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Geophysical site characterization for strong motion stations, a case study in North Macedonia

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Abstract

Definition of seismo-geological characteristics of a terrain is of a great importance when it comes to selection of strong-motion station sites. Local site conditions can modify the amplitude-frequency content of the seismic motion during an earthquake. Therefore, site characterization is very significant for correct analysis and use of earthquake records.

Key words: strong-motion station, site characterization, seismic methods, local soil conditions

Definition of seismo-geological characteristics of a terrain is of a great importance when it comes to selection of strong-motion station sites. Local site conditions can modify the amplitude-frequency content of the seismic motion during an earthquake. Therefore, site characterization is very significant for correct analysis and use of earthquake records [1, 2].

Geophysical surveys using surface seismic methods were performed at few different characteristic locations in the territory of North Macedonia (Figure .1). The potential sites were, first of all, selected based on off-site (office) studies, which include parameters such as geographical region of interest, seismo-geological characteristics, seismic noise, accessibility, electricity, communication, transport, etc.

Surface seismic methods represent widely accepted geophysical methods for seismo-geological modeling and evaluation of parameters that have a direct influence on the site response during an earthquake, such as seismic velocities and topography of bedrock. At each selected location, time and cost-effective surveys were conducted by joint acquisition of seismic refraction, seismic reflection and Multichannel Analysis of Surface Waves (MASW) data. Microtremor measurements for HVSR (Horizontal to Vertical Spectral Ratio) analysis were also performed for definition of the predominant frequency and joint inversion of the dispersion and HVSR curve [3, 4, 5].

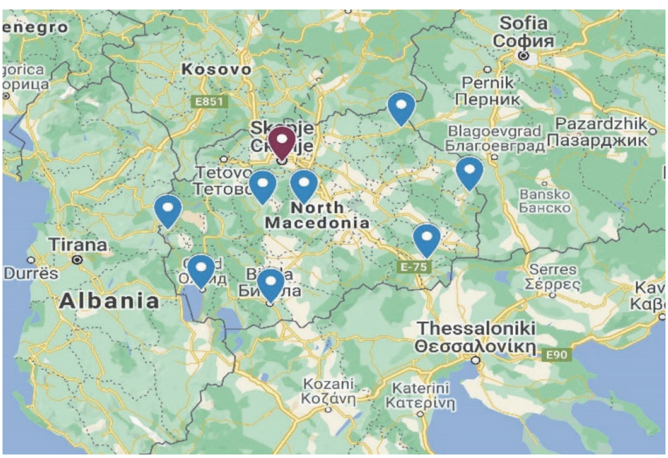

Figure 1. Map of potential strong motion sites

The final results from this integrated seismic survey approach are 1D Vs and 2D Vp and Vs models that, according to the variation of Vp and Vs velocities, map the thickness variation in non-consolidated sediments as well as 2D reflective sections, which define the weathered zones, discontinuities and faults in rocks.

Presented in this study are the results from the geophysical survey performed at IZIIS - Skopje, as a potential site for strong-motion instrumentation. The location is situated at the foothills of Vodno hill and it is part of the Skopje sedimentary basin [6].

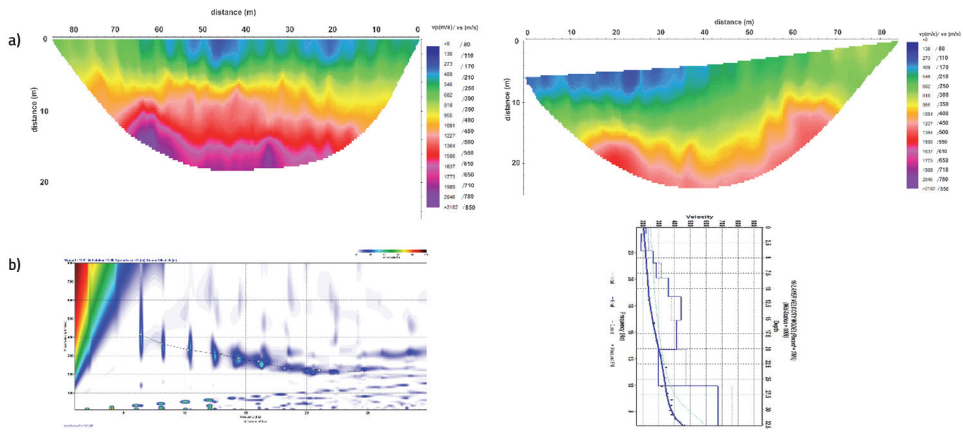

Figure 2. a) 2D Vp and Vs Seismic refraction profiles. b) Dispersion curve and 1D MASW Vs model

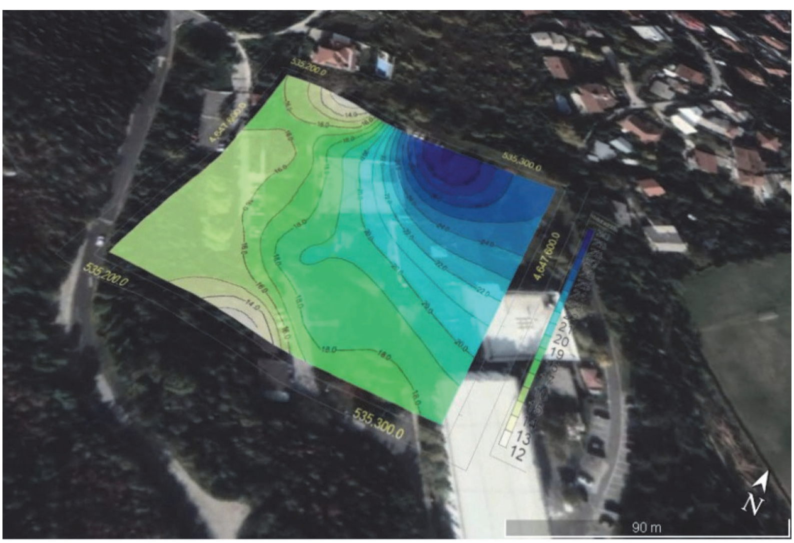

Figure 3. 2D map of unconsolidated deposits (Vs<600m/s) thickness variation at the survey location (isopach map)

The main objective of the survey was mapping of the seismo-geological characteristics of the terrain in order to determine the suitability of the location for strong-motion instrument installation.

The result of the seismic refraction surveys are 2D seismic models which clearly show the variation of the Vp and Vs value laterally and in depth. The seismic refraction method, i.e., the tomographic refraction concept in combination with the MASW method proved to be quite efficient in these investigations, particularly in defining the thickness of the unconsolidated sediments, which is of a particular importance for further investigations [7, 8].

The thickness variation is represented as a 2D isopach map, generated on the basis of seismic refraction and MASW data. According to the 2D isopach map, the most unfavourable zone belongs to the lower North-eastern part of the location, where the thickness of the unconsolidated sediments (Vs<600m/s) reaches up to 25-30 m.

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