Agreement INGV-DPC 2007-2009

Project S4: ITALIAN STRONG MOTION DATA BASE

Responsibles: Francesca Pacor, INGV MIlano – Pavia
and Roberto Paolucci, Politecnico Milano

http://esse4.mi.ingv.it

Appendix C

EC8 subsoil classification of ITACA stations based on Vs profiles (V_{S30})

June 2010

edited by:

UR6 - Giuseppe Lanzo, Sapienza University of Rome

1. EC8 subsoil classification

It's well known that the EC8 code (CEN, 2004) divides soil sites into five "Ground Types", namely A, B, C, D and E (excluding the two special categories S1 and S2). These five ground types are identified in terms of their stratigraphic description, the approximate thickness H of soil deposits and the average values of the SPT blow count N_{SPT}, the undrained shear strength Cu and the shear wave velocity V_{S30}. This latter parameter is the equivalent shear wave velocity in the upper 30 m, which is defined according to the following equation:

$$V_{s30} = \frac{30}{\sum \frac{h_i}{V_{si}}}$$

where V_{si} is the shear wave velocity of the i-th layer having thickness h_i. The different ground types according to the EC8 classification system are reported for convenience in Table 1.

Table 1 – Ground types according to EC8 classification system

Subsoil	Description of stratigraphic profile	Parameters		
		$V_{s,30}$ [m/s]	N_{SPT} (blows/30cm)	c_u [kPa]
A	Rock or other rock-like geological formation, including at most 5 m of weaker material at the surface	> 800	-	-
B	Deposits of very dense sand, gravel, or very stiff clay, at least several tens of meters in thickness and characterized 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 thicknesses from several tens to many hundreds of meters	180 - 360	15 - 50	70 - 250
D	Deposits of loose-to-medium noncohesive soil (with or without some soft cohesive layers), or of predominantly soft-to-firm cohesive soil	< 180	< 15	< 70
E	Soil profile consisting of a surface alluvium layer with $V_{s,30}$ values of type C or D, and thicknesses varying between 5 m and 20 m, underlain by stiffer materials 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	-	10 -20
S_2	Deposits of liquefiable soils, sensitive clays, or any other soil profile not included in types A-E or S_1			

2. Classification of ITACA stations based on Vs profile (V_{S30})

The activity carried out by RU6 concerned the completion of the catalogue of ITACA recording stations having shear wave velocity profile. The Vs profile was then used to provide site classification according to EC8 system. For the stations with V_S profile geotechnical data, if available, were also collected, organized and synthesized in the station monograph.

Moreover, a synthesis of information relevant to site classification was also reported in the station monograph including the depth of bedrock and the average V_S to bedrock.

The compilation of the stations with V_S profile was made using the data already available or collected in the previous S6 project (DPC-INGV 2004-2006 agreement) and that obtained in the framework of the new S4 Project, collected as well as measured from *ad hoc* in situ tests carried out by different research units. Overall, 102 monographs with V_S profile were compiled using the new standard format.
If the velocity profile was available only to depth d< 30m, a correlation between shallow velocity and V_{S30} was used. Specifically, V_{S30} was determined by means of the relationship calibrated based on the borehole data of the KikNet network (Figini, 2006), which is reported below:

$$\log V_{s,30} = a + b \log V_{s,d}$$

In this equation V_{Sd} is the equivalent shear wave velocity to a depth d< 30m, calculated according to the following equation:

$$V_{s,d} = \frac{d}{\sum \frac{h_i}{V_{s,i}}}$$

while a and b are regression coefficients tabulated for each depth d. The a and b values are summarized in Table 2.

Table 2 – Values of the regression coefficients for calculating V_{S30} from V_{Sd} (d<30m)

d **(m)**	***a***	***b***	***d*** **(m)**	***a***	***b***
5	1,228	0,609	18	0,295	0,93
6	1,155	0,637	19	0,255	0,941
7	1,078	0,665	20	0,22	0,951
8	1,02	0,686	21	0,187	0,96
9	0,909	0,726	22	0,157	0,967
10	0,812	0,761	23	0,131	0,974
11	0,722	0,792	24	0,109	0,978
12	0,643	0,819	25	0,086	0,984
13	0,566	0,846	26	0,065	0,988
14	0,497	0,868	27	0,047	0,992
15	0,436	0,888	28	0,031	0,995
16	0,389	0,902	29	0,014	0,998
17	0,339	0,917	30	0	1

A list of the stations for which V_S profile is available is reported in Tables 3 (43 stations with V_S profiles from collected data) and 4 (61 stations with V_S profiles form in situ tests within

the S4 project-Task 3) together with the V_{S30} value and the EC8 site classification. The two stations Aquila Colle Grilli (AQG) and Aquila Valle Aterno (AQA) have been investigated by different research units by means of down-hole as well as MASW tests but the V_S profile reported in the monograph as well as the V_{S30} value are based on the DH test.

Table 3 – List of accelerometer stations with shear wave velocity profile obtained from collected data and EC8 site classification according to V_{S30}

#	Name	Code	V_{S30} (m/s)	EC8
1	AULETTA	ALT	1149	A
2	BISACCIA	BSC	997	A
3	SANNICANDRO GARGANICO	SNN	965	A
4	TARCENTO	TRC	901	A
5	ANCONA ROCCA	ANR	549	B
6	BAGNOLI IRPINO	BGI	498	B
7	BAGNONE	BGN	640	B
8	BENEVENTO	BNV	716	B
9	BORGO CERRETO CS	BCC	486	B
10	BOVINO	BVN	364	B
11	BRIENZA	BRN	402	B
12	CALITRI	CLT	495	B
13	CESENA	CSN	540	B
14	CITTÀ DI CASTELLO	CTC	390	B
15	FORGARIA CORNINO	FRC	454	B
16	LAURIA GALDO	LRG	603	B
17	MERCATO S. SEVERINO	MRT	483	B
18	NORCIA	NRC	687	B
18	PIEVE S. STEFANO	PVS	613	B
20	RIONERO IN VULTURE	RNR	538	B
21	S. SEVERO	SSV	390	B
22	SELLANO EST	SELE	520	B
23	SELLANO OVEST	SELW	518	B
24	STURNO	STR	382	B
25	TOLMEZZO DIGA AMBIESTA	TLM1	522	B
26	TRICARICO	TRR	467	B
27	VALLE ATERNO CENTRO VALLE	AQV	474	B
28	VIESTE	VSS	440	B
29	ANCONA PALOMBINA	ANP	256	C
30	BOJANO	BOJ	306	C
31	BUIA	BUI	258	C
32	FIRENZUOLA	FRE1	312	C
33	FORLÌ	FOR	295	C
34	GARIGLIANO	GRG2	191	C
35	GUBBIO PIANA	GBP	224	C
36	MAJANO PRATO	MAP	344	C
37	S. GIULIANO SCUOLA	SGIUB	391	C
38	SAN SEPOLCRO	SNS	322	C
30	COLFIORITO	CLF	140	D
40	ARIENZO	ARN	578	E
41	FIVIZZANO	FVZ	495	E
42	NOCERA UMBRA	NCR	534	E
43	S. CASCIANO DEI BAGNI	SSC	485	E

Table 4 – List of accelerometer stations with shear wave velocity profile obtained from in situ tests carried out within the S4 project and EC8 site classification according to V_{S30}

#	RU	Nome	Code	V_{S30} (m/s)	EC8
1	RU2-INGV RM1	BIBBIENA NUOVA	BBN	1000	A
2	"	DICOMANO	DCM	1000	A
3	"	ASSERGI	GSA	488	B
4	"	CASSINO	CSS	630	B
5	"	AVEZZANO	AVZ	199	C
6	"	BORGO8000	BTT	92	D
7	"	RIETI	RTI	170	D
8	RU4-PoliTO	ISPICA	ISI	1482	A
9	"	GENOVA	GNV	987	A
10	"	SANTA CROCE CAMERINA	SCR	894	A
11	"	RAGUSA	RGS	1091	A
12	"	AQUILA FIUME ATERNO	AQA	495	B
13	"	CALTAGIRONE	CLG	373	B
14	"	ECOURS	LS4	473	B
15	"	GEMONA	GMN	445	B
16	"	LASALLE	LS2	496	B
17	"	NOTO	NTE	710	B
18	"	PACHINO	PCH	593	B
19	"	PINEROLO	PNR	383	B
20		RONCO SCRIVIA	RNS	737	B
21	"	SESTRI LEVANTE	SEL	606	B
22	"	TORRE FARO (MESSINA) (CAB. ENEL)	TRF0	302	B
23	"	TORRE PELLICE 4	TP4	547	B
24	"	TORTONA	TRT	483	B
25	"	TORTORICI	TOR	525	B
26	"	VARESE LIGURE	VRL	758	B
27	"	GELA	GEA	245	C
28	"	PATTI (CAB. ENEL)	PTT0	251	C
29	"	TORRE PELLICE 7	TP7	290	C
30	"	CATANIA - PIANA	CAT	160	D
31	"	PALAZZOLO ACREIDE	PLZ	670	E
32	RU6-UNI RM1	AQUIL A FIUME ATERNO	AQA	552	B
33	"	AQUILA COLLE GRILLI	AQG	685	B
34	"	AQUILPARK	AQK	717	B
35	RU7-UniSI	AQUILA COLLE GRILLI	AQG	1150	A
36	"	AQUILA PETTINO	AQP	830	A
37	"	MARATEA	MRA	1020	A
38	"	MONTECASSINO	MTC	1000	A
39	"	MORMANNO	MRM	1400	A
40	"	PESCASSEROLI	PSC	1000	A
41	"	SCANNO	SCN	840	A
42	"	CAPESTRANO	CPS	730	B
43	"	MARSICO VETERE	MRV	680	B
44	"	PIGNOLA	PGA	430	B
45	"	SATRIANO DI LUCANIA	STL	390	B
46	"	TRICARICO	TRO	780	B
47	"	VIBO MARINA	VBM	450	B

48	“	VIBO VALENTIA	VBV	510	B
49	“	SPEZZANO SILA	SPS	320	C
50	RU8-GFZ	BAZZANO	BZZ	679	B
51	“	LAGONEGRO	LGN	431	B
52	“	NORCIA ZONA INDUSTRIALE	NRZI	557	B
53	“	ONNA	MI03	378	B
54	“	SANT ARCANGELO	SNA	420	B
55	“	CATTOLICA	CTL	208	C
56	“	FAENZA	FAZ	293	C
57	“	GRUMENTO NOVA	GRM	283	C
58	“	MODENA	MDN	213	C
59	“	NOVELLARA	NVL	190	C
60	“	ARGENTA	ARG	170	D
61	“	BEVAGNA	BVG	162	D

References

CEN (2004). Eurocode 8: “Design of Structures for Earthquake Resistance – Part I: General Rules, seismic actions and rules for buildings”, (EN-1998-1). Brussels, May 2004.

Figini R (2006). Analisi degli effetti di sito sui lunghi periodi degli spettri di risposta di spostamento. Master’s Thesis, Politecnico di Milano (in Italian).