SOME RESULTS OF THE INVESTIGATIONS IN THE SEISMIC MICROZONING OF BANJA LUKA

by

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INTRODUCTION

The urban area of Banja Luka was attacked by a severe earthquake on October 27,1969. The epicenter of this earthquake was 9 km from the city centre to the north, the origin was at a depth of 25 km, and the magnitude of the earthquake was 6,6 by the Rihter scale. During this earthquake, the largest number of the structures suffered serious damage, while a small number of structures failed. Immediately after the earthquake, the necessary steps for reconstruction of the town and its important functions were undertaken. This imposed the necessity of elaboration of a new Urban Plan, according to which the reconstruction of the town was foreseen to be based on the current principles of aseismic design. Herefrom, a necessity for Seismic Microzoning Map appeared. For the elaboration of such a map, regional tectonic and seismological investigations on a wider seismic area and detailed engineering-geological, geometrical, geophisical and engineering -seismological investigations were carried out. The purpose was determination of the influence of the origin parameters and the surface layers upon the intensity of an earthquake.

This paper presents some of the results from the investigations concerning the influence of the surface layers of the ground upon the intensity of an earthquake. Taking into account the big differences in the damage of the structures in some zones of the town, which could only be explained by the influence of the soil conditions, a map of damage of the rigid masonry building structures widely used in this town was prepared. A total of 2.058 structures uniformly distributed in this area were analysed, 8 to 10 structures within 1 km^2. The degree of damage of each of these structures was determined by the criteria of MSK-64 scale, according to which a correlation between the degree of damage and the degree of seismic intensity was established. The isolines obtained on the map of damage clearly show the difference in the degree of structural damage in certain urban zones, which in fact was a difference in the intensity of the earthquake. For determination of the surface layer parameters of the ground besides the geological borings, geoelectrical and refractional seismic measurements, the predominant periods of ground oscillations were

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determined from the measurements of the microseismic noise. These measurements were made on 360 points uniformly distributed. Special attention was paid to the check , so that the predominant periods should be characteristic for the soil and not for the source of noise. This check was done through the formula $T_O=4H/V$, where T_O, H and V are notation of the predominant period of the ground, thickness of the layer and shear wave velocity. Fig. 1 shows the correlation between the measured and the calculated predominant periods of the ground.

BRIEF REVIW OF SOME IMPORTANT RESULTS FROM THE INVESTIGATIONS

Analysing the results obtained by the investigations, it was found that a good correlation exists between the degree of damage of rigid masonry building structure and the ground predominant periods, which is shown by the diagram No. 2. Also, the diagram No. 3 shows a good correlation between the degree of damage of structures, the predominant periods and the type of ground on which the structure was founded. Special attention was given to the establishing of a correlation between the degree of damage, the number of stories of the structure and the ground predominant periods. Figs. 4 and 5 show the obtained corellations. The shapes of the curves and the presence of certain regular change in these curves shows that the earthquake effect followed certain dynamic law which agrees with the general spectral characteristics of the local earthquakes and that the structural damage depends upon the number of stories and the ground predominant periods.

With special measurements of the oscillations of the structures caused by the city noise, the relation between the natural periods of the structures and their number of stories was determined. This relation is given in the empiric formula: $T=0.064N + 0,010$, for $1 \leq N \leq 6$, where N is the number of stories. If we consider the points of maximum damage shown on the curves of figs. 4 and 5, we can observe a divergence between the real and the elastic resonance which could be explained by a non-uniform increase of the periods of structures and soil during an earthquake. An attempt has been made on fig. 6 for presentation of this divergence for periods of ground and structures obtained by microseismic excitation only. It can be concluded that the divergence depends upon the number of stories, i.e. upon the stifness of structures and that it is not linear one but changes according to a curve.

CONCLUSION

Generally, it can be concluded that the predominant periods are important seismic ground characteristics and that there is arather good correlation between them and the degree of damage for rigid masonry structures. Besides, the damage of structures depends upon the correlation between the periods of oscillation of the soil and the structures. Also, during strong earthquakes, some divergence between the real and the elastic resonance appears, which depends upon the number of stories, i.e. upon the rigidity of structures. It is important to be mentioned also, that the dependance of this divergence upon the number of stories is not linear.

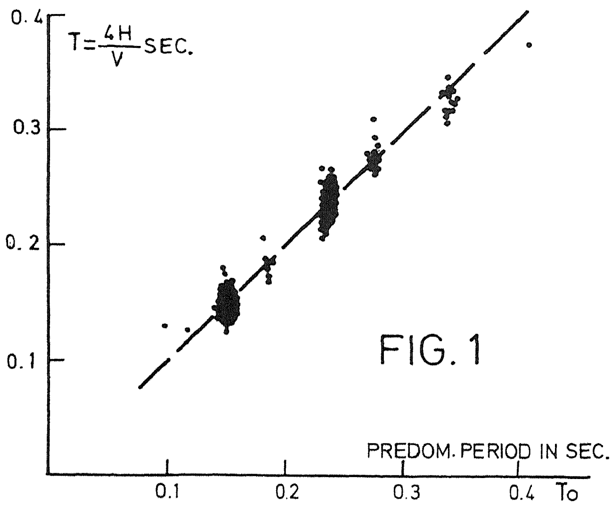

FIG. 1

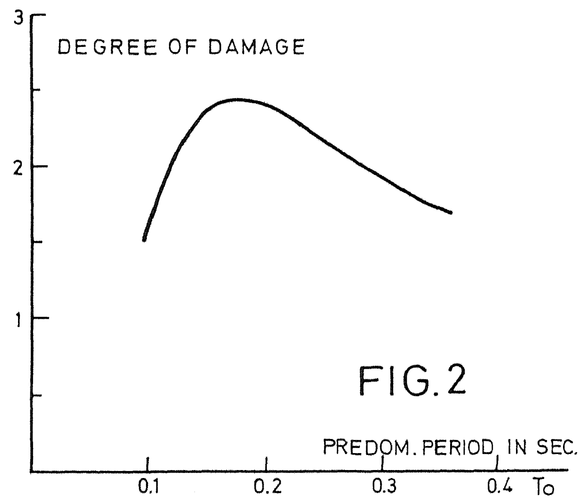

FIG. 2

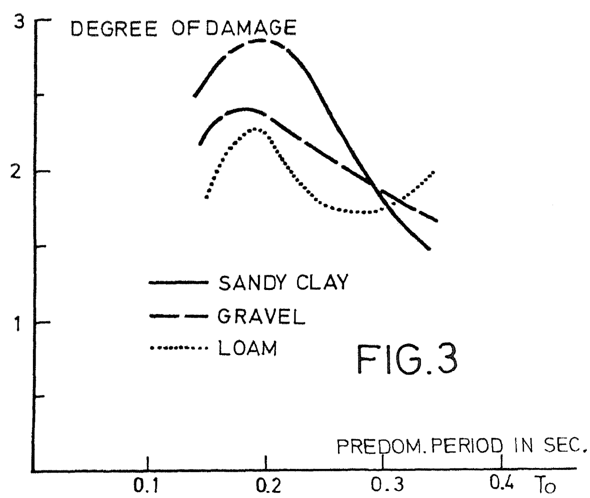

FIG. 3

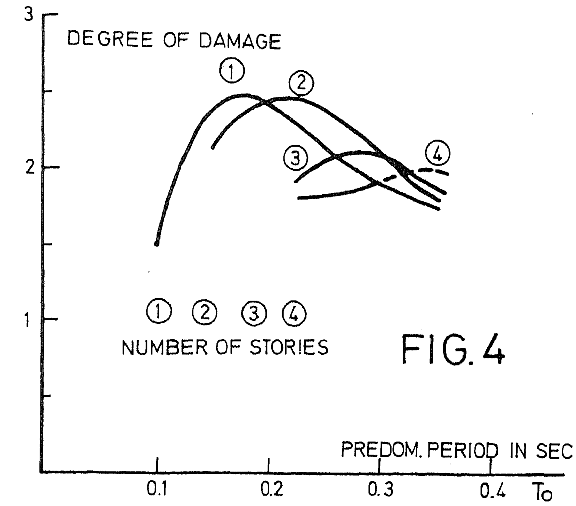

FIG. 4

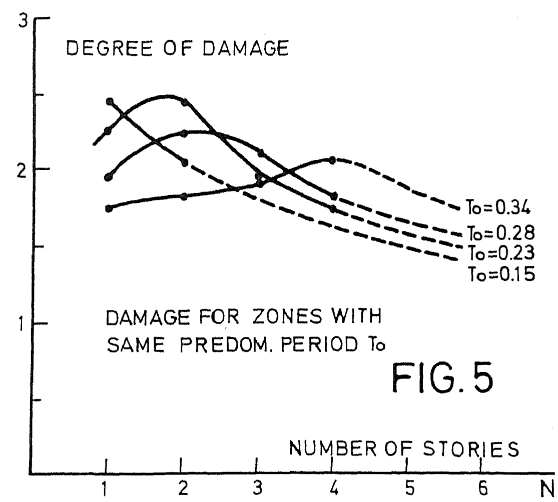

FIG. 5

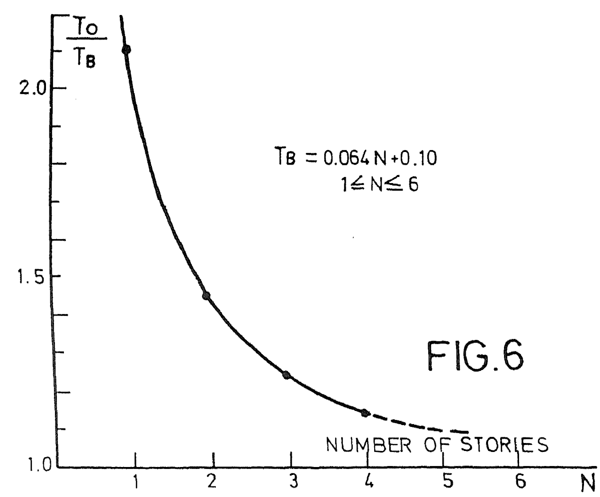

FIG. 6

INTRODUCTION TO THE SEISMIC RISK IN ITALY

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Italy has the fortunate circumstance to have records of seismic activity 2000 years long; also an efficient network of seismic stations supplies instrumental data from the beginning of this century.

To our knowledge today there are no objective satisfactory methods to draw contours of areas of equal seismic risk. In this paper we present a solution of this problem based on a two-dimensional filtering technique, we also give a tentative map of qualitative seismic risk in Italy.

The completeness of the catalogue used is also discussed.