CRISP DB INGV 2021- Site Classification

This document reports the standard analysis performed routinely and archived in the section Site Classification.

Note: all the parameters here reported are to be considered as indicative, the values actually used depend on the available data and the analyst experience.

1. Soil Class

Soil classification is mainly expressed according to the Italian seismic codes (NTC08, 2009; NTC18, 2018) with codes A B C B E, which depend on the $V_{S,30}$ and $V_{S,eq}$ respectively; these codes can be derived from different direct measurements or deduced from geological observations.
The soil class could also be expressed according to the European seismic code (EC8, 2004) and to the USA seismic code (NEHRP, 2009).

Definitions
$V_{S,30}$ - Travel-time average of seismic shear-wave velocity Vs (m/s) over the first 30 m depth:

$$V_{S,30} = 30 / \Sigma_{i=1}^{N} \frac{h_i}{V_{S,i}}$$

$V_{S,eq}$ - Equivalent shear-wave velocity: Travel-time average of seismic shear-wave velocity Vs (m/s) down to the bedrock depth (Vs>=800 m/s). If the bedrock depth is larger than 30m, $V_{S,eq}$ is equal to $V_{S,30}$.

$$V_{S,eq} = H / \Sigma_{i=1}^{N} \frac{h_i}{V_{S,i}}$$

where:
h_i denote the thickness (in meters) of i-layer
V_i denote the shear-wave velocity of the i-layer,
N is the total number of layers
H is the bedrock depth

2. Topography class

The slope and ridge data, necessary for the assignment of the topographic class, derive from morphometric analyses of high resolution digital elevation models (DEM), performed with the semi-automatic procedure of Pessina and Fiorini (2014). The software adopted for the analyses is the ArcGIS (ESRI) software (https://www.esri.com/it-it/arcgis/products/arcgis-desktop/overview).
The topographic class T1-T4 (specified in the Italian seismic code NTC08/18), is assigned to the stations through the combination of ridge and slope codes as described in Pessina and Fiorini (2014). Fig. 1 shows the ridge code and slope code definition, while Fig. 2 shows their combinations generating the topographic classes, including the unclassifiable combinations (NC) that are manually reviewed by an expert and reassigned, if possible.

Ridge

Min	Max	Sum	% of Cases	Description	*Ridge_code*
0	0	0	73.87	No ridge	*R0*
0	1	1–14	25.99	If SUM < *D*, the ridge is closet to the station, $H_{30} > 30$	*R1*
				If SUM ≥ *D* the station is presumably on the ridge, $H_{30} > 30$	*R2*
1	1	1	0.13	Station on the ridge	*R2*

Slope

Min	Max	Mean	% of Cases	Description	*Slope_code*
0	0	0	58.68	No slope, flat area	*S0*
0	1	1–46	27.54	$H_{30} < 30$	*S0*
				If MEAN ≤ 1, small part of the area around the station is slope in the [15°–30°] range; $H_{30} > 30$	*S1*
				If MEAN > 1, significant part of the area around the station is on slope in the [15°–30°] range; $H_{30} > 30$	*S2*
0	2	20–76	10.10	Presence of flat zone, slope in the [15°–30°] range and slope > 30°	*S3*
1	1	41–42	1.03	Full slope in the [15°–30°] range	*S2*
1	2	51–77	2.32	Full slope > 15°	*S4*
2	2	96	0.13	Full slope > 30°	*S5*

Fig.1: Zonal statistical analysis parameters and their combination in the ridge and slope characterization, from Pessina and Fiorini (2014).

	Ridge_code		
	R0	***R1***	***R2***
Slope_code			
S0	T1	T1	T1
S1	NC	NC	NC
S2	T2	T2	T3
S3	NC	NC	T3
S4	T2	T4	
S5	T2		

NC=not directly classifiable.

Fig. 2: Definition of topographic classes according to the combination of ridge code and slope code, modified from Pessina and Fiorini (2014).

- **T1:** Localities without amplification effects, with average slope **i**<15°. Note that some stations classified as T1 are located close to the ridge on very gentle hills or on elongated elevations with H<30m. Amplification factor =1.
- **T2:** Stations on slopes with average inclination **i**>15°, without presence of ridge or, when the ridge is close, without accentuate slope (**i**<30°). Most of these cases refer to stations located on a slope or close to a flat morphological platform. Amplification factor =1.2.
- **T3:** Stations in areas characterized by average inclination 15°<**i**<30° on reliefs with ridge top width much smaller than the base. Amplification factor =1.2.
- **T4:** Stations in areas with average inclination **i**>30° on reliefs with ridge top width much smaller than the base. Amplification factor =1.4
- **NC**: Stations in not classifiable areas.

This analysis was applied on the global scale DEM model GDEM v.2 (https://asterweb.jpl.nasa.gov/gdem.asp) with a resolution of 1" which corresponds to horizontal values between 21 and 24 m and a vertical accuracy between 7 and 50 m for the Italian territory (Hirano, Welch and Lang 2003), indicated on website as DEM resolution=30m. The same analysis was also applied on the DEM TINITALY/01 model with a resolution of 10 m and vertical accuracy between 0.8 and 6 m (Tarquini, et al. 2017), indicated on the website as DEM resolution=10m.
The accelerometric sites from http://ismd.mi.ingv.it/ get the slope analysis with DEM GDEM v.2 resolution, the sites from the national network RSN get the analysis with both models.