On the seismic hazard along the road Bansko (Razlog)–Gotse Delchev

Сеизмичен риск по пътя Банско (Разлог)–Гоце Делчев

Vilma Petkova[1, 2], Ivanka Paskaleva[3], Bilyana Kostova[1], Vladislav Kostov-Kytin[2], Ralitsa Berberova[1], Theodosis Papaliangas[4]
Вилма Петкова[1, 2], Иванка Паскалева[3], Биляна Костова[1], Владислав Костов-Китин[2], Ралица Берберова[1], Теодосис Папалиангас[4]

[1] New Bulgarian University, Department of Natural Sciences, 21 Montevideo Blvd., 1618 Sofia;
E-mails: vpetkova@nbu.bg; bkostova@nbu.bg
[2] IMC, Bulgarian Academy of Sciences, Acad. G. Bonchev str. , bl. 107, 1113 Sofia
[3] European Polytechnical University, 23 Kiril i Metodiy str., 2300 Pernik
[4] Technological Educational Institute of Thessaloniki, Department of Civil Infrastructure Engineering, Sindos, PO Box 141, GR 57400 Thessaloniki

Keywords: seismic hazard, earthquake, risk management, Kresna seismic zone.

Introduction. The presented work is a part of obtained results of the realized project “Risk management of natural and anthropogenic landslides in the Greek-Bulgarian cross-border area” (RISKLIDES). The project was in program European territorial cooperation “Greece-Bulgaria 2007–2013”, financed by the EU through the European regional development fund. Areas that are subject to defrosted in the project RISKLIDES are thoroughfares in the area Lilyas–Serres–AS – from Greece (92 km) and Gotse Delchev–Koprivlen–Bansko – of Bulgaria (68 km). Region is characterized by mountainous terrain and very promising development prospects, as on its territory are ski resorts Lilyas and bathing.

The present study is related to the implementation of a specific action of Work packege “Data collection, analysis and organization of existing data” of the project plan related to the analysis of seismic hazard along the road Bansko (Razlog)–Gotse Delchev and presents the results of its implementation.

Results and Discussion. *Local seismicity.* Region (radius 200 km) around the target line (the road Bansko (Razlog)–Gotse Delchev) covers marginal parts of FYRO Macedonia and Northern Greece. Extensive seismic surveys in this region were held in 1982 in relation to the seismic zoning of Bulgaria (reflected in Boncev et al., 1982), and then 1992, for the seismic safety of important structures (Sokerova et al., 1992). From the analysis of depth distribution (Sokerova et al., 1992) found that earthquakes in the region are in the crust at a depth of 50 km. The strongest events (M ≥7.0) are generated mainly in the upper crust (at depth interval 10–25 km). With a maximum density of seismicity is characterized deep layer between 5 and 25 km. The spatial distribution of seismicity in the region is presented in Figure 1. It represent epicentral map of known earthquakes by M ≥4.0 (entire period) and M ≥3.0 since 1981, became the region by 2003. The seismicity in the region under consideration is attached to distinct geographical areas, seismic zones. These are seismic zones: Rhodopes, Kresna, Maritza and Sofia. For the present study, Kresna and Maritsa seismic zones are of major importance. The seismicity outside of Bulgaria was attached to the seismic zones: Northern Greece and Aegean Sea.

Kresna seismic zone. The main structure in the fault zone is Struma fault stretching in NW-SE direction, which is crossed by numerous neotectonic faults. High seismic activity in the area associated with Kresna-Struma fault system. Two of the strongest earthquakes occurring in Europe in the 20th century, are generated in a Kresna seismic zone – earthquakes of April 4, 1904 (MS 7.1 and MS 7.8). Earthquakes since 1904 are implemented in the region Kresna–Simitli of intersection of the Neogene–Quaternary active faults, Krupnik and Struma. In Kresna area where the Earth’s crust thickness is significant (in the western part of the Rhodopes it reaches a depth of 45–50 km), generated the deepest earthquakes in Bulgaria. The hypocenters of realized earthquakes are distributed mainly in the upper 30 km

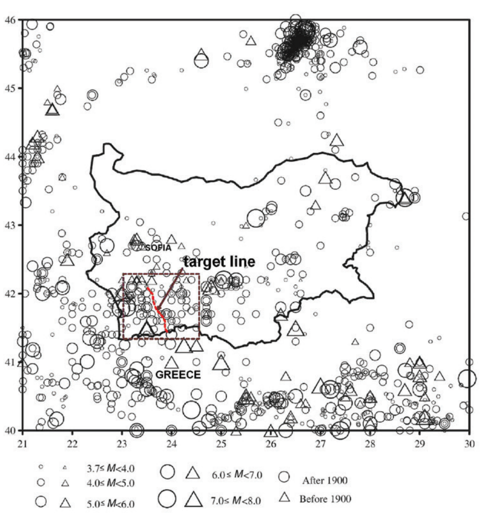

Fig. 1. Epicentral map for the earthquake with M >3.7 during the period 1700–2003 (according to Foteva et al., 2006)

Table 1. *Numerical values of the probabilities of non-exceedance of the parameter (A) (PGA, spectral amplitude, etc.) for the exploitation period of the structural system (%)*

Return period (R)	Risk 1/R	Probability of NON exceedence of the parameter (A) during the exposure time (T)				
Years (ys)		10 ys	50 ys	100 ys	150 ys	200 ys
95	0.01	**90.00**	59.07	34.901	20.62	12.18
475	0.0021	97.91	**90.00**	81.01	72.92	65.63
1000	0.001	99.00	95.12	**90.47**	86.07	81.87
10 000	0.0001	99.90	99.5	99.00	98.51	98.01
100 000	0.00001	99.99	99.95	99.90	99.85	99.80
1 000 000	0.000001	99.99	99.99	99.99	99.98	99.98

of the crust, with a maximum concentration between 5 and 20 km. The maximum focal depth of seismic events in the area is up to 50 km (Boncev et al., 1982).

Maritsa seismic zone. The seismicity in the area is attached to the famous Maritsa fault system. The strongest earthquakes occurred in the area are events of 1928 (Chirpan earthquake of April 14, 1928 with MS 6.8 and Plovdiv on April 18, 1928 with MS 7.0). The seismic zone is developed in the upper 20 km of the crust, as separate events were made at a depth of 45 km. Top high density hypocenters observed at depths of 5–10 km (Sokerova et al., 1992).

An approach for assessment seismic hazard. The principal option in the approach is that the seismic hazard is function of geometry of the seismic sources, the attenuation of the seismic waves with the distance, the number of earthquakes nM having magnitude greater than M occurring in a source area usually is assumed to conform to the Richter's relation. Following this, the modeling of the hazard consists in two components: model of the seismic sources and model of expected effects on the site. The resulting hazard for given place represents sum of the effects of the earthquakes with different magnitudes and different occurring. Earthquakes occur as a series of events in space and time. Each earthquake can be specified as a point in time (the origin-time) or a point in space (the focus). This "point source model" does hardly satisfy extended earthquake sources like faults, but since the site is at great distance to such elongated and prominent features, the point source model is a simple but reasonable start.

Assuming that seismicity is stationary in space and time we can estimate properties of the seismicity from our recorded sample of earthquakes. The distribution of a completely random and time homogeneous series of earthquakes is a Poisson distribution. Thus the probability, P, that the frequency of earthquake magnitude a does not exceeds a particular value for a given set of data N is given by:

$$P\,(\alpha \leq aIN = \mathrm{F}\,(a)$$

From that, one can calculate the return period and the probability that a magnitude M_{max} will not being exceeded during an exposure time, T, given in Table 1. Figure 2 shows the relation between probability and return period for a given exposure time (or life time of a system). According Eurocode 8, the return period of the design earthquake is 475 years, which means 10% probability of exceedance for 50 years construction exploitation period. With the purpose of limiting the damages and financial losses due weaker, but more frequent earthquakes, second seismic hazard level has been defined to correspond to 95 years return period (10% probability of exceedance for 10 years exposure time). The return period of 1000 years for exposure time of 100 years is assumed for important structure and lifeline systems. The numerical values of the probabilities not to exceed parameter A (acceleration or spectral amplitude) for the structure exploitation periods are shown in Table 1.

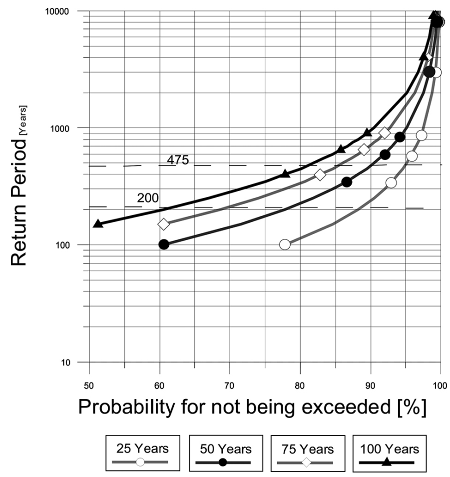

Fig. 2. Probability of exceedance of different levels of preliminary selected ground motion parameter (PGA, spectral amplitude etc.) for a given return period and given exposure times

Conclusion. The target line passes a territory with high seismic hazard. In assessing and monitoring of the risk of the natural disasters and landslides along the road Bansko–Gotse Delchev should take into account the high seismic risk.

Acknowledgments: Authors gratefully acknowledge the financial support of the Department of Natural Sciences, Chemical Laboratory – MF Laboratory for natural disasters and risks – BF and Gemology Laboratory – BF of New Bulgarian University.

References

Boncev, E., V. Bune, L. Christoskov, J. Karagjuleva, V. Kostadinov, G. Reisner, S. Rizhikova, N. Shebalin, V. Sholpo, D. Sokerova. 1982. A method for compilation of seismic zoning prognostic maps for the territory of Bulgaria. – *Geologica Balc.*, *12*, 2, 2–48.

Christoskov, L., D. Sokerova, S. Rijikova. 1979. *New Catalogue of the Earthquakes in Bulgaria for the Period V Century B.C. to XIX Century (1899)*. Sofia, Geophys. Inst., BAS, 54 p.

Foteva, G., M. Ilieva, E. Botev. 2006. Seismic hazard assessment for Bulgarian territory based on the method of spatially-smoothed seismicity. – *Geophys. J.*, *28*, 6, 105–113.

Sokerova, D., S. Simeonova, S. Nikolova, D. Solakov, E. Botev, R. Glavcheva, S. Dineva, B. Babachkova, S. Velichkova, S. Maslinkova, K. Donkova, S. Rizikova, M. Arsovski, M. Matova, I. Vaptzarov, L. Filipov. 1992. *Geomorphology, Neotectonic, Seismicity and Seismotectonic of NPP Kozloduy. Final Report.* Sofia, Geophys. Inst., BAS, 200 p.