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SEISMIC RISK ANALYSIS OF THE INDIAN SUBCONTINENT AND PROPOSED SIMPLIFIED RISK SPECTRA FOR THE NORTHERN REGION

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ABSTRACT: The increasing industrialization and concentration of human habitations in developing nations like the Indian sub-continent region have resulted in greater importance to public safety from natural disasters like earthquakes. The aim of this study is to estimate the seismic risk in the Indian sub-continent, using various methodologies and available knowledge, to provide a more rational design criteria for structures. Macroregionalization of seismicity of the region in terms of recurrence parameters a and b has been done. Seismic hazard analysis for the region has been performed using a computer program <ERISA-P>. A simplified method is proposed which describes the general level of hazard by means of a period dependent index.

METHODOLOGY: The present knowledge of Indian seismicity is reviewed. Space, time, depth, and magnitude distributions of the past earthquakes have been thoroughly analyzed in order to confirm and clarify the results of various authors. The region has been divided into 8 blocks using the available geological, tectonic and seismological data (Fig. 1). Simple statistical computations are performed on available database to estimate the recurrence relations for different subregions. Table 1 shows the estimated b values for the subregions by using i) least square method, b1, (earthquakes of magnitude 5.0 and above) ii) maximum likelihood method, b2,(earthquakes above magnitude 4.0). In the second method, incompleteness of the database has been incorporated by estimating the parameters using data of unequal observation periods for different magnitude ranges. Actual and theoretical distributions of annual seismic activity have been computed for the regions where sufficient data is available. The probability distribution in % is drawn for these regions and compared with the corresponding Poisson's distribution.

Seismic hazard analysis for the region has been performed using the historical record of magnitudes and epicentral locations of earthquakes. The on-line graphics computer program <ERISA-P> developed by Katayama and Tomatsu has been modified and adapted for the region. Attenuation models are assumed to calculate the peak ground acceleration and response spectral co-ordinates, for various probabilities of exceedance and a particular service life of the structure. A comparison of available acceleration attenuation models was made to understand its effects on the final hazard results and a suitable one was chosen. An engineering prediction model of acceleration response spectra proposed by Katayama has been utilized as the attenuation model.

PRELIMINARY ANALYSIS AND PROPOSED SPECTRA: A preliminary hazard analysis of 21 selected cities, lying in 5 different blocks has been done. The results indicate the vulnerability of taller structures in important northern Indian cities, located in the alluvial plain at large distance from the active seismic source, to earthquake damage. Table 2 indicates the correlation coefficient of peak ground acceleration (PGA) to expected response acceleration at four representative periods. The expected spectral acceleration for long period structures has low correlation with the expected PGA. It is found that a period dependent index is needed to define in a more realistic manner the seismic loading for design purposes. From the preliminary analysis, some cities having the same level of PGA were found to have different spectral response depending on the seismicity surrounding the site.

The 21 sites were classified into 3 categories depending upon the ratio of spectral acceleration at periods of 4.0 and 0.2 second and normalized response spectra curves were constructed (Fig. 2). From Fig. 2 it can be seen that though the three classifications have almost similar response in the short period range, considerable

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variation occurs in the long period part.

The northern Indian highly seismic region has been divided into grid ($1^{o}x1^{o}$) and seismic risk analysis performed at the midpoint of each grid. The results of the hazard analysis, based on the earthquake occurrence data, in combination with the seismo-statistical analysis carried out for various macroblocks are to be utilized to prepare period dependent seismic risk maps at two representative periods of T=0.2 sec and T=4.0 sec.

Finally, it is understood that for not so important structures a detailed seismic hazard analysis is not always economically feasible. However, on the other hand it is desirable to know about the frequency characteristics of the ground motion, besides its amplitude. Hence, a simplified methodology is proposed to predict the design spectra at the site by utilizing the expected response spectral acceleration maps at periods of 0.2 and 4.0 sec and the calculated normalized response spectra. The ratio of spectral acceleration obtained from the map for the two representative periods is used to classify the site type. The appropriate normalized response spectrum depending upon the site type is multiplied by the spectral acceleration for a period of 0.2 sec (obtained from the map) to give the 100 year risk spectrum, for a particular probability of non-exceedance . The risk spectrum for other ground conditions may be then obtained by multiplying the spectrum by appropriate factors.

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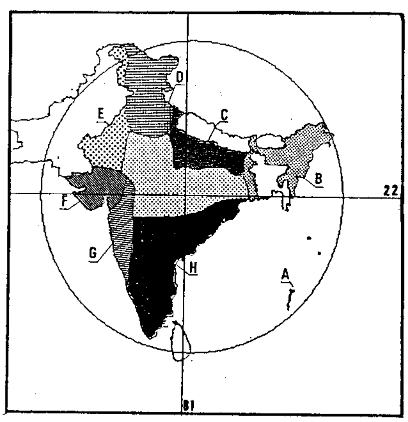

Fig.1 Seismic macroblocks of India

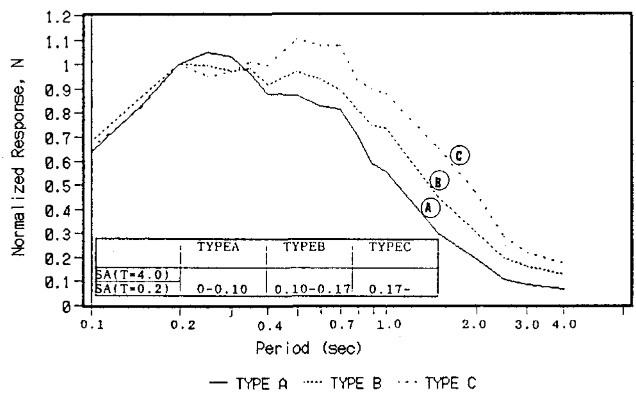

Fig.2 Normalized response spectra for 100 year service life of structure (alluvial soil)

Table 1 Recurrence parameters for macroblocks

	b1	b2	N5*	a**
BLOCK A	0.86	0.54	7.07	3.97
BLOCK B	0.65	0.55	5.88	3.93
BLOCK C	0.61	0.53	4.84	3.69
BLOCK D	0.80	0.54	3.62	3.63
BLOCK E	0.83	0.69	15.07	5.17
BLOCK F	0.96	0.32	0.31	1.13
BLOCK G	0.76	0.52	0.32	2.42
BLOCK H	0.38	-0.42	0.43	

*annual rate above magnitude 5

**a in equation log N = a - b*m

Table 2 Correlation between PGA and spectral response at different periods

	SA(T=0.2)	SA(T=0.7)	SA(T=1.0)	SA(T=4.0)
PGA & SA correlation	0.90	0.87	0.71	0.42