PRE-EARTHQUAKE PLANNING FOR POST-EARTHQUAKE REBUILDING* IN THE CITY OF LOS ANGELES

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SUMMARY

This paper presents the results of research in process on the feasibility of planning before an anticipated earthquake for rebuilding following such earthquake. Methodologies used in defining the seismic environment of the study area and estimating probable earthquake intensities and probable building damage are described. The use of the seismic and structural damage information in formulating a planning response for post-earthquake rebuilding is outlined. Findings are presented regarding probable extent of damage in the study area from selected scenario earthquakes, the processes and organization needed for pre-earthquake planning and post-earthquake rebuilding, and factors affecting feasibility of such pre-earthquake planning.

THE STUDY AREA AND THE RESEARCH TEAM

The City of Los Angeles was selected for study because of the complexity of seismic-geologic conditions in the region, the variety of structures and uses of land in the City, and the concern of the City government regarding the problems presented by the high probability of a great earthquake on the nearby San Andreas fault. The City is being used for prototype application of methodology and research findings developed in the project. The complexity of the seismic environment is illustrated by the network of identified faults portrayed on Figure 1 (following page).

The research team includes: William Spangle and Associates, Inc., city and regional planning; Earth Sciences Associates, engineering geology; H.J. Degenkolb Associates, structural engineering; and staff from the Los Angeles City Planning Department. A 13 member Review Panel has met twice to review results of the study to date. Four members of the Review Panel with special expertise in seismology, geologic effects of earthquakes, and earthquake damage to structures constitute a Validation Panel with responsibility for technical review of project work in these subject areas.

PROBABILITY OF EARTHQUAKE AND EARTHQUAKE SCENARIOS

Based on study of the seismic and geologic environment of the City it has been concluded that there is high probability (2% to 5% chance per year)

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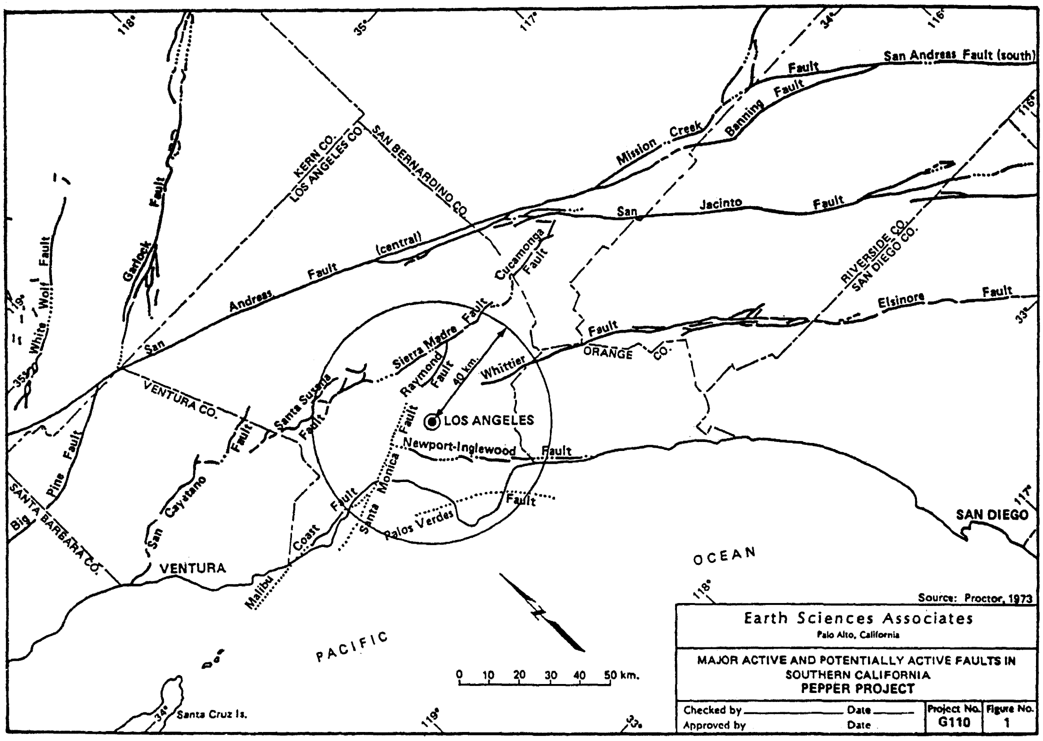
of a great earthquake (M = 8.3) on the central segment of the San Andreas fault and about an equal chance of an M = 6+ event in some location within the City itself. The M = 6+ earthquake could occur either on one of the numerous faults underlying the City (Figure 1 following) or in another location associated with an as yet unidentified source of seismic activity (Ref. 1).



Earthquake scenarios have been developed for the anticipated M = 8.3 earthquake on the San Andreas fault and three M = 6+ earthquakes at locations selected to illustrate the potential for damage in different parts of the City from such earthquakes. Locations selected were: Central City, West Los Angeles and Long Beach. An "Earthquake Shaking Intensity Map" was prepared for each earthquake showing the probable pattern of Modified Mercalli intensities that would result. Areas within which some liquefaction or landsliding may occur are also identified. However, information on underlying geology is not sufficiently detailed to pinpoint where such ground failures would be likely to result (Ref. 1). Table S-1, following, compiled from the shaking intensity maps, indicates the estimated MM intensities for the four scenario earthquakes for each of the 35 planning areas in the City shown on Figure 2.

ESTIMATES OF STRUCTURAL DAMAGE

Estimating the amount of structural damage to be expexted in any given earthquake depends on several factors. First, it is necessary to obtain an estimate of the severity and areal extent of ground shaking. Next, the severity of ground shaking must be correlated to the damage to be expected for various types of structures. Both of these components can be derived by studying the effects of past earthquakes. Then it is necessary to obtain an inventory of structures and their types for the area under consideration. The damage pattern and estimate of the amount of damage can then be estimated by combining these three components - 1) ground shaking, 2) percent damage due to shaking for the several classes of structures, and 3) number and type of structures in the study area (Ref. 2).

The inventory of structures was derived primarily from the City's Land Use Planning and Management System (LUPAMS) computor file. Substantial difficulty was encountered in using the LUPAMS file because of incomplete or inaccurate coding of structures for the data needed for the structural analysis. Data in this file were, therefore, supplemented from several other sources and adjustments made. One major gap in the information was identified - most publicly owned buildings are not included in the inventory. Solving these problems caused delays in completing the damage estimate. Substantial work on the LUPAMS file is needed to make it fully operational for use in making earthquake damage estimates and other purposes. A fully operational file would be of great value not only for post-earthquake rebuilding but also for emergency response planning and emergency response operations.

Factors relating percent damage to structure type and intensity of shaking were derived from studies of building damage in prior earthquakes (Ref.3 and Ref. 4). To use these factors, the five classes of buildings provided in the LUPAMS file had to be divided into several sub-categories related in part to age of buildings and in part to identifiable sub-categories of steel and masonry buildings (Ref. 2).

For each of the four earthquakes estimates have been made of probable extent of building damage by type of structure and type of occupancy. In addition, estimates have been developed of the probable distribution of building damage by categories "Damaged but Reparable" and "Damaged Beyond Repair". The "Reparable" category is subdivided into "Habitable" and "Not Habitable". Estimates have also been made of probable dollar loss. All of these estimates are at present limited to losses in privately owned buildings because the City LUPAMS file, derived primarily from County Assessor's records, does not include necessary data on public buildings and other buildings not assessed for property taxes. The relative effects of the four scenario earthquakes are vividly illustrated by the estimated dollar losses in the private building stock <u>within</u> the City of Los Angeles:

San Andreas	M = 8.3	$ 790,000,000
Central Area	M = 6+	$2,804,000,000
West Los Angeles	M = 6+	$2,098,000,000
Long Beach	M = 6+	$ 637,000,000

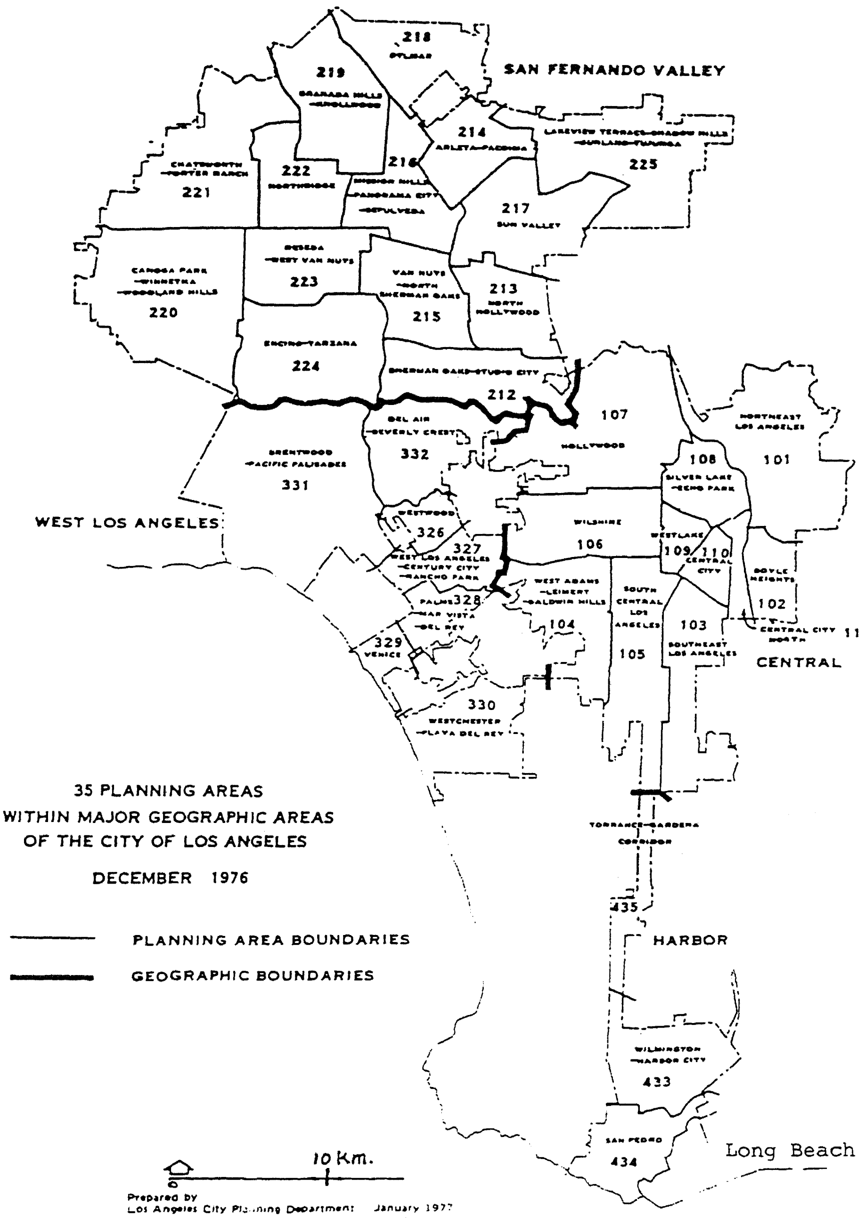
TABLE S-1

Modified Mercalli Intensities for Four Design Earthquakes

LUPAMS NUMBER	PLANNING AREA	SAN ANDREAS 8+	CBD 6+	WEST LA 6+	L.B. 6+
1	Northeast Los Angeles	6+ 7−	7	6	6
2	Boyle Heights	6+	8	7	6
3	Southeast Los Angeles	6+	7−8	7	7
4	West Adams-Baldwin Hills-Leimert	6	8	8	6
5	South Central Los Angeles	6+	8	7	6−7
6	Wilshire	6 6+	8	7−8	6
7	Hollywood	6 6−	7	7	6
8	Silver Lake-Echo Park	6	8	6−7	6
9	Westlake	6	8	7	6
10	Central City	6+	8	7	6
11	Central City North	6+	8	7	6
12	Sherman Oaks-Studio City-Toluca Lake	6+ 7−	7	7	6
13	North Hollywood	7−	7	6	6
14	Arleta - Pacoima	6+ 8−	6	6	6
15	Van Nuys - North Sherman Oaks	7−	6−7	6	6
16	Mission Hills-Panorama City-Sepulveda	7−	6	6	6
17	Sun Valley	7−8	6	6	6
18	Sylmar	7+	6	6	6
19	Granada Hills - Knollwood	6+ 7 7+	6	6	6
20	Canoga Park-Winnetka-Woodland Hills	7−	6	6	6
21	Chatsworth - Porter Ranch	7−	6	6	6
22	Northridge	7−	6	6	6
23	Reseda - West Van Nuys	7−	6	6	6
24	Encino - Tarzana	5−6	6	6−7	6
25	Sunland-Tujunga-Shadow H's.-L.V. Terr.	6−	6	6	6
26	Westwood	6+	7	8	6
27	West Los Angeles	6	7	8	6
28	Palms - Mar Vista - Del Rey	6	7	8	6
29	Venice	6+	7	8	6−7
30	Westchester - Playa Del Rey	6− 6+	7	8	6
31	Brentwood - Pacific Palisades	6−	6	7	6
32	Bel Air - Beverly Crest	6−	6−7	7−8	6
33	Wilmington - Harbor City	6	6	6	7
34	San Pedro	6−	6	6	6−7
35	Torrance - Gardena Corridor	6	6−7	6−7	7
36	Port of Los Angeles	6	6	6	7
37	Los Angeles International Airport	6	7	7−8	6

Note: Arabic numerals used in place of Roman for ease in reading.

Where two or more intensities are tabulated, the Planning Area is subject to two or more intensities for a given earthquake either because an intensity isoseismal divides the area or because of differences in foundation soils conditions within the Area.


SAN FERNANDO VALLEY
WEST LOS ANGELES
CENTRAL
HARBOR
Long Beach
218
219
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225
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217
220
223
215
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101
108
332
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35 PLANNING AREAS
WITHIN MAJOR GEOGRAPHIC AREAS
OF THE CITY OF LOS ANGELES
DECEMBER 1976
PLANNING AREA BOUNDARIES
GEOGRAPHIC BOUNDARIES
10 Km.
Prepared by
Los Angeles City Planning Department January 1977

Figure 2

The loss figure from the Long Beach earthquake is low for the City of Los Angeles because only a small portion of the City is subject to high intensity effects (see Fig. 2).

Use of Damage Estimates

These estimates of probable damage, although incomplete, can be used in several ways, such as

1) To provide an indication of the nature and magnitude of emergency response needed following a "scenario" earthquake (or other similar earthquakes)

2) To help the City in further defining its earthquake hazards mitigation program

3) To prepare schematic or more definitive plans for rebuilding heavily damaged areas when an earthquake does occur

4) To define the nature of the rebuilding/restoration team needed to respond to damaging earthquakes (or other major disasters)

5) To outline programs for rebuilding/restoration (or to describe the necessary elements of such programs).

Even though there is no specific prediction (time, location and magnitude), the high annual probability of a major to great earthquake on the nearby segment of the San Andreas fault seems to justify both land use/rebuilding planning and projecting the nature of the problems and responses needed for rebuilding and restoration. Preliminary data from the damage estimates indicate widespread scattered but generally light damage to wood-frame buildings plus concentrated damage where there are concentrations of old unreinforced masonry buildings. This is a generalization intended only to indicate the probable pattern of damage. Major land use/rebuilding planning and programming would focus on the areas of concentrated damage. Organization of City resources to speed rebuilding/restoration would be critical.

A Process for Reducing Disaster Impact

Review of past and current experiences in post-disaster rebuilding strongly indicates the need for an officially established Rebuilding/Restoration Team to be in place immediately after a major disaster (Ref. 5). The diversity of possible damaging earthquakes (and other disasters) which could severely impact the City of Los Angeles increases the importance of having a team "in place" with well defined role, responsibility and authority for post-disaster rebuilding/restoration. Such a team should have pre-established guidelines to follow and sufficient powers to insure effectiveness of its efforts. To relate pre-event actions to post-event recovery, a five phase framework is used. Actions appropriate to each phase are outlined below with activities related particularly to urban areas in highly seismic regions.

I Pre-Disaster Equilibrium.

a. Pursue business as usual

b. Plan for the future of the area with primary emphasis on "normal" conditions

c. Identify special earthquake hazards and probability of damaging earthquake

d. Guide and control development to avoid or overcome hazards through regulation and public information

e. Take special hazard mitigation measures - institute programs to upgrade or demolish hazardous buildings - review and revise regulations for hazardous occupancies

f. Formulate an emergency response plan and conduct emergency response exercises

g. Establish organizations and procedures for 1) emergency response, 2) rebuilding/recovery

h. prepare contingency plans for post-earthquake rebuilding.

II Pre-Earthquake Warnings - (Special warning or prediction of impending earthquake.) Specific activities must be related to nature of warning - long term, intermediate, short term - and the probable effects.

a. Evaluate facts - potential nature of event or events

b. Review emergency plans and modify as necessary to respond to impending earthquake

c. Evacuate specially hazardous buildings and locations when earthquake is imminent

d. Review contingency plans for post-earthquake rebuilding.

III Earthquake Impact and Emergency Response. Emergency Response Organization takes over, business as usual suspended.

a. Initial seismic hazard evaluation (Hazard Evaluation Team--H.E.T.)

b. Initial inventory of damage (Building Inspection/Structural Engineer Team)

c. Phase in Rebuilding/Recovery Team.

IV Rebuilding/Recovery. Rebuilding/Recovery Team in charge, Emergency Response activities phased out.

a. Assess actual damage in relation to anticipated damage

b. Re-evaluate pre-earthquake plans for rebuilding.

V Post-Disaster Equilibrium. (Business as usual.)

Based on work to date on our PEPPER* project we are convinced that pre-earthquake planning for post-earthquake rebuilding makes sense in highly seismic regions. Our research and application of methodology to the City of

* Pre-Earthquake Planning for Post-Earthquake Rebuilding

Los Angeles indicates that the present state-of-the-art makes it possible to assess the probability of a damaging earthquake and to describe general patterns of intensity of shaking and resulting damage. With this information, recommendations can be formulated for post-earthquake rebuilding/recovery.

Disaster impact can be reduced by pre-event actions, including hazard mitigation measures, preparation for emergency response, and pre-event preparation for post-disaster rebuilding. All of these activities require planning and, in part, depend upon the same store of organized information. These data include:

- characteristics of the hazard and geographic areas likely to be impacted
- population (numbers, characteristics, distribution)
- measures of economic activity
- resources available (financial, human)
- powers, programs, and responsibilities of local, state and federal governments
- land use and building stock (numbers, characteristics, location)
- infrastructure (water, power, communication and transportation systems)

This same information is also needed for normal local and regional comprehensive planning and programming for government. In addition, it is useful for private industry's planning and marketing. Developing and maintaining an accurate, up-to-date, and accessible store of such data should be a high priority item.

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