only the first step. It must then be followed by incorporation of the data into the planning process. Numerous resource evaluation techniques already exist, but methods are required to assist in integrating and weighing this information with other planning considerations. Using resource assessment overlays to identify environmentally sensitive areas is one technique that is now employed in the U.S. which has included the evaluation of geologic hazards in some local applications. The use of geo-based computer information systems would permit more sophisticated resource evaluation because the computer has the flexibility to systematically test numerous scenarios varying the severity of the event and the affected urban systems.

Besides resource evaluation, hazards considerations must also become a part of the other phases of the planning process. In particular, planners need a compendium of ideas for plan alternatives that meet earthquake mitigation objectives at the same time that they fulfill other community goals.

Once the plan is complete, two problems confront planners who desire to incorporate hazard information in the planning decisionmaking process. First, beyond building codes and overlay zoning, few implementation tools have been tested or applied. Other approaches are needed which can address all aspects of urban scale vulnerability. For example, a "floating zone" is one option a community might consider. The "floating zone" would only be applied to an area after an earthquake struck. The boundaries would be drawn around the damaged area and within the zone, the regulations would guide allowable temporary and permanent reconstruction and would remain in effect until comprehensive reconstruction plans had been completed. The regulations could be pre-tailored to different segments of the city that are characterized by similar hazards or rebuilding problems.[4]

The second implementation problem is the lack of political "will" to make hazard reduction a community priority and thereby allocate funds and effort to develop mitigation programs or incorporate hazard considerations in ongoing programs. Methods are needed to assess and weigh the costs and benefits of achieving various levels of hazard mitigation and to array these against similar assessments of all other community goals and programs. Methods and strategies are also needed to enhance public awareness as well as to determine how to influence "City Hall".

Research Agenda

Formulating a range of questions suitable for interdisciplinary and/or comparative research was the goal targeted for the Rome Colloquium. During the course of the week's presentations and ensuring discussions, numerous ideas emerged which then crystallized in the large and small group synoptic work sessions on the final day. A catalog of these topics is presented here both as a means of recording gaps in the current understanding of urban scale vulnerability and also as a menu of topics for those interested in understanding research projects in the area of urban vulnerability and earthquake hazard mitigation.

The list presented here is by no means exhaustive; and it should not be viewed as placing any limits on the direction of research. In fact, the research environment can be depicted as a virtually empty cube, as shown in Figure 3. Given the interdisciplinary and holistic nature of urban scale vulnerability, each research question can be positioned at a point or points within the U.S.V. cube, depending upon the specific interrelationship/s between scale, time, and information that is or are being examined. As our knowledge of earthquakes and mitigation strategies grows, the U.S.V. cube will begin to fill in. Indeed, the ultimate test of the colloquium's value rests on the research that builds on the somewhat general and preliminary ideas that are presented here and begins to increase our ability to design safer cities.

REGIONAL VULNERABILITY

1. Develop interdisciplinary comparative case studies between Italy and the U.S. that examine vulnerability at two scales: (1) the city within the territorial context, or regional vulnerability, and (2) the city and its various parts, or urban vulnerability. Differences in respective seismic risk conditions and socioeconomic and settlement characteristics should be assessed during the investigations. The studies might proceed as follows:

   a. Articulate the nodes and paths that define the regional and urban structures in the selected case studies and classify them hierarchically by their physical function.

   b. Relate these elements to their economic and social functions.

   c. Compare the conditions of physical and socioeconomic vulnerability.

   d. Construct composite vulnerability maps and compare these with seismic vulnerability assessments based solely on geology. From this, draw normative inferences regarding regional vulnerability.

   e. Bring together the assessment of regional vulnerability with related analyses of building standards in order to define needed additional standards or regulations.

   (Discussion, Day 5)

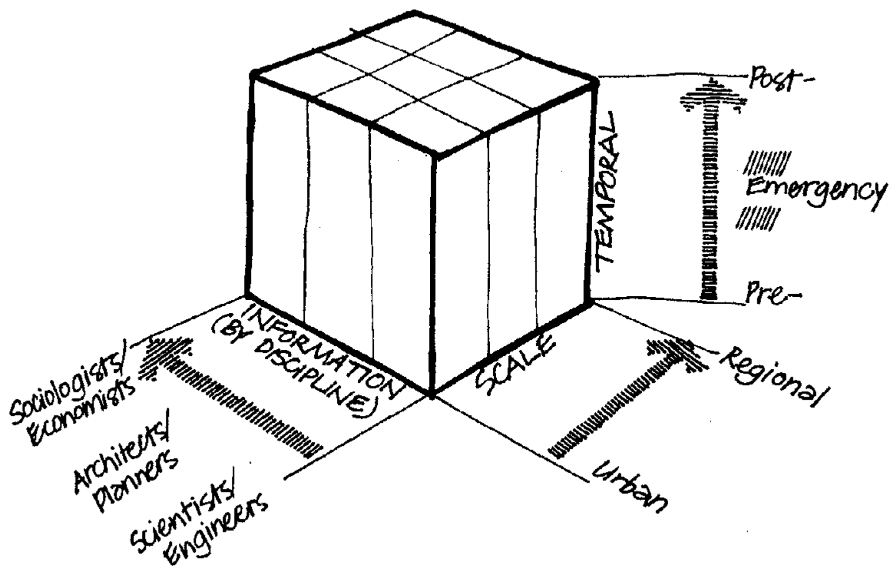


Figure 3. "Urban Scale Vulnerability Cube"
(Contributed by Fred Krimgold)

2. Determine the earthquake resistance or resilience of prototypical regional and urban development patterns comparing, for example, a dense urban center linked to several subcenters; low-density sprawling cities; multiple, clustered centers; and regional centers with radial open space corridors. Next, what is the feasibility and cost-effectiveness of applying form determining policies to regional and urban development? (Wolfe, page 5)

3. Identify regional lifeline systems and/or facilities such as bridges, pipelines, transportation networks, and communications systems that can be located, designed and constructed to resist earthquake damage. Research is needed to develop both criteria for siting new facilities and methods to upgrade, supplement, or otherwise reduce the vulnerability of existing systems. (Brower, page 5)

URBAN VULNERABILITY

1. Review the way the term "vulnerability" is used in various disciplines—geology, seismology, seismic engineering, earthquake engineering and the social sciences—to expand, synthesize, and refine a new definition which reflects an integrated view of vulnerability and would be a concept appropriate for use by the planner at the urban scale. First, an interdisciplinary team must consider the urban system in its totality, including the physical, social, economic and political components. Second, the variations in system vulnerability between different regional and development contexts should be evaluated, considering such variables as age, size, demographic structure, function, level of development, degree of dispersion, and morphology as well as geological conditions. The concepts of resiliency and recoverability should be incorporated. (Discussion, Day 5)

2. Develop a model of a functioning urban system and indices or other measures of vulnerability and resiliency which will facilitate comparisons of systems within or between countries. Distinctions between physical and socioeconomic vulnerability should be articulated and maintained. (The physical urban structure encompasses public facilities, infrastructure, level of public service, scale, etc. while the socioeconomic system includes the cultural context, types of economic activities, temporal patterns, activity patterns, and the political-decisionmaking context.) Investigations of previous earthquakes may be helpful developing the vulnerability indices. (Discussion, Day 5)

3. Identify and develop methods to measure the vulnerability of physical elements of the urban form—building groups, nodes, linkages, etc.—to earthquake damage and/or disruption. Are certain urban forms or patterns more resilient than others? Are there significant international variations? Can mathematical or computer models assist in predicting the response of an urban system to a particular seismic event? (Clementi, page 7, and Banerjee, page 8)

4. Develop, test and evaluate an urban vulnerability index for use by decisionmakers and planners which would relate geologically based seismic zones with vulnerable aspects of the urban form—land use patterns, lifeline systems, density, building materials, construction techniques, age, form—as well as human activity patterns, time of day, and season of the year. (Wolfe/Heikkala, page 22)

5. Given their distinctly different development patterns, morphologies, scales and socioeconomic and cultural contexts, determine if separate vulnerability indices are appropriate for rural and urban areas. If developed, these indices could be applied and tested in case study evaluations. For example, useful comparisons might be constructed between small agricultural communities in the Friuli or Basilicata-Campania regions of Italy and the less urbanized areas of the Puget Sound region or the San Francisco Bay area in the United States. Potential case study comparisons at the urban scale include the cities of Anchorage, Los Angeles, Naples, Skopje, Tangshan, Tokyo, and Managua. (Discussion, Day 5)

6. Compare the costs of increasing the safety of individual structures with the cost of strengthening the urban infrastructure in order to determine the effectiveness of the approaches—either separately or in combination—in reducing seismic damages and recovering from a disasterous earthquake. (Gallocurcio, Day 2)

7. Determine how people from different cultures, social classes, age and education levels, or with other demographic differences such as occupation or income, respond to and recover from an earthquake. Do significant differ-

ences exist that should be addressed through changes in the planning process? (Banerjee, page 16)

8. Examine the urban economic system and determine its vulnerability to seismic disasters. Can indicators or other measures of vulnerability be developed that would be useful in developing mitigation or recovery programs? (Selkregg, Day 1)

BUILDING VULNERABILITY

1. Prepare planning strategies for upgrading existing buildings. This will require resolution of some of the following questions:

   a. What is an operational definition of "building vulnerability"?

   b. How can the vulnerability of existing buildings be quickly and economically evaluated?

   c. Are the criteria and questions on housing quality now being incorporated in Italy's census data useful for assessing building vulnerability? Could similar criteria be included in the U.S. census?

   d. What is the relation of criteria, policy and success measures in risk reduction? What are the relevant aspects of policy and strategy that will affect risk reductions? How can risk reduction be measured?

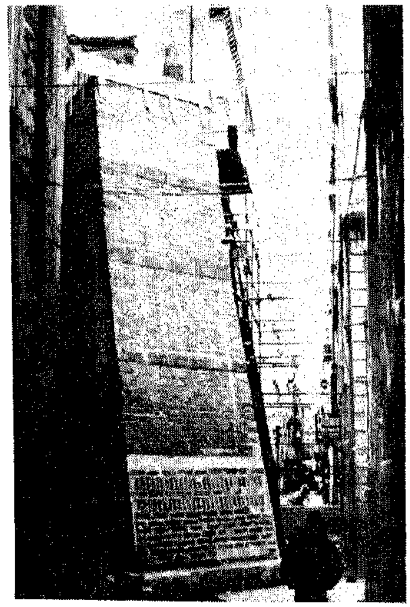
   e. What are the social and economic consequences of various building repair, strengthening and demolition programs?

   f. Can seismic considerations be integrated in modelling the decision process for investment in rehabilitation?

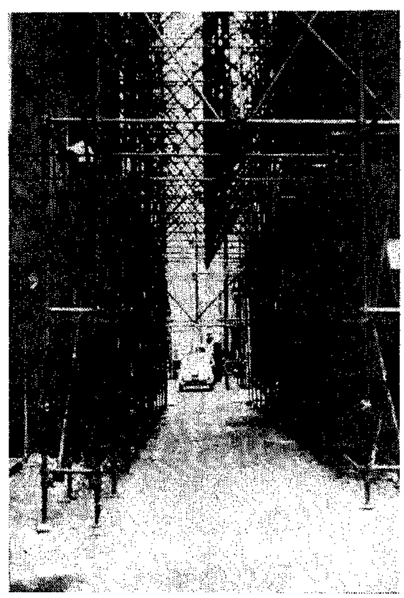
   g. What are the possibilities of only partially strengthening buildings?

   (Discussion, Day 5)

2. Identify building types, configurations, style and/or design, materials, and construction practices that have, over time consistently exhibited resistance to seismic-related damage and those that have failed. Are there comparative international implications? (Arnold, 1981, page 41)



In Naple's Spanish Quarter, buildings were buttressed to protect against failure after the 1980 earthquake



Photos by George Mader

Other buildings in the same quarter were braced, one aginst another, to provide support

3. Determine cost differentials in designing buildings to meet a predetermined range of structural standards. At one end of the spectrum, the standards might allow building failure which entails loss of human lives, while the more stringent set of design requirements would accept some structural damage but no injury to occupants. Excluding the value of human lives, the evaluation would compare the cost of demolition, clearance and reconstruction after collapse with the cost of seismic zoning, special building design and construction, maintenance and repair. (Braga and Calzona, page 2)

4. Assess how non-structural building elements contribute to building vulnerability in terms of function and economics by examining:

   a. The consequences of failure of non-structural systems, and

   b. The functional consequences of non-structural failure in critical facilities.

   (Discussion, Day 5)

5. Develop a model building code which defines appropriate levels of seismic reistance for types and configurations of structures and infrastructure systems and also provides a rational relationship between each incremental increase in design requirements with the expected earthquake damage reduction. (Zsutty and Shah, 1981, page 514)

6. Examine loss estimation techniques for large building stocks. (Discussion, Day 5)

7. Examine the correspondence of physical and functional structural performance. (Discussion, Day 5)

HISTORIC DISTRICT VULNERABILITY AND RECONSTRUCTION

1. Identify structural vulnerabilities as well as other unique urban scale concerns for historic buildings and districts. Are these specific to each area or country, or can cross-cultural similarities be found? (Discussion, Day 5)

2. Determine the cost-effectiveness of retrofitting programs for historic structures? (Discussion, Day 5)

3. Identify any special considerations for recovery and reconstruction programs in historic centers. What are the implications of restoring a city exactly as it was before the the quake, like the Italian town of Tuscania, versus allowing those alterations in the urban form that are consistent with the historic character? (Discussion, Day 5)

4. Determine who pays for historic retrofitting or reconstruction and how these programs are to be administered? (Discussion, Day 5)

VULNERABILITY REDUCTION

1. Investigate the range of options available for reducing structural and lifeline vulnerability where the costs of improvements are arrayed against the expected reduction of losses. (Discussion, Day 4)

2. Establish an ongoing international program of earthquake damage evaluation and mapping that addresses pre-existing uses, structural types and conditions, earthquake damage, and subsequent reconstruction. Such a program would contribute to the understanding of the nature of urban scale vulnerability and be useful for making more reliable predictions of urban structure and system response when subject to earthquake stress. It would also serve as necessary base information for the development of physical vulnerability mitigation or reduction programs and comparative analyses of vulnerability and/or damage patterns. (Mader, Day 5)

POST DISASTER RESPONSE AND RECOVERY

1. Develop comparative studies of recovery efforts examining how to intervene in the pre-earthquake scene to increase the resiliency of the system and also how to create stability and continuity between the pre- and post-earthquake event. Examine histories of public and private decisionmaking responses regarding reconstruction. (Minerbi, Day 2)

2. Disruption of functioning urban economic systems is one side of urban scale vulnerability; therefore, determine how cities can approach pre-quake preparation or planning for maintaining and/or restoring critical business, industrial and other economic activities. (Selkregg, Day 2)

3. Determine how different social and cultural

systems respond to earthquake disasters and how the recovery process affects this. What emergency and rebuilding programs contribute to the effective reestablishment of pre-quake activities? Do some temporary reconstruction efforts, such as providing barracks-like housing, become permanent fixtures and thereby frustrate long range reconstruction that respects former community patterns? (Heikkala, Day 2)

4. Reconstruction strategies are often dictated by an emergency planning team organized in response to a disaster where normal decision-making processes are suspended in favor of expedient action. This has sometimes led to community dissatisfaction with the result or complete failure of the solution because of the lack of continuity between the old town and the reconstructed or new town. After the Friuli earthquake of 1976, some Italian communities tried a different approach, forming cooperatives where the inhabitants had a direct role in managing all aspects of construction from the technical, economic, to the design. What are the potentials for more extensive use of self-managed reconstruction, as well as the possibilities of using this for developing plans prior to the occurrence of the earthquake? (Mader, 1979)

SCIENTIFIC INFORMATION FLOW

1. Bring together planners, engineers and scientists to identify:

   a. The geologic and seismic information most needed to develop guidelines for the selection of suitable building sites and the formulation of community development performance guidelines or standards, and

   b. The social and economic information that is required for the refinement of engineering models.

   Techniques for translating information into forms suitable for interdisciplinary use should be developed. (Clementi, page 4)

2. Seismic zonation, if utilized, has been said to be one of the most effective tools for reducing earthquake risk. Investigate the planning applications of seismic zonation considering the following questions:

   a. What has been the success of previous zonation efforts? What are their

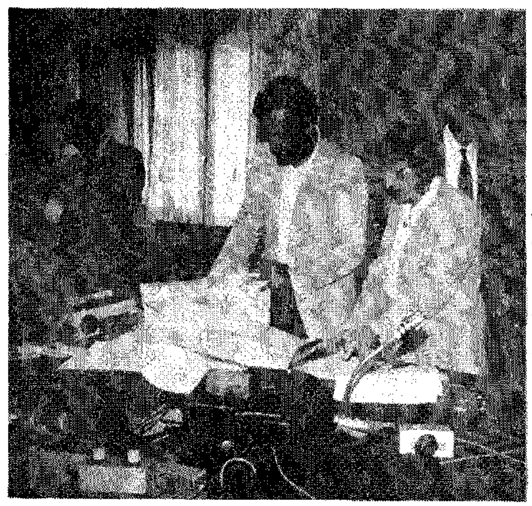


Photo by Valerie Kockelman

A discussion of the application of microzonation techniques to reconstruction in Southern Italy.

strengths and weaknesses from an application point of view?

b. Can economically feasible zonation techniques be developed for use at the urban scale?

c. How are current construction practices influenced by zonation?

d. How can planners and local governments make use of zonation? To assess this, evaluate the usefulness and accuracy of macro- and micro-scale seismic zonation maps for use by planners and decisionmakers in designing and selecting resistant building types, directing urban and regional development, and regulating these development activities. Also, what level of refinement in the data is politically or economically useful? (Kockelman, Day 1)

e. How do site conditions effect the expected behavior of existing buildings and other urban systems?

f. How can zonation be used to influence existing land use and the local land use control system in light of the fact that contemporary planning tools are not always effective in controlling development in known hazardous areas?

g. How does the issue at question relate to the type of investigation called for? How does the cost of study and, therefore level of detail, relate to certainty or the quality of information?

h. What is required to justify where zonation surveys are to be undertaken?

(Discussion, Day 5)

3. Develop an optimum community planning model that indicates where and what kind of seismic information is required, where political support is required, and what the key decision points are. (Brower, Day 4)

PLANNING AND IMPLEMENTATION TECHNIQUES

1. Determine how a community's plan to reduce earthquake hazards can best be related to the community's vulnerability and its capability to implement the plan. (Lagorio, Day 1)

2. Determine the cost-effectiveness of mitigating hazards through urban design and convey the results in economic terms. (Heikkala, Day 1)

3. Identify national, state and local policies/programs/regulations that have a direct or indirect effect on building or rebuilding in seismically active areas. Identify where these programs conflict as well as where they are mutually reinforcing, particularly where one program or policy can fulfill more than the hazard mitigation objective. (Brower, page 10-12)

4. Identify the political, economic and attitudinal constraints to mitigating seismic hazards through retrofitting, planning and reconstruction, including the range of explicit and implicit costs, the time required for investigation and design, and inertia and/or the absence of a sense of risk. Develop approaches to deal with these problems. (Imbesi and Brower, Day 1)

5. Develop guidelines for use by community decisionmakers in earthquake prone areas in determining where to build or rebuild, appropriate development densities, and the facilities that require high resistance to earthquake damage. The guidelines should address both expected growth and recovery following an earthquake. (Shah, Day 2)

Appendices

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A. Participants

U.S. PARTICIPANTS

TRIDIB BANERJEE
School of Urban & Regional Planning
University of Southern California
Los Angeles, California 90007

DAVID J. BROWER
Center for Urban & Regional Studies
University of North Carolina
Chapel Hill, North Carolina 27514

SUSAN HEIKKALA
College of Architecture & Urban Planning, JO-26
Unviersity of Washington
Seattle, Washington 98195

LIDIA L. SELKREGG
Director of Planning Programs
University of Alaska
3221 Providence Drive
Anchorage, Alaska 99504

BARCLAY JONES
Department of City & Regional Planning
Cornell University
106 W. Sibley Hall
Ithaca, New York 14853

WILLIAM J. KOCKELMAN
Office of Earth Sciences Applications
U.S. Geological Survey
345 Middlefield Road, MS-22
Menlo Park, California 94025

FREDERICK KRIMGOLD
Civil Engineering Division
National Science Foundation
1800 'G' Street N.W., Rm. 1130
Washington, D.C. 20550

HENRY LAGORIO
Center for Planning & Development Research
373 Wurster Hall
University of California-Berkeley
Berkeley, California 94720

GEORGE MADER
Department of Applied Earth Sciences
Stanford University
Stanford, California 94305

LUCIANO MINERBI
Urban & Regional Planning
Porteus Hall, Rm. 107
University of Hawaii
2424 Maile Way
Honolulu, Hawaii 96826

HARESH SHAH
Department of Civil Engineering
Stanford University
Stanford, California 94305

JOHN STANTON
Department of Civil Engineering, FX-10
University of Washington
Seattle, Washington 98195

MYER R. WOLFE
College of Architecture & Urban Planning, JO-26
University of Washington
Seattle, Washington 98195

ASTRA ZARINA
Department of Architecture, JO-20
University of Washington
Seattle, Washington 98195

ITALIAN PARTICIPANTS

GUIDO ANCONA
Universita di Roma
Istituto di Architettura,
Edilizia e Tecnica Urbanistica
Via Eudossiana 18
00100 Roma

ANTONIO BELLACICCO
Facolta di Statistica
Istituto di Statistica e Istituto
di Calcolo delle Probabilita
Roma

SERGIO BONAMICO
Istituto di Architettura
e Urbanistica
Universita di Udine
Udine

REMO CALZONA
Istituto di Scienza delle Costruzioni
Facolta di Ingegneria
Universita di Roma
Via Eudossiana 18
Roma

GIANFRANCO CARRARA
Istituto di Architettura
Edilizia e Technica Urbanistica
Facolta di Ingegneria
Universita di Roma
Via Eudossiana 18
00100 Roma

ALBERTO CLEMENTI
Istituto di Architettura
Edilizia e Tecnica Urbanistica
Facolta di Ingegereria
Universita di Roma
Via Eudossiana 18
00100 Roma

ANTONIO DE BELLIS
Via C. Maes 65
00162 Roma

FRANCO FIORELLI
Cattedra di Geografia
Politica e Economica
dell'Università di Bari
Piazza di Monte Savello 30
Roma

ANTONIO GALLOCURCIO
Istituto di Scienza delle Costruzioni
Facolta di Architettura
Universita di Roma
Via A. Gramsci
Roma

GIUSEPPE GRANDORI
Politecnico di Milano
Piazza Leonardo da Vinci 32
Milano

MICHELE GRIMALDI
Provincia di Roma
Assessorato ai Lavori Pubblici e
Assetto del Territorio
Ufficio Programmazione
Via IV Novembre 119/A
00187 Roma

GIUSEPPE IMBESI
Istituto di Architettura
Edilizia e Tecnica Urbanistica
Facolta di Ingegneria
University of Roma
Via Eudossiana 18
00100 Roma

MARA PANUNTI
Giurista
Piazza C.A. Scotti, No. 8
00151 Roma

ALBERTO PARDUCCI
Istituto di Scienza delle Costruzioni
Universita of Roma
Via Eudossiana 18
00184 Roma

VINCENZO PETRINI
Istituto Scienza delle Costruzioni
Politecnico di Milano
Piazza L. da Vinci 32
Milano

GIULIO ROSSI-CRESPI
ITALECO
Via Messina 46
Roma

B. Program

SUNDAY, OCTOBER 11 — Arrival in Rome

6:00-8:00 PM — Wine/Cheese Reception for American Participants at the home of Astra Zarina, Via Monserrato 48

MONDAY, OCTOBER 12

Colloquium begins at Consiglio Nazionale dell Richerche (CNR) Facilities, Piazzale A. Moro, N. 7

Morning

- Welcome and opening remarks by American and Italian representatives and overview of the week's program and desired achievements.

- Session 1: Land Use Planning and Regulation

  George Mader, American Co-Chair
  , Italian Co-Chair
  Barclay Jones, Rapporteur

  American Perspective:
  David J. Brower, "Planning and Regulation of Urban Development as a Means of Mitigating the Effects of an Earthquake"

Afternoon

- Italian Perspective:
  Guiseppe Imbesi, "Land Use Control and Earthquakes"

- Comparative Discussion

Evening

- Event to be announced.

TUESDAY, OCTOBER 13

Morning	-	Session 2: Urban Scale Vulnerability Luciano Minerbi, American Co-Chair , Italian Co-Chair Braco Music, Rapporteur Italian Perspective: Alberto Clementi, "Urban Planning Contributions to Urban Scale Vulnerability Mitigation"
Afternoon	-	American Perspective: Tridib Banerjee: "Earthquakes, Urban Scale Vulnerability and City Design: Some Observations"
	-	Comparative Discussion
Evening	-	OPEN

WEDNESDAY, OCTOBER 14

All Day	-	Field trip to Tuscania

THURSDAY, OCTOBER 15

Morning	-	Session 3: Building Typology Guidelines Astra Zarina, American Co-Chair , Italian Co-Chair Fred Krimgold, Rapporteur American Perspective: Myer R. Wolfe, "Urban Scale Vulnerability: Focusing Down from City Regions to Community Clusters and Building Typologies"
Afternoon	-	Italian Perspective: Franco Braga and Remo Calzona, "Building Typology Guidelines"
	-	Comparative Discussion
6:00-8:00 PM	-	Reception at the American Academy Via Angelo Masina 5 (Porta S. Pancrazio)

FRIDAY, OCTOBER 16

Morning	-	Synthesis of findings and conclusions regarding areas of potential comparative research presented by rapporteurs. Group session to refine and expand upon the rapporteurs' report. William Kockelman, Chair
Afternoon	-	Wrap-up work session. Closing comments by Professor Ing. Mandolesi and Professor Wolfe

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C. Papers and Meeting Summaries

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Italian Legislation on Earthquakes

Guido Ancona
Facoltà di Ingegneria
Università di Roma
Mara Panunti
Facoltà di Giurisprudenza
Università di Roma
Mauro Panunti

1. INTRODUCTION

The mitigation of earthquake effects on people, property and activities involves three types of closely related functions: prevention, rescue and reconstruction.

In Italy such functions are regulated by legal standards that have not been systematically integrated, which has led to contradictions within each of these functions.

1.1 Prevention

The Italian laws on earthquake prevention are based on Article 871 of the civil law code which states that: "The building codes are established by the "Special Act" and by municipal building standards — the "Special Act" also establishes the standards governing construction in areas of seismic activity."

This source stimulated the promulgation of "construction measures with special regulations for earthquake-prone areas" between 1908 and 1974. The contents of such measures evolved with the recurrence of natural disasters; they control the planning and implementation of earthquake resistant construction.

These laws are accompanied by lists of municipalities or smaller communities in areas of known seismic activity. The addition of a municipality to the list requires the application of the special regulations.

1.2. Rescue operations

Rescue operations are controlled by a law that

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provides for interventions against any type of natural disaster. This law proposes a complex organizational model which involves all institutions in the ordinary practice of their public and private functions, but without specifically determining any actual coordination among them. On the other hand, even the individual institutions did not ascertain their role in rescue operations by designing interventions and allocating resources in preparation for a future threat (the law lacks references to the regulations mentioned in point 1.1.).

1.3. Reconstruction

Reconstruction activities in Italian earthquake disaster areas have been, and are, ruled by means of a specific set of heterogeneous regulatory measures issued after the disaster.

They refer to:

- provisions in favor of affected populations
- financing for rescue operations
- financing for the repair and reconstruction of public works, housing and infrastructures
- provisions for the illustration of procedures in the administrative field and city planning.

2. LEGISLATION ON EARTHQUAKE-PRONE AREAS

2.1. General legislation

2.1.1. Technical regulations for construction in earthquake-prone areas

The measures for earthquake resistent buildings in force at present were enacted by the February 2, 1974 Law Number 64 known as "Measures for Construction with Special Standards for Earthquake-Prone Areas", and by subsequent Ministerial Decrees.

The law provides for a list dividing muncipalities and communities into two categories according to the damages caused by the earthquake disaster.

For new construction in municipalities included on the list, the law imposes regulations regarding:

a) The maximum height of buildings vis a vis the construction techniques,[1] the level of seismic activity in the area, and street widths.

b) Minimum distances between buildings and connections between adjacent buildings, and

c) General building design criteria, entrusting to the Ministerial Decree of March 3, 1975 further specifications on static and dynamic analysis concerning building systems.

The law also relegated the following to subsequent Ministerial Decrees:

A. The formulation of general criteria for the control of construction safety and technical rules on loads and overloads (D.M. October 3, 1978).

B. Soil and rock surveys, stability of natural slopes and embankments; general criteria and technical specifications for the design, implementation and inspection of supporting structures and foundations (D.M. June 21, 1981).

C. General criteria for the strengthening of masonry buildings.

D. General criteria for the design, implementation and inspection of special works (bridges, dams, reservoirs, piping, towers, prefabricated construction in general, aqueducts, and sewage systems), and

E. Fire protection methods for buildings.

Points 3, 4, and 5 still await implementation decrees even though road networks, acqueducts, sewage systems, and power lines represent the urban structure "lifelines" in the stages following an earthquake disaster. Therefore, the most significant guidelines regarding the issues pertinent to the mitigation of urban and regional vulnerability lack legal protection. This occurs in spite of the fact that this regulation has to be issued by Decree of the Department of Public Works along with the Department of the Interior which is directly responsible for civil defense services. While the strengthening of buildings referred to in point 3 is a provision of the law, it has not been regulated, even though the greatest damages to people, property and activities in general, are due to the collapse of buildings.

2.1.2. Regulations for the protection of the population and property in case of natural catastrophes

Ever since 1919, provisions have been made for immediate rescue services to the population affected by natural disasters. Today this matter is controlled by the 1970 Law Number 996 and by implementation regulations that were issued eleven years after the provisions of the law, right at the time of the Campania-Basilicata earthquake. However, there is still some confusion regarding the concept of civil defense and the kind of activities that should come under its jurisdiction in order to achieve this goal. This confusion is evident in the current problem of establishing an effective organization and drawing up intervention plans closely related to prevention and reconstruction actions.

According to the law, the State should guide and coordinate such actions, as well as tackle public calamities. The State is assigned the task of preventing calamities by detecting and studying their causes. It should also organize and implement rescue and relief services.

According to expert opinion, research and prevention form the basis of defense in the broad sense but, in reality, these areas are the most neglected aspects. Immediate rescue and relief in the strict sense, are activities organized only after the hazard occurs. At a minimum, this implies:

1) Time required for the collection of accurate data on the area affected and on the dimensions of the disasters,

2) Time required to find skilled personnel,

3) Time required to find enough special vehicles, and

4) Time required for rescue services to arrive.

The institutions concerned in the event of a disaster include: the Department of the Interior, the Department of Civil Defense and the National Firemen Corps, all civil and military public administrations, regions, and other local bodies, institutional public bodies, the interministerial committee for civil defense, the technical interministerial committee, the combined operational center, the rescue coordination center, the joint operational center, the special commissioner (Article 5, Law Number 996), the government commissioner, the prefect, the mayor, the regional and provincial committees for civil defense, the regional fire brigade inspector, and the new department on civil defense established in July, 1981 (however, no funds have as yet been appropriated).

Among all these people concerned with civil defense actions, it is difficult to distribute tasks, implement coordination actions and plan interventions.

The structural evolution has given priority to special bodies, to task forces such as the special commissioner and the joint general staff who intervene when the disaster occurs, precluding the possibility of establishing a sound and permanent first intervention structure. As a consequence, attempts to organize means of intervention are made only after a disaster has taken place, with considerable chance of error. The following activities are still outside the realm of civil defense:

1) Analysis of and on disasters
2) Study of possible causes
3) Detection in the area of the main strategic lines of interventions
4) Operational interventions in the event of a disaster.

Evolution guidelines

Italian political forces advocate a broader definition of civil defense bound to a regional policy aiming not only at economic development, but also at the protection of the population and its property on the basis of a sound law. This should identify the main guidelines and entrust their implementation to local planning, thus bringing to an end the excessive sectorial fragmentation of interventions which are very burdensome and do not achieve the established goals.

2.2. Special legislation

2.2.1. Belice

January 14, 1968 - earthquakes of 7th and 9th degree Mercalli scale.

Gibellina, Montevago, Salaparuta, completely destroyed.

Poggioreale, S. Margherita Belice, S. Ninfa, Menfi - 90% destruction.

Salemi, Sambuca, Contessa Centelenia - seriously damaged.

Camporeale, Vita, Roccamena - some damage. 136 municipalities are involved with reconstruction.

Quality of planning - priority: the contents of the regional plan are established by state law.

City plans, sub-regional plans and detailed or executive plans have a fundamental role concerning the population; there are discrepancies between adopting pre-established plans (English and Swedish post-war models like row-houses and garden cities located a few kilometers away from the damaged city) and following the requirements of the area which might entail regional planning for development and for reconstruction that is completely separated from the previous area-at least for some projects. The basic city plan is the sub-regional one, in that it contains the functions of and regulations for land use. Safeguard measures provided by the master plan have been applied to these plans.

Municipalities without a master plan that are located within the territorial area must have a building code and construction regulations.

Actually, the sub-regional plan has not been very successful: each municipality has independently determined — even as regards neighboring municipalities — its reconstruction design close to the previous settlement site by means of the tools it had at its disposal. Overall control and coordination was impossible; there was a separation between financial and economic-regional plans.

Respective roles and responsibilities:

1) STATE: Guidelines on sub-regional plan formulation.
Identification of buildings to be transferred.
Formulation of programs for work to be performed in new areas.
Approval of the reconstruction plans (Cassa Mezzogiorno, Board of Directors).

Implementation projects for the reconstruction of real estate in the displaced municipalities (Inspectorate).

2) REGION: Organization of Consortia.
Formulation and approval of Decrees for the extension of each district area.
Coordinated intervention programs among EMS, ESA, ESPI, and urgent plans.
Development plans.

3) MUNICIPALITY AND MUNICIPAL CONSORTIA:

Adoption of the building code sub-regional plan and of the PDF.
Implementation of the general inspectorate projects for earthquake disaster areas.
Programming of reconstruction plans.

2.2.2. Ancona

The earthquake tremors that occurred on January 25th 1972 and on June 14th 1972 with a magnitude of 6.2/6.9 degree on the Richter scale, affected the city of Ancona and its hinterland. Although they did not cause any casualties among the population, buildings and services were seriously damaged.

On that occasion, the master plan enforced on October 3rd 1973 had to be amended, being the only city planning tool capable of providing a different organization of the entire city.

In compliance with Bill 552 of October 6, 1972, later passed as Law Number 734 on December 2nd, 1972, dealing with, "further subsidies to benefit the population of municipalities in the Marche Region which were affected by the earthquakes", the Government specified that the funds be allocated to the following authorities:

- Department of Education for the recovery and restoration of monuments and the historical and archeological endowment.
- Department of Public Works for the recovery, repair, and reconstruction of housing and public works.
- Workers' Housing Association (Gestione Case Lavoratori - GESCAL) for the construction of housing and carrying out first and second level city planning work.
- Low-Income Housing Institute (IACP) for public interventions in the field of low-income building areas.

Moreover, the city of Ancona, pursuant to this law, can implement special measures of intervention for the historical city center.

These measures provide for:

a) The identification of the historical town center's borders, through the Decree of the President of the Marche Region following the proposal of the Municipality, having received the opinion of the Monuments and Galleries Protection Board of Ancona (Sovrintendenza ai Monumenti e Gallerie).

b) Programs for the historical town center;[2]

c) The Marche Region's 10-year detailed plan to be used as a city-planning tool;

d) The establishment of a special technical committee, to be chaired by the President of the Marche Region and include the following officials:

   1) The regional city planning counselor, who has the proxy of chairing the Committee;

   2) The regional counselor for Public Works;

   3) Two representatives of the municipal administration of Ancona;

   4) A representative of the Department of Public Works;

   5) The chairman of the Monuments and Galleries Protection Board of Ancona, or his representative;

   6) The head of the Historical Endowment Board, or his representative;

   7) The chief engineer of Ancona's Engineering Corps, or his representative;

   8) The Ancona Health Officer;

   9) The Chief Engineer of the Municipality of Ancona;

   10) Two city-planning experts, to be appointed by the Municipal Council of Ancona;

   11) An expert in building methodology, and a geotechnical specialist, to be appointed by the Ministry of Public Works and approved by the Municipality of Ancona. They are to comment on building plans and licenses.

The most innovative aspect of Ancona's situation is the interrelation between city planning and investments, with the inclusion of territory management in only one Project Plan. Consequently there is a specific policy intended to channel GESCAL and IACP funds towards the recovery of existing residential housing, as well as that of future housing which will be developed in those areas of the historical town-center that are available because of war damages.

Another major point worth mentioning is the implementation of Law Number 865 of October 22nd, 1971,[3] given its two-fold juridical and city planning nature. This law provides for the occupation and expropriation of real estate necessary to implement the plans.

In fact, in order to implement the provisions for the historical downtown area, the City Council can resort to the expropriation or occupation of the real estate, taking the place of the owners involved, by direct intervention or through agencies and institutions appointed by the Council.

In conclusion, a special technical committee was established, with the responsibility of presenting its opinion on building designs and licenses, thus replacing all local and state administrative bodies as well as the Municipal Housing Committee. This element represents an interesting new phase which simplifies bureaucratic procedures and facilitates recovery programs.

2.1.3. Friuli

May 6, 1976: Earthquake of 6.3 magnitude on the Richter scale, heavy damage in 137 municipalities of the Friuli Venezia-Giulia Region, affecting an area of 5,700 square kilometers.

Daniele, Gemona, Venzano, Osoppo, Maggio were essentially destroyed; very serious damage also occurred in other important towns (many cities that sustained damages were not included in the list of 1974 Biel).

Residential buildings: 15,000 to be reconstructed; 70,000 to be repaired.

Public buildings: damage estimated at 300 billion lira. (Hydrogeological damages — 500 billion lira).

Productive sectors: 500 billion lira to repair damage.

Rescue operations in the emergency phase were adequate due to the presence of highly skilled military troops in the area.

Civil Defense activities were not adequate due to the lack of available facilities and equipment for provisional shelters, for immediate repairs and for the recovery of the telecommunications network, etc.

Since the large road network was in good condition, rescue squads could reach disaster areas expeditiously.

Among the many provisions issued by the State on that occasion, it is important to mention Law Number 336 of May 29, 1976. This law provided measures regarding the population and, more importantly, authorized the appointment of the Special Commissioner for Civil Defense (Hon. Giuseppe Zamberletti) in Article 5 of the December 8, 1970 Law — Guidelines for Rescue and Relief to Populations Affected by Earthquakes.

The National Law Number 546 of August 6, 1977 on "Reconstruction of the Friuli-Venezia-Giulia areas affected by the 1976 earthquake" stipulated a special pluri-annual contribution to the Friuli-Venezia-Giulia Region and gave proxy to this region to issue laws on the ". . .reconstruction in the areas of economic, social and regional planning development, and the expansion of industrial and agricultural production, employment, services, and finally, the protection of the ethnic and cultural heritage of the population. . ."

With this provision the region has a corpus juris especially concerned with:

- organization of the regional administration;
- recovery and reconstruction of houses and public works;
- urban and regional planning;
- school and health facilities
- productive activity;
- transportation, etc.

With regard to the planning of regional interventions, the regional law provides for three levels of city planning procedures to be implemented by the region, mountain communities and municipalities respectively.[4]

Regional level: The region prepares an economic and social development plan to back up the Regional Plan (PUR). The region must dictate the criteria for the formulation of city planning tools as well as their control and approval. If municipalities do not comply with the provisions stipulated in the law, the regions will have to carry out such tasks.

Sub-regional level: Through consideration of the district plan in relation to the new territorial and economic situation, the mountain communities, which are associated by state law, specify the contents of the Regional Plan (PUR) and determine the sites for collective services to extend beyond individual communities. The provisions of the district plans are compelling guidelines for subordinate planning of public interventions that affect the area. In order to draw up their plans, the mountain communities must organize their own planning offices, as stipulated by the regional law issued prior to the earthquake.

Municipal level: Municipalities must arrange for "recognition or adjustment variants" of their city planning tools or of the construction regulations. The law does not establish a time limit within which such tools must be adopted; however, it does dictate specific deadlines for the specification of criteria, guidelines and objectives according to which the municipality intends to revise the existing provisions. The law defines, moreover, norms for the procedures and adoption of the variant and for the final approval by the Region. The revision procedure requires that municipalities:

- identify the context in which reconstruction and reclamation are implemented by means of executive plans to be enacted within six months after the formulation of the General Master Plan revision criteria.
- determine the areas in which reconstruction projects are allowed, as long as these actions are not incompatible with the city plans or other regulations in force.

Furthermore, the law defines norms concerning urban planning tools and executive plan implementation for which it establishes the goals, procedures, adoption terms and relationships between these and the main city planning provisions.

In brief, we may conclude by asserting that reconstruction in Friuli refers to ordinary city planning tools that are well tested in practice. An innovative aspect of the law is the introduction of procedures for the approval of the above mentioned tools as well as the possibility of giving priority to the adoption of executive plans vis à vis the formulation of general tools, due to the critical nature of interventions provided for by the implementation plans.

2.2.4. Basilicata and Campania

November 1980-February 1981. November 23, 1980; 7:34 PM tremors between 6.2 and 6.9 on the Richter Scale; 7th and 9th degrees on the Mercalli Scale; 27,000 square kilometers affected.

Total deaths:	3,100
Total wounded:	7,671
Total people missing:	1,575
Homeless:	145,470
	147,470 people affected by the catastrophe

163 heavily damaged municipalities, with 70-100% destruction.

15 seriously damaged municipalities, with 40-70% destruction.

- Cost of rescue operations - 100 billion lira
- Allocations for repairs and reconstruction - 8,000 billion lira for 1981-1983 of which:

  700 billion lira for reconstruction and repair of public works.

  900 billion lira for reconstruction of industrial structures and areas for related use.

  700 billion lira for interventions regarding productive activities.

  570 billion lira for reconstruction and repair of private buildings, and historical, artistic and cultural buildings.

All of the above costs were the responsibility of the State, registered in the budget of the Ministry for Budget and Economic Planning in a specific item.

The measures stipulated by Bill Number 219 of May 14, 1981 concerning regional planning include some innovative elements:

1) OPERATIONS: DETECTION OF HOMOGENEOUS AREAS OF INTERVENTION. IMMEDIATE ADOPTION OF OPERATIONAL PROGRAMS, without which no allocations are granted.

   Actually, the Treasury Department transfers from the "Fund for disaster area reclamation and reconstruction..." the sums for state and local administrations only when "projects" are finalized and not as a periodic transfer.

2) MINIMIZING "stop-gap" interventions to favor an expeditious adoption of REGIONAL DEVELOPMENT PLANS as well as area (territorial) planning.

3) REVALUATION OF THE ROLE OF LOCAL BODIES.

   REGION: Detection of general guidelines to be followed by city plans and yearly local plans for the harmonization of regional planning problems; it is based on the detection of the homogeneous areas to be protected, the protection of the main infrastructure networks, and on positioning the main services and industrial installation areas; generally to be allocated for productive activities. The Region is seen as the focus of the entire intervention planning system.

   MUNICIPALITY: Adoption and/or modification of the MASTER PLAN and preparation of implementation tools according to the above mentioned guidelines. Annual intervention planning.

PLANNING-LEVELS

COUNCIL OF MINISTERS: Coordinates and guides implementation of interventions.

1) STATE:CIPE: Distributes allocations among municipalities for reconstruction and recovery works among Regions for interventions in trade, craft and tourist activities. Distribution of expenses among Public Administrations.

   Approves pluri-annual interventions on regional planning and development projects submitted by regions, and allocates the respective sums.

   Approves urgent intervention plans even before approving regional development plans: Urban reclamation of Naples and of the most populated and affected areas of the Salerno Province and hinterland.

MINISTRY FOR THE MEZZOGIORNO: Each semester, sends a report on the implementation of interventions provided for by the reconstruction law to the Presidents of the Senate and the House.

TREASURY DEPARTMENT	Allocates funds for approved projects.
DEPARTMENT OF THE ARTS, DEPARTMENT OF THE INTERIOR, DEPARTMENT OF TRANSPORTATION, DEPARTMENT OF EDUCATION, DEPARTMENT OF AGRICULTURE, DEPARTMENT OF INDUSTRY, PUBLIC WORKS	Present yearly programs for the repair, reconstruction and improvement of works in their respective fields. The work is carried out through programs of a sectorial and intersectorial nature, extending beyond individual municipalities.
DEPARTMENT OF PUBLIC WORKS	Sets technical standards for the repair and reinforcement of damaged buildings, and establishes limits beyond which repairs are no longer feasible.
SUPERVISORS	Present their ideas and comments on municipal recovery plans concerning historical and artistic areas.
2) REGION:	Prepares and approves Territorial Disaster Mitigation Plans and Development Programs. Prepares intervention programs lasting more than one year (to be approved by the CIPE). Approves the yearly Intervention Program which reports the yearly programs of the municipalities, provinces, mountain communities, government bodies and region, determining what the priorities are and verifying the coordination between the territorial disaster mitigation plans and development plans with the long term intervention programs.

The region has the power to substitute other local agencies which fail to meet their obligations for the preparation of yearly intervention programs. It prepares specific annual intervention programs for reconstruction in zones sustaining damages in developed areas, and the reconstruction of public works. Furthermore, the coordination of territorial disaster mitigation plans and the determination of goals for municipal plans are the responsibility of the region.

3) MUNICIPALITIES MOUNTAIN COMMUNITIES	Define and interpret annual programs
HEAVILY DAMAGED MUNICIPALITIES	Adopt the Master Plan or update the reconstruction plan, and prepare implementation tools as a precaution and/or a variation of the choices offered by the Master Plan when necessary. For example, Zone 167 plans include plans for industrial zones and recovery plans; however, the planning criteria stipulated by the Master Plan must be adopted within 12 months.

The illustrative reports include:

- Geological studies of the areas affected by the interventions
- Data necessary to determine the dimensions of the plans, which includes:

  Number of families and family members to be housed

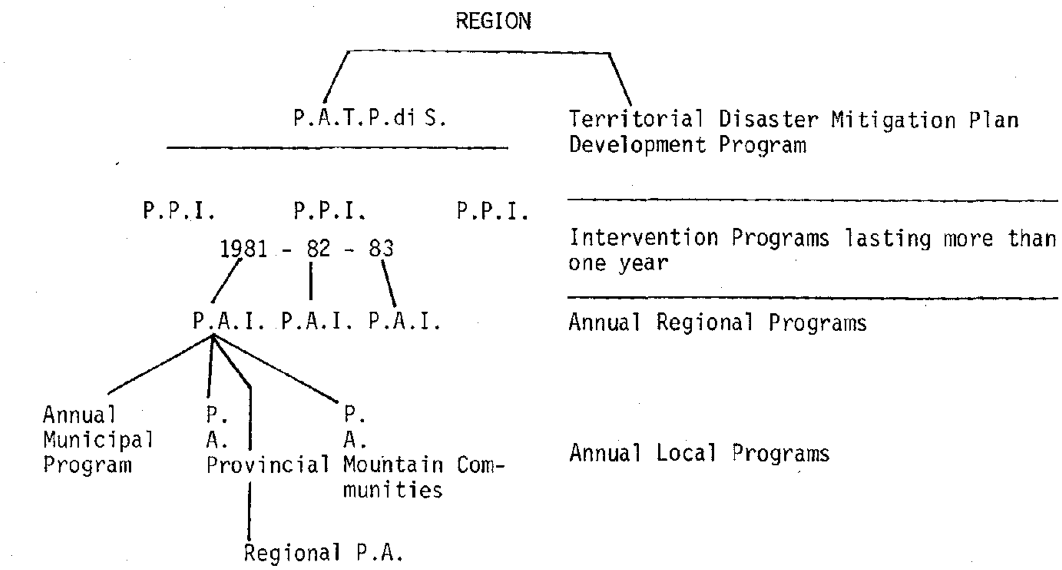
  Dimensions of industrial establishments requiring reconstruction

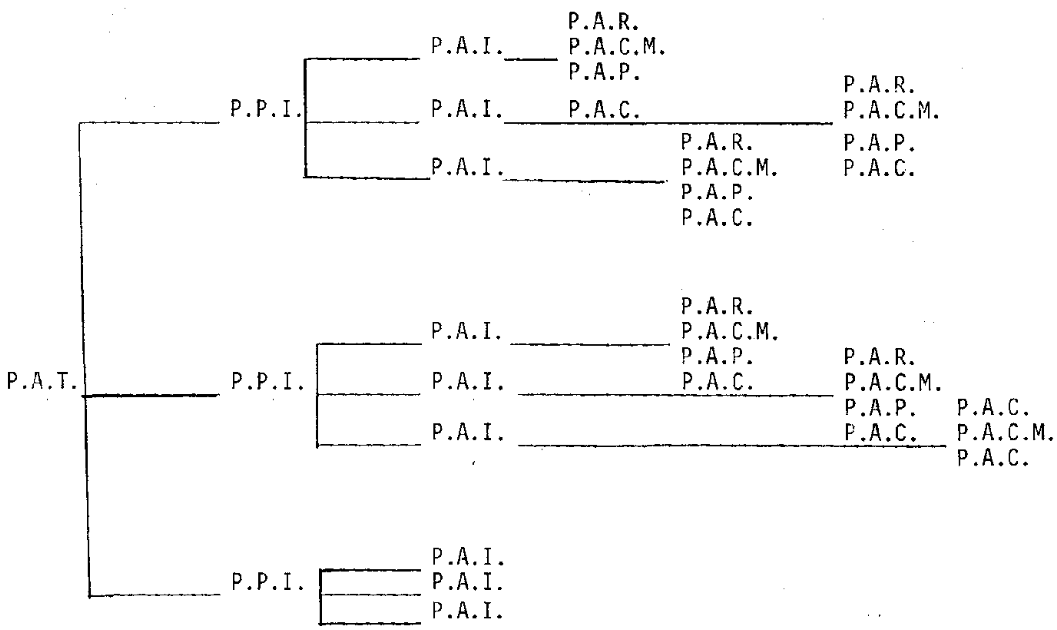
  Number of demolished, repairable or intact housing units, as well as those to be demolished

The plans must be adopted in conformity with the guidelines and standards established to promote seismic safety.

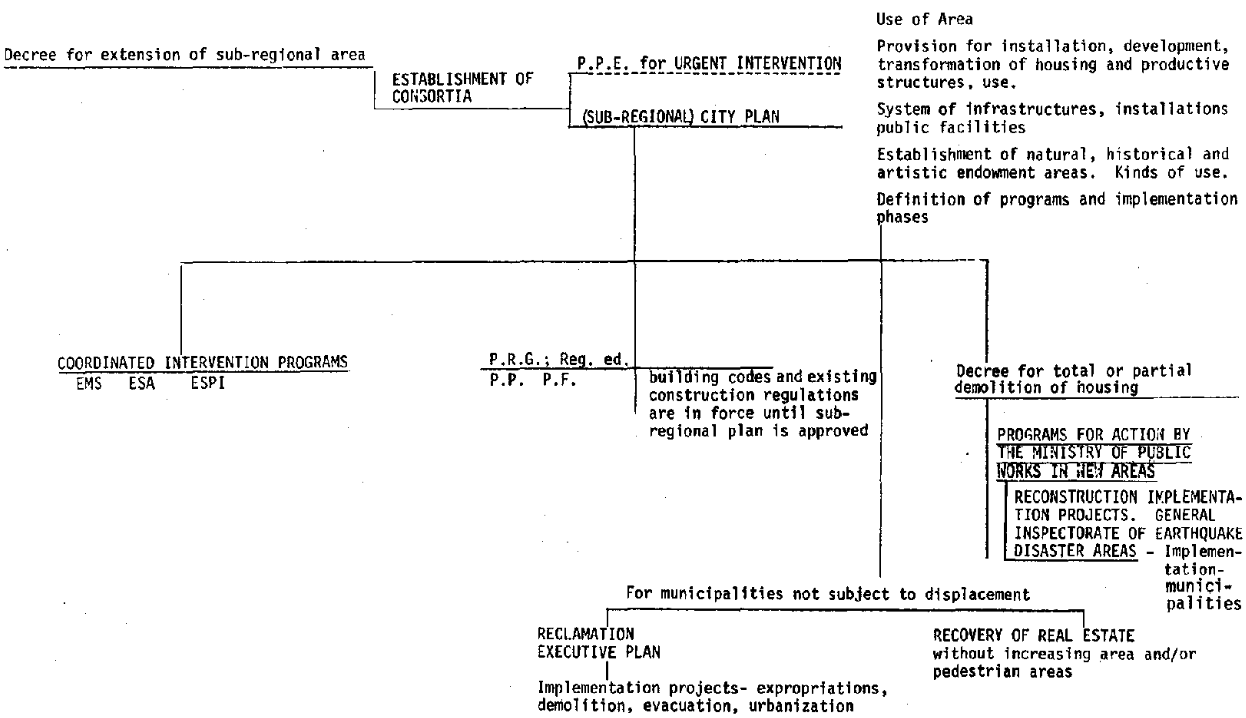
STANDARDS FOR THE AREAS HIT BY EARTHQUAKES.

D.P.C.M. - November 24, 1980, Bill 776 - November 26, 1980, Passed as Law 874/1980, in effect until December 31, 1980.	Appointment of the special commissioner, Article 5, Law 996/1970 authorization of special powers: power to adopt any measure which might be necessary for the rescue and relief of populations; for civil, administrative, social and economic recovery of the damaged regions; and for the coordination of the public administration's emergency interventions, even if the measures taken are not in compliance with the regulations in force at the time.





Legend: P.A.T. = Territorial Disaster Mitigation Plan
P.di S. = Development Program
P.P.I. = Intervention Programs lasting more than one year
P.A.I. = Municipal Program for Intervention - region
mountain communities
province
municipality


Use of Area
Provision for installation, development, transformation of housing and productive structures, use.
System of infrastructures, installations public facilities
Establishment of natural, historical and artistic endowment areas. Kinds of use.
Definition of programs and implementation phases
Decree for extension of sub-regional area
ESTABLISHMENT OF CONSORTIA
P.P.E. for URGENT INTERVENTION
(SUB-REGIONAL) CITY PLAN
COORDINATED INTERVENTION PROGRAMS
EMS ESA ESPI
P.R.G.; Reg. ed.
P.P. P.F.
building codes and existing construction regulations are in force until sub-regional plan is approved
Decree for total or partial demolition of housing
PROGRAMS FOR ACTION BY THE MINISTRY OF PUBLIC WORKS IN NEW AREAS
RECONSTRUCTION IMPLEMENTATION PROJECTS. GENERAL INSPECTORATE OF EARTHQUAKE DISASTER AREAS - Implementation-municipalities
For municipalities not subject to displacement
RECLAMATION EXECUTIVE PLAN
Implementation projects- expropriations, demolition, evacuation, urbanization
RECOVERY OF REAL ESTATE without increasing area and/or pedestrian areas

The definitive reconstruction plans and procedures are not under the jurisdiction of this regulation. Establishment of unbudgeted funds is provided for but benefits are contingent upon assessment of damages.

Article 14 - The Department of Public Works provides for the reclassification of municipalities in areas of seismic activity, within 60 days from this law's date of issuance.

The Department for Scientific Research provides for the establishment of a national group with a two year life span in conjunction with the National Research Council. The group would address earthquake safety and be responsible for promoting studies and research amounting to 2,000 billion lira.

Article 14 "ter." delegates deposits and loans to the fund for financing reconstruction plans and programming public works under local jurisdiction, with an estimated cost of 1,000 billion lira.

Bill 19 - February 13, 1981. Law 128/1981 - D.M. March 7, 1981.	Determination of municipalities affected by the earthquake of November, 1980. Declaration of zones of seismic activity in the Basilicata, Campania and Puglie regions.
Bill 75 - February 19, 1982. Law 291 - May 14, 1981.	Provisions for the reconstruction and development of affected areas. See outline.
D.P.C.M. April 30, 1981.	Determination of municipalities with mild to severe damages.
D.P.C.M. May 22, 1981.	Determination of heavily damaged municipalities in Basilicata, Campania, and Puglie.

CONCLUSIONS

From an analysis of the regulations in question the following is evident.

Italian legislation aims at achieving protection from earthquake disasters by focusing on the protection of individual buildings. It does not confront the issues concerning the protection of the urban organism in its entirety — housing, infrastructure, and life-support systems — although they are tightly interrelated activities in the region and involve a variety of concerns.

The recent and painful experiences have shown that destructive results are not only caused by earthquake tremors, but also when there is no program for prevention activities geared to defend the urban and/or territorial system, or there is unbalanced territorial development which does not utilize criteria for the planning of territories subject to seismic risk.

Lacking information on territorial characteristics and a territorial program, the sub-regional plan aims only at immediate rescue and relief following a disaster.

There are no provisions for infrastructures, facilities, or areas planned for the execution of rescue activities, and the few that exist (fire station and police headquarters) do not receive special protection.

The reconstruction after each disaster brings out the same issue:

> As the procedural organization is not governed by general established standards, it must be reinvented each time with urgency and necessity as tools which may present some prejudicial limitations to the development of severely damaged areas.

If the goal is the reduction of earthquake damages by mitigating urban vulnerability in its entirety, then the activities (of prevention, rescue, reconstruction) that intentionally have been delegated to separate agencies due to the Italian, and other, legal systems should be regulated in an integrated manner. In order to do this the governing body of the territory must establish this fundamental goal by using the tools which are already at its disposal.

URBAN PROCEDURES - SPECIAL LAW NUMBER 219, May 14, 1981. BASIC PROVISIONS

Means	Contents	Body Responsible for Preparation	Approving Body	Time Limit	Article/Law
Territorial Disaster Mitigation Plans Development Programs	Indications for municipal plans Field of building and public works Consolidation inhabited area Transfer inhabited area Determination of similar intervention zones Determination of main infrastructures Identification of main centers Identification of industrial areas Determination of priorities for: - area of Naples - area of Salerno - internal areas Exception: immediate implementation Naples Recovery Program	Region	Region	----	35
Intervention Programs lasting more than one year	For execution of Territorial Preparedness Plan and Development Program Determine completed works and responsible public and private parties Establish intervention priorities Means of completion and management Periods for completion and financing Substitutional terms for responsible parties	Region	CIPE	----	36 u.c. 36
Annual Intervention Program	Reports the yearly programs of the municipality, provinces, mountain communities, agencies, regions Control integration of preparedness programs and long term intervention programs	Region	Region	Before Sept. 15, 1981-82-83	6 II,
Annual Intervention Programs of:					
Municipalities	Public works and infrastructural interventions	Municipalities	Region	Before June 30 1981-82-83	61
Province	Emergency interventions in field of economic	Province			
Agencies	Acquisition of real estate Urganization Recovery plans Reconstruction and repair Programs for cultural activities	Agencies			

URBAN PROCEDURES, (continued)

Means	Content	Body Responsible for Prepration	Approving Body	Time Limit	Article/Law
Annual Mountain Community Programs	Programs for hydro-geological systems Projects and execution of industrial areas Technical institutions Reconstruction and repair	Mountain Communities	Region	----	31 & 32
PRG (Master Plan)					
Plans for Industrial Areas	According to Master Plan,or with modifications	Heavily damaged municipality	Region	Within 12 mos. after law's date of issuance	28 I
Recovery Plans		"			
Recovery Plans in Historical City Centers		"	Supervisors	Building plans before August 16, 1981	28 II, V
Applicable analogous procedures		Affected municipality			55

NOTES

[1]The construction systems considered are: a) structures framed in standard or prestressed concrete, steel or systems combining above mentioned materials; b) structures with supporting walls; c) structures in masonry; d) wood structures.

[2]These interventions include: a) recovery and restoration of public and private buildings sustaining partial damages, and undamaged residential buildings that require health services; b) realization of urbanization projects (public works and housing); c) reconstruction of parts of the historical city center when their characteristics do not require the total preservation of the existing structures.

[3]Programs and coordination of public residential construction; regulations for expropriation for reasons of public use; modifications to and integration of public works (August 17, 1942, Number 115d; April 13, 1962, Number 167; September 20, 1964, Number 847), and authorization of spending for emergency intervention in the sector of reasonable controlled residential building.

[4]Law 63, December 23, 1977, concerning "Regulations and first stage interventions for the implementation of reclamation and reconstruction works for earthquake disaster areas in the field of city planning, building codes and public works."

Urban Scale Vulnerability: Some Implications for Planning

Myer R. Wolfe with
Susan G. Heikkala
College of Architecture and Urban Planning
University of Washington

Introduction: The Mandates and Imperatives of Earthquake Hazard Mitigation

The notion of intervention in the environment to mitigate the consequences of disasters — in the specific instance earthquakes — implies the use of fundamental government powers to manipulate environmental change towards the goal of achieving public safety. The question in a comparative context is what are the mandates and/or imperatives that emerge relating to institutional, political, or even cultural determinants. Secondly, as it is premised on the ability to wield these powers, what are the functions of planning and urban design in this milieu?

The powers which sovereign bodies can bring to bear on disaster mitigation might be characterized as coercive on the one hand and permissive on the other. Numerous precedents exist for the use of coercive measures, or those leading to regulation by public bodies, to influence environmental change which may be useful in a pre- or post-earthquake situation. Land use regulations, such as zoning and subdivision ordinances, are now extensively utilized in the United States. These mechanisms were first employed only as a means of preventing problems arising from the juxtaposition of noxious uses, but later as a means of promoting the development of public amenities. As this exemplifies, applications of police powers are dynamic.

In fact, as the understanding of environmental complexity becomes more sophisticated, the network of regulations to deal with it has become correspondingly more detailed. As a case in point, the U.S. 1968 Enviornmental Policy Act requiring impact statements for federal actions which have a "direct and significant" impact on the environment, is neither regulation per se nor an incentive per se, but an instance of institutionalized evaluation. By examining a proposed action for its impact — including adverse effects, feasible alternatives, long and short term implications — the assessment is relying on a <u>systematic and selective predictive process</u>. The relevance for hazard mitigation is obvious. As Andrews noted, the "process of planning is shot through from start to finish with judgments, intuitive predictions and assumptions about the impacts of alternative actions" (Andrews, 1975).

Precedents also exist for the use of permissive measures to achieve planning goals using incentives between and among levels of government. The national flood insurance program requires states to identify and employ development controls in floodplains in order to be eligible for national insurance, an approach which may have application in known fault zones or areas of severe ground instability. American coastal management planning which in and of itself is a voluntary national program precipitated by the Coastal Zone Management Act of 1972, requires that those states which choose to take federal money to develop a plan include an assessment of natural hazards in the coastal zone (The Conservation Foundation, 1980). Requirements for the disclosure of hazard information in real estate transactions have been adopted in some states which then rely on the public to act in accord with the information (Kockelman, 1981). Public education and information programs, like the State of Texas' Hurricane Awareness Program, assume knowledge of risk provides the incentive for action, whether it be for financial or personal safety reasons, although skepticism remains regarding the efficacy of such an approach. Financial incentives in general, provided primarily through the federal government, often motivate state and local governments to undertake planning programs such as coastal zone management, water quality planning or even research in the area of hazard mitigation. Although the U.S. is a federated country, the ostensible allocation of power is deceptive. For example, the dual coercive and incentive effects of the tax power are well known, and federal, state and local government policies and programs have significant effects on investment, development and the resultant urban scene.

Urban Planning: Changing Views of the Planning Process

Before looking at earthquake hazard mitigation as a planning issue, the word "planning" must be explored. Broadly speaking, planning is an approach to problem solving; it is a process for making informed decisions about the future. But since its inception as a profession applied to the urban environment, the scope and method of planning have been the subjects of continuing debate. From planning's early focus on civic design and municipal order, there was an emphasis on product. Underlying the notion of a general plan was the implicit assumption that problems and relationships could be precisely defined in physical terms; therefore, the master plan identified physical relationships between land uses projected to a future point in time. Community decisions, such as capital expenditures or public regulatory measures, would deliberately follow from the plan. This physically deterministic perspective was intrinsically static. Much of the ensuing planning enabling legislation reflected this predisposition.

This determinist view is now held to be an untenable model of how a city functions, and the concept of planning as a dynamic, if not comprehensive, process has taken its place. The newer outlook on planning emphasizes the development of general goals statements and the recognition of informational feedback and iterations. Physical planning is coupled with policy and program planning where there is the deliberation of goals, development of alternative physical or policy configurations related to those goals, and consideration of implementation through specific action programs. The process approach also recognizes the need for continuing adjustments to reflect changing circumstances. Significant, too, is the fact that the scope of planning expanded far beyond physical land use relationships. Problems caused by urban growth and resource development and a more sophisticated understanding of urban decisionmaking dynamics have led planners to consider growth management approaches and more sophisticated views of economic development; environmental quality; energy and resource conservation; historic preservation; and health, education, and welfare problems among others (American Planning Association, 1979).

Although the American Planning Association now defines planning as a "comprehensive, coordinated and continuing process," theoreticians debate whether planning can be truly comprehensive or remains relegated to the incremental (APA, 1979). Indeed, social pressures have given rise to "advocacy" planning where pressure groups who have hithertofore been closed out of the decision-making stream of public action are brought into the planning process. Furthermore, in doing planning, many state and local governments operate from the basis of legislation that is still premised on a static general plan model. There is also a dilemma inherent in the process definition of planning. Local plans are required to be reliable and predictable guides for public and private community development decisions, particularly since litigation in the courts seeks precise description and analyses insofar as can be developed. Therefore, plans must balance a degree of stasis with the need to recognize that they are part of an ongoing process. Consequently, in the absence of visionary guidance, most local governments prepare plans.

Urban Planning: The Federal Role in Earthquake Hazard Mitigation

Since urban planning is an exercise of the police power which was generally reserved to the states by the United States Constitution, the federal role in planning is more or less limited to providing incentives for state and local governments to actively "plan". Usually those incentives have been monetary. American cities have relied to a large degree on federal programs to support comprehensive community planning and urban development programs. Programs administered by the Department of Housing and Urban Development, such as Comprehensive Planning Assistance 701, Community Block Grant and Community Development Block Grants have been the mainstays of comprehensive city planning. In recent years, other incentive programs have been instituted, reflecting the broadening scope of planning. Economic development planning, water quality planning, and comprehensive planning in the coastal zone are but a few examples of the specialization of planning priorities that resulted from federal policy and funding decisions. By virtue of the fact that they set funding requirements, establish the content of planning programs, set environmental standards, and perform special functions like building interstate highways, the federal agencies have supposedly an indirect, but actually significant, effort on planning generally and hazard planning specifically.

The public sector in the United States, as in other countries, has a broad mandate through it's Constitution to protect the health, safety, and welfare of all its residents which includes protection from natural disasters and/or their effects. But while the end is more or less universal, the means are not. Questions arise as to how far government should go in protecting its citizens from an unpredictable earthquake risk and how much responsibility individuals should themselves bear. To date, the U.S. experience has not provided complete answers to these questions. Before looking at how the concept of urban scale vulnerability can be incorporated in contemporary planning, a thumbnail sketch of the American experience in seismic hazard mitigation is in order.

In the United States today, there are three basic strategies to deal with seismic hazards:

(1) The emergency preparedness plan which sets forth the networking mechanisms and provides the necessary facilities to cope with a disaster and provide relief once it has occurred.

(2) Disaster mitigation planning which combines land use planning and code enforcement to minimize vulnerability to seismic damage prior to its occurrence, and

(3) Disaster recovery planning which develops strategies to reconstruct a functioning and safer city following a disaster. This latter strategy may be further subdivided into short-range recovery actions which are designed to put basic services, such as water, power, or communication systems, back in functioning order, and longer-range recovery of the entire urban area which can and should address major locational and form implications of rebuilding on that particular site. For example, Managua, Nicaragua, although not in the U.S.A. attempted some major urban form changes following the devastating 1972 earthquake by identifying areas where redevelopment was prohibited and steering redevelopment to safer areas (Haas, Kates, and Bowden, 1972).

A community or regional disaster mitigation program may contain components of all three, preferably integrated and coordinated in one overall scheme.

Until relatively recent times, the federal government has focused most of its attention on providing relief from earthquake disasters. Even federal legislation dealing directly with disaster relief is new on the scene. Prompted in part by the enormous property losses of the 1971 San Fernando Earthquake, Congress enacted the "Disaster Relief Act of 1974" (Public Law 93-288) to provide "an orderly and continuing means of assistance by the federal government to state and local governments in carrying out their responsibilities to alleviate the suffering and damage which results from disaster" (Blair and Spangle, 1979). The Act required each state to designate a lead agency and prepare a State Emergency Plan that provides a framework for state agency and local government action in the event of a disaster and outlined the procedures for delivering federal aid. In order to receive federal disaster aid, the state must agree to assess its existing hazards and take action to mitigate these hazards through construction and land use planning. Even so, the act does not specify standards for state emergency plans nor subsequent mitigation planning; the emphasis in on providing warning and relief.

The federal government has paid less attention to programs designed to minimize exposure to seismic risk. This limited activity has concentrated in four areas: minimizing structural failure, providing technical information and supporting scientific research, requiring consideration of seismic hazards in other public programs, and encouraging planning. The most widely accepted and applied means of reducing seismic risks as well as other hazards to life and structures in the United States is through the International Conference of Building Officials (ICBO) Uniform Building Code (UBC). Prompted by California's earthquake experience, lateral force provisions were included in the appendix of the first 1927 Uniform Building Code. Later, in 1961, these provisions were considered important enough to be made mandatory and were moved to the main body of the code. Local governments can adopt the UBC as written or may amend portions, add sections, or write their own building code using the UBC as a model, as Los Angeles and San Francisco, California have done (Berlin, 1980).

By establishing minimum design criteria for earthquake resistent structures, the code is aimed at avoiding major structural failures. Nevertheless, some local governments have gone beyond these general guidelines and enacted ordinances designed to reduce damage to structures from ground shaking as well as restricting building on or near fault zones. In 1933, after the Long Beach earthquake, California's Field Act set forth seismic standards for school construction and the Riley Act specified lateral force standards for certain other buildings. After the 1971 San Fernando earthquake, the California Legislature enacted the Hospital Safety Act and the Dam Safety Act as well (Blair and Spangler, 1979). In addition, they passed a bill requiring local governments to update their general plans to include a seismic and a safety element. This will be described in more detail in a later section. Then, the 1972 Alquist-Priolo Special Studies Zone Act authorized the State Geologist to designate and map special zones along potentially-active and recently active fault traces where an assessment of geologic response must accompany new development. The Uniform Building Code's national mandatory standards have had a salutary effect on reducing seismic hazard vulnerability by increasing building strength and resistance, even though these standards are based only on best guesses of earthquake magnitude.

Seismic risk reduction was also the focus of the "Earthquake Hazards Reduction Act of 1977" (United States Public Law, 95-124). Its stated purpose was to "reduce the risks to life and property from future earthquakes in the United States through the establishment and maintenance of an effective earthquake hazards reduction program." The program would focus upon developing implementable earthquake-resistent construction techniques, prediction methods, model codes, and research and education programs. This Act concentrated national attention for the first time upon approaches to mitigating problems stemming from exposure to seismic hazards. State and local governments, however, have not played a major part in developing the program nor are there incentives or directives for them to develop their own mitigation programs. Perhaps this is in recognition of the fact that planning and police power applications are the prerogatives of state and local governments.

One result of the Hazards Reduction Act was the consolidation of five federal agencies and six programs dealing with national emergencies. On July 20, 1979, former President Carter signed an Executive Order creating the Federal Emergency Management Agency whose responsibilities now range from civil defense to earthquake disaster assistance to floodplain insurance. Among the objectives of this streamlined approach to emergency management were increasing administrative efficiencies, disaster mitigation effectiveness and the effectiveness of preparedness, relief, and recovery programs (The Conservation Foundation, 1980). This same Act also emphasized two other important federal government functions: sponsoring research in the area of disaster mitigation and providing technical information to state and local governments. Such activities are carried on today by the National Science Foundation, the United States Geological Survey, and the National Oceanic and Atmospheric Administration.

Concern for seismic hazards can also be indirectly incorporated in the administration of other federal programs. Seismic risk should be identified and evaluated in the environmental impact assessment process as mandated by the 1969 National Environmental Policy Act as well as in the A-95 review process established by the Intergovernmental Cooperation Act of 1968 to insure that federally-funded projects are in keeping with state, area-wide, and local planning objectives. But these and other programs administered by the federal government have had limited, if any, success in increasing seismic safety since there are no specific criteria developed relating to seismic hazard mitigation and there is little commitment at the administrative level to promote seismic safety through these mechanisms. Therefore, they have seldom been used to achieve these ends.

To summarize, the U.S. federal government role in dealing with earthquake hazard mitigation has been one of providing relief, advice, information, and a few incentives to develop more extensive hazard mitigation measures. The responsibility of mitigating earthquake hazards through land use planning has been passed to state and local governments. Yet, in spite of these attempts to bring seismic and other natural hazards and public safety to the attention of local government officials and the public, the success of these efforts is dubious. For example, the planning profession as a whole has not demonstrated much concern with natural hazards. In 1979, the newly-reorganized American Planning Association (APA) adopted a comprehensive statement of planning goals which made no direct mention of the need to consider seismic safety or other hazards in local planning. At the state level, the record of using planning to reduce seismic risk is spotty. In the United States, California is one of the few states to respond to the existence of earthquake hazards through specific planning legislation. Alaska, on the other hand, which has also experienced severe earthquakes in the past, has done nothing to modify its growth pattern and is now redeveloping in areas that experienced extensive damage from liquefaction and subsidence in the 1964 earthquake.

Urban Planning: Earthquake Hazard Mitigation in California-An Example

To exemplify the American approach to state and local planning in general and seismic hazard mitigation specifically, the State of California will be used.[1] Although it may not be at the zenith or nadir of American planning practice, California probably represents the state-of-the-art in its approach to earthquake hazard mitigation.

California is unusual in that since 1955, it has required county and city governments to adopt a general plan (Government Code Sections 65300 et seq.).[2] In addition to requiring local governments to prepare and adopt a general plan, zoning and subdivision ordinances were required to be consistent with the plan after 1971. Following the 1971 San Fernando earthquake which took 64 lives and caused over $500 million in property damage, the California legislature passed a bill requiring local governments to add a seismic element to county and city general plans as a means of reducing losses of life, property damage, and other social or economic disruptions as a result of earthquakes. Each plan must include at a minimum all of the following elements: land use, circulation, housing, conservation, open space, seismic safety, noise, scenic highway, and safety. Required to contain data and analysis, policies, and an implementation program, the seismic element must specifically include: "an identification and appraisal of seismic hazards such as susceptibility to surface ruptures from faulting, to ground shaking, to ground failures, or to effects of seismically induced waves such as tsunamis or seiches" (emphasis added) (Government Code 65302(f)). Mudslides, landslides, slope stability and other hazards are also to be considered. The 1980 draft General Plan Guidelines further state: "The seismic safety element is primarily a vehicle for identifying hazards that must be considered in planning the location, type, and density of development" (emphasis added) (Office of Planning and Research, 1980). State guidelines thus give local governments latitude in determining how the identification and appraisal of hazards will be reflected in land use decision-making. Indeed, California's approach apparently relies upon structural soundness and building restrictions in specified hazard zones as the major means for promoting seismic safety. Although there is no mandatory state planning review and approval process, cities and counties must submit their seismic safety elements and any related technical studies to the State Division of Mines and Geology (Government Code Section 65302(f)).

Oakland, California, a large city on San Francisco Bay which sits astride traces of the Hayward Fault, is typical of cities in the most seismically active part of the state. Its Environmental Hazards element, combining the seismic and safety requirements, is also representative of how local governments approach earthquake mitigation. The document contains four essential parts (City of Oakland, 1974):

1. The Environmental Hazard Identification section technically describes and maps the history and current status of the various hazards as specified in the code, but at a gross scale. It also predicts some urban development implications of these hazards.

2. Structural Hazard Identification. The plan identifies areas where the potential for structural or facility damage is high. It identifies by census tract where there are concentrations of residential structures containing three or more units; of those, which dwellings were built before 1939 (date the earthquake resistant building code was instituted); number of commercial and industrial masonry buildings built before 1940; and the location of several types of critical facilities: schools, hospitals and fire stations. The vulnerability of utility and transportation facilities is acknowledged and the existence of stricter development standards with back-up systems are noted.

3. Hazard Prone Areas. Based on analysis of the previous data, general hazard prone areas are isolated; and hazards specific to each area are described, including structural hazards, special studies zones (faulting), poor ground response, and other non-seismic hazards.

4. Policies and Programs. The policies and programs attempt to prevent the creation of new risks and eventually eliminate existing ones. To that end, programs emphasize information dissemination, hazard identification, siting key facilities and other buildings away from identified fault zones, and enforcing codes for new and old buildings.

Like Oakland, most other seismic elements for California cities stress structural safety or development setbacks near known faults. For example, a 1969 San Francisco ordinance, seldom enforced, required the removal or strengthening of unsafe parapets or building appendages (Blair, et al., 1979 and Lu, 1979). San Jose has identified seven ground-response zones where ground-shaking may cause serious damage to certain types of structures (Blair, et al., 1979). Portola Valley has adopted building setbacks along known fault traces as well as hired a town geologist to review building permits, supervise town geologic mapping, and advise on General Plan amendments (Mader, et al., 1972).

To generalize from California's experience, the focus of mitigation to date has been on: (1) hazard identification and location, (2) building and structural soundness, and (3) development setbacks — especially for critical facilities — near known faults. Facilities such as communication lines, roads, water and sewer services are acknowledged to be susceptible to damage, but this has yet to be approached from a planning perspective. There is yet a need to step back and look at the urban scale, that is, how the town morphology and physical form and activity patterns impinge upon urban vulnerability.

Urban Planning and Urban Scale Vulnerability-A Model

The character of urban America is changing as was documented by the President's National Urban Policy Report of 1978 (U.S. Department of Housing and Urban Development, 1978). Mass migrations from rural to urban areas have ceased, the national fertility rate is down, smaller households are becoming the norm, and technological forces leading to decentralization of urban development, population, and economic activity are changing. Given these new conditions, the report recommends that federal policies which favor new construction over the rehabilitation of existing facilities and housing should be changed in order to conserve energy and materials. Policies that favor sprawling development should be exchanged for those which promote energy and capital-conserving patterns of urban growth. But these policy changes pose questions regarding their urban form implications and, concommitantly, the implications for seismic safety. Viewed from one perspective, older sections of cities contain a greater concentration of hazardous multi-story, unreinforced masonry structures while new, low-density development may be more resistant to earthquake shocks and quicker to recover from disasters. Although this should not be viewed as an argument in favor of one development pattern over another, it does speak to the need for attention to the broad range of implications of our urban development and economic policies.

The general subject area of earthquake hazard mitigation at the urban scale emphasizes the preventative. This does not preclude attention to or evaluation of detailed seismic damage to individual buildings or other facilities; instead, there is an additional task of anticipating the alternative spatial and regional implications given the potential for earthquake disasters. In so doing, the preparatory and remedial are not set aside, but should be considered implicit in the process of determining the factors that contribute to recovery if and when earthquakes strike. It is the nature of planning to pose alternatives and to evaluate and compare their respective consequences, but this does not seem to be incorporated into the experience or literature of disaster mitigation at the urban scale. The following purposes to isolate significant elements and factors for study at several scales, noting the comparative issues, and then test whether these fundamentals are reflected in current planning practice.

Any effort that compares presumably compares similarities and differences, so the immediate problem is to abstract out the internal and external variables that pertain to the general scene or to specifically designated study areas selected for comparison. Therefore, the additional intent here is to: (a) pinpoint problems, issues, or areas for comparison and (b) construct a more abstract, or prototypical, model to compare to, while (c) suggesting methodologies for the use of proxy or surrogate measures for comparison. For planners, this implies considering systems of operation or hierarchial frameworks before focusing on the specifics.

Scale is to be considered a major issue. "Urban scale" vulnerability in this case may be conceived in both macro and micro terms. The principal concern is the context, that is where, when, and how the disaster takes place given the constraints, possibilities, and probabilities of the preventative or remedial actions that could occur. It should be emphasized, however, that territorial scale, or "where" is crucial.

The urban scale can be broken down into regions, city-wide areas, and city sectors. Although such words are ambiguous, for purposes here the area under examination encompasses a city center plus the area surrounding it that affects and is affected by the daily rhythms of urban life. Without differentiating between rural vs. urban or dense vs. scattered development, such an area could be construed to mean centers and subcenters encircled by a number of overlapping employment, recreational, housing, and various service or catchment areas.

Distinguishing between macro and micro analyses, it is hypothesized that the macro urban settlement form and pattern may be broken down into: (1) density and land use intensity[3] patterns; (2) regional nodes and focal points, or the centers and subcenters of urban activity; and (3) the lines of accessibility, communication, and transportation, considering the systems of interaction, points of clustering and focusing, and fields of "traffic" generation. What should be sought is a diagrammatic portrayal of macro-scale development or redevelopment as shaped by economic intervention and socio/political factors.

Then, given the above contextual framework, micro analyses follow. The "micro" scale, as such, could be construed as a residential neighborhood with its ancillary shopping facilities, schools and recreation areas. The same genetics of macro scale examinations as described above apply here, but the scales — or level of dimension, texture or activity — are different. Basically, the immediate locale should be viewed within the city sector and the city region, conceptualizing the micro problem in a macro setting, but with each "zone" differentiated by measurement or evaluation characteristics. At the micro scale, there may be surveys of building groups and their existing conditions, particularly in areas of potential change or damage. It might also be relevant to examine the adaptive reuse potential of certain structures with the possibility of emphasizing inherent differences in past building practices in a sector of a city.

Before describing a hypothetical urban scale vulnerability model for use in a comparative context, two bases of comparison must be defined: the homological and the analogical. In urban and regional planning terms, the first means comparison of "a" or "the" plan for action, whereas the other emphasizes the "planning," or the process out of which a plan emerges. One contemplates a product and the other, a process. Planners must do both, but at varying scales in various places at various times.

Given, therefore, that planners are concerned with systems and interactions within macro and micro spheres of urban environments, the underpinnings of earthquake hazard mitigation must be examined in this context. While much of the work to date has been directed towards the avoidance of structural failure of individual buildings, it is recognized that the secondary effects of urban systems failure may cause equal or even greater disruption to the urban equilibrium than specific, direct losses (Krimgold, n.d.). Fires in the absence of a functioning water system can decimate a city reeling from a quake; transportation system failure can frustrate both rescue and long-term recovery. In addition, on a more intimate scale, the disruption of community and individual activity patterns can have longer term social, psychological and economic ramifications. Due to their nature, lifeline facilities and other network systems are certainly susceptible to earthquake disruption; moreover, because they function as a network, the failure of one element or one segment of the system can impair the function of the entire system (Krimgold, n.d.).

At the risk of oversimplification, an earthquake disrupts a physical system consisting of four major elements common to any urban environment, each of which is integral to the whole. Therefore, disequilibrium induced in one will have ramifications for all the others. Although the distinctions blur at the edges, the four include: the urban artifact itself; the spatial dimension; an activity element; and a time element:[4]

1. The urban artifact consists of all the man-made structures and systems in the environment, including buildings and lifeline systems. Also subsumed here are considerations of land use density and intensity, age and technology of development, types of construction, materials used, existing conditions, and the like.

2. The spatial dimension is concerned with the location of these artifacts in the physical environment - the morphology of the place - as characterized by form, spatial relationships, distribution, linkages, custom, and socio-economic forces as well as geophysical characteristics. It also includes the spatial ecology of urban residents, especially of critical groups such as the elderly, ill or the young.

3. The activity element includes the types of activities that take place in the environment — work, shopping, play, rest, etc. — and looks at their distribution, density and configurations, and their relationship to the urban artifact.

4. Finally, the time element examines the temporal and seasonal aspects of the macro-region, recording the "pulse" of activities in time and at places. Changes in the "configuration" of these elements obviously can make a significant difference in urban

scale vulnerability.[5]

The forthcoming model thus serves two purposes. First, it sets forth those elements which an earthquake mitigation strategy must address, and second, it provides a basis for comparability with other countries.

These are however, two other realms that also have critical implications for earthquake hazard mitigation. The first is so obvious it only needs a passing mention here, and that is knowledge of the underlying geology of an urban area. Nevertheless, in spite of the central role it should play as the basis for hazard mitigation, many planning agencies have short-cut this category of data collection, and in addition, planning professionals frequently do not know how to use the information if it is available.

The other realm is the overriding political decisionmaking system which is responsible for carrying out policies, plans and programs. The physical environmental elements and systems are governed and managed by a complex network of federal, state, and local government agencies and private sector players. Coordination among jurisdictions, agencies and governments is essential to avoid delays, ineffective responses, and ineffectively coordinated support delivery in the event of a catastrophic earthquake. Not only is this coordination essential to respond to a disaster, it is also essential if preparation is to be successful in mitigating the hazard. International comparisons of organizational frameworks to deal with disasters would also be instructive.

Thus, when addressing the issue of urban scale vulnerability to earthquake hazards from a planning perspective, the problem goes beyond public safety, least cost, and workability alone. Clearly, it becomes a matter of perception and analysis of the continuum extending from public policy actions to the achievement of community goals in a three dimensional built or rebuilt environment. As the urban form represents the physical result of the exogenous forces embodied in public and private policy decisions, these physical outcomes must be seen in an interrelated context. Applying this logic to the issue of earthquakes implies that attention to structures or lifeline systems alone ignores the contextual issues and is therefore inadequate.

Using the model, some potential areas for international comparison fall out:

1. The age and pace of development in selected geographic areas and the "appropriate technology" that was or was not traditionally used, and thus its consequent vulnerability. The types of construction should be a significant issue here as well.

2. The morphology of development as characterized by time, custom, socioeconomic forces, and geophysical characteristics.

3. Regionalism and political decisionmaking. For example, what impacts do the historical as well as existing patterns of unitary vs. federated forms of government have on regulations, appropriations, and the like? (Italy represents a more unitary form of government, Yugoslavia is quite federated, while the U.S. is, comparatively at least, somewhere in between.)

These three are only gross examples of what could be considered proxy measures for international comparison that will serve as indicators of political, social, physical and economic history.[6]

Urban Planning and Urban Scale Vulnerability—The Model Tested In Oakland

The assumption has been made in this paper that the foregoing is a reasonable model of an appropriate planning framework for evaluating urban scale vulnerability. Taking this somewhat abstract model, it may be valuable to return to Oakland's seismic element to assess the scope of planning in one of the U.S.'s most seismically sophisticated states. As an initial caveat, it should be mentioned that the analysis here is not meant to be exhaustive, rather it only highlights key areas of coverage.

California's Government Code directs local jurisdictions to "identify and appraise" a variety of seismic hazards, which, in a summary fashion, the Oakland element does for generalized geology, known faults, susceptibility to ground shaking, and landslide potential. The mapping scale is gross, but at the same time, the general absence of precise geologic information makes more detailed mapping somewhat specious.

Examination of the (1) urban artifact is limited to an overview of man-made structures with some attention to age, construction type, and building conditions. Density and intensity considerations as they may impinge upon vulnerability and recovery are absent. There is only a passing assessment of standards for urban infrastructure systems.

(2) While attention is paid to hazard location, the morphology and distribution of urban areas and activities and other spatial dimensions are virtually ignored. The location of several critical facilities and certain seismically vulnerable structures represents the extent of Oakland's attention to the complexity of the spatial aspects of vulnerability. But equally important are the relationships between the built environment and transportation, communication, and open space systems vis a vis the hazards, the location of activity nodes, special districts, and the like. A conspicuous omission is the absence of any consideration of system linkages and interactions. Earthquakes do not recognize political boundaries: while Oakland may not be physically damaged by an earthquake in San Francisco, secondary impacts on transportation, communication, flow of goods, and the general economy could be severe.

(3) The Oakland element does not examine the vulnerability of various activities and activity centers other than several critical facilities. For example, what might the implications be for a disaster occurring during work hours or rush hour vs. a major sporting event in terms of public safety, rescue, or short- and long-term recovery?

(4) Temporal or seasonal considerations are also overlooked, although it is well-known that the coincidence of the factors of time, season, and activity can significantly effect the extent of loss and the difficulty of recovery, i.e., emergency shelter in the middle of winter entails a different set of requirements than during the summer.

Oakland's implementation system relies upon codes and ordinances addressing structural soundness and the location of certain structures with respect to known hazardous areas. It recommends developing criteria or regulations for streets, utilities, transmission lines and other facilities which may traverse hazard areas, but again the focus is on structural integrity of the individual systems, not the overall pattern of the utility network and its response to disaster. Since utilities and transportation systems themselves influence the morphology of urban growth, it is essential that earthquake hazard mitigation expand its definition of the scope of the problem.

The plan acknowledges that the city has yet to identify the level of "acceptable risk" — or that point below which no specific local government action is deemed necessary; that is, where costs, both economic and social, outweight the value of minimized hazards. As a study which identifies and locates the hazards, discusses potential consequences, and provides information, the Oakland Environmental Hazards Element represents a step toward that end.

The City's Emergency Operations Plan, adopted in 1973 to conform to the previously mentioned federal mandate for such plans, has the stated purpose of providing governmental continuity, providing emergency services, restoring essential systems and services, and coordinating with emergency services organizations of other jurisdictions in the event of a significant disaster. Although the sufficiency of this emergency plan is not examined here, in 1980 the Federal Emergency Management Agency evaluated California's readiness to cope with the effects of a catastrophic earthquake. They concluded: "While current response plans and preparedness measures may be adequate for moderate earthquakes, federal, state, and local officials agree that preparations are woefully inadequate to cope with the damage and casualties from a catastrophic earthquake, and with the disruptions in communications, social fabric, and governmental structure that may follow" (FEMA, 1980). Coordination among overlapping jurisdictions, agencies, and levels of government dealing with the panoply of urban systems and services affected by an earthquake was also found to be inadequate. As a case in point, Oakland's Emergency Operations Plan is apparently not integrated into an earthquake mitigation decision-making continuum, but considered apart from land use planning approaches.

In summing up, California's code and guidelines ask for little more than an identification of seismic hazards. There is no quality control or approval process required for the elements (although they are submitted to the California State Division of Mines and Geology), nor do the guidelines provide direction on what additionally should be addressed. In view of the fact that California may be America's most sophisticated state in dealing with earthquakes and Oakland a typical example of a local government's approach, the absence of a well-developed concept of urban scale vulnerability in the U.S.A. becomes apparent.

Applications and Directions

Planners and urban designers could examine the possibilities of developing an "urban vulnerability index" which incorporates the variety of vulnerability determinants that have been previously mentioned—from geologic data; land use type, intensity and density; structural form, age, material, and size; spatial configurations; lines of access and services; general morphology; activity patterns; time envelopes; seasonal dimensions, to the magnitude of the event and others. Such a system could be particularly versatile if it were computerized to faciliitiate the development and execution of numerous scenarios and allow the manipulation of a variety of intervention or mitigation approaches. Since earthquakes will continue to be unpredictable events for some time to come, a vulnerability index would allow governments and individuals to target attention to those areas most in need of code enforcement, zoning changes, land use redistribution, restoration, or any of a number of alterations.

A more sophisticated vulnerability index should also factor in the economic and other costs of mitigation. In so doing, communities may develop a repertoire of mitigative responses that respond to safety, social, cultural, economic and political considerations and range from preparation, prevention to recovery. For example, in certain areas complete retrofitting or renewal may be economically infeasible and culturally, socially and architecturally undesirable. The community may then be willing to accept a higher level of risk exposure, but balance that with a greater emphasis on preparation for disaster and recovery should an earthquake strike. Residents or other users of the area may be the subject of an unusually intensive information campaign, "safe areas" may be provided for gathering and refuge following a disaster, temporary housing could be stockpiled, and a rebuilding strategy could be developed ahead of time so that important cultural and social attributes would be retained and extreme hazardous conditions eliminated.

The questions for urban planners operating in an international comparative context therefore revolve around new probes into:

1. Land use planning and regulation in disaster impacted urban areas considering the urban morphology and examining the applicability of existing regulatory and incentive measures to disaster mitigation, including institutionalized impact analyses. In addition, the effects of changes in land use management and seismic zonation, zero-lotline housing, and downtown development can be compared.

2. The vulnerability and rebuilding problems of the urban pattern considering: (a) land use densities and intensities, (b) nodes of activities, or centers and sub-centers, (c) the accessibility system, and (d) the upgrading of existing structures.

3. Building typology guidelines which inventory the urban fabric and volumetric aspects of the extent and character of building groups and develop classifications and evaluations of existing buildings along with methods of documentation and assessment. Respective international experiences in developing and applying various technical methods can be investigated such as Yugoslavian and Italian expertise in assessing and documenting their built environment and the American experiments with remote sensing, computerized as-built drawings, and computerized geo-based information systems.

4. Systems analysis of activity patterns, and the primary, secondary, and tertiary impacts of disruption.

5. Emergency planning and the continuum of hazard mitigation strategies for a range of earthquake magnitudes.

6. Preparation of risk and vulnerability maps, incorporating the time and tempo of urban activities and networking of service areas. Defining "acceptable risk" at the urban scale should be considered here.

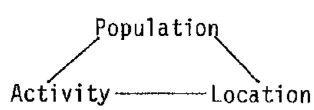
NOTES

[1]It should be noted here that this paper relies almost exclusively upon American examples to illustrate key points, but it does so within a framework that is designed to accommodate extrapolations to the international scene.

[2]All states have planning enabling legislation, but fewer require local jurisdictions to adopt plans, and fewer still specify their content by means of required elements.

[3]For exemplification of the use of proxy measures as described above and for comparative purposes, "land use intensity" relates to activity per unit area (not "density" per se) and involves considerations of: (1) quality - measurements of, say, volumes of traffic generated within given land use areas, (2) time shape, or the variations in such traffic, (3) zones of influence - hard or soft edges of activity areas, service or catchment areas, etc., (4) material effects - sensory perceptions of noise, odor, mass, bulk, opacity - and the like (Modified from A. Z. Guttenberg, "A Multiple Land Use Classification, Journal of the American Institute of Planners, August, 1959).

[4]The implications here have been debated, historically, extending from the works of those who have analyzed human activity patterns in space to those who have set up numerical models (August Losch, The Economics of Location. Yale University Press, 1945; Patrick Geddes, Cities in Evolution, Oxford Press, 1950 [Appendix 1, Part 2, details Geddes' extension of Frederick LePlay's "Place, Work and Folk"]). The framework and the questions coming forth are:



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(Indebted to Professor Barclay Jones and C. R. Wolfe, Graduate Student, Cornell University, for this example)

[5]One example which spans several of the four elements will suffice to illustrate the general point here. Ugo Morelli points out that the severity of the recent Italian earthquake resulted from: (1) The season and the time of day, in that at 7:35 PM on a Sunday in November, most people were at home preparing dinner and watching a soccer match. (2) The age and morphology of the towns, reflected in the unreinforced masonry construction with roofs of heavy wooden beams and clay tiles. Here is where a comparison becomes interesting. As Morelli goes on to state, in the United States, most homes are of wood frame construction making them resilient to earthquake damage and relatively safe refuges in the event of an earthquake. Unreinforced masonry construction, on the other hand is typical in Italian towns and prone to collapse from earthquake shaking. (3) The inability to muster aid quickly; thus, questions of responsibility become as important as physical mobility (Morelli, 1981).

[6]As a case in point, one can examine and compare how patterns of development, which might now be different, may be moving toward being similar. What are the experiences in formulating regulatory measures that tend to encourage recycling in an area where, historically, preservation has been going on, yet where conservation efforts are hampered by the development of outlying centers? A more pertinent question here is: given earthquake possibilities, what potential effects can be expected, what gross and fine alternatives exist for rebuilding and/or prevention? More pointedly, are the Yugoslav and/or Italian efforts at conservation of historic structures useful for comparison with the U.S. in this context? If not "historic," are the reuse potentials greater in those countries; are the regulatory measures more efficacious, but are our distribution (transportation) patterns more efficient? Given the necessity of rebuilding, what are the urban form implications within political, social, and economic constraints that make countries similar in some ways but different in others?

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This paper provides both an overview of earthquake hazard mitigation planning in an American setting and an initial definition of the concept of urban scale vulnerability. An abridged version of this paper was presented at the Third International Conference: "Social and Economic Aspects of Earthquakes and Planning to Mitigate Their Impacts" held in Bled, Yugoslavia, June 29-July 2, 1981.

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Planning and Regulation of Urban Development as a Means of Mitigating the Effects of an Earthquake

David J. Brower
Center for Urban and Regional Studies
University of North Carolina at Chapel Hill

The scales at which these hazards may occur vary widely. Ground shaking may affect hundreds of square kilometers, and surface faulting may extend for tens of kilometers. Landslides and soil liquefaction, on the other hand, may be limited to areas of a few hectares or less.

Even for more widespread hazards, such as ground shaking, experience has shown that the hazard intensity and degree of damage may change abruptly over distances as short as 0.5 to 1 km. Such variations have been attributed to local geology and soil conditions. The result is that urban areas in earthquake-prone regions are characterized by a mosaic of risk, comprised of the various risks associated with earthquake-related hazards, and in which the cells of substantially uniform risk are often quite small.

The scale at which earthquake risk is spatially heterogeneous has important ramifications for earthquake mitigation in urban areas, but only if the pattern of risk can be estimated with some degree of confidence. Unless we know how risk varies spatially, we cannot adjust mitigation measures to the different risk levels. Important advances have been made in seismic zoning and micro-zoning, to the point where the risks associated with some earthquake hazards can be estimated with a fair degree of confidence, but there is still a great deal of research that needs to be done.

There are several ways by which planning and regulation in urban areas can mitigate the effects of earthquakes:

1. mitigation through the design and construction of buildings

2. mitigation through the design and construction of public facilities

3. mitigation through other government programs intended to influence the rate, amount, type and location of future development.

These approaches should not be considered independent of each other, and are best designed to complement each other for each particular hazard. Different types of hazards and different situations will call for different mixes of these approaches as well as different specific measures within each. This paper will briefly introduce the first two and then discuss a method of designing a growth management system consisting of a combination of approaches.

MITIGATION THROUGH THE DESIGN AND CONSTRUCTION OF BUILDINGS

It is well recognized that the design of a building is basic to the way it will react to the stresses and strains placed upon it by an earthquake. It is probably not possible to design a building that is completely able to withstand an earthquake without damage. But it is possible to design a building that is "earthquake resistant." The extent to which it is resistent depends on how a number of goals are dealt with:

1. protection of the occupant

2. ability of occupants to evacuate after an earthquake

3. rescue and emergency workers must be able to enter the building

4. the building must be returned to useful service as quickly as possible.

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The public can influence the extent to which these goals are met by setting standards for the construction of buildings within the jurisdiction. This is done by means of a law, regulation, or ordinance called a "building code." Sachanski has reported on the experience with building codes:

> Since building codes influence to a great extent the earthquake resistance of structures by bringing into their design the results of investigations and experience, their role in controlling earthquake risk is of great importance. Not only do seismic activity, geological and soil conditions, methods of design and building, climatic conditions and building materials differ from country to country but also traditions, customs and economic and technical potential vary enormously. These differences lead to a great variety of building norms, standards and construction practices, and we can therefore treat only some of the main features of earthquake resistance codes.
>
> It must be borne in mind that norms for the design of structures under normal loading are based on three different methods—allowable stresses, rupture stage and limit design. The use of one or other method influences the real earthquake resistance of structures.
>
> The following conclusions can be drawn from the examination and comparison of existing earthquake resistance codes.
>
> No other norms in the construction field differ so much, not only in their form and content, but also by the various points of view in treating individual problems as do those applied in earthquake design. In general, the norms applied in 1973, though very different from those in force ten years earlier, offer considerably better prospects for standardization. Almost all are based on the dynamic method, some countries applying the basic principles of the U.S.S.R. norms, others those of the U.S.A., while a third group of countries adopted combinations of both U.S.S.R. and U.S.A. norms with some amendments. In the norms of some countries, seismic zones are indicated by numbers as 0,1,2,3 or letters as A, B, C without any indication as to magnitudes or intensities. In the norms of the majority of countries, the seismic coefficient is doubled from one zone to the next; in other countries this factor is only 1.2 to 1.5. The earthquake forces corresponding to a given seismic intensity, as defined in the norms, vary considerably from country to country.
>
> When defining earthquake forces, the majority of norms take into account the influence of various factors with different coefficients. Thus, while some norms take no account of the influence of ground conditions on seismic forces in the structures, others allow changes of 25% to 50% between two adjacent categories of soil. Only a few norms take into account the type of foundation. Some norms include a coefficient for design earthquake forces depending on the importance of the buildings. This coefficient has a very large range, from 20% to 100%, but it contains the idea of seismic risk as a function of return period. There are also differences in defining the part of the live load in calculating seismic forces. Some norms take into account the whole live load, others only a part of it, and the remaining norms do not consider it at all.
>
> While the methods involved in defining the general seismic force for the design of a particular building are extremely varied and complicated, the procedures used for determining the response coefficient and the coefficient of distribution are, despite some differences, relatively uniform. This uniformity is a consequence of the application of similar criteria based on the response of structures.
>
> Some norms use damping coefficients determined by the flexibility of structures. The detailing of these coefficients, which often include some other factors, requires additional proof.
>
> The determination of the natural periods of buildings is of great importance in choosing reasonable criteria for design. The majority of norms recommend empirical formulae for determining the natural periods of different kinds of buildings in both the elastic and the non-elastic ranges. The superposition of the strains due to seismic loads on those due to other loads (dead, live, snow, wind), as well as modal superposition, needs further discussion and definition in order to resolve the existing differences. Substantial differences also remain with regard to the vertical seismic forces to be used in the calculations of different structural elements.
>
> The problem of assuring sufficient resistance of subsidiary elements (balconies, consoles, chimneys, parapets, ornaments, independent walls) is treated in only a few norms, though it is an important aspect of earthquake-resistant design. Only a few norms treat the calculation of buildings for torsion, draft limitation, distance from adjacent buildings, etc.

These problems may be of decisive importance for the resistance of some buildings. Not all norms give structural prescriptions for traditional buildings. The limits of admissible strains in different materials (soil, masonry, concrete, steel) during earthquakes depend closely on the accepted design methods for basic loads but are determined by the real earthquake resistance of the structure and the seismic risk.

In spite of the substantial differences between the norms in various countries, standardization of the basic principles is possible. The results of the work carried out by the Working Group of the European Commission on Earthquake Engineering on the unification of norms is a proof of this. The requirements of the building code are intended to protect against damage in the event of moderate ground motions and against injury and loss of life in the event of a strong earthquake.

The cost of an earthquake includes not only the direct expense of repairing the physical damage, but also the indirect cost resulting from the interruption of normal productive activity and the setback to economic expansion. It is the goal of earthquake engineering to minimize the total cost over a given period. Although the provisions of building codes should be based on a cost-benefit analysis, earthquake engineering has not yet developed to the point where completely satisfactory cost-benefit studies can be made. As a result, very large long-term investments are being made in buildings and other structures without any knowledge of the cost-benefit ratio. Each country should analyze its own situation in this respect and decide at what level of damage prevention to aim in its building codes and regulations. An additional problem that requires special attention is the development of methods of inspection and control to insure that adequate strength and ductility are available in structures.

MITIGATION THROUGH THE DESIGN AND CONSTRUCTION OF PUBLIC FACILITIES

Three aspects of design and construction should be considered:

1. the use of public facilities to encourage development in less earthquake-prone, or seismically safe, areas. This will be discussed in a later section
2. the design and location of high-occupancy public structures, such as schools, sports arenas, etc. This is usually covered by building codes or other more specialized regulations of which California's Field Act, which requires state review of public school building designs for earthquake resistance, is a good example
3. the design and location of public facilities that will be needed in the hours and days following an earthquake

The latter group of facilities contains two basic types:

1. Single, individual facilities (hospitals, police, fire and emergency facilities). It is crucial that these facilities survive disaster; this involves a combination of design and location considerations (California's Hospital Act of 1972 requires that new hospitals meet certain standards of earthquake resistant design.) But facilities are useless without access, so it is equally crucial that these facilities be located, and transportation systems be designed, so that access to their service areas will survive
2. Utility "lifeline" facilities (water, electricity, gas, sewage, communication and transportation facilities). Seismic damage to these facilities is rarely a direct cause of loss of life and property, but damage can severely disrupt rescue and recovery operations and contribute to secondary disasters, such as fire and epidemics. There are three complementary components to designing earthquake-resistant utilities:
   a. earthquake-resistant design of individual components, such as highway bridges, buried pipelines, etc.; a great deal of research has been done, but much more is needed
   b. location of facilities to avoid fault lines, areas susceptible to liquefaction, landsliding, etc. as much as possible
   c. system or network design: design of utility networks with multiple connections and loops, so that if certain portions are damaged, other routes can continue to serve the area; multiple sources may also be desirable, as in the case of water supply systems. For example, the California Department of Transportation has identified 3,000 detailed freeway bypasses for the 650-mile urban freeway system in the L.A. metropolitan region, and published plans that doc-

ument these bypasses and identify roles of traffic, engineering and police personnel to put them into effect should an earthquake destroy part of freeway system. And Nippon Telegraph and Telephone Public Corporation (Japan) provides multiple telecommunication routes 50 to 100 km apart so that all available routes will not be affected by a single earthquake.

MITIGATION THROUGH GROWTH MANAGEMENT

During the past few years in the United States, there has been an increasing interest in growth management. Many communities have developed systems of regulations and policies for dealing with the problems and demands of growth. Growth management is defined as a conscious government program to influence the characteristics of growth and achieve community land use goals. The development of a growth management system involves five basic steps: (1) the determination of community goals; (2) the analysis of tools and techniques for goal achievement; (3) the adjustment of the management techniques to the community; (4) growth management system synthesis; and (5) monitoring for system effectiveness (see Figure 1). Although the process of system development is described step by step, in practice, many of the steps will overlap and will be undertaken simultaneously.

The first and most important step in developing a growth management system is the determination of community goals. The planning profession is often criticized for trying to decide what the goals of a community should be with little citizen input. Instead of deciding a community's goals, the planner should "discover" the goals of community residents. In this process of discovery, the planner should seek input from all the special interest groups which will be affected by the growth management program, but most importantly the planner should find out the needs and desires of all segments of the community's population. No matter what method is used, the final result should be a set or sets of goals which community residents feel the planning effort should achieve.

In a community seeking to mitigate the effects of an earthquake, it may be desirable to formulate two sets of goals: one to be used to mitigate the effects of an anticipated earthquake and another to be used to redevelop after the earthquake. The substance of the various elements of the system may change as well; a different set being triggered by the occurance of an earthquake. Experience in the U.S. and elsewhere has shown that in the absence of specific post-disaster redevelopment policies, urban areas tend to be redeveloped as they were before the disaster.

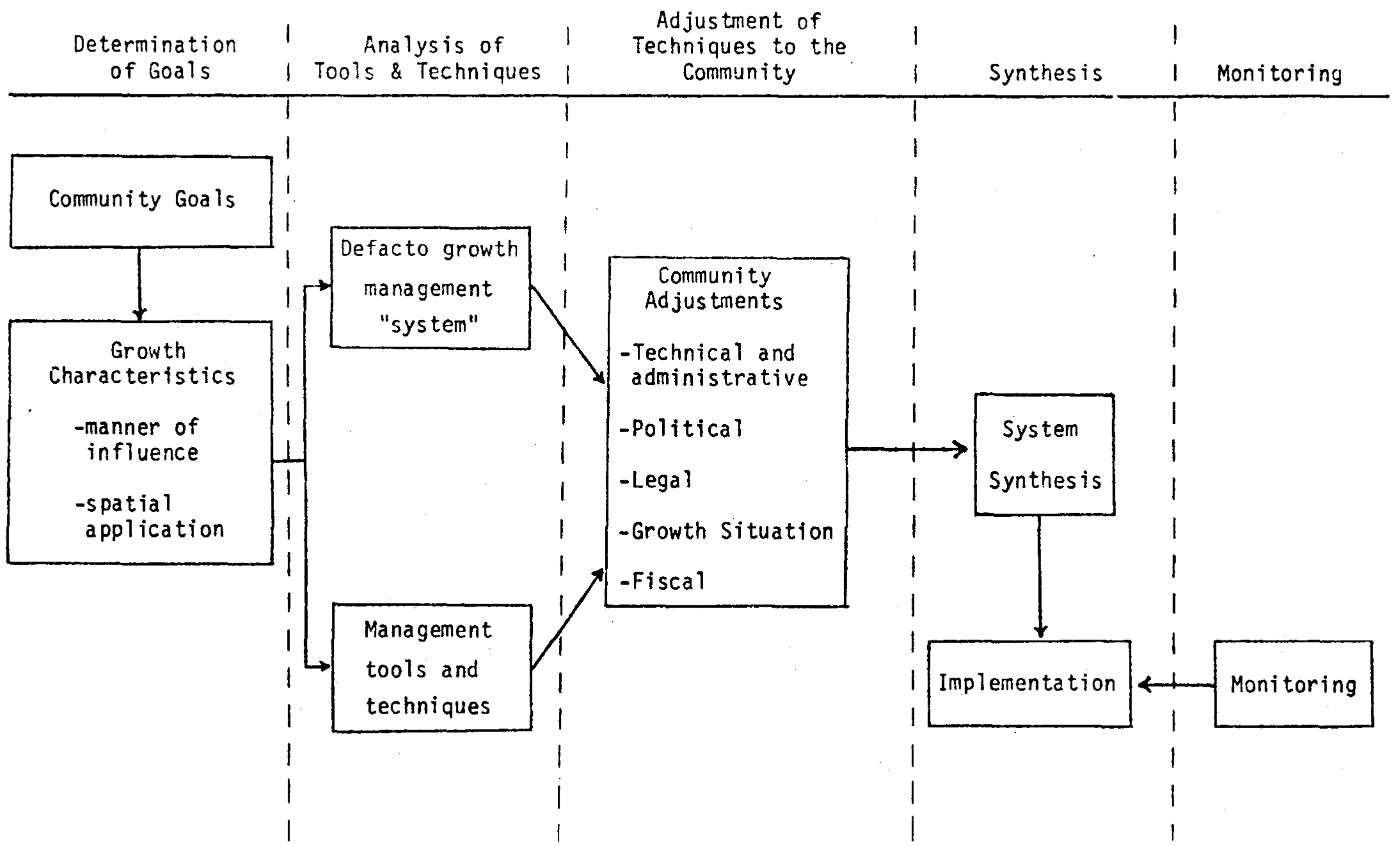
In addition to local goals, regional, state and national goals also may have to be considered in local growth management activities. For example, communities in the coastal zone may be required to plan for the protection of the land and water resources of the coast in accordance with the Federal Coastal Zone Management Act and state coastal management practices.

In the process of deciding the goals of the community, the geographic area of their application should be determined. This is especially true in communities with high hazard areas. Some goals will apply to the entire planning jurisdiction, while others will be concerned with specific areas which may be distinguished by the present availability of public services, present uses or special environmental characteristics. For example, a community may desire to improve the economic well-being of its citizens throughout its jurisdiction. At the same time, however, the community may wish to encourage industrial or commercial development in areas which already have similar uses while discouraging any development in environmentally sensitive areas. In essence, the community's goals have a spatial aspect that may require the adoption of different growth management tools and techniques for different parts of the planning jurisdiction.

Some communities may discover a single overriding goal which will be the dominant emphasis of the growth management system, and in such a case the process of system design will be much simplified. The residents of Sanibel Island, Florida, for example, are concerned primarily with protecting the environment of their fragile barrier island, so Sanibel's entire planning process and management system is based on preserving the integrity of the island ecosystems. In the case of Portola Valley, California, a primary focus was mitigation of the impacts of a potential earthquake and their growth management system was designed accordingly.

Before the community begins the process of actually choosing the components of its growth management system, all of the community's goals and objectives should be defined in terms of the characteristics of growth which must be influenced for goal achievement. If this is done during the comprehensive planning process, it will be very similar (and can be done in conjunction with) the development of policies and performance criteria necessary for the achievement of the community's goals. There are seven basic characteristics of growth that are influenced by the growth management systems:

Figure 1


Determination of Goals
Analysis of Tools & Techniques
Adjustment of Techniques to the Community
Synthesis
Monitoring
Community Goals
Growth Characteristics
-manner of influence
-spatial application
Defacto growth management "system"
Management tools and techniques
Community Adjustments
-Technical and administrative
-Political
-Legal
-Growth Situation
-Fiscal
System Synthesis
Implementation
Monitoring

1. the absolute amount or quantity of development

2. the type of development, both major types such as residential, commercial, industrial and open space and sub-types such as single or multifamily residential.

3. the cost of growth, either the economic costs, the manner in which these economic costs are distributed (distribution costs) or the environmental costs

4. the location of development, both the geographic direction of growth and the types of development which can take place on a particular parcel of land (site options)

5. the timing or rate of growth

6. the quality of development

7. the density of development

Each of the components of a growth management system will have an impact on one or more of these aspects of growth, so matching the community's goals to characteristics of growth directly related to their implementation is an essential step in choosing the tools and techniques for managing development. For example, suppose the community desires to encourage industrial and commercial development in areas presently served by public utilities. In order to achieve this goal, the growth management system will need to influence the type of development, the location of this development and perhaps the particular sites for development. In designing the management system, the community will want to choose programs, tools, and techniques which affect these aspects of growth.

In the process of matching community goals with the relevant characteristics of growth, the manner in which the characteristic is to be influenced should be determined. For example, a goal may require the density or quantity of growth to be influenced, and there are several techniques available for these purposes. Some of these techniques, however, tend to increase while others decrease the density and amount of development. The correct growth management tool or technique can be determined only if the community has decided how the relevant growth characteristics are to be influenced.

Once the goals have been defined in terms of the characteristics of growth, it is important to take stock of the community's progress toward its goals and the factors that have influenced aspects of growth that aid or detract from goal achievement. In essence, this step represents an attempt to understand the existing growth management "system" and the manner in which it is affecting the community's development. Even though a community has not made a conscious decision to manage growth in a particular way, existing local regulations, tax policies, federal programs and state laws work together (and sometimes against each other) to influence the type and patterns of development. When viewed as a whole, all of these factors form, what has been termed, a defacto growth management system. It is important to understand this defacto management system for several reasons. First, existing programs, policies, tools and techniques actually may be accomplishing most of the community's goals so that few revisions or additions to the existing system will be needed. In addition, communities often adopt a growth management tool or system of tools with no consideration of the factors which are already influencing development. Such an action may impose another layer of unneeded regulation, or the new tools actually may conflict with the existing system preventing the achievement of community objectives. Whether the defacto management system provides a base for or raises barriers to the achievement of community goals, it must be understood before it will be possible to develop an effective growth management system.

The first step in evaluating the defacto management system is determining its various components. Essential elements in this system, which are often overlooked, are federal and state programs that have both direct and indirect impacts on the different characteristics of growth.

In reviewing the federal programs which are part of the existing defacto management system, it is important to identify those programs with major impacts in the area and the manner in which they influence the characteristics of growth. Although a locality may be unable to change the focus of these programs, an awareness of their impacts may lead to adjustments in the management system and more effective and efficient achievement of community goals.

Much like the federal programs, existing state programs will affect the various aspects of growth and must be considered as part of the defacto growth management system. A state's decision to construct highways or acquire land for parks and other facilities influences the location, amount and quality of development.

In analyzing both the federal and state programs which are elements of the defacto management system, a locality may find that existing programs and regulations effectively accomplish a local goal. For example, a community which seeks to protect critical environmental areas might find that existing federal and state permit programs are more than adequate to prevent harm to fragile environments. In such a case, there would be no need for direct local regulation in this area unless the community desired to protect environments not covered by the state or federal programs. The locality might better concentrate its energies on supplementing the federal and state programs by designing performance standards for activities adjacent to critical areas.

In addition, the tax policies of various levels of government affect land use investment and development patterns. A community will have little control over some of these policies such as the encouragement of land speculation by federal capital gains tax rates, local property assessments and tax rates; however, they may have a substantial effect upon development. For example, although property tax rates may have little impact on growth when development pressures are great, when market values are stagnating, high property taxes tend to discourage investment in redeveloping areas. In reviewing the defacto management system, assessment policies and tax rates should be analyzed to determine their effect on land development and changed, if needed, to coincide with goal achievement.

The components of the defacto growth management system with the most potential for direct control of the land development process are existing local land use regulations and policies, as well as capital investment policies. In analyzing this segment of the management system, the planner should first determine the tools and techniques that are presently being used by the community. The purposes for which these techniques were adopted may not always coincide with their actual impacts. In cataloging the characteristics of growth influenced by these regulations and policies, both their actual and intended effects should be reviewed. This analysis can be similar to that of the federal and state programs and should include the characteristics of growth that are influenced, the manner of influence and the geographic area of influence. Even though a local zoning or subdivision ordinance may appear to aid in the achievement of community goals, the continuing failure to enforce the ordinance (for whatever reasons) or a tendency to permit variances from such ordinances may have results counter to goal achievement. This enforcement policy is as much a part of the management system as the regulations themselves and should not be overlooked in analyzing the defacto management system.

The final analysis of the defacto management system involves a comparison of the present effects of the system with the goals of the community. This can be done by matching the characteristics of growth that must be influenced for goal achievement with the characteristics of growth influenced by existing federal programs, state programs, and local regulations and policies. In some cases, the existing system may be achieving community goals, but there may be needless duplications which can be eliminated to make the system more efficient and effective. If the system is not achieving community goals, then modification of presently used tools and techniques may be in order. For example, if the existing zoning ordinance prohibits multifamily dwellings in areas where such housing is desired by the community, changes in height regulations, lot sizes, or use regulations will conform the zoning ordinance to community goals. If the present system, even with changes in the components, seems to be inadequate or incapable of achieving community goals, then additional tools and techniques will have to be analyzed for possible additions to the present system or for the development of a new growth management system.

Assuming that the existing management system is not achieving all of the community's goals, the next step in system development is an inventory of tools and techniques that might increase the system's effectiveness. The characteristics of growth that are relevant to each of the community's goals should be compared to determine the tools and techniques that might be used to achieve each goal (see Appendix). It is important to remember that although a tool influences a characteristic of growth which must be affected for goal achievement, it may not affect the characteristic in the desired manner. For example, if the community desires to encourage increased densities in the developing area of town, there will be several tools that influence the density of development such as: the transfer of development rights, conventional zoning, minimum lot size, height restrictions, bonus zoning, performance zoning and maximum lot size. Minimum lot size, height restrictions and performance zoning, however, tend to limit density and would not help in the achievement of this objective. After this review, there should be a list of tools and techniques that can be used individually to achieve each of the community's goals. The sole purpose of the inventory is to discover all the tools and techniques that might aid in the achievement of singular community goals; refinement of the tools to local needs is left until later.

After the inventory of growth management tools and techniques is completed, further analysis should reveal the techniques that are most practical for local use. Theoretical management system formulations coordinating various tools may seem to accomplish community goals, but if the system components are not acceptable to the local community or within the community's capabilities, then the system will not be successful. At this stage in management system development, an attempt is made to limit consideration to those tools that are compatible with the local situation. Those tools which do not seem acceptable in their present form should be analyzed to determine if some variation would result in more compatibility with the community's environment. If a tool is still unacceptable, it should be placed in a reserve of possibilities since it may become very appropriate as the community's composition and growth pressures changes.

In choosing the tools and techniques which are most appropriate for the community, each technique should be viewed in relation to several factors: (1) the technical and administrative expertise available to the locality; (2) the local political situation; (3) the local status of the technique; (4) the community's growth situation; and (5) the fiscal resources available to the community.

Each tool in the inventory will require a certain level of technical expertise and administrative capability. In a small town, management techniques which require extensive planning studies, environmental monitoring and design evaluation may be ineffective because of the lack of technical support. This may not be a major constraint, however, if a locality is able to obtain technical assistance from state or regional planning agencies. Even if technical assistance is available, administration of the permit and appeal procedures which accompany many of the newer, more flexible management techniques may overwhelm a community which presently uses part-time inspectors and citizen boards in land use regulation. At the same time, a permit procedure based on clear standards that can be easily managed by existing personnel may form a key part of the community's final management system.

After the inventory of possible growth management tools and techniques has been evaluated in terms of the community's characteristics, there will be a list of techniques that are particularly attuned to local conditions. In most cases, there will be several appropriate tools for achieving each of the community's goals. If, however, all the tools that influence a growth characteristic of particular concern have been eliminated, these tools should be reevaluated and restructured in terms of local conditions.

At this point, the process of growth management system development should have resulted in several products. There should be a list or lists of community goals and the characteristics of growth that must be influenced for goal achievement (along with the manner and area of influence). Corresponding with each of these goals are tools and techniques that are compatible with the community's environment and will be effective in goal achievement. In addition, there should be a compilation of federal and state programs that influence the community's growth. The next step will involve the blending of these products into the actual growth management system.

The state and federal programs that are beyond local control are good places to start in the development of the actual growth management system. As mentioned previously, such programs may have influences that must be countered by the community, or they may preempt the need for local action in regard to a particular goal. From this basis, several alternative management system formulations should be developed by putting together various tools and techniques needed to achieve each of the community's goals. One of these alternatives might include only those tools that are presently used in the community (relying heavily on the defacto management system), and others would be comprised of various combinations of old and new management techniques. In developing each alternative system, different management techniques might be used for each goal; however, tools that can be used to achieve several goals are preferred over single-goal tools since systems with fewer tools to coordinate will be easier to administer and probably more effective. In addition, tools and techniques that supplement and complement each other should be used together. For example, a preferential taxing scheme would ease the burden of use restrictions placed on land in very restrictive zones and might reduce the political pressures for changing such classifications. While complementary tools will be helpful in system development, it may be desirable to avoid using techniques in combination that affect the same characteristics of growth in the same manner. It would seem to make little sense, for example, to establish performance zoning to prohibit certain types of development while adopting conventional zoning to prohibit the same uses. In most situations, such combinations only detract from system efficiency, but they may be necessary to manage rapid growth. Because the community may have numerous goals, the techniques for the achievement of these goals may appear to conflict when first combined in the management system. Many of these conflicts will be resolved by the geographic or spatial application of the particular techniques (i.e. according to the area of the goal's application) or by a restructuring of the individual techniques. Some tools may conflict, however, because community goals are inconsistent, and such conflicts will be resolved only if the community adjusts its goals or reorders its goal priorities. Needless to say, the process of combining various tools and techniques into a system that achieves all the community's goals is a most difficult step requiring the coordination of complementary tools, elimination of duplication and the resolution of inconsistencies.

Once alternative growth management systems have been developed, a system should be chosen for implementation based on effectiveness and efficiency. The main question in gauging effectiveness is whether or not the system will achieve community goals. The standard of system efficiency will vary between communities and may involve review of the cost of implementation, the time required for development approval under the system, or the number of new personnel required for implementation. Although a planning staff can predict the effectiveness and efficiency of a particular combination of technqiues, the actual selection of a growth management system will take place through the political process and may be tested by the legal process.

Once the growth management system has been implemented, some means of monitoring its effectiveness should be developed. This might involve the collection of detailed statistics concerning housing starts, government expenditures and other factors on a weekly or monthly basis, but in its simplest form, such an evaluation would ask periodically whether or not community goals are being achieved. Such a procedure is necessary since the management system may not have the desired impact either because of misjudgments in system development or because the pressures for development and community goals change over time. With some form of monitoring, deficiencies in the system could be recognized and adjustments made in the actual implementation process or by selecting new management techniques. Without periodic evaluations, a growth management system may be no more dynamic or effective in achieving community goals than pre-system land use regulations.

CONCLUSION

Growth management does not have to be restricted to those localities that are facing heavy development pressures, but can be used to meet the demands of many levels of growth. It is clear that methods exist for managing growth on the urban scale. Whether the goals set within a given community are effective in mitigating the effects of earthquakes will depend on the political will of the community, the ability of the scientific community to predict the occurrence of an earthquake, especially spatially, and the skill of the planner in combining all of this into an efficient, effective system.

		TYPE		COST			LOCATION				
ACQUISITION	QUANTITY	Major Type	Sub-Type	Economic	Environ-mental	Distri-bution	Direction	Site	TIMING/ RATE	QUALITY	DENSITY
Fee Simple Acquisition					X	X		X			
Acquisition of Less Than Fee Interests					X	X	X	X		X	
Advance Site Acquisition				X			*	*			
Growth Management Land Bank	*	*			*	X	X	*	X	*	*
Transfer of Development Rights	X	X	X		X	X	X	X			X
Compensable Regulation											
SPENDING											
Capital Programming	*			*	*	*	X		X		
Urban & Rural Service Areas	*			X		X	*		*		
Annexation	X			*	*		X		X		
Development Timing				*		*			X	*	
TAXATION											
Special Assessment						X					
Preferential Assessment of Property						X		X			
Land Gains Taxation						X			X		

DEVELOPMENT REGULATION	QUANTITY	TYPE		COST			LOCATION		TIMING/ RATE	QUALITY	DENSITY
		Major Type	Sub-Type	Economic	Environ-mental	Distri-bution	Direction	Site			
Interim or Temporary Development Regulations									X		
Conventional Zoning	X	X	X		*			X			X
Exclusive Agricultural or Nonresidential Zones	X	X		*			X				
Minimum Lot Size	X		X		*						X
Height Restrictions	X		X							*	X
Conditional and Contractual Zoning					X	X		X		X	
Special Exception			*	X	X			X		X	
Bonus and Incentive Zoning	X		*	X	X			*		X	X
Floating Zones			X					X			
Performance Zoning (overlay)					X			X		X	
Performance Zoning (without conventional zoning)	X	X	X		X					X	X
Planned Unit Development (PUD)		X	X	X	X			X		X	
Cluster Zoning				X	X			X		X	
Traditional Subdivision Regulation				X	X	X		X		X	
Off-site Subdivision Regulation				X	X	X	X		X		

DEVELOPMENT REGULATION (continued)	QUANTITY	TYPE		COST			LOCATION		TIMING/ RATE	QUALITY	DENSITY
		Major Type	Sub-Type	Economic	Environ-mental	Distri-bution	Direction	Site			
Total Population Provisions	X										
Annual Permit Limits									X		
Official Mapping				X				X			
Mandatory Low Income Housing Construction Ordinance			X			X					
Regional Fair Share Housing Agreements			X			X					
Maximum Lot Sizes	X		X								X
Building Codes										X	
Regulation of Mobile Homes			X					X			
Municipal Enforcement of Restrictive Covenants		X	X		X			X		X	
Local Environmental Impact Statement					X			X			

Regional Planning and Safety Measures Against Earthquakes

Giuseppe Imbesi
Facoltà di Ingegneria
Università di Roma

INTRODUCTION

Is it possible to adequately account for earthquake risks when developing regional policies? If so, what would the prospects and limits be? What methods, means and techniques should be used to investigate the vulnerability of buildings on the one hand, and to mitigate the damages that such buildings would undergo if involved in an earthquake on the other?

This research area attempts to provide answers to these questions and to clarify the exact meaning that urban planners attach to the terms and phrases "earthquake risk", "vulnerability" and "mitigation of damages".

It is worthwhile stating that we are still not in a position to point out the operational aspects of the ways in which the research may develop. It is still in its infancy and I expect that much help will come from the contributions to this seminar which will be critical in identifying such guidelines. I think this is particularly true for this research area, at least much more than for others.

Consequently, this report gives only a range of indications of the problematic type, starting from a comparison between the following two realities:

(a) the Italian regional structure and its relation to a variety of relevant resources;

(b) the constituent parts of the process of regional intervention, both at the present time and for the future.

The latter represent the operational framework or setting within which there is the interaction between the decisionmaking system, the technical-administrative authorities, the behavior of economic operators and citizens, and the system of regional resources. These are analyzed with respect to the urban planning implications of earthquakes as well as natural disasters from a more general standpoint.

In other words, this report has been structured as a "grid", and a definition is given of only some of the basic crossing-points. Within this grid, answers to the questions made at the beginning of this paper will later be placed together with the operational proposals that may emerge from this seminar.

It must also be pointed out in this introduction that this line of conduct has been chosen because of the insufficiency of the content of the idea of "research" from a general standpoint; and in particular, because regional and environmental sciences are still not in a position to provide solutions with means of their own to these complex problems since there has not been sufficient systematic work in this area.

Indeed, besides scarcely reliable deterministic assessments in this field, a certain number of external factors must be borne in mind (such as costs, the time required for developing designs and investigations, implementation inertia, etc.) which have not yet been exhaustively examined. On the other hand, it is quite obvious that regional planning can define its standards and criteria only after the establishment of the interrelations between its techniques and those of the multiple constituent sectors.

1. CURRENT RESEARCH IN ITALY: OBJECTIVES AND MAIN FEATURES

The earthquake that ravaged most of the region of Campania and Basilicata last November once again focused the attention of technicians and researchers — if there was any need of further evidence — on the problem of how "frail" the Italian territory is and how helpless it is when exposed to earthquakes.

At that time there was a rather small number of research projects underway on the issue, especially on the urban planning implications. Apart from the Geodynamics Project of CNR started in 1976 aimed at making a seismic map of the country, all other initiatives were related to the solution of design problems. A large number of regional plans and urban plans were put forth, with an objective of rationalizing the reconstruction of the buildings and towns that had been destroyed.

Just as for the more recent earthquakes, on that occasion there was a crescendo of special measures and activities that stemmed from the need to provide a more organic framework to the "emergency" problems. The recent Code on civil protection represents a further attempt to rationalize and give "dignity" to the criteria used for organizing aid to the people affected by disasters and for taking necessary measures to return the complex production mechanism into operation.

Regarding, instead, the "reconstruction" of towns, as had occurred after the Friuli earthquake, researchers focused the bulk of their attention on trying to promote greater industrialization of the house-building procedures. This is to be considered in relation to the influence of research bodies and institutions affiliated with larger building enterprises.

It was immediately self-evident that the severity of the earthquake which encompassed such a large and varied territory had broken down the already precarious social and production system, not only throughout the "emergency" period but also afterwards for a period of up to ten-fifteen years. Moreover, the imperative need to "reconstruct" had to come to terms with the problems deriving from the social tensions caused by the lack of jobs, the disruption of the social structure and from the appearance of an economic "leadership" of the mafia type.

Thus, the apparent certainty of initiatives based on the one-to-one correspondence between "destroyed towns" and their "reconstruction" has ceased to be.

As can be inferred from the remarks made by close observers, there appears to be a second phase characterized by greater caution in the attempt to understand the complex facets of the problem before isolating each single part for a technical and operational approach. In this connection, it is worthwhile involving some groups of urban planners and sociologists for a better knowledge of the broad spectrum of social, economic and physical components affected by earthquakes and understanding the causes that have brought about on the one hand, the solution of continuity of the habitat transformation process, and on the other, the appearance of such considerable phenomena of economic regression and regional crisis. These motivations also account for the importance that has now been attached to the preventive assessment of probable effects of natural catastrophes.

Even though the methods used in regional planning entail difficulties and uncertainties, reference is often made to them when a review process for a scientific purpose is undertaken, aiming at interrelating factors that have so far been heterogeneous, such as earthquakes, habitats, economic systems, and community life. This could be the starting point for seeking acceptable solutions.

A first look at the papers, other evidence and initial findings of recently initiated research[1] shows that there are a variety of ways of interpreting the whole problem, each of which point to broadly different objectives and attitudes.

On the one hand, there is room for fruitful examination of conscience on the implicit shortcomings in the culture of our country, deficiencies of a general nature as well as specific deficiencies in the sector.

In one of his last essays,[2] Campos Venuti holds the political culture — interwoven with "firm beliefs" but lacking "knowledge" — responsible for the lack of capability to seriously deal with habitat problems in relation to natural disasters. Thus he points out that the "incapability" of the present government to cope with the "emergency" surfaces immediately, and furthermore it is unable to take the necessary practical steps "to avoid the disaster and to decide what must be done to avoid future catastrophes". Moreover, this situation is attributed to the "long-standing imbalance in Italy in favor of humanistic-literary knowledge and to the detriment of scientific-technical knowledge": an imbalanced relationship, that is in the cultural setting between the "sciences of man" and the "sciences of nature".

Instead, the report, made by the authors of the special project for geodynamics to the Senate of the Republic on December 10, 1980,[3] focuses on a criticism of the "planning and organizing incapability of public bodies accompanied by a very poor sensitivity of scientific people towards social issues". The fact that the operators of the project had come to the "conviction that State bureaucracy and political power were incapable of acquiring, within reasonable delay, the necessary awareness of the terms of the problem" was of extreme severity.

Both these remarks lead to an additional point which concerns the splitting of the process of scientific acquisition which still prevails in our country, and concurrently, the segregation of various operational fields. Such features have so far led to the development of sectorial research programs and activities that do not inter-communicate. This situation then comes into conflict with the complexity of the regional organization and with the need for interdisciplinary regional planning methods.[4]

Finally, with respect to the degree of knowledge in this sector, other statements made in Grandori's report appear to be of great importance. "The process of adapting buildings to seismic principles in various regions had, until a few years ago and virtually until today, been based on a clearly antiscientific logic".[5] Only the occurrence of an earthquake attaches the label of "seismic area" to the territory of a Commune, and therefore from that moment onwards antiseismic criteria are to be followed for the new buildings. What is completely lacking is a seismo-tectonic knowledge and an historical analysis of the earthquakes that occurred in the past, in order to be able to identify areas exposed to high seismic risks.

The research initiatives that are being undertaken point to differences that are linked not only to the different scale used for observing the phenomena, to the standpoint from which analyses are made and to the main interest of the group of researchers, but they also outline an interpretation which is general in nature and which is worthwhile emphasizing. Such initiatives are different according to the role attributed to the man-nature relationship.

In some cases there is a tendency to provide all-inclusive answers to the problem through planning and its tools: one sees the viability of making good plans, of supplying exhaustive rules or codes for developing buildings with acceptable risks, of rebuilding the region "tout court". This guideline yields research work in which one can identify, like in a filigree, passwords such as "what there was, how it was, where it was"[6] or systems of global and definitive knowledge of the "community unconscious" that techniques can now control.

This is one way of getting over the misfortunes that oppose man and nature and that cannot be solved because of social, political, economic (and even ethical) reasons. Man is in a certain sense accused because of his inability to keep nature in check.

Other research work starts off by accepting that the relationship between man and nature has never been solved. In this latter case, there is an awareness of the limits of the possible actions according to the available resources and the level of scientific knowledge that can be attained in an adequate period of time.[7]

This does not mean that the latter approach denies the need to "reconstruct" or to "concede". This must be confirmed because quite often an earthquake involves interests and situations that are directly related to the entire building stock, and therefore it would be better to relocate out of that particular region. This, however, would mean large displacements of people into areas where the processes of capital accumulation are more convenient. This is not a fatalistic standpoint.

Rather, observing the frequency with which earthquakes occur as well as other natural disasters makes us aware that we cannot ignore their existence.[8] It is by now evident that natural disasters still play a critical role. However, they tend to have a greater impact on the habitat as this role becomes more complex and articulated; as if the "machine for living" that we are building becomes increasingly weaker and liable to get jammed for a speck of sand. Therefore it is necessary to constantly review, through a dialectic and critical attitude, the relationship that one manages to set up with the environment.

2. REGIONAL ORGANIZATION AND URBAN PLANNING: GENERAL FEATURES

The need to make correct correlations between the problems of the disciplines that deal with earthquakes and those of disciplines that have implications for planned regional activities invites us to define some of the terms that will be used throughout the research.

An effective interpretation takes the <u>region</u> as being a structured set of resources as <u>well</u> as a resource itself. In its turn, a <u>resource</u> is any natural or artifical element (due to man's intervention) whose use — either present or potential — has the capability of being used for a purpose or that can be used for performing functions that are related to human activity.

This definition adds to the word region not only the common meaning of being a localizing substrate (the "place", the "site") and that of being a functional and spatial link between different places ("regionality"), but also the meaning of "utilization value" which naturally belongs to it. Because of their nature and the interrelations then bring about, all the elements that make up the territory (and therefore all the regional resources) become "goods" since they are indispensible factors for man's activity. Furthermore, it must be pointed out that such "goods" are rather "scarce", that is there is a limited availability over space and time for reasons pertaining both to the relation between "demand" (expanding) and "supply" (which is depletable, as in the case of natural resources) and to economic factors, that is the cost to be incurred for using, processing and re-integrating them.

The phrase "regional organization" instead describes the way resources are dispersed throughout a region — the physical and spatial characteristics of resource location (not only in terms of quality but also in terms of quantity) and interrelationships.

In defining the measures to be taken, the close connection existing between regional resources and the economic-productive structure is rather evident. Thus it can be stated that the regional organization undergoes changes in order to adapt to the structure of production relations (as the site of such relations, as a productive source, etc.) and conversely, the regional organization itself can continue the evolution of such relations due to its intrinsic characteristics and history.

Thus the terms region, resource, regional organization can be called both the "datum" of the intervention process and its "effects" as well.

Even instrumental hypotheses of analytic methodologies establishing "just like for any other real object, the structural laws that regulate its existence and transformation as occurs with any other element of a historic reality",[9] are required for the spheres of disciplinary autonomy that are identified through the above mentioned definitions.

Consequently, an appropriate definition can also be given of regional urban planning.[10] Indeed, the latter can be defined as being the tool — a conceptual one before being an operational one — through which the regional organization can be optimized with the aim of achieving certain general and specific sectorial objectives. This can be done by means of a series of interventions and controls that help "anticipate" the changes through stepped implementation over time.

This definition implicitly entails two features. The first is its "public nature" which permeates the objectives of the planned intervention (and therefore considers the public body to be the natural referer of the regional "management") and makes us view the actions of the plan as closely dependent upon the aims that society has set in a precise historic moment. The second feature is that of the "complexity" which is inherent in the attempt made through planning to deal with sectorial problems (whose solution necessarily consists of distinct achievements in space and time) from a global and unitary standpoint. This entails the need to make synthetic assessments of the complex problems being dealt with.

3. INITIAL GUIDELINES FOR RESEARCH

When an earthquake occurs we are overwhelmed by the feeling of total destruction — of men, things and nature being wiped out. Then we are faced with the laborious task of having to start all over again.

This is a misunderstanding which must be clarified.

Even after the most disastrous earthquake, the most important thing is what still exists and can somehow be used again. This always holds true and is even more meaningful today, first because buildings, infrastructure and connection networks are built following criteria of greater safety, and second, the complex functional relations that make up the organization are not just contained in the physical area involved in the earthquake.

It is thus necessary to refer to the regional organization and to its "history" in order to find correlations between "seismic risk", and the "regional planning process". In particular, the working guidelines for a more thorough approach to this section are:

(a) to identify the criteria for aiming at assessing the seismic "vulnerability" of the regional organization or of its parts, and

(b) to choose types of initiatives to successfully counter its disastrous effects.

On the basis of the definitions made in the previous paragraph, it is possible to provide some initial guidance. However we are still speaking in strictly general terms since a better outline of the objectives to be achieved and of the contents of the operations to be performed can be done only after more exhaustive investigation of the environmental characteristics and an inspection of the methods, techniques and tools for the purposes of regional interventions that are organized in an increasingly organic manner — in our country as in many others.

A concept which by now has been accepted by everybody is that earthquakes — events that are caused by natural processes — are a part of the environment whether inhabited by man or not.

Consequently, earthquakes should be taken into account just like any other factor or element that makes up the regional organization and determines its transformation.

From this standpoint then, the planning process must also be an expression of the inputs relating to earthquakes and to their effects.

Some specifications must, however, be made.

First, it is high time to change the cultural practice adopted so far by which earthquakes are taken as being entirely fortuitous, external factors that only occasionally interact with the urban environment and are to be coped with by resorting to exceptional measures and interventions if they cause damages that exceed the minimum "threshold of public attention".

In addressing this needed change it would, however, be a mistake to consider the "earthquake risk" only as a conceptual category to be used in a restrictive manner without fully exploiting the potentials during the regional planning stage, and only limiting the maximum height of buildings, increasing the distance between buildings, decreasing housing density, etc. This approach would not be fully satisfactory if searching for a solution from the town planning point of view because it would not provide the means for having a say when making qualitative organization choices nor when the best resource use decisions are being taken. (For example, consider how variable the geomorphologic situation is in Italy and the narrowness of the coastal strip along most of the Tyrrhenian coast). At the most, this sort of approach would mean reducing the contribution that could be made by planning to the mere compiling of codes and typology schemes for settlements. It ignores the conditions of the territory and their probable evolution and pays attention only to the new buildings that can be built. It would be enough to examine implementation policies for which a final historical evaluation could already be made and determine the implicit limits to this way of proceeding.

Let us consider, for example, the current settlement structure of most of the urban centers in the provinces of Messina and Regio Calabria that were reconstructed after the 1908 earthquake. By observing the ways in which the urban planning schemes have developed which comply with the projects and seismic code issued from 1909 onwards, one can immediately see the limits of these initiatives that did not account for the original environmental conditions nor the dynamics of the urbanization processes that have occurred over time. Building heights have gradually increased (from the original eight meters to the current twenty-one and even more) whereas the distances between them have virtually remained the same due to the flexibility of the building regulations as compared with the urbanistic rules. The orthogonal grid scheme of the road network has proved to be more rigid and permanent when compared with buildings. Furthermore, urban expansion has encroached upon soils that are not flat, but often steep slopes that are not very stable. Finally, entire new districts arose to replace the former "bidon-villes" from many European countries immediately after the earthquake.

As time passed, building criteria based on the reduction of costs (and here annuities secured by real estate play an important role) prevailed over the original ones based on safety and the technical rationale of the design process.

The second point concerns the approach which only assesses the independent influence of certain natural events (landslides, earthquakes) on the habitat.

On the one hand, this prevents us from appropriately assessing the complex interrelationships existing between the various natural phenomena that occur and their dynamics; and on the other, it once again promotes the development of sectorial plans and projects to "regulate" them (such as catchment basin projects for flooding) or provide a "defense" from probable damages (such as hydrogeologic defense, the protection of coastal strips, and so on). Their effects have often proved to be negative, or in any case slightly relevant for the onset of contraindications).

We must then constantly recall the close relationship existing between the various natural events and try to assess the impact they can have either as a whole or individually on the habitat, both under normal conditions and above all, during exceptional cases such as natural disasters (earthquakes, sea-quakes, floods, landslides, volcanic eruptions, etc.).

Besides, since major disasters can cause similar behavior over more or less large areas prompts us to consider both the degree and the characteristics of the possible "risks" according to comparable parameters. Also, quite often, the occurrence of one natural event increases the "risk" factor or probability that another disaster may occur.

Obviously this does not mean one refuses to acknowledge a disciplinary autonomy for the study of individual natural events regarding the specific knowledge of how they work, the analysis of their components, or the arrangement of certain intervention projects. Rather, this means that within the disciplines involved in planning there should be an effort towards integration and for interdisciplinary exchange that leads to the development of common working methodologies and operational tools for solving territorial problems.

For example, this spirit is present in the working methodologies proposed by the CNR Geodynamics Project where offers are made to territorial sciences and to planning in particular. In addition, giving preference to investigations aimed at "forecasting" earthquakes rather than "predicting" them allows the needs of seismology to blend with those of territorial sciences. This will become even more possible if an effort is made to integrate thematic map-making (shakeability maps, seismotectonic maps and other statistical processes, including "microzonation") at all levels and according to the practical needs of town planning.

NOTES

[1]See Annexe.

[2]G. Campos Venuti, Dopo il Terremoto. Una Cultura per il Terremoto in "Problemi della Transizione", June, 1981.

[3]Senato Della Repubblica, La difesa dei terremoti, esposizione dei problemi G. Grandori and F. Barberi, at the 10th December 1980 Session.

[4]AA.VV. Problemi di formazione per la gestione delle risorse territoriali. RS 25, FORMEZ, Roma, 1978.

[5]See note.

[6]In this connection it is worthwhile recalling the categorical "imperatives" imposed on reconstruction in sites damaged in the war, particularly those town districts destroyed by bombardment (Coventry, Warsaw, etc.).

[7]B. Gabrielli, Il terremoto e gli urbanisti. Occorrono piani?, in Campo, No. 4/5, 1981.

[8]In Campos Venuti's above mentioned essay, paraphrasing a well-known statement he says "it is necessary to learn to live with earthquakes".

[9]M. Castels, La questione urbana, 1974.

[10]In the present Italian cultural situation, this phrase has an implicit ambiguity which dates back to the original distinction between town and territory or region. In practice, this ambiguity appears now to have been overcome. Beyond theoretical assertions this has occurred above all for the contribution made by the recent developments following the introduction of regional governments in our country.

The Contribution of Urban Planning to the Mitigation of Urban Scale Vulnerability

Alberto Clementi
Facolta di Ingegneria
Università di Roma

Preventive crisis management, as a political action, is fully operational only when capable of reacting with flexibility to the recurrence of risks within the complete system and of tackling with priority the problems which may give rise to the most serious hazards (...). This means that although the social groups which are experiencing a structural crisis cannot reverse the consequences of such a crisis to the stability of the system, they have fewer possibilities of obtaining adequate intervention assistance from the State.

(C. Offe, 1978)

The purpose of this document is the study of some problems regarding the adjustment of urban planning methods in earthquake hazard prone areas and the determination of their degree of coherence in relation to public policies.

The scale used as a frame of reference is that of the city itself and its internal components.

1. SOME ACQUIRED CRITERIA OF URBAN PLANNING TECHNIQUES IN EARTHQUAKE RISK MITIGATION

Urban planning can, in some instances, affect economic and social processes which determine spatial variations. It is, therefore, a useful tool for developing policies aimed at earthquake disaster mitigation, as well as one of the objectives of preventative measures such as: a. reducing potential earthquake risk; b. minimizing the consequences of seismic events; c. limiting the environment affected by earthquakes; d. facilitating relief operations in the emergency phase; e. permitting the proper functioning of the city immediately after the earthquake; and f. facilitating the city's reconstruction operations.

With regard to these objectives, urban planning involves intervention criteria and tools characterized by various levels of effectiveness. In general terms, one may assert that whenever there is a problem of selecting the locations and strategies for developing new settlements, the effectiveness of urban planning reaches the maximum level. It is actually possible to direct development, avoiding the most hazard-prone areas and selecting the most suitable soil classes and building types in order to mitigate possible earthquake disasters. Whenever the problem primarily concerns adaptation of the already existing city, the effectiveness level drops, since it is not possible to rely on massive changes in the built environment where there are higher priorities for the use of limited resources.

Thus, when new settlements are to be built, the effectiveness of the project depends on the optimization of the locational, functional, typological and structural requirements of the new developments. In the case of development in existing cities, the effectiveness of the project depends on the possibility of increasing the resistence of the urban structure to earthquake shocks by means of measures which do not deal with locational changes of individual components but the "systemic" functioning of the entire urban structure. This is accomplished not only through physical actions, but also through functional re-organization and better management of the existing structures. In this case, physical urban planning tends to become only one part of a broader planning and management process where the goal is to improve the general safety conditions of the city and its inhabitants.

To date, approaches to earthquake hazard mitigation, seem to have concentrated in the construction sector "ex novo" which, in fact, is characterized by sufficiently reliable planning criteria.

When developing a city plan at a local level, Ciborowski proposes the following criteria to minimize earthquake risk: a) organizing land use depending upon the foreseen degree of hazards; b) avoiding multipurpose settlements due to the extra hazards involved; c) introducing adequate green belts between productive areas and residential sectors, yet separating the reresidential units by open space corridors so as to limit fires which frequently occur after earthquakes and to ensure emergency evacuation of the occupants; d) decentralizing tertiary activities within the city; and e) maintaining a low development density in accordance with the economic and technical constraints which characterize local situations (Figure 1). With regard to the road system, the urban plan should provide for effective performance even in emergency situations, both for resident evacuation and access for relief vehicles. Networks having several entrances/exits and routes crossing the settlement area will be preferred. These should be larger than needed to accommodate the flow of traffic in normal conditions.

Network systems will also be preferred for water distribution. Special reservoirs or emergency tanks for use in extinguishing fires and other purposes immediately after the disaster should be provided for.

Ciborowsky's criteria derive from an empirical knowledge of past experience. Although the theoretical assumptions have not been fully examined (i.e. is it true that multipurpose facilities increase urban scale vulnerability?) they appear ready for practical application in city planning for earthquake hazard-prone areas.

Projects for reducing the vulnerability of the already existing city (especially within historical centers) have not yet reached an advanced stage. The delay may be due to several reasons. First of all, until today attention has focussed on reconstruction problems following earthquake disasters. Furthermore, the so-called culture of "unlimited growth" strongly influenced city planning practices and ideologies in past years. It was believed that the housing problem could be solved only by building new homes. In addition, it was implicitly assumed that earthquake destruction raised only the problem of reconstruction, overlooking the fact that the quantitative growth of the city gave less importance to the problem of the conservation of the old city. Yet, the fundamental reason is that preventive action to reduce vulnerability involves the investment of both public and private resources, as well as a number of problems of transferring costs that may give rise to conflicts among the individuals involved.

Since there appeared to be no political advantages, one may assert that it was preferrable to manage a posteriori the effect of earthquakes, although this implied more failures and inestimable human costs.

Have the objective conditions that curbed the development of research and discouraged city planning's contribution to earthquake hazard mitigation remain unchanged?

This question may be answered by considering the specific conditions which characterize city planning in different national contexts.

2. BACKWARD CITY PLANNING PRACTICES AND NEW PROBLEMS: THE CASE OF ITALY

Even with the recurrence of severe earthquakes, in Italy there are no advanced urban planning techniques that consider earthquake hazards. Yet, what is worse, city planning measures adopted for hazard-prone areas are unable to take into adequate account the context in which they should operate.

In other words, the criteria for city design in an earthquake-prone area are basically the same as those used in safe areas. In an earthquake-prone area hydrogeological and geotectonic surveys should be carried out in order to provide the guidelines for the selection of the most suitable building sites and typological and structural requirements to comply with the norms for the design implementation.

In the past, city designs tended to give priority to the building scale — strengthening or replacing individual buildings since such designs were based on planning criteria similar to those used in historical district conservation; that is to say: maintenance of functions compatible with the objective of social and physical conservation; minimization of physical and functional transformation of real property units not in

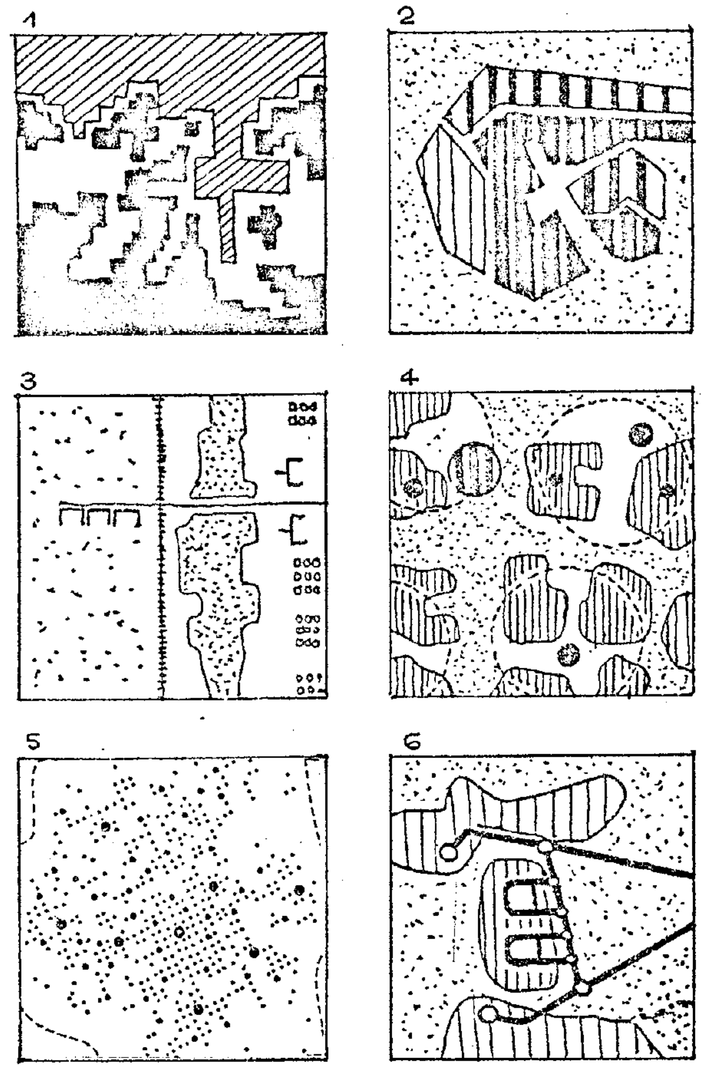


Figure 1. Urban design criteria to mitigate urban vulnerability

1. Avoid building in high risk areas
2. Specialize land use
3. Develop green belts between productive and residential areas
4. Articulate the urban framework with unit settlements separated by open space
5. Maintain low density land uses
6. Develop alternative road systems and utility networks

compliance with already existing typologies; etc. (Figures 2A, 2B, 2C).

What are the implicit assumptions in such an approach? What have been the guidelines for a design that is consistent with official land use management systems?

In my opinion, the following are some problems that define the significant issues, how they should be tackled and their priorities:

a) the idea that safety problems refer mainly to building measures (strengthening already existing structures; adjusting static and structural norms for new buildings) and is not combined with other disciplines (engineering, geology);

b) the idea that prevention is effective if there are adequate civil protection services, aiming at organizing relief services in the emergency phase and immediately after when reconstruction operations must be initiated;

c) the belief that the unreliability of prediction methodologies should eliminate the consideration of earthquake risk in the city planning process.

d) the idea that minimizing urban scale vulnerability cannot be a decisive fundamental objective of city design due to its high costs and to the hazards an earthquake involves.

Moreover, the objective of reducing urban vulnerability clashes with others (e.g.: maximum use of the property and real property profitability; limiting public costs for development; etc.) which appear to be more economically and socially important and have greater priority. Therefore, seismic design requirements for urban projects are not often adopted.

It should be kept in mind that this concept of planning seems to have been historically adequate with the constraints imposed by the decision-making system and with the requirements of the territorial planning system. Are there structural motivations which may explain the coherence between public policies and disciplinary approaches?

It is not simple to provide an answer to a question that goes beyond the earthquake issue and entails fundamental problems of city planning itself and its role in territorial transformation processes.

As a working hypothesis, I believe it would be useful to pursue a suggestion proposed by Offe in the analysis of the functioning of political and institutional systems within the welfare state. According to him, there is a concentric scheme of priorities among social needs. The issues and problems arising from social needs are located closest to the center (that is, they have the highest degree of urgency); the greater the non-satisfaction of social needs the more likely this will lead to a crisis in the political system. Those social needs that do not lead to adverse social reactions if disregarded will be located at the periphery of the scheme.

In the design of a city plan, there is a tendency to give preference to the needs that have political constituencies and have proved to be a priority. In discussions related to the process of "filtering" needs and public policies design, the institutional political systems should be capable of responding immediately, thus maintaining the consensus of the social and economic groups involved.

Yet, in such a situation, who will assert the reasons in favor of long-term safety over the short term? Will it be the administration in charge or the generation of users? Who will be strong enough to impose solutions that involve a considerable increase in immediate costs — not fully borne by the State — needed for the adjustment of the urban structure?

Thus the story of transferring a plan from one seismic prone area to an other may serve to support the use of intervention policies aiming at the satisfaction of the short term needs "nearest to the center". Should the equilibrium be undermined by a real hazard, it will always be possible to transfer reconstruction costs to the State, trying to take advantage of this appropriate political instance to shift the needs "nearest to the center", according to Offe's metaphor. Further evidence of the value of the proposed hypothesis is the fact that a much greater amount of resources was invested for the reconstruction actions after the earthquake which affected Basilicata and Campania than that for the development of these less developed regions.

Have the assumptions of the crisis management model according to which it is not necessary for city planning to contribute to earthquake-risk mitigation now changed? In my opinion such assumptions have not changed at all. Nevertheless, there is evidence that gives hope of a possible change.

In the meantime, the scarcity of available resources gives rise to doubts on the hypotheses

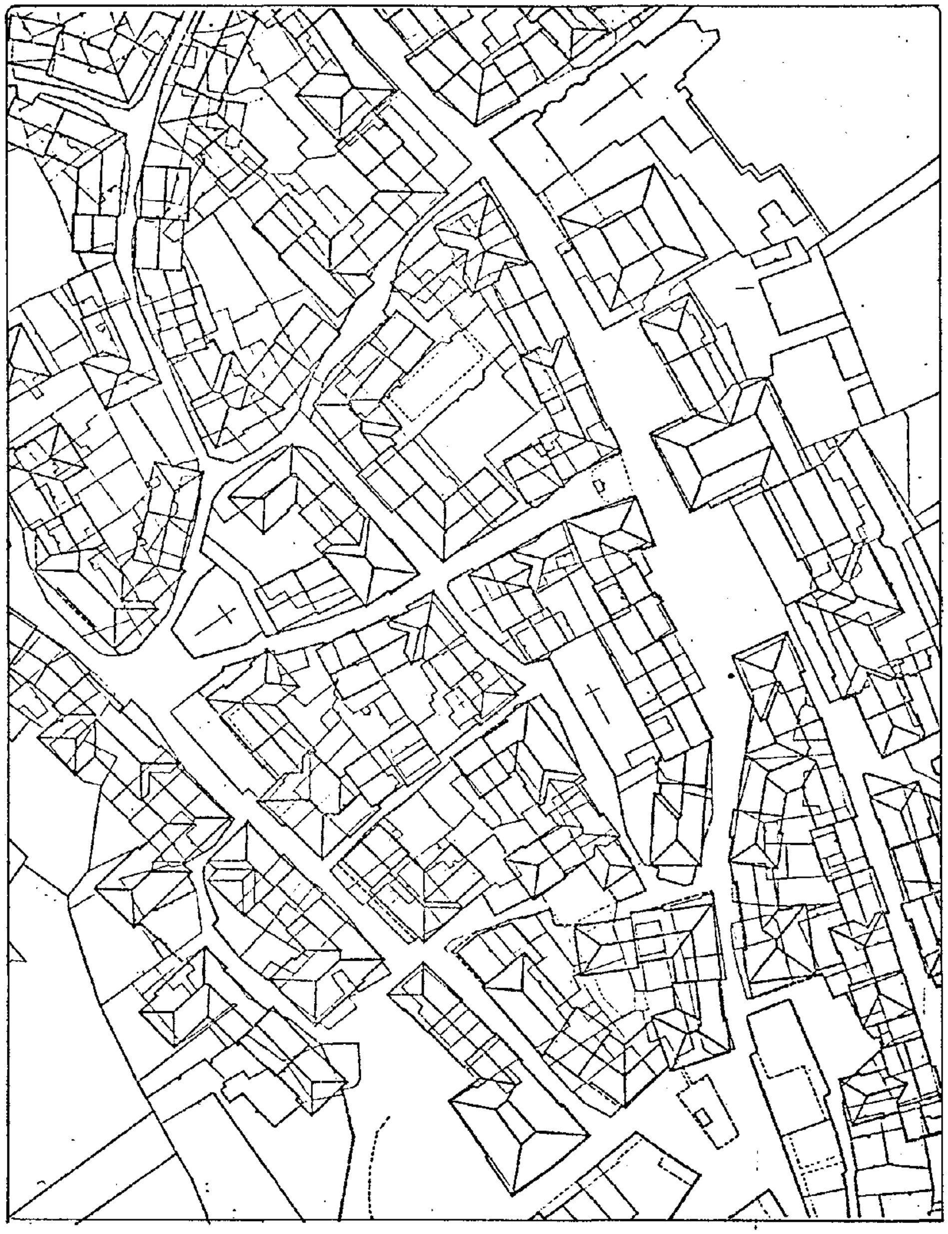


Figure 2a. Reconstruction of the "piano particolareggiato" of Gemona's historical center. The new development system is imposed over the ancient urban framework.

Figure 2b. Public space systems
Legend:

——— Prescriptive alignment
— — — Indicative alignment
········ Alternative alignment

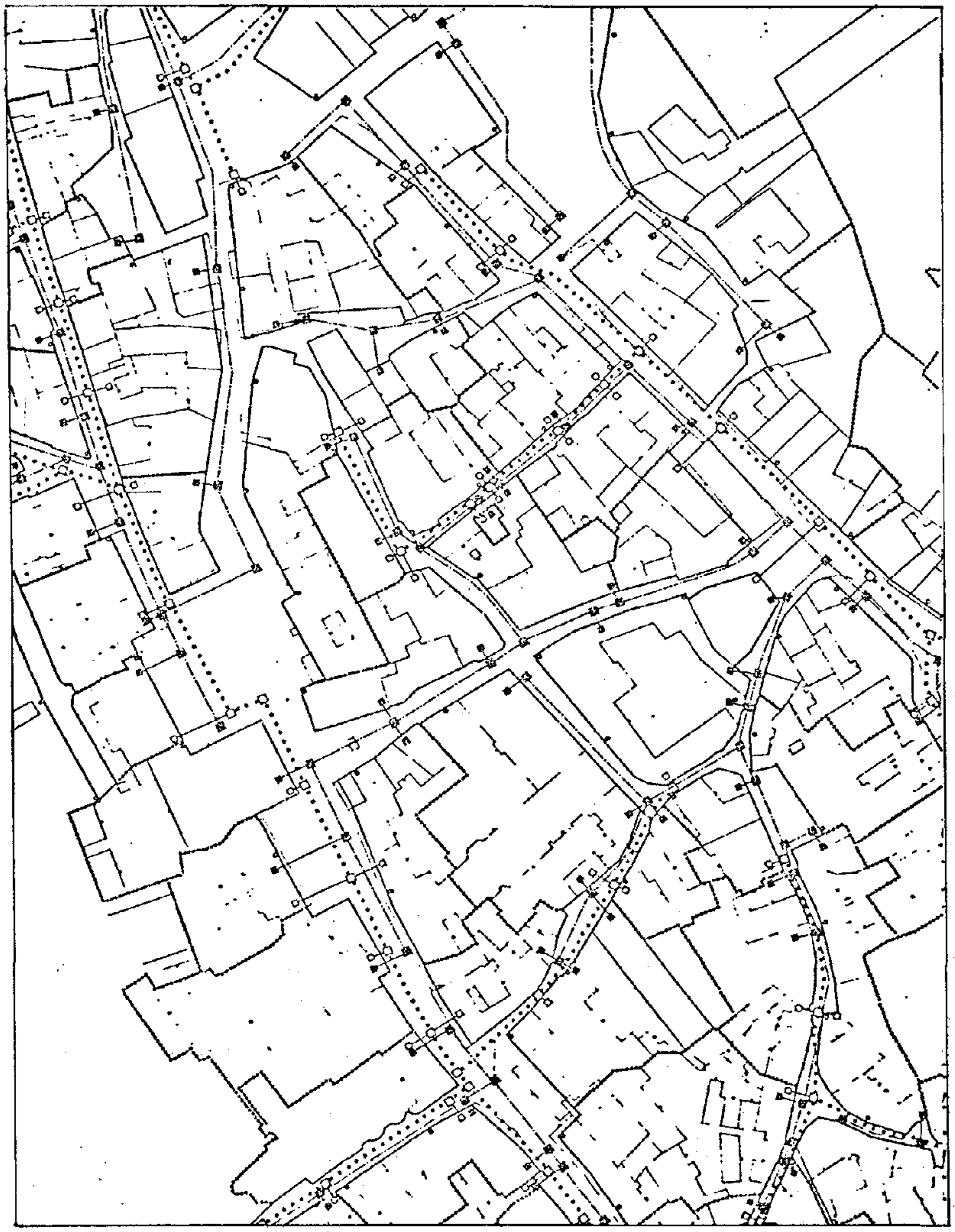


Figure 2c. Utilities
Legend:

—·—· Sewer and water supply
········ Electricity and telephone network

according to which the additional costs necessary for consolidation should be allocated only for residential housing by means of interventions solely at the scale of the single building unit.

If it is true that the amount of investment necessary for adapting the existing building stock to minimize seismic risk would be 40,000 billion lira (estimate according to Grandori, Geodynamics Project, 1980), it will be necessary to prioritize interventions to maximize the benefit of investing these resources through careful selection of the social directions and sites of intervention. Other actions, and not necessarily just physical ones,must be considered. Most of all, this shifts the attention to the functioning of the entire urban structure, looking for more effective solutions than specific actions related to the strengthening of individual building units.

Moreover, the launching of a true civil protection policy (for which Italy has expressed, at least, its political intention) imposes the requirement of harmonizing the organization of safety service schemes with spatial organization ones. Let us think, for instance, of the obvious need for the establishment, as a preventative measure, of emergency centers equipped to maintain the essential urban functions and to supply the needs of relief operations such as food, medicine, building material, prefabricated elements for provisional shelters, etc.

Emergency centers should be envisioned not as elements foreign to the normal functioning of the city, such as atomic shelters. On the contrary, these centers should be part of the total system of facilities since they are part of the social functions which aim at the improvement of the standard of living at the site where they are located.

Finally, refining predictive techniques makes their use within the urban planning process more reliable. Furthermore, research has developed in a different manner: spatially disaggregated data on earthquake risks as well as sophisticated models interpreting the static behavior of buildings are both available today; yet, theories on the behavior of the entire urban structure subject to the trauma of earthquakes are in their infancy.

Accepting that such research projects — according to the above mentioned work hypothesis — may not yet be feasible in the Italian political context, we will try to analyze in depth the behavior of the urban structure under earthquake stress in order to define possible urban planning interventions to mitigate the consequences of the earthquake hazard.

3. THE NOTION OF URBAN SCALE VULNERABILITY AND ITS POSSIBLE USE IN CITY PLANNING

3.1. Alternative definitions

Urban vulnerability to earthquake effects is usually defined according to the quality and quantity of the damages suffered by the urban structure (considered as the set of interrelated activities, functions and space) affected by an earthquake.

There is also another definition. Making an analogy with chemical sciences, one may suppose that vulnerability is related to the capability of the urban structure to absorb the energy caused by the seismic shock remaining in the elastic field, i.e. maintaining the functional levels necessary for reproducing the customary activities performed within it. According to the latter, priority is given not so much to the extent of damage to people and property as to the loss of capability of service of the urban structure. Consequently, indices should not only consider the number of people injured per thousand population or the percent of damaged buildings, but also the parameters related to the level of functioning of the urban structure. Vulnerability regarding damages and vulnerability regarding the levels of services are two complementary definitions, yet considerably different.

I believe that considering the functioning of the urban structure as a working hypothesis may give rise to fruitful research projects on unresolved problems of significance for urban planning and urban design. How can the level of service of an urban structure be defined?

What are the strategic elements on which service depends? How can the level of the service, although of a lower quality because of the stress caused by the earthquake, remain above a minimum threshold compatible with the viability of the community? From this standpoint the issue can no longer be viewed in the following terms: how can vulnerability be reduced to a standard value of, let us suppose, 10 deaths per 1,000 inhabitants from the initial unmitigated conditions of 50 deaths/1,000 inhabitants?

Instead, the issue should be viewed as follows: how can the level of urban structure service in a system subject to earthquake stress be maintained above the critical value beyond which one may foresee the functional collapse of the structure?

From this outlook, some useful methodological indications can be derived from transportation planning: the design of the road network is controlled by the incorporation of some functional requirements to be met in instances of extraordinary load.[1]

3.2. Alternatives to the methdological approach

Notwithstanding the definitions of vulnerability, it may be analyzed referring to various methodological approaches.

Returning to the above mentioned analogy, we may assume that there are intrinsic properties of the urban structure which determine a higher or lower degree of vulnerability. After detecting the variables that describe such properties and after quantifying their value with specific coefficients, it will be possible to produce "vulnerability functions" which serve as operational tools for the study of the variations of vulnerability with reference to contextual conditions.

"Vulnerability functions" may be produced in several ways. One way, for instance, is to determine the effects following the loss of functionality of some elements of the urban structure. The detection of such effects — if properly arranged — would enable one to create a hierarchy of the elements which determine vulnerability.

The classification of the elements according to their effect on vulnerability is the tool for the formulation of possible functions which should be referred to the measure of the effects induced by the behavior of the elements examined.

Given this classification of urban elements, it is possible to perform an in-depth study of the behavior of strategic elements only, as well as to restrict the field of anticipation or mitigation control only to significant elements. Finally, the classification enables one to limit interventions by selecting only those compatible with a realistic evaluation of available resources.

According to this second type of approach, the most important problem concerns the detection of the effects and their quantitative significance within an explanatory model that enables the isolation of the strategic elements of the urban structure. The issues to be solved will be the following:

a) What is the relative importance of the various impact channels represented by infrastructural networks and urban equipment?

b) If an element of the urban system experiences a crisis, what are the secondary propagation effects induced in other elements of the system?

c) How are the direct or indirect impacts of a crisis spatially distributed over elements of the urban system?

d) What are the temporal dynamics of an earthquake induced crisis on urban system elements and its impacts?

From the questions raised, it is possible to detect some of the components of the concept of vulnerability. Special reference will be made to three unique aspects of the concept:

1. Direct vulnerability, which may be defined as the immediate effect of the crisis on individual elements whether they are networks of individual structures — an infrastructure network (acqueducts, gas pipes, etc.) — or a public facility (health services, schools, administrative services).

2. Induced vulnerability, which may be defined as the indirect effects resulting from the failure of one of the elements of the urban system (for instance, the crisis of the entire road system induced by the obstruction of a major arterial).

3. Deferred vulnerability, which refers to the long range problems that arise following the emergency phase (e.g. the inconveniences caused when schools are used as provisional shelters, inconveniences due to a lowered occupational capacity).

Analysis and intervention systems should be specifically tailored for each component of vulnerability, yet it is also useful to consider the overall system vulnerability which is the (non-linear) composite of the three defined components.

3.3. Possible use of the vulnerability chart

In historic districts an archeological map is an indispensable planning tool to ensure development respects the historic values; in hazard-prone areas it is equally necessary to have "vulnerability charts" which provide at the regional level, data on earthquake hazards including geotectonic features of the soil and the vulnerability characteristics of the urban structure.

The archeological map or the vulnerability chart depict a number of constraints for planning. In some cases, the constraints will be so significant that they will substantially condition development design. For example, if historical qualities are of great value, allowable modifications may be limited to preservation or restoration, for which the archeological map will serve as the guide.

In the same manner, if the vulnerability risk is very high, it may be necessary to exclude certain land uses and harmonize the contents of the project with safety objectives.

In other cases, it will be more difficult to assess the risk; thus there will be more design options. The morphology of roads and open space inherited from the past poses some constraints for the possible transformation of an urban structure, yet, it will not necessarily predetermine the design. Thus, the knowledge of potential seismic risk to the arrangement of the road network may lead to a number of alternative interventions, ranging from traffic regulation to the re-design of the entire network.

It should be noted that the "vulnerability chart" can be a useful tool for urban land use planning, both because of its ability to guide design decisions and the possible control it gives to central administrations in directing local planning activities. This chart will also be extremely useful in promoting specific interventions in the urban environment where city planning will be coordinated with the wider range of public policies for civil defense and for development in earthquake-vulnerable areas. Italy's only regional planning experience in those areas affected by the last earthquake (Basilicata and Campania) provides partial, but not entirely satisfactory, evidence of this.

4. METHODOLOGIES — AN HYPOTHESIS FOR A DESCRIPTIVE MODEL OF URBAN SCALE VULNERABILITY

In the situation described above, the research problems of greatest methodological importance do not concern the quantitative formulation of a vulnerability function as much as the formulation of a descriptive model of vulnerability that accounts for the variable conditions of the urban structure and the specific solutions for the organization of public facilities.

Thence, instead of adopting an unreliable "average vulnerability" of a given urban system, a vulnerability chart will facilitate the identification of the reasons for differences among variations of the urban configuration.

The first step is the selection, with adequate parameters, of the case study areas to use for comparative analysis. The case studies should be chosen so that it is easy to assess the degree of vulnerability of the elements making up the urban system (infrastructures, urban installations). In this manner, the so-called vulnerability matrices would be developed identifying the interrelationships between service elements and significant contextual situations in order to minimize vulnerability.

4.1. Construction of vulnerability matrices

Let us analyze in depth some problems regarding the construction of vulnerability matrices.

As a hypothesis, we assume that vulnerability can be represented by the variation of functionality levels of the urban structure due to the collapse of some elements in the network of public services. In mathematical terms:

$$V_{ul} = f_1 \ (S_r, S_p)$$

where

S_r = network infrastructures; S_p = facilities.

The problem, therefore, consists in how to evaluate the vulnerability function when the behavior of infrastructures and of facilities is varied. It could also be assumed that the behavior of services is a function of the characteristics of the system of services, of the contextual situation in which the system operates, of the intensity of seismic stress, and of the degree of risk related to geomorphologic soil conditions.

$$f_1(S_r, S_p) = f(\alpha, \beta, I, R_s)$$

where:

α = parameter that describes the characteristics of each sector of infrastructures and facilities

β = parameter describing contextual situations

I = value of earthquake intensity

R_s = parameter related to the geomorphologic structure of soil.

The formalization of the issue in these terms has a number of advantages. The set of variables represented by paramter α consists of the specific planning objectives which can direct action if one is intervening to adapt the system of services.

The set of variables represented by parameter β defines contextual situations; that is, those that are the "limit conditions" of a project. Earthquake intensity is an exogenous datum which should be taken as a hypothesis or as a result of an anticipation. Even the seismic risk should be taken as input on the basis of the earthquake zoning maps.

Thence, the objective consists of evaluating each element of the system of services for variations in vulnerability produced by variables it directly depends on ($\alpha_1, \alpha_2, \alpha_3, \cdots, \alpha_n$); by the variables it indirectly depends on ($\beta_1, \beta_2, \cdots, \beta_n$); and by the pre-established I and R_s values.

For this purpose it will be useful to adopt a matrix scheme in which the elements of the system of services arranged according to the α variables appear on the vertical axis and the parameters for the definition of the β_i context appear on the horizontal axis (see Figure 3).

With such definitions, the matrix enables the detection of a possible ratio relating a given variable of the system of services with the contextual parameters. The main issue, therefore, consists in the method of quantifying the ratio detected. In other words, how does one quantify the assessment that given a specific intensity of seismic stress and of a given geomorphologic structure there will be a change in the level of service due to the collapse of one (or more) element described by α_i, in a context described by β_i.

If the variation of the level of urban service were to be successfully quantified, the matrix would become the proper operational tool to study variations in vulnerability as a function of the urban context and of service characteristics.

Some more remarks on the use of matrix will follow. The column totals in relation to the contextual parameters should allow the assessment of the relative incidence of a parameter compared with others, in order to produce the vulnerability datum. One could even assess, for instance, whether the size of the city plays an important role in comparison with its age, the degree of development, etc. The row totals in relation to the descriptive variables of services should allow for the assessment of the effectiveness of some morphological structures and/or service densities, in order to mitigate vulnerability in given contextual situations. Finally, from the entire matrix, it should be possible to detect solutions that may minimize the loss of function of the urban structure, taking into consideration all the different service sectors.

In order to assess and quantify the variation in levels of urban service, the process for the generation of effects related to the crisis of the system of services should be examined. Breaking a water main, for instance, may be measured in terms of the reduced effectiveness of the network service (direct effect). Yet, the lack of water may lead to further damages in the case of fires (induced effect). In the second case, the reduced level of service becomes more severe, undermining the functioning of the whole neighborhood. Consequently, the index for assessment should have higher values, not proportionate to the direct effect. It would be expedient to note that the recovery of the interdependent linkages and of the possible synergistic effects related to the crisis of a service element may lead to a hierarchy of the system of services according to their capability of inducing effects of vulnerability. Limiting the analysis only to strategic elements could considerably simplify research, allowing for a more in-depth study of problems and one that is more planning oriented.

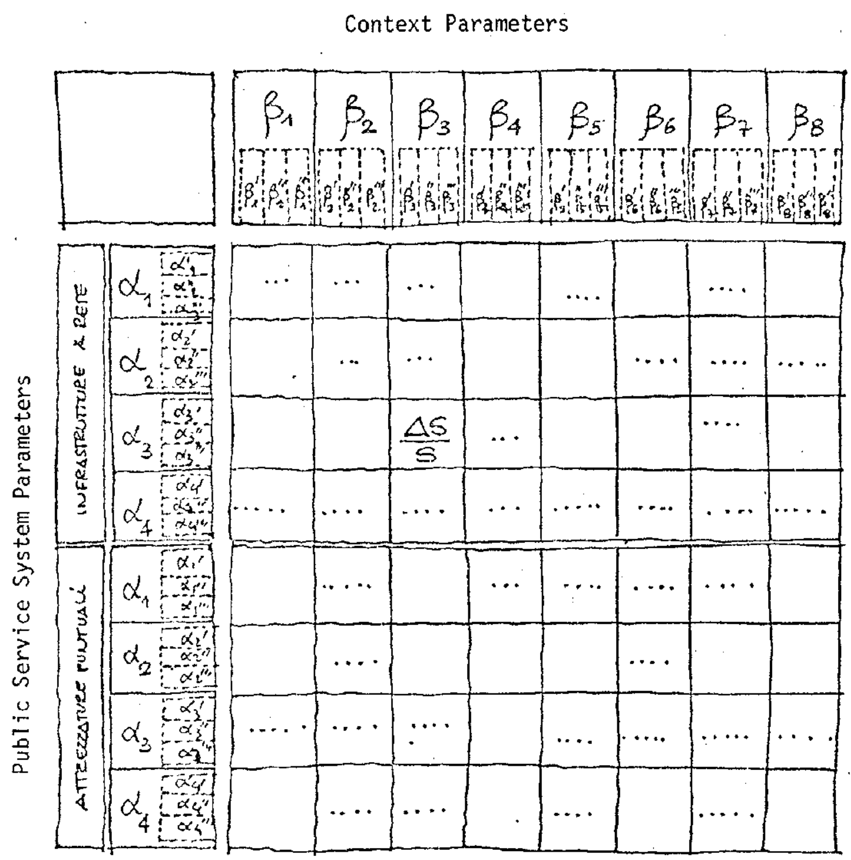
4.2. Selection of variables for the system of services

When differentiating network infrastructures — road systems, water distribution systems, power systems — and facilities — schools, health services, administration, safety, or supply and distribution facilities — the following variables may be considered as reference points:

α_1 : morphological structure of the network (tree-like network, ring-like network, link-type network)

α_2 : density of services (concentrated distribution, average distribution, diffused distribution)

α_3 : technologies and building techniques



$\frac{\Delta S}{S_o}$ = Urban service level reference variation with initial level - S_0

Figure 3. Matrix of vulnerability - Explicative scheme

(traditional, industrialized, prefabricated technologies)

α_4 : residual capacity of services under normal load conditions (the current service load is greater than, equal to or less than its capacity).

4.3. Selection of variables for contextual situations.

The definition of contextual situations for the assessment of vulnerability levels is more complicated. The following could be considered as working hypotheses:

β_1 : size of the settlement area (city-metropolis, medium size center, small town)

β_2 : functional characteristics (tertiary, industrial, residential city)

β_3 : scale of area under survey (entire settlement, only selected components)

β_4 : age and development level of settlement [a) high development level; b) under development level; c) both a and b; old cities; new cities]

β_5 : structure models (compact, division into nuclei, horizontal extension)

β_6 : densities and features of land use (high, average, or low residential and productive densities)

β_7 : dynamics of land use system (daily, weekly, monthly-seasonal variations)

β_8 : age predominant building typologies and their preservation degree.

The list of variables submitted both for services and contextual situations are only examples and require further refinement. Yet, it is extremely useful to work with such variables, so that the joint workshop may be the factual point of departure of bilateral research, based on the ability to compare significant situations common to both countries.

5. CONCLUSIONS, SOME GUIDELINES FOR THE PRESENT MOMENT

The methodological difficulty of formalizing vulnerability functions should not make us disregard the main goal of our research which is to adapt urban planning techniques to mitigate the consequences of earthquake hazards. From this outlook, the vulnerability matrix appears to be a useful tool since it provides a general frame of reference for the interrelationships between elements of the urban structure and contextual situations. Nevertheless, this obviously represents only the first step of the factual rationalization of the planning process. With regard to the various aspects of the use of matrices, the following problems should be mentioned:

a. When drawing up a land use plan, one of the main difficulties will be translating the ratios defined by the matrix into spatial "vulnerability maps" for the compatibility/incompatibility analysis regarding specific land uses;

b. When designing specific interventions, for which operational tasks are assigned to planning, it appears useful to draw the attention to strategic service elements to mitigate urban vulnerability.

For these essential service elements it is necessary to study the behavior of the agents who participate in the process of production and consumption. It is also necessary to consider the distribution of the decisional powers related to their management. Furthermore, it is worth mentioning that, in Italy, complex procedures and red tape associated with managing infrastructure and services hinders the construction of a "geography of power" under ordinary working conditions. If an emergency complicates the situation, the picture will appear even more confusing and contradictory; as a matter of fact, it leaves little room for optimism regarding the possibility of implementing a preventive consolidation policy vis à vis earthquake hazards. Considering these difficulties along with the optimistic outlook which often characterizes urban designers, I would like to come to my conclusion by trying to outline some parameters of an operational project aiming at urban vulnerability mitigation through interventions in public service systems. It appears necessary to develop a consolidated spatial safety system (a utilities and facilities crisis management system) which can maintain primary functioning levels even in critical situations. This system will be characterized by a set of "service links" and connections between links and their service environment, as well as links between other communication networks. The system will also be characterized by a network of infrastructures capable of withstanding seismic stress and providing support for emergency needs. Service centers will be arranged according to levels (or grades) from the elementary or primary ones handling single residential enclaves (5/10,000 inhabitants) which serve as crisis management centers, to area-centers that direct the wide-scale relief operations and are linked with the former. The degree of protection for access routes to service centers and major intersecting routes should undoubtedly be greater than the degree envisaged for other areas. Special restructuring measures should be foreseen for the above mentioned routes, as well as the addition of new, protective elements (arcades, cantilever roofs). Such financial burdens could be assigned to government directly or, by means of agreements, to property owners supported by special financial or credit arrangements. In this case, for instance, the recovery plans introduced in Italy by Act Number 457/1978 — and not yet employed in compliance with seismic risk — could be used. With reference to the normal operation of service centers, it should be asserted that their use as support elements during an emergency and during reconstruction phases should not hinder their use for other purposes in normal situations. They could be used as neighborhood centers, maison du peuple, social centers, etc., thus linking the implementation of other social goals to earthquake prevention measures. Siting requirements would, therefore, be modified to maximize the safety of these access centers. An example of how siting criteria for services change in view of seismic risks will be submitted by Engineer Ancona in addition to this report.

Finally, I would like to briefly review the working hypotheses mentioned, emphasizing their limits and development potential. The theoretical assumption of vulnerability as an expression of the level of urban system functioning (that is: the effectiveness of a service) has many implications which are not very clear. Yet, at present, application of the vulnerability concept is obviously subject to limits due to the absence of extensive research on urban structure behavior and on the possibilities of quantifying all of the service levels. Furthermore, the reference to the service level appears to be less direct if compared with that of damages caused to people or property which immediately affects the meaning of vulnerability. Considering the extreme consequences of the above mentioned approach, an urban structure where services still functioned would have a low vulnerability rating even in cases of serious casualties to people and buildings. The Lebanese situation where Beirut survives and develops in spite of the strong conflicts that cause daily deaths and damages to buildings is worthy of mention. Moreover, considering the behavior of an urban system subject to external stress as the subject of research provides the considerable opportunity of generalizing far beyond the specific situation of an earthquake disaster. In these times, characterized by world-wide political unsteadiness and by the race to invest in military defense facilities, such considerations may, paradoxically, support the assertion that there is some political advantage in developing this research.

NOTES

[1]It is common knowledge that when assessing the performance of roads, for instance, there is frequent use of the level of service parameter. This indicates the range of road conditions when it is subject to increasing traffic flows. It is a synthetical measurement of the effect of a number of variables such as: speed, time of travel, traffic interruptions, freedom of maneuvers, safety, and driving comfort. The assessment of the level of the service takes place on the basis of specific limit values of the above mentioned factors. The measurement is expressed in terms of very comfortable, average comfort, down to the level of intolerable.

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Earthquakes, Urban Scale Vulnerability and City Design: Some Observations

Tridib Banerjee
School of Urban and Regional Planning
University of Southern California

"199 *EXT. HIGH DESERT LANDSCAPE*
East of L.A. The camera is at eye level. It tilts down toward the earth. Camera is shaking from the agitation of the earth. There is a tremendous booming sound.

200 *CLOSE SHOT (MODEL)*
We see the earth rip apart. The camera travels along the crack with enormous speed. Suddenly there is an explosive sound as the earth tilts and is torn apart, revealing a break of some twenty-five feet.

200-A *EXT. CARILLON - LONG SHOT*
A high bell carillon shakes badly. The bells are ringing madly, as if gone mad.

201 *EXT. GIGANTIC CLOVERLEAF - IN DOWNTOWN L.A.*
The span trembles, cars swerve from side to side. One of the vehicles — a truck loaded with cattle — heads right for the rail.

* * *

203 *MODEL SHOT*
The force of the quake crushes a section of the concrete wall of the L.A. Riverbed. Beyond, the line towers move in opposite directions, the lines swaying back and forth.

204 *FULL SHOT - (MODEL) A SERIES OF HIGH VOLTAGE TOWERS*
The tower lines snap, shooting sparks.

* * *

206 *(MODEL) THE ELECTRIC TOWERS TOPPLING ACROSS THE RIVERBED*
As they fall, they knock over several smaller utility poles. One of them, its wires stretched taut but still unbroken, lies across the section of bridge from which Corry fell, supported by loose wreckage."

---- *from the final screenplay of EARTHQUAKE by George Fox; Mark Robson, The Filmmaker Group/Red Lion Productions, Inc. February 12, 1974. typescript. pp. 71-71.*

This is how a popular disaster movie dramatizes the first few seconds of the onslaught of a fictional, but cataclysmic, earthquake in Los Angeles.[1] As the scenes unfold, we see devastations of an unprecedented scale which damage buildings and infrastructure and cripple lifeline services. Death and injury abound. Masterfully, this Hollywood production tries to play on our collective hidden fears about some fateful doomsday. Most of us probably would come out of the movie unaffected, and remain generally unconvinced. These things can only happen in movies, we would reason!

If this Hollywood scenario seems too exaggerated, it is sobering to know that many scenarios done in a more serious vein are not all that different from what we see in this movie. Seismologists keep warning us that a major earthquake is imminent and inevitable near the two most populous areas of California — San Francisco and Los Angeles. They say that a major earthquake will probably come in our time, and when it comes it will be by far the most devastating disaster in North American history (Nilson, 1981). How should we prepare ourselves? What is the role of public policy in this regard? What specif-

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ically is the role of planning and design in minimizing risks to life and property? These are some of the questions this paper proposes to examine, focusing in particular on the very last question.

Earthquake Scenarios, Risks and City Design

Some time ago two earthquake scenarios were written for the Los Angeles area. The larger one, called Pearlblossom, was of 8.4 Richter scale magnitude and located on the San Andreas fault with its epicenter outside the built-up area of Los Angeles. It was expected to affect 1,200 square miles, cost about $48 billion in damage in 1970 dollars,[2] and cause 3,100 deaths. The smaller one, called Racetrack, of 7.2 Richter scale magnitude located on the Inglewood fault, would have affected 1,000 square miles, leading to damages of $40 billion in 1970 dollars and 2,600 deaths (Scott, 1971). In other estimates, depending on the time of the day, the loss of human lives in a major Los Angeles earthquake ranged from 6,000 to 43,000 (Scott, 1971). In comparison, the San Fernando Valley earthquake of 1971, measuring 6.6 on the Richter scale, affected only 25 square miles, cost approximately $1 billion in damage, and caused just under 70 deaths.

A more detailed scenario is now available for a major earthquake in the San Francisco area, also considered equally likely by most experts. In a report prepared for the Federal Emergency Management Agency, researchers at Stanford Research Institute International (Earle et al., 1980) estimate that an earthquake of a magnitude of 8.3 on the Richter scale, occurring on the San Andreas fault with the epicenter near Bolinas in Marin County, will wreak havoc in the San Francisco Bay area. The dimensions of the havoc: over 10,000 dead; over 1,500 missing; about 30,000 injured requiring hospitalization; and another 28,000 or so in need of outpatient care. About 15,000 dwelling units will be destroyed or will be so severely damaged that demolition will be necessary; an additional 28,000 dwelling units will need extensive repairs. About 5,000 industrial or commercial buildings will have collapsed or will be so severely damaged that demolition will be necessary. Although most bridges and tunnels are expected to survive, the approaches to the Golden Gate, Bay, Richmond, San Mateo and Dumbarton bridges are likely to be extensively damaged. Major overhead sections of the Bayshore freeway, Route 17, Route 280, and the Marin County portion of Route 101 will collapse, requiring anywhere from six months to two years to be fully restored and made operational. Most airports in the region, which are located on filled land on the inner rim of the Bay, will be out of commission for some time; it will take six months to a year to restore the San Francisco International Airport. Moderate to serious damage is also expected in the metropolitan water supply, sewage disposal, gas and electricity services, telephone systems, and petroleum pipelines.

These scenarios begin to outline the nature of the vulnerability of residents in urban or metropolitan areas with known seismic activity. There is always the disturbing prospect that a catastrophic earthquake can occur when most urban residents are at work, on the road, away from home, in high occupancy public places, or in crowded quarters, with the potential of being killed, maimed, injured, trapped, isolated and being subjected to such secondary effects of earthquakes as fires, explosions, human stampedes, flooding, subsidence, landslides, and the like. In addition to death and injury, the psychological trauma of shock, disorientation, uncertainty, and grief over losing a friend, or a relative, or a home or a favorite place, can be devastating. The general paralysis of the physical city, its economy and life-line support systems can continue to further aggravate human miseries for days and months as food in refrigerators spoils; as telephones, elevators and plumbing do not work; and as gasoline and water are in short supply. Short of a total nuclear holocaust, there are very few other short-lived phenomena that can bring so much destruction to an American metropolitan area.

These are frightful scenarios. But then "(H)ell is more impressive than heaven", as Lynch (1981) observed and "'cacotopias' — imaginary descriptions of horrifying worlds to come" (Lynch, p. 69) have always been more vivid than utopias. City design has long been inspired by utopias. But can these cacotopias of today be averted through city design? Can something be done about the physical city that might prevent, or at least minimize, earthquake disasters? Can cities be designed to be resilient,[3] to absorb sudden shocks?

The rest of this paper examines this question in a general and preliminary fashion, outlining possible directions rather than definitive solutions.

But before we come to that, it may be necessary to examine if, and why, city design mechanisms may be considered an appropriate public policy response to earthquake vulnerabilities at the urban scale. Risk and equity are two important concepts in public policy, especially in connection with disaster mitigation.[4] Since city design largely falls within the arena of public policy, questions of risk and equity must be considered before we can make a strong case for the role of city design in earthquake planning.

A key question in public policies of this sort is how risk is to be shared. Should it be a responsibility of the public-at-loss or the public-at-large? Typically, federal emergency aid programs to disaster-stricken areas have assumed it should be the latter, although increasingly this is being questioned as unfair and inequitable. In view of rising costs, there is a growing sentiment that the public-at-loss should largely be responsible for the risk they face. That is, the public-at-large should not be responsible for the replacement cost of homes leveled, or property damaged, or business inventories destroyed by a flood, a hurricane or an earthquake. As a practical matter, however, disaster insurance in disaster-prone areas tends to be prohibitively expensive, and individual property owners and businesses often have no other option but to rely on federal and state emergency aid and other private philanthropy. Even at a theoretical level, the question of risk-sharing and equity remains a complicated matter, and largely an ethical issue. Schulze (1980) has argued this point effectively by considering different ethical systems. He has shown that the nature of social choice can be quite different if we use an utilitarian (Bethamite) ethic as opposed to a libertarian (Paretian) one; we might get a still different outcome if we draw on an totally egalitarian (Rawlsian) ethical system, which in turn will be radically different from the outcome derived from an elitist (Nietzschean) one. If some day it is possible to devise a socially and politically acceptable calculus for distribution of risks, responsibilities, and compensations, decision rules will no doubt become specific. But until then public policy must somehow muddle through and continue to assume the bulk of the responsibility for minimizing risk to property and life from earthquake hazard. In the absence of any other form of clear guidelines, it can be assumed that an ethical difference exists between public and private safety, i.e. knowingly imposing risk on oneself may be a private matter, but imposing it on someone else is unethical and matter of public safety concern. Schulze (1980) has shown that uncompensated risks are seen as wrong some of the time under all ethical systems, and always wrong under the Paretian ethic which tends to dominate Western democracies. He has also shown that as a matter of lexicographic preference, an individual would always prefer the notion of public safety as a reduced uncompensated risk to private safety or reduced compensated risk. (He desires that too but only secondarily to public safety). One implication of this is that earthquake hazard risks stemming from uses of land privately owned can be seen as negative externalities, and much of the charge for city design may be seen essentially as minimizing these externalities, or requiring individuals to internalize or pay for these externalities. Thus the building owners in San Francisco's Chinatown must do something about their cornices and parapets so that they do not become public liabilities. But not only does city design manage interfaces between the private and public environment, but it also must be responsible to all public properties, structures, places and rights-of-way. This is a major responsibility because at any given time of the day most people are in public spaces, places and rights-of-way. In addition, all of the lifeline systems are a public responsibility. Thus the case for city design as a means for improving public safety must be considered unassailable. Who should pay for it? It will be shown that in most cases, the local communities — be it Los Angeles or San Francisco — will bear the cost of preventive measures, since state and federal funds are available only after the disaster, not before. Thus, in a way, the public-at-loss pays for the preventive measures for a disaster, not the public-at-large. How these costs and benefits are shared within a community is yet another thorny issue of equity and justice.

Resiliency and Urban Form

Cities have been designed with all kinds of goals in mind — from the cosmic to the mundane, from the sacred to the profane (cf. Lynch, 1981) — but there is no record of a city ever being designed to minimize earthquake disaster. Here we will examine resiliency — the ability to absorb shocks — as a theoretical goal for city design (cf. Lynch, 1966). Several questions can be raised at the outset: Are there urban patterns that might perform more efficiently in the case of a sudden shock such as an earthquake? Are there some intrinsic properties of the urban form which make it more resilient? The first question is a difficult one. It may not be possible to specify any particular urban form which maximizes the goal of resiliency. We simply do not know enough to claim that one urban pattern performs better in absorbing sudden disasters and shocks than another, or that a linear city is more resilient than a radial city. On the other hand, and in response to the second question, it may be possible to make some very tentative postulations about the relative resiliency of one form versus the other. Lessinger (1962) and Lynch (1958) have both argued that "open" forms — urbanized areas interspersed with unbuilt areas — are likely to be more adaptable to growth and change than densely built-up areas. It can be suggested that, for the same basic reasons, "open" forms are likely to be more resilient to sudden shocks and disasters. In addition to adaptability, redundancy might be another characteristic that can make one urban form more resilient than another. Redundancy in transportation and commercial channels, in services and facilities, and in infrastructure and utilities can certainly make a city perform much better in the case of emergency and disaster.

It has been said that Los Angeles is "the safest earthquake-prone city in the world" (Scott, 1971, p. 7). It is possible that the "safeness" of the Los Angeles urban form is a function of both "openness" and redundancy in the way the metropolitan area has grown. The ubiquitous grid and low density development, along with an efficient freeway network, wide rights of way and post World War II construction, which characterize much of Los Angeles, may be some of its best assets. A comparison of the damages caused by the 1971 San Fernando Valley (in Los Angeles) earthquake with that of the 1972 Managua earthquake tends to support this argument. For an earthquake of a much lower intensity, Managua's fatalities were 100 times greater and injuries 10 times greater. Although the absolute value of property losses were roughly comparable, the relative impact in terms of income was 15 times greater (Kates et al., 1973). This comparison also suggests how the urban form of transitional societies can be particularly vulnerable to earthquake damage. Much of Managua's losses can be attributed to the crowded slums and squatter settlements in the central city where wood shanties sheltered thousands (Kates et al., 1973). This highly vulnerable "soft underbelly" is a common feature of the third world urban form — an outgrowth of their dualistic economies — and may not be eliminated by city design efforts alone. A case can be made however, more generally, for a dispersed and decentralized urban form which avoids a high degree of concentration of people, production units and valued resources in any one spot.

Dispersed and decentralized urban forms, however, are not very popular these days. It has been argued that sprawl is costly, (R.E.R. Corp, 1974; Whyte, 1968; McHarg, 1969) environmentally degrading and socially inequitable, that it may contribute to anomie, placelessness and decline of community (Relph, 1977; Appleyard and Jacobs, 1980). Indeed with increasing energy and housing costs, a trend towards greater concentration and intensification of land use is already underway, even in Los Angeles. At least on paper the city of Los Angeles is committed to emerge as a system of centers from its otherwise undistinguished spread form. But will this "Centers Concept" be effective in minimizing disaster risks? In emergency management? In reconstruction efforts? Even if this policy appears counterproductive from a disaster management standpoint, it will be difficult to call for a total indictment of this proposal if it serves the purposes of economic efficiency, social justice and environmental protection in a most effective way. What might appear as a highly resilient urban form may not always be the best model from the standpoint of efficiency or equity. Where such conflicts are unavoidable, the choice of one urban form over another must depend on how the societal risk of earthquake disaster is assessed, how the private and public components of the responsibility are balanced, and what time-discount rates are used to compute future costs and benefits.

There might be other reasons for shrinking from urban form objectives as a target of disaster mitigation, especially in existing urban areas. After all, the business of reshaping an existing urban or metropolitan pattern is a long-range endeavor. It involves those elements of the physical plant of the city which, as Webber (1963) points out, have a fairly long "half-life" of consequences — transportation, utilities, public works, high intensity land use, and the like. It takes many years for the policies designed to reshape the urban form to bear fruit.

But there are other applications of city design through which many disaster mitigation goals can be achieved. City designers are routinely engaged in projects involving different parts of the physical city: open space systems; recreational facilities; transit corridors; commercial revitalization; neighborhood conservation; urban redevelopment; industrial renewal; transportation systems; subdivision layout; historic preservation; design of institutional complexes; conservation of scenic and natural resources; and the like. Through each of these projects disaster mitigation goals can be achieved and the cumulative vulnerability of the environmental form reduced. This is essential a piggyback strategy. And although an incremental process, here the resiliency of the physical city can be improved within the existing constraints and without having to come to a head-on conflict with other social, economic and environmental goals.

In this latter approach of integrating earthquake mitigation objectives in the on-going city design process, at least three types of research and professional undertakings can be identified. First, it will be necessary to define the concept of vulnerability in broader social and behavioral terms, thus going beyond the traditional methods of seismic hazard mapping, economic risk assessment and "life-line" engineering. Second, and based on such operational concepts, relative vulnerabilities of different parts of the city in human terms must be assessed, priorities for action or improvements established, and the performance characterics of resiliency in environmental form appropriately specified. Third, strategies for implementation within the existing framework of public improvement programs, building codes and land use controls will have to be proposed and reviewed. In the following text these three elements will be elaborated in some detail.

Urban Scale Vulnerability: Toward a Definition

Geological studies can identify and map seismic vulnerabilities in a given locality (Borcherdt et al., 1975). At the very basic level, the plotting of faultlines and their traces provides an important piece of information, even when faultlines cannot be exactly located and can be best indicated as a band or a strip of land. Since surface rupture, shear and snapping are the most common types of damages likely to occur along a fault line, this information alone can suggest possible vulnerable locations for buildings, structures and utility lines. But the fault lines may not necessarily be the area of greatest damage. Depending on the geologic conditions, the seismic forces released can cause much greater damage in areas quite distant from the faultline. Through technical analysis it is now possible to estimate the variable intensities of ground shaking throughout an urbanized area. Thus maximum earthquake intensities have been predicted and mapped for a recurrence of a 1906-type earthquake in the San Francisco area (Figure 1) which stratifies different parts of the city according to their relative vulnerabilities (Borcherdt, Joyner, Warrick and Gibbs, 1975). Based on the earthquake intensity information and other physiographic data, it is possible further to map the types of surface damages likely to occur from an earthquake — landslides, liquefaction, subsidence and tsunami inundation areas (see Figure 2) — which offer another dimension of vulnerability. All of this provides the baseline data for additional levels of vulnerability assessment. Further attempts are then made to establish zones of seismic risk and an assessment of seismic risk measured in terms of dollar loss, death and injuries, population at risk, relative risk and other such concepts (Blair and Spangle, 1979).

Although most efforts at land use planning for seismic safety have utilized analyses of this sort, at the city design level we need to go a step or two beyond and establish some additional concepts of vulnerability based on social and behavioral functions of environmental form. Some of these concepts pertain to the built characteristics of the physical place itself, others concern the characteristics of the people who inhabit or use the physical place. These can be called indicators of place vulnerability.

A preliminary list of these indicators are offered below:

A. System Redundancy - This can be defined as those characteristics of the environment which can be measured in terms of availability of excess capacity, built-in factors of safety, back-up systems, alternative systems and the like. The assumption here is that the greater the redundancy of physical systems, the lower the vulnerability of the environment. Thus a neighborhood which has individual septic tank connections for waste disposal, or home solar collectors, or access to a natural spring for potable water is likely to survive better in the case of a total collapse of metropolitan water, electricity, gas or sewage disposal systems.

B. Restorability - Recovery time can be considered a measure of this indicator. The expected time needed to restore an affected area to its original status in terms of normal life activities — work, sleep, potable water, toilet, meal, bath, etc. — can give an overall sense of priorities and improvement (Takano, n.d.). In a way this indicator can be seen as correlated to the extent of damages, but in a nonlinear fashion. That is, restoration is possible up to an extent; but if the damage is too great, demolition followed by reconstruction is more sensible. Thus the relevant measure of recovery time is valid until the threshold of critical damage is reached after which restoration is not cost-effective anymore. Clearly, restorability is a function of physical

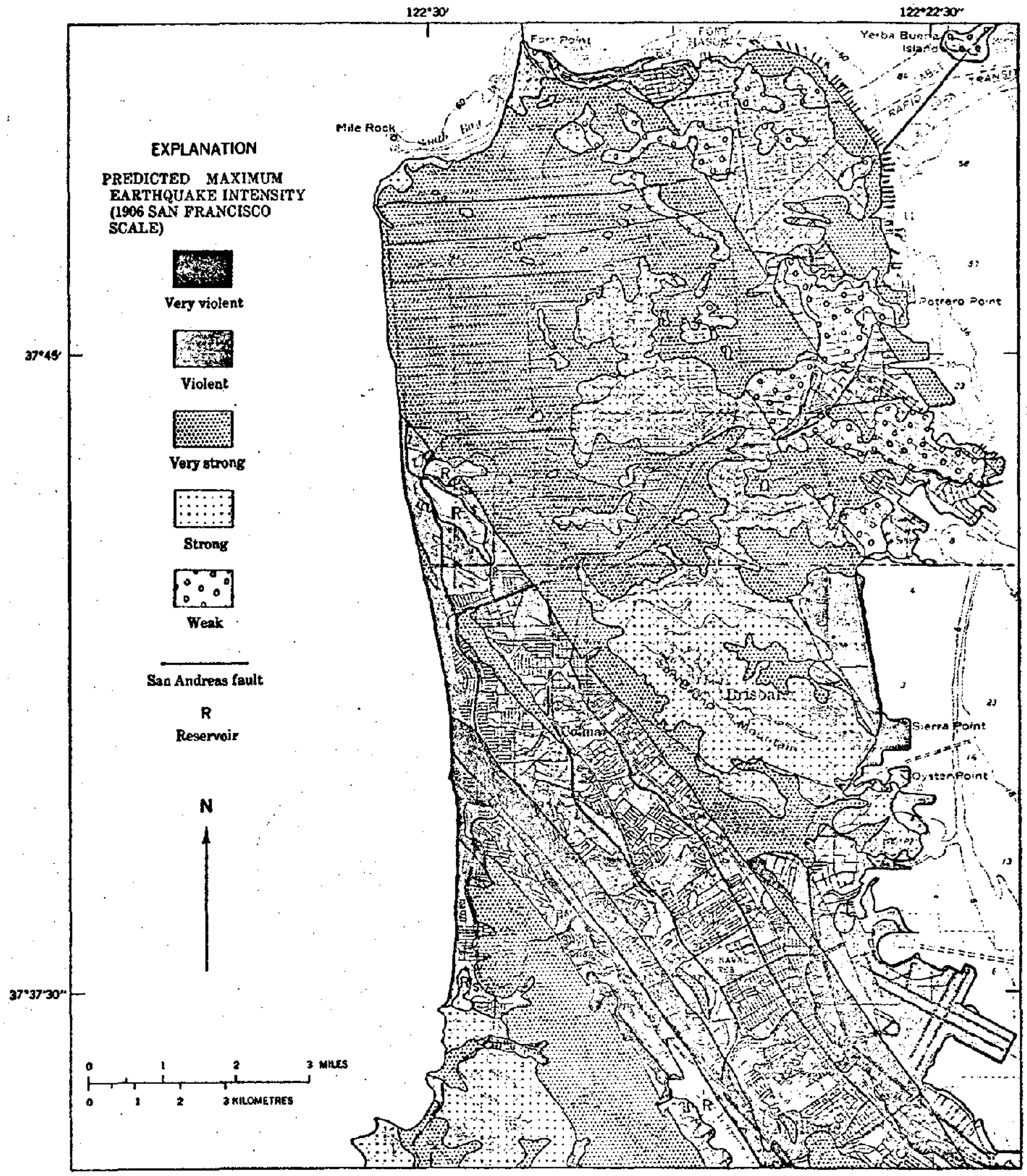

Figure 1. Maximum earthquake intensities predicted for San Francisco based on a 1960-type earthquake. Source: Borcherdt, et al., 1975, p. A-62.

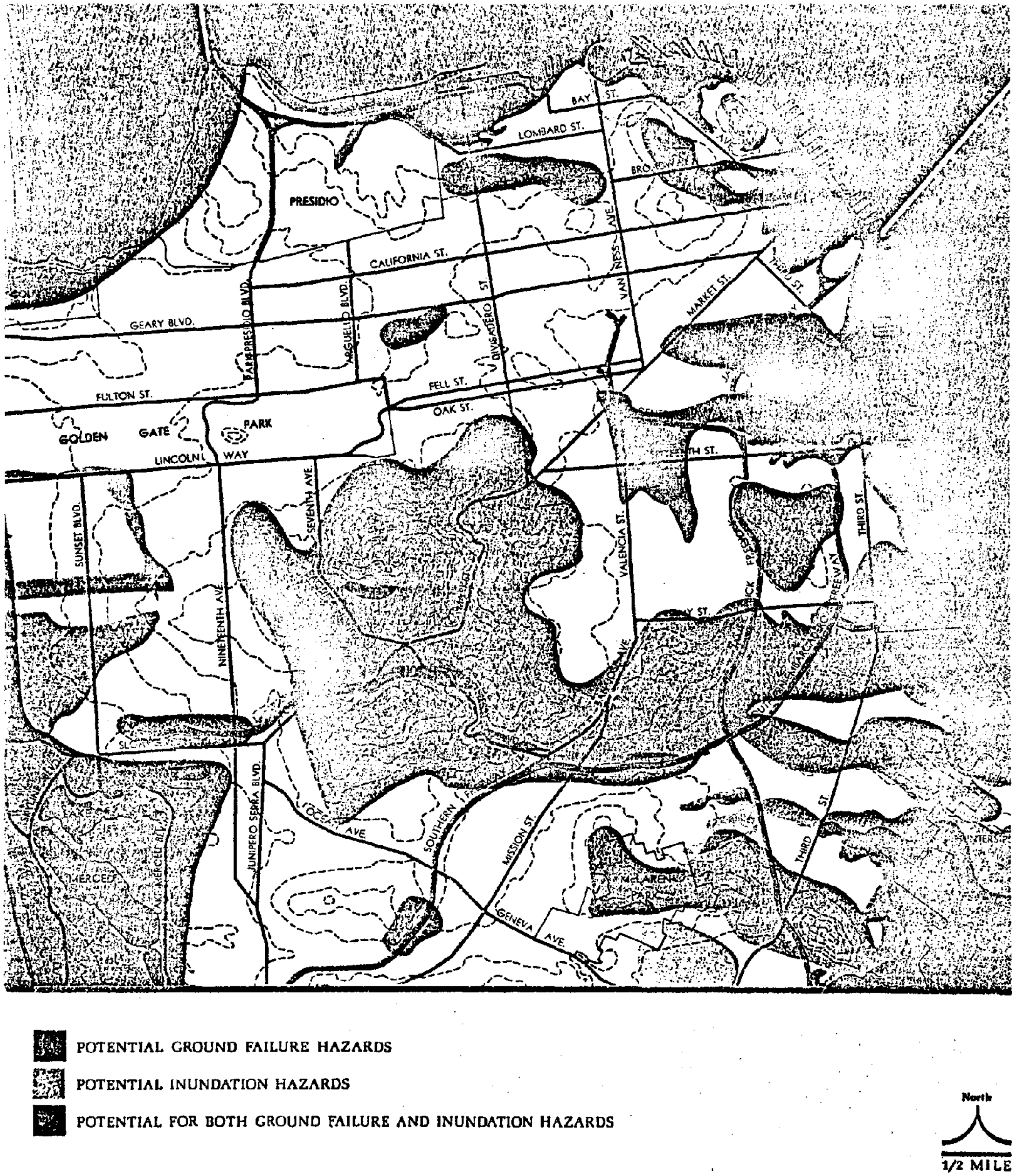

Figure 2. Special Geologic Study Areas — City of San Francisco. Source: The Community Safety Element of the Comprehensive Plan, San Francisco City Planning Department.

form, the age and conditions of buildings. Restoration of the physical structures may be more challenging and time-consuming if they belong to an earlier vintage of building technology. Location can be a factor as well. Neighborhoods located in the periphery, or served by the farthest branches of the infrastructure "tree" may be slower to recover than closer-in, or strategically located neighborhoods.

C. Serviceability - This refers to the degree to which an area could be reached, serviced, and aided in the case of an emergency. The vulnerability of a neighborhood is high if it has potential of being cut off from the rest of the community because of a collapsed bridge or tunnel, or if it does not have a suitable place for emergency helicopters to land, or if it does not have adequate access roads for fire, ambulance and other emergency vehicles. Malibu, a coastal neighborhood in Los Angeles was completely cut off for days when a massive landslide blocked the only access route, the Pacific Coast Highway. Many neighborhoods in the hills of Los Angeles are not particularly serviceable because of their steep, narrow and winding streets. Understandably, automobile insurance companies see these areas as hazardous and accident prone, and charge higher insurance rates. The same is true for many of the canyon neighborhoods in the Santa Monica mountains whose poor serviceability becomes periodically evident whenever there is a fire, a flood or a landslide. Even where the terrain is flat, irregular or discontinuous grids may offer much greater impedence to emergency services than a simple grid.

D. Evacuation Potential - A complementary concept to serviceability is the degree of ease with which an area can be vacated by its users, residents and animals in the case of fire, flood, landslides and the like. Once again, it is a function of location and topography, but it is also influenced by the design and capacity of the local street system and the way it is linked to the larger citywide network of arteries.

E. Hazard Potential - Certain neighborhoods and districts of the city might be especially vulnerable to specific hazards because of either natural or manmade characteristics of the site. Once again in hilly neighborhoods, houses located on steep hillsides or at the base of steep canyons are vulnerable to landslides in the case of intense ground-shaking. Others, because of their proximity to a dam, a reservoir, an oil-storage facility, a chemical factory or a nuclear reactor, are vulnerable to inundation, fire, toxic fumes, or radiation hazards. There are areas in Los Angeles with long histories of fire, resulting from a combination of topography, ground cover and microclimatic factors.

F. Trauma Potential - This involves estimating the trauma in a pathological sense that can be inflicted on the users and residents of an area by the wreckage and debris of the built environment. Most San Franciscans know that Chinatown is not the place where they would want to be when the big earthquake hits the city. Clearly, the earthquake vulnerability of existing buildings and structures will provide a major clue. Such assessments can be based on the known earthquake rating of common building types (See Table 12, p. 354 in Blair and Spangle, 1979, for example). But field assessments may also be needed to determine trauma potentials of outdoor spaces resulting from the incidence of overhangs, cornices and parapets, signs and billboards, building ornaments and veneers, curtain walls and glass windows, bridges and underpasses, and the like. Such assessments are particularly critical in downtown areas where there is a heavy volume of pedestrian traffic during the work and shopping hours.

G. Occupancy - This is a very important consideration in assessing the vulnerability of an area. Essentially it involves looking at the temporal and spatial patterns of urban activity systems. Occupancy can be categorized as incessant, cyclical, seasonal, transient, episodic, rhythmic, and so on. For a baseball stadium occupancy is episodic; for a hospital it is incessant; for a school it is cyclical; and for a neighborhood it is rhythmic. Occupancy must also be examined in terms of density and intensity, as well as duration and amplitude. Urban areas can be analyzed and mapped according to variable patterns of occupancy as shown in Figures 3 and 4 (Lynch, 1976; Parkes and Thrift, 1980).

H. Coping Ability - This is a measure of human resiliency. It can be examined in terms of the social, psychological and financial abilities of the residents of a neighborhood to cope with post-disaster bereavement, stress and uncertainty. According to one report, past studies of post-disaster behavior show that people tend to cope well with the disaster and even develop a sense of camaraderie and "good Samaritanism" toward their fellow victims — a phenomenon called "the therapeutic community" by social scientists — and that crime rates fall dramatically until life starts returning to normal (Nilson, 1981). But Kates et al. (1973) report that after the earthquake in Managua there was

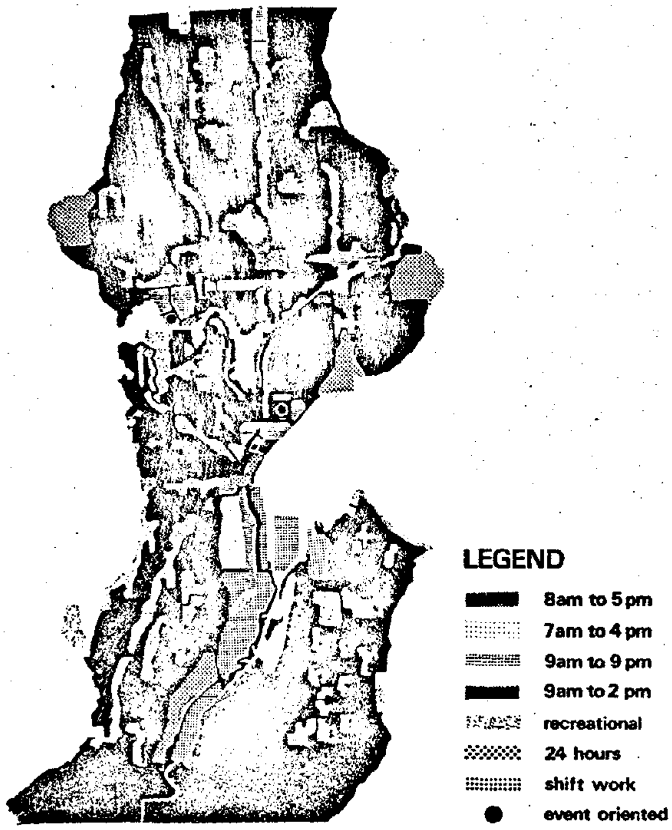

Figure 3. The "time envelope" of Seattle, showing the daily "pulse" of occupancy. Source: Lynch, 1976 (printed backward).

considerable evidence that people took what they could get from homes, shops, supermarkets and even warehouses, and some of the fires may have been set deliberately to divert attention from organized looting. These authors suggest that no special norms exist in the disaster situation and the prevalent community norm may provide the justification for the taking of unguarded property. What is not known is how people from different social classes, stages in family cycle, education and occupation cope with such distress. It is not known to what extent class and ethnic solidarity and social or racial homogeneity contributes to the spontaneity of such therapeutic communities.

It is particularly important to examine the financial coping abilities of different social groups. Those who have personal or family wealth, access to resources and "networks", appropriate credit rating, insurance, equity, and the like would no doubt bounce back more quickly and successfully from the disaster than those who eke out a living at the margin of society — the unemployed, elderly on social security, people on welfare, and even many working lower income families. For these people pre-disaster improvements are a must, and post-disaster aid programs are also necessary. It is common knowledge that these people typically are ghettoized in the inner city, older, transitional and deteriorating neighborhoods where dwelling structures are patently unsafe, and the trauma and hazard potentials are also quite high.

I. Critical Residents - Another people-oriented indicator of place vulnerability has to do with the concentration of "critical" urban residents in an area. Critical residents can be defined as those who are either developmentally or clinically unable to respond to an emergency disaster situation as competently as an able, healthy person, and who normally require care and supervision of others. The following are some examples of critical residents: very young children; the elderly; the critically or chronically ill; the mentally retarded; the mentally ill; the physically handicapped; the addicts and alcoholics; and the like. In assessing vulnerability of this kind, a mere inventory of such residents is not enough. It is necessary further to identify specific buildings, places and spaces where these people are likely to congregate: schools, nursing homes, retirement hotels, hospitals, clinics, rehabilitation centers, missions, "Skid Row" areas, and the like.

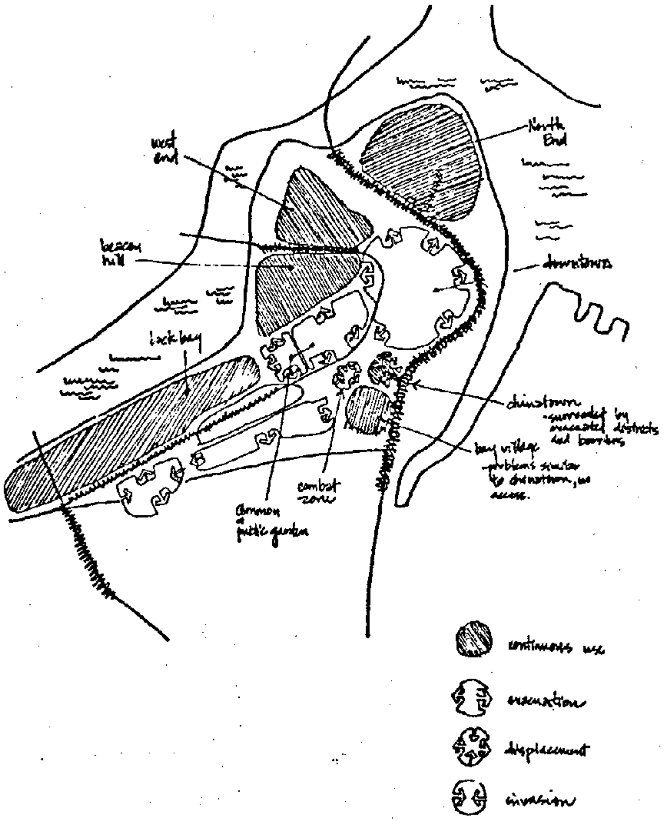

Figure 4. Cycles of use in central Boston. Source: Lynch, 1976.

The Nature of Design Response

These indicators can be seen as a set of criteria according to which the specific nature of the vulnerability of an urban district or a neighborhood can be assessed. Anyalsis of this nature can be done graphically — by mapping different attributes — thus doing the groundwork for developing specific policy measures or proposals for physical improvements. An illustrative analysis of downtown Los Angeles is shown in Figure 5. It is also possible to rewrite each of these place indicators as performance characteristics of a resilient place. That is, system redundancy, evacuation potential, restorability, serviceability, and the like can be seen as characteristics that must be met or maximized to make a place less vulnerable to disasters. Similarly, hazard and trauma potential must be minimized; safeguards should be designed to minimize risks during peak occupancy and for critical residents; and the coping ability of the residents must be supplemented by adequate physical improvements. Details of these performance characteristics and related design proposals will of course depend on the specific problem context. Figure 6 shows some illustrative examples using the Los Angeles case. Policy measures such as these can be appended to existing community or district plans; they can be incorporated in a district scale redevelopment plan, or a neighborhood conservation project; existing zoning and subdivision regulations can be amended to include earthquake safety provisions; and so on.

These indicators can be useful in another way, not just to analyze the physical form deficiencies in one area, but to determine city-wide priorities and policy measures. It is possible that the operational measures of these indicators can be developed and transformed to a common metric, or that a composite index using multi-dimensional scaling techniques can be developed. We can call this an Urban Vulnerability Scale (UVS), a measure for urban scale vulnerabilities. The most simple form of this scale will be a linear scoring function, (cf. Manheim et al., 1969) where the total score is a weighted average of scores on each of the indicators.[5] Since vulnerability implies risk it will be useful to express UVS values in terms of some accepted measures of risk such as number of deaths/1,000/year or dollars/capita/year. This scale thus can become an effective means for evaluating the degree of vulnerability for different districts or neighborhoods of the city. Also these scale values can be used to set overall performance targets for different districts — e.g. reduce current vulnerability

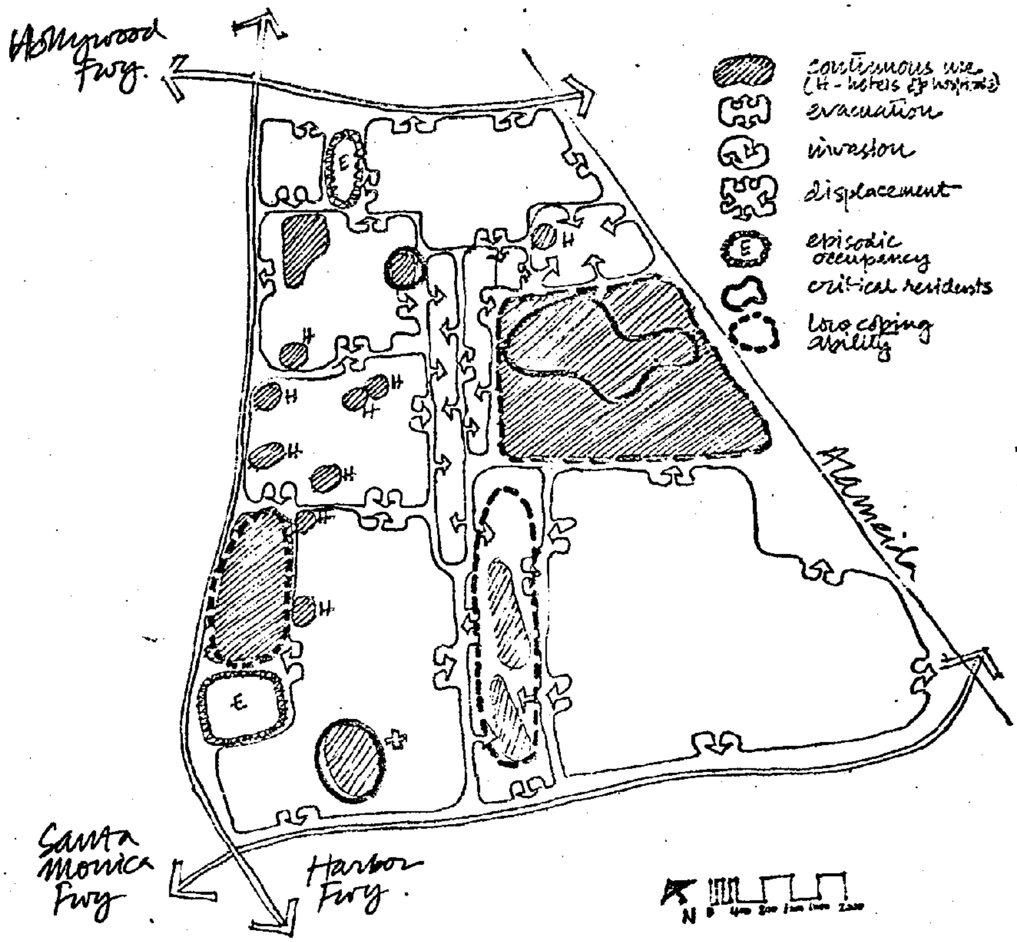

Figure 5. Patterns of Occupancy

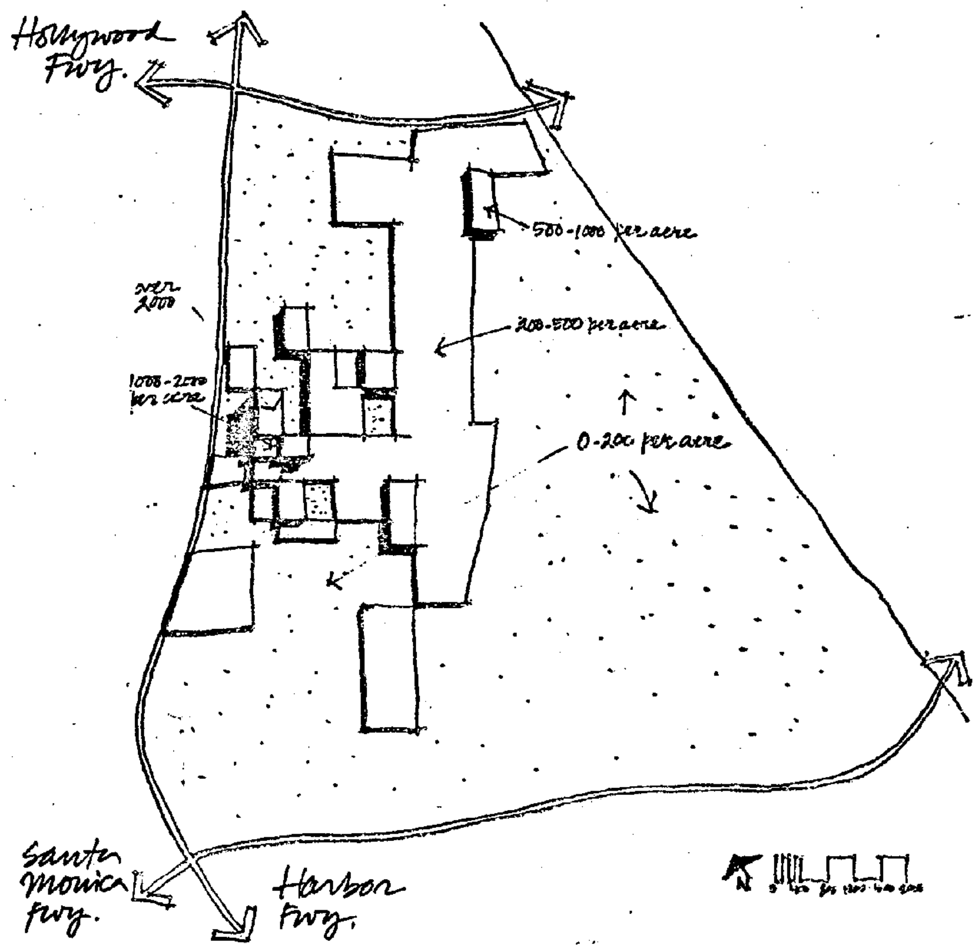

Figure 6. Employment Density

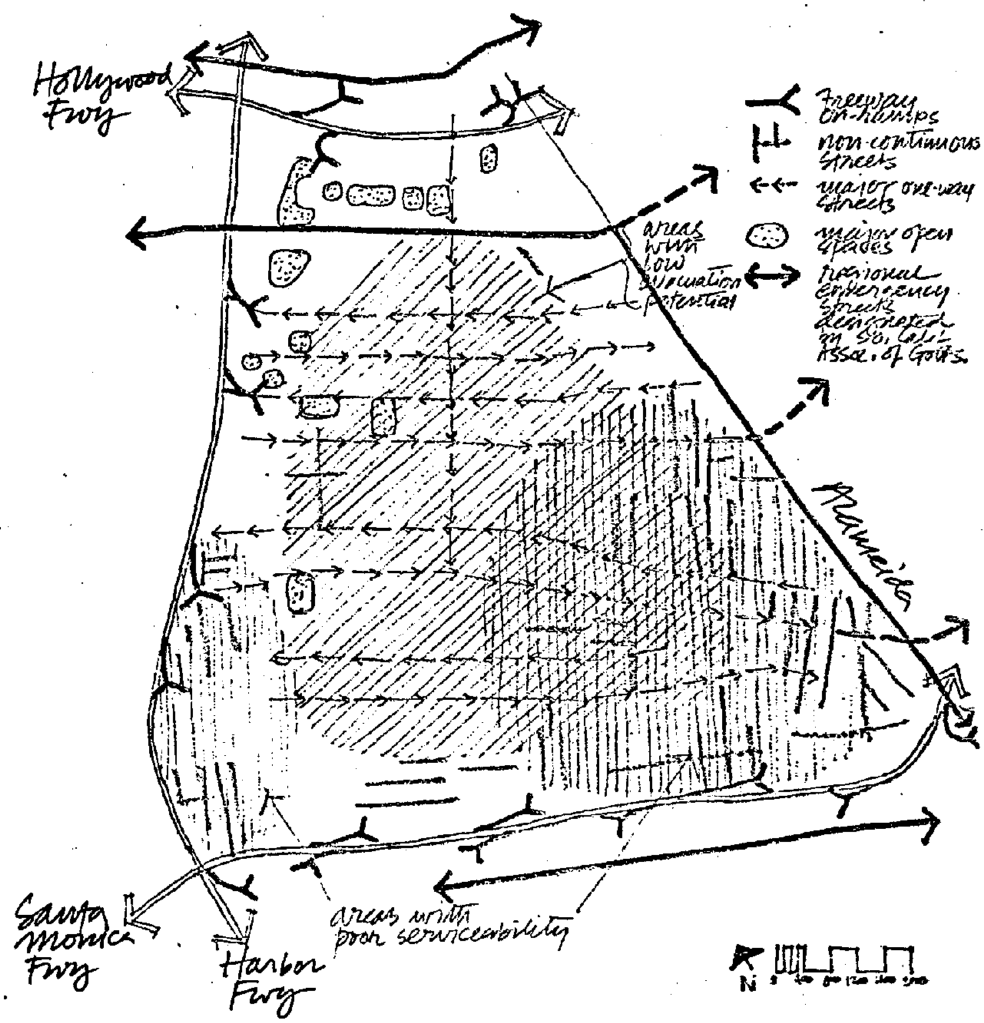

Figure 7. Serviceability, Constraints and Emergency Routes

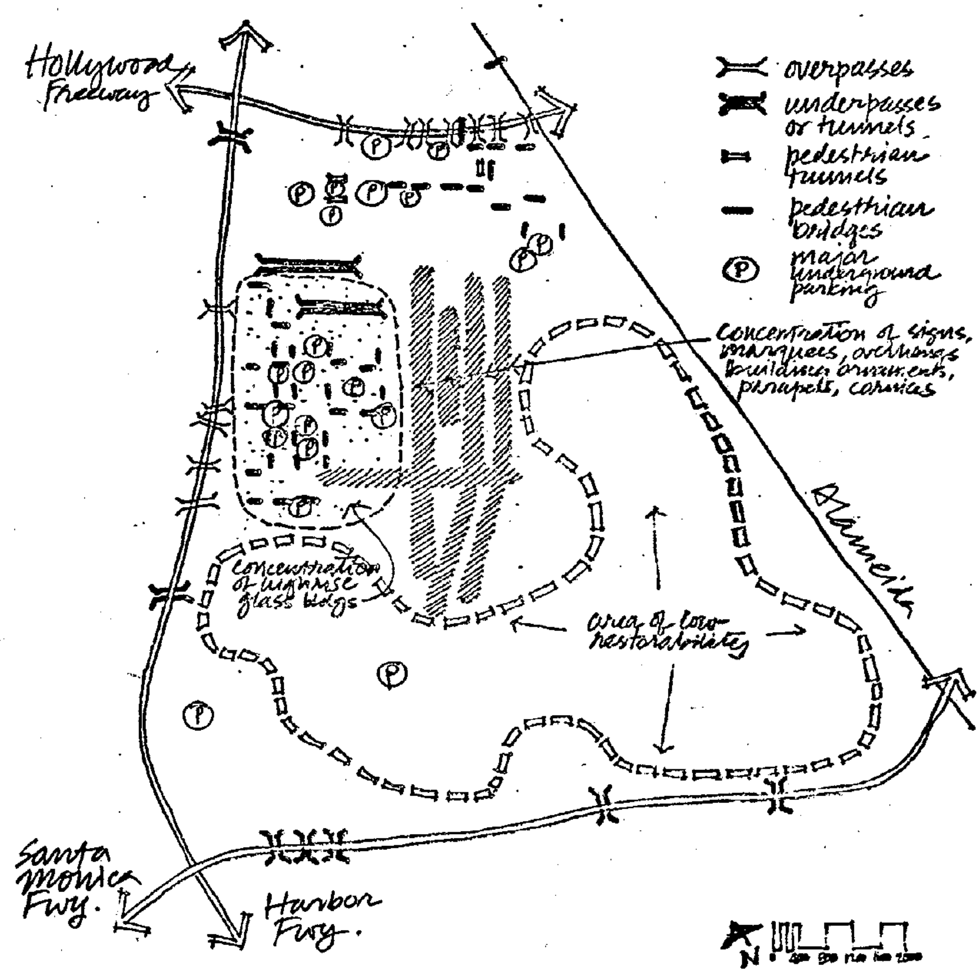

Figure 8. Trauma and Hazard Potentials

by 20%, or reduce risk level from 10 deaths/1,000/year to 5 deaths/1,000/year, or risk must not exceed 5 deaths/1,000/year citywide, etc.— which will then guide appropriate physical improvement programs.

Strategies for Implementation

In most cases, it would seem the earthquake safety improvement targets can be reached by piggybacking on-going projects, public improvement projects, ordinances and the like. Thus for example, the vulnerable sections of the life-line systems can be improved through existing public works program. Road construction, repairs, expansion, closure or vacation programs can be redirected to satisfy street improvement goals. Acquisition of new park sites can be a way to demolish hazardous buildings and structures. But in most cases new, innovative programs may be necessary. This will remain a fertile area of research and exploration. Some specific, earthquake safety oriented programs and ordinances have already been undertaken in some of the Bay area cities. Portola Valley has, for example, enacted a fault line easement within which no structures for human occupancy can be permitted. Santa Clara County has developed standards for bulding types allowable in different seismic zoning categories (Blair and Spangle, 1979).

There may never be enough public resources to accomplish all physical improvements or preventive programs; thus amortization of hazardous structures, risky occupancies, or vulnerable land uses in a prime location may be difficult to accomplish without compensation. An alternative to direct cash compensation will be transferrable development rights — a legal idea whose time finally seems to have come — which the property owner can use to recover his investment or the potential market value. Private building abatement programs can be triggered by low interest loans, tax write-offs or other fiscal incentives. The same idea can be used to keep high risk, undeveloped land open. Special architecturally oriented ordinances or review procedures may have to be enacted to ensure the safety of high rise buildings — largely from exterior veneers, curtain walls and glass windows. Some of the public safety features for large scale developments — downtown offices, shopping centers, industrial parks, entertainment centers, etc. — can be required by modifying existing zoning ordinances, subdivision regulations or specific area plans. Alternatively, private improvements of public places can be obtained by offering incentives — by relaxing existing buildable limit requirements, and the like.

Summary and Conclusions

This paper has tried to make a case for city design efforts in earthquake disaster minimization and mitigation. Some conceptual issues have been raised, and some operational definitions given. The paper has tried to develop an outline for a city design process (with illustrative examples) through which earthquake safety goals can be achieved. This has been done on the premise that the most expedient route to get maximum coverage on earthquake safety goals is to piggyback existing physical development, preservation and conservation efforts. It is expected, however, that serious earthquake vulnerability analysis will force these priorities to the forefront and will be carried on their own weight. It is also expected that innovative implementation strategies will be necessary given the expenses involved and a shrinking public coffer, especially in a post-Proposition 13 California. How to engage the private sector in sharing these improvements will remain a major challenge.

The reconstruction issue — although very much in the bailiwick of city design — has not been addressed here. There is something fatalistic, if not morbid, about inventing public policy in anticipation of reconstruction "opportunities", even in the fact of an inexorable disaster.

NOTES

[1]This scenario assumes a magnitude of 9.9 on Richter Scale (we presume). In one scene, a seismologist exclaims in an incredulous tone, "Nine point nine before the seismograph broke!" — final screenplay of Earthquake by George Fox (Shot 292-H, p. 80).

[2]These scenarios are cited in Scott (1971) but no date was given. Assuming they were quite recent at that time, 1970 dollars were considered reasonable to earmark the damage estimates.

[3]This term is taken from Lynch (1966).

[4]I am indebted to James Yumeji, a doctoral student in urban and regional planning here at U.S.C., who has brought these concepts and related literature to my attention, and thereby, I think, has subtly nudged me to respond to some of these issues.

[5]Here U.V.S. = Σ w.s., where w = weight, s = scale value, and Σ w = 1.0. It assumes that a common metric is possible for all indicators as in the Dee et al. (1972) study. How one obtains weights is another tricky problem.

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Vulnerability of the Urban Pattern: Synopsis

William J. Kockelman, Rapporteur

Prior to the presentations, Mr. George Mader suggested that two goals of the seminar be to define comparative studies to be undertaken by the Italians and the Americans and to more precisely define "urban scale vulnerability". In the U.S., we tend to consider metropolitan areas to be of major concern, such as Los Angeles and San Francisco, and think of them as being of an urban scale. In Italy, the most recent earthquakes have affected large regions with numerous small towns rather than extensive urban areas. We need to establish a framework that will facilitate comparisons between the two countries. Professor Henry Lagorio agreed that there was a need to define "urban scale" and stated that it must be an interdisciplinary effort. As an example, he asked "what do we do with the city of Rome"? Here, comparisons with San Francisco or Los Angeles might be instructive.

First Presentation

Dr. Alberto Clementi, Professor of Urban Planning in the Department of Engineering at the University of Rome, recapped his paper, "The Contribution of Urban Planning to the Mitigation of Urban Scale Vulnerability". He stressed several aspects, including the possibility of emphasizing recovery from an earthquake disaster as well as the reduction of seismic hazards. He suggested that "vulnerability" might be related to the capability of an urban structure to absorb seismic energy and still maintain its function. Such a definition of vulnerability would emphasize the urban structure's "loss of capability of service" rather than the extent of damage to people and property. He felt that this change of emphasis might lead to fruitful collaborative research projects of significance to urban planning and design.

In his paper Dr. Clementi assumed that there are intrinsic properties of the urban structure which determine its degree of vulnerability. After having detected such properties and quantifying their value it is possible to produce "vulnerability functions." Dr. Clementi listed types of vulnerability as direct, induced, deferred, and aggregated. He then introduced his "matrices of vulnerability" and described their construction and how to select the variables for the system of services and for an array of contextual situations. The system of services would be measured in terms of the morphological structure, density of services, building techniques, and residual capacity of services under normal load conditions. The contextual situations would be evaluated for the size of the settlement area; its functional characteristics, age, and scale; and the densities, special features, and dynamics of land use.

In conclusion, Dr. Clementi stressed the need to determine who the decisionmakers might be, and the types of decisions they might make, both before and after a disastrous earthquake. He added that there was a need for a "safety net", easy credit, and seismic resistant design and construction.

Discussion

Professor Giuseppe Imbesi agreed with Clementi's identification of needs and the possibility of developing matrices of vulnerability. Professor Antonio Gallocurcio suggested that the use of an underground safety room might be appropriate to reduce the danger from natural hazards. He noted pervasive attitudinal problems with the result that many people do not consider seismic risk. For example, funds are often spent on home im-

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provements without giving any thought to seismic resistance. Professor Gallocurcio stressed that maintaining the entire urban system is a primary goal; therefore, it is essential to examine the vulnerability of lifeline and societal networks. He noted that making existing buildings safer is very expensive and that reducing seismic impact on the urban infrastructure as a method of minimizing seismic risk may be more effective. Problems or vulnerabilities that may increase with time should also be identified. What are the variables affecting and methods effectuating the return of a damaged or destroyed system to operation?

It was noted during the discussion that the Italians were very familiar with actual damage, recovery, and reconstruction practices whereas the Americans had not experienced comparable damaging events. Therefore a collaborative research study might examine both recovery and reconstruction methods as well as avoidance and preventive techniques.

Professor Haresh Shah reviewed risk analysis techniques presently used in engineering to deal with urban systems. The systems are depicted as networks of nodes and links and can be described in physical terms — a system of gas mains and pipes — as well as functional terms — the system's economic performance. Current techniques permit mathematical analysis of system interaction and impacts resulting from a particular load, such as an earthquake. This analysis considers five variables: (1) total global loss, (2) the flow through pattern, (3) number of non-operating components, (4) path of network vulnerability, and (5) the network of system impedence. The network limits can be determined by employing impedence functions. However, what engineering analyses are missing are parameters defining the functionality of the system nodes. This is an area where planners can provide valuable assistance.

Professor Shah also introduced the idea of design-resistant, as opposed to "earthquake proof", construction and identified the factors that play a significant role in a structure's performance. The factors are frame-line redundancy, plan redundancy, plan symmetry, elevation regularity, construction quality control, and applicable codes under which the structures are designed. He pointed out that it does not matter what is built or rebuilt, but the important decisions concern where to rebuild, the density of the buildings, and what facilities need to be seismic resistant.

Dr. Imbesi summarized the history of his country's government and political structure, participatory types of governments, passage of the innovative 1940 planning law, and the history of urban planning since the end of World War II. After some discussion it was concluded that even though Italy and the United States are different in size, seismic history, government structure, planning practices, and response experience, the two countries have the common goal of reducing their vulnerability to earthquakes.

Chairman Minerbi distributed and described a simplified model showing the flow of resources, products, and harmful effects related to economic, environmental, and social stages, and related to the "description" of the stocks of resources, economic activities, consumption, and responses.

Second Presentation

Dr. Tridib Banerjee, Professor at the University of Southern California School of Urban and Regional Planning, recapped his paper on "Earthquakes, Urban Scale Vulnerability and City Design: Some Observations". He emphasized that city planning must include reducing seismic hazards as one of its goals; that the public bears a responsibility for reducing hazards to public lands and buildings; that urban design is a valuable technique for reducing such hazards; that some urban forms are more resilient than others; and that there are different ways to define urban vulnerability. He stated that when defining urban scale vulnerability, planners can provide insights on the social and behavioral context. He also noted that the distributional aspects of mitigation planning, including social equity questions, should be considered. While essential, he observed that seismic mapping is a passive tool. City planning and design should take a more active approach, perhaps by managing the interface between the public and private sectors as well as managing clearly public areas.

Then Dr. Banerjee queried "How do we change existing urban forms and existing programs?" Stating that developing performance criteria may be a useful approach, he listed the following "indicators of place vulnerability": redundancy, restorability, serviceability, evacuation potential, hazard potential, trauma potential, occupancy, coping ability, and critical residents. These indicators were then illustrated in an application to the Los Angeles, California area. Performance criteria such as these could be used to develop an "urban vulnerability scale" for the assessment of regions and districts as a prelude to planning and development programs. They could also be used in ongoing physical analysis for current city planning and design.

Discussion

Dr. Shah emphasized that earthquakes have a relatively low risk for loss of life and property damage when compared to most other risks both natural and manmade. Mr. William Kockelman pointed out that "seismic zonation" is a prerequisite to locating and designing urban areas, siting and designing structures, and adopting and enforcing regulations for reducing seismic hazards. Seismic zonation is defined by the U.S. Geological Survey as:

- Postulating an earthquake of a certain size and location
- Grouping geologic materials that have similar physical properties
- Predicting the effects of an earthquake on each geologic unit according to the type of hazard or ground failure
- Combining the effects onto maps usable by planners and decisionmakers

Chairman Minerbi summarized the presentations and the discussions. He suggested that research into urban scale vulnerability be started by developing a matrix similar to Clementi's and comparing two cities — one Italian and one American. He suggested that a case study of two contemporary events — one in Italy and one in the U.S. — be used to determine the public and private decisionmaking responses concerning reconstruction, examining short, medium, and long range decisions. The study might focus on places that have experienced and recovered from earthquakes and also areas where one is expected to occur. These studies should evaluate the full gamut of sociocultural factors bearing on urban vulnerability.

Mr. Mader suggested three candidates for such case studies, all of which had similar characteristics that were indicators of urban vulnerability. The three candidates were the 1980 Italian (Campania-Basilicata), the 1964 Alaskan, and the 1976 Chinese (Tangshan) earthquakes. The characteristics identified included: unstable ground, many older buildings, temporary housing, need for access and lifelines, socioeconomic dislocation, disruption of critical facilities, relocation considerations, and new housing.

Urban Scale Vulnerability: Focusing Down From City Regions to Community Clusters and Building Typologies

Myer R. Wolfe
College of Architecture and Urban Planning
University of Washington

I. Introduction

The purpose here is to raise additional questions pertaining to one of the three general subject areas delineated for the Workshop. (See Grant Program - National Science Foundation, University of Washington, "Seminar on Urban Scale Vulnerability"; (1) Land Use Planning and Regulation, (2) Vulnerability and Rebuilding Programs, and (3) Building Typology Guidelines). As such a closer look at the key words "urban scale vulnerability" is intended, focusing on several points:

(1) Questions of Scale: The setting of a place is examined within larger settings extending from: (1) building groupings, (2) to clusters of land uses, (3) to city sectors, (4) to communities or cities within the metropolitan area (Wolfe/Heikkala - "scale" and "macro/micro"). It is not addressed to individual buildings in-and-of-themselves nor is the emphasis on "lifelines" in the narrow sense (Eberhard - "urban systems" and "lifelines"), even though both are germane when considering seismic disaster mitigation. The focus here is on aspects of other environmental variables: location, size and character of settlement patterns, and the like.

(2) Questions of Planning and Design: Facets of urban planning and urban design, rather than structures and facility/service design, are emphasized here on the assumption that they make a difference in disaster mitigation. These fields cover aspects of new development but they also are involved in redevelopment, or even no development, which is indeed part of urban design and/or planning. Thus the spectrum of coverage in urban design matters extends from old city development to new, particularly in comparative analyses. Similarly, the spectrum encompasses de facto (inadverent) as well as de jure (deliberate) planning and urban design, noting that in a comparative setting both reflect socioeconomic and political determinants. We start with the premise that even if the state-of-the-art of earthquake prediction was superbly developed and the location(s) of earthquakes, their intensity, and the time and character of impact were known exactly, complete and comprehensive urban design for hazard mitigation might be somewhat similar in different international locales but would also vary because of socioeconomic, cultural or other circumstances.

Generic notions of planning, at least, are pertinent here. The presumption is that a form of advance decisionmaking is important when considering strategies of mitigation, allowing for contingencies and preparing for recovery. As it is so for a military campaign, a new town design, a shoreline preservation project so does it also pertain to a disaster mitigation "plan". (See Wolfe/Heikkala - discussion of planning vs. plan making, the nature of constituencies, etc.)

(3) Questions of Settlement Patterns: If one were to risk some hypotheses with regard to the urban form they would resemble these: (a) analysis and prescription of settlement/development patterns for mitigation purposes at several urban scales should make a difference, (b) the grouping

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and clustering of land uses, if examined for these same purposes, should have some effect on planning, (Blair - ". . .appropriate building and uses"), (c) typologies of building groups should be questioned in the same light. It may be noted that the issue of the whole urban form, while mentioned, is not stressed here. For example, depending on how acceptable risk is defined, the decision to build separate new cities and towns in metropolitan areas could be evaluated against accretion to the central city mass.[1]

(4) Comparative Questions: While all of the specifics of such questions are not to be touched on here, it may be fruitful to raise the issue of building codes because they are attempts at prevention (mitigation) and because they are universal.[2]

The arrangement of this paper is in three parts. First is this "Introduction" which states the coverage and emphases intended, noting the groundwork supplied in a companion paper.

Secondly, there is reference to the constellation of "communities" existing in the city region, hierarchically arranged and playing a part in a whole system. Several salient parts of that system are illustrated extending down to building groups. Following, is somewhat of a "Demonstration" using a hypothetical community to illuminate the application of information to a place and to prompt questions.

Thirdly, some "Implications" coming out of the previous discussion are noted. There are some tentative findings regarding the use of preventative measures that exist and their possible restructuring. These could set the stage for prescribing fruitful areas of research.

The graphic pages contained in this paper are more than illustrative; they are intended to be explanatory and are to be relied on as being exploratory parts. While reference is made to them in the text, they must be read in of themselves; there is no intent to repeat in the text what they show or explain.[3]

II. Demonstration

The city-region can be addressed as a first level of inquiry. Following are some extracts from concerns of urban planners when planning was mainly directed towards physical land use planning as against what may be characterized as policy planning of today.[4] Alternative physical plan configurations have been on the agendas of those seeking useful plans: Were they, are they, or could they be important insofar as disaster mitigation is concerned?

Certain typologies of alternative plan configurations have been formalized. They come out of the rationale behind the goal statement; for example, they reflected the natural features of the urban area to be considered and, implicitly or explicitly, they emphasized the economics of transportation. They also concerned themselves with the doctrinaire, that is to say, those patterns which might be affected by "principles." Catherine Bauer Wurster recognized this in supplying a rationale for choice in the wide range of hypothetical forms available (Wolfe). Her rationalizations led to essentially four possibilities noting they would not be equally applicable everywhere. It was reasoned that historical growth patterns, the stage of growth, the strengths of vested interests, etc., could affect such structure in an old city as compared to a new one. Also it was maintained that the dominant functions of the urban region could influence one pattern over another.

However, the use of alternative form considerations might supply the "consistency needed" towards pursuing a set of goals, perhaps more easily than trying to gain one specific preconception in a particular design form. Given this idea, a coordinate-like arrangement was described to exemplify four alternatives that were purportedly emerging, labeled:

(1) Present Trends Projected: fostering specialization already occurring in urban regions;

(2) "Dispersion": built on low density scattered development;

(3) Sub-regional Integration: postulating a constellation of somewhat autonomous cities which are diversified and are self-integrated; and

(4) "Concentration": built on the notion of a concentrated super-city.

Figure (1), Illustrative Examples: Development Alternatives for Year 2000, gives a line planning agency's view of how these descriptions could be applied to the Minneapolis-St. Paul metropolitan area. Mrs. Wurster noted that because of the hypothetical nature involved in such evaluations and because of the primitive state of cost/benefit analysis, choice among alternatives could be structured around means

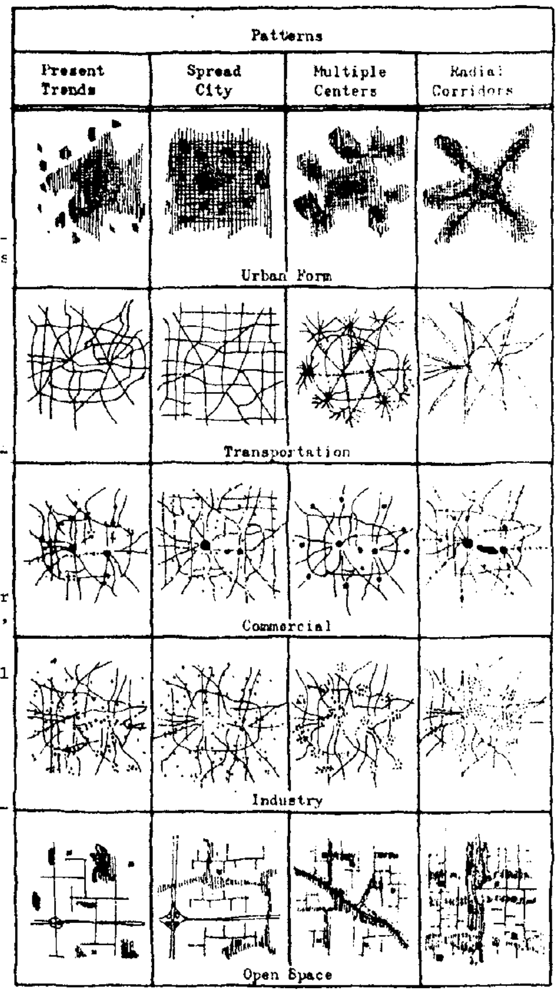
Figure 1

Basic Assumptions:
All alternatives meet the same functional goals; the difference depends on emphasis, priorities, and weights placed on certain values.

Transportation Orientation Exists: Several alternatives emphasize tendency toward dispersion through use of individual automobiles. The others are based on a premise of concentration using mass transit as a major element of transport.

Some Other Characteristics of the Alternatives:

(1) Present trends - emphasis is on a principal center plus a number of subcenters, etc., as present today.
(2) Spread city - equalizing accessibility; dispersal of industry, etc.
(3) Multiple centers - clustering in sub-regions; all purpose centers throughout.
(4) Radial corridors - concentrated patterns organized around transportation routes.



Illustrative Example - Development Alternatives for Year 2000
Minneapolis-St. Paul Metropolitian Area (By Twin Cities Inter-Agency Land Use-Transportation Planning Program)

From: Newsletter - American Society of Planning Officials, November, 1964.

Taken from: Wolfe, "Intricacies. . ."

and ends relationships. Specific ends such as accessibility to jobs could be compared relatively simply, but deeper social and economic effects would obviously be harder to assess; nevertheless, there was the suggestion that the attempts should be made.

Some important questions come out of this that are pertinent to the purposes of this paper. For example, continuing with the means and ends point and assuming seismic hazard mitigation is the goal, how does the assessment and definition of vulnerabilities correspond to the assessment and definition of categories of acceptable risk? What are the costs vs. benefits of encouraging or mandating "dispersion (spread city)" as against "multiple centers (subregional integration)"? How mandatory should radial open space patterns be in the region to provide disaster breaks, to isolate potential disaster areas, to leave relief and treatment room for a populace displaced by an earthquake, etc.? Is it better to concentrate in high density aggregations which are designed for maximum earthquake forces as against a low density spread where, if safer, nevertheless contain other cost penalities that can be attributed to space friction, transport costs, and the like? How does the acceptable risk factor enter into these macroforms as may be influenced by the state of economic development, cultural aspects and/or political ability to skew towards one pattern or another?

City Sector

While the city region must be considered the initial locus of concern for earthquake damage, it follows that a more sharply defined focus of human activity is a community within the system of communities making up the region. Figures (2) and (2A), "Urban Form Components and Growth Framework", illustrate the spatial disposition and pattern of cities and towns that make up the modern metropolis of megalopoli. Figure (2) represents the whole system generally and as it breaks down into parts. Figure (2A) attempts to delinate elements of a city sector schematically and the parts that could effect and be effected by disaster mitigation measures (Note the aspects of polynucleation, infrastructure, transport infill, and open space.) So, here is the context in which urban life takes place. If we should consider vulnerabilities at an urban scale within this complex a logical area of concentration might be a city sector.

Thus far the level of abstraction is arranged to be useful for international comparisons. But as one begins to consider basic elements of physical planning such as land uses, circulation modes and the location and dimensions of public services and facilities, questions arise as to the variables that shape them.[5] Yet it is apparent that professional concern should be directed to how growing city sectors contribute to the whole region since, as noted above, we assume that these aspects are vital in disaster mitigation.

Community Level

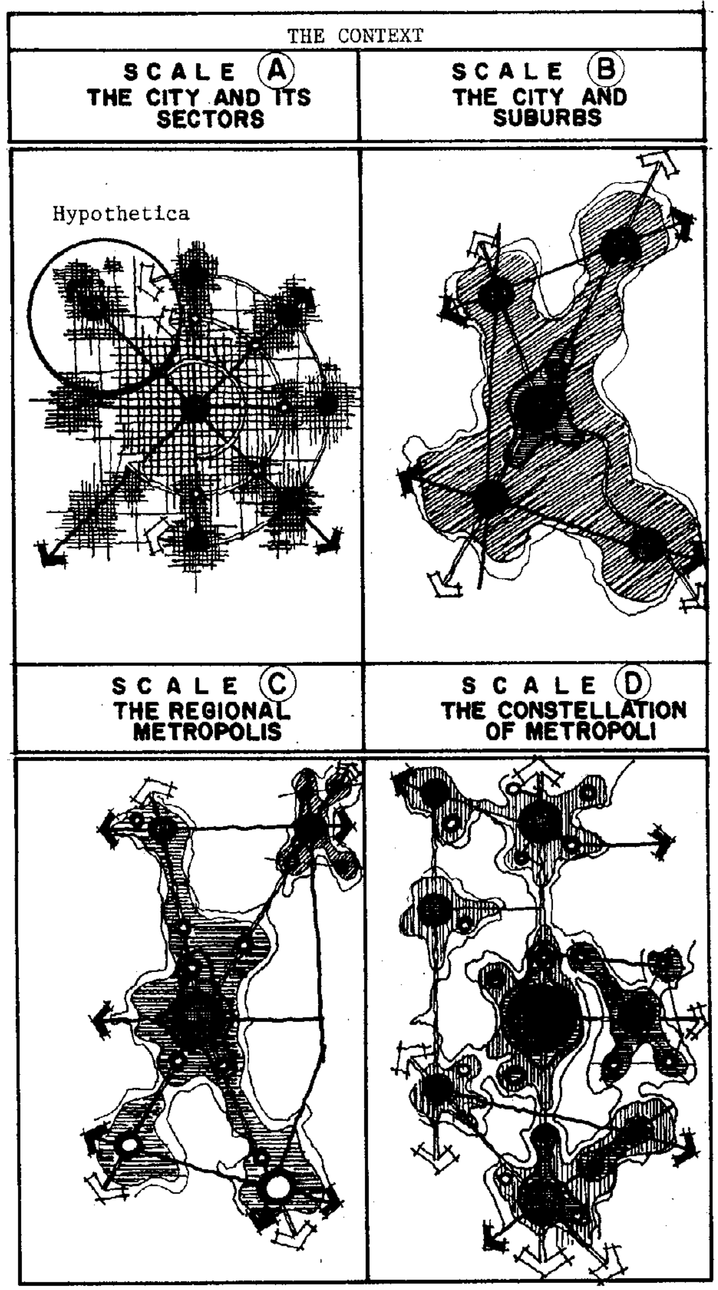
But this metropolitan city sector is where the local community also exists.[6] The foregoing represented macro issues; in scaling down to a community (micro) level the following schematic is used for comparative purposes: a hypothetical, small, formerly incorporated city that exists within a pattern of regional urbanization. It is an older town somewhat removed from the metropolitan center. It once was physically separated from the latter but since has lost its physical autonomy as the built area has spread. Certainly its economic separateness is a thing of the past. It is assumed, however, that a sense of historical community still exists partially reinforced by some visual boundaries and also some psychological ones inherent in names and artifacts.

Consider then, the imaginary city of Hypothetica, old but with new accretions on its edges. It has a population of approximately 150,000; its economic base is changing from that oriented to its coastlines (fishing, tourism, etc.) to that of a bedroom suburb and dispersed employment center. Figures (3) and (3A & B) exemplify its physical pattern, suggesting land uses, densities, travel flow, activity nodes and the like. Thus far the community form can be construed as a product of de facto actions and constraints, meaning that the whole pattern is a result of separate multiplicities of private and public decisions over time.

Figure (4) implies the temporal rhythms as they may be viewed alongside high density buildings. Figure (5), Zoning, could be considered a surrogate for public policy decisions as might result from careful comprehensive planning.[7] It is therefore a record of an institutional response to urban problem mitigation and is an example of shaping urban development de jure. Up to this point, the assembly of information has been descriptive of the place and that which exists. The zoning scheme, however, is evidence of the constraints placed on the community by government action to assure some sort

Figure 2

Hypothetica: Urban Form Components and Growth Framework



Revised from: Wolfe, "Intricacies. . ."

Figure 2A

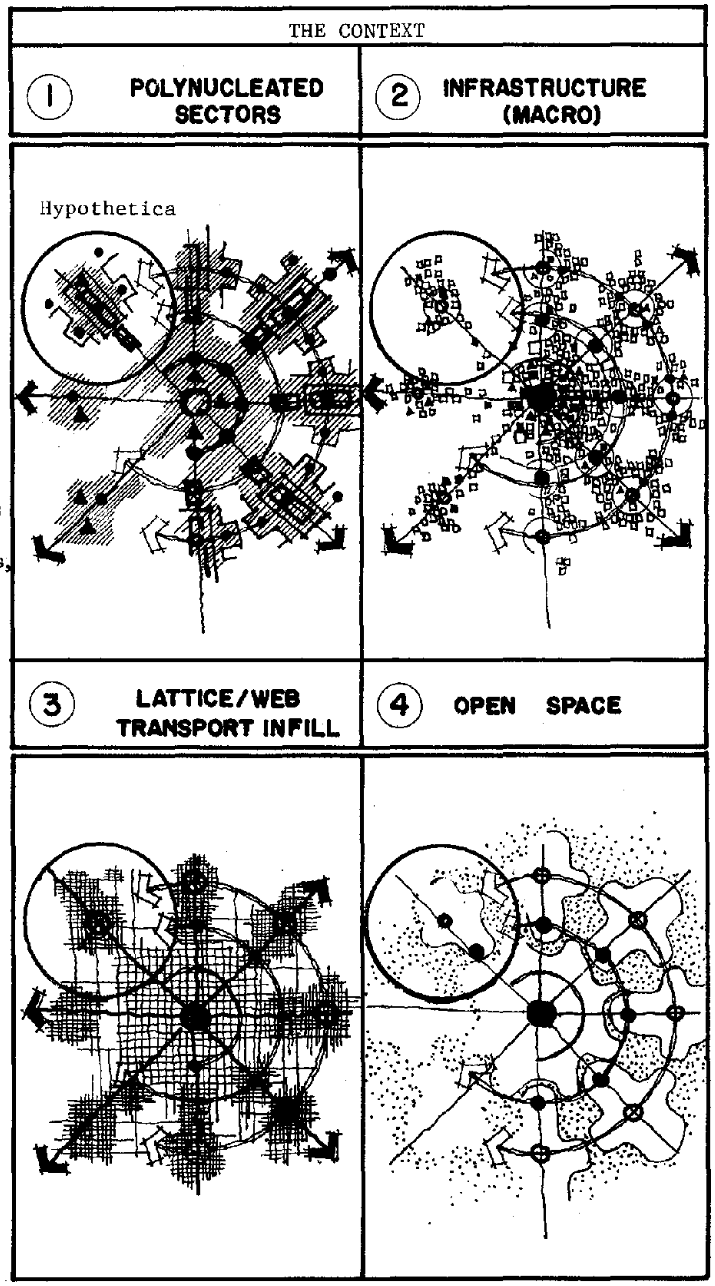
Hypothetica: Urban Form Components and Growth Framework

Polynucleated Sectors:
Tendency to gather, or structure, into communities around regional subcenters (commercial etc.) served by major transportation facilities and separated by less intensively used land.

Infrastructure:
Major facilities to move people and goods — road and transit lines. In addition, major regional activity nodes — shopping, recreation centers and similar act as places of gathering. This combination of linear transportation channels plus the activity nodal points produces a primary skeleton. Supported by facilities and services such as sewer, solid waste disposal systems, water, gas, power systems, etc.

Transport Infill:
The web-lattice network. The pattern of major roads and transit lines (web) super-imposed over grids (lattice) of varying spacing according to population density, traffic generators, and the like.

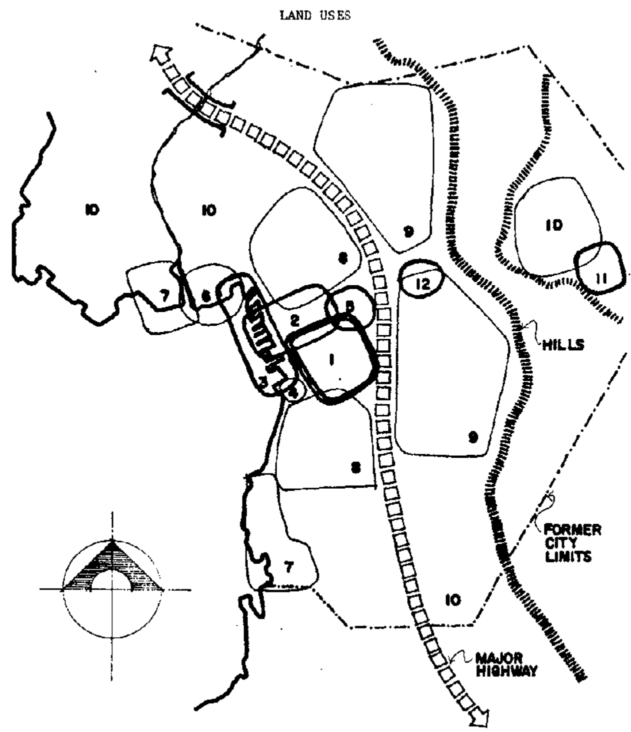
Open Space:
The major urban regional form delineator. Hierarchial; may articulate cities, towns, and agricultural land uses; may separate intensive land uses from extensive; may structure urban, suburban, etc. bands in terms of their density, juxtaposition and the like.



Revised from: Wolfe, "Intricacies. . ."

Figure 3

Hypothetica: Physical Patterns



1	CENTRAL BUSINESS DISTRICT	7	PUBLIC PARK / MARINA
2	HISTORIC DISTRICT	8	OLD NEIGHBORHOOD
3	LIGHT INDUSTRY	9	NEIGHBORHOOD (35 YEARS)
4	FERRY LANDING	10	NEW NEIGHBORHOOD
5	GOVERNMENT CENTER	11	NEW EMPLOYMENT CENTER
6	FISHING CENTER	12	NEW SHOPPING CENTER

Figure 3A

Hypothetica: Physical Patterns

DENSITIES

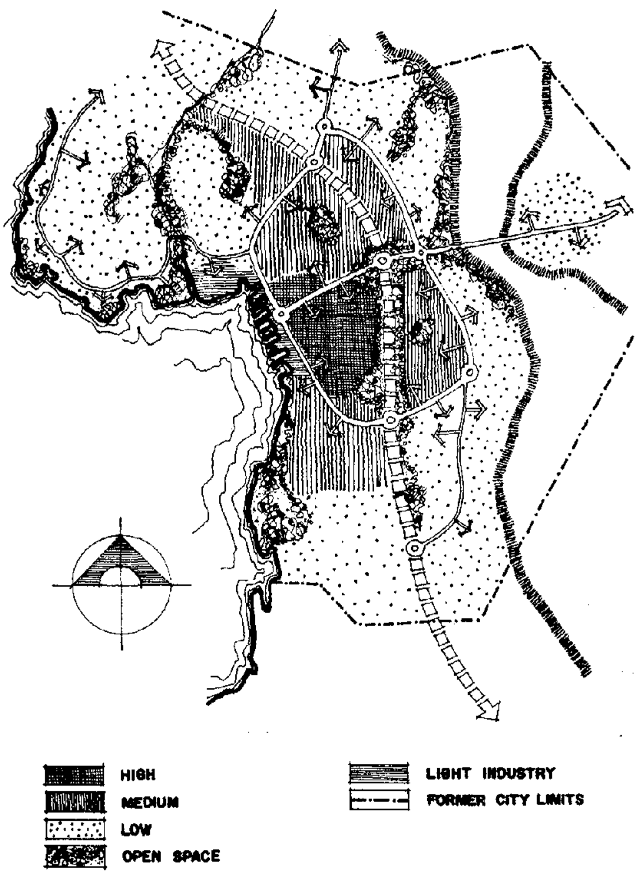


Figure 3B

Hypothetica: Physical Patterns

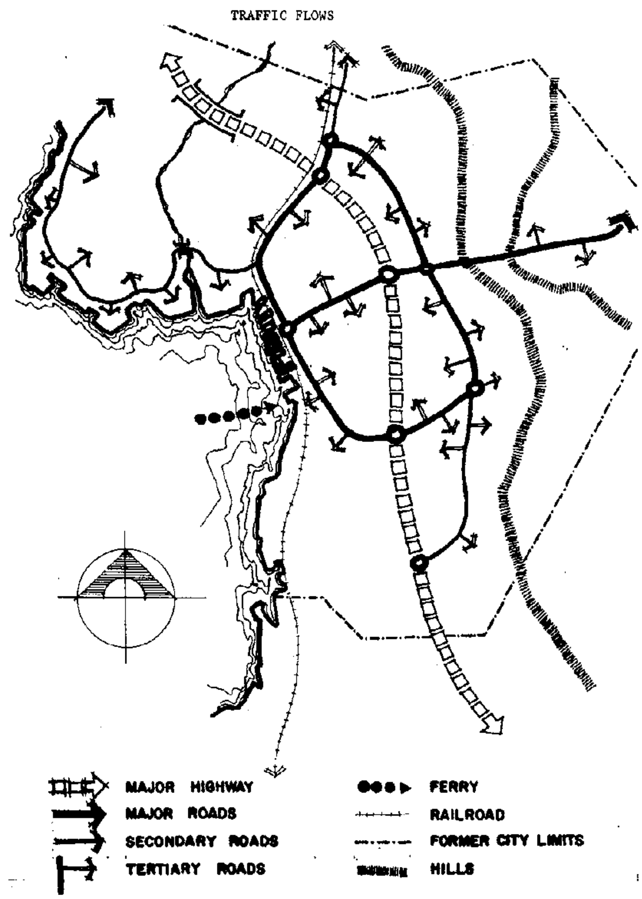
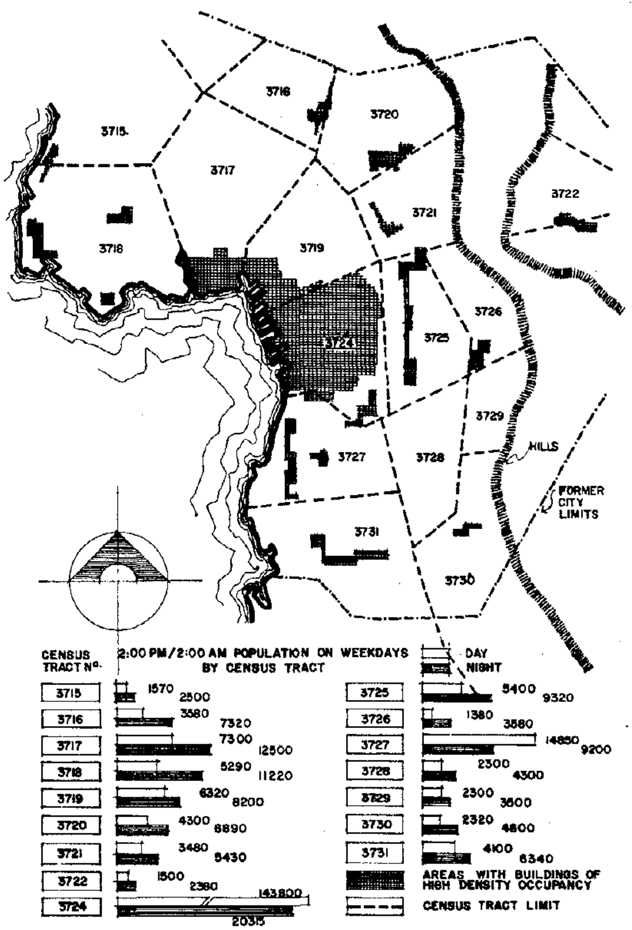


Figure 4

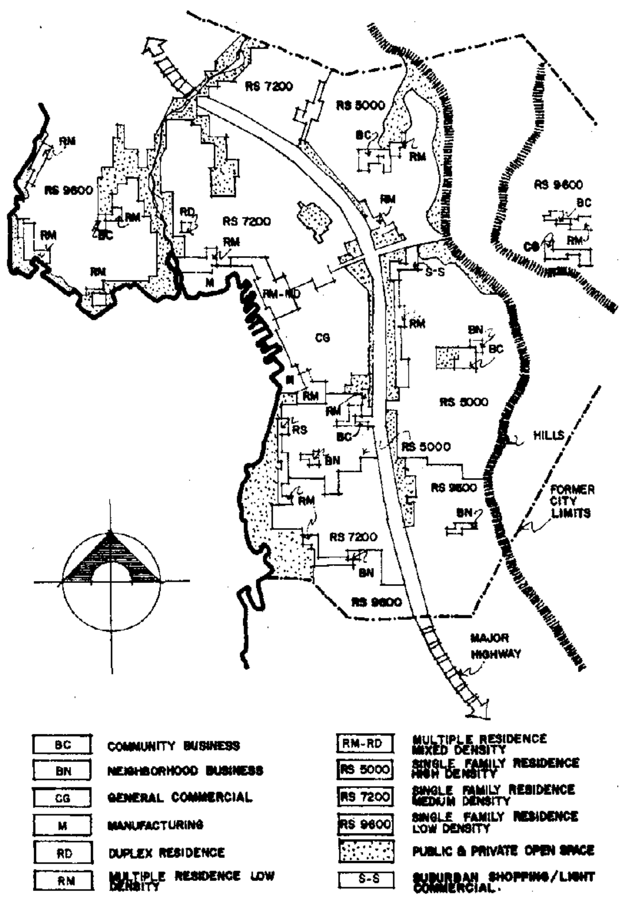
Hypothetica: Temporal Patterns and Densities



Modeled after work in Palo Alto, California, Blair and Spangle.

Figure 5

Hypothetica: Zoning



of balanced optimum growth, at least that is the objective. It is assumed that the topography and geology of the area shown in Figure (6) also influenced the pattern described in the preceding schematics. Figures (7) and (7A) constitute a simplified identification of hazards occasioned by earthquakes and the resultant vulnerabilities.

One interesting if not significant point here is that this range of information—from land use densities and activity patterns, to zoning, and to natural hazard vulnerabilities—often appears in separate land planning and earthquake mitigation documents and does not usually appear together.[8] The implication here is that if overlayed, literally and figuratively, one could examine any correlations or the lack thereof between the built environment, the regulatory framework, and urban scale vulnerabilities. One caveat should be noted. This paper makes no attempt to interpret these pseudo maps even as they may be envisioned overlapping. The emphasis here is to postulate that the state of the art in disaster mitigation: (1) does not seem to address itself comprehensively to the holistic community, (2) does not seem to aggregate various inventories of social and economic parameters as well as physical which will be impacted by severe earthquakes, and (3) does not seem to look at the full panoply of restrictive, coercive, permissive and incentive measures that do exist beyond the building code and planning exercises and their potential relationship to seismic hazard mitigation.

Building Typologies

Should building types as they appear in groups be classified and be subject to study as to their potential role in seismic disasters? If it could be held that form springs out of function, then the shape of the pattern of buildings should be looked at. Is the potential ability of building groups or clusters to withstand extraordinary stresses merely a matter of structural stress alone?

To what degree should changing land and building uses be a factor in disaster mitigation? Do adaptive reuse concerns of urban designers of today stop at the evaluation of the buildings for economic purposes or purposes of historical preservation, or can new multi-uses be geared to mitigation ends as well?

Questions concerning the age, character, and inherent ability to use groups of buildings in a mitigation milieu ought to be augmented by studies examining the use characteristics, income levels, unit types, densities, land use intensities and the like.[9] Land coverage, open space and building orientations are considered in designing; therefore, would the shape and form of the most intimate micro "community" (clusters of buildings) be changed if the design was skewed to accomodate a disaster preventative imperative?

III. Implications

Thus far some major elements that impinge on the operations of the physical systems of urban environments have been identified here: (1) the form of the urban artifact, (2) spatial dimensions inherent in scale, (3) activity patterns, and (4) temporal considerations (Wolfe/Heikkala). In discussing the scale and hierarchy of urban areas, and in overlaying the physical activity patterns with typical vulnerability and risk factors (see Hypothetica), there is at least a germ of concern for each of these four major elements.

At the risk of redundancy, it should be equally useful to repeat other things that have been stated as "areas for comparison" (Wolfe/Heikkala). There are researchable questions inherent in comparing the age and pace of development, the urban morphology and the political decision-making inherent in urban development, all of which are directly related to vulnerability and risk analysis. Certainly identifying how these factors overlap and interact in a place should result in making more explicit that which may be done implicitly.

More on Buildings

It can be hypothesized that most of the same concerns for individual building types could be construed as equally applicable to groups or clusters of them. For example, it is important to define:

(1) The character and extent of their occupancy, i.e. when occupied, by whom and in what numbers.

(2) The shape of the development pattern, i.e. the structure of the form which is critical in design. It is this identification that differs from the consideration of individual buildings since it encompasses the life-line design determinants for a group

Figure 6

Hypothetica: Physical Determinants

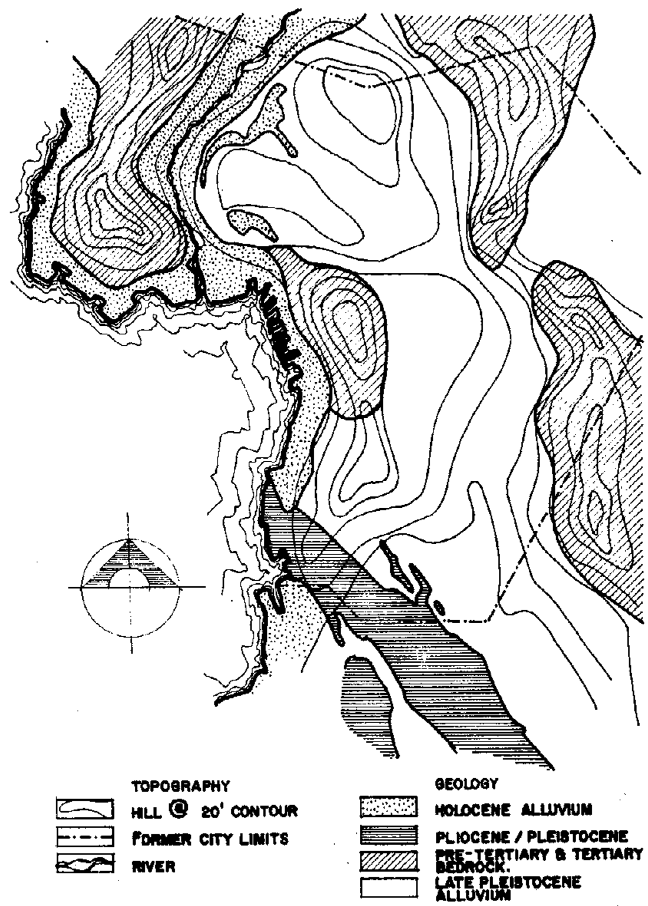
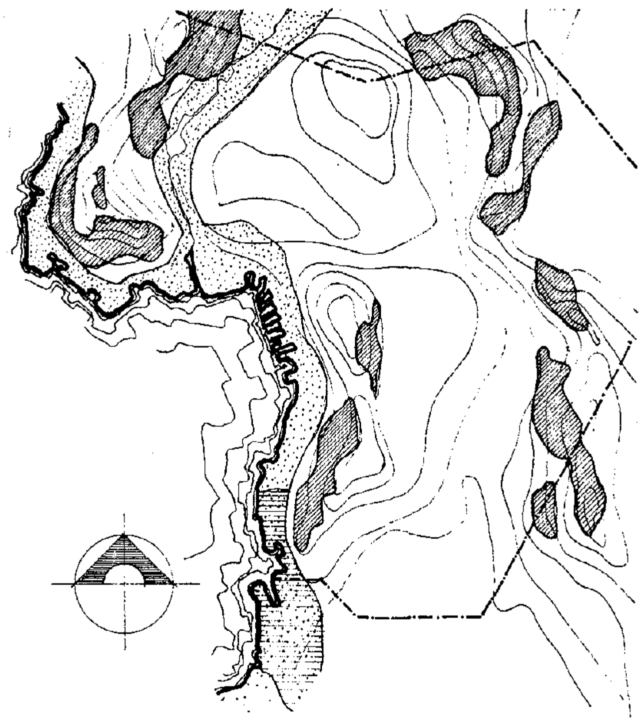


Figure 7

Hypothetical: Vulnerabilities



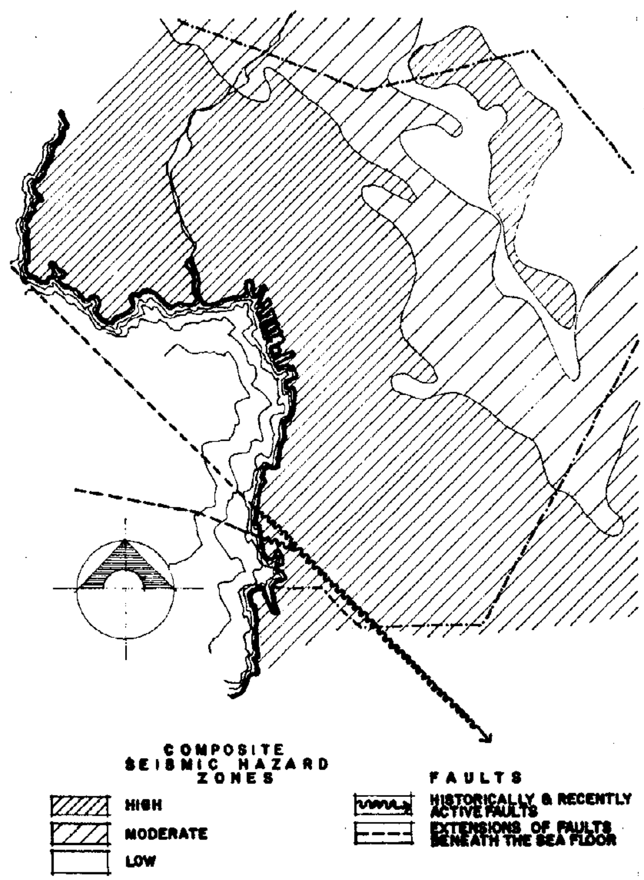
HIGH POTENTIAL FOR LANDSLIDING

HIGH POTENTIAL FOR LIQUEFACTION

PARTIAL FLOODING POSSIBLE

Figure 7A

Hypothetica: Vulnerabilities



of buildings as opposed to a single building. We would be dealing with a subsystem not just one unit within the system.

(3) The relationships of buildings to other buildings, to open space, to parking, and the traffic generated. Here too we raise the potential differences insofar as how groups relate to each other and how they fit in city sectors. Note the analysis which might be directed to this scale, to the density/intensity items and the like.[10]

However the risk and vulnerability propositions apply again (see Blair). If vulnerability indices could be developed for buildings and if risk could be clarified as "acceptable", the premise is that groups of buildings should be considered, not just one building.[11] There are precedents. For example, floodplain zoning and flood hazard mitigation measures have been developed on the basis of whether the community is willing to suffer area damage by estimates of expected maximum flood times (a 20 year flood, a 50 year flood, etc.). More germane however is that these time-risk areas may apply to some land uses and buildings but not to others. So a large space user — a stadium — may be located in a 20 year maximum flood zone.[12]

The problem with that analogy is that cost/benefit or cost/effectiveness analysis behind the determination of the "acceptable risk" is based on a much greater confidence in predictability. (That stadium use may be acceptable because we can predict and warn of floods so that the structure becomes timely unoccupied, to put it simply.) There is no intention here to comment on the lack of early-warning systems for earthquakes; suffice it to say if we knew specifically where the impacts of earthquakes will be felt (microzonation efforts represent a step towards this) plus, the frequency, extent and intensity of the shocks, our confidence in averting disasterous effects would mount. The obvious point is made to reflect on evaluation methods, which in seismic terms may be better concerned with the tenet of military strategies and tactics, chess planning, Monte Carlo methods or, in any case, with the use of scenarios, alternatives, options and/or conditioned probabilities. In the last analysis, public policy decisions will prevail: the question raised is will these decisions be backed by knowledge of optional consequences?

But the assumption can be made that the design and layouts forthcoming in multi-building projects is relevant if information is available, notwithstanding the prediction state-of-the-art. If the intensities of seismic action, locations, motions, plus side effects of liquefaction, tsunamis, etc. are part of a vulnerability analysis, site design factors can help in decreasing risk. Along with that sort of urban design for new areas and projects, the question comes up whether disaster mitigation measures of the sort discussed here should be considered for older areas not being cleared but reused.

There is a heightened concern for "adaptive reuse" of older buildings for economic and/or preservation reasons which may be also germane for purposes intended here. Can a complex of old public school buildings, now obsolete (because school-age children are not in the service area or the buildings are no longer suitable as schools) but architecturally and historically significant, be adapted to other uses which meet code and design requirements? Could the use be changed from high, intense, critical, daily activities to another kind that does not have the same structural safety requirements, such as changing a school to a museum complex? Could a group of older, joined (common wall) housing units become a more acceptable risk if altered to meet conditions of vulnerability and risk by collective structural reinforcement of buildings and, in context with similar units in the cluster, by providing strategic open spaces, inserting new uses, and scaling the development area to the lifeline systems?

More on the Deliberate[13]

Consider the manifestation of existing de jure actions that pertain to the subject. Development regulation by zoning has already been mentioned. It seemingly controls impacts by regulating densities and build-up (thus allowing the scaling of services) and building bulks (thus setting patterns of undeveloped spaces and heights, and limits, say, fire damage). There are other regulations that might be part of a program for mitigating disasters. Zoning has much built into it directed to single buildings and single property ownerships but a look at other public restrictive measures raises questions as to whether they might be applicable to areas in which buildings stand or will be built.

Subdivision regulations have to do with parcelization (i.e. the break-up of large land holdings into "parcels" and lots to be owned or leased) and minimum requirements of lot size. Also they contain requirements for the provision of water systems, satisfactory sewage disposal systems and appropriate road access. Note the impingement on matters of density and build-up which will be affected in seismically active areas.

There are others: housing codes requiring standards of decency and overcrowding plus others of a special nature such as shoreline management laws which are directed to specific areas but which often have more stringent environmental requirements than more conventional ones.

To single out one other, the Environmental Impact Statement (Wolfe/Heikkala) is used to elucidate before hand the potential impact of significant developments of any sort. There are two principal points here: (1) there must be a public acknowledgment of impact by officers of the local government, and (2) the potential of such impact must be described publicly through formally constituted hearings. Note what must be covered in the analysis:

(a) The environmental impact (containing a detailed description including technical data of potentially adverse effects).

(b) Analysis of environmental effects that are unavoidable.

(c) Alternatives to the proposed action (evaluated and rationalized as to why each was selected or rejected).

(d) Reporting on the relationship between short term uses and long term productivity.

(e) If implemented, analysis of what irreversible and irretrievable commitment of resources has been expended.

While they may not be applied to the degree and to the depth as wished in reality, this action is useful in that formal notice is required of public officials, and those who may be affected are afforded notice and opportunity to comment. With the substitution of a few words, the five requirements noted above could easily slip into the literature of disaster mitigation, adopting the wording as well as the intent.

All these public measures are directed to the use of land, its break-up by size, the use and volumetric aspects of buildings and open space, the code requirement of safety and decency, required assessment of development, etc. before hand. The question arises if they were all applied to seismic disaster mitigation whether new ones would be needed? The terms "mitigation", "planning", "urban", and the like, if used generically, extend across the spectrum of preventative and remedial activity that are the prerogative of the planning and design professions and it is suspected that they have not been optimized as yet.

NOTES

[1]See Arnold, - for an excellent treatment of how form affects individual buildings. His building form criterion, however, is applied here to places. See also Kirijas who addresses places but in rather strict lifeline specifics, i.e. sizes and multiplicities of utilities and roads.

[2]See Wolfe/Heikkala regarding the use of analogical and homological methods for comparative purposes. It could be said that the latter tends to emphasize process and structures of planning decisionmaking rather than an emphasis on a physical plan. The first tends to identify national, cultural, social or even perhaps regional differences more distinctly. In other words physical end product plans may not be as germane to examine comparatively nearly as much as the planning process which determined the plan.

[3]It is interesting to note that the sketch plan device which is a matter of depicting spatial hypotheses as is used here, is rarely found in the mitigation literature. Yet it is an important conceptualizing device used by architects or urban designers in the process of examining intricate three dimensional systems in alternative conjectural frameworks. The examples here represent schematically what is; it is only a step away to represent the options of what could or should be subject to evaluation and choice. This graphic language not only connotes a place, it can pose the variants produced by prediction, projection or alternates for mitigation purposes.

[4]There is no intent here to debate the intellectual and professional excursions that have gone on under the rubric of "urban planning" which have swung from monolithically physical to unfettered "social". Suffice it to say, one must go back a decade at least in American professional planning literature to find such examples as used here. (See Wolfe/Heikkala and Wolfe)

[5]Consider again the measures of density and intensity: quality, time shape, zones of influence and material effects which all have national economic, and cultural determinants built into them. (Wolfe/Heikkala)

[6]By the word "community" is meant a smaller aggregation of an urban entity. One could call it a small city, town or recognizable part of an urban area that possesses attributes of physical and social cohesion.

[7]The word "zoning" is used here to describe the American application of police powers in the interests of preserving and enhancing the public morals, safety and general welfare. A local ordinance permitted by the sovereign body, the state, is formulated by which private property may be controlled in terms of the size, bulk, and height of buildings; yard space to be provided; the use of land and other volumetric attributes of development. Zoning purports to control density (relating land use and traffic generation), prevent hazards (occasioned by building), conserve property values, etc. Variants in form, but not in general substance, exist in many developed countries.

[8]See Wolfe/Heikkala. As described, the State of California, perhaps more advanced than others in earthquake concerns, requires a seismic disaster element be included in all city general plans. But there are few that join these with their zoning ordinance and map. Building codes, yes; zoning codes, no.

[9]See Appendix (A) "Design Guidelines for Residential Areas" and (B) "Housing Configuration in Relation to Open Space for Low Rise Building", for examples of the beginnings of such classification.

[10]One can understand why urban designers (as opposed to "architects" or "planners") tend to define their sphere of activity by citing objectives of urban design as: ". . .those things potentially manipulable. . ." "(1) spatial forms of environmental settings (topography, shape, scale, definition, boundaries of physical areas, internal organization of spaces, and connections to other spaces.) (2) Standing or reoccurring patterns of activity (location, intensity, type, flows, and scheduling). (3) Ambiance (visual attributes and elements; light, sound, etc. as associated with activity cycles)" (Wolfe).

[11]See Blair, etc. Appendix (C). "Land and Building Uses Appropriate. . .", Table 17.

[12]The character of the risk is also involved. Another example: consider a hospital complex— not just a building – which must be excluded from zones of soil liquefaction at all costs because of the nature of the facility's use. The risk factor here is somewhat more immutable; can there be an "acceptable" risk? Consider also the necessity of assuring lifeline protection or alternative systems. Consider furthermore that lifeline in this case must dramatically include accessibility from all parts of the city since its function becomes even more important in times of disaster.

[13]See Wolfe/Heikkala - pp. 5 and 6 which indicates Oakland, California's "Environmental Hazards Element" of the general plan. Also, pp. 12-14, comments on its coverage.

Drawings by Guillermo Gómez-Pedrozo Rea

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Wolfe, M. R., assisted by Susan Heikkala; "Urban Scale Vulnerability: Some Implications for Planning"; Paper given at Third International Conference: "The Social and Economic Aspects of Earthquakes and Planning to Mitigate Their Impacts", Bled, Yugoslavia, June, 1981.

This is a continuation and extension of a previous paper — "Urban Scale Vulnerability: Some Implications for Planning" — prepared for this purpose and also for the Third International Conference: "Social and Economic Aspects of Earthquakes and Planning to Mitigate Their Impacts"; Bled, Yugoslavia, June 29-July 2, 1981. That paper should be considered the background setting for this one.

APPENDIX A

Table VI-1 - DESIGN GUIDELINES FOR RESIDENTIAL CHARACTER AREAS
(Lower densities, i.e. single family dwelling, etc. not included here)

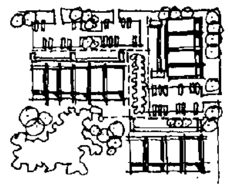
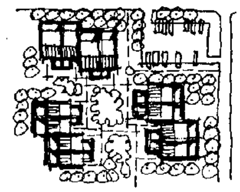
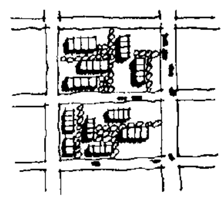
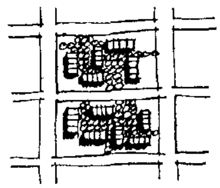
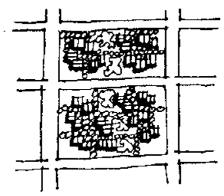
Land Use Characteristic	Income Category[1]	User	User & Unit Mix	Unit Type[2] Bedrooms	Unit Type[2] Baths	Density (Units/Acre)	Land Use Intensity	Building Height (No. of Floors)	Parking	Open Space Ratios
Residential	Low to Medium	Family[3] Couples Singles Elderly	50% 20% 15% 15%	2 & 3 Studio / 1 Studio / 1 Studio / 1	2 1 1 1	60 to 80	High	6 to 9	Public parking structures provided	Low, public open space provided
Mixed[4] Residential/ Commercial	Medium	Family[3] Couples Singles Elderly	50% 20% 15% 15%	2 & 3 Studio / 1 Studio / 1 Studio / 1	2 1 1 1	60 to 80	High	6 to 9	Public parking structures provided	Low, public open space provided
Mixed[4] Residential/ Commercial	Medium to High	Family[3] Couples Singles Elderly	25% 25% 35% 15%	2 & 3 Studio / 1 Studio / 1 Studio / 1	2 1 - 2 1 1	60 to 80	High	6 to 9	Integrated with Structure	High
Mixed[5] Residential/ Office	Medium to High	Family[3] Couples Singles Elderly	10% 20% 50% 20%	2 & 3 Studio / 1 & 2 Studio / 1 Studio / 1 & 2	2 1 - 2 1 1 - 2	80 to 100	High	20 to 35	Integrated with Structure	Medium
Residential[4]/ Commercial	High	Family[3] Couples Singles Elderly	10% 20% 50% 20%	2 & 3 Studio / 1 & 2 Studio / 1 Studio / 1 & 2	2 1 - 2 1 1 - 2	30 to 40[6]	Medium	4 to 8	Integrated with Structure	Medium

Assumptions:
1. Low and medium income units are partially "subsidized" through provision of publicly-financed parking structures and park and recreation areas.
2. Average unit size: 850 square feet (2 bedroom/1 bath). Some 4 bedroom units may be required for extended families or those with a large number of children.
3. Familes with young children on first six floors only.
4. Commercial space provided at pedestrian level.
5. Office, first 10 floors.
6. Cluster configuration

Kakaako: An Urban Design Demonstration Study; State of Hawaii, Department of Planning and Economic Development December, 1975 (Wolfe - "Principal Urban Design Consultant")

APPENDIX B

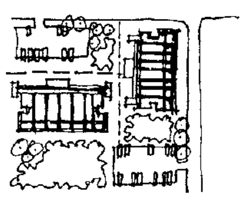
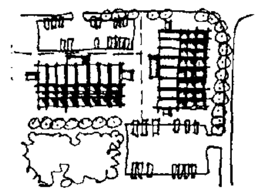
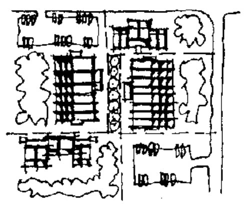
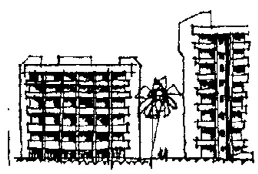
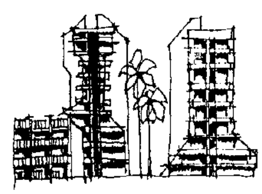
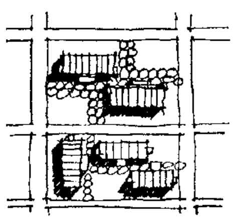
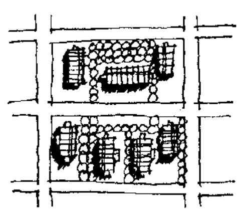
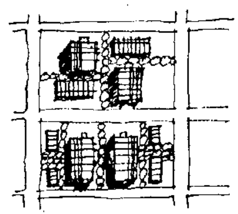
Table VI-2 - HOUSING CONFIGURATION IN RELATION TO OPEN SPACE FOR LOW RISE BUILDINGS

Low Rise Walk Up[1]	Slab	Court	Cluster
Plan			
Elevation			
Sector Scale			
Housing Description	•Floors stacked horizontally •Horizontal/vertical mix of units •Private yard at grade level •Private lanais at upper levels •Unit size (approx.) 700 sq.ft. to 1,000 sq.ft.	•Floors stacked horizontally •Horizontal/vertical mix of units •Private yard at grade level •Private lanais at upper levels •Unit size (approx.) 700 sq.ft. to 1,000 sq.ft.	•Horizontal/vertical mix of units •Units staggered in horizontal plane •Variable building heights •Private lanais •Unit size[2] (approx.) 800 sq.ft. to 1,500 sq.ft.
Open Space Per Unit	625 square feet	625 square feet	625 square feet
Land Coverage[2]	40-50%	40-50%	40-50%
Building Height	3 Floors	3 Floors	3 Floors
Building Orientations	•Perpendicular/parallel site configuration •Min. 60-80' between parallel buildings •Min. 50-20' between perpendicular buildings - one end wall blank	•Perpendicular/parallel site configuration •Min. 60-80' between parallel buildings •Min. 15-20' between perpendicular buildings - one end wall blank	•Perpendicular/parallel site configuration •Min. 60-80' between parallel buildings •Min. 15-20' between perpendicular buildings - one end wall blank
Entry Orientations	•Entry visible from public areas •Not more than 4 units per entry space	•Entry visible from public areas •Not more than 4 units per entry space	•Not more than 2 units per exterior entry space
Open Space Orientations	•Semi-public "shared" open space •Supervision of children from lower floors •Access to variety of views	•Semi-public "shared" open space •Supervision of children from lower units •Access to variety of views (panoramic)	•Semi-public "shared" space •Supervision of children from lower units •Access to variety of views (panoramic)

1. Entered at mid-levels to eliminate elevators.
2. Assumed density is 30-50 dwelling units per acre.

APPENDIX B-1

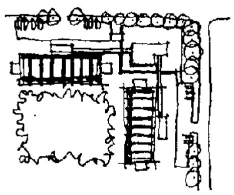
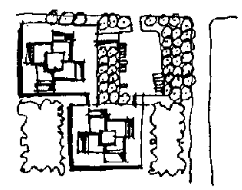
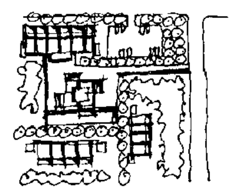
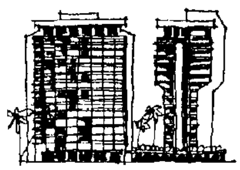
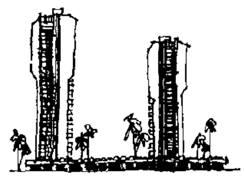
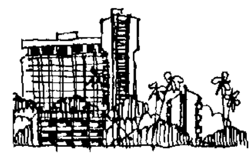
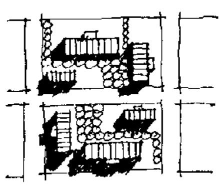
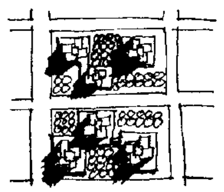
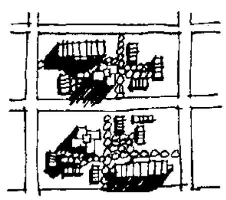
Table VI-3- HOUSING CONFIGURATION IN RELATION TO OPEN SPACE FOR MID-RISE BUILDINGS

Mid Rise	Slab	Terrace	Combination Terrace/Walk Up
Plan			
Elevation			
Sector Scale			
Housing Description	•Floors stacked vertically •Horizontal/vertical mix of units •Private yard at grade •Private lanais •Unit size (approx.) 700 sq.ft. to 1,000 sq.ft.	•Floors stacked vertically •Horizontal/vertical mix of units •Private yard at grade •Private lanais •Unit size (approx.) 700 sq.ft. to 1,000 sq.ft.	•Floors stacked vertically •Horizontal/vertical mix of units •Private yard at grade •Private lanais •Unit size (approx.) 800 sq.ft. to 1,500 sq.ft.
Open Space Per Unit	260 square feet	260 square feet	260 square feet
Land Coverage[1]	30%	30%	30%
Building Height	4-9 Floors	4-9 Floors	4-9 Floors
Building Orientations	•Perpendicular/parallel site configuration •100' between parallel buildings •25-50' between perpendicular buildings	•Perpendicular/parallel site configuration •100' between parallel buildings . •25-50' between perpendicular buildings	•Distance between buildings variable (depends on height and open space relationships of other buildings)
Entry Orientations	•Entry visible from public areas	•Entry visible from public areas	•Entry visible from public areas •Not more than 2 units per entry space for walk ups
Open Space Orientations	•Semi-public "shared" open space •Supervision of children from lower units •Access to variety of views	•Semi-public "shared" open space •Supervision of children from lower units •Access to variety of views	•Semi-public "shared" open space •Supervision of children from lower units •Access to variety of views

1. Assumed density is 40-60 dwelling units per acre.

APPENDIX B-2

Table VI-4- HOUSING CONFIGURATION IN RELATION TO OPEN SPACE FOR HIGH RISE BUILDINGS

High Rise[1]	Slab	Tower	Combination Tower/ Mid-Rise/Walk-Up
Plan			
Elevation			
Sector Scale			
Housing Description	•Floors stacked vertically •Horizontal/vertical mix of units •Skip floor system where possible •Private lanais •Unit size (approx.) 700 sq.ft. to 1,000 sq.ft.	•Floors stacked vertically •Units on one level arranged around core •Private lanai •4-6 units per floor •Unit size (approx.) 700 sq.ft. to 1,000 sq.ft.	•Floors stacked vertically •Units on one level arranged around core •Private lanai •4-6 units per floor •Unit size (approx.) 700 sq.ft. to 1,000 sq.ft.
Open Space Per Unit	130 square feet	130 square feet	100 square feet
Land Coverage[2]	30%	30%	45%
Building Height	15-25 Floors	20-35 Floors	20-35 Floors
Building Orientations	•Perpendicular/parallel site configuration •Mauka/makai to protect views	•Distance between towers variable (depends on height and open space relationships of other buildings)	•Distance between towers variable (depends on height and open space relationships of other buildings)
Entry Orientations	•Entry visible from public areas	•Entry visible from public areas	•Entry visible from public areas
Open Space Orientations	•Semi-public "shared" open space •Supervision of children from lower floors •Access to variety of views	•Semi-public "shared" open space •Supervision of children from lower units •Access to variety of views (panoramic)	•Semi-public "shared" open space •Supervision of children from lower units •Access to variety of views (panoramic)

1. Long double-loaded corridors should be avoided. Promote "skip floor" concept or arrange not more than 4-6 units around each elevator core.
2. Assumed density is 80-100 dwelling units per acre.

APPENDIX C

TABLE 17.—*Land and building uses appropriate for various risk zones, Santa Clara County*

[Adapted from Santa Clara County Planning Policy Committee, 1972, p. 22]

Land and Building Uses	Risk Zones A	B	C	D
Group A Buildings				
Hospitals and nursing homes	×			
Auditoriums and theatres	×			
Schools	×			
Transportation and airport	×			
Public and private office	×			
Major utility	×			
Group B Buildings				
Residential-multiple units	×	×		
Residential- 1 and 2 family	×	×		
Small commercial	×	×		
Small public	×	×		
Small schools-one story	×	×		
Utilities	×	×		
Group C Buildings				
"Industrial park" commercial	×	×	×	
Light and heavy industry	×	×	×	
Small public, if mandatory	×	×	×	
Airport maintenance	×	×	×	
Group D Buildings				
Water-oriented industry	×	×	×	
Wharves and docks	×	×	×	
Warehouses	×	×	×	
Group D Open Space				
Agriculture, marinas, public and private open spaces, marshlands and saltponds, and small appurtenant buildings	×	×	×	×

Seismic Safety and Land-use Planning — Selected Examples from California, by M. L. Blair and W. E. Spangle, William Spangle and Associates, Geological Survey Professional Paper, 941-B, 1979.

Building Typology Guidelines

Franco Braga and Remo Calzona
Universitá di Roma

SUMMARY

For any region, earthquakes can be classified into two groups according to their intensity:

(a) high-intensity earthquakes with a long return period (about 500 years), and

(b) medium-to-low intensity earthquakes with a short return period (about 50 years).

Buildings are to be designed — and the existing ones adapted — to achieve a pre-establishing probability of collapsing with a specified expected death-rate for earthquakes of the (a) type, and a certain probability of being damaged for earthquakes of the (b) type. The probability levels are obtained through economic optimizations.

The same philosophy should govern urban scale designs or adaptations. This report deals with the problems related to seismic risks from the standpoint of the above mentioned earthquake classifications.

1. INTRODUCTION

An earthquake is the ground shaking which causes inertia forces to act on buildings (see Figure 1). The shaking, and thus the inertia forces, have two horizontal components (undulation) and a vertical one (sussultatory movement). A man-made structure must be capable of supporting such inertia forces:

$$S = m(\ddot{y} + \ddot{X}) \qquad (1)$$

where m stands for the mass of the building, $\ddot{y}$ is the acceleration of the mass — which is a function of the dulling and deformation characteristics of the structure — and of the acceleration, $\ddot{X}$, of the ground.

For a particular area it is possible to predict whether an earthquake will occur, within what time interval and with what intensity (for example with a certain acceleration $\ddot{X}$).

From this standpoint earthquakes can be classified into two groups:

(a) High-intensity earthquakes with a long return period (for example 500 years); in other words, disastrous but infrequent earthquakes.

(b) Medium-to-low intensity earthquakes with short return periods (for example 50 years), or non-catastrophic but more frequent earthquakes.

Building design should optimize construction costs, maintenance and eventual consolidation and restoration costs, with a pre-established probability of:

(a) Collapse of the building entailing deaths; or

(b) Damage to the building or to part of it without endangering people's lives (the building is put out of use).

For on-going building design, this philosophy would mean ensuring safety in case of the following two limit conditions:

(1) Ultimate boundary conditions: under the action of maximum pressures, the structure must have a sufficiently small probability

of collapsing. The current code fixes this probability value at 1×10^{-5}.

(2) Boundary conditions for use and productive activities: in an earthquake, the service activities of the structure must comply with the use and durability needs both of the structure itself, and of the loads for which it has been designed.

It is obvious that the ultimate boundary conditions refer to preventing the loss of the structure and of human lives, whereas the utilization boundaries refer to the conservation and use of the structure and supporting systems.

By extrapolating this concept to building structural requirements and to the building as a whole, the design specifications can be described as follows:

(1) For high intensity earthquakes, the ultimate boundary condition must be met: the earthquake can greatly damage the structure but it must survive the disaster.

(2) For medium intensity earthquakes, verifying the effectiveness of the utilization boundaries means that the structure must remain secure, but the non-resistant elements may be damaged.

2. EARTHQUAKE-RESISTANCE CONTROL

2.1. Ultimate Boundary Condition

The ultimate boundary condition for the survival of a structure can be checked by making sure that the following conditions are met (in probabilistic terms):

$$R > S_o$$

$$\delta_R > \delta_{S_o}$$

where:

R represents the resistance of the structure, that is, the maximum stress it can support.

S_o represents the maximum probable earthquake stresses.

δ_R represents the maximum deformed configuration that the structure can undergo.

δ_{S_o} represents the maximum deformed configuration of the structure caused by a high-intensity earthquake (see Figure 2).

All the above mentioned magnitudes generally represent vectors having n dimensions.

The conditions expressed in (1) can be satisfied by:

(a) increasing R and δ_R, that is the ultimate strength and deformability of the structural elements;

(b) decreasing S and δ_S, that is the seismic forces on the structure.

Structural designers essentially take care of the first operation, whereas architectural designers can notably influence the second operation.

Indeed, unlike other forces (for example vertical loads) the effects that an earthquake can have on a building depend on the planimetric form and height of the building.

Consequently, just as the design of a structure built in a seismic area must differ from that of a structure built in a non-seismic area, there must likewise be architectural differences. Good designs will account for this, especially if cost optimization is a basic criterion.

2.2. Boundary Conditions for Utilization

The boundary condition for the utilization of a structure can be checked by making sure that the following conditions are met:

$$\frac{\delta_E}{\gamma} \overset{S}{>} \delta_{S_1} \qquad (2)$$

$$f(d) = \alpha \quad \text{or } F(u) = 1 - \alpha$$

where:

$\frac{\delta_E}{\gamma}$ represents the maximum deformed configuration whereby the structure remains within the elastic range

γ is a factor included between 1 and 2

δ_{S_1} represents the maximum deformed configuration caused by an earthquake of medium intensity

f(d) represents the damage function

f(u) represents the utilization function

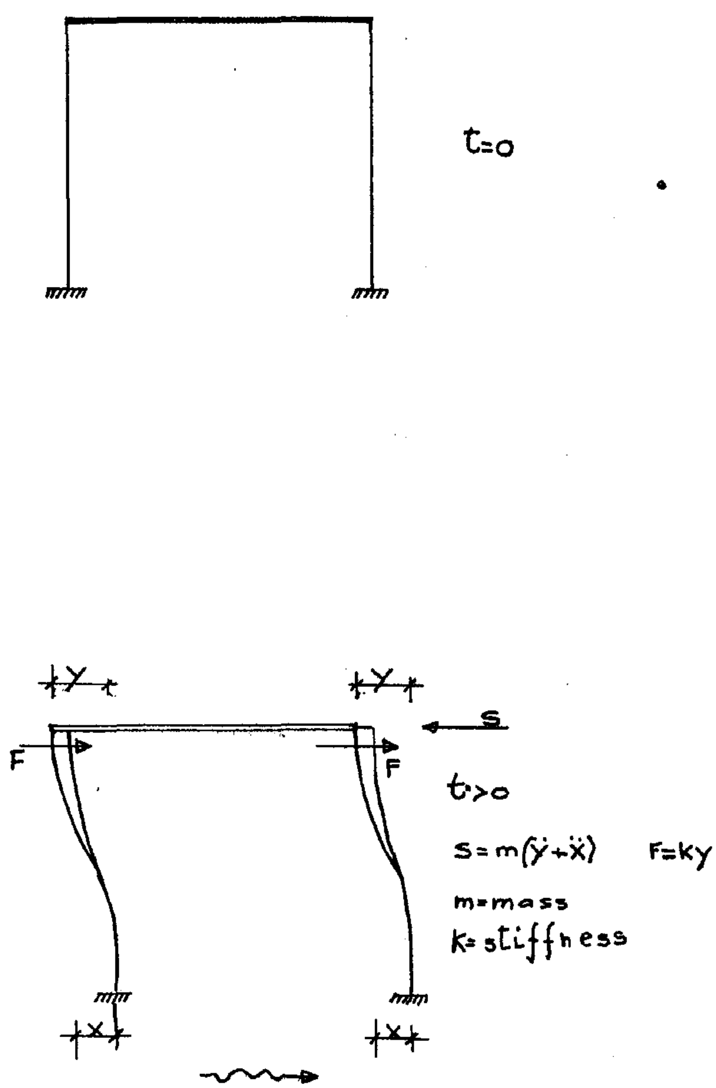


Figure 1

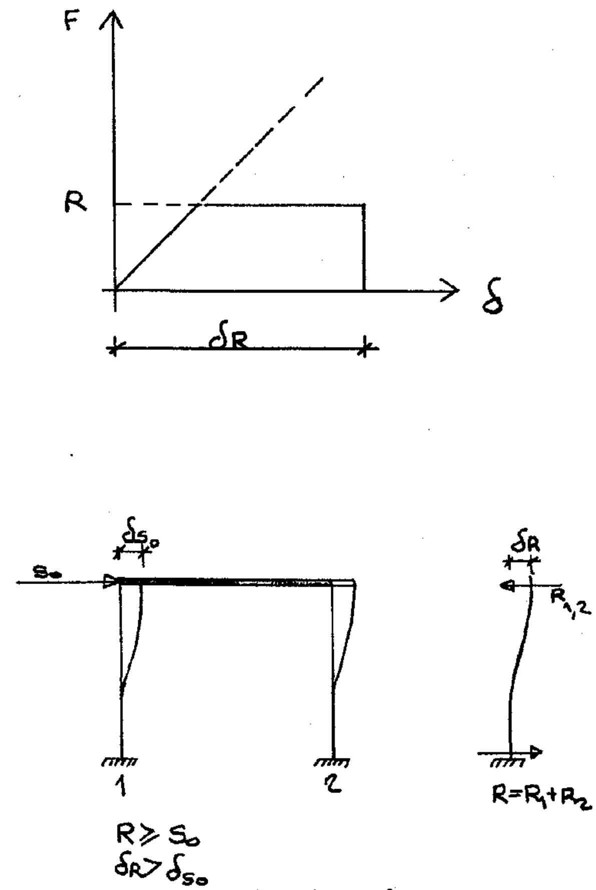


Figure 2a

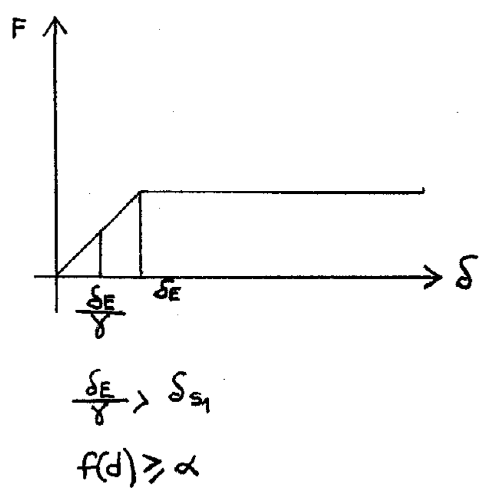


Figure 2b

α is a parameter that measures the acceptable damage that would not put the building out of use, which goes from 0 (undisturbed building) to 1 (building whose non-structural elements and facilities are totally destroyed) (see Figure 2).

At present there are no norms or regulations that provide for α. The limit of acceptable damage quite obviously depends on the importance and purpose of the building involved. For example, for functional and psychological reasons the value of α for a hospital will have to be very low, whereas for a dwelling the value of α can be much greater.

3. THE NEED FOR EARTHQUAKE-RESISTANT DESIGNS

The objectives pointed out in the foregoing can be achieved by acting on the parameters that interplay during the design stage. Evidently, the design choices to be made for medium- or high-intensity earthquake areas are different.

The following provides a concise description of the variables that should be modified according to the situation.

3.1. High-intensity Earthquakes

The objective of the design is to minimize the probability of collapse while minimizing cost.

$$\text{Essential conditions:} \begin{cases} R > S_0 \\ \sigma_R > \sigma_{S_0} \end{cases}$$

Variables that should be modified include the following:

3.1.1. Horizontal and vertical symmetry

3.1.2. Shape of the building (joints)

3.1.3. Materials (minimum mass, maximum period)

3.1.4. Form of the structural elements

3.1.5. Non-structural elements (influence on strength)

3.1.6. Use of more than one material

3.2. Medium-intensity Earthquakes

The objective of the design is to minimize the damages that the non-structural elements undergo.

$$\text{Essential conditions:} \begin{cases} \frac{\sigma_E}{\gamma} > \sigma_{S_1} \\ f(d) = \alpha \end{cases}$$

Variables that should be modified:

3.2.1. Horizontal and vertical symmetry

3.2.2. Shape of the building

3.2.3. Non-structural materials (characteristics)

3.2.4. Bonds of the non-structural elements

3.2.5. Facilities (characteristics, restraints, repair work)

3.1.1. Horizontal and Vertical Symmetry

Horizontal and vertical symmetry is required to minimize the effects of:

S_0 and σ_0 .

For a square building with an evenly distributed structure and constant forces along its height, the barycenter of the masses — point of application of S_0, and the barycenter of the stiffness — point of application of R — coincide.

In this case, supposing the floors were rigid, the displacement of each plan would be a translation, which is parallel to the direction of the movement, and would be equal to S_R, displacement of the stiffness barycenter (see Figure 3a).

Conversely, if the two barycenters do not coincide (see Figure 3b), the building would also be subject to a torque moment $M = S_0\Delta$, that would amplify the displacement of the piers because the floors are submitted to rotation.

The eccentricity, Δ, can be caused by the most diverse irregular movements; some are shown in Figure 4.

3.1.2. Shape of the Building

An earthquake is a shear wave that progresses at a finite speed (500-5000 meters/second). At a certain point — parallel to the advancing direction of the earthquake — the ground takes on an approximately sinusoidal form, its wave length being approximately 500 meters which overlaps the face of the shear wave (see Figure 5).

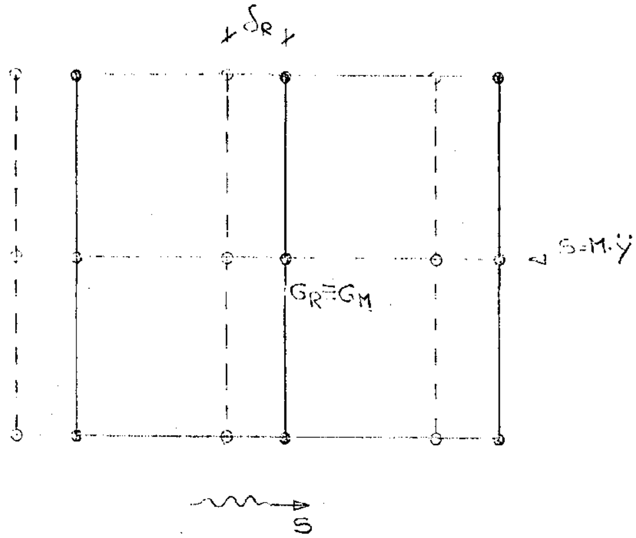


Figure 3a

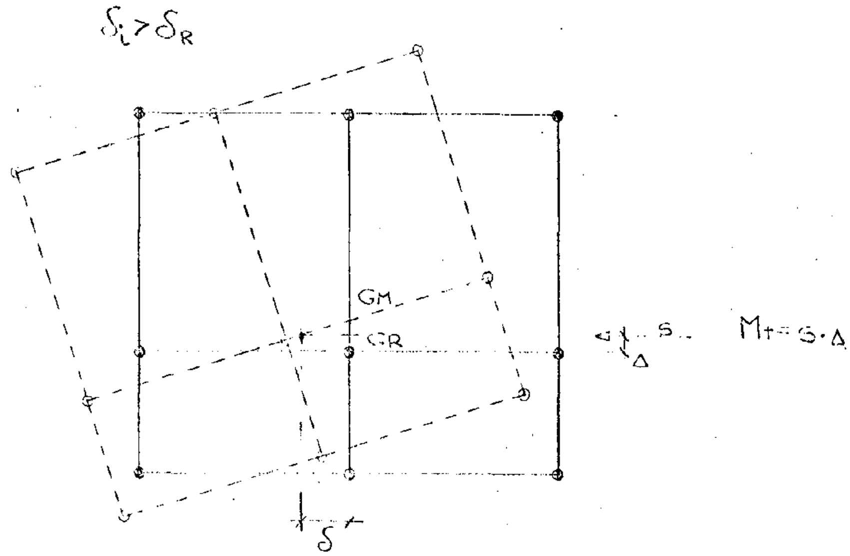


Figure 3b

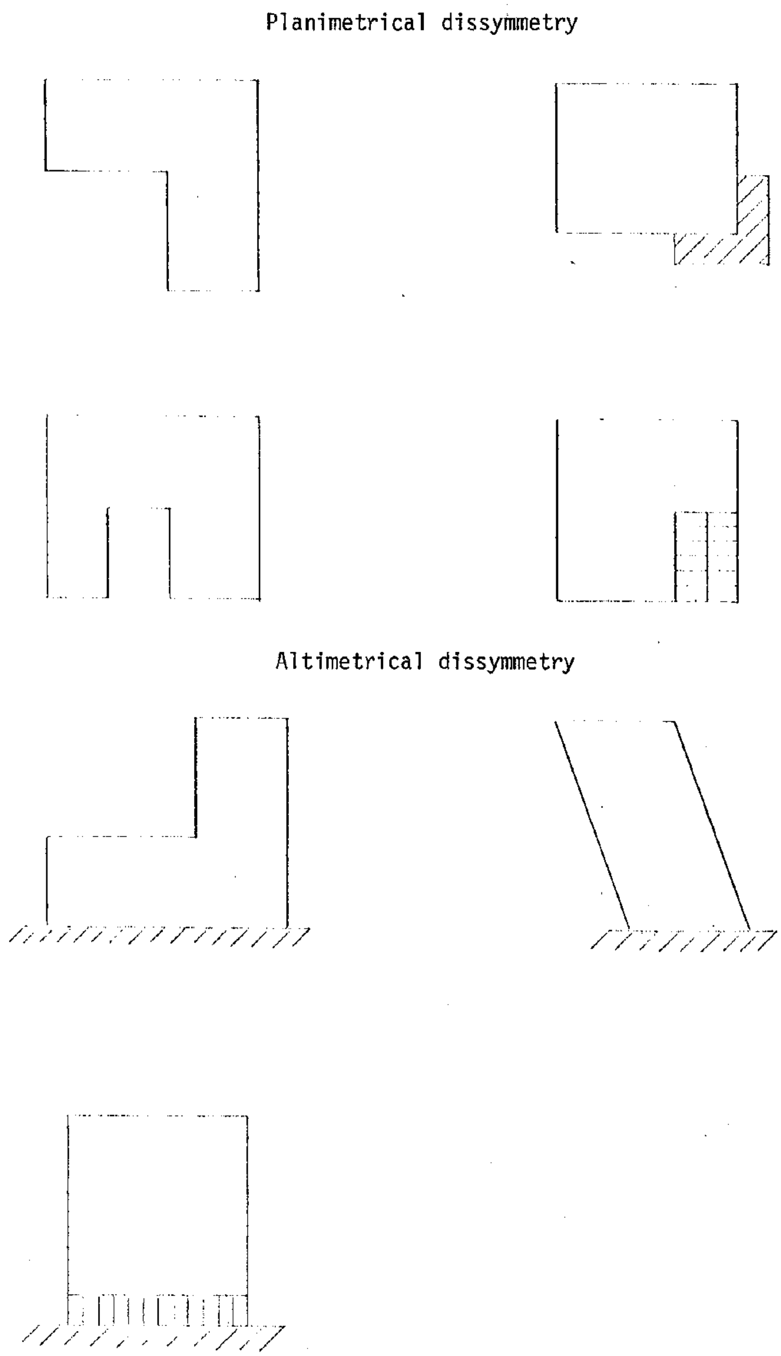


Figure 4

As shown in the figure, every building is subject to torsion. This effect increases with perimeter length, regardless of the surface of the building. A very long building enhances the very damaging effects of torsion. One solution is to use joints.

3.1.3. Materials

The action of an earthquake, as emerges from the foregoing discussion, is an inertia force:

$$S = m(\ddot{y} + \ddot{x})$$

It is obvious that in order to reduce it, m must be reduced by using lighter materials both for the structures and for the supported elements.

A building responds to the stresses of an earthquake by vibrating for a fundamental period of:

$$T_0 = 2\sqrt{\frac{M}{K}}$$

where K is the stiffness of the building. The $\ddot{y}$ of the building is greater, equal to, or smaller than the acceleration $\ddot{x}$ of the soil, according to the value of T_0 (see Figure 6). As can be seen for $T_0 > 0.8$, $\ddot{y} < \ddot{x}$. As can be seen, m being the same, it is convenient to reduce the stiffness K of the building.

For example, the size and mass being the same, a steel building undergoes a lighter seismic action than one built of reinforced concrete; one built of piles and beams is less affected than one built of setti and so on.

3.1.4. Shape of the Structural Elements

Structural elements must be symmetrically shaped in order to avoid a concentration of tensions and lack of flexibility.

3.1.5. Non-structural Elements

By this we generally mean curtain walls and internal separating walls. These can have a strong negative effect because they tend to cause non-homogeneous behavior. Examples of this are seen in buildings constructed on piles or those with flexible floors.

3.1.6. Use of more than one material

These have the same effects of inducing both horizontal and vertical irregularities. Furthermore, since the various items (such as reinforced concrete and masonry) have different deformation and flexibility characteristics, there is no collaboration among the various elements, and so the earthquake strength coincides with that of the less resistant elements.

3.2.1. Horizontal and Vertical Symmetry

As explained in paragraph 3.1.1., the lack of symmetry enhances the displacement of the building. This causes the curtain walls, the separating walls and the facilities to suffer greater damages. The damage levels could be reduced by making the structure more rigid, but this would negatively affect the service the structure must supply.

3.2.2. Shape of the Building

As to the linear planimetry, what was said in 3.1.2. holds true. However, from the standpoint of building strength, tall buildings would be acceptable, but they should be kept within certain limits because of the psychologic effects on the people who live in the building. The exaggerated swaying motion of the upper floors would surely cause panic for victims during flight.

3.2.3. Non-structural Materials

These must be light and flexible, and repair or replacement should be easy. Care should be taken in selecting these materials so they do not injure people if they should fail.

3.2.4. Bonds of the Non-structural Elements

The non-structural elements should be capable of absorbing their own inertia forces. Particular care must be paid to the elements on the facade so that the streets that are adjacent to the building are not endangered by falling debris. On the other hand, non-structural elements need not be required to follow the deformation of the structure (for example, window panes).

3.2.5. Facilities

The inside and outside service facilities must be designed in such a manner as to make sure they will continue to function. Absolute care must be taken so that the facilities — like the electric system, the gas mains, and so on — besides remaining undisturbed, do not themselves become dangerous as occurred in the San Francisco earthquake. Non-structural elements should not be difficult to repair or replace.

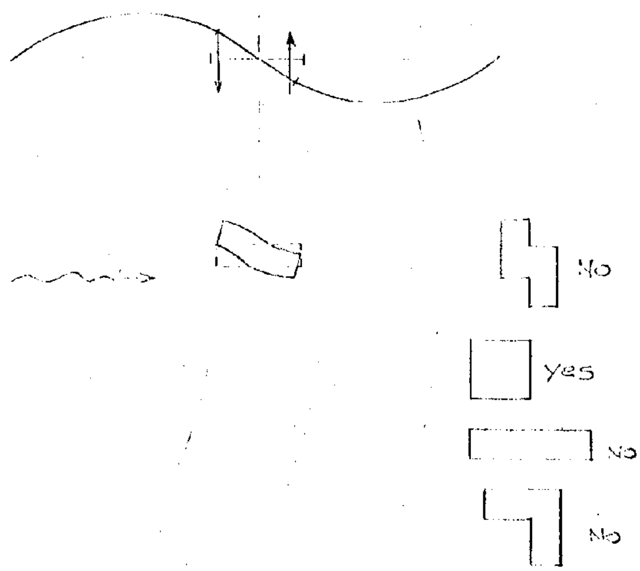


Figure 5

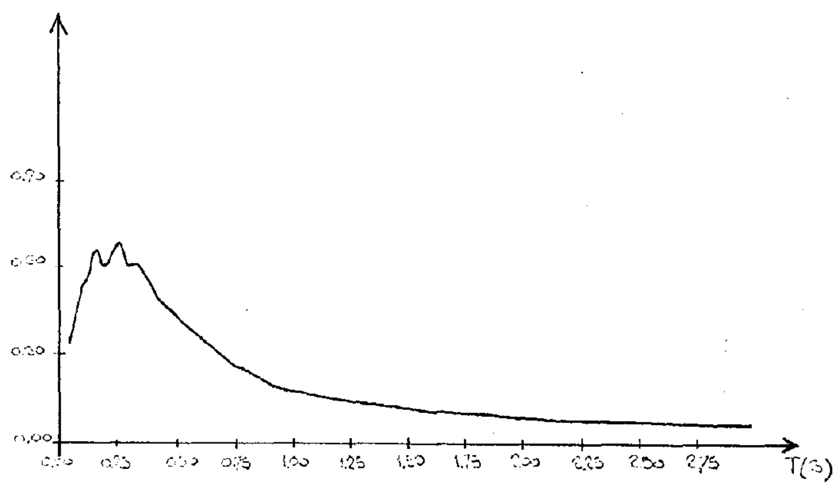


Figure 6 (Tolmezzo)

4. CONCLUSIONS

Even if earthquakes have become more frequently recurring natural disasters, the issue of anti-seismic design is being dealt with in a rational manner. Cost-benefit analysis shows that the distinction made in this paper between structural and architectural elements for high- and medium-intensity earthquakes is a promising and successful approach.

The foregoing shows that the design requirements for the two types of earthquakes are not always the same, at times they even contradict each other. This dichotomy is increased if the building is considered to be part of the urban texture, where the conditions for utilization and damage are often of greater importance, or where the building's historic and functional importance are considerable.

Greater difficulties are encountered when trying to satisfy the conditions for resistance and use of existing buildings, especially in areas that have not yet been labelled as seismic.

In the latter case, the problem becomes a very severe one, especially if safety is to be guaranteed against high-intensity earthquakes. A close cost-benefit analysis could guarantee safety only for medium-intensity earthquakes.

In this field, there must be a separate consideration of historical buildings, for which a very thorough review of the restoration philosophy used will be necessary.

Building Vulnerability: Synopsis

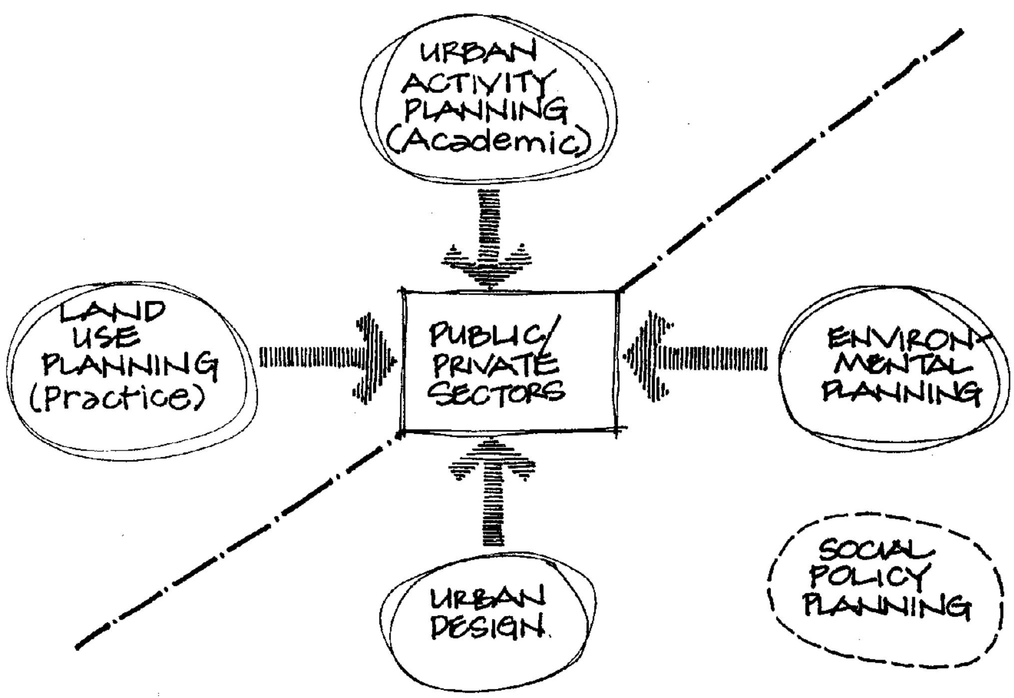
Frederick Krimgold, Rapporteur

Discussion

Following the presentation of the papers, Professor Myer Wolfe offered comments on the general definition of planning. He described the relationship of four different types of planning which are evident in the United States today:

1) Urban Activity Planning
2) Land Use Planning
3) Environmental Planning
4) Urban Design

The interrelationships of the four types of planning are illustrated in Figure 1. Urban Activity Planning is primarily academic in character and has not yet had much influence on planning practice. Land Use Planning has been the primary activity of practicing planners and has not received significant attention from academic planning recently. What is being taught in planning schools does not necessarily relate to what is done in practice. Planning research is not clearly evident in either education or practice at present.



Urban Design and Environmental Planning have emerged from trends developing over the last ten years. Urban Design relates to architectural concepts of planning and Environmental Planning builds upon concepts of ecology.

So far, in earthquake hazard mitigation all planning input has come from Land Use Planning. There has been very little input from the other areas of planning activity. There has been no significant development of Social Policy Planning related to earthquake hazard mitigation. Clearly, these other areas of planning are relevant to the problem and should be explored and enhanced.

Professor Astra Zarina suggested that an expansion on Wolfe's four points might consider:

1) The form of the urban artifact
2) Activities and patterns
3) Temporal configurations
4) Spatial implications
5) Human nature, or how people react

She also suggested the need for an increased emphasis on interdisciplinary collaboration or a "polygamy of the disciplines." This must be based on mutual trust and respect. Engineers should be educated to understand and appreciate the concerns and methods of planners.

Professor Lidia Selkregg noted that following the 1964 earthquake, planning had to be forced on Alaska. She suggested the need to define and develop a planning curriculum that responds to the earthquake mitigation problem. Three skills are essential in her view. The planner must first be a generalist, like the general practitioner of medicine, since mitigation planning can be looked upon as preventive medicine. The planner should also be seen as the director of the orchestra in music. The planner must finally be a humanist to maintain social values in the allocation of space and resources.

Professor Selkregg suggested a model (see Figure 2) of the coordinating role of an planner. The planner manages the interaction of the various parts, and economic considerations are the lubricant for the interaction. The planner is the link between the scientific world and the social/political world, with the job of applying scientifically based concepts to "real" world decisions and actions.

Mr. George Mader commented on the relevance of microzonation for land use planning. Data is assembled in microzonation but seldom applied in the land use planning process. To date there has been little analysis, application or evaluation of the microzonation data that has been collected. He cited a few positive instances where this data was applied and influenced plans.

However, planners face a dilemma. They must balance microzonation data with many other factors and, therefore, require methods for communicating and integrating microzonation information into the multifaceted process of planning. In addition, planners must be able to communicate with decisionmakers who optimize over a wider range of community issues.

Professor Haresh Shah mentioned that planning for the reconstruction of Managua, Nicaragua after the 1972 quake was a perfect example of multidisciplinary collaboration. Microzonation provided the basis for planning, however, there was a later failure of the political system and the plans were never implemented.

Shah also referred to the "gripe of engineers". After an earthquake, immediate decisions must be made for the provision of housing and medical facilities. The objective is to quickly bring people back to an acceptable standard of living; there is no need for a collection of planner-futurists looking for a design job. In some cases the elaboration of the planning process has postponed reconstruction and aggravated recovery problems.

Professor Henry Lagorio noted that the by-products of planning for earthquake mitigation have other uses. The development of building typologies is of general value. He also suggested that we need to assess existing typologies and to consider the relationship of adjacent buildings to one another. In Italy, for example, there have been cases where sound buildings have been destroyed by the collapse of adjacent ones in poor condition.

Professor Giuseppe Grandori stated that as an engineer he was interacting at the boundary of his field of expertise in dealing with planners. He suggested two primary areas of cooperation for engineers and planners are (1) reconstruction following earthquakes and (2) predisaster mitigation.

In discussing the issue of reconstruction, Grandori noted that Italy has not recently faced the problem of rebuilding major cities. Recent earthquakes in Italy have affected collections of villages where many have been destroyed and all have been rendered unsafe. Thousands of people have been killed or injured, and the social structure of numerous communities has also been destroyed. Grandori maintained that the problem of reconstruction is not the immediate design of a new town. Construction should be the third or fourth priority.

The village is the expression of certain types of connections between people. The buildings and their juxtaposition are a statement of a unique social collective. In a major disaster, many of these connections are destroyed and key individuals and institutions may perish. As a result, reconstruction of the pre-existing physical environment is no longer appropriate or viable. Therefore, the following approach should be adopted:

1) The first priority of the emergency relief phase is to hold together the community's social connections in order to keep the society intact. Survivors must be maintained as close to their homes as possible. Temporary shelters must support the reformation of the human community.

2) The second priority is the reestablishment of the region's or town's economic viability. People must have something to do, therefore, the productive system must be replaced and the industrial system must return to functioning. Work and income are keys to local survival and enfranchisement.

3) Rebuilding of the physical environment is then possible as the third priority. Reconstruction must be accomplished by the local people themselves with the assistance of planners and government authorities. This has happened successfully in the Friuli. The physical reconstruction must reflect the new reality of social connections and economic processes which have been established and stabilized since the earthquake and will be different from that existing prior to the earthquake. Effective permanent reconstruction may not be possible until five years after the earthquake. It is in fact important that reconstruction not take place much earlier because physical development must follow the stabilization of social and economic patterns. In the interim, temporary shelter must be designed to accommodate the fluid process of readjustment.

Professor Grandori summarized the three phases of reconstruction as:

1) Immediate, temporary shelters built on site
2) Reestablishment of economic viability
3) Permanent reconstruction (approximately five years after the event)

This process may vary from case to case. In the instance of the Friuli earthquake, economic recovery was very rapid and therefore the reconstruction could begin earlier. In the case of the recent Southern Italian earthquake, economic questions pose a greater problem and adjustments in the regional and local economy may radically influence, and thus delay, reconstruction timing.

Professor Selkregg stated her deep appreciation for the humanistic aspect of Professor Grandori's approach. She noted that the real function of planners is to respond to the changed social context following disasters. Reconstruction planning is not the place for abstract models nor the time for imposing expert-generated ideal concepts of physical planning. Planning must respond to particular local needs and resources.

Professor Clementi also agreed with Professor Grandori that the social and behavioral context of disasters must be distinguished from the physical. Also, physical planning must be directed by the social and economic reality of the post-earthquake society. This distinction provides the basis for useful comparative studies. Rather than simply comparing the final artifacts of the reconstruction process, we can make comparative studies of techniques for assessing the social and economic context and their translation into physical reconstruction.

Professor Clementi affirmed the earlier statements of Professor Imbesi on the need for study of social and economic consequences of earthquakes. He suggested comparative studies of these social and economic consequences and of the nature of governmental systems which deal with those consequences. Comparative analyses should be both for post-earthquake cases and for situations where potential risks exist. Clementi divided the work of the session under two headings:

1) Development of criteria for identification of potential research topics

2) Development of methodological issues.

Both areas would benefit from future U.S.-Italian collaboration. Both qualitative and quantitative methods need to be developed.

Professor Luciano Minerbi stated that available data related to natural hazards is not useful for planning. More emphasis must be placed on understanding and explaining relevant decision processes. We must study decisionmakers and community behavior. Relevant aspects of community behavior include self reliance, participation, and decentralization. We must develop measures of social organization at the community level. Furthermore, we must develop a typology of implementation processes. Such study may initially be based on case studies.

Minerbi also cited the problem of interpolation from the territorial scale of the regional planner and the social community scale of the sociologist. Interdisciplinary collaboration is complicated by the fact that the relevant disciplines work at different scales and have defined the bounds of the object of study differently.

A general topic requiring further study which would benefit from comparative study is that of allocation of reconstruction responsibilities at the local level.

Professor Imbesi initiated a listing of areas for potential collaborative research which served to summarize the session's discussion. He proposed the following list:

1) Comparative study of governmental systems as they effect mitigation and reconstruction efforts.

2) Development of a typology of social and economic settings of earthquake-prone communities including those previously damaged and those at risk.

3) Development of case studies on: a) historic rehabilitation, b) recovery (Southern Italy), and c) large cities at risk (i.e., Rome or Los Angeles).

4) Development of quantitative methods for planning research on hazard mitigation.

5) Study to understand community behavior and to facilitate participatory planning.

6) Study of the philosophical basis of building codes and the basis for establishing acceptable risk levels.

7) Study of the balance of economic, safety and cultural issues relating to the preservation of historic monuments and buildings.

8) Development of social decision criteria for input to engineering design optimization procedures.

D. Discussion Group Participants

I. REGIONAL VULNERABILITY

Italy

Michele Grimaldi, Provincia di Roma
Giuseppe Imbesi, Universita di Roma

U.S.

Luciano Minerbi, University of Hawaii
Lidia Selkregg, University of Alaska
Myer R. Wolfe, University of Washington

II. URBAN VULNERABILITY

Italy

Guido Ancona, Universita di Roma
Antonio Bellacicco, Universita di Roma
Sergio Bonamico, Universita di Udine
Alberto Clementi, Universita di Roma

U.S.

Tridib Banerjee, University of Southern California
Susan Heikkala, University of Washington
Barclay Jones, Cornell University
George Mader, Stanford University
John Stanton, University of Washington
Astra Zarina, University of Washington

III. BUILDING VULNERABILITY

Italy - Participants

Sergio Bonamico, Universita di Udine
Gianfranco Carrara, Universita di Roma
Prof. Faccioli, Politecnico di Milano
Antonio Gallocurcio, Universita di Roma
Michele Grissoti, Universita di Bari
Alberto Parducci, Universita di Roma

Italy - Other Contacts

Enrico Mandolesi, Universita di Roma

U.S. - Participants

Barclay Jones, Cornell University
William Kockelman, U.S. Geological Survey
Henry Lagorio, University of California-Berkeley
George Mader, Stanford University
John Stanton, University of Washington

U.S. - Other Contacts

Christopher Arnold, Building Systems Development, Inc., San Mateo, California
Irving J. Oppenheim, Carnegie-Mellon University
Jeanne Perkins, Association of Bay Area Governments
Dan Schodek, Harvard University
Mehmet Sherif, University of Washington
Peter Yaw, Purdue University

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E. Proposal Summary

General Description and International Cooperation

This proposal's central purpose is to hold a seminar to enable sponsoring institutions - the College of Architecture and Urban Planning, University of Washington, and the Institute of Engineering and Architecture, University of Rome - to deliberate earthquake hazards as they pertain to urban vulnerability. As such, this proposal is not meant to accomplish a specific research project, but it is to provide the meeting ground from which such projects can emerge.

This proposal should be seen in the context of the NATO CCMS Pilot Study on Seismology and Earthquake Loss Reduction, Sub-group 3, which was initiated in Italy in 1978. One of the national correspondents for Sub-group 3 is also one of this proposal's Italian participants. Appendix A includes a letter from Enrico Mandolesi, Director of the Institute of Architettura, Edilizia e Tecnica Urbanistica, University of Rome, which communicates concrete interest in developing "the initiative for the Italian counterpart". Dr. Mandolesi is proceeding at this time to contact the CNR regarding this joint venture.

The conceptual scheme here is as follows:

(1) Entails comparative analysis in that both counterpart countries have high risk seismic urban regions (specifically the west coast of the United States and the Italian central region) and in that broad input from Yugoslav[1] observers/participants is also planned based on experience from the three major, recent earthquakes[2] in Skopje, Banja Luka, and Friuli-N.W. Yugoslavia.

(2) Entails comparative analysis of another kind, i.e. that which brings together urban designers and planners, social scientists, and engineers to explore mitigation at several regional scales including and beyond what is usually labeled "lifeline engineering";

(3) Entails, therefore, clarification of the general term "urban scale vulnerability", beyond what is defined herein, with the purpose of identifying topics of mutual interest and importance to the researchers as the basis for future cooperative research;

(4) Stresses that researchable foci and mechanisms be sought, that the purpose of debating the subject areas be to put inquiry into operationally researchable terms, and that, thus collaboration be furthered

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in the context of lessons to be exchanged and/or learned.[3]

Given the four principal emphases - (a) comparative study and exchanges, (b) potential collaboration in specific research, (c) urban scale vulnerability, and (d) cross disciplinary and professional fields - the mechanics of implementation include:

(i) Meeting of some six to eight Americans and a similar number of Italians and Yugoslav counterparts in central Italy in September 1981 (alternatively May 1982)[4] for a week, and

(ii) A three step program: first, a preparatory stage handled at the University of Washington to get three theme, subject papers (three from each country, six in all) written, reproduced, and distributed before the seminar occurs; second, the in situs seminar; and third, the follow-up consolidation of papers, discussion, and analyses reproduced in a report monograph form.[5]

Further Rationale as Support

Justification is warranted for this project because among other things various governments have established guidelines and regulations which incorporate seismic safety considerations in urban scale planning and design. In addition, the nature of professional practice now is beginning to encompass germane analysis, such as publicly mandated environmental impact statements and the like. While seismic, problem-oriented engineers have dealt with safety and preparedness planning at that urban scale, there has been a limited overlap with other professionals who also deal with urban systems. Considering the triumvirate group that should be involved, engineers, social scientists, and urban designers/planners, it is the latter who also need to interact with the former on a face to face basis.[6]

Therefore, it is not just a matter of safety as such, of least cost as such, of workability as such, but rather a matter of perception and analysis of the continuum extending from public policy actions to the achievement of community goals in a three dimensional built or rebuilt environment. The physical outcomes of public and private policy decisions must be seen in an interrelated context, hence, the importance of this proposal in assembling, probably for the first time anywhere, such a profesisonally ecumenical group.

We, also, do not underestimate the inherent value of education to be gained and emphasize that this is considered an important goal of exchange in-and-of-itself. That is to say that such gains are to be achieved not only from the international exposure but also from the interprofessional exchange in-and-of-itself. All the participants are not earthquake specialists; on the other hand those with seismic disaster experience may not know of the field and/or the depth of responsbilities and coverage of the others. The seminar program design sets out to get participants that represent ends of such a spectrum, with a few at least who are central and overlap.

Further, the binational nature of such a meeting contains other dimensions beyond that already stated or implied.[7] There have been communications extending back over a year to reach mutual agreements between the U.S. and Italian counterparts plus a Yugoslav observer.[8] These explorations have led to an understanding of potentially mutual benefits.

The fact that earthquake problems are common to the countries named is obviously not enough. What must be stressed are the givens of the situations and the differences that can be identified as meaningful enough so that lessons can be transferred. Whereas a major purpose of the seminar is to pinpoint such things, there are those which are apparent enough now so as to assure some value in going further. Appendix (B) expands on the fact that there are underlying similarities and more obvious differences pertaining to the age and morphology of urban development that apply, say, to a Viterbo, Italy and a Seattle, Washington. The same goes for the facets of regionalism and decision making as well. The point is that we hypothesize that, by providing insights on these matters as a backdrop, the seminar participants, by way of the papers and discussions, can isolate the significant researchable items among the myriad of possibilities that come to mind.

Considering a more specific example of that mentioned (Appendix B), that of scale, given the similarities of today's settlement patterns (suburbanization and counter forces of energy needs on the horizon) and barring past excessive differences of historical forces, here is an issue that is specifically germane. The scale or size of the recent earthquake disasters in these regions of Europe provide a difference which has lessons for the U.S. There are fruitful possibilities of education for U.S. participants since our experiences have not had these dimensions. Comparatively, we have not had experiences in similar urbanized and populated areas, barring the Anchorage, Alaska example and certain exercises of modeling such immensities by N.O.A.A.[9]

Other specifics to be considered are: (1) Italian experiences in historic preservation vs. those of the U.S. and adaptive reuses of building groups rehabilitated in certain density patterns in Italy as compared to the lack of experiences of the similar in the United States; (2) the changes of land use management and seismic zonation, zero lotline housing, etc.; (3) technical techniques as are, could be, or should be developed of building topology guidelines, i.e., the Italian expertise in assessing and documenting their built environment compared to American experimentation with photogrammetry or computerized as-built drawings; (4) Italian practices in repair of earthquake damaged structures (5) Italian and American viewpoints on the problems of upgrading common structure for earthquake hazard safety; and (6) Italian experiences with resettlement after earthquake damage.

Program Agenda Items

Given common coverage and three major themes, below, six papers (three by each) are to be prepared and distributed in advance by American and Italian counterparts:

(1) Land Use Planning and Regulation in Disaster Impacted Urban Areas: Considerations of the urban morphology (preparation by principals with background in Urban Planning and Social Sciences).

(2) The Vulnerability and Rebuilding Problems of the Urban Pattern: Considering (a) land use densities and intensities, (b) nodes of activities i.e. centers and sub-centers, (c) the accessibility system (traffic flows apropos roads of differing hierarchy — local to freeway, transit, etc.), and (d) the upgrading of existing structures. (Preparation by principles with background in Urban Planning, Urban Design and/or Engineering.)

(3) Building Typology Guidelines: Inventory potentials pertaining to the urban fabric, volumetric aspects of the extent and character of building groups, classification and evaluation of existing buildings, and methods of documentation and assessment. (Preparation by principals with background in Urban Design, Architecture, and/or Engineering.)

Each paper should have built into it (beyond the general subject area noted above) consideration of:

(1) Scale issues, that is, considering the potential size or extent of an earthquake disaster;

(2) Remedial measures that take into account institutional determinants such as historical preservation and/or adaptive reuses;

(3) The role of governmental regulatory and financial incentive measures that pertain to preventative policies;

(4) Urban region case study examples as elaboration of the general points made;

(5) The above might be considered "required" considerations; optional (or substitute) possibilities could be:

(a) Temporal dimensions of the macroregion; the problems and possibilities of recording the "pulse" of urban activities in time and space --- leading to "time-lapse" mapping of concentrations of people in time and at places. (Concentrations at noon vs. midnight, weekday or weekend; implications for "urban scale vulnerability".)

(b) Spatial ecology of "critical" urban residents - elderly, ill, young --- mapped and overlayed on urban form as another dimension of vulnerability.

(c) Physical conditions by types of construction, ages of building, terminals, etc. to be mapped and recorded by area, district, or neighborhood under some process of a vulnerability index.

(d) Possibilities of developing an "urban vulnerability scale" corresponding to the conventional Richter Scale; i.e. to scale according to level of vulnerability as may be used as a policy or earthquake management guide. (Areas could be targeted for code reinforcement, zoning change, etc.)

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[1] This proposed seminar intends to build on the outcomes of the NSF sponsored Research Conference on Earthquake Engineering held in Skopje, Yugoslavia, June 30-July 3, 1980. While the Skopje conference provided for the airing of broad and significant issues from the engineering perspective, this seminar will explore the architecture and planning connections with earthquake engineering.

[2] "Skopje Resurgent", Adolf Chiborowsky, United Nations, 1968.

"Study of the Development of Spacial Regulation of Part of Bosanska Krajina Hit by the Earthquake", Milos Somborski, et al., Center for Urban Development Research, Cornell University, Ithaca, New York, 1975.

"Friuli, Italy Earthquakes of 1976", James L. Stratta and Loring A. Wyllie, Jr., Earthquake Engineering Research Institute, Berkeley, California, August 1979.

[3] See Appendix (B), Narrative Addition which elaborates on the above and supplies more rationale to the purpose.

[4] See Biographical Sketches.

[5] See Appendix (C), The Phases of the Project, the Resources Requested, etc.

[6]Reference-California: Oakland. A general plan requirement in the State of California is a "seismic safety element". This is only one example of the attempts to aggregate the work of such professionals. Given a common understanding of what engineers and social scientists are about, a definition here of "urban designer/planner" is those trained to be responsive to the physical and spatial manifestations of the built environment in urban regions and the dynamics of their changes. This is not exclusive of prerogatives of the first two, but it adds responsibility for prescribing actions to be taken that encompass efficiency, commodity and manifestations of amenity of the built, three dimensional environment as well.

[7]See the Appendices and the following which elaborate on the rationale behind such a seminar, the personnel to be involved and details of the program itself which not only proposes arrangements per se but arrangements to facilitate comparative analysis.

[8]Involving discussions, meetings and agreements in all these countries; in other words considerable resources have already been expended to assure credence for such a proposal. These arrangements have influenced the selection of participants not just by professional competence but also by the selection of some who have had considerable background in all the countries by education and/or experience. This must be considered a significant part of the research design for the seminar as well.

[9]"A Study of Earthquake Loss in the San Francisco Bay Area: Data and Analysis", Report prepared for the Office of Emergency Preparedness; N.O.A.A., U.S. Dept. of Commerece, 1972. "A Study of Earthquake Losses in Los Angeles, California Area", Report prepared for the Federal Disaster Assistance Administration, U.S. Dept. of Housing and Urban Development, N.O.A.A., U.S. Department of Commerce, 1973. "A Study of Earthquake Losses in the Puget Sound, Washington Area", Open File Report, 75-375, U.S. Geological Survey, U.S. Dept. of Interior, 1975. "A Study of Earthquake Losses in Salt Lake City, Utah", Open File Report, 76-89, U.S. Geological Survey, U.S. Dept. of Interior, 1976.

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