

Empirical correlations of shear wave velocity (V_s) and penetration resistance (SPT-N) for different soils in an earthquake-prone area (Erbaa-Turkey)

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ABSTRACT

The seismicity of the northern part of Turkey is mainly controlled by the North Anatolian Fault zone (NAFZ). The NAFZ is one of the world's most active seismic zones, and has produced destructive earthquakes and related hazards in the northern region of Turkey. Several earthquakes and earthquake-related hazards have occurred along different segments of this fault zone in the recent past. The study area, Erbaa town, is located along the eastern segment of North Anatolian Fault Zone (NAFZ) and is one of the largest towns of Tokat Province in the Middle Black Sea Region of Turkey. The center of Erbaa is located on the left embankment of the Kelkit River. After the disastrous 1942 ($M_s = 7.2$) and 1943 ($M_s = 7.6$) earthquakes, the settlement was shifted southwards.

As a part of a seismic microzonation study of the Erbaa area, shear wave velocity (V_s) values of the geological units exposed in this area were required for site response analyses. The geological units in the study area consist mainly of alluvial and Pliocene units. These layers were evaluated on the basis of drilling, in-situ (SPT, SCPTU and SPT-based uphole) and laboratory testing. In this study, empirical correlations between shear wave velocity (V_s) and standard penetration test blow counts (SPT-N) were considered in order to define shear wave velocity profiles for the study area. The relationships between shear wave velocity, Standard Penetration Test (SPT) blow-counts and the soil properties were evaluated as functions of depth. SPT-based uphole tests were performed to measure shear wave velocity during drilling operations in some of the borings. The SPT-based V_s values were computed with different empirical formulas and compared with the measured SPT-based uphole V_s measurements. The empirical correlations were found to require modification to provide the best correlation for this site. The depth factor was considered during the development of new empirical equations. Therefore, a site-specific formula was proposed in order to obtain V_s profiles for all layers in the study area.

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1. Introduction

Turkey is one of the most earthquake-prone countries in the world. The seismicity of the northern part of Turkey is mainly controlled by the active North Anatolian Fault Zone (NAFZ). The NAFZ is one of the main active seismic zones, and has caused numerous destructive earthquakes and related hazards in the northern region of Turkey. The settlement of Erbaa (population approximately 100,000), located along the eastern segment of the NAFZ, is one of the largest towns of Tokat Province in the Middle Black Sea Region of Turkey. It is located in a critical area in terms of the construction and development aspects. The city center of Erbaa is located on the left embankment of the Kelkit River. After the disastrous 1942 ($M_s = 7.2$) and 1943 ($M_s = 7.6$) earthquakes, most subsequent development in the Erbaa

region was shifted to the hilly region south of the Kelkit River. Substantial development remained on the alluvial deposits near the river, however, and rapid increase in population has led to pressure to expand the developed areas back toward the Kelkit River. The locations of the new and old settlements are depicted in Fig. 1.

As a part of a microzonation study for the Erbaa area, shear wave velocity (V_s) values of the geological units exposed in this area are required for site response analyses. The shear wave velocity is a fundamental parameter required to define the dynamic properties of soils. It is useful in the evaluation of foundation stiffness, earthquake site response, liquefaction potential, soil density, site classification, soil stratigraphy and foundation settlements (Richart et al., 1970; Seed and Idriss, 1970; Schnabel et al., 1972; Sykora and Stokoe, 1983; Burland, 1989; Sasitharan et al., 1994; Shibuya et al., 1995; Kramer, 1996; Andrus and Stokoe, 1997; Wills and Silva, 1998; Mayne et al., 1999; Dobry et al., 2000; Lehane and Fahey, 2002; Seed et al., 2003; Stewart et al., 2003; McGillivray and Mayne, 2004; Holzer et al., 2005; McGillivray, 2007).

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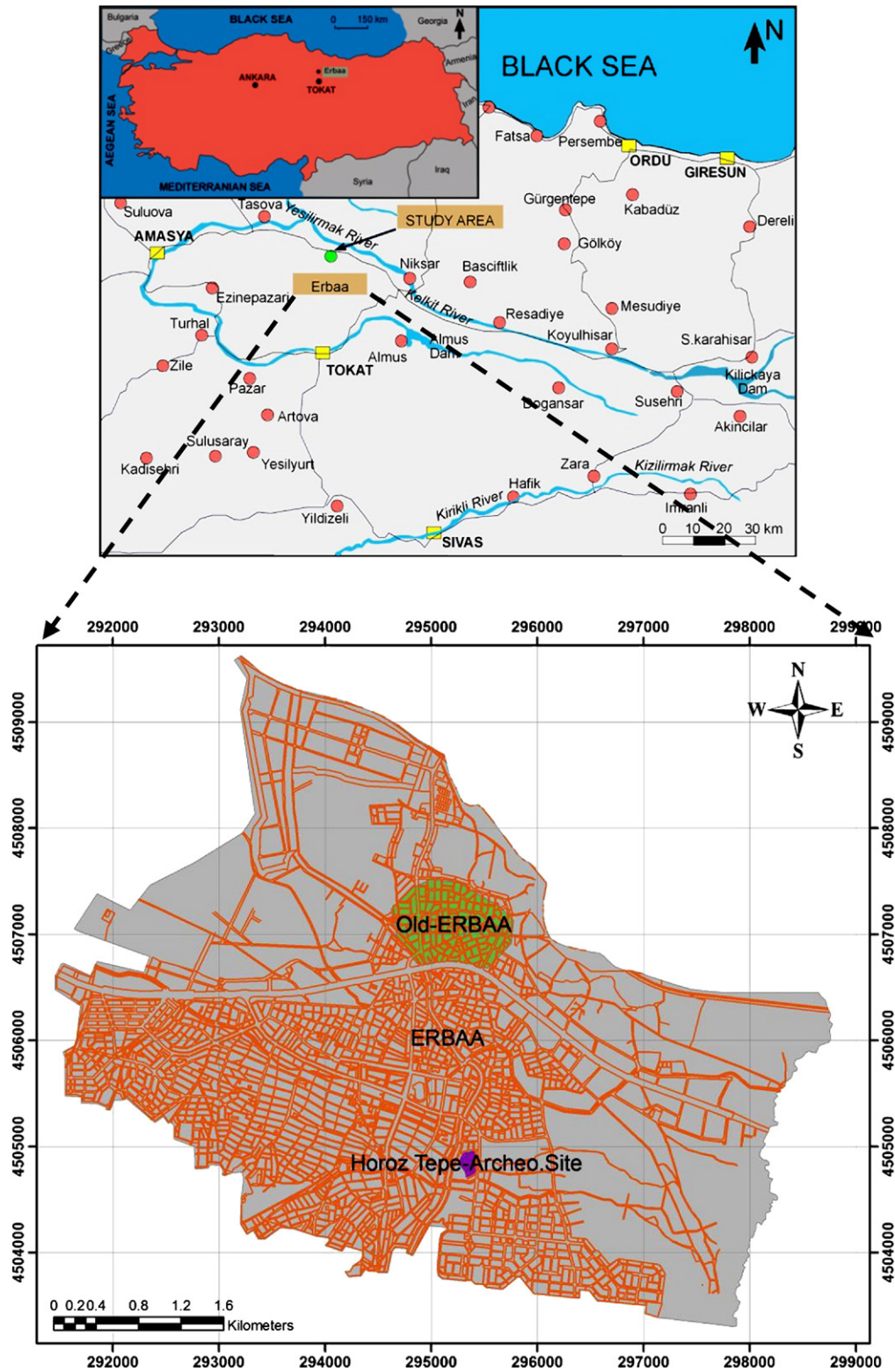


Fig. 1. Location map of the study area.

Shear wave velocities of soil profiles are most accurately determined using in-situ seismic measurements. Because in-situ measurements involve very low strain levels, the measured shear wave velocity can be used to obtain the maximum shear modulus ($G_{\max}$) at a particular depth in a soil deposit. The maximum shear

modulus can be computed from shear wave velocity and mass density (ρ) using the following expression:

$$G_{\max} = \rho V_s^2 \quad (1)$$

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