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AN UPGRADE OF THE MICROZONATION STUDY OF THE CENTRE OF TIRANA CITY

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ABSTRACT

An attempt was made in this paper to present an upgrade of the seismic microzonation of a part of the Tirana City. Some results of the previous, complete study performed in the late 80-s were used in this paper. The new aspect of this study is related to the probabilistic assessment of the ground motion parameters. Using gridded seismicity methodology, the PGA and the uniform response spectrum at the base rock corresponding to the 475-years return period were estimated. Based on them, five acceleration time histories are selected, which are later used to assess the response of the geotechnical models that compose this part of Tirana City.

INTRODUCTION

Until late, the macroseismic intensity was the basic parameter for the assessment of seismic hazard in Albania (Sulstarova *et al*., 1980). The map of seismic zonation of Albania published in 1980, as well as the seismic hazard maps compiled during the seismic microzonation studies performed during the period 1984-1991 for the seven largest urban areas (Vlora, Durrës, Shkodra, Tirana, Korça, Fier and Pogradeci towns) have been used as reference for such assessments.

The seismic microzonation study of Tirana City was completed on 1988 (Konomi *et al*., 1988, Kociu *et al*., 1988) and since that period of time we are facing more rapid changes regarding the methodology of seismic hazard assessment. It is already a necessity in the engineering practice to represent the results of microzonation, and engineering seismology studies in general, in terms of strong motion parameters, such as acceleration, velocity and displacement of ground motion shaking during strong earthquakes.

The Centre of Tirana has been reconsidered recently and a new regulatory plan is foreseen. Under these circumstances it is of great interest to review the seismic hazard assessment aspects of this part of the City. For this purpose, we used all the available information on seismic microzonation of Tirana city completed in 1988, regarding the geotechnical and engineering geological aspects of soil, including the physical-mechanical and seismic wave velocity properties given in that study (Konomi *et al*., 1988, Kociu *et al*., 1988).

The evaluation of seismic hazard that can threat Tirana Centre (Fig. 1) is carried out using probabilistic methodology. Seismic hazard has been represented in terms of strong motion parameters, such as peak ground acceleration PGA and spectral accelerations SA, for five periods of soil vibration. We calculated the seismic hazard curves of this area and the response spectra expressed in terms of absolute acceleration. The seismic hazard deaggregation in terms of PGA was done and based on the results of this procedure, the time histories for rock site conditions were developed. Then, these time histories are used as input motion and are propagated into the geotechnical models given in the study of microzonation of Tirana for this part of the City. Finally, the PGA for different levels of soil depth is calculated. The comparison of the mean resulting response spectra with the relevant spectral shapes of the Eurocode 8 (Eurocode 8, 2003) was performed.

GEOLOGIC FRAMEWORK OF TIRANA CITY

Tirana City takes place in the Periadriatic Depression, right on the most southern plain part of Tirana molasse syncline. Tirana syncline, about 80 km long and 10-12 km wide, represents an asymmetric syncline with the strongly dipping up to overturned western flank and gently dipping eastern flank. It is built by molasse deposits of Middle-Upper Miocene age and partly by Pliocene molasse in the most northern part of it (Aliaj, 2000).

Miocene molasse is placed transgressively and with unconformity on the carbonate-flysch structures of Ionian and Kruja Zones (Fig. 2). Only on the eastern flank of Tirana syncline is observed the transgressive and discordant placing of Miocene molasse over the Oligocene flysch of Kruja Zone.

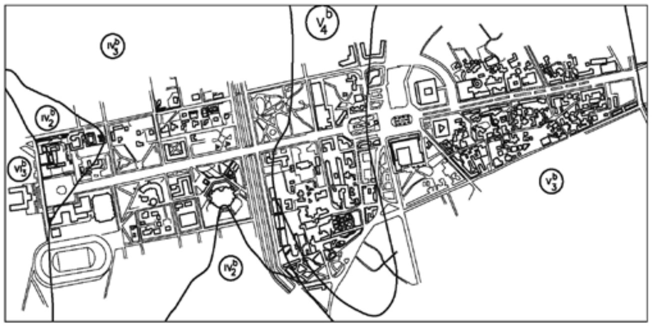

Fig. 1. Tirana Centre area and position of geotechnical models of this part of the City

Serravalian sediments, about 600 m thick, are represented by lithotamnium and organogene limestones in the lower part of section, passing upward into clays and sandstones. Tortonian sediments are characterized by clays passing upwards into clayey-sandstone intercalations, 100-2000 m thick.

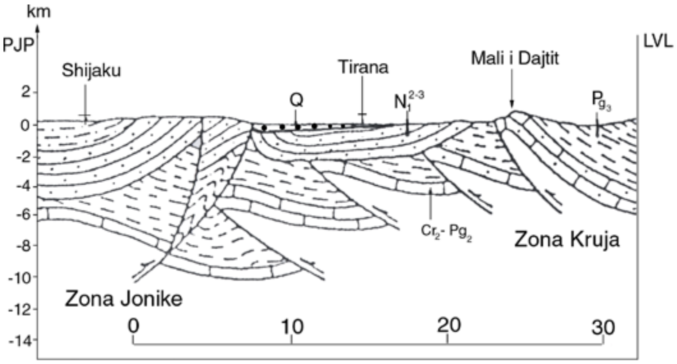

Fig. 2. Shijak-Dajti Mountain geologic cross-section (Aliaj, 2000)

Quaternary sediments are represented by gravels intercalated with clayey and sandy layers. They are about 15-20 m thick in Tirana City, and towards the north up to around 200 m thick near the Mati River (Aliaj, 1996).

Tirana City takes place in the most south-eastern part of plain area, 100-140 m over the sea level. From the east, south and west Tirana plain borders by low hills, built by Miocene molasse sediments. This plain, overplaced on Tirana syncline, represents a graben-like structure, bordered from the west by Preza backthrust and from the east by Dajti thrust (Aliaj, 2001).

SEISMIC ACTIVITY OF TIRANA AREA

Tirana is a relatively new inhabited area. It became capital of the country in 1920. As a consequence, the data for the seismic activity for this City and surrounding area are limited (Sulstarova and Koçiu, 1975; Sulstarova *et al*., 1980).

The strongest earthquake that has hit the town of Tirana is that of 09.01.1988, with M_s=5.4 and intensity I_o=7-8 degree (MSK-64), (Koçiu and Pitarka, 1990). The effect of this earthquake on the surface showed once more the importance of the ground conditions in the intensity of moderate earthquakes.

From the seismic faults that surround Tirana many earthquakes have been generated, the strongest of them are: 1617 year, with I_o=8 degree (MSK-64) in Kruja, 26.08.1852 with I_o=8 degree (MSK-64) in Rodoni Cape, 16.05.1860 with I_o=8 degree (MSK-64) in Beshiri bridge, 04.02.1934 with M_s=5.6 in Ndroq, 19.08.1970 with M_s=5.5 and I_o=7 degree (MSK-64) in Vrapi area, 16.09.1975 with M_s=5.3 in Rodoni Cape, 22.11.1985 with M_s=5.5 in Drini Gulf and 09.01.1988 with M_s=5.4 in Tirana. So, Tirana area is stricken from historical earthquakes with I_o=8 degree (MSK-64) and during the XX century from earthquakes of magnitude M=5.3-5.6.

ENGINEERING GEOLOGICAL CONDITIONS OF TIRANA CITY CENTRE

Tirana City Centre from engineering geological point of view is characterized by four zones, from which the zones III and V belong to the second terrace of Tirana river, the zone IV belongs to the first terrace of Lana river, while the zone VI belongs to the rocks of Upper Miocene molasse, with or without the elluvial-delluvial cover (Konomi *et al*., 1988; Koçiu *et al*., 1988).

In zone III is included a part of first terrace of Tirana river, extending from ex Dinamo plant up to the train station and following in the shape of an narrow belt 400-500 m wide up to ex School of Party. According to the basement on which the Quaternary sediments are overplaced, two subzones are divided:

a. Subzone III^a with sandstone basement
b. Subzone III^b with clayey-silty basement.

In the most northern part of the City Centre, at train station the model III_3^b is developed.

In engineering geological zone IV is included the first terrace of Lana River, which is extended along the Lana River flowing. This zone is divided into two subzones:

a. Subzone IV^a with sandstone basement, and
b. Subzone IV^b with clayey-silty basement.

In Tirana City Centre two geotechnical models IV_2^b and IV_3^b are developed (Fig. 1).

In engineering geological zone V included is the second terrace of Tirana River, which follows along the Tirana City Centre from the train station up to the Lana River. This zone is divided also into two subzones:

a. Subzone V^a with the sandstone basement, and
b. Subzone V^b with clayey-silty basement.

In Tirana City two geotechnical models V_3^b and V_4^b are developed (Fig. 1).

In engineering geological zone VI included is the hilly unit, which is also divided into two subzones:

a. Subzone with sandstone basement, and
b. Subzone with clayey-silty basement.

In most southern part of Tirana City Centre is developed only the geotechnical model VI_3^b (Fig. 1).

In the following paragraph are treated in details all geotechnical models building the Tirana City Centre.

Geotechnical models of Tirana Centre area

The effects of earthquakes on the surface depends not only from the regional characteristics of the geological settings, but also from the local soil layers that forms the soil profile from the surface up to bedrock.

Depending on their geometrical, physical-mechanical and dynamic characteristics, surface layers modify the amplitude-frequency content of seismic waves, whereby they directly affect the intensity of their destructive effect upon structures.

For the determination of the above mentioned characteristics of the surface layers and their effect upon earthquake motion at the basement of structures, it is necessary the geological and geophysical investigations with seismic methods of geotechnical models to be performed, in order to determine their velocity properties, apart physical-mechanical ones. Based on these values, the determination of the representative geotechnical models of specified areas that are necessary for the study of the effect these models exercise on earthquake vibration is possible.

Geotechnical models of Tirana centre represented in Fig. 1 are those compiled in the framework of microzonation study of Tirana city in 1988 (Konomi *et al.*, 1988; Koçiu *et al.*, 1988). These are the following: model IV_2^b, model IV_3^b, model V_3^b, model V_4^b and model VI_3^b. The amplification medium of seismic waves is the surface Quaternary layers with general thickness starting from 6.5 to 21m.

Due to the good stiffness and physical characteristics, the wide extension and the large thickness supposed, the medium of Neogene sediments was adopted as seismic bedrock. Models structure with the necessary geometrical, physical (H, V_S, γ) and lithological parameters are presented in the tables 1- 5. In these tables, presented are the plasticity indexes and appropriate data base numbers of 11 relations for the normalized shear modulus and damping ratios in regard to the shear strain level as they are required in the computer code WESHAKE5 for the earthquake equivalent linear analyses used in this study for the assessment of geotechnical models response (Yule *et al.*, 1995).

Table1. Geotechnical model IV_2^b

	Layer's Index		Thickness (m)	Plasticity Index	V_S (m/s)	Bulk Density (T/ m3)
	Sh.M	D.R				
1	7	6	1.5	(15)	100	1.50
2	7	6	2.5	(15)	210	1.62
3	7	6	2.0	(15)	210	1.90
4	7	6	3.0	(15)	350	1.87
5	1	1			600	1.96

1-Filling; 2-Inorganic silts and fine sands; 3-Inorganic silts and fine sands Inorganic silts with 10-30% gravel content; 5-Bedrock

Table 2. Geotechnical model IV_3^b

	Layer's Index		Thickness (m)	Plasticity Index	V_S (m/s)	Bulk Density (T/ m3)
	Sh.M	D.R				
1	7	6	1.0	(15)	150	1.45
2	7	6	1.5	(15)	250	1.60
3	7	6	1.5	(15)	350	1.74
4	7	6	3.5	(15)	350	1.74
5	2	2	5.0		450	2.00
6	1	1			700	2.10

Layers: 1-Filling; 2-Inorganic silts and fine sands; 3-Mixture of silts with gravel and sands; 4- Mixture of silts with gravel and sands; 5-Gravel; 6-Bedrock

Table 3. Geotechnical model V_3^b

	Layer's Index		Thickness (m)	Plasticity Index	V_S (m/s)	Bulk Density (T/ m3)
	Sh.M	D.R				
1	7	6	1.0	(15)	190	1.47
2	7	6	3.0	(15)	300	1.48
3	7	6	6.0	(15)	490	1.90
4	2	2	2.0		500	2.03
5	1	1			700	2.10

Layers: 1-Filling; 2-Inorganic silts and fine sands; 3-Inorganic silts with 20-30% gravel content; 4-Gravel; 5-Bedrock

Table 4. Geotechnical model V_4^b

	Layer's Index		Thickness (m)	Plasticity Index	V_S (m/s)	Bulk Density (T/ m3)
	Sh.M	D.R				
1	7	6	2.0	(15)	190	1.47
2	7	6	2.0	(15)	290	1.67
3	7	6	4.0	(15)	430	1.83
4	2	2	13.0		500	1.93
5	1	1			800	2.15

Layers: 1-Filling; 2-Inorganic silts and fine sands; 3-Mixture of silts with gravel and sands; 4-Gravel; 5-Bedrock

Table 5. Geotechnical model VI_3^b

	Layer's Index		Thickness (m)	Plasticity Index	VS (m/s)	Bulk Density (T/ m3)
	Sh.M	D.R				
1	7	6	2.5	(15)	130	1.40
2	7	6	1.5	(15)	220	1.57
3	7	6	2.5	(15)	340	1.74
4	1	1			550	2.05

Layers: 1- Eluvial-deluvial formations; 2-Inorganic silts; 3-weathered formation; 4-Bedrock

PROBABILISTIC SEISMIC HAZARD ASSESSMENT FOR TIRANA CENTRE

Of various probabilistic methods in use, we choose the spatially smoothed seismicity approach, developed by Frankel (1995) and further refined by Lapajne *et al.* (2003), and widely used today (Frankel *et al.*, 2000; 2002; Petersen *et al.*, 2008). The method still follows the basic approach established by Cornell in 1968, but no delineation of seismic sources is needed. An earthquake data file comprising the Albanian territory and extending about 100 km from its geographical borders, that covers the time period 373 BC up to 31/12/2005, and the area between 18.0-22.5°E and 38-43.5°N comprising a total of about 2770 events with $M_W \geq 4.5$ was used in the calculations (Kuka and Duni, 2007). The observed area is divided into grid cells, and in each cell the seismic activity rate (the number of earthquakes above the threshold magnitude) is calculated and then spatially smoothed with a Gaussian function. The annual rate of exceedance of the specified level for a given ground motion parameter, and finally the relevant value corresponding to a given return period is calculated. The adopted approach considers different alternatives about fundamental hypothesis on input parameters to account for and to propagate uncertainties in the model within a logic-tree framework.

The hazard computations have been carried out by the use of an upgraded version of the "OHAZ" software (Zabukovec, Kuka *et. al*., 2007).

Site specific PSHA

PSHA has been performed for the Tirana Centre area for return periods of 95, 475, 975, and 2475 years, corresponding to probabilities of exceedance of 10% in 10 years, and 10%, 5%, and 2%, respectively, in 50 years. PGA and spectral accelerations SA 10, 5, 3.3, 2, 1, and 0.5 Hz has been target of our study.

The reference site condition is firm rock, defined as having an average shear-wave velocity of 800 m/sec, corresponding site class A of Eurocode 8 provisions (Eurocode 8, 2003). The doubly-truncated exponential GR recurrence relation is used, with b-value equal 1.2, lower bound magnitude M_W=4.5, and upper bound magnitude M_{max}=7.2. The maximum distance applied in the computation is 100 km. As predictive ground-motion model we used that of Boore *et al*., (1997).

Table 5. Maximum horizontal bedrock PGA and SA at the Tirana Centre area

Period Sec	Spectral Acceleration, g			
	RP=95y	RP=475y	RP=975y	RP=2475y
PGA	0.184	0.274	0.319	0.385
0.10	0.262	0.434	0.526	0.671
0.20	0.349	0.562	0.682	0.853
0.30	0.306	0.499	0.610	0.771
0.50	0.196	0.331	0.408	0.529
1.00	0.008	0.141	0.177	0.235
2.00	0.043	0.075	0.095	0.125

Hazard curves

The relationship between the ground motion level and its annual probability of occurrence is described by a hazard curve. In the Fig. 3 presented are the hazard curves we developed for PGA and response spectral accelerations for a suite of periods with engineering interest, for Tirana Centre area. Then, the annual frequency of exceedances are plotted (dashed horizontal lines), which correspond to probabilities typically used for the design, as 10% in 10 years (RP=95years), and respectively 10% (RP=475), 5% (RP=975), and 2% (RP=2475) in 50 years. In Eurocode 8 provisions, two hazard levels, which are 10% probability of exceedance in 10 years (damage limitation requirements), and 10% probability of exceedance in 50 years (no-collapse requirements), are considered.

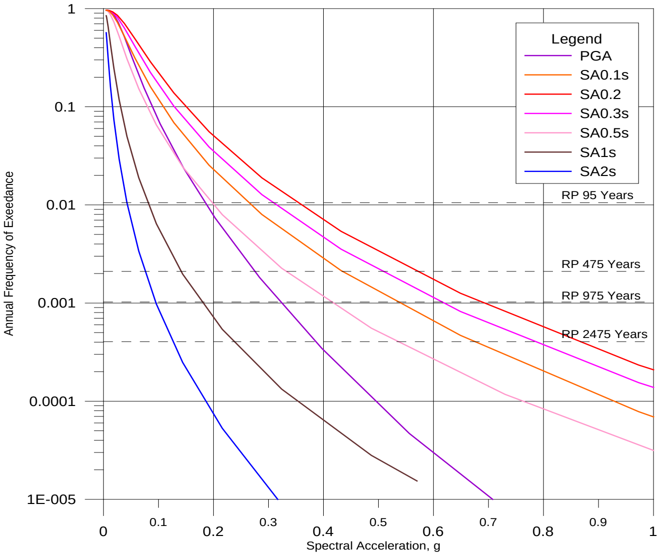

Fig. 3. Seismic hazard curves (rock conditions) for PGA and spectral accelerations SA 10, 5, 3.3, 2,1- and 0.5 Hz, for Tirana Centre area

Uniform Hazard Response Spectrum (UHRS)

The decision to use response spectral values is based on earthquake data obtained during the past 20 plus years showing that site-specific spectral values are more appropriate for design input than the coefficients based on peak ground acceleration used with standard spectral shapes. The differences are particularly pronounced for the short-period portion in the response spectra (Leyendecker *et al*., 2002). In this study we considered four hazard levels: 10% of exceedance probability in 10 years, and 10%, 5%, and 2% of exceedance probability in 50 years, corresponding to the 95-, 475, 975- and 2475-year return periods, respectively. The maximum horizontal bedrock PGA and spectral accelerations (SA) for each RP are obtained from PSHA and are listed in Table 5. The uniform hazard spectra (UHRS) for each return period are plotted in the Fig. 4.

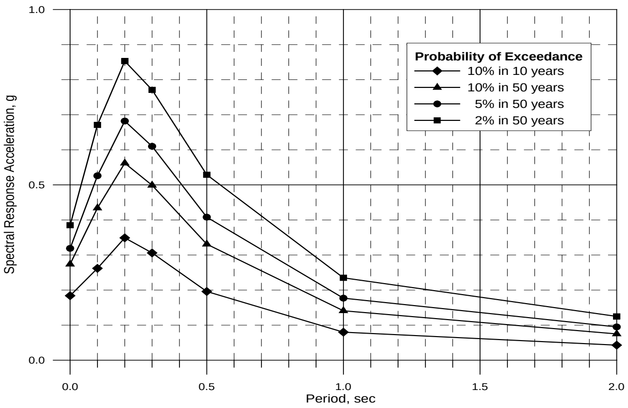

Fig. 4. Uniform hazard spectra for 2%, 5%, 10% probability of exceedance in 50 years, and 10% probability of exceedance in 10 years.

Deaggregation of seismic hazard for Tirana Centre area

PSHA uses aggregate contribution of various potential earthquake sources to calculate the annual rate of exceedance of a given site. The resulting hazard does not represent a single earthquake scenario associated with a specific magnitude and distance. It is, however, possible to calculate the relative contributions of the individual sources to the hazard. An important element of probabilistic seismic hazard analysis is the incorporation of ground-motion uncertainty from the earthquakes sources. The results are commonly displayed in terms of relative contributions for a range of magnitude, distance, and epsilon,ε, which represents the number of standard deviation from the median ground motions estimated from the Predictive Ground Motion Model (PGMM). It allows estimation of earthquake scenarios that have high likelihood of occurrence. This process is referred to as deaggregation.

For the modal-event R,M,ε_0, denoted $(\hat{R}, \hat{M}, \hat{\varepsilon}_0)$, it is reasonable to suppose that (Harmsen *et al*., 2003):

$$SA_0 \approx \exp(\mu_A + \hat{\varepsilon}_0 \sigma_A) \qquad (1)$$

where μ_A and σ_A are mean and standard deviation of the normal distribution of $\ln(SA)$ given distance $\hat{R}$ and magnitude $\hat{M}$. SA_0 is the ground motion associated with a specific probability of exceedance (PE), for example, 10% in 50 year. The right-hand side of (1) should be computed using a PGM model that is used in the PSHA.

The deaggregation for Tirana Centre area was done for PGA for return period 475 years and is presented in Fig. 5. The deaggregation of seismic hazard was performed using the computer codes of USGS National Seismic Hazard Maps Program (2002-2003), provided to us thanks the courtesy of S. C. Harmsen of USGS. Because the original codes were written for UNIX platforms, we adjusted them for use in PC environment.

So, considering the deaggregarion results for PGA in terms of R, M, ε_0, for the mean event we have D=7.6 km, M=5.4 and epsilon =1.52.

In fact, if we observe the map of active faults presented in Fig. 6, we can assume that the above mentioned scenario is related to the nearest faults circumscribing the City. Based on the map of active faults of Albania (Aliaj, 1997; 2000), as most hazardous for this site are the two active tectonic faults that circumscribe the Tirana syncline: in the west by the Preza back-thrust and to the east by the Dajti thrust, so here is formed a graben-like structure (Aliaj *et al*., 2001). These faults are shown in greater details in Fig. 6. The shortest site distance of Centre area of Tirana from the two above mentioned faults is in the order of 6.4 – 7 km.

Another source of threat for Tirana City is the system of active faults of back-thrust type, active during Quaternary age that are evidenced very well in the Durrësi area, at the distance of 30-35 km from Tirana. The maximum magnitude of these faults is estimated at the order of M_{max}=6.9 (Aliaj, 1988; 2000). So, the second distance-magnitude pair for Tirana Centre that can be considered as source of threat is D=35 km, M=6.9.

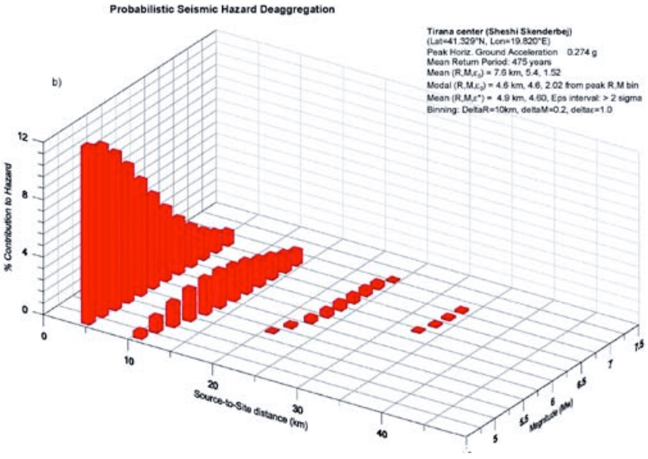

Fig. 5. Deaggregation of seismic hazard at the Tirana Centre area by magnitude and distance for PGA, 475-year return period;

PSHA AND DEVELOPMENT OF GROUND MOTION TIME HISTORIES

One of the objectives of this study is to develop time histories for use in linear or/and non-linear time history analysis of the various structures to be built in the area of Tirana Centre. For this reason we generated synthetic seismograms using the well-tested program SMSIM_TD, by David Boore (Boore, 2000). This program uses the stochastic method and assumes a point source.

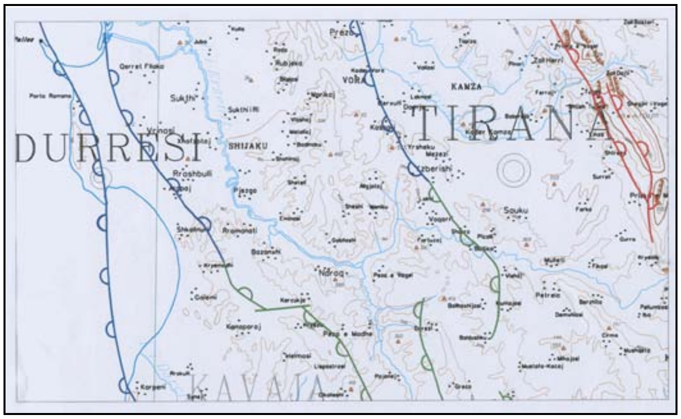

Fig. 6. Map of active faults surrounding Tirana City

Stochastic simulation of strong motion time series

The most widely used method to generate the synthetic ground motions is the stochastic point-source method (Boore, 1983). The stochastic models utilize the characteristics that observed ground motions can be characterized as finite-duration band limited Gaussian noise with an amplitude spectrum specified by a simple source model and path effects. Based on the analysis of the latest records of the Albanian Strong Motion Network (ASMN) that has been recently put in operation, a seismological model that supports the simulation of high frequency ground motions was established, making use of the theoretical models, the most popular of which is the stochastic model of Hanks and McGuire, (1981), (Duni, 2004, Duni and Kuka, 2005; 2008). The adequacy of the single corner-frequency ω-square source model of Brune (1970, 1971) in estimating stress-drop parameter comparing visually simulated and observed PSRV response spectra derived from a small number of recordings taken at five stations of ASMN, was shown. Two distinct variation intervals of Brune stress-drop are observed, analyzing the records of our data set. The first interval is related to values between 15 bars and 60 bars with main shocks having the largest values $\Delta\sigma$ = 50–60 bars, typical for areas of normal focal mechanism. The second interval is characterized by values in the range $\Delta\sigma$ = 200–300 bars, but the estimates are based on only three records generated by two earthquakes (Duni and Kuka, 2008). These values of stress-drop release are typical for thrust focal mechanism. Estimates of high-frequency diminution parameter κ_o by our data set have differenced the ground type A according EC8 (EC8, 2003) by values in the range $0.02 \le \kappa_o \le 0.04$, while for ground type B the estimates for two sites is quite the same, $\kappa_o = 0.07$. The conclusion was reached that these results can be used for predictions of ground motions in Albania taken into account not only the different $\Delta\sigma$ values found for the two main tectonic zones characterized by compressional and extensional movements, but also the κ_o and amplification factors used in the analysis (Duni and Kuka, 2005; 2008). For the generation of synthetic time histories for Tirana Centre site the value of stress-drop $\Delta\sigma$ = 200 bars and high-frequency diminution parameter κ_o = 0.0338, typical for rock conditions at Tirana, were used.

The two time histories TIR1_S and TIR2_S simulated using the SIM_TD code of the SMSIM programme (Boore, 2000) for D1=7.6 km; M1=5.4 and D2=35 km; M2=6.9, respectively are shown in the Fig. 7.

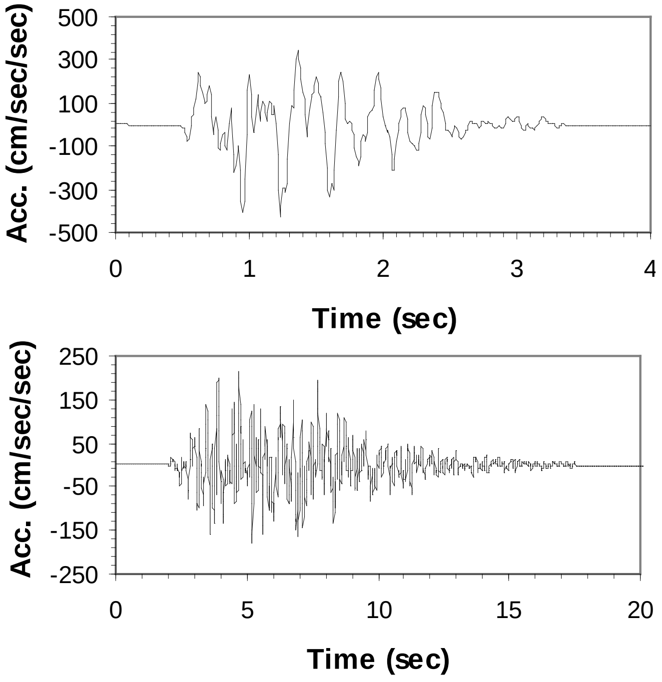

Fig. 7. Simulated acceleration time histories for Tirana Centre: TIR1_S (D1=7.6 km; M1=5.4, upper, and TIR2_S (D2=35 km; M2=6.9) lower.

REPRESENTATIVE RECORDED ACCELERATION TIME HISTORIES FOR THE ANALYSIS

Except the two above mentioned simulated time histories, we can choose three records taken by the ASMN and other networks of the region. One of the strongest earthquake that has hit Tirana City is the event of January 9, 1988, $M_S = 5.4$ (ISC), $I_o = 7$-8 degree of MSK-64 scale and epicentral distance D=8 km. This earthquake was recorded by the strong motion instrument of SMA-1 type of the Tirana Seismological Station situated on Tortonian sandstones, near the causative fault. The maximum acceleration recorded on E-W component, showing a strong directivity effect, was PGA=0.4 g, PGA=0.1 g on N-S component and PGA=0.07 g on vertical one. The time duration was no more than 6 seconds (Koçiu and Pitarka, 1990). We have nominated these two records as: TIR1_R (TIR-EW) and TIR2_R (TIR-NS).

The other record is that of the Montenegro, Aprill 15, 1979 earthquake (Mw=6.9), AL-NS, recorded on rock condition (sandstones) in Albatros Hotel in Ulqini (Montenegro). The similarity of the seismotectonic environment between coastal areas of that country and Albania is evident that gives us confidence to use this record for the assessment of seismic hazard of Tirana Centre. On Fig. 8 presented are these three recorded time histories used for the analysis of the soil response of the geotechnical models that compose the area of our study.

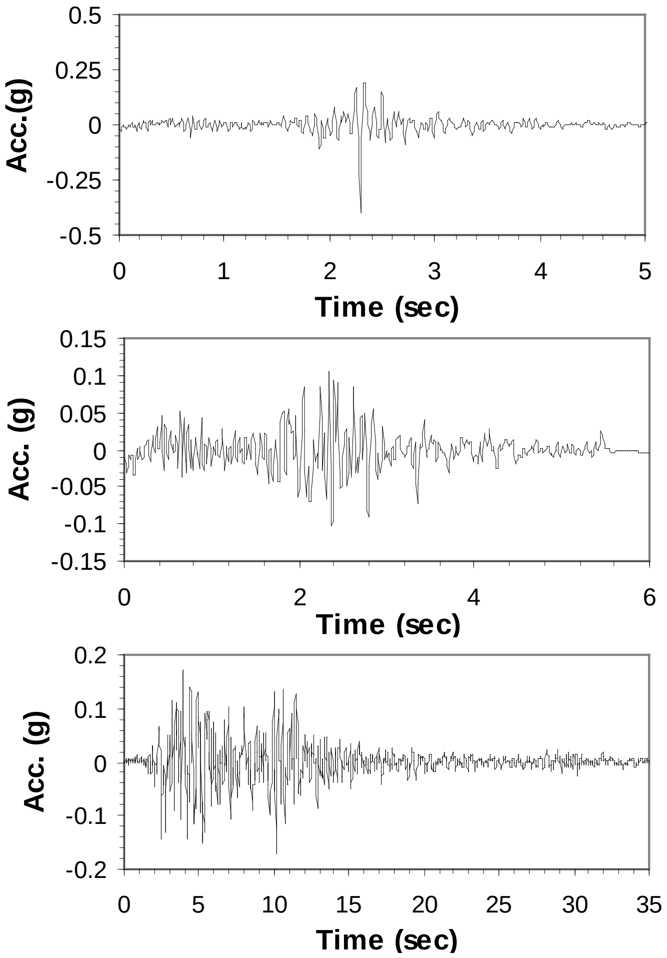

Fig. 8 Recorded acceleration time histories TIR1_R (upper), TIR2_R (middle) and AL-NS (bottom).

DYNAMIC RESPONSE OF THE GEOTECHNICAL MODELS

For the study of geotechnical models behavior during earthquakes, represented in Tables 1-5, WESHAKE 5 computer code was used (Yule *et al.*, 1995). As input motion functions five acceleration time histories shown in the Fig. 7 and 8 were used. All these time histories have been scaled to the PGA value 0.27 g, according to the seismic hazard estimated for the area of Tirana Centre in bedrock level. In Fig. 9 and Table 6 presented are the PGA values at the top of each soil layer according to the parameters of every geotechnical model.

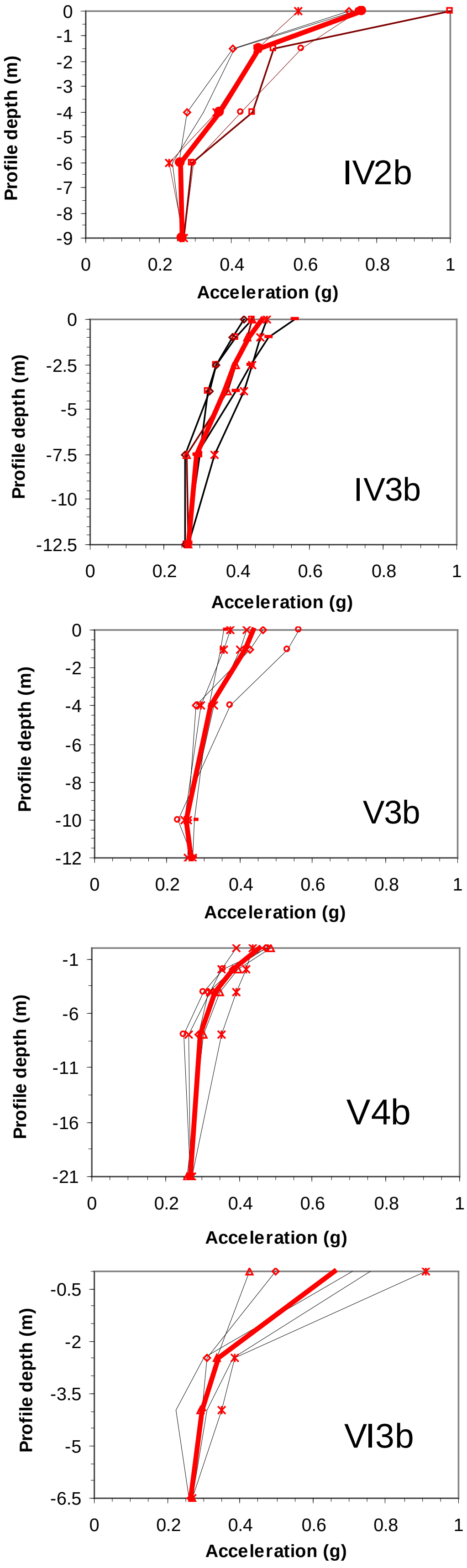

Fig. 9. Variation of PGA in the 5 geotechnical models of Tirana Centre

Table 6 Distribution of the mean PGA values into the soil profile

IV_2^b	Depth (m)	0.0	1.5	4.0	6.0	9.0	
	PGA (g)	0.76	0.48	0.37	0.26	0.27	
IV_3^b	Depth (m)	0.0	1.0	2.5	4.0	7.5	12.5
	PGA (g)	0.47	0.43	0.39	0.37	0.29	0.27
V_3^b	Depth (m)	0.0	1.0	4.0	10.0	12.0	
	PGA (g)	0.44	0.41	0.32	0.25	0.27	
V_4^b	Depth (m)	0.0	2.0	4.0	8.0	21.0	
	PGA (g)	0.45	0.38	0.34	0.29	0.27	
VI_3^b	Depth (m)	0.0	2.5	4.0	6.5		
	PGA (g)	0.66	0.34	0.30	0.27		

In Fig. 10 we present the elastic acceleration response spectra with 5% damping at the surface of the geotechnical models together with the EC8 spectral shapes according the soil categories of this design code.

DISCUSSION AND CONCLUSIONS

Presented in this paper are the results of an investigation for the microzonation of the Centre of Tirana City. The data regarding the soil profiles included into the study of Tirana microzonation performed in the late 80-s (Konomi *et al.*, 1988; Koçiu *et al.*, 1988) were used. The new aspect of the actual study regards the level of the seismic input that serves for the evaluation of the soil profiles response. The probabilistic methodology is used for the assessment of seismic hazard and the PGA for 475 years return period as well as the uniform hazard spectrum for this part of the City was determined. Deaggregation of seismic hazard for PGA for 475 years return period is accomplished and the mean D and M pair is used for the simulation of acceleration time histories, to be used as input motion. From the comparison with the system of faults that circumscribe the City, it is evident that these deaggregation results reflect the two active tectonic faults at two sides of Tirana syncline: in the west the Preza back-thrust and to the east, the Dajti thrust. Further, the system of active faults of back-thrust type, active during Quaternary age that are evidenced very well in the Durrësi area was taken as another source of threat for Tirana City. The total number of time histories chosen as representative for the assessment of soil response is five. The time histories were propagated into the five geotechnical models and the PGA values at the top of every layer were evaluated, together with the response spectra of 5% damping were shown.

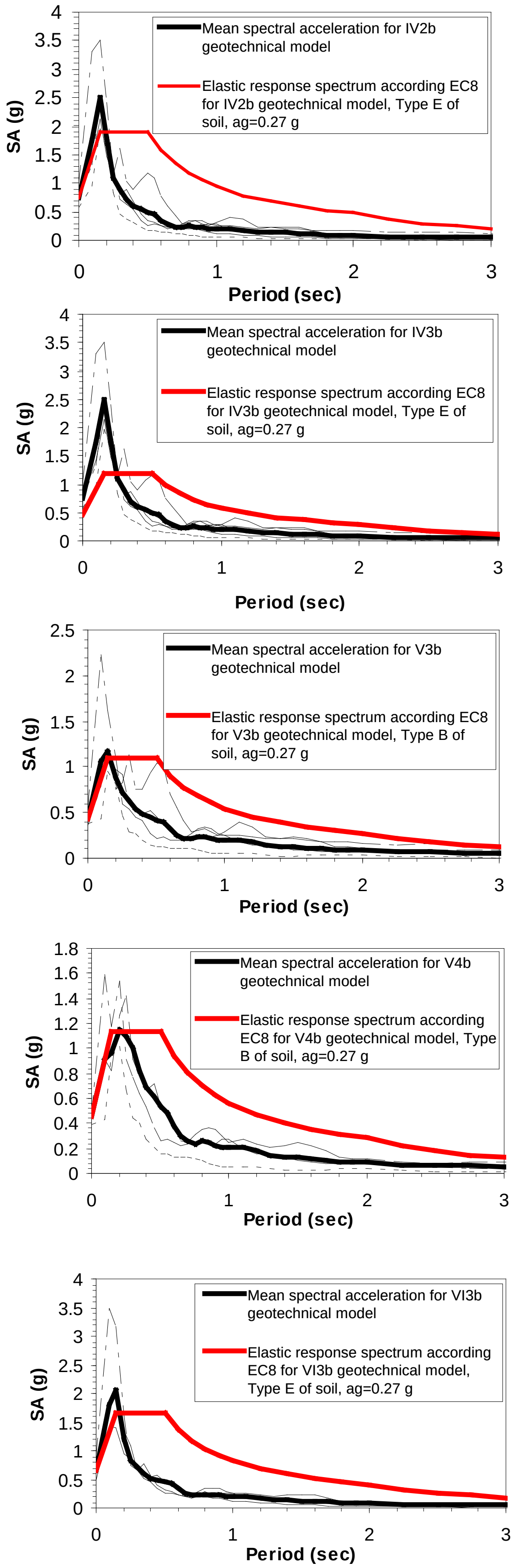

Fig. 10. Elastic acceleration response spectra with 5% damping at the top of soil profiles as well as the spectral shapes of EC8.

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