PRE-EARTHQUAKE PLANNING FOR POST-EARTHQUAKE RECONSTRUCTION IN LOS ANGELES, CALIFORNIA

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SUMMARY

Potential effects of three probable earthquakes in the Los Angeles basin were examined during a NSF-sponsored project to develop post-earthquake land use plans for reconstruction efforts. Postulated epicenters are: repetition of the 1933 Long Beach event, downtown Los Angeles, and West Los Angeles. A scenario of expected physical effects was prepared, including strong ground shaking, slope failures, potential liquefaction, and MM isoseismal maps. This information was reviewed and validated by a panel of earthquake experts. It was to be used to assess potential structural damages, recommend changes to the General Plan, suggest redevelopment plans, and provide guidelines for rebuilding.

INTRODUCTION

This paper summarizes a technical report prepared as part of project PEPPER - Pre-Earthquake Planning for Post-Earthquake Rebuilding - sponsored by the Earthquake Hazards Mitigation Program, Division of Problem Focused Research, National Science Foundation. The project's objectives were to study the problems of and prospects for pre-earthquake land use planning for the post-earthquake situation in the city of Los Angeles, and to identify the nature of the process needed for such planning. The project team selected three earthquakes considered probable within the city limits as a basis for predicting geologic and seismologic effects and estimating structural damage. Development of a credible, realistic scenario proved to be a not so simple task because of the variety of expert opinions on magnitudes, epicentral locations and actual effects to be expected. The consensus was reached after prolonged debate and thorough research of similar earthquakes that occurred historically in the region.

EARTHQUAKE SCENARIO SELECTION

Scenarios based on maximum credible earthquakes have been used for emergency preparedness and other pre-disaster planning (Refs. 1 and 2). Such scenarios are appropriate in establishing design and siting criteria for critical facilities such as dams and nuclear power plants. For purposes of pre-planning for rebuilding after an earthquake, the rebuilding plans must reflect the land use pattern and government authorities in place at the time of the event. These cannot be predicted hundreds of years in advance. Therefore, the selection of earthquake scenarios for the study was limited to events with a reasonable likelihood of occurring within the next 50 years, i.e., the near future.

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A M=8+ earthquake on the San Andreas fault has a 2 to 5 % annual probability of occurring in southern California (Ref. 3) and is the largest earthquake likely to affect the city of Los Angeles within the next 50 to 100 years. However, the San Andreas fault is about 53 km from downtown Los Angeles and about 34 km from the closest city limit. The effects of a great earthquake on the fault would be much attenuated in the city.

Earthquakes of magnitude greater than about 6.5 are usually associated with relatively large, active faults, and for seismic risk studies such larger earthquakes are considered to occur on, or be caused by known faults. However, in California, earthquakes of magnitude smaller than 6.5, and particularly of magnitude smaller than 6, can be generated by lesser tectonic movements that do not necessarily cause fault ground rupture. Earthquakes of up to this size might occur almost anywhere in seismically active areas, regardless of the location of significant faults. The recent Coalinga earthquake (M=6.7) is an example of this.

The 1933 M=6.3 Long Beach earthquake is thought to have occurred on the Newport-Inglewood fault (Ref. 4). Presumably an earthquake of up to this size could occur again, either on any known active faults, or on minor or unknown subsurface faults anywhere in the basin. It is geologically possible that a quake of this size could occur anywhere within the city of Los Angeles. The PEPPER study considers three possibilities: a repeat of the 1933 Long Beach earthquake, a M=6.3 earthquake centered in downtown Los Angeles, and a M=6.3 earthquake centered in the West Los Angeles area. From the standpoint of any given geographical area or feature -- a neighborhood, structure or group of structures -- it seems reasonable to prepare post-earthquake plans for impacts from such events.

PREDICTED EFFECTS OF POSTULATED EARTHQUAKES

Predicted Strong Ground Shaking Intensities

Records of previous southern California earthquakes (1933, 1971, 1979) suggest that a M=6.3-6.5 quake in the Los Angeles area might cause Modified Mercalli (MM) Intensity=VIII within an area up to about 8 km from the earthquake source, surrounded by a belt of Intensity VII to about 16 km. Some local "hot spots" of Intensity IX effects could be expected within the inner epicentral area. Such anomalies in shaking intensity cannot by presently predicted for close-in areas with much reliability.

The 1933 Long Beach earthquake provided two records which indicated accelerations on the order of 0.2 g in the epicentral (i.e., Intensity= VIII) area. This value corresponds with estimates made by structural engineers of that day, based on structural performance.

Although the improved data on ground motion parameters from recent quakes is of considerable interest from a scientific and engineering research standpoint, these data cannot be directly translated into precise damage estimates. Engineering judgment, based on experience and observations of damage in the epicentral areas of comparable moderately strong, shallow-focus earthquakes in areas like southern California, still remains the most reliable means of predicting damage. The engineering literature describing the 1933 quake (Ref. 5) and a series of articles in Engineering News Record in the months following the 1933 quake, provide information on the response at least of older buildings to such an earthquake.

Descriptive records, especially of the effects of the 1933 Long Beach earthquake, are the primary basis for the MM Intensity maps shown on Figures 1, 2, and 3 for the three M=6.3 earthquakes selected for this study. Figure 1 is an Intensity map of a repeat of the 1933 event, and the isoseismals are based on the observed effects of that earthquake. Figure 2 shows the predicted intensities for a M=6.3 earthquake centered in downtown Los Angeles, and Figure 3 shows the same for a M=6.3 earthquake centered in West Los Angeles.

Ground Failures

The records of the 1933 Long Beach and 1971 San Fernando earthquakes provide some evidence of the typical ground failure effects that might be caused by a M=6+ earthquake in southern California. However, intensities of these events were low in the central and western parts of the city of Los Angeles. Thus, these earthquakes did not provide a true test of the susceptibility of these areas to ground failure. However, some estimates of ground failures can be made based on knowledge of local geological, soils, and ground water conditions; evidence of past landsliding; distribution of saturated alluvial soils; and effects recorded during historic California earthquakes.

Fault rupture - The record indicates that ground rupture due to faulting can accompany earthquakes with magnitudes greater than about 6. A great (M=8+) earthquake on the San Andreas fault would be accompanied by ground rupture along the fault trace (Refs. 2 and 3). The 1933 Long Beach event was not accompanied by recognizable fault ground rupture, but the San Fernando (M=6.4) and 1979 Imperial Valley (M=6.5) earthquakes were. The scenario chosen in the project includes earthquakes centered in Los Angeles south of the Santa Monica Mountains, where no historical fault ground rupture has occurred. Consequently, it was assumed for purposes of the project that the postulated earthquakes would not be accompanied by fault ground rupture.

Liquefaction - Past earthquakes indicate a moderate liquefaction potential, given the appropriate soil conditions, in areas of Intensity VIII, and a lesser or slight potential in areas of Intensity VII. Hence, for the three earthquakes studied, one might expect liquefaction potential in susceptible soils within the areas bounded by the Intensity VIII isoseismal. Recent studies (Ref. 6), based particularly on the 1979 Imperial Valley earthquake and on laboratory behaviour of soils, indicate that liquefaction may occur at distances up to 10-16 km from the causative fault in a M=6.3 earthquake. On Figures 1, 2, and 3 this corresponds to a distance somewhere between the VII and VIII isoseismals. It is estimated that only about 5-10 % of the potential liquefaction area shown will be affected by actual liquefaction in the event of an earthquake centered in the down town Los Angeles area (Ref. 7). A M=6.3 earthquake centered in West Los Angeles could cause liquefaction in the Playa del Rey area, and the Los Angeles Port area would probably be affected by liquefaction if the quake centered in the Long Beach area.

Liquefaction in the Los Angeles Port area would be of particular concern because concentrated damage in that area could seriously damage ship loading and other facilities of the harbour area, disrupting commerce and interrupting transportation activities.

Slope Failures - Numerous slope failures occurred in the Santa Susana and San Gabriel Mountains as a result of the 1971 San Fernando earthquake. Similar landsliding is probably going to be experienced in the Santa Monica Mountains with a M=6.3 earthquake in downtown Los Angeles or in West Los Angeles. Numerous landslides exist in those mountains (Ref. 8), many of them active or relatively young, and it is reasonable to assume that these, as well as some older landslides, will move as a result of strong ground shaking from a closely centered earthquake.

Many landslides would probably occur in the Hollywood Hills area as a result of an earthquake centered nearby, but most would be small and not result in concentrated damage. It is probable that reactivation of the large landslides in the Palos Verdes area will result from an earthquake centered in the Long Beach area. This is a conservative assumption, since there are no reports of massive slope failures in the area as a result of the 1933 earthquake there.

Pacific Palisades is the only urban area with significant susceptibility to major landsliding from a M=6.3 earthquake in west Los Angeles. This area contains many large, historically active landslides (Ref. 9) which have damaged homes, roads and utilities. Large movements of both recently active and older landslide masses are expected to occur in that area as a result of an earthquake in the vicinity. However, no massive landsliding is expected to occur there as a result of an earthquake centered in downtown Los Angeles or in the Long Beach area (Joe Cobarrubias, personal communication, 1982).

CONCLUSIONS

The present state-of-the-art in earthquake prediction does not allow forecasting precisely the location, timing, nor magnitude of future earthquakes. However, there is general consensus that a great (M larger than 7.5) earthquake will occur soon near Los Angeles in southern California. The potential for large (between about 5.5 and 6.5) earthquakes in that region is also high, and the consequences of either a large or a great event could lead to severe damage and loss of life in Los Angeles and surrounding communities. Among the earthquake and planning experts in Government, academic and private circles, emphasis has been placed on analyzing potential effects of the largest events, and in developing emergency plans to cope with the problems arising from such a catastrophe. Less attention has been given heretofore to analyzing the effects of a large earthquake occurring within the city of Los Angeles.

The PEPPER study focuses on the effects of a great earthquake occurring on the San Andreas fault near Los Angeles and on a M=6.3 event occurring somewhere within the city of Los Angeles. Scenarios of damages expected from these latter events located on three different potential epicenters were developed to serve as basis for pre- and post-earhquake planning. The final report of the study addresses the expected physical effects (described in this paper), related structural damages, recommended changes to the General Plan, redevelopment plans, and guidelines for rebuilding. The planning aspects of the study are being presented at this Eighth World Conference on Earthquake Engineering by others (Ref. 10).

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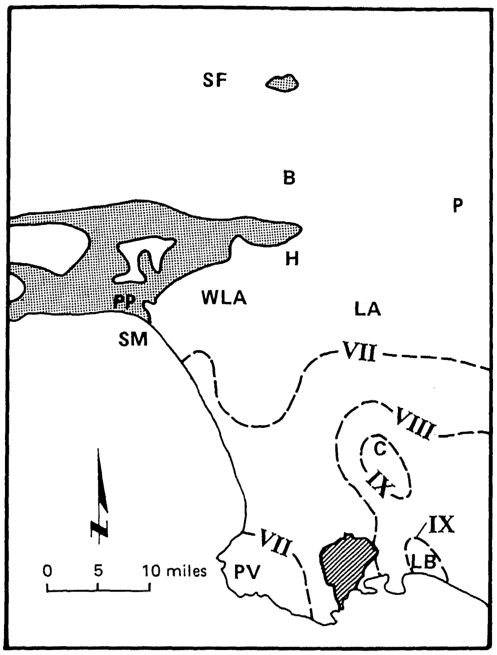

Figure 1

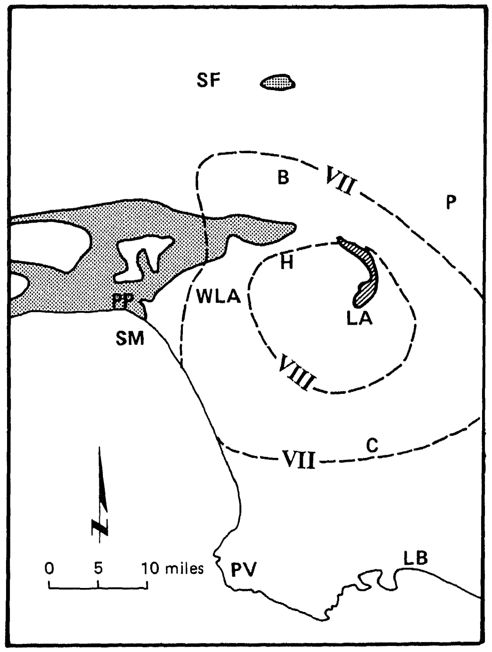

Figure 2

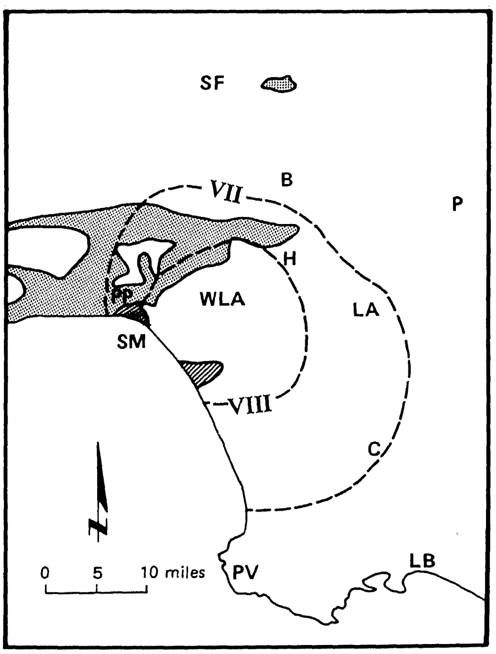

Figure 3

Figure 1. Isoseismals predicted for M = 6.3 earthquake in the Long Beach area

Figure 2. Isoseismals predicted for M = 6.3 earthquake centered in downtown Los Angeles

Figure 3. Isoseismals predicted for M = 6.3 earthquake centered in West Los Angeles

Explanation of Symbols:

VII, VIII, IX: Modified Mercalli Intensity

LA: downtown Los Angeles
SF: San Fernando
B: Burbank
P: Pasadena
H: Hollywood
WLA: West Los Angeles
PP: Pacific Palisades
SM: Santa Monica
C: Compton
PV: Palos Verdes Peninsula
LB: Long Beach

Mountainous area with numerous existing landslides

Area with potential liquefaction