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Deliverable # D12

Critical review of methods proposed in the literature for seismic site classification

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1. Description of the Deliverable

Introduction

Significant damage and loss of life has been directly related to the effects of local site conditions during recent earthquakes (1985 Mexico City, 1989 Loma Prieta, 1994 Northridge, 1995 Kobe, 1999 Chi-Chi, among others). Site effects should be inevitably present in seismic code provisions, and the selection of appropriate elastic response spectra according to soil categories is the simplest way to account for site effects in engineering projects and general-purpose hazard maps. Ground motion prediction equations also need a soil categorization, in order to quantify the variation of ground motion due to the presence of soil layers of different depths and nature.
The works of Borcherdt et al. (1992) and Borcherdt (1994) were the first to propose the adoption of the $Vs_{,30}$ parameter (average shear wave velocity of the upper 30m) as a tool to discriminate soil with similar seismic response. In engineering site investigation, 30m is a typical depth of borings and detailed site characterizations. Therefore, most of the site-effect studies in earthquake ground motions are based on the properties of the topmost 30m.
Outside the region where the method was developed (southern California) some doubts arose about the capability of $Vs_{,30}$ to predict amplification. Steidl (2000) found a poor correlation between site class and site amplification and suggested that a depth-to-basement parameter might be more useful to predict ground motion. Park and Hashash (2004) studied the problem in deep basins, with the example of the Mississippi embayment, finding that NEHRP provisions may not be appropriate for thick sediments because they are overconservative at short periods and underconservative at long periods. Stewart et al. (2003) enlarged the database to other tectonically active regions and added to the California earthquakes other events from Turkey and Japan, concluding that neither shear-wave classification nor detailed surface geology can provide an optimal predictive scheme when long periods are concerned ($T > 1$ sec). Di Giacomo et al. (2005) examined the case of a shallow velocity inversion, concluding that in this case $Vs_{,30}$ could also be misleading, while Gallipoli and Mucciarelli (2009) propose that $Vs_{,10}$ could predict site classification with the same performances of $Vs_{,30}$. They consider alternative soil classification schemes that include soil frequency besides the velocity profile, proposing that in this two-parameter approach $Vs_{,10}$ could substitute $Vs_{,30}$.
During the '80 alternative classification schemes were proposed, such as the Japan Road Association classification (1980, 1990), which parallely to the $Vs_{,30}$ used the predominant soil period to discriminate among classes, accounting, although in an indirect way, for soil thickness, the parameter invoked by many authors as the principal deficiency of the $Vs_{,30}$. The most recent works explore the predominant period as a more reliable tool for site classification.
In the paragraphs that follow the soil classification methods are grouped in three categories: i) methods based on the $Vs_{,30}$; ii) methods based on the soil predominant period and iii) methods based on a combination of several parameters

Methods based on $Vs_{,30}$

In 1978 the ATC 3 report of the Applied Technology Council, *Tentative Provisions for the Development of Seismic Regulation for Buildings* (ATC 1978) introduced the site effects in the U.S. seismic code, providing three soil categories characterized by distinct site coefficients S. These categories were based on statistical studies conducted by Seed and his co-workers (Seed et al., 1976) and by Mohraz (1976). After the experience of the Messico city earthquake a fourth category was introduced to represent deep soft clay deposits . Each category was associated to a spectral shape and the coefficient S only amplified the long period part of the spectrum (figure 1), while the soil acceleration was assumed to be equal or close to the rock acceleration. Four site classes were identified on the base of a description of soil type, depth and, in some cases, shear wave velocity. (table 1).

Soil Profile Type	Description	Site Coefficient, S
S_1	A soil profile with either (1) rock of any characteristic, either shale-like or crystalline in nature, that has a shear wave velocity greater than 2,500 feet per second or (2) stiff soil conditions where the soil depth is less than 200 feet and the soil types overlying the rock are stable deposits of sands, gravels, or still clays.	1.0
S_2	A soil profile with deep cohesionless or stiff clay conditions where the soil depth exceeds 200 feet and the soil types overlying rock are stable deposits of sands, gravels, or stiff clays.	1.2
S_3	A soil profile containing 20 to 40 feet in thickness of soft-to medium-stiff clays with or without intervening layers of cohesionless soils.	1.5
S_4	A soil profile characterized by a shear wave velocity of less than 500 feet per second containing more than 40 feet of soft clays or silts.	2.0

Table 1: Soil profile types and site factors for calculation of lateral force contained in seismic codes prior to the 1994 NEHRP provisions (from Dobry et al. 2000)

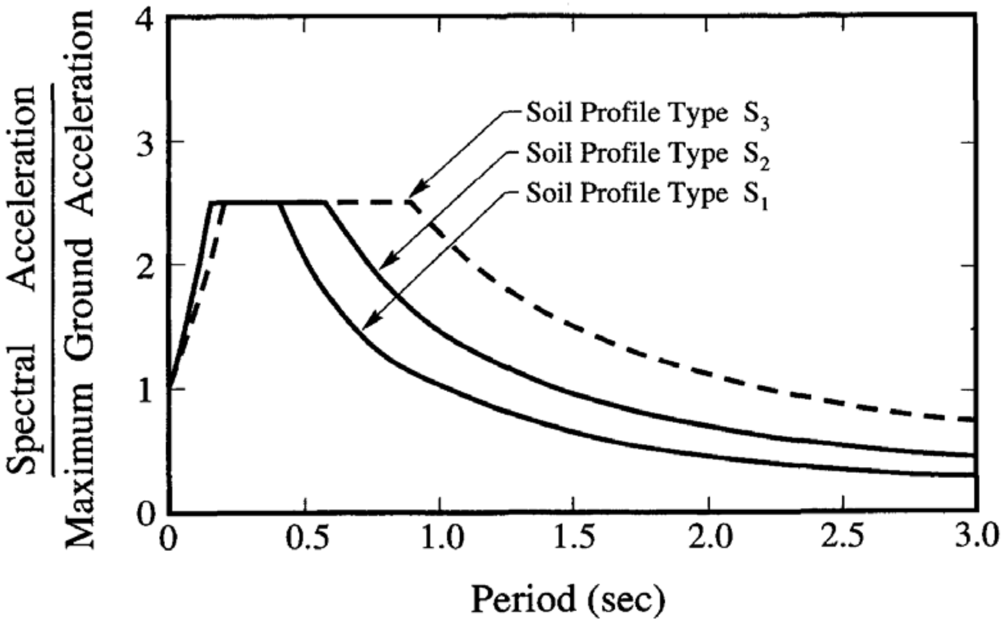


Figure 1: Spectral shapes proposed in seismic codes prior to the 1994 NEHRP provisions (from Dobry et al. 2000)

In 1994 Borcherdt developed intensity-dependent short and mid-long period amplification factors F_a and F_b, which replaced the single long-period amplification factor S. The two site coefficients depend both on soil category and intensity of ground shaking. Each soil category was unambiguously defined by the average shear wave velocity in the upper 30m, calculated as:

$$V_{s,30} = \frac{30}{\sum h/V_s} \quad (1)$$

Where V_s is the shear wave velocity in the interval h.

The parameters used to identify the amplification level were the average spectral ratios of single stations with respect to the nearest rock site, to minimize the effects of distance from the source and propagation. Averages of Fourier spectral ratios over specified period bands provide estimates of ground response useful for summarizing variations on a regional scale and pertinent to various types of structures. Averages over short (0.1 – 0.5 s), intermediate (0.5 – 1.5s), long- (1.5 – 5s), mid-period band (0.4 – 2.0s) and entire-period band (0.1 5.0s) were calculated. The author found that average spectral ratios increased with decreasing firmness of the deposits and, in particular, with the decreasing of the mean shear-wave velocity over the upper 30m. The amount of amplification is distinctly less for short-period motion than for intermediate-, long-, or mid-period.
Borcherdt (1994) site amplification factors are based primarily on observations from the 1989 Loma Prieta earthquake, which indeed showed significant nonlinear site response effects.

The 1997 NEHRP Provisions and 1997 Uniform Building Code (UBC) incorporates the works of Seed et al. (1991), Dobry et al. (1994) and Borcherdt (1994). The long-period amplification factor S, adopted before 1994, was substituted by short- and mid- period amplification factors, and the soil classification was based on objective parameters, such as the shear wave velocity value or, in alternative, by the number of blows in a Standard Penetration Test or by the undrained shear strength.

Soil profile type	Description	Shear wave velocity top 30 m (m/s)	Standard Pen. Resistance N (blows/ft)	Undrained shear strength (kPa)
A	Hard rock	> 1500	-	-
B	Rock	760-1500	-	-
C	Very dense soil/soft rock	360-760	> 50	> 100
D	Stiff soil	180-360	15 – 50	50 – 100
E	Soft soil	< 180	< 15	< 50
F	Special soils requiring site-specific evaluation	-	-	-

Table2: summary of soil profile types in 1997 NEHRP provisions and 1997 UBC.

The NEHRP classification scheme was almost entirely assimilated by the Eurocode 8 (*Eurocode 8: Design of structures for earthquake resistance, prEN 1998-1,* hereinafter referred to EC8). In the EC8 the soil classification is based on the same distinctive parameter as NEHRP, $Vs_{,30}$, (or, in alternative, on the number of blows in a Standard Penetration Test or on the undrained shear strength) and the influence of local ground conditions on the seismic action are generally accounted for by considering the five subsoil classes A, B, C, D and E, described by the stratigraphic profiles and parameters given in table 3. The earthquake motion at a given point of the surface is generally represented by an elastic ground acceleration response spectrum, whose shape is defined by a set of equations function of: vibration period of a linear single degree of freedom system (*T*), design ground acceleration (a_g), modification factor to account for special regional situations (*k*), limits of the constant spectral acceleration branch (*TB* and *TC*), value defining the beginning of the constant displacement response range of the spectrum (*TD*), soil coefficient (*S*) and damping correction factor with reference value 5% (η).

Subsoil class	Description of stratigraphic profile	Parameters		
		$V_{s,30}$ (m/s)	N_{SPT} (bl/30cm)	c_u (kPa)
A	Rock or other rock-like geological formation, including at most 5m of weaker material at the surface	> 800	_	_
B	Deposits of very dense sand, gravel, or very stiff clay, at least several tens of m in thickness, characterised by a gradual increase of mechanical properties with depth	360 – 800	> 50	> 250
C	Deep deposits of dense or medium-dense sand, gravel or stiff clay with thickness from several tens to many hundreds of m	180 – 360	15 - 50	70 – 250
D	Deposits of loose-to-medium cohesionless soil (with or without some soft cohesive layers), or of predominantly soft-to-firm cohesive soil	< 180	< 15	< 70
E	A soil profile consisting of a surface alluvium layer with $V_{s,30}$ values of class C or D and thickness varying between about 5 m and 20 m, underlain by stiffer material with $V_{s,30}$ > 800 m/s			
S_1	Deposits consisting – or containing a layer at least 10 m thick – of soft clays/silts with high plasticity index (PI > 40) and high water content	< 100 (indicative)	_	10 – 20
S_2	Deposits of liquefiable soils, of sensitive clays, or any other soil profile not included in classes A –E or S_1			

Table 3: soil categories in the EC8 seismic provision.

The Italian *Norme tecniche per le costruzioni* (Chapt. 3 *Azioni sulle costruzioni*, Par. 3.2 *Azione sismica*) propose the same soil categories as identified in the EC8 code. The direct measure of the shear wave velocity propagation is strongly recommended. Nevertheless, when a direct estimate is not feasible, the classification may be alternatively done on the base of the

number of blows of a *Standard Penetration Test* ($N_{SPT,30}$), for coarse grained terrain, or on the base of undrained soil strength ($cu_{,30}$) for soft soils.
The main differences between EC8 and NEHP are:

- NEHRP accounts for two different type of rock sites (Hard rock, Vs,30 > 1500 m/s and rock, Vs,30 between 760 and 1500 m/s), while EC8 does not;

- EC8 differentiate, among stiff sites, class E, which is characterized by a high impedance ratio between rock and soil (and generally has high amplification values).

Methods using the soil predominant period

Parallely to the definition of the NEHRP provisions, in the '80 the Japanese Road Association (JRA) came up with a soil classification scheme based on both $Vs_{,30}$ and predominant soil period, which is an indirect way to account for soil depth.
They distinguished the four classes listed in table 4.

Subsoil class	Description	$Vs_{,30}$ (m/s)	f_0(Hz)	T_0 (s)
SC I	Rock or stiff soil	> 600	> 5	< 0.2
SC II	Hard soil	300 – 600	5-2.5	0.2 – 0.4
SC III	Medium soil	200 – 300	2.5-0.166	0.4 – 0.6
SC IV	Soft soil	< 200	<0.166	> 0.6

Table 4: classification scheme adopted by Japanese Road Association (1980, 1990).

This classification scheme does not recommend any threshold in fundamental periods for rock sites, for which identifies a threshold of 600 m/s for $Vs_{,30}$. Figure 2 compares this classification scheme with EC8 and NEHRP. The most relevant feature is that class SCI of JRA is equivalent to calls A and part B of EC8 and class A, B and C of NEHRP.

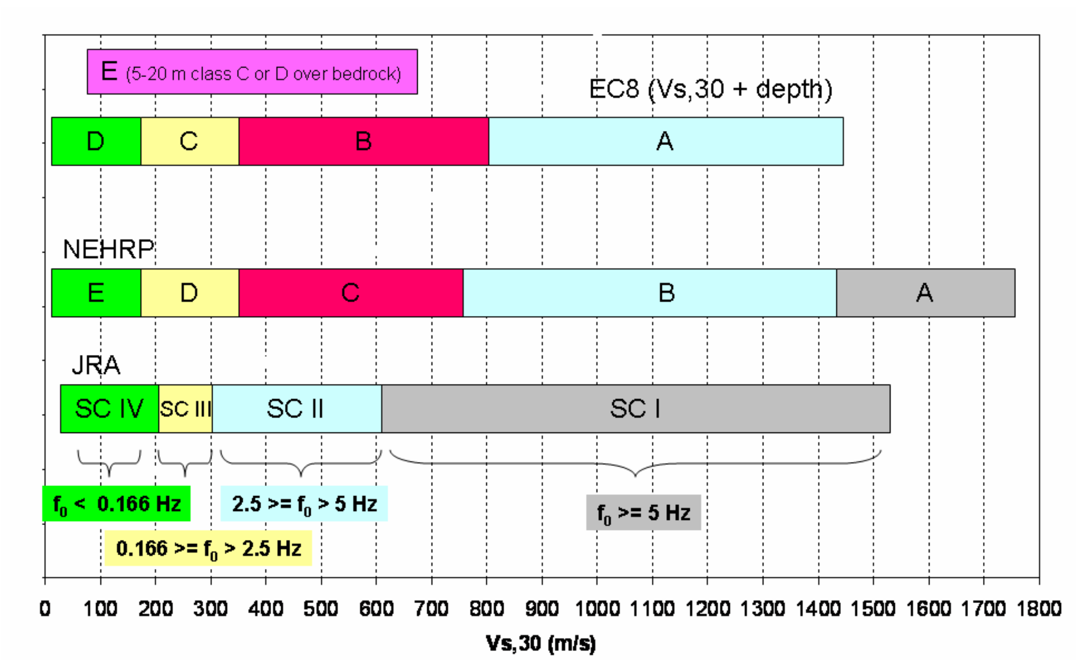


Figure 2: comparison among EC8, NEHRP and Japan Road Association classification

Different ways can be followed to calculate the fundamental frequency from empirical observations, that is Standard Spectral Ratio, the Horizontal to Vertical Fourier spectral ratio at single station (HVSR) or horizontal to vertical response spectra ratio (HVRSR). The horizontal to vertical spectral ratio can be performed on earthquake or ambient noise recordings. Alternatively the fundamental frequency can be evaluated from theoretical modelling, if a geotechnical model of the site is available.

Zhao et al. (2006) proposed a classification scheme based on the site fundamental period. They pointed out the advantages of using HVRSR versus shear-wave velocity profiles for the classification of seismic stations and introduced an empirical site classification method based on the mean HVRSR amplitude across all periods for strong-motion stations in Japan.
The use of the H/V acceleration response spectra ratio instead of the conventional receiver function method has many reasons. Smoothing the Fourier spectra is essential in the computation of spectral ratios and the smoothing method and the extent of the smoothing have to be consistent for all records. It is also essential that a large number of records should be used so that spikes due to causes unrelated to the site response can be removed by averaging the spectral ratios of a number of records. When a large number of stations needs to be classified, the amount of effort and time is enormous. Instead of Fourier spectral ratios, H/V ratios of 5% damped response spectra can be used (Yamazaki and Ansary, 1997). The undamped response spectrum of an earthquake record is very similar to the Fourier spectrum, and the damping used in calculating a response spectrum has a smoothing effect. For a damping ratio of 5% the response spectra have few spikes, and the smoothing effect is similar for all records if the same damping ratio is used.

Fukushima et al. (2007) classified sites based on their predominant period computed using average horizontal-to-vertical (H/V) response spectral ratios and examined the impact of this classification scheme on empirical ground-motion models. One advantage of this classification is that deep geological profiles and high shear-wave velocities are mapped to the resonance frequency of the site (table 5). The classification scheme was applied to the database of Fukushima et al. (2003), for which stations were originally classified as simply rock or soil. Ground-motion prediction equations were then computed using this alternative classification scheme. The aleatoric variability of these equations (measured by their standard deviations) was slightly lower than those derived using only soil and rock classes. However, predicted response spectra were radically different to those predicted using the soil/rock classification.

Site classes	Site natural period	Average shear wave velocity	NEHRP class
SC-1	$TG<0.2s$	$Vs30>600$ m/s	A+B
SC-2	$0.2s\leq TG<0.6s$	200 m/s$\leq Vs30<600$	C+D
SC-3	$0.6s\leq TG$	$Vs30\leq200$ m/s	E
SC-4*	Unknown	$Vs30>800$ m/s	A+B
SC-5*	Unknown	300 m/s$\leq Vs30<800$ m/s	C

Table 5: Site class definition used Fukushima et al. (2007) and the approximate correspondence with NEHRP site classes (* = SC-4 and SC-5 are general rock and soil classes that were impossible to classify using the new procedure).

Methods based on a combination of several parameters

Rodriguez Marek et al. (2001) proposed a simplified empirically based seismic site response evaluation procedure that includes measures of the dynamic stiffness of the superficial materials and the depth to bedrock as primary parameters (table 6). This classification scheme provides and alternative to geologic-based and shear wave velocity based site classification schemes. They analyse the ground motion data from the 1989 Loma Prieta and 1994 Northridge earthquakes and developed ground motion prediction equations for elastic 5% damped acceleration response spectra. Period-dependent and intensity-dependent spectral acceleration amplification factors for different site conditions are presented. The proposed scheme results in significant reduction in the standard error when compared to a simple rock/soil. Moreover they found that the sites generally classified as rock should be subdivided into competent rock and soft/weathered rock to reduce uncertainties in the predictions. Results show also that depth is an important parameters in estimating seismic site response.

Site	Description	Site Period	Comments
A	Hard Rock	≤ 0.1 s	Hard, strong, intact rock; $V_s \geq 1500$ m/s
B	Rock	≤ 0.2 s	Most "unweathered" California rock cases ($V_s \geq 760$ m/s or < 6 m of soil).
C-1	Weathered/Soft Rock	≤ 0.4 s	Weathered zone > 6 m and < 30 m (V_s > 360 m/s increasing to > 700 m/s).
-2	Shallow Stiff Soil	≤ 0.5 s	Soil depth > 6 m and < 30 m
-3	Intermediate Depth Stiff Soil	≤ 0.8 s	Soil depth > 30 m and < 60 m
D-1	Deep Stiff Holocene Soil, either **S** (Sand) or **C** (Clay)	≤ 1.4 s	Soil depth > 60 m and < 200 m. Sand has low fines content (< 15%) or nonplastic fines (PI < 5). Clay has high fines content (> 15%) and plastic fines (PI > 5).
-2	Deep Stiff Pleistocene Soil, **S** (Sand) or **C** (Clay)	≤ 1.4 s	Soil depth > 60 m and < 200 m. See D_1 for S or C sub-categorization.
-3	Very Deep Stiff Soil	≤ 2 s	Soil depth > 200 m.
E-1	Medium Depth Soft Clay	≤ 0.7 s	Thickness of soft clay layer 3 m to 12 m
-2	Deep Soft Clay Layer	≤ 1.4 s	Thickness of soft clay layer > 12 m.
F	Special, e.g., Potentially Liquefiable Sand or Peat	≈ 1 s	Holocene loose sand with high water table ($z_w \leq 6$ m) or organic peat.

Table 6: classification scheme proposed by Rodriguez-Marek et al. (2001)

Pitilakis et al. (2006) proposed improved spectral amplification factors for different site conditions based on an extensive theoretical and experimental study of the characteristics of seismic ground response. They analyzed a large set of worldwide well-documented strong motion recordings and performed a large number of theoretical analyses (~600) of various representative models of realistic site conditions.
Special emphasis was given to the non-linear soil behaviour, the impedance contrast between bedrock and soil deposits, the thickness of soil deposits and the presence of a lower stiffness soil layer near the ground surface. The selected soil models and the applied numerical code were validated with real recordings at about 100 well-documented sites in Greece and worldwide. They determined statistically the basic parameters that influence the characteristics of seismic vibration in the defined soil categories and presented the categorization of subsoil conditions shown in table 7, including parameters like thickness of the soil deposits, depth to bedrock, fundamental period of the site, stratigraphy, soil type, mean Vs value determined in the entire thickness etc. They also propose the corresponding response spectra shapes.

SOIL CATEG.		DESCRIPTION	To (sec)	REMARKS
A	A_1	Healthy rock formations		Vs ≥1500 m/s
	A_2	Slightly weathered/segmented rock formations,(thickness of weathered layer < 5.0m)	≤0.2	Weak layer: V_s ≥ 300 m/s Rock form.: V_s ≥ 800 m/s
		Geologic formations which resemble to rock formations in their mechanical properties and their composition (e.g. conglomerates)		V_s ≥ 800 m/sec
B	B_1	Highly weathered rock formations whose weathered layer has a considerable thickness of 5.0 - 30.0m	≤ 0.4	Weathered layer: $V_{s\,(1)}$ ≥ 300 m/s
		Soft rock formations of great thickness or formations of similar stiffness and mechanical properties (e.g. stiff marls)		V_s = 400 - 800 m/s $N_{SPT(2)}$ > 50 $S_{u(3)}$>200KPa
		Homogeneous soil formations of very dense sand – sand gravel and/or very stiff clay, and small thickness (less than 30.0m)		V_s = 400 - 800 m/s N_{SPT} > 50 S_u >200Kpa
	B_2	Homogeneous soil formations of very dense sand – sand gravel and/or very stiff clay, and medium thickness (30.0 - 60.0m), whose mechanical properties and stiffness increase with depth	≤0.8	V_s = 400 - 800 m/s N_{SPT} > 50 S_u >200Kpa
C	C_1	Soil formations of dense to very dense sand–sand gravel and/or stiff to very stiff clay, of great thickness (>60.0m), whose mechanical properties and strength are constant and/or increasing with depth	≤1.2	V_s = 400 - 800 m/s N_{SPT} > 50 S_u >200KPa
	C_2	Soil formations of medium dense sand – sand gravel and/or medium stiffness clay (PI > 15, fines percentage > 30%) of medium thickness (20.0m – 60.0m)	≤1.2	V_s = 200 - 400 m/s N_{SPT} > 20 S_u >70KPa
	C_3	Category C2 soil formations of great thickness (>60.0 m), homogenous or stratified that are not interrupted by any other soil formation with a thickness of more than 5.0m and of lower strength and Vs velocity	≤1.4	V_s = 200 - 400 m/s N_{SPT} > 20 Su >70KPa
D	D_1	Recent soil deposits of substantial thickness (up to 60m), with the prevailing formations being soft clays of a high plasticity index (PI>40), with a high water content and low values of strength parameters	≤ 2.0	V_s ≤200 m/s N_{SPT} < 20 Su <70KPa
	D_2	Recent soil deposits of substantial thickness (up to 60m), with prevailing fairly loose sandy to sandy-silty formations with a substantial fines percentage (so as not to be considered susceptible to liquefaction)	≤2.0	V_s ≤200 m/s N_{SPT} < 20
	D_3	Soil formations of category C with Vs >300m/s and great overall thickness (>60.0m), interrupted at the first 40 meters by soil layers of category D1 or D2 of a small thickness (5 – 15m),	≤ 1.2	
E		Surface soil formations of small thickness (5m - 20m), small strength and stiffness, likely to be classified in category C or D according to geotechnical properties, which overlie category A formations (Vs≥ 800 m/s).	≤0.5	Surface soil layers: V_s = 150 - 300 m/s
X		- Loose fine sandy-silty soils beneath the water table, susceptible to liquefaction (unless a special study proves no such danger, or if the soil's mechanical properties are improved). - Soils near well documented seismically active tectonic faults. - Steep slopes covered with loose lateral deposits. - Loose granular or soft silty-clayey soils, provided they have been proven to be hazardous in terms of dynamic compaction or loss of strength, Recent loose landfills. - Soils with a very high percentage in organic material.		
(1), (2), (3) : *mean values over the whole soil column until the bedrock.*				

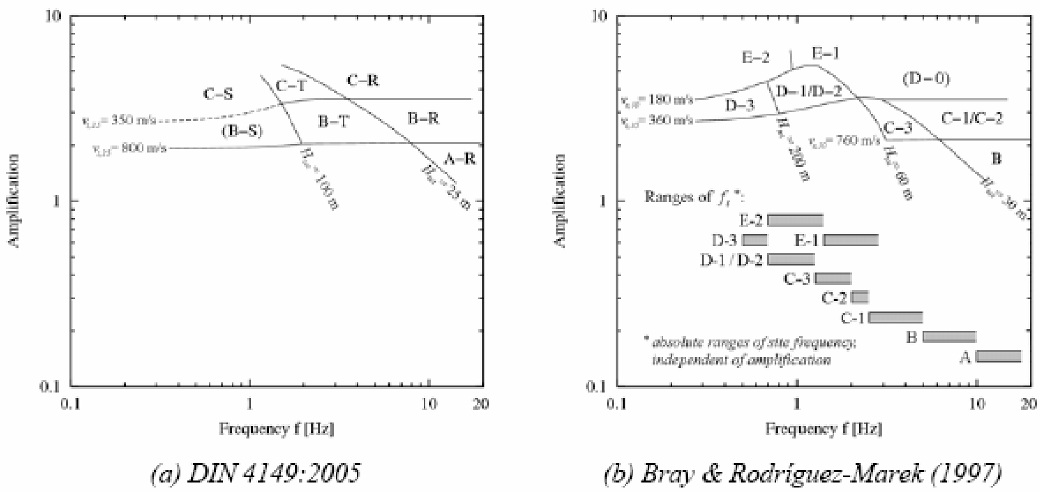
Table 7: classification scheme proposed by Pitilakis et al. (2006)

Cadet et al. (2008) proposed an alternative site classification and the associated spectral shapes, that could be easily used in building codes and microzonation studies. The site classification is based on a two-parameter characterization, consisting of the average shear wave velocity, VS_z, over the top z meters (z between 5 and 30), and the site fundamental frequency f_0. A comprehensive analysis on about 500 sites from the KIKNET network, shows that f_0 is very poorly correlated with any of the VS_z values, thus providing independent, complementary information on the overall thickness and stiffness of sedimentary cover, and the surface stiffness. The corresponding site amplification factors are derived empirically from the average surface / downhole (SDSR) spectral ratios, with a correction procedure to normalize the raw SDSR to a standard reference (with VS_{30} = 800 m/s) located at surface. The correlation between site parameters and site amplification factors is achieved by normalizing the frequency axis with respect to f_0, and a least-square fit of the amplitude with VS_z. The largest variance reduction is obtained for the couple (VS_{30}, f_0), while a very simple site classification based only on f_0 also leads to satisfactory misfit values (table 8). The authors claim that VS_{30} and f_0 parameters are easily available from non-invasive survey techniques (ambient vibrations, MASW, SASW).

Site parameters	Overall misfit value
f_0 and $Vs_{,5}$	0.182
f_0 and $Vs_{,10}$	0.178
f_0 and $Vs_{,20}$	0.172
f_0 and $Vs_{,30}$	0.169
f_0 alone	0.186
Initial std	0.27

Table 8: overall misfits obtained from the correlation between site parameters and site amplification factors

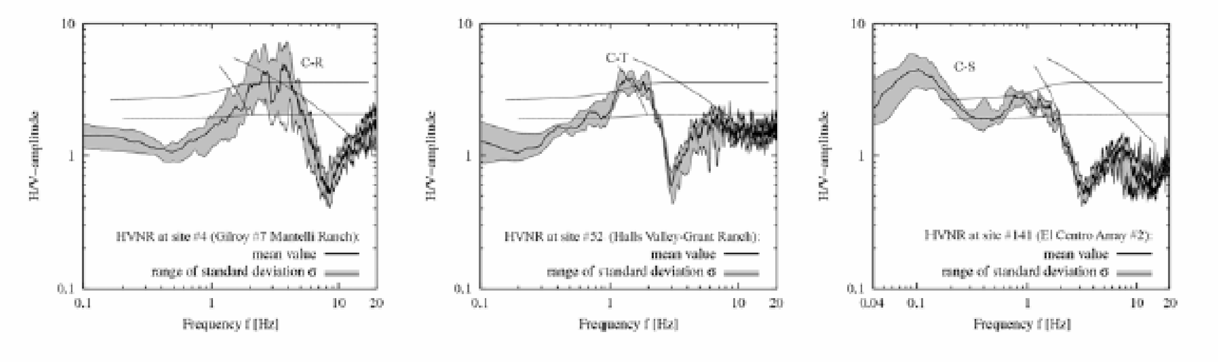
Lang and Schwartz (2006) proposed a site classification method based on the spectral H/V-ratios of microtremor data recorded at the ground surface. They assume that these ratios represent the quasi-transfer function of the underlying soil profile, and therefore a quick site classification can be carried out by comparing the shape of H/V-ratio with the transfer function of a complying theoretical model profile or by simply arranging the H/V-peak into ranges of possible peak locations. According to the authors this site classification scheme contains more information about the site than the commonly used average shear-wave velocity in the upper 30m. The scheme involves the total thickness of sedimentary layers over geological bedrock in addition to the shear-wave velocities. Due to standardization reason, the classification avails oneself of the site classes individuated by Bray and Rodríguez-Marek (1997) and the seismic code provisions, adopted in Germany (DIN 4149:2005). Since the site classes of both classification schemes can be described by a range of average shear-wave velocity in the uppermost soil materials ($Vs_{,25}$ resp. $Vs_{,30}$) and by a range of total sedimentary thickness H_{tot}, a variety of onedimensional subsoil profiles can be modelled to meet the upper and lower boundary conditions of the respective site class.
Figure 3 depicts the ranges of possible peak locations for generated site classes based on the criteria of DIN 4149:2005 and Bray and Rodríguez-Marek (1997).



(a) DIN 4149:2005 *(b) Bray & Rodríguez-Marek (1997)*

Figure 3 Qualitative ranges of possible peak locations of one-dimensional transfer functions for (a) site-specific subsoil classes according to DIN 4149:2005 and (b) refined NEHRP site classes by Bray & Rodríguez-Marek (1997).

Figure 4 illustrates the classification of 3 recording sites into the site classes of DIN 4149:2005. Even though each of the three sites were classified as soft soil sites according to conventional procedures (Vs,30 < 360 m/s), a more refined classification can be achieved by considering the range of sedimentary soil thickness H_{tot}.



(a) 1595: Gilroy #7 Mantelli Ranch *(b) 1422: Halls Valley – Grant Ranch* *(c) 5115: El Centro Array #2*

Figure 4: Spectral H/V-ratios of microtremors overlain with the classification scheme based on DIN 4149:2005 site classes.

2. Relevance for DPC and/or for the scientific community

This deliverable is relevant for the DPC and the scientific community since it provides the state of the art on the topic of soil classification for engineering seismology and earthquake engineering purposes, such as evaluation of ground motion prediction equations or definition of response spectra shapes for seismic codes.

3. Changes with respect to the original plans and reasons for it

No changes with the respect to original plans occurred during the first year of the project

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5. Key publications/presentation

Luzi L., Pacor F., Puglia R., Parolai S., Mucciarelli M., Gallipoli M. R. Paolucci R. (2009) Characterization of Italian strong motion recording sites in the perspective of a new classification. SSA Annual Meeting 8-10 April 2009, Monterey, California (Poster presentation)

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