Earthcrust Model under the Territory of Kosovo

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Abstract: The NDSHA procedure provides strong ground motion parameters based on the seismic wave propagation modelling at different scales-regional, national and metropolitan accounting for a wide set of possible seismic sources and for the available information about structural models. The scenario-based methodology relies on observable data and is complemented by physical modelling techniques which can be submitted to a formalized validation process. The combination of NDSHA and other alternatives is a must to obtain reliable results concerning the safety of our society. Earth crust model were performed for the purpose of defining the parameters of the geological media that have local effect upon the variation of the regional seismic motions such are: thickness H, values of seismic V_p and V_s velocities and the surface amplification layers the quaternary deposit and the surface loose layers of Neogene sediments and older geological rocks.

Key words: Wave, thickness, seismic, velocity, period, NDSHA

INTRODUCTION

Definition of a flat layered anelastic structural modelis needed in order to complete the input data for neo-deterministic hazard assessment procedure. When it comes to defining the Earth crust model for the region of Kosovo, there is lack of direct studies that include deep seismic sounding and gravimetric measurements as well as indirect studies using equilibrium theory that are used in estimation of Earth crust thickness.

In 1973/74, deep seismic sounding was performed for the region of Balkan Peninsula in order to estimate the construction of the Earths crust under the Balkan Peninsula (Gvishiani *et al.*, 1977). The results in the generalized form are presented on Fig. 1. As seen from Fig. 1 the Earth's crust has maximum thickness of 45 km along the axis of deepest immersion in synclinal form, starting from the West part of Ohrid Lake in Albania and than extends in North-South direction along the border with Macedonia into Kosovo near Prizren. Further North the axis turns slightly towards North-West. Towards the Eastern border of Kosovo Earth's crust decreases to 35 km. Likewise Westward, the Earth's crust decreases to 30 km under waters of the Adriatic and further on West in the Adriatic Sea, reaches the minimum thickens of 25 km.

The border between regions with relatively thin crust (30-35 km) and regions with thick crust (over 40 km) is regarded as a zone which penetrates deep in the mantle (Aliaj, 1988, 1998; Aliaj *et al.*, 2004).
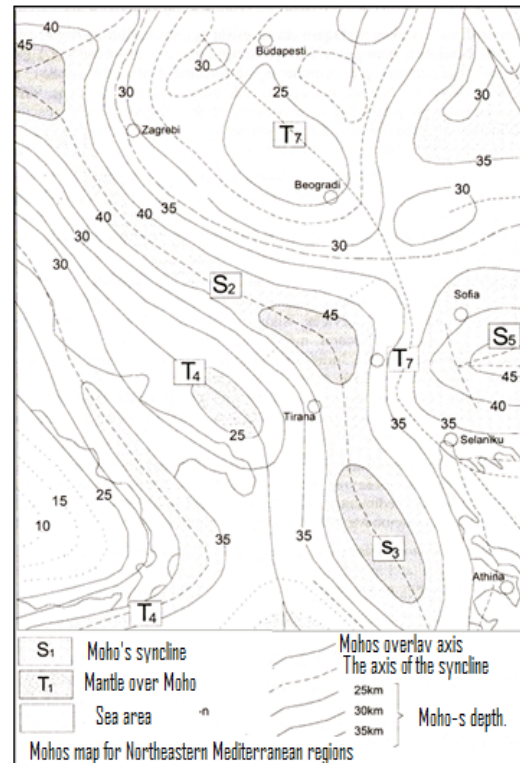

Fig. 1: Crust of the Earth under the Balkan Peninsula and the surrounding territory; Depth of Moho's discontinuity

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MATERIALS AND METHODS

The crust models for defined seismic source zones were elaborated using available data from various investigations performed for different parts of Balkan Region as well as analysis of earthquakes recorded on the seismologic network in Kosovo. The Kosovo Seismological Telemetric Network is composed of 5 stations an example of recorded earthquake used in the analysis in order to assess the v_p and v_s velocities (Ambraseys *et al.*, 2005) in the model is presented on Fig. 2-6.
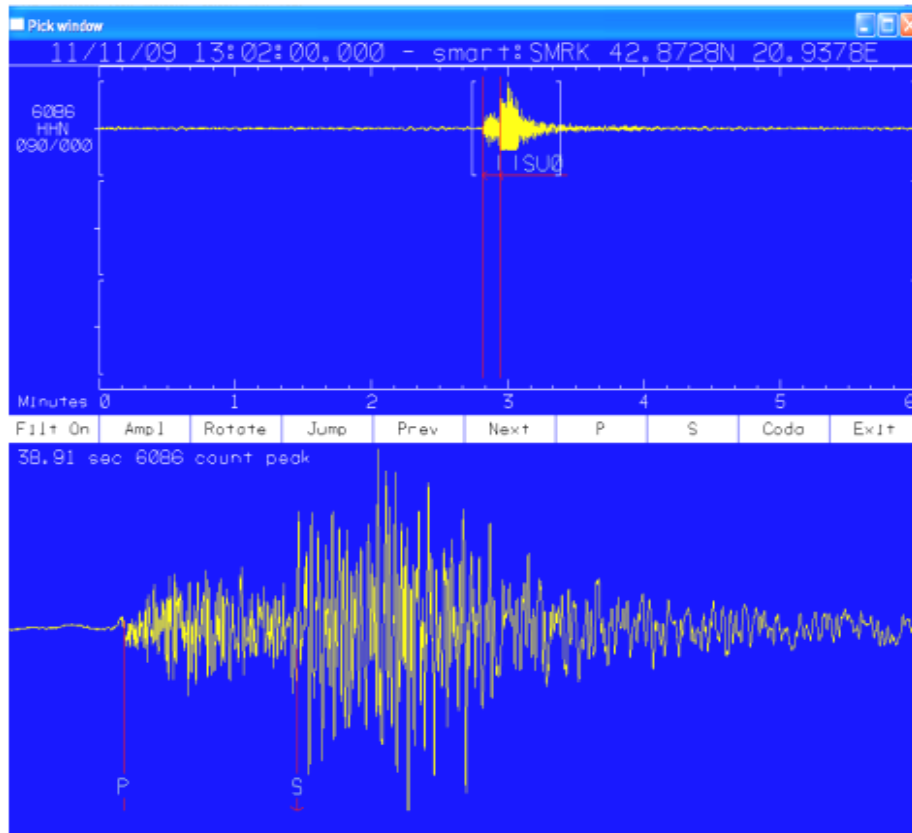
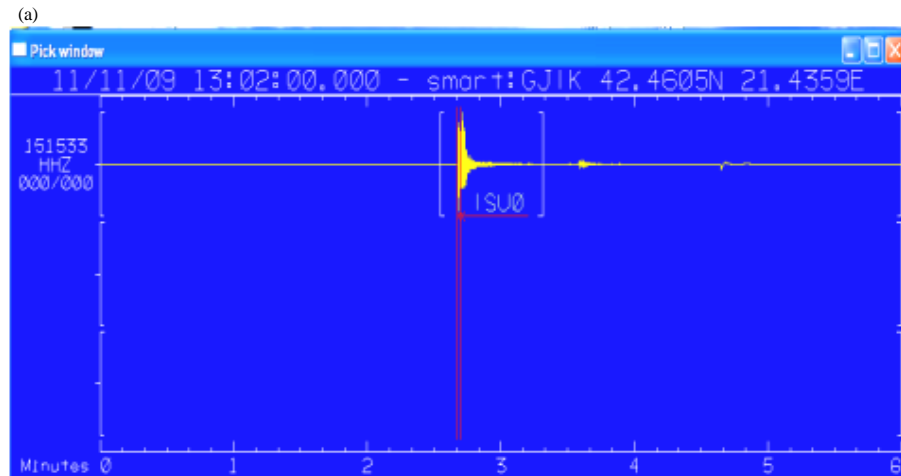Fig. 2: Registration on Seismic Station Smrekonica (SMRK)
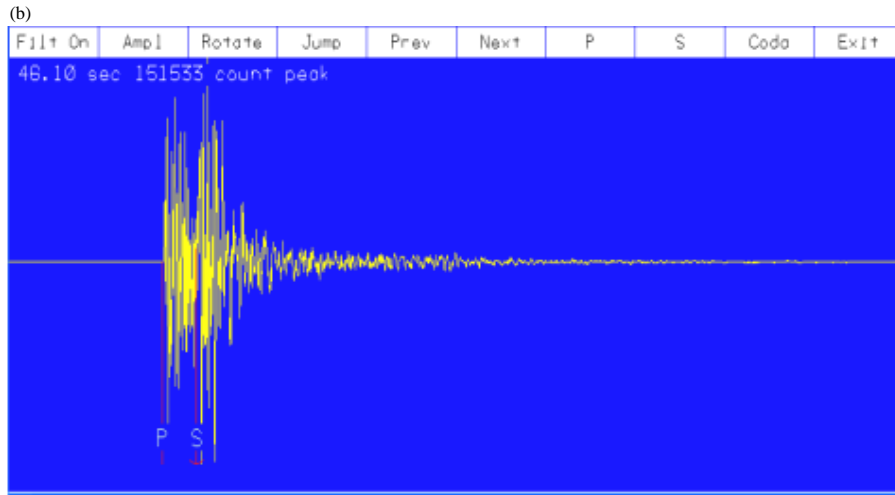

Fig. 3: Continue:

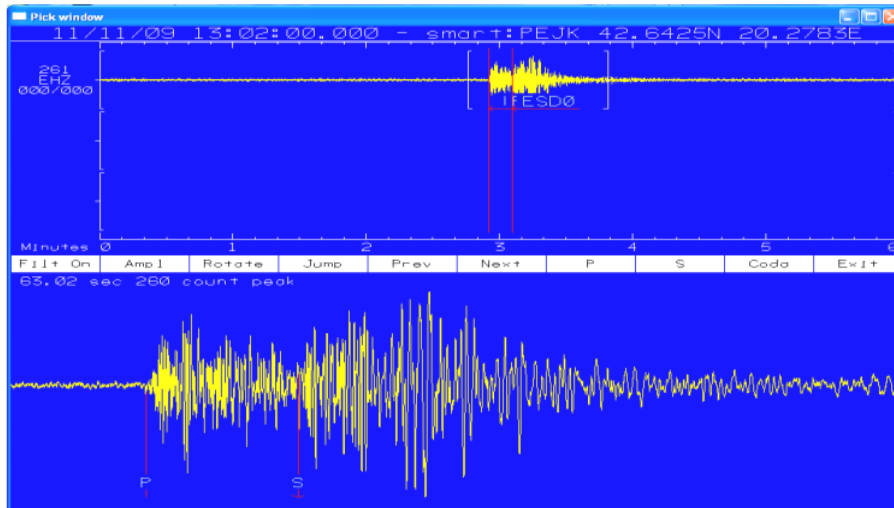Fig. 3: a, b) Registration on Seismic Station Gjilan (GJIK)

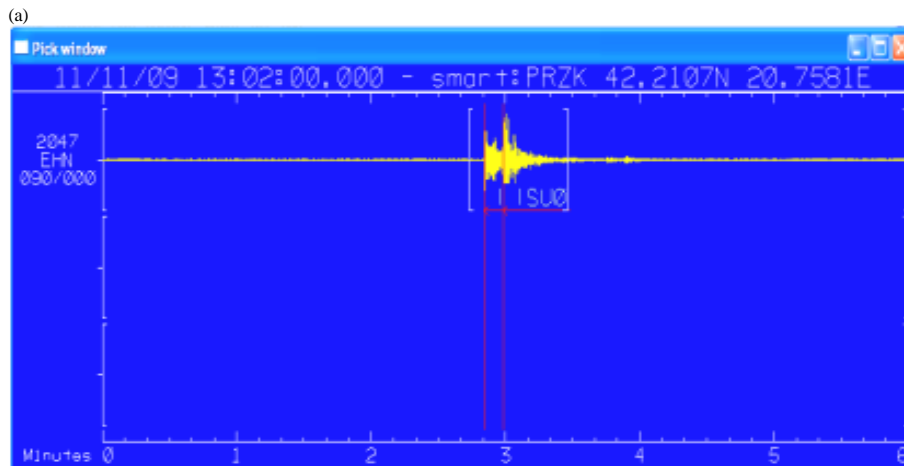Fig. 4: Registration on Seismic Station Peja (PEJK)
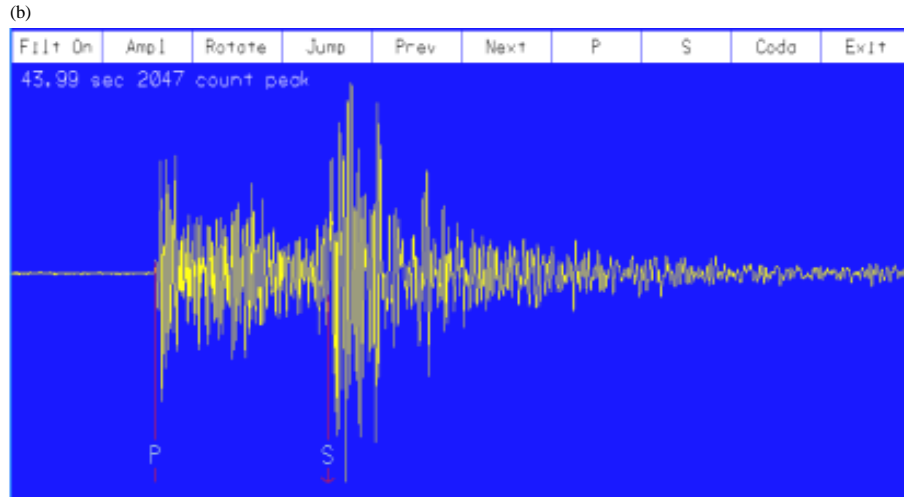

Fig. 5: Continue:

(b)

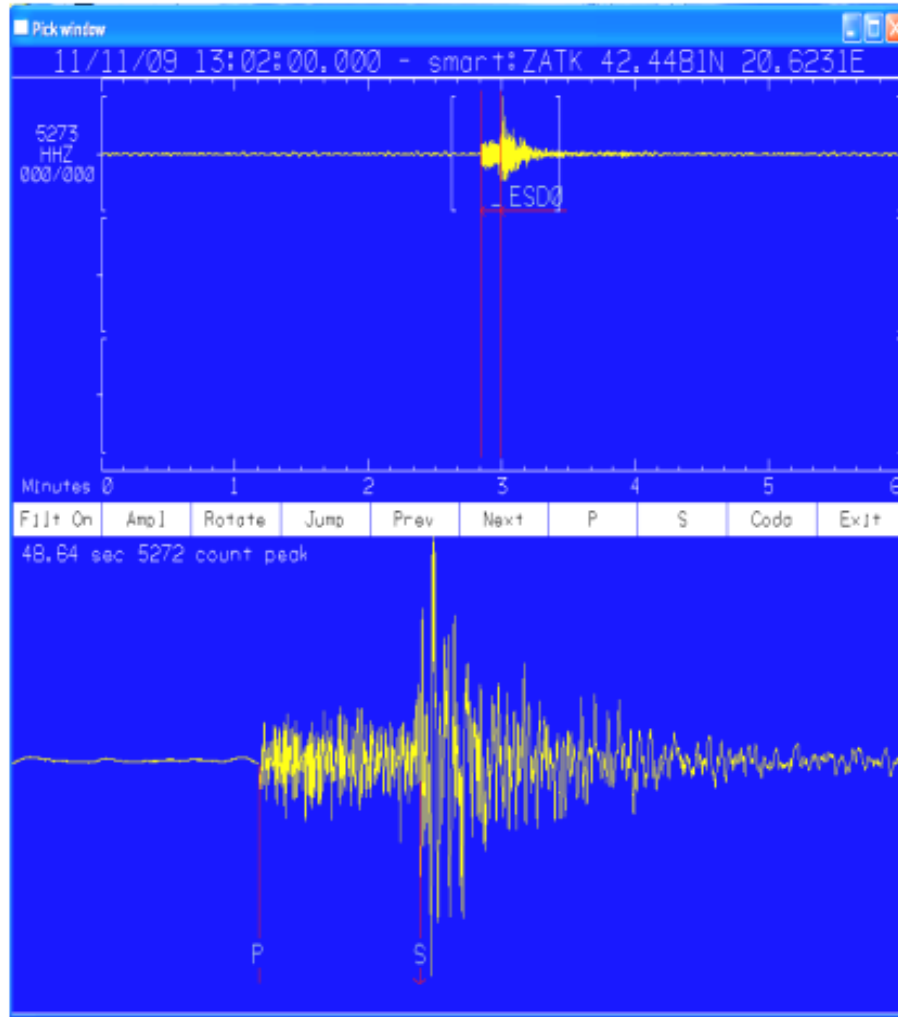Fig. 5: a, b) Registration on Seismic Station Prizren (PRZK)

Fig. 6: Registration on Seismic Station Zatriq (ZATK)

RESULTS AND DISCUSSION

Figure 7-13 are represented Earth crust models derived for all seven defined seismic source zones. Generally, derived seismic models keep the trend characteristic for the wider Balkan Region, i.e., the seismic zones in the Western part of Kosovo have deep Moho discontinuity than the Eastward ones. Since, the geology of Kosovo is quite complex, there are some differences in the upper sediment layer that reflect the local geological conditions.
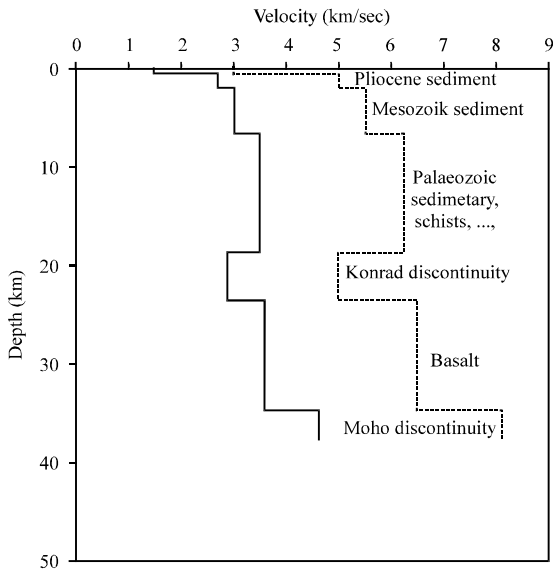

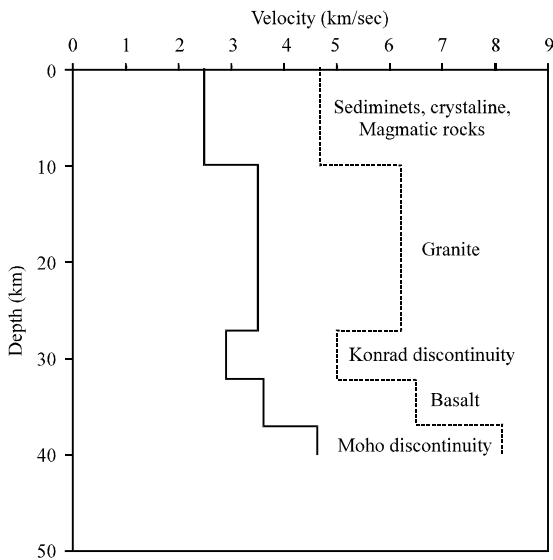Fig. 7: Earth crust model for Seismic Zone Vitina

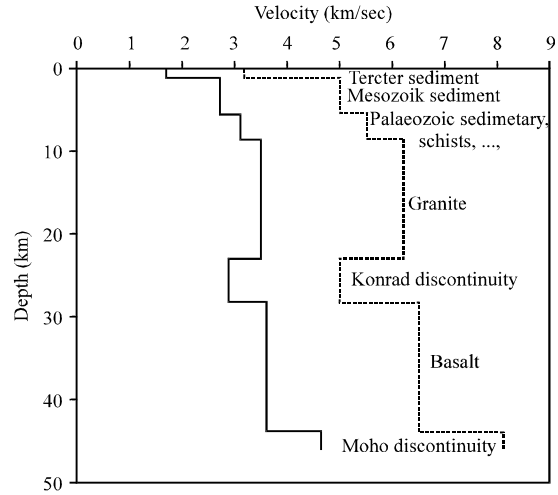Fig. 8: Earth crust model for Seismic Zone Gjilan

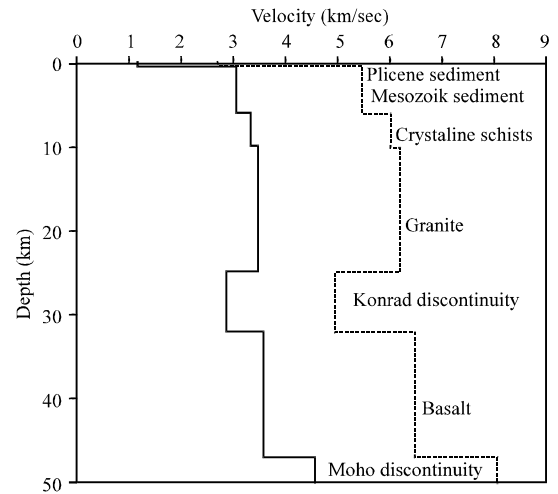Fig. 9: Earth crust model for Seismic Zone Smrekovnica

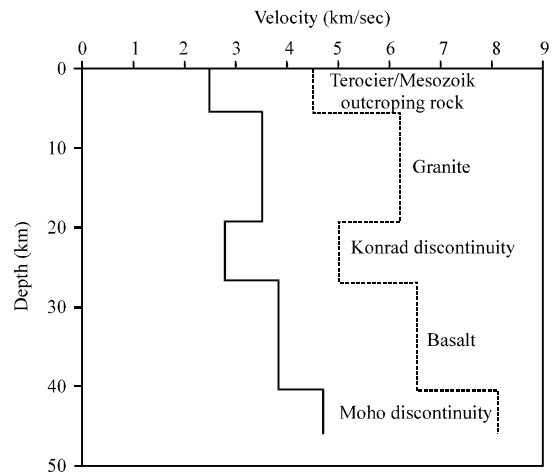Fig. 10: Earth crust model for Seismic Zone Prizren

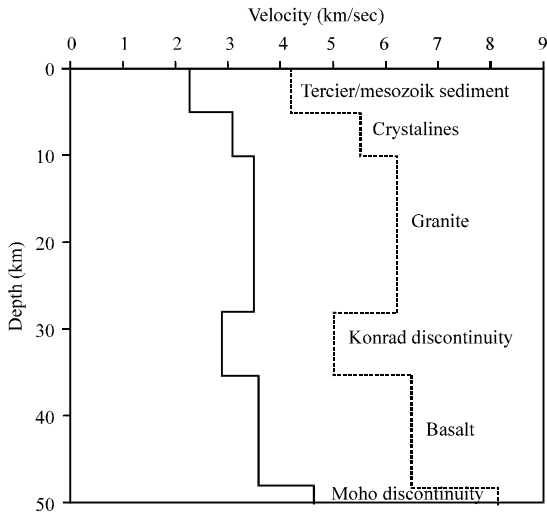Fig. 11: Earth crust model for seismic zone gjakovo
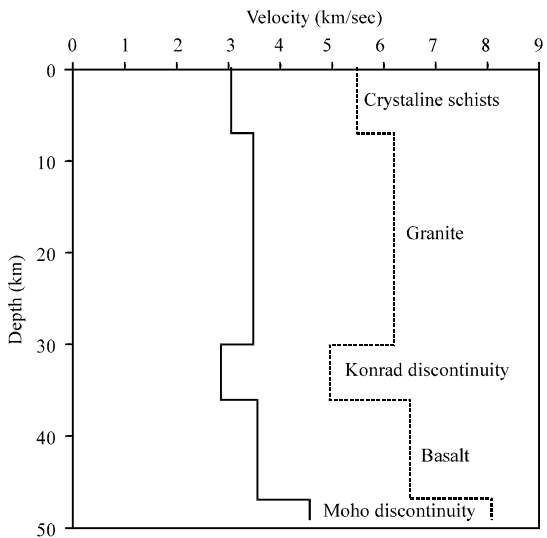
Fig. 12: Earth crust model for Seismic Zone Peja

Fig. 13: Earth crust model for Seismic Zone Kopaonik

CONCLUSION

The NDSHA procedure provide strong ground motion parameters based on the seismic waves propagation modeling at different scales-regional, national and metropolitan accounting for a wide set of possible seismic sources and for the available information about structural models (Zuccolo *et al.*, 2008, 2011; Panza *et al.*, 1999). The scenario-based methodology relies on observable data being complemented by physical modeling techniques, which can be submitted to a formalized validation process. Seismic hazard of the territory of Kosovo is determined

using a method of NDSHA approach. This approach is based on computation of synthetic seismograms for referenced earthquakes. The input data are as follows: catalogue of earthquakes for the territory under investigation, structural models for the crust and upper mantle under the separate seismogene zones and the fault-plane solutions for the referenced earthquakes with the (best) reliable seismological data. Synthetic seismograms (Al-Attar, 2007) are computed using method of normal mode summation (up to 1 Hz) for receiversiteson 0.2×0.2/0.1×0.1 degrees grid (two cases) and scaled to the magnitude of the maximum expected earthquake. The calculated maximum values of ground horizontal velocity, horizontal displacement and design ground acceleration (Aki, 1987) are considered as seismic hazard parameters. The objective of the study is elaboration of seismic hazard map of Kosovo using the deterministic approach. One of the ways of mitigating the seismic risk is the elaboration of a seismic hazard map of a certain region territory by using the deterministic approach. The second important element is that there are no such types of maps that are the basis for urban planning in seismically active regions as is the territory of Kosovo in this case. The Neigh boring countries (Macedonia, Bulgaria, Albania and Greece) have deterministically elaborated seismic hazard maps already for a longer period of time. This will cover the "gap" in this part of the Balkan Peninsula. Such an analysis was done for this region for the first time. Its upgrading will be done after a certain period of time.

The practical limits to the use of PSHA analysis for adequate structural design and in general for seismic risk mitigation are clearly outlined by the comparative analysis of PSHA and NDSHA estimates. The NDSHA provides values larger than those given by the PSHA in high-seismicity areas and in areas identified as prone to large earthquakes while lower values are provided in low-seismicity areas. In addition the PSHA expected ground shaking estimated with 10% probability of being exceeded in 50 years (associated with a return period of 475 years) appears severely underestimated (by about a factor 2) with respect to NDSHA estimates, particularly for the largest values of PGA. When a 2% probability of being exceeded in 50 years is considered, (i.e., return period of 2475 years) PSHA estimates in high-seismicity areas become comparable with NDSHA in this case however, the over all in crease related with probabilistic estimates leads to significantly overestimate the hazard in low-seismicity areas. These observations point out one of the basic limits of PSHA estimates, particularly severe as far as building codes are concerned, that is the overly

dependency of ground shaking on earthquakes recurrence, (i.e., on the probability threshold selected for the maps). The estimates of seismic hazard obtained according to the NDSHA and to the probabilistic (PSHA) approaches have been compared for the Kosovo territory. The NDSHA provides values larger than those given by the PSHA in high-seismicity areas and in areas identified as prone to large earthquakes while lower values are provided in low-seismicity areas. Besides the standard NDSHA estimates, the flexibility of the neo-deterministic approach permits to account for earthquake recurrence and eventually allows for the generation of ground shaking maps at specified return periods, (i.e., probability of exceedance). This permits a straight forward comparison between the NDSHA and the PSHA maps which provide the hazard estimates in terms of probability of exceedance of a given threshold of ground motion at a specific site. One of the most important advantages of the NDSHA approach is the capability to incorporate in a rather straight forward way, the newly available geophysical data and new advanced methods in seismological and geophysical data analysis.

REFERENCES

Aki, K., 1987. Strong Motion Seismology. In: Strong Ground Motion Seismology, Erdik, M.O. and M.N. Toksoz (Eds.). D. Reidel Publishing Company, Dordrecht, Boston, pp: 3-39.

Al-Attar, D., 2007. The calculation of synthetic seismograms in linearly anelastic earth models using normal mode summation. BS Thesis, Department of Earth Sciences, University of Oxford, ýOxford, Englandý, UK.

Aliaj, S., 1988. [Neotectonics and sectomotion of Albania (In Albanian)]. Ph.D Thesis, Funds of Seismological Institute, Tirana, Albania.

Aliaj, S., J. Adams, S. Halchuk, E. Sulstarova and V. Peci *et al.*, 2004. Probabilistic seismic hazard maps for Albania. Proceedings of the 13th World Conference on Earthquake Engineering (WCEE'04), August 1-6, 2004, International Association for Earthquake Engineering (IAEE), Vancouver, British Columbia, Canada, pp: 1-14.

Aliaj, S.H., 1998. Neotectonic structure of Albania. Albanian J. Natural Tech. Sci., 4: 89-101.

Ambraseys, N.N., J. Douglas, S.K. Sarma and P.M. Smit, 2005. Equations for the estimation of strong ground motions from shallow crustal earthquakes using data from Europe and the Middle East: Horizontal peak ground acceleration and spectral acceleration. Bull. Earthquake Eng., 3: 1-53.

Gvishiani, A.D., M.A. Alekseevskaya, A.M. Gabrielov, I.M. Gel'fand and E.I. Rantzman, 1977. Formal morphostructural zoning of mountain territories. Geophys., 43: 227-233.

Panza, G.F., F. Vaccari and R. Cazzaro, 1999. Deterministic Seismic Hazard Assessment. In: Vrancea Earthquakes: Tectonics, Hazard and Risk Mitigation, Wenzel, F. and D. Lungu (Eds.). Kluwer Academic Publishers, Dordrecht, The Netherlands, pp: 269-286.

Zuccolo, E., F. Vaccari, A. Peresan and G.F. Panza, 2011. Neo-deterministic and probabilistic seismic hazard assessments: A comparison over the Italian territory. Pure Appl. Geophys., 168: 69-83.

Zuccolo, E., F. Vaccari, A. Peresan, A. Dusi and A. Martelli *et al.*, 2008. Neo-deterministic definition of seismic input for residential seismically isolated buildings. Eng. Geol., 101: 89-95.