SEISMIC SOIL CLASS MAP ACCORDING TO EUROPEAN AND ITALIAN CODES

Giovanni Forte; Eugenio Chioccarelli; De Felice Melanza; Pasquale Cito; Antonio Santoro; Iulino Iervolino

1 Dipartimento d’Ingegneria Civile, Edile e Ambiente, Università degli Studi di Napoli Federico II, Via Claudio 21, 80125, Naples, Italy
2 Università Telematica Pegaso, Piazza Tietro e Trento 48, 80132, Naples, Italy
3 Dipartimento di Strutture per l’Ingegneria e l’Architettura, Università degli Studi di Napoli Federico II, Via Claudio 21, 80125, Naples, Italy

Introduction

Seismic soil classification aims to make soil classification accessible to the scientific community. In order to account for these local effects, some proxies which account for the soil behaviour can be identified, e.g., the average shear-wave velocity of the upper 30 m (VS30), or the equivalent shear-wave velocity from the depth of the seismic bedrock (VS eq). In this study, two maps of seismic shallow soil classification for Italy according to Eurocode 8 (EC8) and the new Italian Building Code (IBC2018) are presented. The methodology from which the maps are derived is described in Forte et al. (2019) and accounts for two sources of information: site-specific measurements and large-scale geological maps. The soil maps are obtained via a four-step procedure: (1) a database of about four-thousand shear-waves velocity (Vs) measurements coming from in-hole tests, surface geophysical tests and microtremors is built, covering (un)evenly the whole national territory; (2) twenty geo-lithological complexes are identified from the available geological maps; (3) the investigations are grouped as a function of the geo-lithological complex and the distribution of Vs values from the seismic bedrock contribution, (VS eq), are derived; (4) medians and standard deviations of such distributions are assumed to be representative of the corresponding complexes that are consequently assigned to soil classes.

The EC8 soil class map and the available databases of Vs measurements were compared with the seismic soil map provided by the USGS based on a topographic slope-proxy (Allen and Wald, 2007). The latter is obtained by the correlation between topographic slope and VS30, assuming morphometric characteristics of the terrain as representative of the lithology. The slope-based method appears less reliable than the proposed approach, because its predictions resulted in a slight but systematic overestimation of the measured soil classes. Therefore, the proposed map can be more suitable for large-scale seismic risk studies, despite it is not a substitute of seismic microzonation and local site response analyses.

Data

Vs data comes from In-Hole Tests, Surface Geophysical Tests and Microtremors, they were collected from a wide range of sources, resulting in a strongly uneven distribution in both quantity and quality of the information. All data were stored in a GIS database and, for each investigation, the values of Vs and Veq were calculated (Figure 1). The complete database features 3842 VS measurements. 1570 In-Hole Tests (DH, CH, SCT), 319 Surface Geophysical Tests (MWSH, SASW, seismic refraction surveys) and 1937 Microtremors (ESAC, RA MI, HVSR). Passive Array, FTAN) designed to measure shear-wave velocity profiles. The figure shows that the overall data distribution clearly follows the Apennine mountain chain, where there is the largest seismic hazard, or identifies the areas affected by the most recent earthquakes.

Starting from the original geological formations as classified by Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA), a simplified geo-lithological classification was set up. The new classification accounts for geological complexes with similar lithology. They were identified on the 1:50,000 Geological Maps (Rollins et al., 1999). The resulting map was compared with the seismic soil map provided by the USGS (Figure 10). The only differences are: (i) LB2 does not belong to the 360–800 m/s interval, having median value of 315 m/s; (ii) IMB2 has median value lower than 300 m/s and equal to 476 m/s. The latter are due to the definition of VS eq, which does not take in account the increase of stiffness provided by the seismic bedrock contribution.

Seismic Soil Classification

Statistics of Vs and soil class for geolithological complexes

The Veq and Vseismic, measurements are grouped in the box-plots for EC8 (Eurocode 8) in Figure 3 and IBC2018 (New Italian Building Code) in Figure 4. Some of geological bedrocks also represent seismic bedrock (V > 600 m/s). The complexes representative of geolithological bedrock characterized by median Veq between 360 and 800 m/s, with the exception of CB and SB, which have median value equal to 947 and 326 m/s, respectively (Quaternary deposits (Figure 3) are characterized by shear-waves velocity clearly decreasing as function of the grain-sizes, sorting and textures.

In Figures 5 and 6 histograms show the distributions of soil classes according to EC8 and IBC2018 in Italy, one soil class is predominant with respect to the others, but for CB and CB2, the frequencies of A and B class occurrences are comparable as well as the frequencies of B and D classes for composition C and D classes for composition E, where A is the soil class not defined only on Veq parameter. Site classification S, eq is therefore described by the fact that the number of investigations that assigned class E (the soil class not defined only on Veq parameter) is negligible. Soil class frequencies in Figure 6 are in agreement with the proposed approach. The code-conforming soil classes are attributed to the geo-lithological complexes as shown in Table 1.

Seismic Soil Classification

Statistics of Veq measurements were associated to each geo-lithological class. Site classification following EC8 was based on the attribution of the V median to the geolithological complex (Figure 3). Conversely, for IBC2018, the frequency of soil class occurrence is assumed as the representative class of the whole complex (Figure 4). EC8 and IBC2018 classifications account for some soil classes that are not defined exclusively on V eq. The former is obtained by the correlation between topographic slope and VS30, assuming morphometric characteristics of the terrain as representative of the lithology. The slope-based method appears less reliable than the proposed approach, because its predictions resulted in a slight but systematic overestimation of the measured soil classes (Forte et al. 2017). Therefore, the proposed map can be more suitable for large-scale seismic risk studies.

References


Forte, G., Fabbrocino G., Lanzano G., Santucci de Magistris F., Silvestri F. A geolithological approach to seismic site classification: an application to the Middle Rhine Valley (Germany). Earthquake Spectra 2009, 1467-1479.

Allen, T. I., Wald, D. J. Topographic slope as a proxy for seismic site-conditions (Vs30) and amplification around the globe. 2007.