EARTHQUAKE HAZARD REDUCTION

Executive Office of the President
Office of Science and Technology
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INTRODUCTION

In a series of thoughtful reports issued during the pas decade, various responsible scientific, professional and governmental groups in the United States have pointed to the catastrophic potential of a great earthquake with respect to human suffering and property damage. These reports have strongly urged the Federal government to undertake or to sponsor a large number of programs and studies in such fields as seismology, geology, engineering, government and disaster relief (including insurance) that are logically related in the context of earthquake hazard. The specific proposals have ranged from immediate steps, which would promptly reduce some aspects of the hazard, to research on the basic causes of earthquakes, which could lead eventually to more effective means of earthquake hazard reduction.

Partially in response to these studies, the Office of Science and Technology has established a Task Force on Earthquake Hazard Reduction. The mission of this Task Force is to develop an appropriate national action program for the reduction of the human suffering and property damage attendant upon an earthquake, including the earthquake-associated geologic hazards and non-geologic (direct) hazards.

Numerous specific recommendations, particularly in the fields of seismology, geology, and engineering, already have been carefully developed and explained. Possibly the most significant of these are included in the following publications:

"Earthquake Prediction: A Proposal for a Ten Year Program of Research", Ad Hoc Panel on Earthquake Prediction, prepared for the Office of Science and Technology, (May 1965);

"Proposal for a Ten Year National Earthquake Hazards Program: A Partnership of Science and the Community", Ad Hoc Interagency Working Group for Earthquake Research, Federal Council for Science and Technology, (December 1968);

"Toward Reduction of Losses from Earthquakes: Conclusions from the Great Alaska Earthquake of 1964", National Academy of Sciences, (1969);

"Earthquake Engineering Research", National Academy of Engineering, (1969);

"Seismology: Responsibilities and Requirements of a Growing Science", National Academy of Sciences:

Part I - "Summary and Recommendations", (1969)
Part II - "Problems and Prospects", (1969)

The Task Force has carefully considered all of the specific proposals listed in the aforementioned studies and reports in the process of defining the best national program leading to the reduction of earthquake hazards. Further, the Task Force has considered additional recommendations, particularly in socio-economic fields which have received less attention than the physical sciences. The overall program will require the best coordinated inputs from the public and private sectors.

It should be made clear that the majority of the recommendations brought to the Task Force's attention have not been included in this report. A number of costly proposals have been omitted, or included on a substantially reduced basis, since they had little or no relevance to a national program on earthquake hazard reduction.

PROGRAM BENEFITS

In a basic sense, no program of earthquake hazard reduction will have significant direct benefits to the public until an earthquake occurs. An earthquake cannot at present be predicted with respect to time, location, and size; therefore, any benefit to be derived from a hazards reduction program must relate to a postulated earthquake. Great destructive earthquakes in the United States have not been frequent events, yet several have occurred during the relatively short span of historic time. It must be assumed that others will occur during the years ahead.

Benefits may be viewed and identified from various standpoints. Thus, we can focus upon increased safety to the public, more and better disaster relief, and reduction of monetary loss or provision for recovery of loss. A different kind of benefit can be the increased knowledge that will be immediately used to reduce the hazard; for example, a building code provision can go into effect at once. Another can be fundamental research or study that is absolutely essential as a basis for other research that will create direct benefits. Or, finally, the benefits can be in the planning or the information needed for planning, for future improvements in safety such as wiser distribution of urban structures and upgraded building codes.

An entirely different aspect is the degree or extent of benefit. Presumably a parapet ordinance, for example, could have an immediate and general effect on safety (i.e. by eliminating hazardous parapets and other building appendages). However, a new provision in a building code affects only the new buildings and so affects the relatively few people who use them. Urban planning, new school safety laws, new regulations for FHA, post offices, etc., are in the same category.

Information on costs is essential for decisions on the most effective use of limited funds, and the soundness of such decisions necessarily depends upon appraisals of cost-benefit relationships. The need for realistic cost-benefit studies in the context of earthquake risk is discussed farther on in Recommendation No. A-7, but a more immediate comment on application of the term "benefit" is offered here.

Any hazard-reduction program begins to produce benefits as soon as it is activated. These benefits are intangible but real, as they take the form of reduced risk to life and property. They accrue without regard to the actual occurrence of damaging events, even though they are not translated into tangible form until such an event does take place. Thus a major earthquake may clearly reveal certain benefits deriving from a viable hazard-reduction program, but in effect this is no more than a demonstration of benefits that have existed throughout the program as contributions to safety for people and property. Protection against a known hazard is as real for the beneficiary before a damaging event as afterward.

Hundreds of possible recommendations have been considered in an effort to formulate a complete, yet workable, program for earthquake hazard reduction. A considerably refined list of interrelated recommendations, all of high priority, has evolved in the form of Table 1. The three-fold grouping into time-related categories reflects appraisals of when significant public benefits would begin to derive from action on each of the recommendations. The time-benefit categories are:

A. Potential for significant benefits beginning in the near term (in less than 5 years)

B. Potential for significant benefits beginning in the intermediate term (within 5 to 10 years)

C. Potential for significant benefits beginning in the long term (after 10 years)

The foregoing categorization perforce involves no more than best estimates. Thus it is quite possible, and indeed it is likely, that one or more unexpected breakthroughs in knowledge will change some expected benefits from long term to short term.

In general, there is a correlation between the extent and importance of benefits from research and the difficulty and cost of the research effort. In time, the greatest benefits are likely to come from the longer range studies. These benefits will come not only from the application of new knowledge, but also from the changes in public attitude resulting from a better understanding of earthquakes and their effects. Many people outside the engineering and scientific communities do not appreciate the seriousness of the gaps that currently exist in our fundamental knowledge of earthquakes and their effects, but most of these gaps are capable of being filled in the course of a well-balanced program that emphasizes long term as well as intermediate and short term benefits. Hence, it would be a serious mistake to allocate most of the available financial resources to thos recommendations having potential short term benefits to the neglect of the others. Neither the three categories nor the order of listing of the recommendations presented below are intended to indicate an order of priority.

The high priority recommendations of the Task Force are given in capsule from in Table 1. These have been summarized from the detailed recommendations on the pages that follow.

Table 1: HIGH PRIORITY RECOMMENDATIONS

Short Title List

A. Significant benefits probably beginning to accrue in the short term (less than 5 years after beginning of recommended action):

- A-1 Engineered earthquake resistance for new governmental facilities
- A-2 Engineered earthquake resistance for new non-governmental facilities
- A-3 Seismicity (or risk, or probability) maps
- A-4 Earthquake geologic hazards maps
- A-5 Urban planning to minimize seismic hazard
- A-6 Earthquake hazards abatement in older facilities
- A-7 Cost-benefit studies
- A-8 State and local government role in geologic hazards reduction
- A-9 Federal total plan for immediate response
- A-10 Federal responsibility in reconstruction
- A-11 Federal responsibility in earthquake insurance
- A-12 Strong motion equipment and analyses
- A-13 Full scale testing

B. Significant benefits probably beginning to accure in the intermediate term (5 to 10 years after beginning of recommended action):

- B-1 Applied research on seismic design criteria
- B-2 Post-earthquake analyses
- B-3 Fault mapping, dating, and specialized geologic mapping
- B-4 Local seismic networks
- B-5 State responsibility in earthquake hazards reduction
- B-6 Newly discovered hazards and older construction
- B-7 Taxes and tax reform

C. Significant benefits probably beginning to accrue mainly in the longer term (10 years or more after beginning of recommended action):

- C-1 Basic research in earthquake engineering
- C-2 Earthquake prediction research
- C-3 Earthquake control research
- C-4 Geodetic research
- C-5 Worldwide seismic network continuation
- C-6 Tsunami hazard research
- C-7 Basic research in seismology
- C-8 Basic research on causes and mechanisms of crustal failure

While the report directs its attention only to the earthquake hazard which is of varying importance throughout the United States, many of the programs are of equal importance to other natural hazards. It is notable that those areas of the United States that are least concerned about earthquake hazard are most concerned about hurricanes, for example. And the principal structural concepts that make a building able to resist earthquakes successfully are either identical or similar

to those that provide adequate wind resistance (A-1, A-2, B-1). The planning concepts (A-5), the disaster relief programs (A-9, A-10), the insurance (A-11) and tax recommendations (B-7), the hazard abatement proposals (A-6, B-6) and the inter-governmental cooperation areas (A-8, B-5) have equal validity for all natural disasters. The geological and mapping studies and recommendations (A-4, B-3) contained in the report are necessary for protection against landslides and other geological hazards. As a result, the major recommendations of the report are suitable for use throughout the United States and should not be confined to those areas that traditionally are concerned about earthquakes.

URBAN RECONSTRUCTION PLANNING: THE ALASKA EXPERIENCE

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Federal Field Committee for
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19th May, 1971

Reconstruction of Alaska's communities after the 27th March, 1964, earthquake is a story of success but also a story of failure for planners. I say this as a geologist and planner who actively participated in the preparation of redevelopment plans for all the communities affected by the earthquake.

Although it had been known by geologists and engineers employed by federal and state agencies that most of the populated area of Alaska lies in an area of high seismic activity, this fact had not been recognized by planners or local, state, and federal officials in planning for development of land uses and capital improvements in urban centers.

The effect of the earthquake was drastic and varied.

In Anchorage, the most sophisticated community in the state, three large landslides were triggered in the most built-up area of the city - the business district and two of the most valuable residential areas.

In Seward and Valdez, large submarine landslides coupled with land subsidence destroyed the cities' industrial waterfronts. In Valdez, in addition, instability of soils throughout the community made the whole community uninhabitable.

In Kodiak, land subsidence, coupled with the effects of innundation resulting from a tsunami, destroyed the industrial and commercial sectors of the community.

In Seldovia, land subsidence left the community's industrial waterfront, commercial facilities and many residences under water at high tide.

In Cordova, land uplift left the small boat harbor, city dock, and other waterfront activities high and dry!

Programs for relief and recovery were needed urgently, but Alaska's planning resources for a reconstruction task of this magnitude were limited. There were only 16 practicing firms of architects and engineers and 8 planners in the state, and the planners were all employed by public agencies. There was no state planning agency adequately staffed to make the

multitude of necessary surveys and studies, or prepare the plans needed to guide reconstruction. Planning commissions were active in only two of the affected communities. Long-range comprehensive land-use plans were available for Kodiak, Anchorage, Cordova, and Seward, but in their preparation, the communities' vulnerable seismic conditions had been ignored; they included no guidelines for reconstruction, relocation, or innovative planning concepts.

The principal tasks that faced those in charge of disaster relief and reconstruction were to provide for rapid temporary restoration followed by permanent reconstruction. The temporary restoration phase was handled effectively by private citizens and local governments with the assistance of the military and other federal agencies. In a matter of days, all citizens were housed and temporary utilities established in all communities.

The permanent reconstruction phase required more time than was allowed! It was recognized that such a major disaster required rapid action for recovery. It was also recognized that disaster presents a rare opportunity for revitalizing the urban structure, developing new land-use patterns directed at safeguarding lives and property, and strengthening the economic base through improved land-use. Teams of soil scientists and engineers were promptly organized to evaluate the extent of high risk areas or other limiting factors to be considered by planners in developing criteria for reconstruction. Consultant firms with national reputations were hired to assist local planners in the development of plans providing for future safety and to rebuild safe and economically sound communities. These plans were accomplished. However, the goals of the plans were not always realized. There was a lack of time to substantiate some of the concepts used by the consultants, a lack of continuity in planning staffs (the consultants originally hired were not retained to carry the program through from the planning phase to the implementation phase), and a lack of time for educating the communities on the value of long-range planning. These factors, together with the speculative build-for-today-and-let-tomorrow-fend-for-itself approach used by many local officials and private citizens, and the quickly forgotten impact that the earthquake had had on peoples' lives, led to plan changes, compromises, and unnecessary delays in final reconstruction activities.

Time limits my making a full review of the various redevelopment plans and the considerations that went into their preparation. I will, however, present a few examples of the changes made to the original plan recommendations which may have a long-range impact on the communities.

In Kodiak, the first plan suggested moving the commercial core away from the waterfront to higher ground and attempted to combine multiple dwellings with a non-industrial retail complex. It also recommended that the land adjacent to the harbor, after being filled, be used for storage and industrial staging areas, badly needed by the growing fishing industry. The plan was changed to allow for the reconstruction of an industrial-commercial complex on the waterfront - as before the earthquake - an unwise decision from both the standpoints of safety and long-range land-use economics. A requirement that all structures built adjacent to the waterfront be constructed of reinforced concrete or reinforced masonry to withstand the force of future tsunamis was also deleted at the request of the Kodiak City Council. On the other hand, Kodiak is today a new community with new stores fronting on paved streets, with adequate packing facilities, and boasts a revitalized fishing industry based on a new boat harbor - protected by a seawall and breakwater, and new canneries using improved methods of fish processing and shipping.

In Seldovia, the consultants had prepared a plan that had kept the community's quaint character - a requirement for a community whose future depends on an increased tourist economy in addition to its fishing industry. Plans were modified, however, to respond primarily to the waterfront needs of canneries, boat yards, and storekeepers. To make room for extensive land fill, historical landmarks were destroyed; the project moved slowly due to controversy and misunderstanding; and today, besides losing its quaint waterfront, Seldovia has lost most of its canneries' activities.

Anchorage was the only community at the time of the earthquake that had in force regulations and ordinances needed to control proper development. Moreover, it had just completed a central business district plan, prompted by the need to create a strong commercial-financial core. Immediately after the quake, soil studies were made to determine the extent of the high risk areas and based on these findings, a land-use plan was prepared. The plan proposed the movement of the primary business core away from the unstable bluff to the adjacent land where more favorable soil conditions exist. The plan designated the risk areas to be used for parks, parking, and other open-space activities. In these open spaces, the only construction to be allowed was construction of pavillions, oriented towards tourist trade. Detailed suggestions for pedestrian malls to revitalize the city core were also made an integral part of the plan. Although some people saw in this plan a method of improving the central business district and putting into effect many of the proposals presented in the pre-earthquake study, as well as protecting the city from future major loss as a result of earthquakes, no public support for the plans developed. With large portions of the central

business district already destroyed, many businessmen disapproved of further demolition as being too destructive of the city's economy. (It must be added that the project's method of land acquisition based on post-earthquake prices was completely unrealistic to allow for effective reassembly of land.)

The decision was made immediately to limit the extent of replanning to one slide area - the Downtown Slide. An earth buttress was designed and built to stabilize the soil that had failed and to prevent the adjacent land from sliding in the event of another earthquake. Nothing else was done to improve the city's core area. In the last five years, intensive construction has occurred in areas considered of high risk by soil scientists. One of the slide areas - the L Street Slide - was never considered; it was, of course, not stabilized.

But plans for reconstruction were not invariably abandoned. Let me use Valdez as an example.

The loss of life and the damage at Valdez was so great that a decision was made to move the entire community. Federal officials expressed skepticism regarding the relocation of a community with a population of only 500 people, but the position of Valdez as an ice-free port and terminous of the Richardson Highway, the shortest and most direct route from tidewater to Fairbanks, and the potential of Valdez as an outlet for development of the natural resources of the interior weighed heavily in the decision to relocate the community. After extensive soil studies, Mineral Creek - the city's first location at the time of the goldrush - was approved as the new townsite. The tremendous efforts of planning and co-ordination that took place in acquisition of all private property at Valdez and relocation of 135 families, 26 individuals, 44 businesses, and construction of new roads, schools, hospital, public facilities, city dock, and small boat harbor cannot be quickly summarized.

The move was rapid and reconstruction closely followed a land-use plan which had incorporated concepts directed to population growth, weather conditions, convenience of shopping, amenities related to development of residential areas close to schools and recreation facilities, expanded waterfront activities, and enhancement of the tourist potential of the area. By fall, 1966, all public facilities had been constructed. This acted as a catalyst to the relocation of residences and businesses. Total relocation was completed by fall, 1967 - a little over three years after the earthquake. The only feature sacrificed in the rapid redevelopment was the aesthetic aspect of construction, a consequence of the lack of adequate financing of private development.

Cordova is the most successful project. Through the reconstruction, recommendations made in a comprehensive land-use plan prepared in 1962 were implemented by improving access to the waterfront and providing additional land for industrial use.

In evaluating the planning process that took place during the recovery period, it is evident that three planning phases are needed to successfully approach planning for areas subject to earthquake disasters - prevention, immediate relief, and long-term recovery.

It was the lack of these established planning systems that created problems, some with long lasting effects, in the reconstruction of communities following the 1964 Alaska earthquake.

What recommendations can be made to this effect as a result of the Alaska experience? What tools are needed to make reconstruction more responsive to the need to improve and prevent occurrence of disasters? It is my opinion that a state disaster prevention planning program should be initiated by the state with the assistance of the federal government and should include, among other things:

preparation of an overall state plan which evaluates potential disaster areas and their treatment in the event of a disaster;

initiation of programs to prevent or minimize disasters such as soil stabilization, harbor protection, avalanche control, and others;

adaptation and enforcement of statewide building codes;

co-ordination of local, state, and federal activities related to development planning in potential disaster areas;

study and evaluation of all state and federal programs applicable to disaster recovery - and - planning for immediate assignment of one agency as a co-ordinator of all physical planning activities;

financial and technical assistance to local planning agencies in preparation of comprehensive plans including hazard considerations as part of land-use determinations;

financial and technical assistance to local governments for the enforcement of zoning ordinances, subdivision regulations, fire codes, building codes, and other regulations required for safe and proper development

initiation of programs of public education.

State and federal governments should cooperate in the preparation of regional plans including data on geology, climatology, ecology, and social-economic conditions, sc that it will be available for reconstruction planning.

Assistance should be given to local governments for the acquisition of lands which are considered to be subject to earthquake induced damages such as slides, subsidence, innundation, and others, for the development of these lands as part of open-space activities - badly needed in most communities.

Clear distinction should be made between disaster relief and long-range recovery; to this endeavor a disaster relief plan should be available for immediate implementation to prevent the hardship caused by the problems of temporary relocation of families and businesses which caused, in the case of Alaska earthquake reconstruction, many of the delays and difficulties in plan implementations.

It is also important that a task force entrusted with the responsibility of preparing the redevelopment plans be established immediately following the disaster, and, besides planners, it must comprise geologists, engineers, economists, sociologists, architects, appraisers, and attorneys. This task force should be familiar with the state and should become the recipient of all input from consultants and other interested technicians who visit the state as a result of the disaster. To do so, an active list of scientific and technical personnel within the state should be prepared and kept jointly by state and federal governments.

Most of all, planners and local government officials must be educated to recognize environmental constraints as an important factor to be considered in the determination of land uses.

The irresponsible way by which local governments in Alaska, at present, are treating known earthquake hazard areas, concerns me greatly. I wish that as careful consideration could be given by Alaska environmentalists to the construction occurring on high-risk areas in urban centers, as is given to the possible effects of earthquakes on the proposed pipeline from Prudhoe to Valdez. After all, the human species in the cities is as valuable as the tundra, the caribou, and the lichens in the wilderness.

THE NATIONAL EMERGENCY COMMITTEE 31ST MAY, 1970 EARTHQUAKE PERU

A full report on the earthquake which took place on 31st May, 1970 at Chimbote y Trujillo, Peru, was presented at the meeting.

Copies of the original text in Spanish may be obtained from:

Auxilio Social de Emergencia Regional (ASER)
Ministerio de Salud,
LIMA,
Peru.

Un rapport détaillé sur le séisme du 31 Mai, 1970 à Chimbote y Trujillo, Pérou, a été presenté au cours de la réunion.

Le texte en espagnol peut être obtenu à l'adresse ci-dissus.

SEISMIC RISK STUDIES IN THE UNITED STATES

S.T. Algermissen

SYNOPSIS

A new Seismic Risk Map of the United States is presented, together with strain release and maximum Modified Mercalli intensity maps of the country. Frequency of occurrence of damaging earthquakes was not considered in assigning ratings to the various zones on the risk map, but studies of earthquake frequency are included as an aid in using the risk map. The Seismic Risk Map is suggested as a revision of the Seismic Probability Map prepared by the Coast and Geodetic Survey in 1947 and withdrawn in 1952.

Copies of the text may be obtained from the following address:

Chief, Geophysics Research Group,
Coast and Geodetic Survey,
ESSA,
US Department of Commerce,
Rockville, Maryland,
U.S.A.