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Abstract

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SEISMIC MICROZONING OF THE CITY OF SKOPJE

BASED ON INSTRUMENTAL DATA

(Presented by Academician M. A. Sadovsky, 18 VIII 1966)

For the development of the master plan for the reconstruction and further growth of the city of Skopje, which suffered from the strong earthquake of July 26, 1963, it was necessary to compile a map of seismic microzoning of the city territory, identifying zones of greater or lesser seismic hazard. To prepare the first version of such a map, its authors

Fig. 1. Recording of the earthquake of December 14, 1964, by the seismic stations Železara (top) and Vodnjansko (bottom). 14 XII 1964, 15 h 45 min.

(M. Arsovski, N. Gruch, D. Gojgić) used engineering-geological and hydrogeological maps, as well as the results of instrumental geophysical observations and data on the destruction and damage of buildings in the city (⁀1). Microzoning was carried out according to the method developed in the USSR—depending on the acoustic rigidity of the soils and the groundwater level (⁀2, ⁀3).

In 1964-1965, in the area of the city of Skopje, a seismological expedition of the Institute of Physics of the Earth of the Academy of Sciences of the USSR (⁀4) was working; the program of work in-

which, in addition to obtaining data on the seismic regime, included obtaining instrumental data for refining the compiled map of seismic microzoning of the city of Skopje.

Records of earthquakes were made in order to determine the total seismic effect on the various most characteristic soils of the city, using two seismic stations equipped with VGEIK seismic receivers and GB-III-B-5 galvanometers, included in the set of an OSE-VI-M magnetoelectric seismic oscillograph ([5–7]). One of the stations—Ovoshcharstvo—remained throughout the entire observation period at one point with soils most favorable from the standpoint of seismic effect. The second, mobile station was placed successively at five points with different soils. At each point, 6–9 earthquakes were recorded.

The record of a nearby earthquake may be divided into three groups of waves: longitudinal, transverse, and surface waves. Since the middle segment (transverse waves) accounts for 80–90% of the total earthquake energy, comparison of the seismic effect was carried out from the record of transverse waves.

Each earthquake was characterized by the mean amplitude and mean period of the transverse waves. The amplitudes were compared according to the mean values of displacements, velocities, and accelerations of the oscillatory motion of a point of the ground. It was assumed that the amplitude decreases inversely proportionally to the hypocentral distance, and the corresponding corrections were introduced into the amplitude values. Figure 1 shows the record of one earthquake registered by two stations.

It is evident from the figure that ground oscillations in the area of the Zhelezara station differ both in amplitudes and in periods from the oscillations in the area of the Ovoshcharstvo station. In the first zone the soils are less favorable seismically than in the second.

Table 1

Results of comparison of the seismic effect on different soils

Seismic stations	Average amplitude ratios: by displacements	Average amplitude ratios: by velocities	Average amplitude ratios: by accelerations	Increments of intensity: by displacements	Increments of intensity: by velocities	Increments of intensity: by accelerations	Increments of intensity: on average	Seismic hazard in points: by calculation	Seismic hazard in points: by map
Skopje	0.67	—	—	−0.59	—	—	0.59	7.4	7
Ovoshcharstvo	1	1	1	0	0	0	0	8.0	8
Ferzlien dom	1.95	1.91	1.99	0.95	0.93	0.99	0.96	8.9	9
Taftalidze	1.59	—	—	0.67	—	—	0.67	8.7	9
Zhelezara	1.66	1.61	1.74	0.73	0.68	0.80	0.74	8.7	8
Chair	2.14	1.92	1.74	1.1	0.94	0.80	0.95	8.9	9

Fig. 2. Map of seismic microzonation of the area of the city of Skopje. 1—eight-intensity zone, 2—nine-intensity zone (the sign − marks relatively better conditions, the sign + worse), 3—seismic stations, 4—flooded territory along the present channel of the Vardar River, 5—orientation boundaries of the city, 6—boundary of the investigated area

Figure 2: Fig. 2. Map of seismic microzonation of the area of the city of Skopje. 1—eight-intensity zone, 2—nine-intensity zone (the sign − marks relatively better conditions, the sign + worse), 3—seismic stations, 4—flooded territory along the present channel of the Vardar River, 5—orientation boundaries of the city, 6—boundary of the investigated area

Seismic stations	Average amplitude ratios: by displacements	Average amplitude ratios: by velocities	Average amplitude ratios: by accelerations	Increments of intensity: by displacements	Increments of intensity: by velocities	Increments of intensity: by accelerations	Increments of intensity: on average	Seismic hazard in points: by calculation	Seismic hazard in points: by map

A summary of the amplitude ratios is given in Table 1. The same table gives the increments of seismic hazard, in points, relative to the Ovoshcharstvo station, calculated in accordance with the method set forth in ([2,3]). It is important to note that the increments in intensity have approximately the same value for displacements, velocities, and accelerations of ground oscillations. In the calculations it was assumed that the intensity for the Ovoshcharstvo area is equal to 8.

Comparison of the instrumental data with data obtained by other methods showed satisfactory agreement. This is especially important, since the measurements carried out served as an experimental check of the calculation methods applied earlier and confirmed that the intensity of oscillations differs greatly depending on the aggregate properties of the soils.

On the basis of the instrumental data obtained, as well as data on the seismic regime of the Skopje basin ([4]), a refined version of the map of seismic microzonation of the city was compiled, shown in Fig. 2 (authors: M. Arsovski, D. Gojgić, N. Grujić, T. Mitrov, D. N. Rustanovich, V. A. Tokmakov, D. Hadžievski). In this

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same figure shows the locations of the movable seismic stations.

The compiled seismic microzonation map was used in developing the project for the placement of construction of buildings and structures of the new city of Skopje.

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Note: Figure translations are in progress. See original paper for figures.