Chapter 2
Local Site Effects Evaluation Using Geophysical Methods

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ABSTRACT

The waves that occur in an earthquake affect the behavior of the soil and the building due to the structural condition of the bedrock and the physical properties of the soil near the surface. To predict this interaction, the deep underground structure models of the areas considered as settlements should be determined and how the earthquake waves will be directed (macro-zoning) depending on this should be revealed. Since the near surface features of the ground can increase the effect of earthquake waves, it is necessary to determine the near surface properties and create their maps (micro-zoning). Earthquake waves are formed in thick sediments compared to the rock environment and cause great damage to both the ground and the buildings. In order to be protected from these damages, it is necessary to determine focusing and scattering conditions arising from the deep underground base topography. Therefore, parameters such as maximum horizontal ground acceleration, soil liquefaction, soil dominant vibration period, soil amplification, and near-surface soil properties should be determined.

INTRODUCTION

SDG 11 (Sustainable Cities and Communities) emphasizes considering natural events to create safe and sustainable cities (SDG, 2023). To build sustainable, safe,

DOI: 10.4018/979-8-3693-0819-6.ch002

and durable cities against the effects of earthquakes, which are the most important natural events, the structural and physical properties of the underground should be determined with macro and micro-zoning. This book chapter emphasizes the importance and necessity of macro and micro-zoning studies. Different damages are observed in areas affected by earthquakes in many parts of the world (Oluwafemi et al., 2018; Wada et al., 2018; Koren and Rus, 2021; Zarski et al., 2022). The most critical factors in earthquakes that cause damage to structures are the factors such as the magnitude, mechanism, location, and duration of the earthquake, as well as the physical and structural properties of the underground where quake waves radiate and the regional behavior of that environment. Some situations, such as the transmission characteristics of these environments, their dynamic elastic properties, the absorption and expansion of earthquake vibrations, the focusing effect of earthquake waves originating from the base topography, the channeling of earthquake waves into a region as a result of successive reflections in low-velocity layers constitute the regional characteristics of the environment. These features significantly affect the ground structure near the surface and its engineering structures. Therefore, it is essential first to reveal the deep underground system. The structural condition of deep underground structures can be determined by applying many geophysical methods (Aki and Richard, 1980; Alverez, 1990; Ulugergerli et al., 2007; Pamukçu et al., 2014; Chaljub et al., 2021).

The duration and intensity of elastic wave vibration at a particular location depend on many factors, such as the space from the quake epicenter, the earthquake's magnitude, and the soil properties of that location (Bullen and Bolt, 1985; Cilsalar and Temiz, 2020). Although seismic waves emanating from the source travel many kilometers within the crust, forming bedrock until they reach the soil layers, their distance within the soil layers is usually less than 100 m. However, soil layers are indispensable in deciding the features of the observed motion on the earth. Soil layers are like a filter for seismic waves. While seismic waves at some frequencies are damped, others are amplified. This situation is revealed by the geophysical methods realized in the field and the determination of the characteristics of the artificially produced seismic wave frequencies in the ground.

While earthquake waves propagate, a seismic impedance difference occurs between the rock and soil. This status causes the amplitude of earthquake waves to increase in the soil near the surface. Aki and Richards (1980) also stated that seismic impedance refers to the medium's resistance against particle movement. From this point of view, the importance of the seismic velocity values, the dominant periods of the bedrock, and the upper layers in soil amplification are revealed. Loose, porous ground conditions amplify the seismic wave amplitude. Therefore, loose and abundantly porous units are shaken more than tight and hard rocks. Geophysical engineers and international organizations (Regulations such as NEHRP, EuroCode,

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