I-505 A METHOD FOR ESTIMATING LOSSES FROM EARTHQUAKES

by

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INTRODUCTION: A methodology for estimating seismic losses is presented including probabilistic seismic hazard analysis, vulnerability relationships (ground motion-damage), considerations on population growth tendencies and distribution and classification of structures. The main aim is to predict the expected behavior of the seismic losses' distribution in the coming years.

FORMULATION: The proposed methodology is presented schematically in Fig. 1. From the studies on seismic hazard for a region and vulnerability relations (ground motion-damage), the <u>Seismic Probability Matrix</u> [P] and the <u>Damage Ratio Matrix</u> [D] are evaluated. By using them, the <u>Matrix of Expected Damage</u> [ED] for the various structural types under consideration can be determined. In order to identify the behavior of the seismic losses' distribution in the future, studies should be carried out on the population growth tendencies as well as on the distribution and usage of the various structural types. The <u>Matrix of the Expected Number of Structures</u> [NS] is then evaluated. Pursuing to express the losses in financial terms the construction costs for all the structural types are to be investigated and expressed by means of the <u>Equivalent Cost Ratio Matrix</u> [C]. Finally, the probable potential losses, [PPL], are estimated using equation (1). It is to be noted that this formulation can be applied for as many periods of time, structural types, and levels of ground motion intensity as considered to be necessary.

$$[PPL] = [ED] * [C] * [NS] \qquad (1)$$

EXAMPLE OF APPLICATION. PPL ESTIMATES FOR ECUADOR: Data of 1725 earthquakes of magnitude $M \geq 4$ were used for the statistical analysis. Seven representative values of peak acceleration, namely, 50, 75, 150, 220, 300, 450, and 500 gals, and four periods of time, i.e., 1, 25, 50, and 100 years were adopted for the evaluation of the seismic probability matrices [P]. From the 1962, 1974, and 1982 national censuses (Ref.1), the population after the considered periods of time was predicted. From the 1982 Census of Housing, 1,844,894 structures were classified into four basic structural types: 1) RC systems with infilled masonry panels, 2) Earthquake resistant masonry structures, 3) Non-earthquake resistant masonry structures, and 4) Wooden structures. From these data, the matrices of the number of structures [NS] were evaluated. Matrix [C] was determined from the study of the construction costs in Ecuador. [D] was assembled using ground motion-damage relationships for the various structural types (Fig. 2). By applying Eq.(1), the PPL were estimated and expressed as percentage of the 1987 Gross National Product of the country (Table I). Zoning maps were prepared grouping areas of similar loss levels (Fig. 3). It was found that about 70% of the country's total area show loss levels lower than the mean value obtained for the country. The higher levels of seismic risk concentrate along the Pacific coast. There is a tendency for the higher levels of losses to move towards the North-Eastern region in the coming years.

CONCLUSIONS: A methodology for estimating the seismic losses, placing special emphasis on the prediction of the future behavior of the loss distribution, is presented. A practical application has been performed for Ecuador and conclusions on the expected distribution of the seismic losses are drawn. The obtained results are of direct application for preparedness measures implementation and economic decision making.

REFERENCES:

1.- INEC, "Proyecciones de la Poblacion Ecuatoriana (1982-1995)," Quito, Ecuador, November 1985.

2.- Sauter, F., McCann, M., Shah, H., "Determination of damage ratios and insurance risk for seismic regions," Proceedings of the Seventh World Conference on Earthquake Engineering, Vol. 9, Turkey, 1980.

TABLE I. PPL FOR ECUADOR (% OF 1987's GNP)

PROVINCE	PPL(1 Y)	PPL(25 Y)	PPL(50 Y)	PPL(100Y)
ESMERALDAS	0.014	0.634	1.951	5.857
MANABI	0.051	1.777	4.899	16.961
LOS RIOS	0.002	0.079	0.246	0.822
GUAYAS	0.116	5.388	15.524	27.626
EL ORO	0.003	0.154	0.530	1.695
CARCHI	0.001	0.037	0.075	0.079
IMBABURA	0.008	0.256	0.551	0.679
PICHINCHA	0.037	2.002	6.523	13.610
COTOPAXI	0.014	0.423	0.854	0.958
TUNGURAHUA	0.014	0.467	1.019	1.265
CHIMBORAZO	0.001	0.036	0.067	0.063
BOLIVAR	0.000	0.005	0.009	0.019
CANAR	0.009	0.302	0.659	0.879
AZUAY	0.016	0.613	1.673	4.141
LOJA	0.015	0.465	1.124	2.893
NAPO	0.005	0.429	2.605	28.003
PASTAZA	0.006	0.245	0.717	2.072
MORONA SGO	0.003	0.149	0.512	1.579
ZAMORA CH.	0.001	0.066	0.285	1.174
TOTAL	0.315	13.527	39.842	110.374
MEAN LOSS	0.017	0.712	2.097	5.809
STANDARD DEVIATION	0.027	1.223	3.576	8.749
COEFF. OF VARIATION	1.602	1.718	1.705	1.506

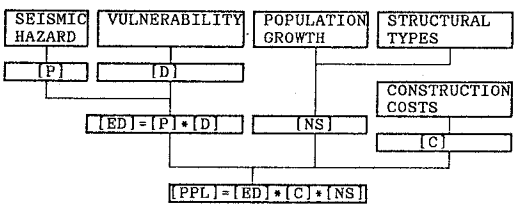
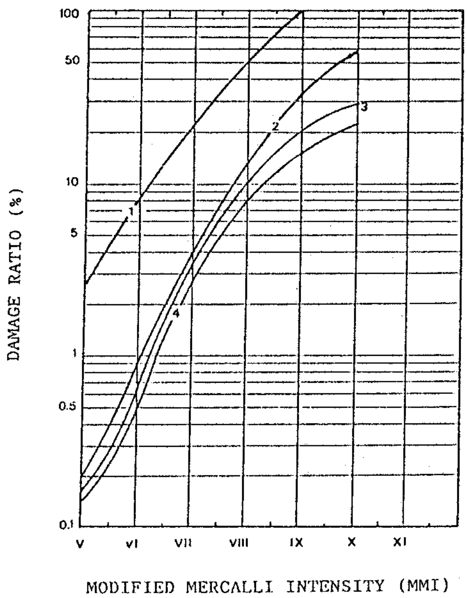


Fig.1 Estimation of seismic losses



1.- Adobe
2.- Reinforced concrete frames. Seismic design.
3.- Wooden structures. Non-seismic design.
4.- Wooden structures. Seismic design.

Fig.2 Ground motion-damage relations (After Sauter and Shah)(2)

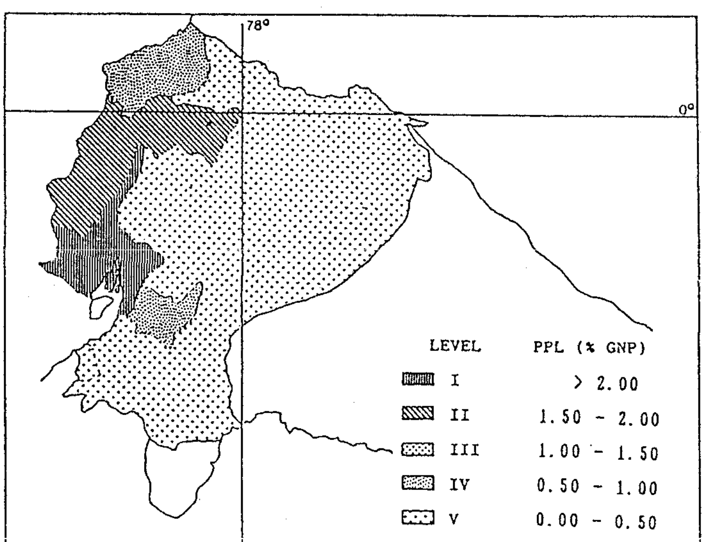


Fig.3 Zoning map for 25 years period