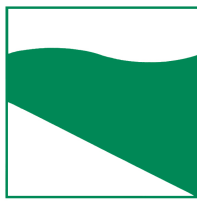




PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile



Regione Emilia-Romagna



CONFERENZA DELLE REGIONI E
DELLE PROVINCE AUTONOME

Attuazione dell'articolo 11 dalla legge 24 giugno 2009, n. 77

MICROZONAZIONE SISMICA

Livello 3

Allegato 2 – Report delle indagini

Regione Emilia–Romagna

Comune di San Benedetto Val di Sambro

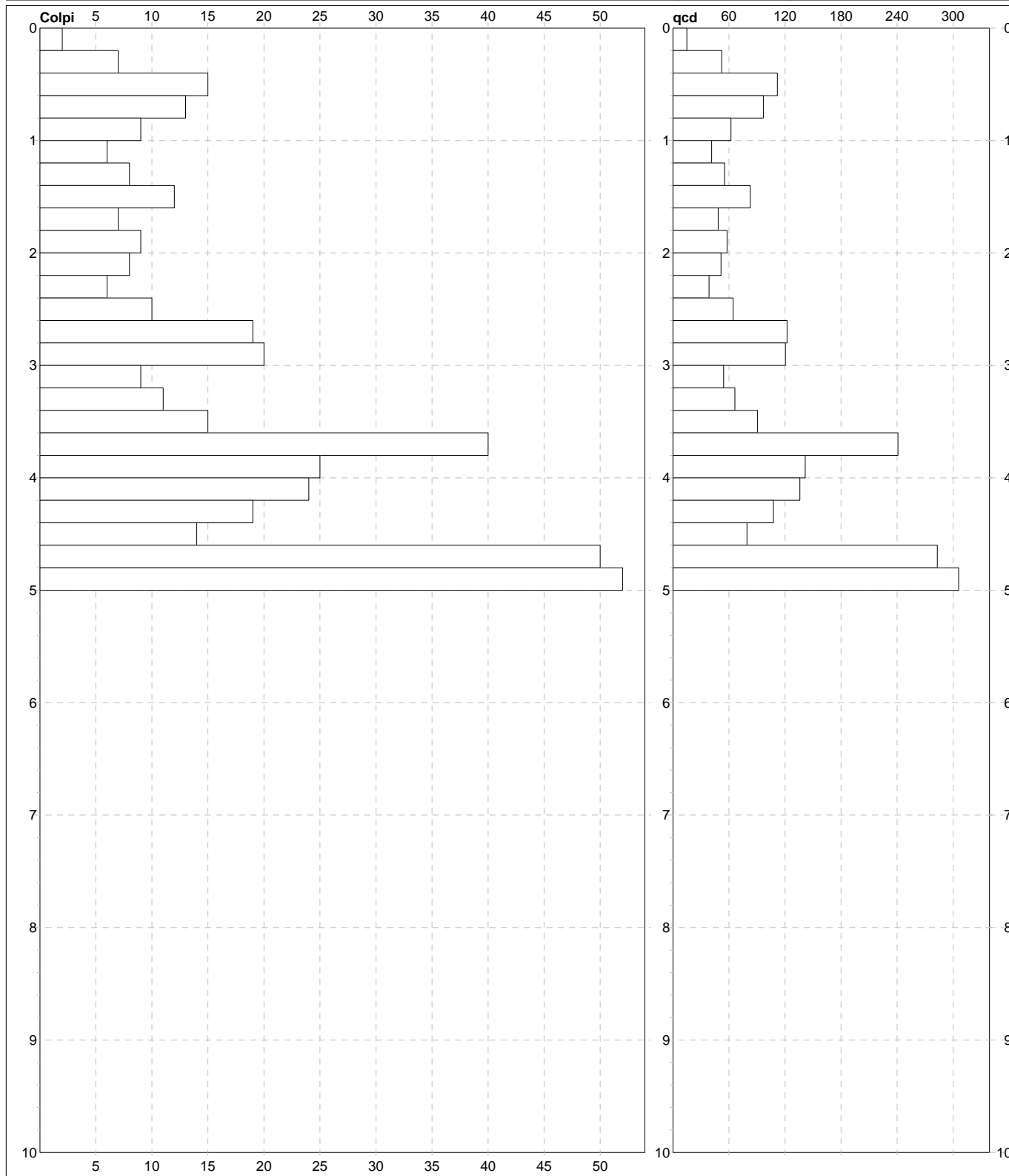


Regione	Soggetto realizzatore	Data
EMILIA–ROMAGNA		
Studio realizzato con il contributo di cui all'OCPC 532/2018 recepita con DGR 2047/2018	Dott. geologo Samuel Sangiorgi	Giugno 2023



PROVA PENETROMETRICA DINAMICA DIAGRAMMI COLPI / RESISTENZA	DIN	3
	riferimento	43-2022

Committente: dott geol Samuel Sangiorgi	U.M.: kg/cm²	Data esec.: 25/06/2022
Cantiere: 44.211749, 11.241214	Scala: 1:50	Quota ass.:
Località: SBenedetto Vdi Sambro	Pagina: 1	
	Elaborato:	Falda: Non rilevata



Penetrometro: DPSH (S. Heavy)	
Massa battente: 63.50 m	
Altezza caduta: 0.75 m	
Avanzamento: 0.20 m	



PROVA PENETROMETRICA DINAMICA LETTURE DI CAMPAGNA PUNTA E/O TOTALE	DIN	3
	riferimento	43-2022

Committente: dott geol Samuel Sangiorgi	U.M.: kg/cm²	Data esec.: 25/06/2022
Cantiere: 44.211749, 11.241214	Pagina: 1	
Località: SBenedetto Vdi Sambro	Elaborato:	Falda: Non rilevata

H m	Asta n°	L1 n°	L2 n°	qcd kg/cm ²	H m	Asta n°	L1 n°	L2 n°	qcd kg/cm ²
0.20	1	2		14.90					
0.40	1	7		52.14					
0.60	2	15		111.73					
0.80	2	13		96.83					
1.00	2	9		62.14					
1.20	2	6		41.43					
1.40	2	8		55.24					
1.60	3	12		82.85					
1.80	3	7		48.33					
2.00	3	9		57.91					
2.20	3	8		51.48					
2.40	3	6		38.61					
2.60	4	10		64.34					
2.80	4	19		122.25					
3.00	4	20		120.49					
3.20	4	9		54.22					
3.40	4	11		66.27					
3.60	5	15		90.36					
3.80	5	40		240.97					
4.00	5	25		141.58					
4.20	5	24		135.92					
4.40	5	19		107.60					
4.60	6	14		79.29					
4.80	6	50		283.16					
5.00	6	60		320.59					

H = profondità
L1 = prima lettura (colpi punta)
L2 = seconda lettura (colpi rivestimento)

qcd = resistenza dinamica punta
Asta = numero di asta impiegata

PROVA PENETROMETRICA DINAMICA SUDDIVISIONE GEOTECNICA	DIN	3
	riferimento	43-2022

Committente: dott geol Samuel Sangiorgi Cantiere: 44.211749, 11.241214 Località: SBenedetto Vdi Sambro	U.M.: kg/cm² Pagina: 1 Elaborato:	Data esec.: 25/06/2022 Falda: Non rilevata
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PARAMETRI GENERALI												
n°	profondità m	statistica	VCA colpi	β -	Nspt colpi	rpđ kg/cm²	qc kg/cm²	Vs m/sec	G kg/cm²	Q kg/cm²	natura	descrizione
1	0.00 : 0.20	Media	2	1.52	3	14.90	7.45	26	117	0.75	Torbosa	
2	0.20 : 3.60	Media	10	1.52	16	68.42	64.21	136	110	3.42	Coes./Gran.	
3	3.60 : 3.80	Media	40	1.52	61	240.97	216.87	213	322	12.05	Coes./Gran.	
4	3.80 : 4.60	Media	21	1.52	31	116.10	104.49	195	187	5.80	Coes./Gran.	
5	4.60 : 5.00	Media	55	1.52	84	301.88	311.48	237	416	15.09	Granulare	

			NATURA COESIVA					NATURA GRANULARE						
n°	profondità m	Nspt colpi	Cu kg/cm²	Ysat t/m³	W %	e -	Mo kg/cm²	Dr %	ø °	E' kg/cm²	Ysat t/m³	Yd t/m³	Mo kg/cm²	Liq. -
1	0.00 : 0.20	3	0.15	1.43	111.11	3.00	23	---	---	---	---	---	---	---
2	0.20 : 3.60	16	1.00	1.97	27.79	0.75	61	44	32	315	1.97	1.55	252	---
3	3.60 : 3.80	61	3.81	2.10	20.20	0.55	152	89	43	662	2.17	1.89	642	---
4	3.80 : 4.60	31	1.94	2.10	20.20	0.55	92	66	36	430	2.06	1.70	386	---
5	4.60 : 5.00	84	---	---	---	---	---	98	45	839	2.22	1.97	838	---



PROVA PENETROMETRICA DINAMICA DIAGRAMMI COLPI / RESISTENZA

DIN

4

referimento

43-2022

Committente: **dott geol Samuel Sangiorgi**

Cantiere: **44.224208, 11.193969**

Località: **Ripoli campo sportivo**

U.M.: **kg/cm²**

Scala: **1:50**

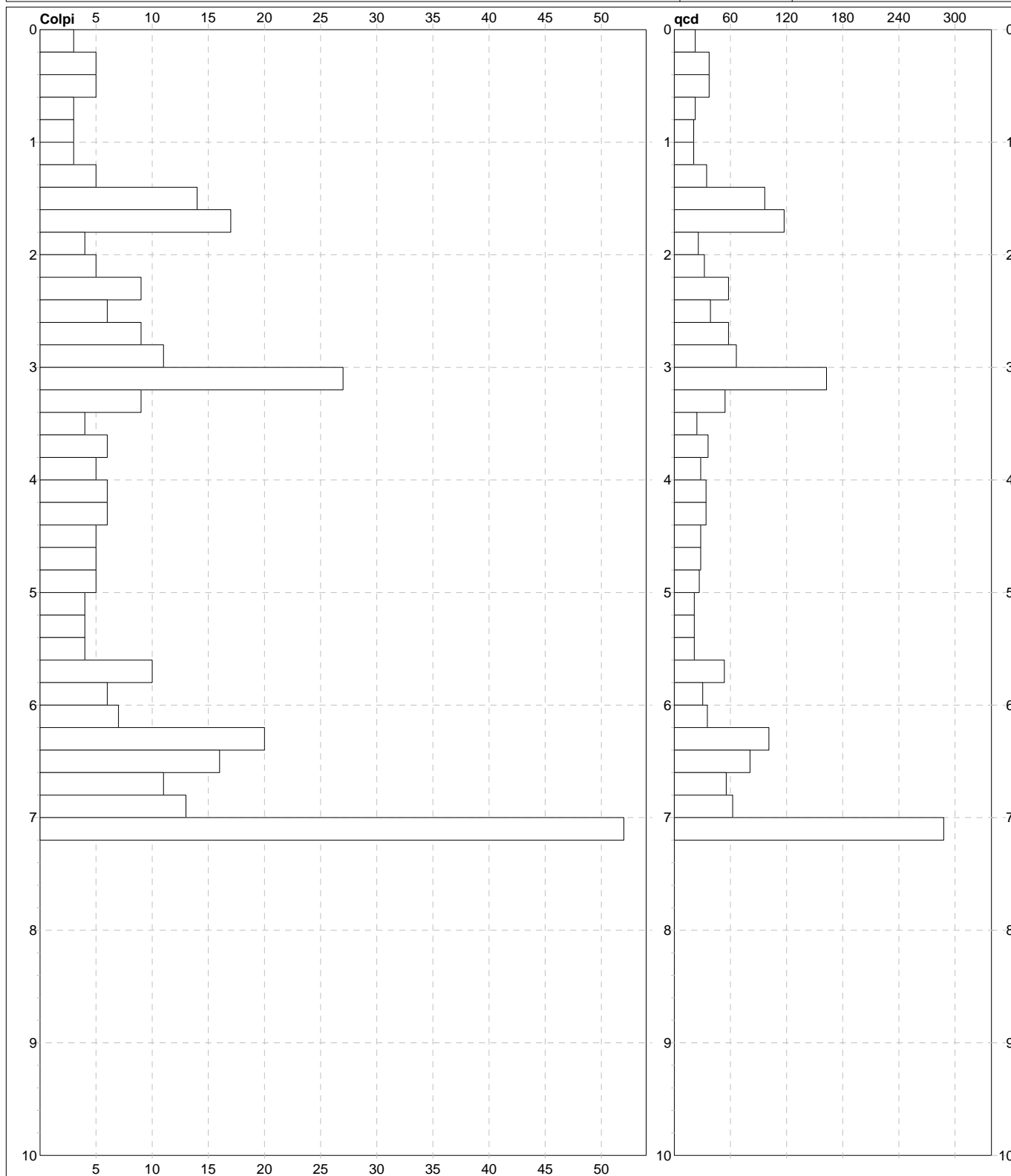
Pagina: **1**

Elaborato:

Data esec.: **25/06/2022**

Quota ass.:

Falda: **Non rilevata**



Penetrometro: **DPSH (S. Heavy)**

Massa battente: **63.50 m**

Altezza caduta: **0.75 m**

Avanzamento: **0.20 m**



PROVA PENETROMETRICA DINAMICA LETTURE DI CAMPAGNA PUNTA E/O TOTALE	DIN	4
	riferimento	43-2022

Committente: dott geol Samuel Sangiorgi	U.M.: kg/cm²	Data esec.: 25/06/2022
Cantiere: 44.224208, 11.193969	Pagina: 1	
Località: Ripoli campo sportivo	Elaborato:	Falda: Non rilevata

H m	Asta n°	L1 n°	L2 n°	qcd kg/cm ²	H m	Asta n°	L1 n°	L2 n°	qcd kg/cm ²
0.20	1	3		22.35					
0.40	1	5		37.24					
0.60	2	5		37.24					
0.80	2	3		22.35					
1.00	2	3		20.71					
1.20	2	3		20.71					
1.40	2	5		34.52					
1.60	3	14		96.66					
1.80	3	17		117.38					
2.00	3	4		25.74					
2.20	3	5		32.17					
2.40	3	9		57.91					
2.60	4	6		38.61					
2.80	4	9		57.91					
3.00	4	11		66.27					
3.20	4	27		162.66					
3.40	4	9		54.22					
3.60	5	4		24.10					
3.80	5	6		36.15					
4.00	5	5		28.32					
4.20	5	6		33.98					
4.40	5	6		33.98					
4.60	6	5		28.32					
4.80	6	5		28.32					
5.00	6	5		26.72					
5.20	6	4		21.37					
5.40	6	4		21.37					
5.60	7	4		21.37					
5.80	7	10		53.43					
6.00	7	6		30.34					
6.20	7	7		35.40					
6.40	7	20		101.14					
6.60	8	16		80.91					
6.80	8	11		55.63					
7.00	8	13		62.40					
7.20	8	60		288.02					

H = profondità
L1 = prima lettura (colpi punta)
L2 = seconda lettura (colpi rivestimento)

qcd = resistenza dinamica punta
Asta = numero di asta impiegata

n°	profondità m	Nspt colpi	Cu kg/cm²	Ysat t/m³	W %	e -	Mo kg/cm²	Dr %	ø °	E' kg/cm²	Ysat t/m³	Yd t/m³	Mo kg/cm²	Liq. -
1	0.00 : 1.40	6	0.38	1.85	37.04	1.00	36	22	28	238	1.89	1.43	139	---
2	1.40 : 1.80	24	1.50	2.07	21.91	0.59	77	56	34	376	2.01	1.63	326	---
3	1.80 : 3.00	11	0.69	1.91	32.11	0.87	50	37	30	276	1.94	1.51	196	---
4	3.00 : 3.20	41	---	---	---	---	---	76	39	507	2.10	1.77	471	---
5	3.20 : 6.20	9	0.56	1.89	34.00	0.92	44	32	30	261	1.92	1.48	173	---
6	6.20 : 7.00	23	1.44	2.06	22.58	0.61	75	55	34	369	2.01	1.62	318	---
7	7.00 : 7.20	91	---	---	---	---	---	100	45	893	2.24	1.99	898	---



PROVA PENETROMETRICA DINAMICA DIAGRAMMI COLPI / RESISTENZA

DIN

riferimento

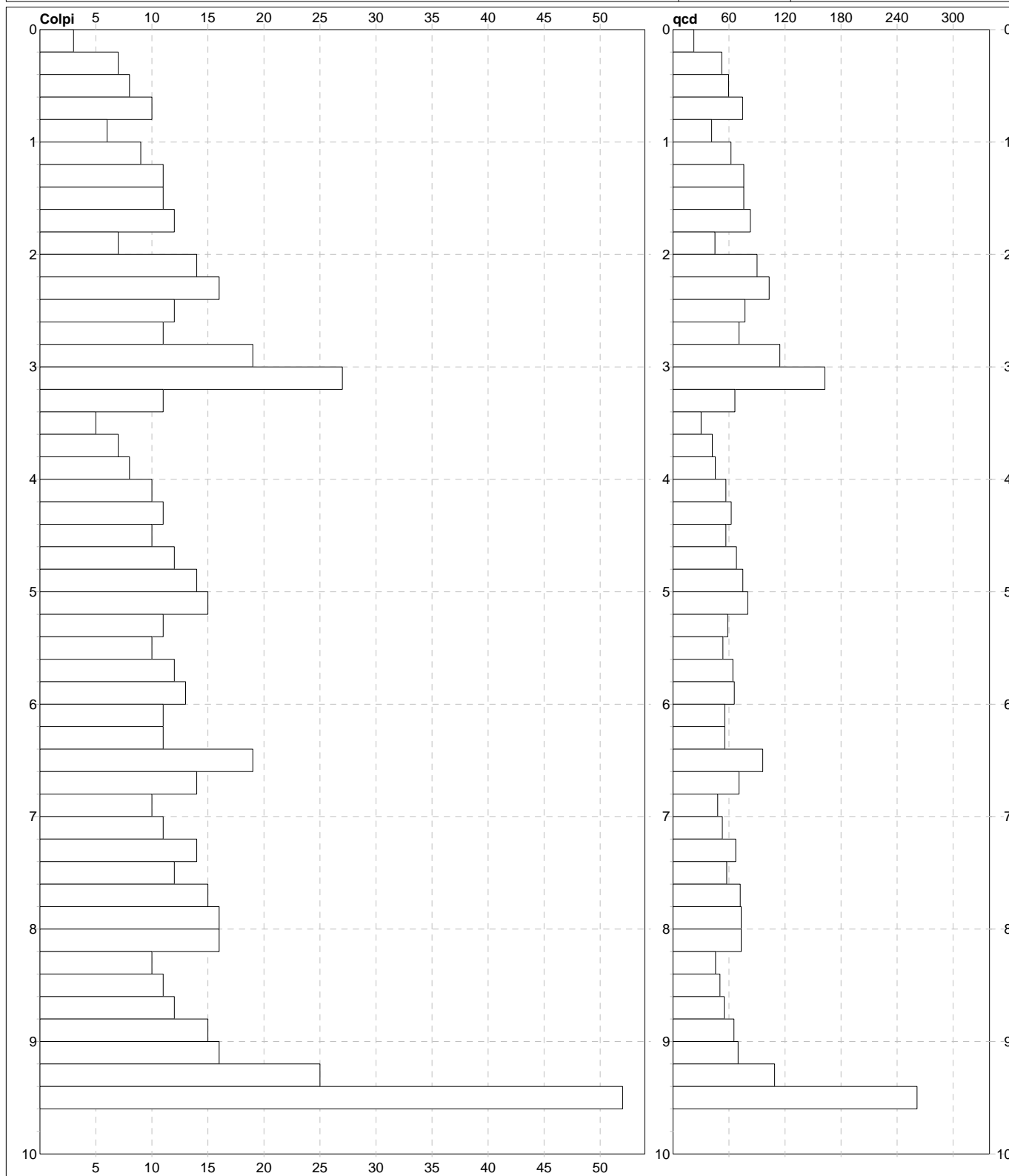
5

43-2022

Committente: **dott geol Samuel Sangiorgi**
Cantiere: **44.160495, 11.209579**
Località: **Pian del Voglio campo sportivo**

U.M.: **kg/cm²**
Scala: **1:50**
Pagina: **1**
Elaborato:

Data esec.: **25/06/2022**
Quota ass.:
Falda: **Non rilevata**



Penetrometro: DPSH (S. Heavy)

Massa battente: 63.50 m

Altezza caduta: 0.75 m

Avanzamento: 0.20 m



PROVA PENETROMETRICA DINAMICA LETTURE DI CAMPAGNA PUNTA E/O TOTALE	DIN	5
	riferimento	43-2022

Committente: dott geol Samuel Sangiorgi	U.M.: kg/cm²	Data esec.: 25/06/2022
Cantiere: 44.160495, 11.209579	Pagina: 1	
Località: Pian del Voglio campo sportivo	Elaborato:	Falda: Non rilevata

H m	Asta n°	L1 n°	L2 n°	qcd kg/cm²	H m	Asta n°	L1 n°	L2 n°	qcd kg/cm²
0.20	1	3		22.35					
0.40	1	7		52.14					
0.60	2	8		59.59					
0.80	2	10		74.49					
1.00	2	6		41.43					
1.20	2	9		62.14					
1.40	2	11		75.95					
1.60	3	11		75.95					
1.80	3	12		82.85					
2.00	3	7		45.04					
2.20	3	14		90.08					
2.40	3	16		102.95					
2.60	4	12		77.21					
2.80	4	11		70.78					
3.00	4	19		114.46					
3.20	4	27		162.66					
3.40	4	11		66.27					
3.60	5	5		30.12					
3.80	5	7		42.17					
4.00	5	8		45.31					
4.20	5	10		56.63					
4.40	5	11		62.30					
4.60	6	10		56.63					
4.80	6	12		67.96					
5.00	6	14		74.80					
5.20	6	15		80.15					
5.40	6	11		58.77					
5.60	7	10		53.43					
5.80	7	12		64.12					
6.00	7	13		65.74					
6.20	7	11		55.63					
6.40	7	11		55.63					
6.60	8	19		96.09					
6.80	8	14		70.80					
7.00	8	10		48.00					
7.20	8	11		52.80					
7.40	8	14		67.20					
7.60	9	12		57.60					
7.80	9	15		72.00					
8.00	9	16		73.09					
8.20	9	16		73.09					
8.40	9	10		45.68					
8.60	10	11		50.25					
8.80	10	12		54.82					
9.00	10	15		65.36					
9.20	10	16		69.72					
9.40	10	25		108.94					
9.60	11	60		261.46					

H = profondità
L1 = prima lettura (colpi punta)
L2 = seconda lettura (colpi rivestimento)

qcd = resistenza dinamica punta
Asta = numero di asta impiegata

PROVA PENETROMETRICA DINAMICA SUDDIVISIONE GEOTECNICA	DIN	5
	referimento	43-2022

Committente: dott geol Samuel Sangiorgi	U.M.: kg/cm²	Data esec.: 25/06/2022
Cantiere: 44.160495, 11.209579	Pagina: 1	
Località: Pian del Voglio campo sportivo	Elaborato:	Falda: Non rilevata

PARAMETRI GENERALI												
n°	profondità m	statistica	VCA colpi	β -	Nspt colpi	rp kg/cm²	qc kg/cm²	Vs m/sec	G kg/cm²	Q kg/cm²	natura	descrizione
1	0.00 : 2.80	Media	10	1.52	15	66.64	60.81	127	105	3.33	Coes./Gran.	
2	2.80 : 3.20	Media	23	1.52	35	138.56	138.56	186	206	6.93	Granulare	
3	3.20 : 9.40	Media	12	1.52	19	62.62	56.82	177	127	3.13	Coes./Gran.	
4	9.40 : 9.60	Media	60	1.52	91	261.46	261.46	274	443	13.07	Granulare	

			NATURA COESIVA					NATURA GRANULARE						
n°	profondità m	Nspt colpi	Cu kg/cm²	Ysat t/m³	W %	e -	Mo kg/cm²	Dr %	ø °	E' kg/cm²	Ysat t/m³	Yd t/m³	Mo kg/cm²	Liq. -
1	0.00 : 2.80	15	0.94	1.96	28.61	0.77	59	43	32	307	1.96	1.54	241	---
2	2.80 : 3.20	35	---	---	---	---	---	70	37	461	2.08	1.73	420	---
3	3.20 : 9.40	19	1.19	2.01	25.45	0.69	67	49	33	338	1.98	1.58	284	---
4	9.40 : 9.60	91	---	---	---	---	---	100	45	893	2.24	1.99	898	---

MS3 SAN BENEDETTO VAL DI SAMBRO – HVSR1

037051P304HVSR304

Instrument: TRZ-0108/01-10

Start recording: 25/03/02 10:06:02 End recording: 25/03/02 10:22:03

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN

Trace length: 0h16'00". Analyzed 90% trace (manual window selection)

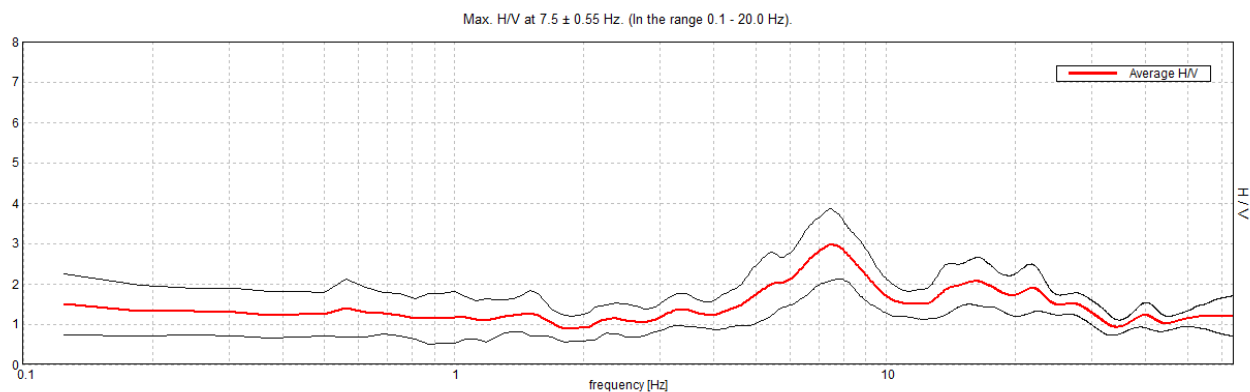
Sampling rate: 128 Hz

Window size: 16 s

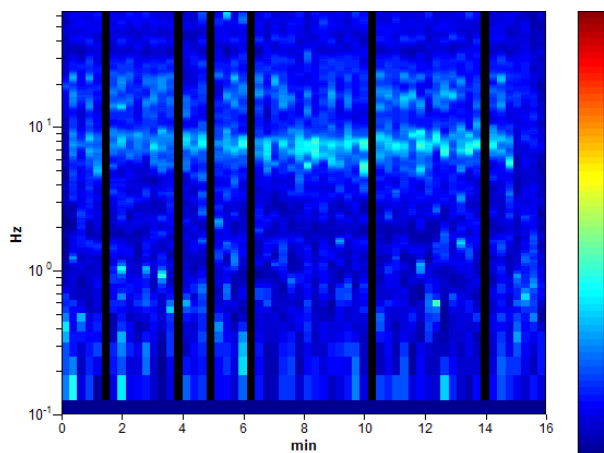
Smoothing type: Triangular window

Smoothing: 10%

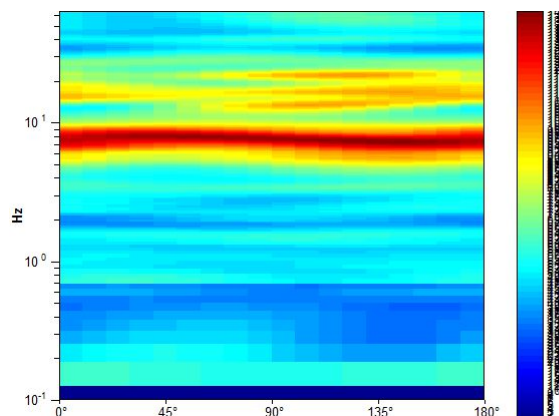
HORIZONTAL TO VERTICAL SPECTRAL RATIO



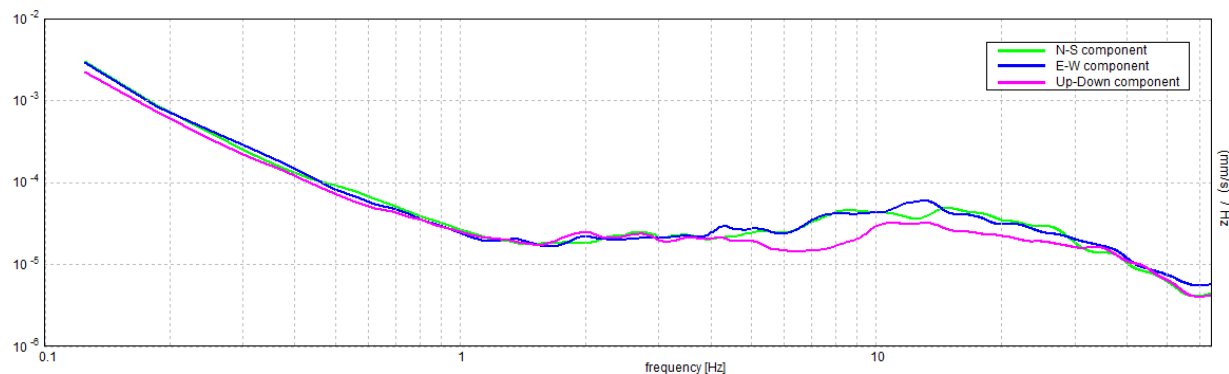
H/V TIME HISTORY



DIRECTIONAL H/V



SINGLE COMPONENT SPECTRA



[According to the SESAME, 2005 guidelines. **Please read carefully the *Grilla* manual before interpreting the following tables.**]

Max. H/V at 7.5 ± 0.55 Hz (in the range 0.1 - 20.0 Hz).

Criteria for a reliable H/V curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$7.50 > 0.63$	OK	
$n_c(f_0) > 200$	$6480.0 > 200$	OK	
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$ if $f_0 > 0.5\text{Hz}$ $\sigma_A(f) < 3$ for $0.5f_0 < f < 2f_0$ if $f_0 < 0.5\text{Hz}$	Exceeded 0 out of 181 times	OK	

Criteria for a clear H/V peak

[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	4.625 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	24.75 Hz	OK	
$A_0 > 2$	$2.97 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.03634 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.27252 < 0.375$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.4399 < 1.58$	OK	

L_w	window length
n_w	number of windows used in the analysis
$n_c = L_w n_w f_0$	number of significant cycles
f	current frequency
f_0	H/V peak frequency
σ_f	standard deviation of H/V peak frequency
$\varepsilon(f_0)$	threshold value for the stability condition $\sigma_f < \varepsilon(f_0)$
A_0	H/V peak amplitude at frequency f_0
$A_{H/V}(f)$	H/V curve amplitude at frequency f
f^-	frequency between $f_0/4$ and f_0 for which $A_{H/V}(f^-) < A_0/2$
f^+	frequency between f_0 and $4f_0$ for which $A_{H/V}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{H/V}(f)$, $\sigma_A(f)$ is the factor by which the mean $A_{H/V}(f)$ curve should be multiplied or divided
$\sigma_{\log H/V}(f)$	standard deviation of $\log A_{H/V}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

Threshold values for σ_f and $\sigma_A(f_0)$

Freq. range [Hz]	< 0.2	0.2 – 0.5	0.5 – 1.0	1.0 – 2.0	> 2.0
$\varepsilon(f_0)$ [Hz]	$0.25 f_0$	$0.2 f_0$	$0.15 f_0$	$0.10 f_0$	$0.05 f_0$
$\theta(f_0)$ for $\sigma_A(f_0)$	3.0	2.5	2.0	1.78	1.58
$\log \theta(f_0)$ for $\sigma_{\log H/V}(f_0)$	0.48	0.40	0.30	0.25	0.20

MS3 SAN BENEDETTO VAL DI SAMBRO – HVSR2

037051P305HVSR305

Instrument: TRZ-0108/01-10

Start recording: 25/03/02 10:29:50 End recording: 25/03/02 10:45:51

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN

Trace length: 0h16'00". Analyzed 82% trace (manual window selection)

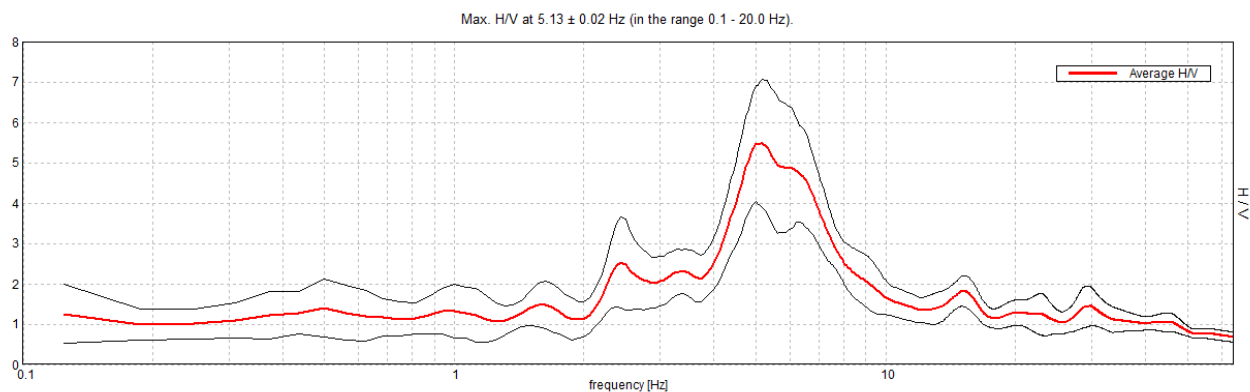
Sampling rate: 128 Hz

Window size: 16 s

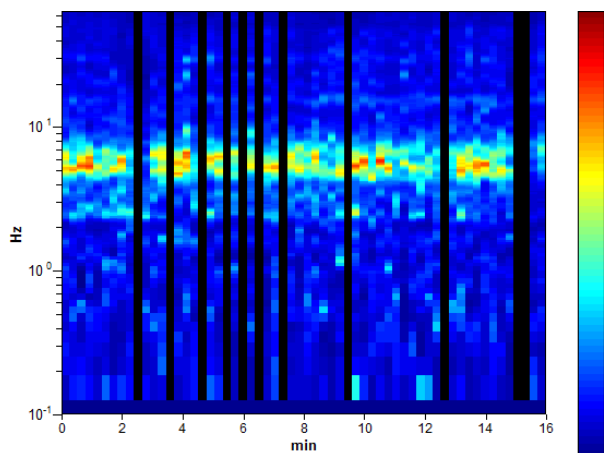
Smoothing type: Triangular window

Smoothing: 10%

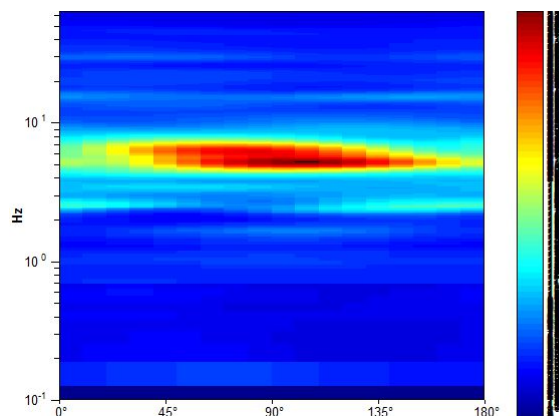
HORIZONTAL TO VERTICAL SPECTRAL RATIO



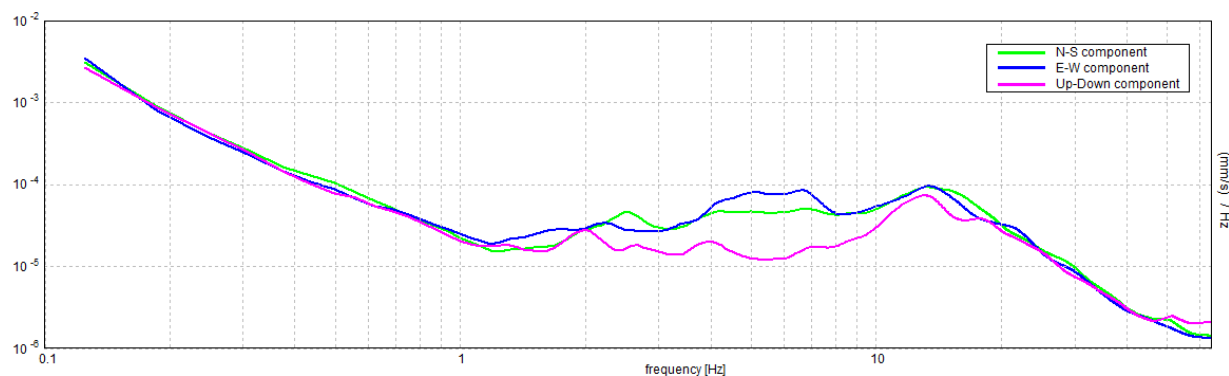
H/V TIME HISTORY



DIRECTIONAL H/V



SINGLE COMPONENT SPECTRA



[According to the SESAME, 2005 guidelines. **Please read carefully the *Grilla* manual before interpreting the following tables.**]

Max. H/V at 5.13 ± 0.02 Hz (in the range 0.1 - 20.0 Hz).

Criteria for a reliable H/V curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$5.13 > 0.63$	OK	
$n_c(f_0) > 200$	$4018.0 > 200$	OK	
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$ if $f_0 > 0.5\text{Hz}$ $\sigma_A(f) < 3$ for $0.5f_0 < f < 2f_0$ if $f_0 < 0.5\text{Hz}$	Exceeded 0 out of 124 times	OK	

Criteria for a clear H/V peak

[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0] \mid A_{H/V}(f^-) < A_0 / 2$	4.063 Hz	OK	
Exists f^+ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0 / 2$	7.813 Hz	OK	
$A_0 > 2$	$5.48 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00194 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.00996 < 0.25625$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.7548 < 1.58$	OK	

L_w	window length
n_w	number of windows used in the analysis
$n_c = L_w n_w f_0$	number of significant cycles
f	current frequency
f_0	H/V peak frequency
σ_f	standard deviation of H/V peak frequency
$\varepsilon(f_0)$	threshold value for the stability condition $\sigma_f < \varepsilon(f_0)$
A_0	H/V peak amplitude at frequency f_0
$A_{H/V}(f)$	H/V curve amplitude at frequency f
f^-	frequency between $f_0/4$ and f_0 for which $A_{H/V}(f^-) < A_0/2$
f^+	frequency between f_0 and $4f_0$ for which $A_{H/V}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{H/V}(f)$, $\sigma_A(f)$ is the factor by which the mean $A_{H/V}(f)$ curve should be multiplied or divided
$\sigma_{\log H/V}(f)$	standard deviation of $\log A_{H/V}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

Threshold values for σ_f and $\sigma_A(f_0)$

Freq. range [Hz]	< 0.2	0.2 – 0.5	0.5 – 1.0	1.0 – 2.0	> 2.0
$\varepsilon(f_0)$ [Hz]	$0.25 f_0$	$0.2 f_0$	$0.15 f_0$	$0.10 f_0$	$0.05 f_0$
$\theta(f_0)$ for $\sigma_A(f_0)$	3.0	2.5	2.0	1.78	1.58
$\log \theta(f_0)$ for $\sigma_{\log H/V}(f_0)$	0.48	0.40	0.30	0.25	0.20

MS3 SAN BENEDETTO VAL DI SAMBRO – HVSR3

037051P306HVSR306

Instrument: TRZ-0108/01-10

Start recording: 25/03/02 10:54:48 End recording: 25/03/02 11:10:49

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN

Trace length: 0h16'00". Analyzed 92% trace (manual window selection)

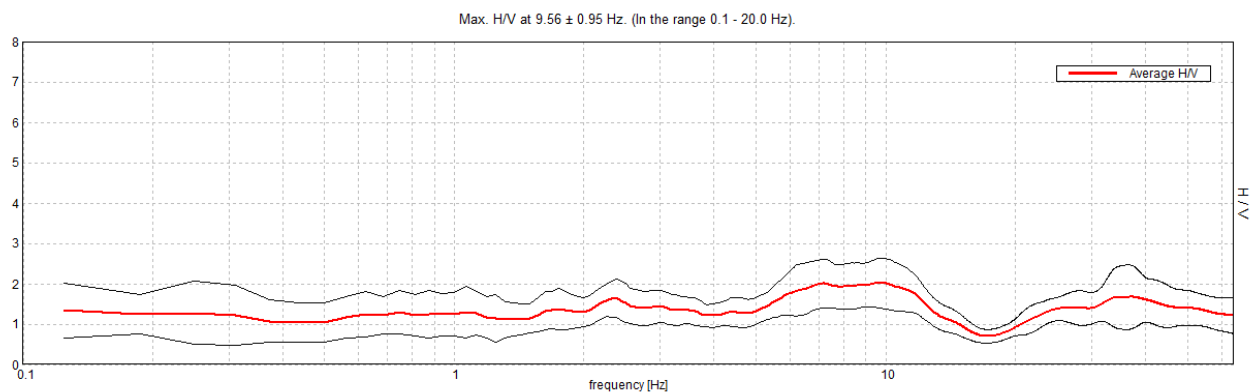
Sampling rate: 128 Hz

Window size: 16 s

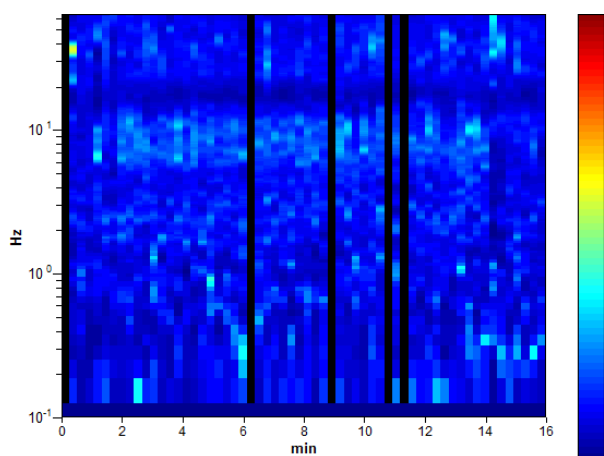
Smoothing type: Triangular window

Smoothing: 10%

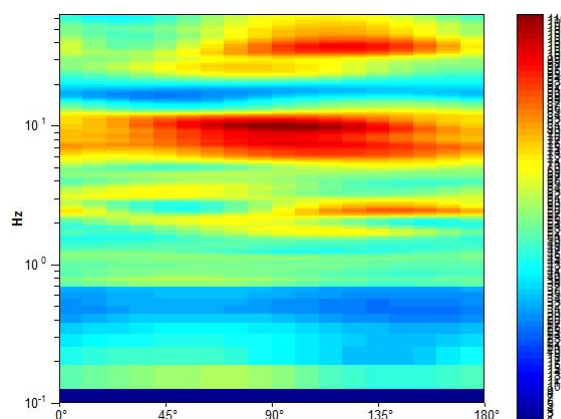
HORIZONTAL TO VERTICAL SPECTRAL RATIO



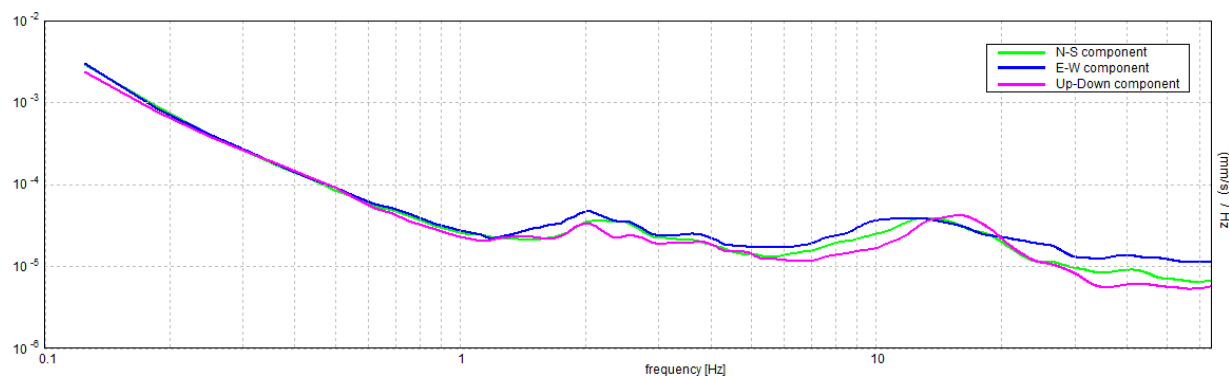
H/V TIME HISTORY



DIRECTIONAL H/V



SINGLE COMPONENT SPECTRA



[According to the SESAME, 2005 guidelines. **Please read carefully the *Grilla* manual before interpreting the following tables.**]

Max. H/V at 9.56 ± 0.95 Hz (in the range 0.1 - 20.0 Hz).

Criteria for a reliable H/V curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$9.56 > 0.63$	OK	
$n_c(f_0) > 200$	$8415.0 > 200$	OK	
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$ if $f_0 > 0.5\text{Hz}$ $\sigma_A(f) < 3$ for $0.5f_0 < f < 2f_0$ if $f_0 < 0.5\text{Hz}$	Exceeded 0 out of 230 times	OK	

Criteria for a clear H/V peak

[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$			NO
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	14.75 Hz	OK	
$A_0 > 2$	$2.02 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.04897 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.4683 < 0.47813$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.3009 < 1.58$	OK	

L_w	window length
n_w	number of windows used in the analysis
$n_c = L_w n_w f_0$	number of significant cycles
f	current frequency
f_0	H/V peak frequency
σ_f	standard deviation of H/V peak frequency
$\varepsilon(f_0)$	threshold value for the stability condition $\sigma_f < \varepsilon(f_0)$
A_0	H/V peak amplitude at frequency f_0
$A_{H/V}(f)$	H/V curve amplitude at frequency f
f^-	frequency between $f_0/4$ and f_0 for which $A_{H/V}(f^-) < A_0/2$
f^+	frequency between f_0 and $4f_0$ for which $A_{H/V}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{H/V}(f)$, $\sigma_A(f)$ is the factor by which the mean $A_{H/V}(f)$ curve should be multiplied or divided
$\sigma_{\log H/V}(f)$	standard deviation of $\log A_{H/V}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

Threshold values for σ_f and $\sigma_A(f_0)$

Freq. range [Hz]	< 0.2	0.2 – 0.5	0.5 – 1.0	1.0 – 2.0	> 2.0
$\varepsilon(f_0)$ [Hz]	$0.25 f_0$	$0.2 f_0$	$0.15 f_0$	$0.10 f_0$	$0.05 f_0$
$\theta(f_0)$ for $\sigma_A(f_0)$	3.0	2.5	2.0	1.78	1.58
$\log \theta(f_0)$ for $\sigma_{\log H/V}(f_0)$	0.48	0.40	0.30	0.25	0.20

MS3 SAN BENEDETTO VAL DI SAMBRO – HVSR4

037051P307HVSR307

Instrument: TRZ-0108/01-10

Start recording: 25/03/02 11:21:00 End recording: 25/03/02 11:37:01

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN

Trace length: 0h16'00". Analyzed 90% trace (manual window selection)

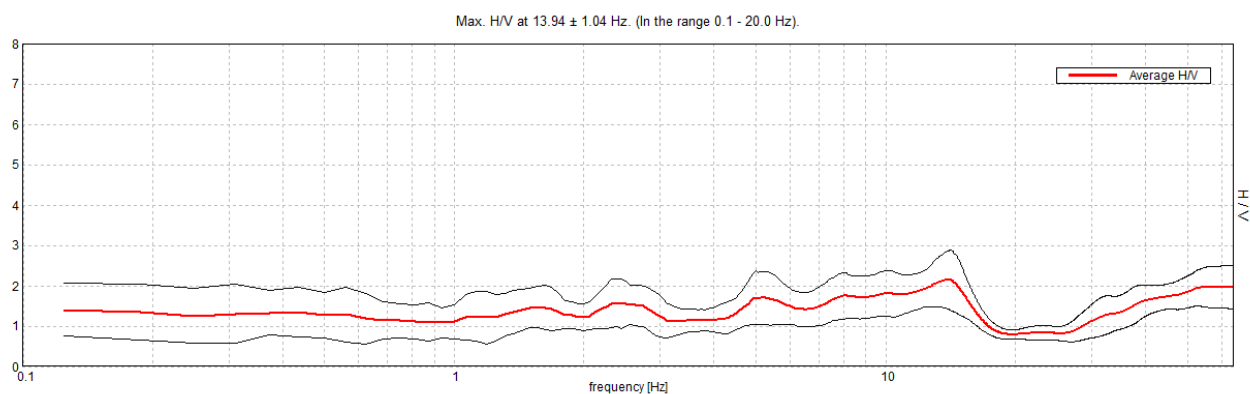
Sampling rate: 128 Hz

Window size: 16 s

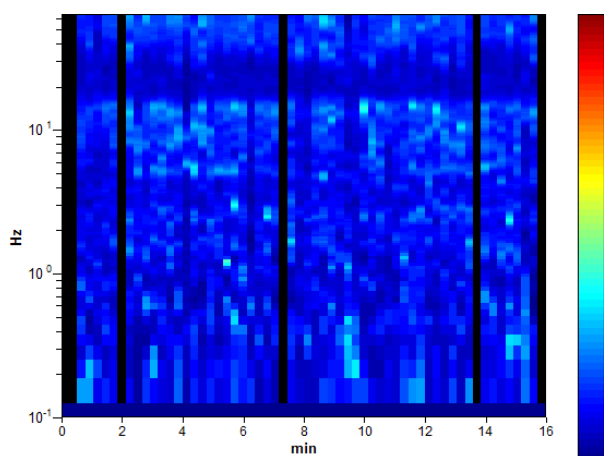
Smoothing type: Triangular window

Smoothing: 10%

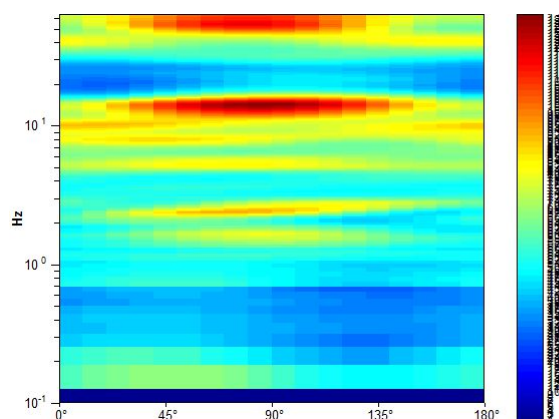
HORIZONTAL TO VERTICAL SPECTRAL RATIO



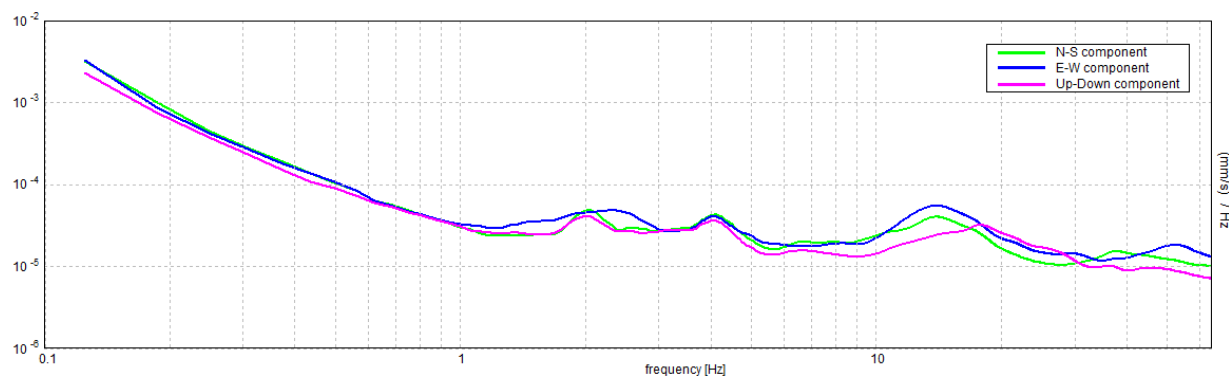
H/V TIME HISTORY



DIRECTIONAL H/V



SINGLE COMPONENT SPECTRA



[According to the SESAME, 2005 guidelines. **Please read carefully the *Grilla* manual before interpreting the following tables.**]

Max. H/V at 13.94 ± 1.04 Hz (in the range 0.1 - 20.0 Hz).

Criteria for a reliable H/V curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$13.94 > 0.63$	OK	
$n_c(f_0) > 200$	$12042.0 > 200$	OK	
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$ if $f_0 > 0.5\text{Hz}$ $\sigma_A(f) < 3$ for $0.5f_0 < f < 2f_0$ if $f_0 < 0.5\text{Hz}$	Exceeded 0 out of 336 times	OK	

Criteria for a clear H/V peak

[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$			NO
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	17.063 Hz	OK	
$A_0 > 2$	$2.14 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.0368 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.51285 < 0.69688$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.3577 < 1.58$	OK	

L_w	window length
n_w	number of windows used in the analysis
$n_c = L_w n_w f_0$	number of significant cycles
f	current frequency
f_0	H/V peak frequency
σ_f	standard deviation of H/V peak frequency
$\varepsilon(f_0)$	threshold value for the stability condition $\sigma_f < \varepsilon(f_0)$
A_0	H/V peak amplitude at frequency f_0
$A_{H/V}(f)$	H/V curve amplitude at frequency f
f^-	frequency between $f_0/4$ and f_0 for which $A_{H/V}(f^-) < A_0/2$
f^+	frequency between f_0 and $4f_0$ for which $A_{H/V}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{H/V}(f)$, $\sigma_A(f)$ is the factor by which the mean $A_{H/V}(f)$ curve should be multiplied or divided
$\sigma_{\log H/V}(f)$	standard deviation of $\log A_{H/V}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

Threshold values for σ_f and $\sigma_A(f_0)$

Freq. range [Hz]	< 0.2	0.2 – 0.5	0.5 – 1.0	1.0 – 2.0	> 2.0
$\varepsilon(f_0)$ [Hz]	$0.25 f_0$	$0.2 f_0$	$0.15 f_0$	$0.10 f_0$	$0.05 f_0$
$\theta(f_0)$ for $\sigma_A(f_0)$	3.0	2.5	2.0	1.78	1.58
$\log \theta(f_0)$ for $\sigma_{\log H/V}(f_0)$	0.48	0.40	0.30	0.25	0.20

MS3 SAN BENEDETTO VAL DI SAMBRO – HVSR5

037051P308HVSR308

Instrument: TRZ-0108/01-10

Start recording: 25/03/02 11:43:00 End recording: 25/03/02 11:59:01

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN

Trace length: 0h16'00". Analyzed 87% trace (manual window selection)

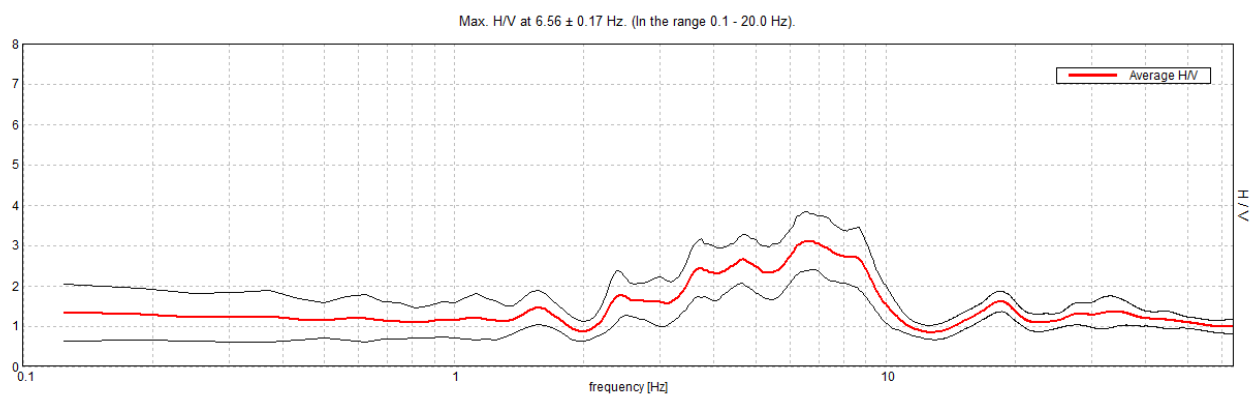
Sampling rate: 128 Hz

Window size: 16 s

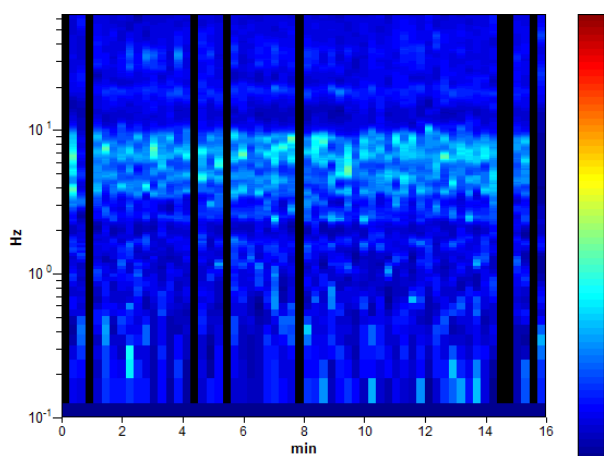
Smoothing type: Triangular window

Smoothing: 10%

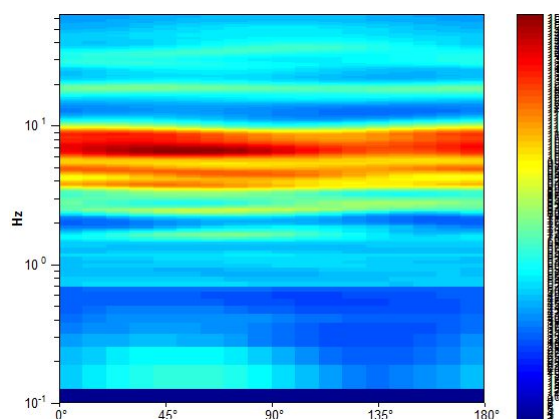
HORIZONTAL TO VERTICAL SPECTRAL RATIO



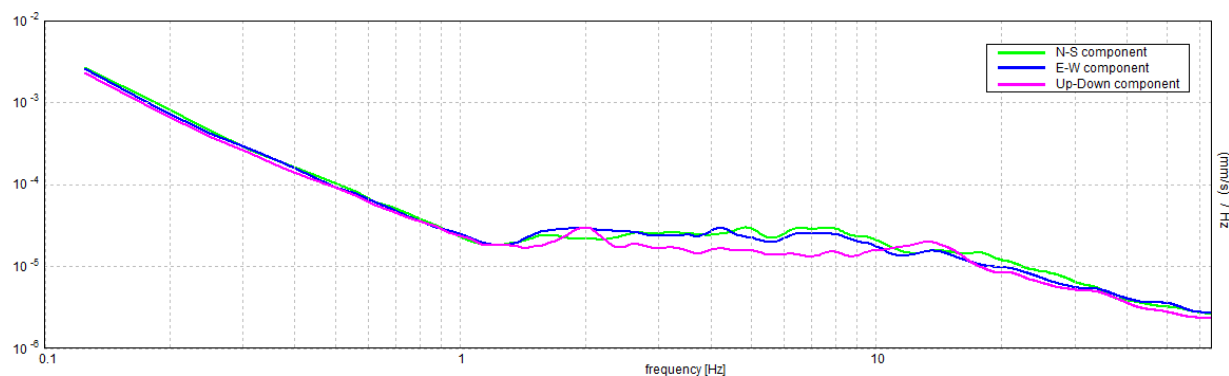
H/V TIME HISTORY



DIRECTIONAL H/V



SINGLE COMPONENT SPECTRA



[According to the SESAME, 2005 guidelines. **Please read carefully the *Grilla* manual before interpreting the following tables.**]

Max. H/V at 6.56 ± 0.17 Hz (in the range 0.1 - 20.0 Hz).

Criteria for a reliable H/V curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$6.56 > 0.63$	OK	
$n_c(f_0) > 200$	$5460.0 > 200$	OK	
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$ if $f_0 > 0.5\text{Hz}$ $\sigma_A(f) < 3$ for $0.5f_0 < f < 2f_0$ if $f_0 < 0.5\text{Hz}$	Exceeded 0 out of 158 times	OK	

Criteria for a clear H/V peak

[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	2.25 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	10.0 Hz	OK	
$A_0 > 2$	$3.11 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.01278 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.08386 < 0.32813$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.3615 < 1.58$	OK	

L_w	window length
n_w	number of windows used in the analysis
$n_c = L_w n_w f_0$	number of significant cycles
f	current frequency
f_0	H/V peak frequency
σ_f	standard deviation of H/V peak frequency
$\varepsilon(f_0)$	threshold value for the stability condition $\sigma_f < \varepsilon(f_0)$
A_0	H/V peak amplitude at frequency f_0
$A_{H/V}(f)$	H/V curve amplitude at frequency f
f^-	frequency between $f_0/4$ and f_0 for which $A_{H/V}(f^-) < A_0/2$
f^+	frequency between f_0 and $4f_0$ for which $A_{H/V}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{H/V}(f)$, $\sigma_A(f)$ is the factor by which the mean $A_{H/V}(f)$ curve should be multiplied or divided
$\sigma_{\log H/V}(f)$	standard deviation of $\log A_{H/V}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

Threshold values for σ_f and $\sigma_A(f_0)$

Freq. range [Hz]	< 0.2	0.2 – 0.5	0.5 – 1.0	1.0 – 2.0	> 2.0
$\varepsilon(f_0)$ [Hz]	$0.25 f_0$	$0.2 f_0$	$0.15 f_0$	$0.10 f_0$	$0.05 f_0$
$\theta(f_0)$ for $\sigma_A(f_0)$	3.0	2.5	2.0	1.78	1.58
$\log \theta(f_0)$ for $\sigma_{\log H/V}(f_0)$	0.48	0.40	0.30	0.25	0.20

MS3 SAN BENEDETTO VAL DI SAMBRO – HVSR6

037051P309HVS309

Instrument: TRZ-0108/01-10

Start recording: 25/03/02 12:25:46 End recording: 25/03/02 12:41:47

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN

Trace length: 0h16'00". Analyzed 85% trace (manual window selection)

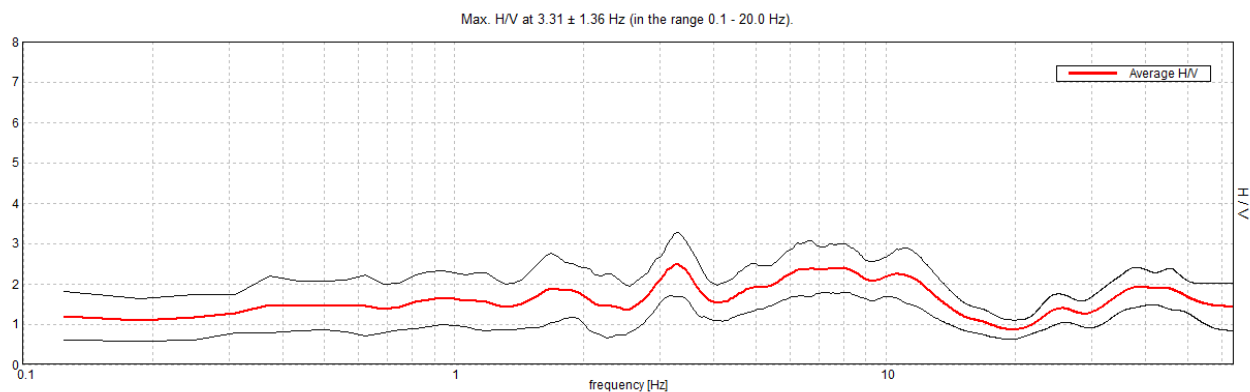
Sampling rate: 128 Hz

Window size: 16 s

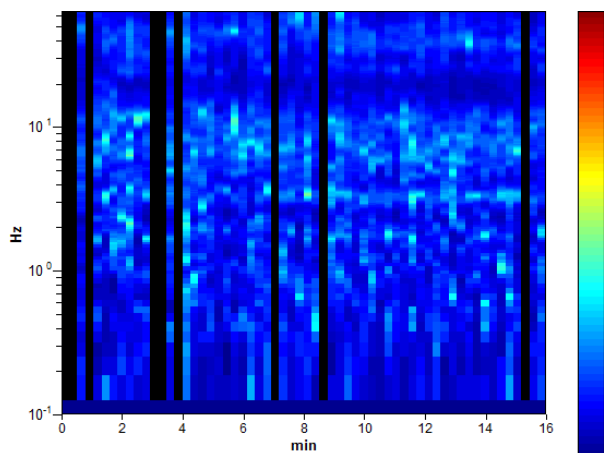
Smoothing type: Triangular window

Smoothing: 10%

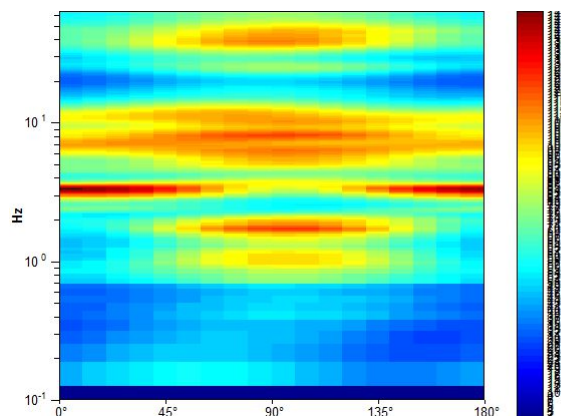
HORIZONTAL TO VERTICAL SPECTRAL RATIO



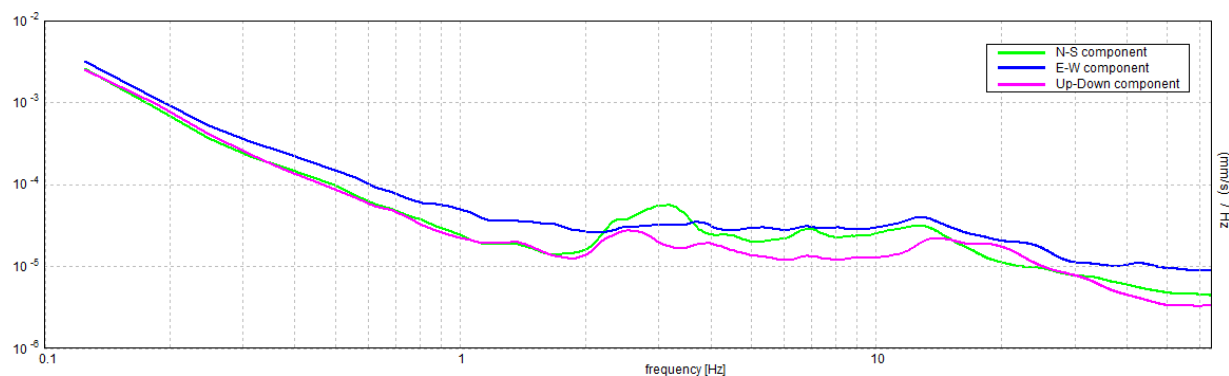
H/V TIME HISTORY



DIRECTIONAL H/V



SINGLE COMPONENT SPECTRA



[According to the SESAME, 2005 guidelines. **Please read carefully the *Grilla* manual before interpreting the following tables.**]

Max. H/V at 3.31 ± 1.36 Hz (in the range 0.1 - 20.0 Hz).

Criteria for a reliable H/V curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$3.31 > 0.63$	OK	
$n_c(f_0) > 200$	$2703.0 > 200$	OK	
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$ if $f_0 > 0.5\text{Hz}$ $\sigma_A(f) < 3$ for $0.5f_0 < f < 2f_0$ if $f_0 < 0.5\text{Hz}$	Exceeded 0 out of 80 times	OK	

Criteria for a clear H/V peak

[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$			NO
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$			NO
$A_0 > 2$	$2.47 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.2018 < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	$0.66846 < 0.16563$		NO
$\sigma_A(f_0) < \theta(f_0)$	$0.3907 < 1.58$	OK	

L_w	window length
n_w	number of windows used in the analysis
$n_c = L_w n_w f_0$	number of significant cycles
f	current frequency
f_0	H/V peak frequency
σ_f	standard deviation of H/V peak frequency
$\varepsilon(f_0)$	threshold value for the stability condition $\sigma_f < \varepsilon(f_0)$
A_0	H/V peak amplitude at frequency f_0
$A_{H/V}(f)$	H/V curve amplitude at frequency f
f^-	frequency between $f_0/4$ and f_0 for which $A_{H/V}(f^-) < A_0/2$
f^+	frequency between f_0 and $4f_0$ for which $A_{H/V}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{H/V}(f)$, $\sigma_A(f)$ is the factor by which the mean $A_{H/V}(f)$ curve should be multiplied or divided
$\sigma_{\log H/V}(f)$	standard deviation of $\log A_{H/V}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

Threshold values for σ_f and $\sigma_A(f_0)$

Freq. range [Hz]	< 0.2	0.2 – 0.5	0.5 – 1.0	1.0 – 2.0	> 2.0
$\varepsilon(f_0)$ [Hz]	$0.25 f_0$	$0.2 f_0$	$0.15 f_0$	$0.10 f_0$	$0.05 f_0$
$\theta(f_0)$ for $\sigma_A(f_0)$	3.0	2.5	2.0	1.78	1.58
$\log \theta(f_0)$ for $\sigma_{\log H/V}(f_0)$	0.48	0.40	0.30	0.25	0.20

MS3 SAN BENEDETTO VAL DI SAMBRO – HVSR7

037051P310HVSR310

Instrument: TRZ-0108/01-10

Start recording: 25/03/02 13:07:20 End recording: 25/03/02 13:23:20

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN

Trace length: 0h16'00". Analyzed 67% trace (manual window selection)

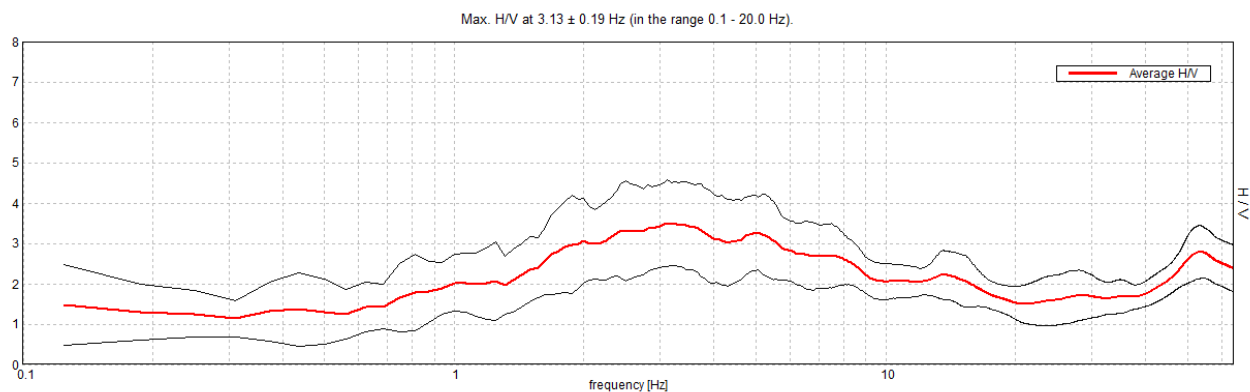
Sampling rate: 128 Hz

Window size: 16 s

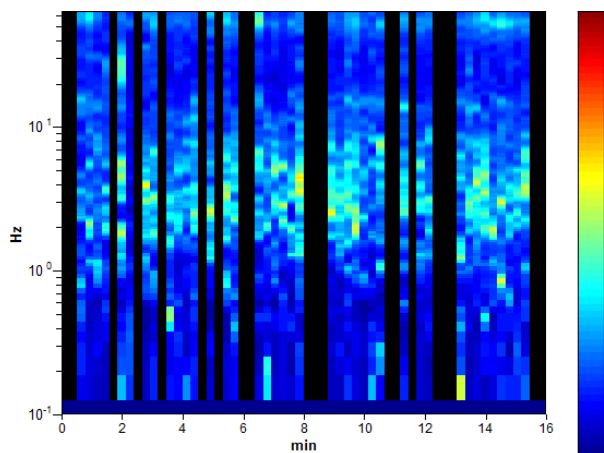
Smoothing type: Triangular window

Smoothing: 10%

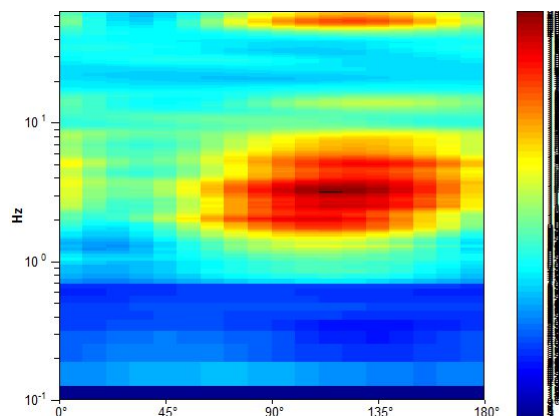
HORIZONTAL TO VERTICAL SPECTRAL RATIO



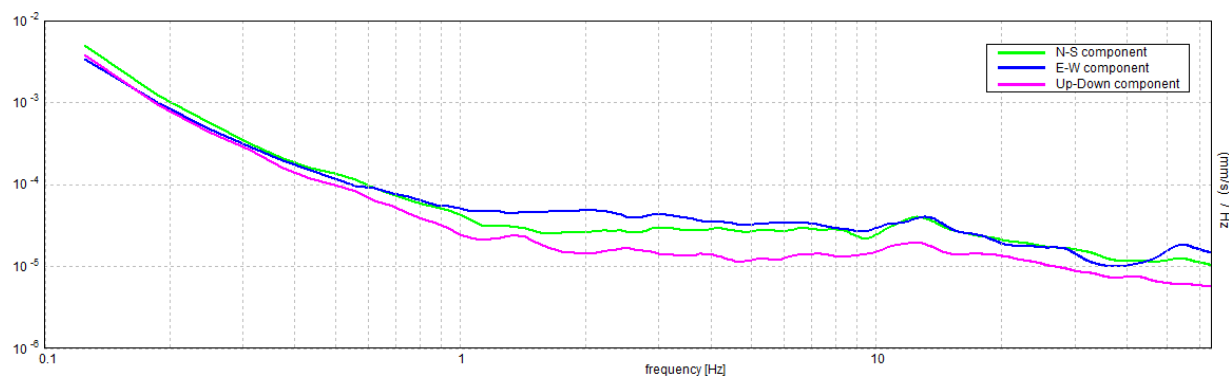
H/V TIME HISTORY



DIRECTIONAL H/V



SINGLE COMPONENT SPECTRA



[According to the SESAME, 2005 guidelines. **Please read carefully the *Grilla* manual before interpreting the following tables.**]

Max. H/V at 3.13 ± 0.19 Hz (in the range 0.1 - 20.0 Hz).

Criteria for a reliable H/V curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$3.13 > 0.63$	OK	
$n_c(f_0) > 200$	$2000.0 > 200$	OK	
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$ if $f_0 > 0.5\text{Hz}$ $\sigma_A(f) < 3$ for $0.5f_0 < f < 2f_0$ if $f_0 < 0.5\text{Hz}$	Exceeded 0 out of 76 times	OK	

Criteria for a clear H/V peak

[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	0.75 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$			NO
$A_0 > 2$	$3.50 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.0304 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.095 < 0.15625$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.5269 < 1.58$	OK	

L_w	window length
n_w	number of windows used in the analysis
$n_c = L_w n_w f_0$	number of significant cycles
f	current frequency
f_0	H/V peak frequency
σ_f	standard deviation of H/V peak frequency
$\varepsilon(f_0)$	threshold value for the stability condition $\sigma_f < \varepsilon(f_0)$
A_0	H/V peak amplitude at frequency f_0
$A_{H/V}(f)$	H/V curve amplitude at frequency f
f^-	frequency between $f_0/4$ and f_0 for which $A_{H/V}(f^-) < A_0/2$
f^+	frequency between f_0 and $4f_0$ for which $A_{H/V}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{H/V}(f)$, $\sigma_A(f)$ is the factor by which the mean $A_{H/V}(f)$ curve should be multiplied or divided
$\sigma_{\log H/V}(f)$	standard deviation of $\log A_{H/V}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

Threshold values for σ_f and $\sigma_A(f_0)$

Freq. range [Hz]	< 0.2	0.2 – 0.5	0.5 – 1.0	1.0 – 2.0	> 2.0
$\varepsilon(f_0)$ [Hz]	$0.25 f_0$	$0.2 f_0$	$0.15 f_0$	$0.10 f_0$	$0.05 f_0$
$\theta(f_0)$ for $\sigma_A(f_0)$	3.0	2.5	2.0	1.78	1.58
$\log \theta(f_0)$ for $\sigma_{\log H/V}(f_0)$	0.48	0.40	0.30	0.25	0.20

MS3 SAN BENEDETTO VAL DI SAMBRO – HVSR8

037051P311HVSR311

Instrument: TRZ-0108/01-10

Start recording: 25/03/02 13:25:55 End recording: 25/03/02 13:41:56

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN

Trace length: 0h16'00". Analyzed 77% trace (manual window selection)

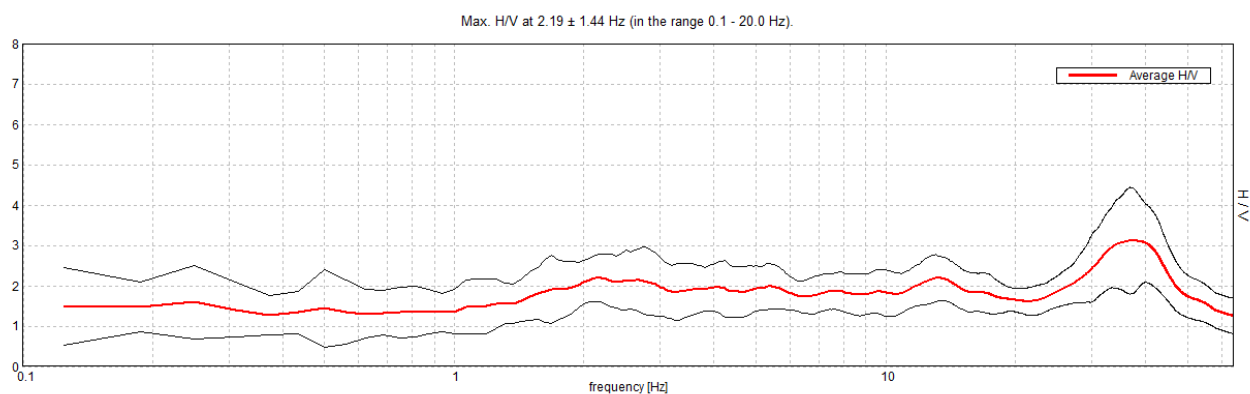
Sampling rate: 128 Hz

Window size: 16 s

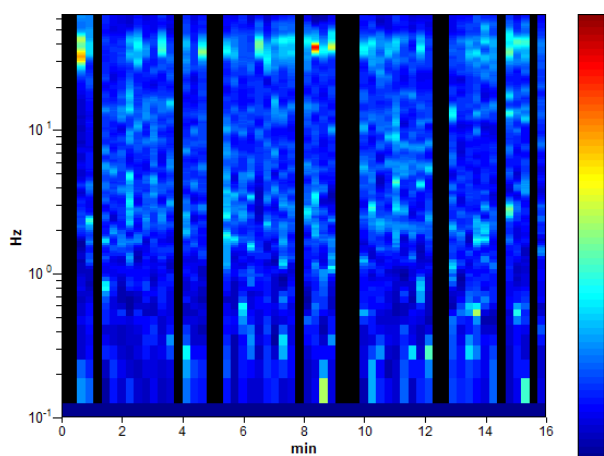
Smoothing type: Triangular window

Smoothing: 10%

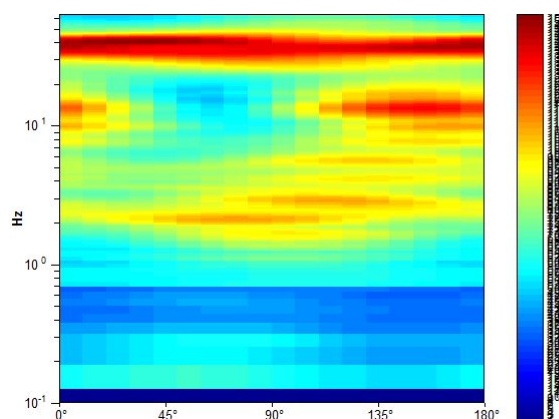
HORIZONTAL TO VERTICAL SPECTRAL RATIO



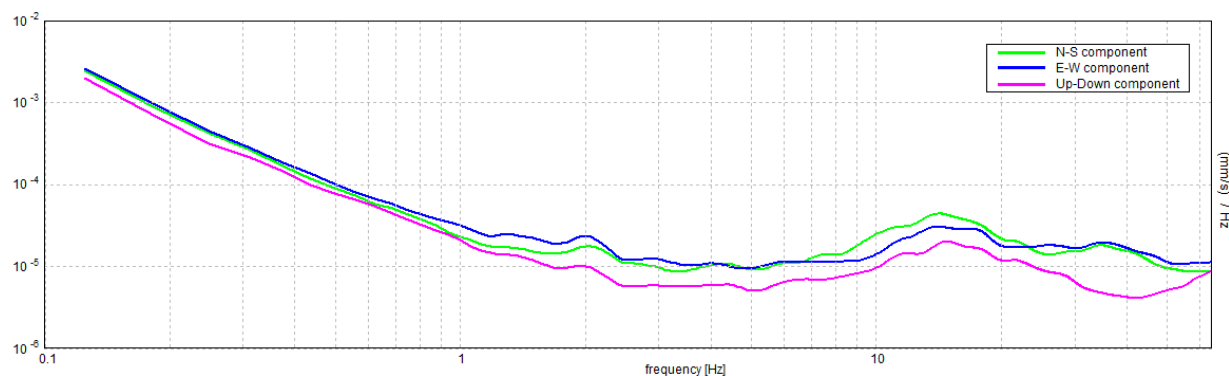
H/V TIME HISTORY



DIRECTIONAL H/V



SINGLE COMPONENT SPECTRA



[According to the SESAME, 2005 guidelines. **Please read carefully the *Grilla* manual before interpreting the following tables.**]

Max. H/V at 2.19 ± 1.44 Hz (in the range 0.1 - 20.0 Hz).

Criteria for a reliable H/V curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$2.19 > 0.63$	OK	
$n_c(f_0) > 200$	$1610.0 > 200$	OK	
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$ if $f_0 > 0.5\text{Hz}$ $\sigma_A(f) < 3$ for $0.5f_0 < f < 2f_0$ if $f_0 < 0.5\text{Hz}$	Exceeded 0 out of 54 times	OK	

Criteria for a clear H/V peak

[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$			NO
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$			NO
$A_0 > 2$	$2.19 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.32421 < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	$0.70922 < 0.10938$		NO
$\sigma_A(f_0) < \theta(f_0)$	$0.288 < 1.58$	OK	

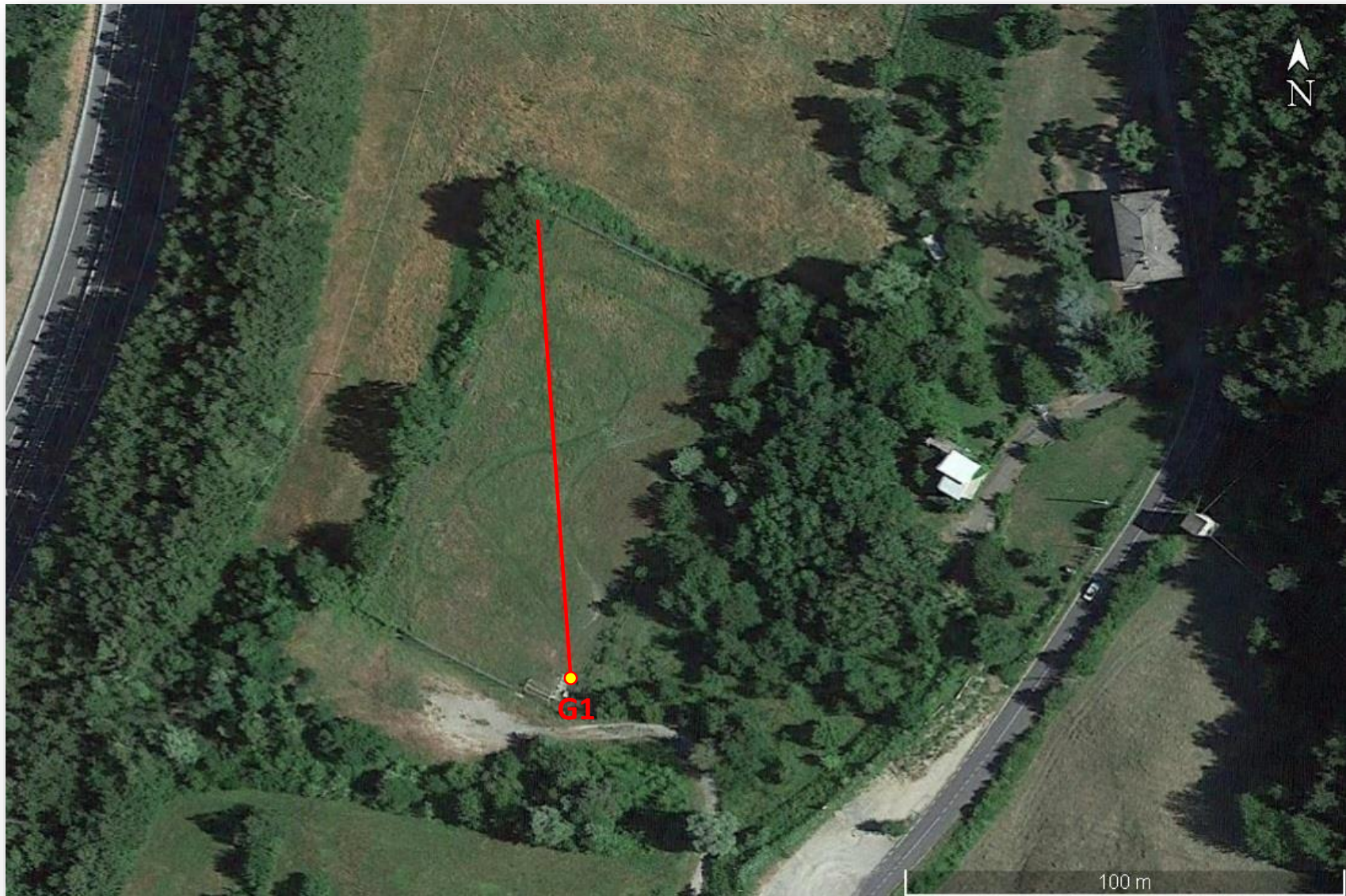
L_w	window length
n_w	number of windows used in the analysis
$n_c = L_w n_w f_0$	number of significant cycles
f	current frequency
f_0	H/V peak frequency
σ_f	standard deviation of H/V peak frequency
$\varepsilon(f_0)$	threshold value for the stability condition $\sigma_f < \varepsilon(f_0)$
A_0	H/V peak amplitude at frequency f_0
$A_{H/V}(f)$	H/V curve amplitude at frequency f
f^-	frequency between $f_0/4$ and f_0 for which $A_{H/V}(f^-) < A_0/2$
f^+	frequency between f_0 and $4f_0$ for which $A_{H/V}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{H/V}(f)$, $\sigma_A(f)$ is the factor by which the mean $A_{H/V}(f)$ curve should be multiplied or divided
$\sigma_{\log H/V}(f)$	standard deviation of $\log A_{H/V}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

Threshold values for σ_f and $\sigma_A(f_0)$

Freq. range [Hz]	< 0.2	0.2 – 0.5	0.5 – 1.0	1.0 – 2.0	> 2.0
$\varepsilon(f_0)$ [Hz]	$0.25 f_0$	$0.2 f_0$	$0.15 f_0$	$0.10 f_0$	$0.05 f_0$
$\theta(f_0)$ for $\sigma_A(f_0)$	3.0	2.5	2.0	1.78	1.58
$\log \theta(f_0)$ for $\sigma_{\log H/V}(f_0)$	0.48	0.40	0.30	0.25	0.20

TAVOLA N°2

Ubicazione indagine SRT 1 onde P e Sh - San Benedetto Val di Sambro (BO)



Lavoro:
Indagini geofisiche per gli studi di MS comunale di livello 2 - San Benedetto Val di Sambro (BO)

Committente:
Geol. Samuel Sangiorgi

Indagini:
SRT
Data di esecuzione:
Giugno 2022

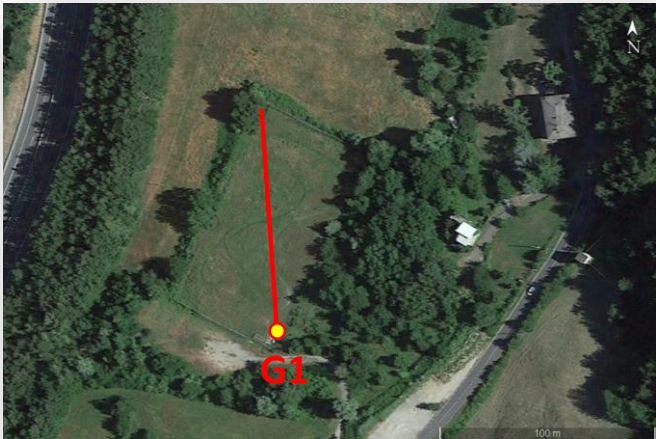
Elaborato: A. Battiato
Verificato: D. Fiore
Approvato: M. De Iasi



TAVOLA N°3

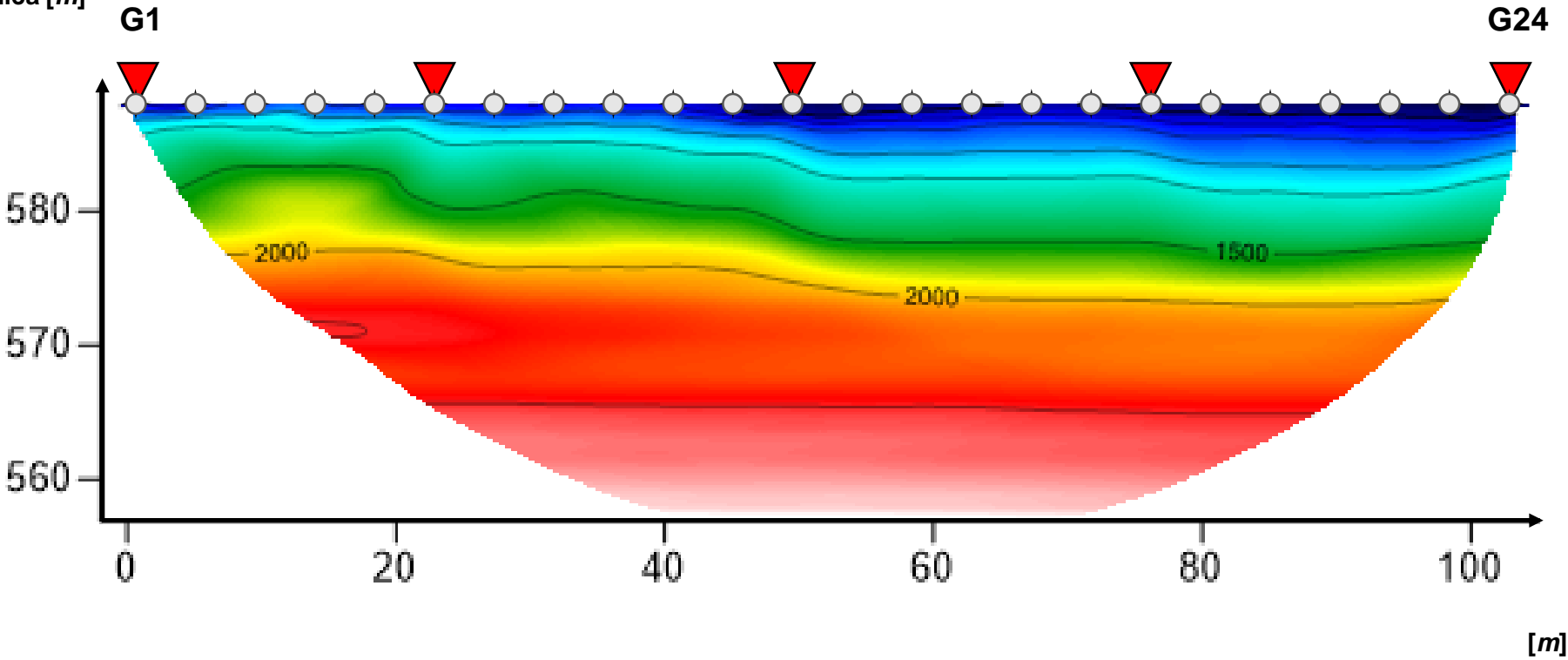
Ubicazione indagine SRT 1 onde P - San Benedetto Val di Sambro (BO)

Passo intergeofonico: 4,5 m



Coordinate UTM-WGS84		
ID	Latitudine	Longitudine
G1	44° 9.620'N	11° 12.585'E
G24	44° 9.676'N	11° 12.580'E

Quota ellissoidica [m]



Scala 1 : 490

Lavoro:
Indagini geofisiche per gli studi di MS comunale di livello 2 - San Benedetto Val di Sambro (BO)

Committente:
Geol. Samuel Sangiorgi

Indagini:
SRT
Data di esecuzione:
Giugno 2022

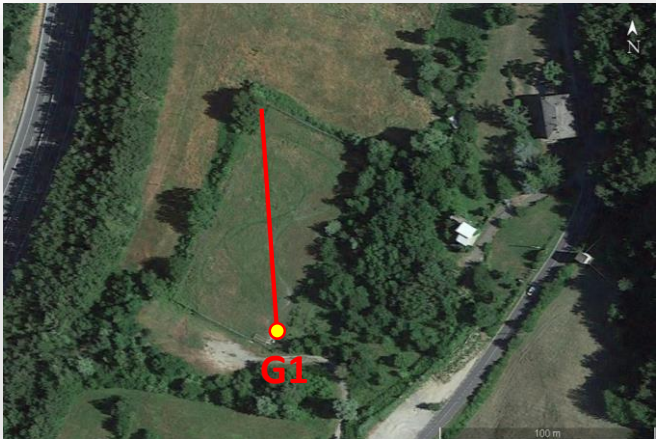
Elaborato: A. Battiato
Verificato: D. Fiore
Approvato: M. De Iasi



TAVOLA N°4

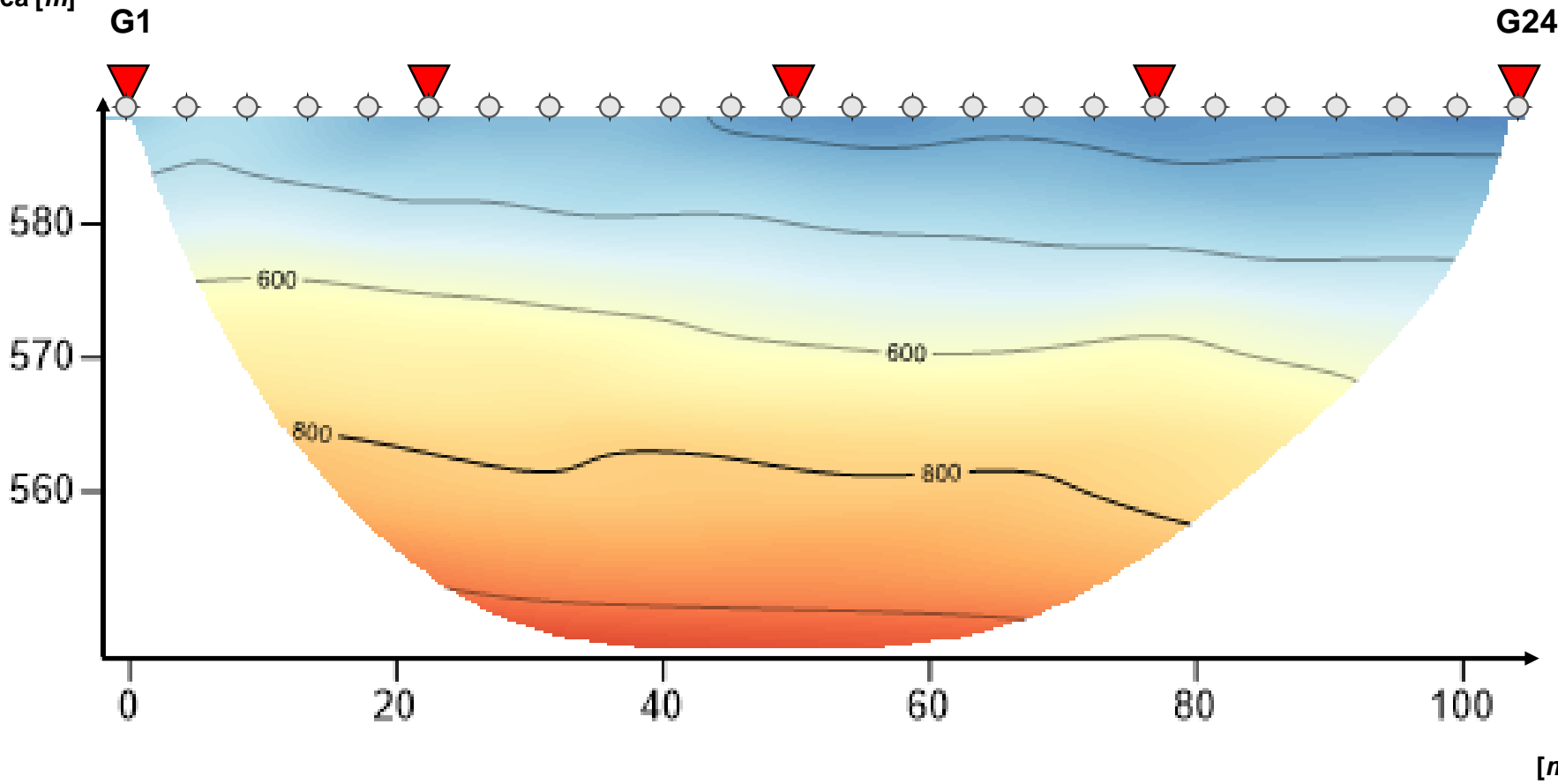
Ubicazione indagine SRT 1 onde Sh - San Benedetto Val di Sambro (BO)

Passo intergeofonico: 4,5 m



Coordinate UTM-WGS84		
ID	Latitudine	Longitudine
G1	44° 9.620'N	11° 12.585'E
G24	44° 9.676'N	11° 12.580'E

Quota ellissoidica [m]



Scala 1 : 490

Lavoro:
Indagini geofisiche per gli studi di MS comunale di livello 2 - San Benedetto Val di Sambro (BO)

Committente:
Geol. Samuel Sangiorgi

Indagini:
SRT
Data di esecuzione:
Giugno 2022

Elaborato: A. Battiato
Verificato: D. Fiore
Approvato: M. De Iasi



TAVOLA N°5

Ubicazione indagine SRT 2 onde P e Sh - San Benedetto Val di Sambro (BO)



Lavoro:
Indagini geofisiche per gli studi di MS comunale di livello 2 - San Benedetto Val di Sambro (BO)

Committente:
Geol. Samuel Sangiorgi

Indagini:
SRT
Data di esecuzione:
Giugno 2022

Elaborato: A. Battiato
Verificato: D. Fiore
Approvato: M. De Iasi

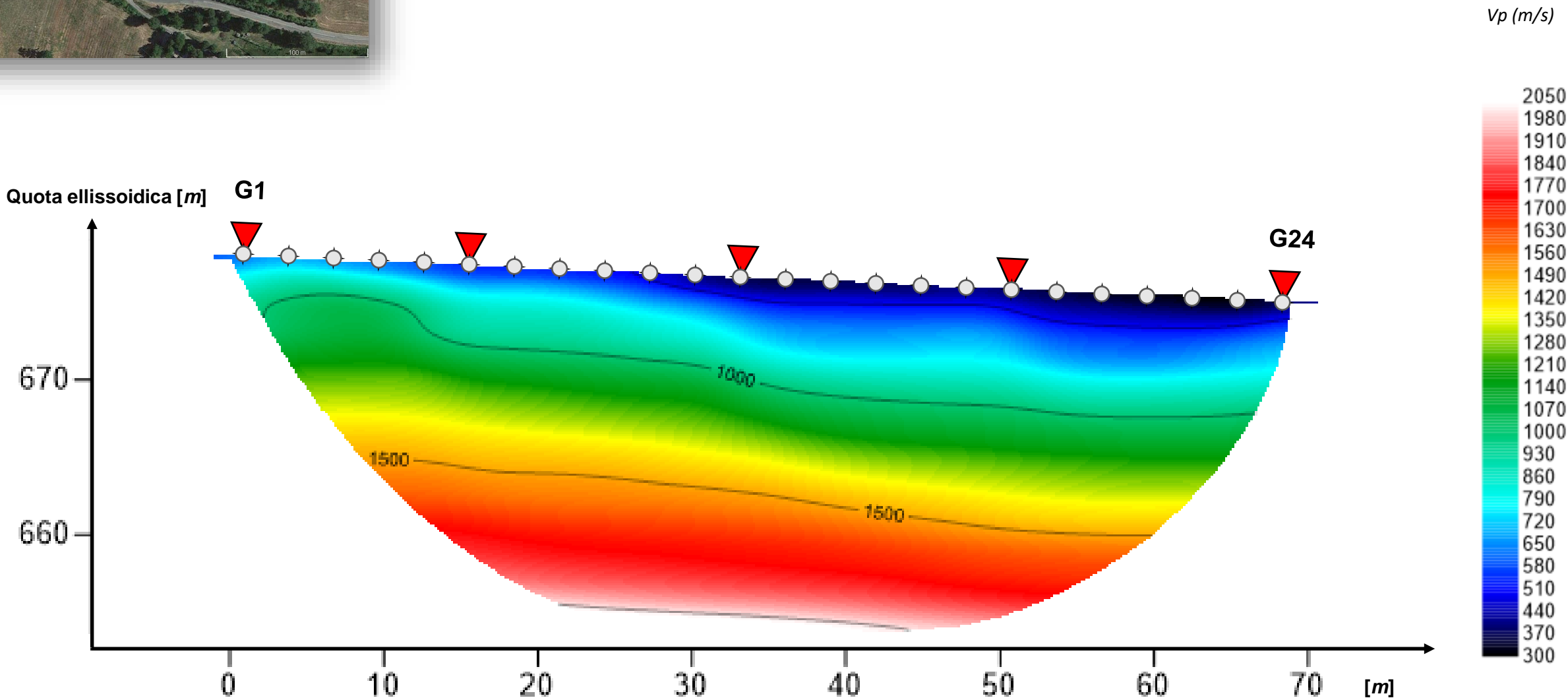
TAVOLA N°6

Ubicazione indagine SRT 2 onde P - San Benedetto Val di Sambro (BO)

Passo intergeofonico: 3 m



Coordinate UTM-WGS84		
ID	Latitudine	Longitudine
G1	44° 12.724'N	11° 14.451'E
G24	44° 12.701'N	11° 14.492'E



Scala 1 : 330

Lavoro:
Indagini geofisiche per gli studi di MS comunale di livello 2 - San Benedetto Val di Sambro (BO)

Committente:
Geol. Samuel Sangiorgi

Indagini:
SRT
Data di esecuzione:
Giugno 2022

Elaborato: A. Battiato
Verificato: D. Fiore
Approvato: M. De Iasi



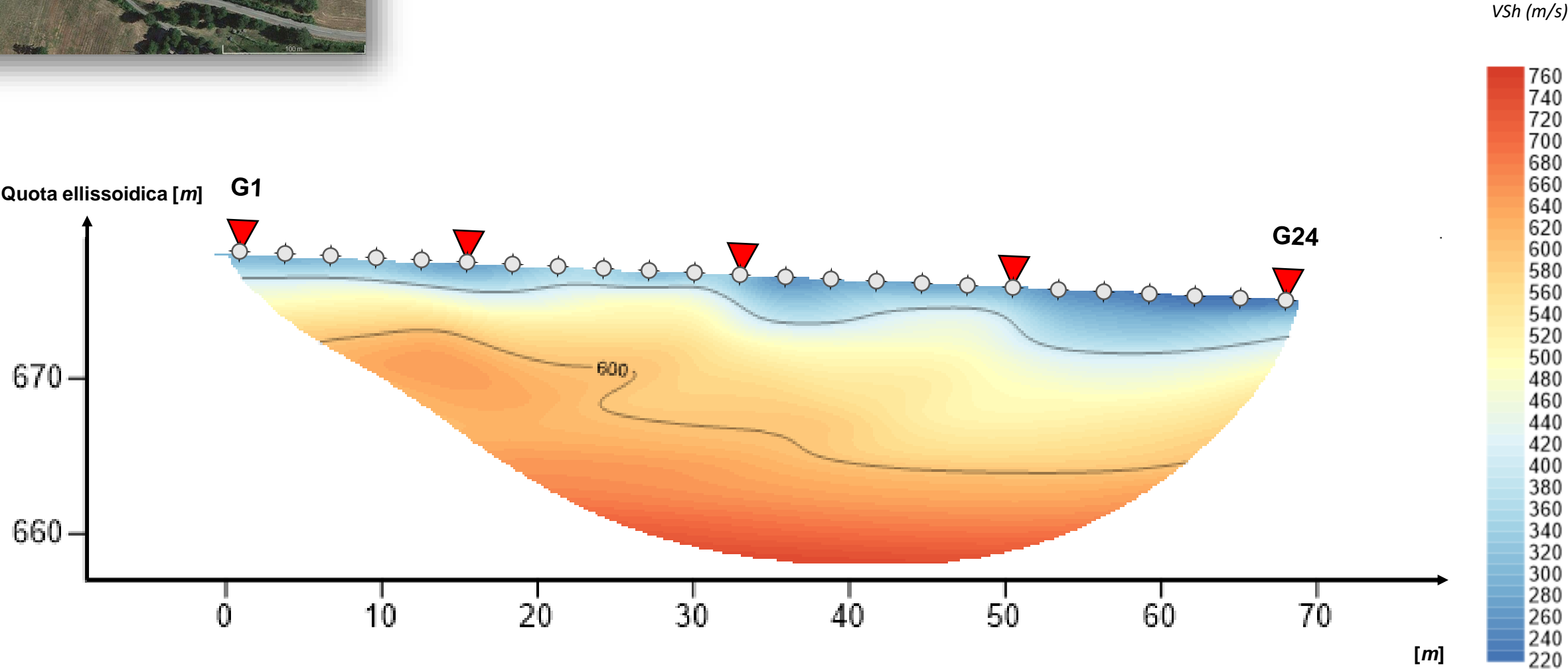
TAVOLA N°7

Ubicazione indagine SRT 2 onde Sh - San Benedetto Val di Sambro (BO)

Passo intergeofonico: 3 m



Coordinate UTM-WGS84		
ID	Latitudine	Longitudine
G1	44° 12.724'N	11° 14.451'E
G24	44° 12.701'N	11° 14.492'E



Scala 1 : 330

Lavoro:
Indagini geofisiche per gli studi di MS comunale di livello 2 - San Benedetto Val di Sambro (BO)

Committente:
Geol. Samuel Sangiorgi

Indagini:
SRT
Data di esecuzione:
Giugno 2022

Elaborato: A. Battiato
Verificato: D. Fiore
Approvato: M. De Iasi

