Chapter 9

Seismic Microzonation and Site Effects Detection Through Microtremors Measures: A Review

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ABSTRACT

Seismic microzonation of a city can be a difficult and expensive undertaking depending on the method used. In the last years, the HVSR method has been one of the most popular ways to define the natural frequency of the soil and seismic amplification factor in order to make quick microzonations due to that it is an expeditious and cheap method. This is very important in developing countries and poor countries. The fundamental reason to use this method is the fact that the amplification factor has well correlation with damage distribution. Additionally with the help of another methods it is possible obtain the structure of the superficial soil strata. In this chapter, an introduction with seismic microzonation, site effects concepts, microtremors, description of the HVSR method, advantages and disadvantages of this method, limitations and comparison with other methods, are presented. Finally, highlight of the importance of the method in order to identify site effects are displayed as examples and the incorporation of these data to Geographic Information Systems is also shown.

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INTRODUCTION

According to the Earthquake Glossary of U.S. Geological Survey, “Seismic Microzonation” is the identification of separate individual areas having different potentials for hazardous earthquake effects. This individualization of areas is needed to the territorial ordainment of cities that are near to seismic sources in order to reduce the seismic risk and the vulnerability of the buildings. Some of the potential hazards are liquefaction, landslide, rock fall, site effect, topographical variations, tsunamis and others. The liquefaction is a process by which water-saturated sediment temporarily loses strength and acts as a fluid, like when someone wiggles its toes in the wet sand near the water at the beach. This effect can be caused by earthquake shaking. Microzonation provides the basis for site-specific risk analysis, which can assist in the mitigation of earthquake damage.

The first microzonations were based on properties of the superficial layers of the soil in a specific site, for example the number of Standard Penetration Test, this is the case of the first seismic code of the city of Mendoza, Argentina, where there were three types of soil with different seismic demand, based on number of SPT and bearing capacity. More recently, predominant period, amplification factor, shear wave velocity, plasticity index and undrained shear strength are used for the identification of the different zones inside a city.

Seismic microzonation of a city can be a difficult and expensive undertaking depending on the method used. For example the determination of $V_{s30}$ is one of the principal ways to define the Site (spectrum) (UBC, 1997) (IC 103, 2013), but this method is expensive, in certain occasions it is not possible to obtain and can be misleading in many cases (Pitilakis, 2004), also the use of $V_{s30}$ as a proxy to seismic amplification has been questioned by several recent works (Pitilakis, Riga & Anastasiadis, 2013).

The modern seismic microzonation contemplated maps with faulting, site periods and amplification, peak ground velocity and peak ground acceleration. These maps usually are integrated in a geography information system. The Figure 1 shows the faulting in the nearby of Mendoza city and the Figure 2 shows the frequency of the soil of Mayagüez, Puerto Rico (Ritta, Suárez & Pando, 2012).

In the last years, the HVSR (horizontal to vertical ratio spectra) method also called Nakamura’s, method or QTS (quasi transfer spectrum) has been one of the most popular ways to define the natural frequency of the soil, but not the seismic amplification, due to that it is an expeditious and cheap method (Nakamura, 1989), (Nakamura, 2000), (Nakamura, 2008), this is demonstrated by the fact that the first work of Nakamura has been cited more than 1000 times in international journals and books. Even this method has been used for the determination of the structure of the surface soil layer of the moon with the data recorded by the instruments placed by the Apollo 14 and 16 missions. Additionally with the help of another method it was possible to obtain the structure of the superficial soil strata (Dal Moro, 2015). Due to this and the troubles that the Vs30 presents, there are new proposals of Site Classification based on the fundamental period of soil deposit (Pitilakis, Riga & Anastasiadis, 2013). Therefore the two principal objectives of microzonation are fulfilled by the HVSR, first the amplification factor (partially) and second the shape of the spectrum and that includes the fundamental period of soil deposit.

BACKGROUND

When we talk of “site effect” we refer to amplifications of the movement due to seismic waves that take place in a punctual site. This effect, also called “bowl of jelly”, occurs when certain geological condi-