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3-D basin geometry model to determine the site effects based on geophysical and geotechnical data: Case study at near-field and high seismicity area of Gölyaka, Düzce, Turkey

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The near-field and high seismicity of the area makes the determination of the bedrock geometry more complex and pioneers the studies of site response analysis in account for a seismic hazard assessment. Without a good model of basin structure, any powerful calculation method would lack a well-developed basin response. The study has been conducted in the Gölyaka basin that uniquely falls within the bifurcated near-field section of the North Anatolian Fault System. The surface rupture of the 1999 Earthquakes of Kocaeli (Mw=7.4) and Düzce (Mw=7.2) bound this tectonically formed basin, respectively.
In this study, a 3-D basin structure model has been developed based on the geophysical and geotechnical data along with the geology of the area. In particular, a combination of active and passive surface wave method measurements at 29 locations, the vertical electrical sounding at 14 locations, the geotechnical boring data at about 30 locations and one deep boring data have been used to develop the structure of the sediment basin. The high-resolution shear wave velocity profile has been obtained through surface wave methods by using active Multichannel Analysis of Surface Waves (MASW) and passive Microtremor Array Method (MAM), respectively. The Schlumberger vertical electrical sounding (VES) method has been applied to evaluate the bedrock of the basin depth. Finally, geotechnical and deep boring data have also been used along with the basin geology to provide a cross-reference for the Vs profile and VES model. The result of this comprehensive survey led to a well-developed 3-D geometry model of the Gölyaka basin.
Based on the dimensional shear wave velocity profiles obtained, a bedrock level with an average velocity of 1100 m/s was accepted as the bedrock depth limit in the region. The implemented deep and geotechnical boring data along with the seismic results suggested that the Gölyaka basin is composed mostly of clay and sand sedimentary layers with a large thickness. It was concluded that the thicknesses of the alluvial sediments within the Gölyaka basin was estimated to be about 250 m, with irregular basin geometry due to over-step faulting near the basin boundary. Consequently, the local site conditions that are generated display spatial variations in the near field area depending on the dimensional basin geometry and topographic effects. The constructed model can successfully be used for site effects and site response studies of the Gölyaka region.