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Geological and Geophysical Models Underneath Bucharest City Responsible for the Variability of Seismic Site Effects

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Bucharest, the capital of Romania, with more than 2 million inhabitants, is considered after Istanbul the second-most earthquake-endangered metropolis in Europe. It is identified as a natural disaster hotspot by a recent global study of the World Bank and the Columbia University (Dilley et al., 2005). Four major earthquakes with moment-magnitudes between 6.9 and 7.7 hit Bucharest in the last 65 years. The most recent destructive earthquake of 4. March 1977, with a moment magnitude of 7.4, caused about 1.500 casualties in the capital alone. All disastrous earthquakes are generated within a small epicentral area – the Vrancea region - about 150 km north-east of Bucharest. Thick unconsolidated sedimentary layers in the area of Bucharest amplify the arriving seismic shear-waves causing severe destruction.
Most of the PGA variation across the city is due to the package of the Quaternary sedimentary layers which amplify the original strong motion arrived from the earthquake. The largest amplification of the soil will occur at the lowest natural frequency or its fundamental period. In situ measurements of shear wave velocity in the soil and the soil thickness, provide a rough measurement of the characteristic site period.
Extensively seismic noise measurements proved to be a much accessible method and computed H/V spectral ratio over large periods of time, may provide a good indication on the fundamental period of the site, even if the position of the bedrock is not well defined.
Within the NATO-funded Science for Peace Project 981882 “Site-effect analyses for the earthquake-endangered metropolis Bucharest, Romania” the drilling and the Vp and Vs (seismic longitudinal and shear-wave velocities) measurements in ten boreholes were done in the years 2006-2008 (Bala et al., 2010). Rock samples were taken from each borehole at different depths for laboratory tests to determine the geotechnical parameters of each sedimentary rock type at the sites. Thus a valuable data base is assembled which contains: Vp and Vs values for each sedimentary layer, density and geologic characteristics of each layer, which are the basic data for equivalent linear modelling of the site; other geotechnical parameters measured in the laboratory on the rock samples will permit the nonlinear modelling of the site.
Using the program SHAKE2000 and EERA we compute spectral acceleration functions at specific depths and transfer functions for the 1D models obtained from the in situ measurements. The acceleration response spectra correspond to the wave amplifications due to the package of sedimentary layers from 50 m depth (maximum depth) up to the surface, that are expected for a moderate real earthquake motion incident at the bottom of each 1D model. Because of the lack of outcropping bedrock in the Bucharest area, a seismic signal recorded in a borehole (PRI - 50 m depth; TEI- 78 m depth; INC - 140 m depth) at a moderate earthquake (Mw= 6), is used as input for the entire study area. 1D models obtained were tested in order to strengthen the importance of various input parameters in the obtained results.
The results of the equivalent linear modeling with SHAKE2000 program for the 10 boreholes are presented and compared as graphs of spectral acceleration. The maximum values of the spectral accelerations occur around the 3 main the periods: T1 = 0.13 s; T2 = 0.2 s; T3 = 0.55 s. The highest values occured at the period T2 = 0.2 s, and they are between 0.22 g and 0.48 g. If we consider a comparison of the values at surface, they are between 0.22 g at Romanian Shooting Fed. (northern part of Bucharest) and 0.48 g (Ecologic Univ. in the central part of Bucharest).