FORECASTING THE RISK IN EARTHQUAKE RESISTANT DESIGN

by

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SYNOPSIS

Uncertainty exists in the phenomenological aspects of the earthquake occurrence and their quantitative effects on structures. A decision statistics based model is proposed in this paper. In particular, a Markov chain decision model is presented. Such a model incorporates the "memory" aspect of the earthquake occurrence. Use of such a model is demonstrated by two examples. In the first example, damage and insurance analysis of mobile homes is studied. In the second example, alternate designs and corresponding risks for light industrial buildings are presented. No derivations or data are presented in this paper due to length limitation. For further details, the reader should refer to reference 1.

MOBILE HOMES

The large number of mobile homes in California and their concentration in mobile home parks represent a potentially costly earthquake hazard. Very little damage data due to past earthquakes is available on such structures. However, reference (2) gives some data due to the San Fernando earthquake of 1971. From analysis of this data, figure 1 can be constructed. It should be kept in mind that this figure is "extrapolated" from the damage data of the San Fernando earthquake. This figure gives the average cost of damage as a function of earthquake magnitude and epicentral distance. Without going into the details of calculations, figure 2 represents the risks involved in a $14,000 mobile home with no insurance. The risk is given as a function of remaining time in the life of the structure. Two epicentral distances are considered; four and twenty miles. It can be seen that at very small epicentral distance, the risk under small earthquake ($4.5 \leq M \leq 5.4$) is greater than the risk under moderate or large earthquakes. One conclusion that can be drawn from this figure is that buying of insurance is justified. Note that the risk is a function of the discount rate β.

LIGHT INDUSTRIAL BUILDINGS

A common structure in shopping centers and industrial parks in California is the light industrial building. Generally, the building consists of a concrete slab floor with masonry or tilt-up walls and a plywood diaphragm roof fastened to the walls by wood ledgers. Single story buildings dominate. Construction costs for a well equipped building are about $15/square foot. Based on the data given in reference (2), it appears that buildings of this type located approximately nine miles from the epicenter

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of an earthquake of Richter magnitude 6.6 will suffer on the average damage of $0.60/square foot.

To improve the performance of this type of building during earthquakes, the roof to wall connections must be strengthened and additional strength given to the points at which the wall is fastened to the floor slab. This represents additional engineering and construction costs. The benefit to be received is to reduce the probability of transition from the undamaged state to the damaged state.

Figure 3 represents some results for light industrial buildings. The curve labeled C' represents an added cost of reducing the probability of damage (references 3, 4). Optimization indicates that an added cost of 5 cents/square foot for earthquake protection will reduce the overall expected cost. Figure 4 represents the total expected cost as a function of remaining time t in the design life of the structure. It is assumed that the structure is not insured for this case.

In conclusion, it can be said that the Markov chain decision model can be effectively used for practical engineering problems. Future risks and alternate designs under such risks could be studied and rational decision could be made.

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FIGURE 1 MOBILE HOMES

focal depth = 8 miles

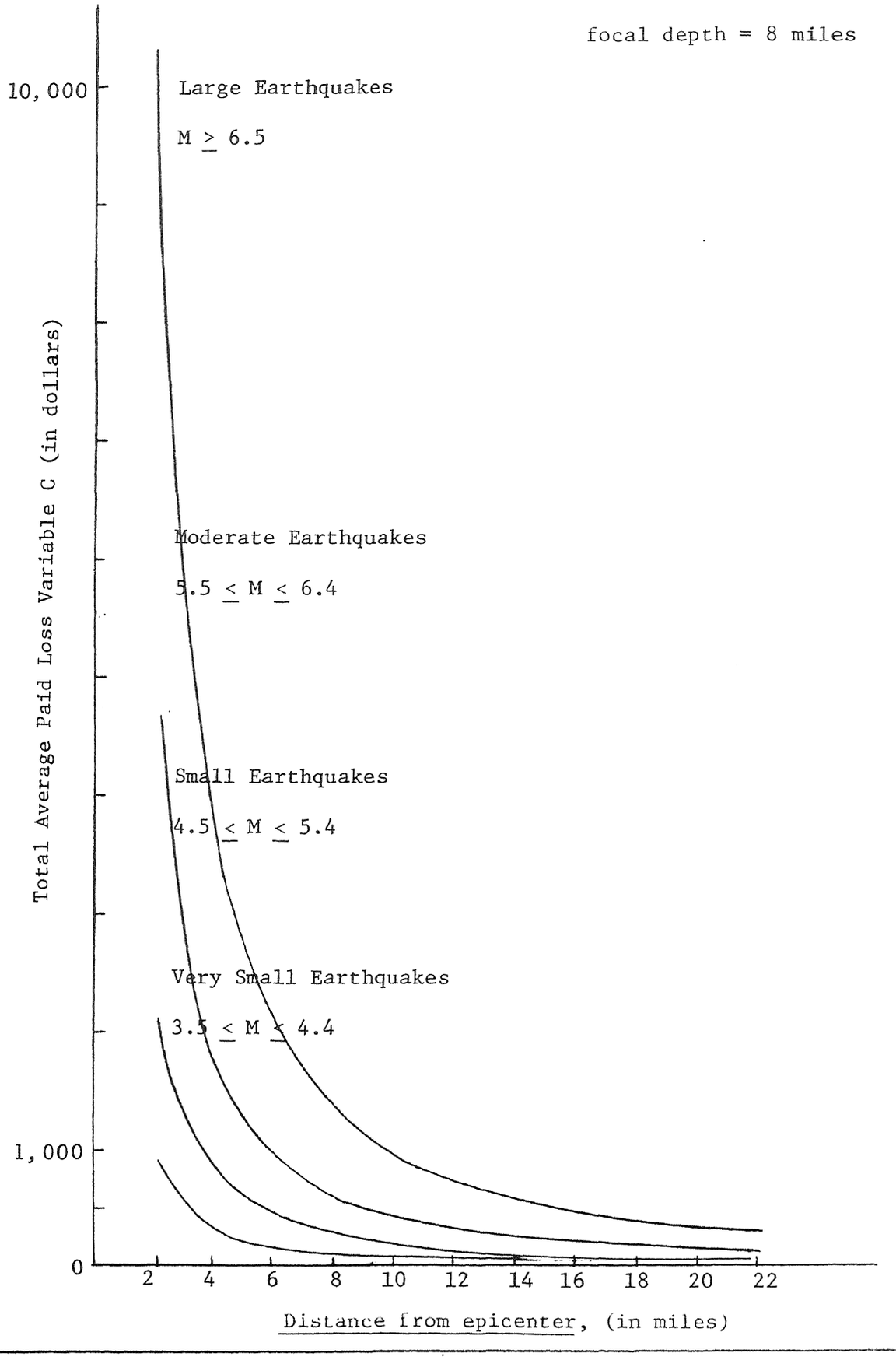

FIGURE 2 MOBILE HOMES

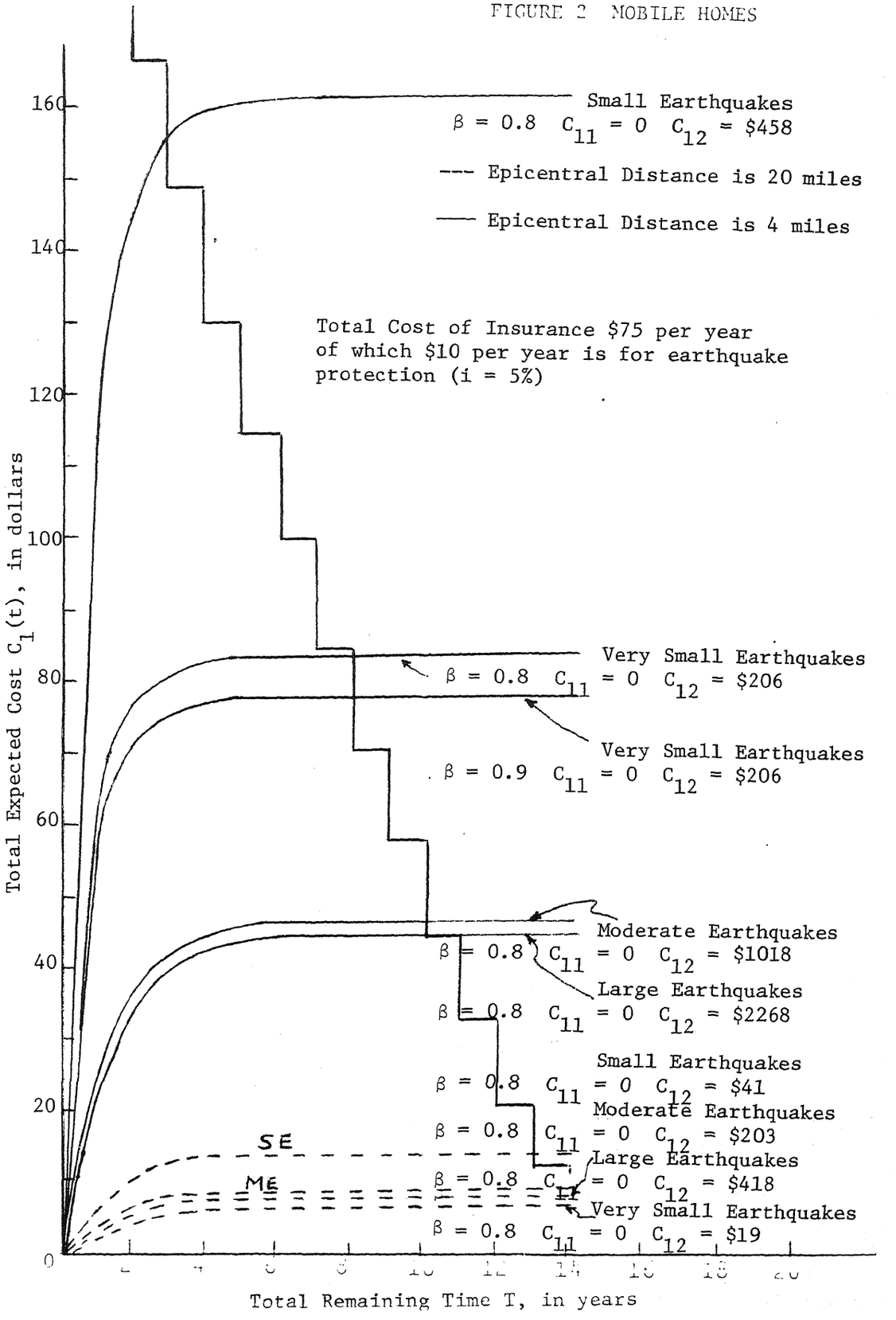

FIGURE 3 LIGHT INDUSTRIAL BUILDINGS

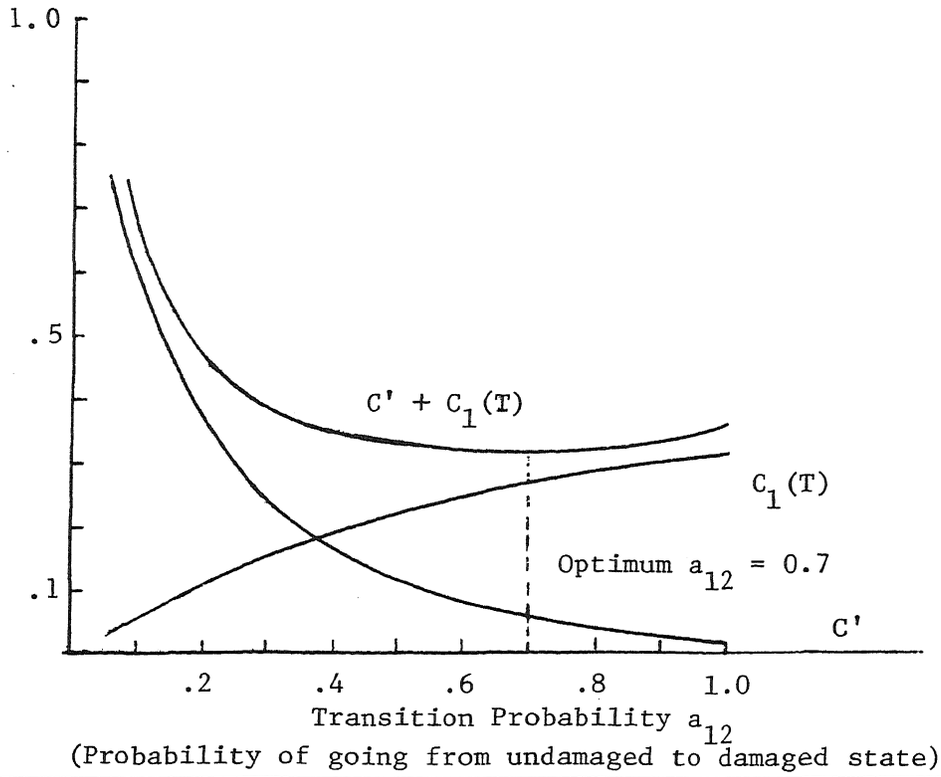

FIGURE 4 LIGHT INDUSTRIAL BUILDINGS