

## Elaborato gestionale

Piano Operativo Comunale  
2010 - 2015

# POC

Piano Operativo Comunale

PRG 2003  
PSC  
POC  
RUE

## POC.6I.1 Esiti delle indagini geofisiche tomografie sismiche a stazione singola

ADOTTATO	Delibera di C.C.	N. 66297/102	del 21/06/2010
PUBBLICATO	B.U.R	N. 86	del 07/07/2010
APPROVATO	Delibera di C.C.	N. 23970/37	del 10/03/2011
PUBBLICATO	B.U.R	N. 48	del 30/03/2011



**COMUNE DI RAVENNA**  
***PROVINCIA DI RAVENNA***

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**POC**  
***PIANO OPERATIVO COMUNALE***

**ESITI DELLE INDAGNI GEOFISICHE  
TROMOGRAFIE SISMICHE  
A STAZIONE SINGOLA**

Il Geologo  
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e-mail: frassinetigio@libero.it

**DICEMBRE 2010**

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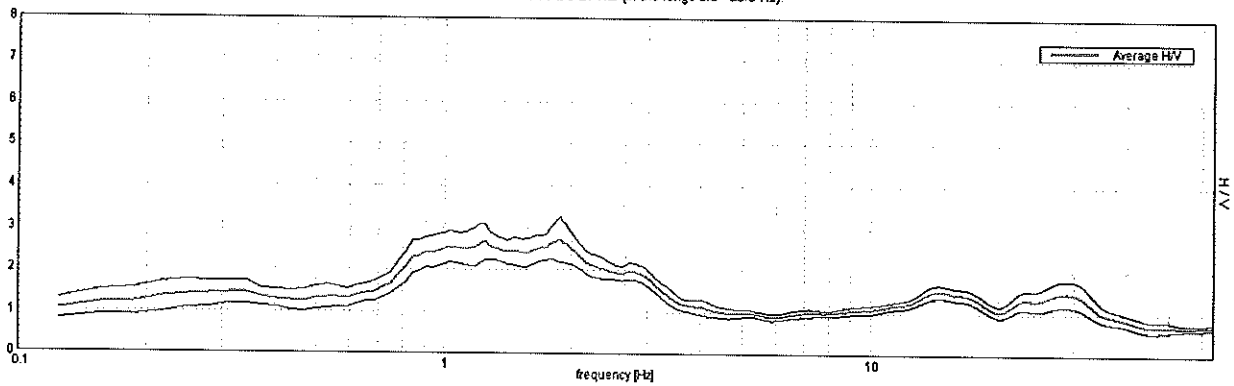
RAVENNA – N. 1

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
 GPS data not available

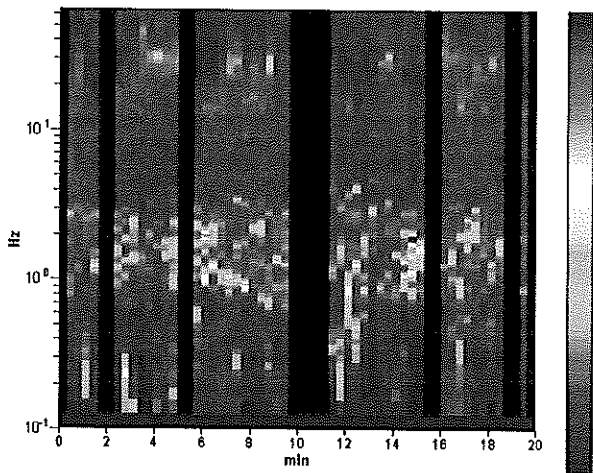
Trace length: 0h20'00". Analyzed 75% trace (manual window selection)  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

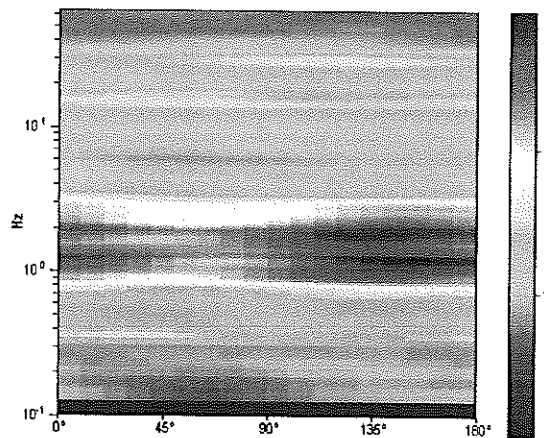
Max. HV at 1.66 ± 0.21 Hz. (n the range 0.0 - 20.0 Hz)



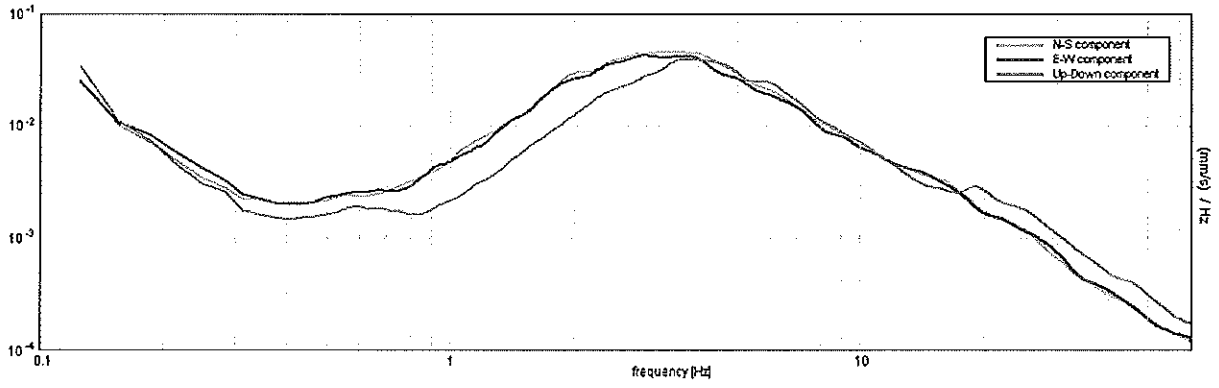
H/V TIME HISTORY



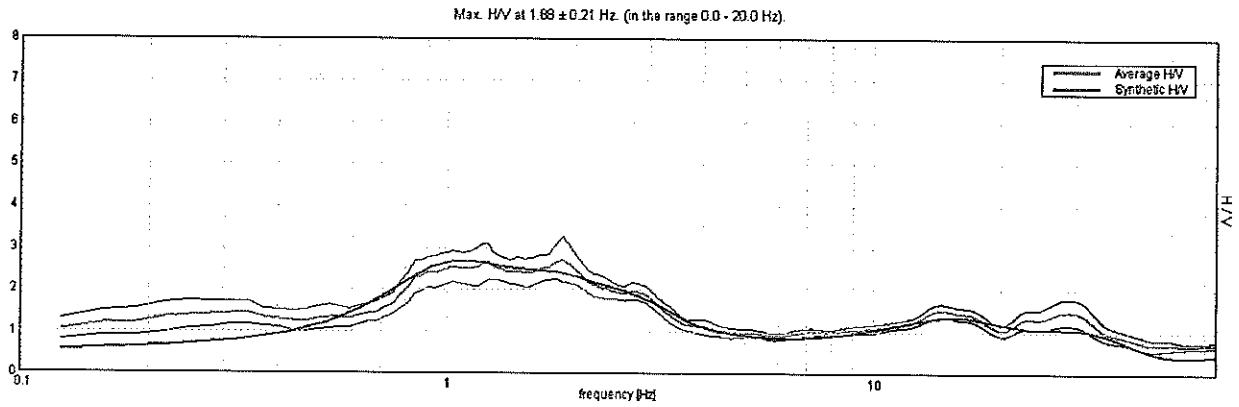
DIRECTIONAL HV



SINGLE COMPONENT SPECTRA

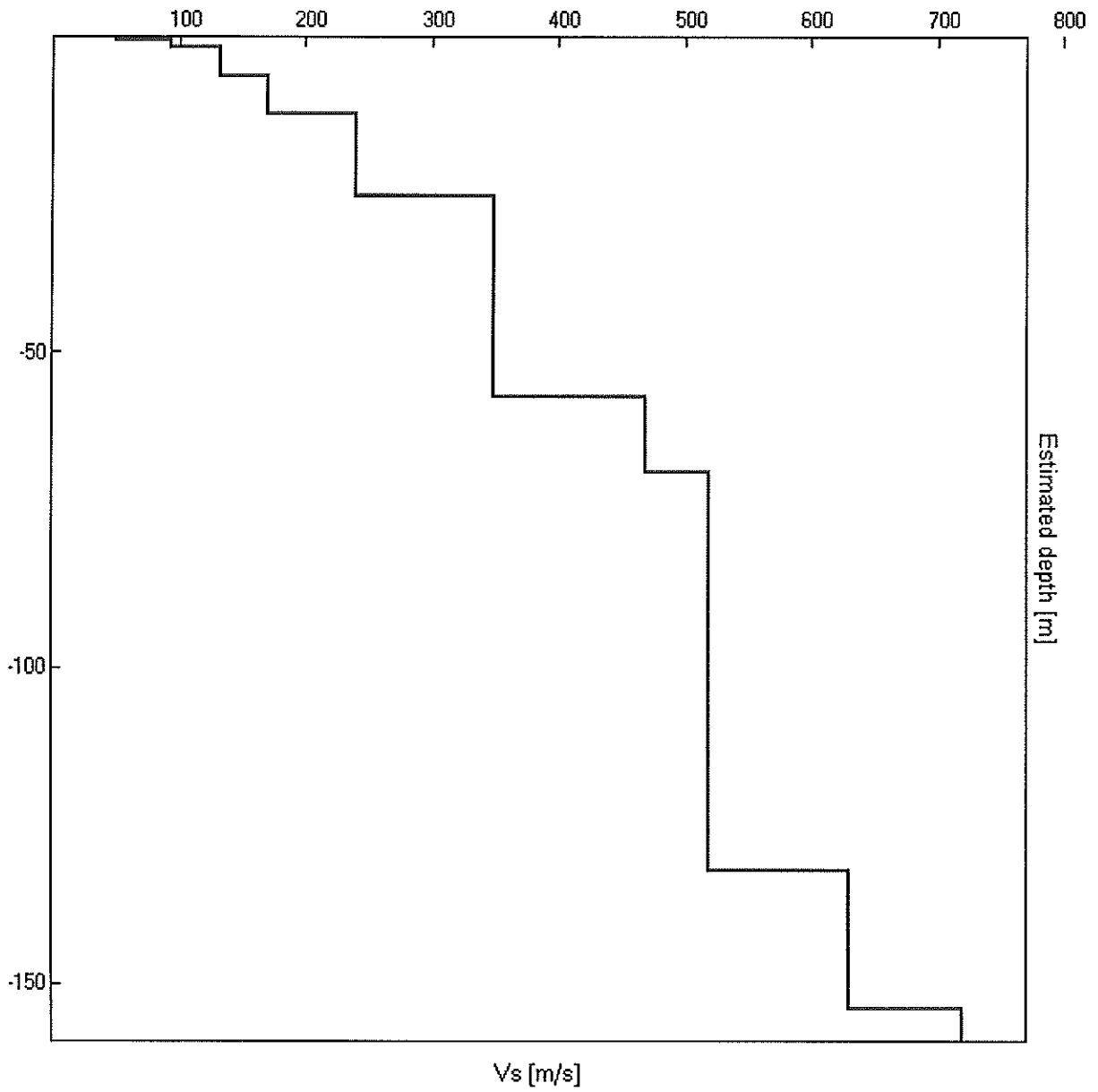


EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.40	0.40	50
1.60	1.20	93
6.10	4.50	133
12.10	6.00	170
25.10	13.00	240
57.10	32.00	350
69.10	12.00	470
132.10	63.00	520
154.10	22.00	630
inf.	inf.	720

Vs(0.0-30.0)=190m/s



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

Max. H/V at 1.88 ± 0.21 Hz. (in the range 0.0 - 20.0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	1.88 > 0.50	OK	
$n_c(f_0) > 200$	1687.5 > 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 91 times	OK	

**Criteria for a clear HVSR peak**

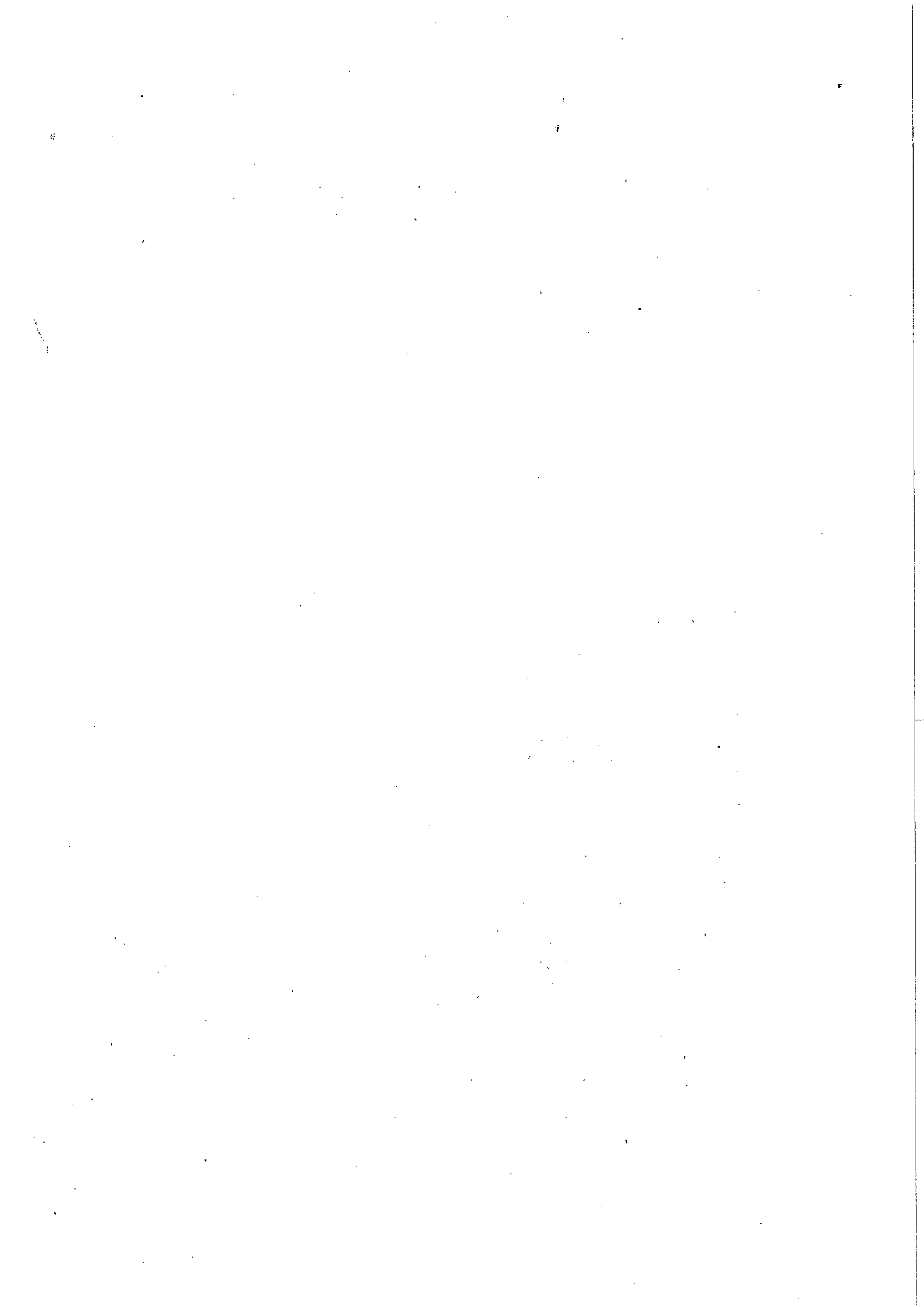
[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0]$   $A_{HV}(f^-) < A_0 / 2$	0.594 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0]$   $A_{HV}(f^+) < A_0 / 2$	3.406 Hz	OK	
$A_0 > 2$	2.73 > 2	OK	
$f_{\text{peak}}[A_{HV}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.05398  < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	0.10121 < 0.1875	OK	
$\sigma_A(f_0) < \theta(f_0)$	0.2633 < 1.78	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
$\sigma_f$	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 $f_0$
$A_{HV}(f)$	H/V curve amplitude at frequency $f$
$f^-$	frequency between $f_0/4$ and $f_0$ for which $A_{HV}(f^-) < A_0/2$
$f^+$	frequency between $f_0$ and $4f_0$ for which $A_{HV}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{HV}(f)$ , $\sigma_A(f)$ is the factor by which the mean $A_{HV}(f)$ curve should be multiplied or divided
$\sigma_{\log HV}(f)$	standard deviation of $\log A_{HV}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

Threshold values for  $\sigma_f$  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 $\sigma_{\log HV}(f_0)$	0.48	0.40	0.30	0.25	0.20





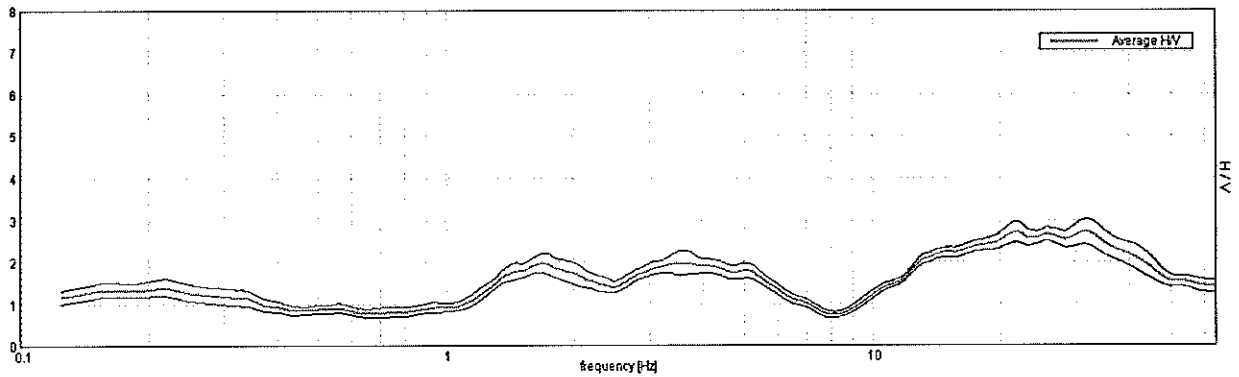
**RAVENNA – n. 2**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
 GPS data not available

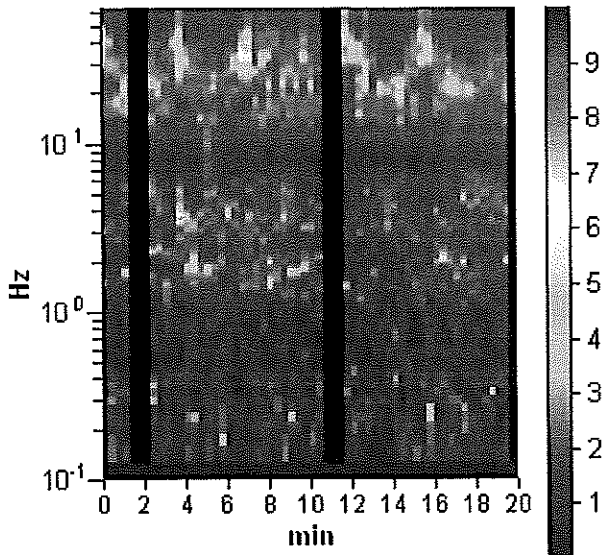
Trace length: 0h20'00". Analyzed 88% trace (manual window selection)  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 10%

**HORIZONTAL TO VERTICAL SPECTRAL RATIO**

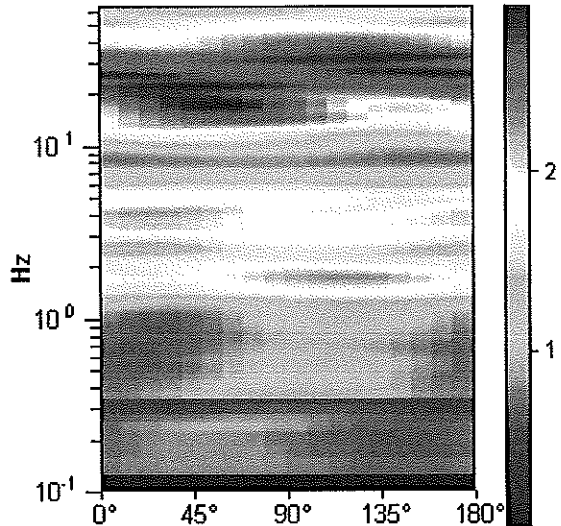
Max. HV at 19.97 ± 2.28 Hz. (in the range 0.0 - 20.0 Hz).



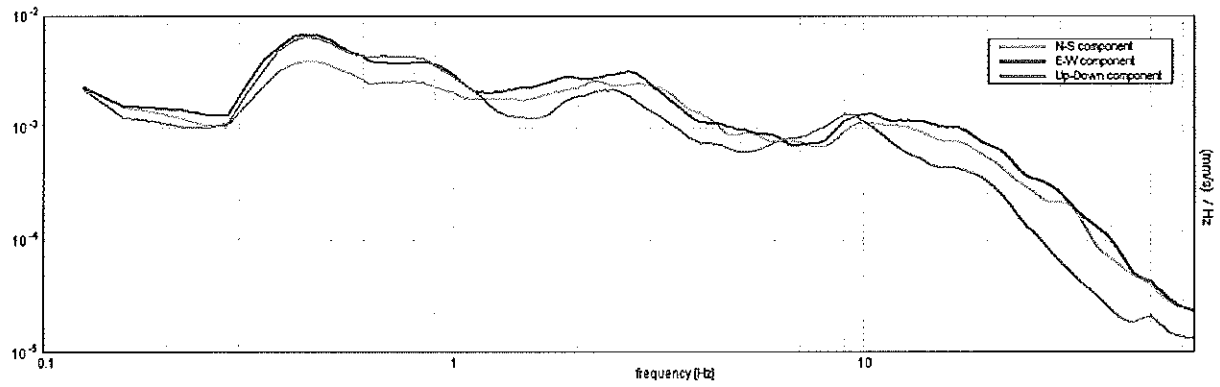
**H/V TIME HISTORY**



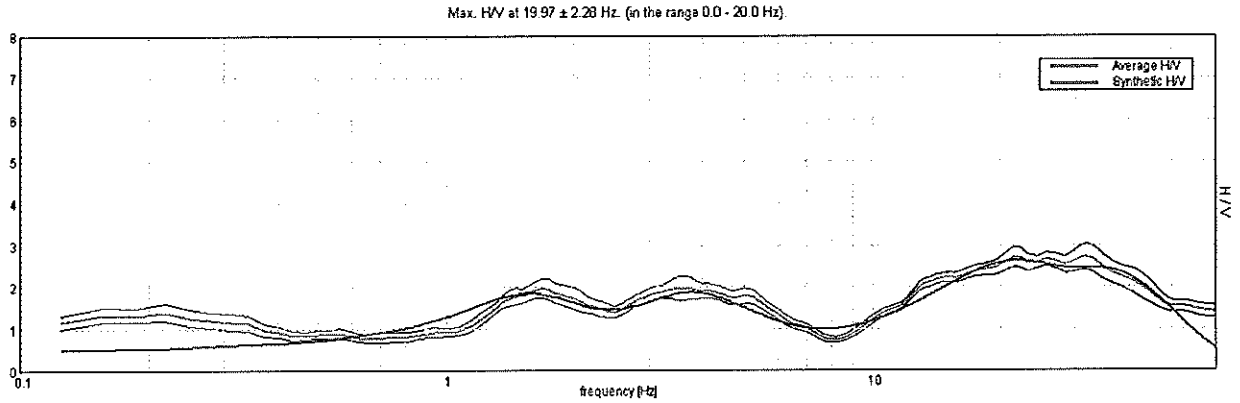
**DIRECTIONAL H/V**



SINGLE COMPONENT SPECTRA

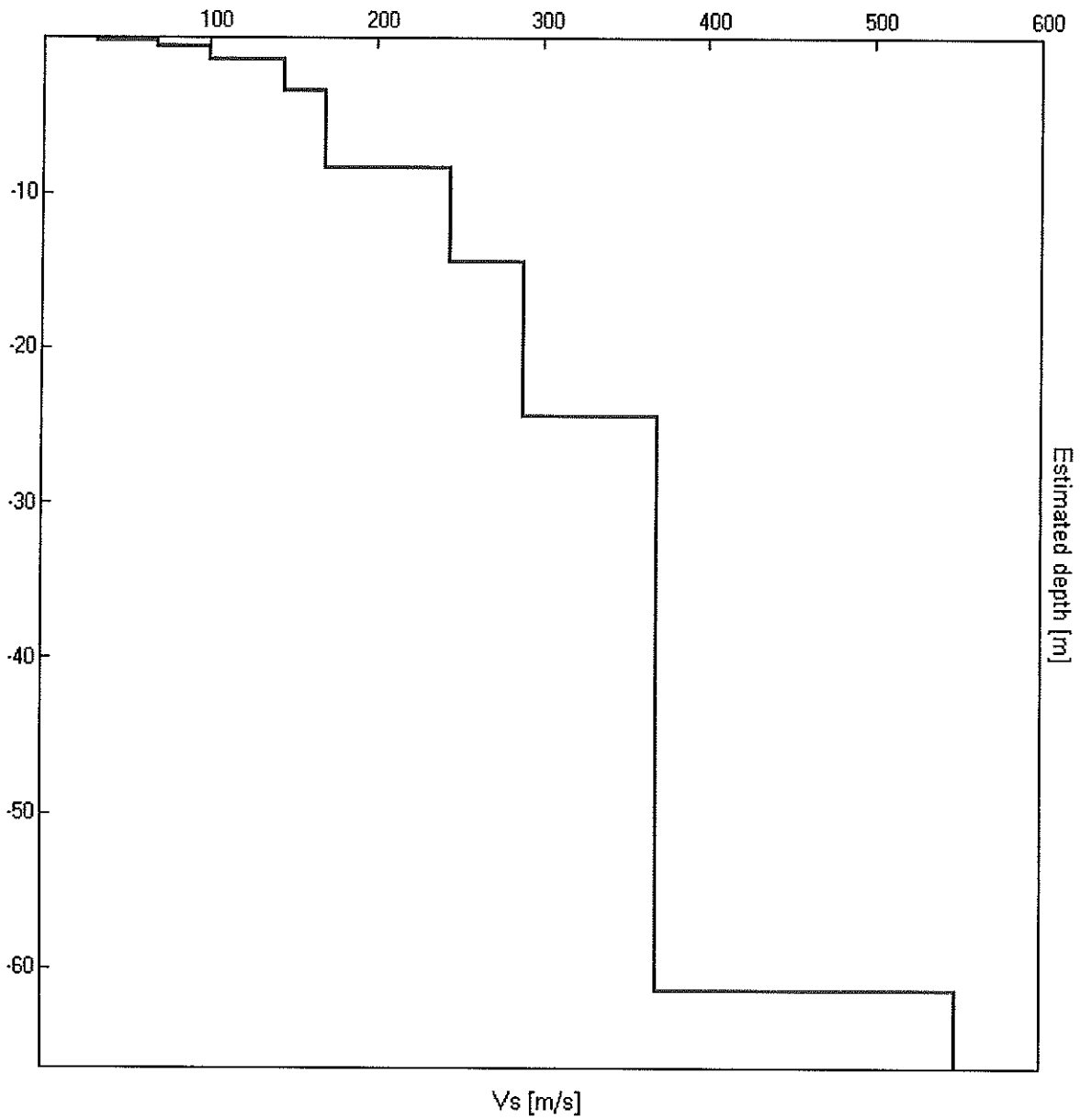


EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.18	0.18	32
0.58	0.40	68
1.38	0.80	100
3.38	2.00	145
8.38	5.00	170
14.38	6.00	245
24.38	10.00	290
61.38	37.00	370
inf.	inf.	550

Vs(0.0-30.0)=219m/s



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

Max. H/V at  $19.97 \pm 2.28$  Hz. (in the range 0.0 - 20.0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$19.97 > 0.50$	OK	
$n_c(f_0) > 200$	$21166.9 > 200$	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 960 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0]$   $A_{HV}(f^-) < A_0 / 2$	10.094 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0]$   $A_{HV}(f^+) < A_0 / 2$			NO
$A_0 > 2$	$2.51 > 2$	OK	
$f_{\text{peak}}[A_{HV}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.05637  < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	$1.12564 < 0.99844$		NO
$\sigma_A(f_0) < \theta(f_0)$	$0.0916 < 1.58$	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
$\sigma_f$	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 $f_0$
$A_{HV}(f)$	H/V curve amplitude at frequency $f$
$f^-$	frequency between $f_0/4$ and $f_0$ for which $A_{HV}(f^-) < A_0/2$
$f^+$	frequency between $f_0$ and $4f_0$ for which $A_{HV}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{HV}(f)$ , $\sigma_A(f)$ is the factor by which the mean $A_{HV}(f)$ curve should be multiplied or divided
$\sigma_{\log HV}(f)$	standard deviation of $\log A_{HV}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

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

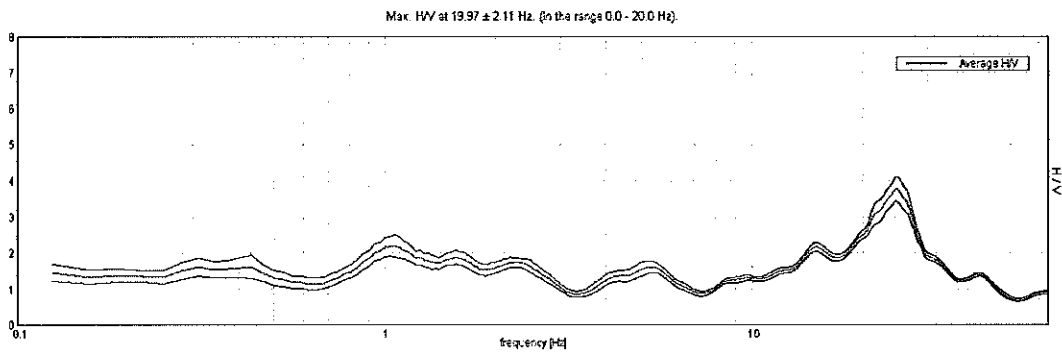
Freq.range [Hz]	< 0.2	0.2 - 0.5	0.5 - 1.0	1.0 - 2.0	> 2.0
$\varepsilon(f_0)$ [Hz]	$0.25 f_0$	$0.2 f_0$	$0.15 f_0$	$0.10 f_0$	$0.05 f_0$
$\theta(f_0)$ for $\sigma_A(f_0)$	3.0	2.5	2.0	1.78	1.58
Log $\theta(f_0)$ for $\sigma_{\log HV}(f_0)$	0.48	0.40	0.30	0.25	0.20

### RAVENNA – n. 3

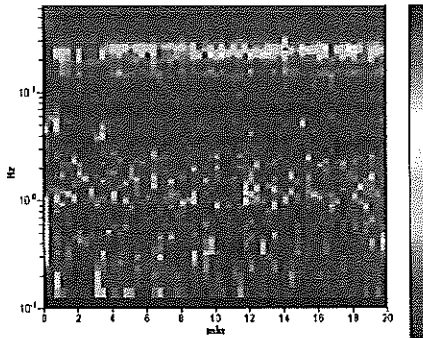
Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
GPS data not available

Trace length: 0h20'00". Analysis performed on the entire trace.  
Sampling frequency: 128 Hz  
Window size: 20 s  
Smoothing window: Triangular window  
Smoothing: 10%

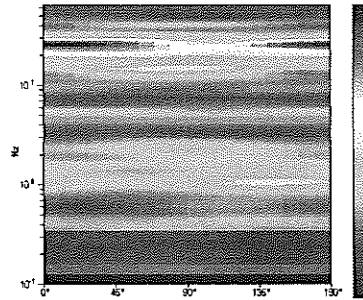
#### HORIZONTAL TO VERTICAL SPECTRAL RATIO



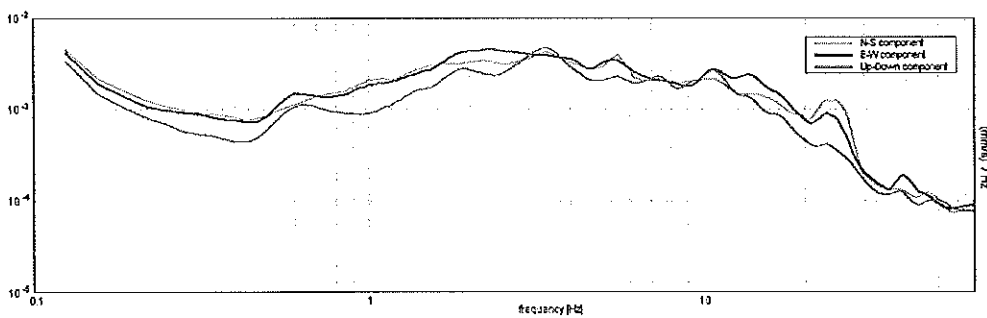
#### H/V TIME HISTORY



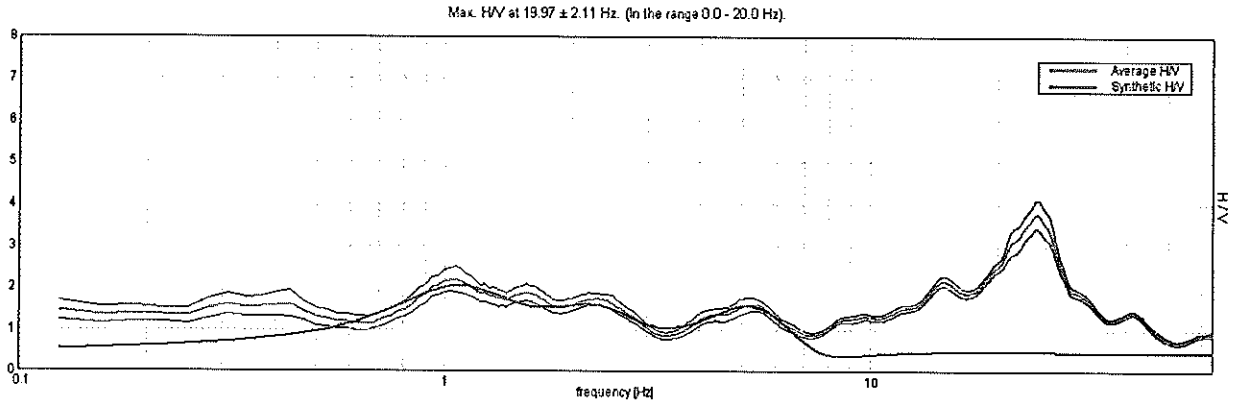
#### DIRECTIONAL H/V



#### SINGLE COMPONENT SPECTRA

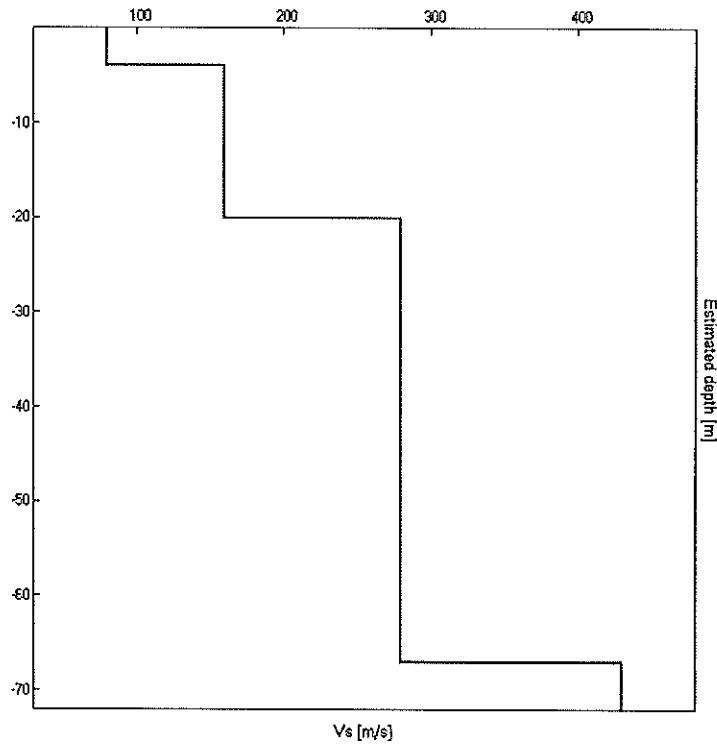


EXPERIMENTAL VS. SYNTHETIC HV



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
4.00	4.00	80
20.00	16.00	160
67.00	47.00	280
inf.	inf.	430

Vs(0.0-30.0)=162m/s



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

Max. H/V at  $19.97 \pm 2.11$  Hz. (in the range 0.0 - 20.0 Hz).

### Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$19.97 > 0.50$	OK	
$n_c(f_0) > 200$	$23962.5 > 200$	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 960 times	OK	

### Criteria for a clear HVSR peak

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0]$   $A_{H/V}(f^-) < A_0 / 2$	9.0 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0]$   $A_{H/V}(f^+) < A_0 / 2$	35.906 Hz	OK	
$A_0 > 2$	$2.50 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.05226  < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	$1.04364 < 0.99844$		NO
$\sigma_A(f_0) < \theta(f_0)$	$0.0587 < 1.58$	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
$\sigma_f$	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 $\sigma_f$ 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

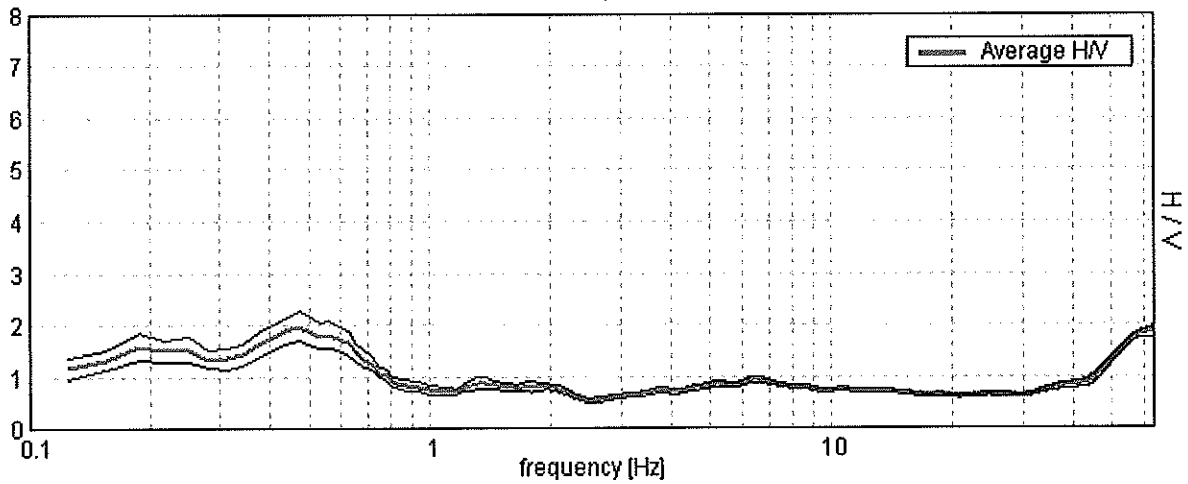


**RAVENNA – n. 4**

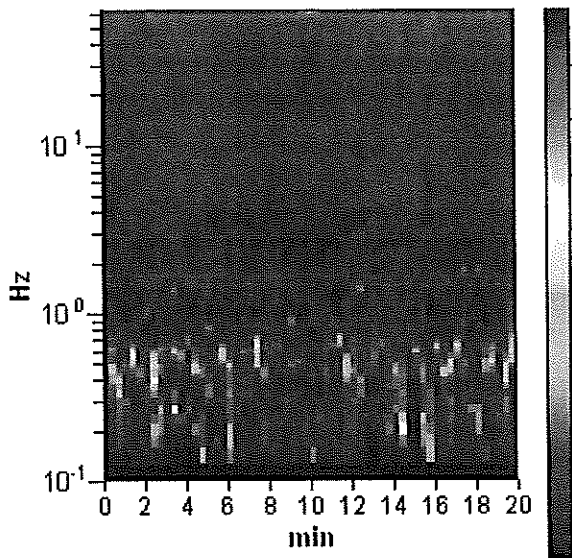
Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
GPS data not available

Trace length: 0h20'00". Analysis performed on the entire trace.  
Sampling frequency: 128 Hz  
Window size: 20 s  
Smoothing window: Triangular window  
Smoothing: 10%

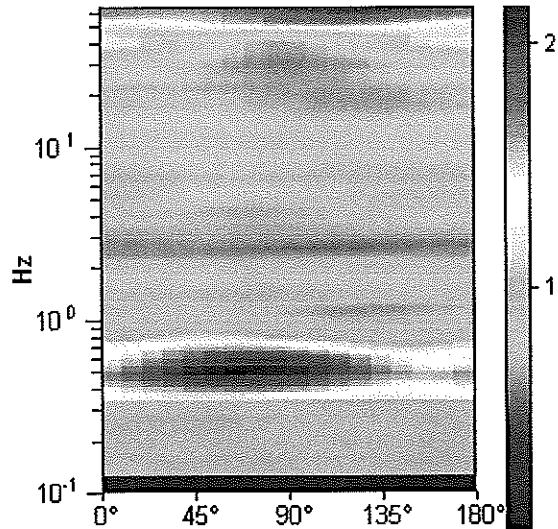
**HORIZONTAL TO VERTICAL SPECTRAL RATIO**  
Max. H/V at  $0.47 \pm 0.01$  Hz. (in the range 0.0 - 30.0 Hz).



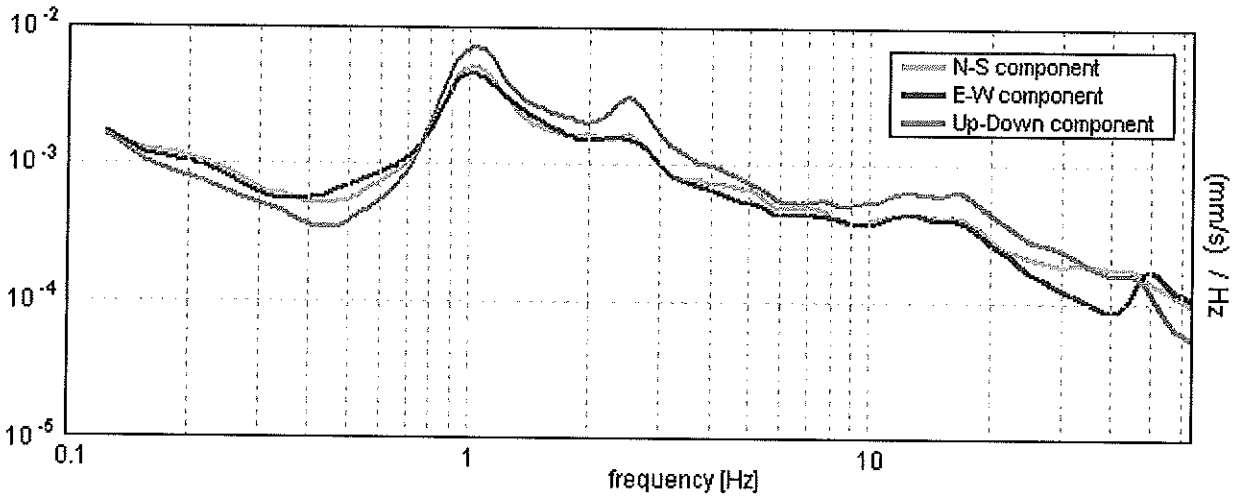
**H/V TIME HISTORY**



**DIRECTIONAL H/V**

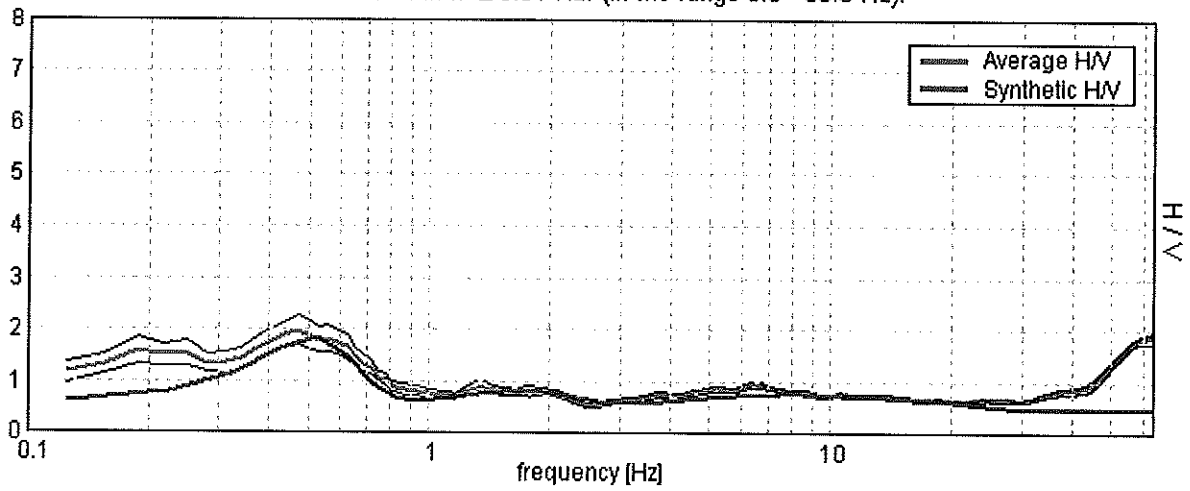


SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V

Max. H/V at  $0.47 \pm 0.01$  Hz. (In the range 0.0 - 30.0 Hz).



Depth at the bottom of the layer

Thickness [m]

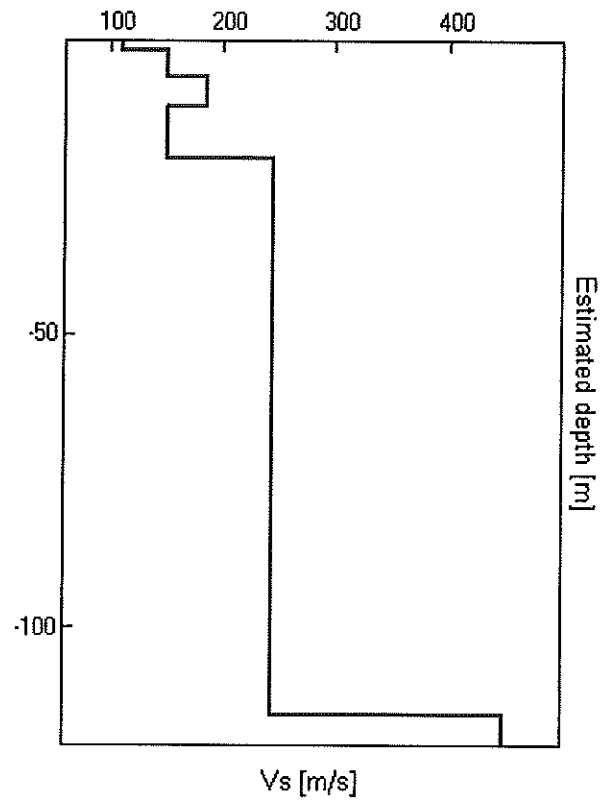
Vs [m/s]

[m]  
1.50  
6.00  
11.00  
20.00  
115.00  
inf.

1.50  
4.50  
5.00  
9.00  
95.00  
inf.

110  
150  
185  
150  
245  
450

Vs(0.0-30.0)=175m/s



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

Max. H/V at  $0.47 \pm 0.01$  Hz. (in the range 0.0 - 30.0 Hz).

**Criteria for a reliable HVSR curve**  
[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$0.47 > 0.50$		NO
$n_c(f_0) > 200$	$562.5 > 200$	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 24 times	OK	

**Criteria for a clear HVSR peak**  
[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0] \mid A_{HV}(f^-) < A_0 / 2$			NO
Exists $f^+$ in $[f_0, 4f_0] \mid A_{HV}(f^+) < A_0 / 2$	0.813 Hz	OK	
$A_0 > 2$	$1.99 > 2$		NO
$f_{\text{peak}}[A_{HV}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00629  < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.00295 < 0.09375$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.1386 < 2.5$	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
$\sigma_f$	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 $f_0$
$A_{HV}(f)$	H/V curve amplitude at frequency $f$
$f^-$	frequency between $f_0/4$ and $f_0$ for which $A_{HV}(f^-) < A_0/2$
$f^+$	frequency between $f_0$ and $4f_0$ for which $A_{HV}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{HV}(f)$ , $\sigma_A(f)$ is the factor by which the mean $A_{HV}(f)$ curve should be multiplied or divided
$\sigma_{\log HV}(f)$	standard deviation of $\log A_{HV}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

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

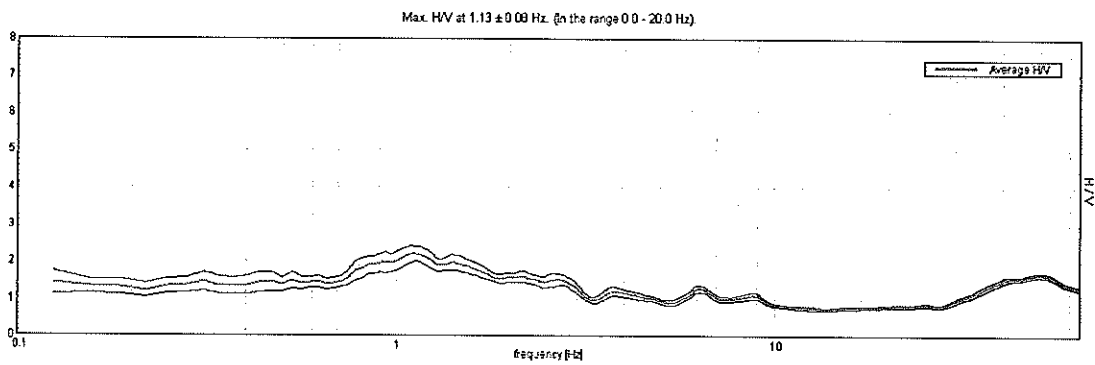
Freq.range [Hz]	< 0.2	0.2 – 0.5	0.5 – 1.0	1.0 – 2.0	> 2.0
$\varepsilon(f_0)$ [Hz]	$0.25 f_0$	$0.2 f_0$	$0.15 f_0$	$0.10 f_0$	$0.05 f_0$
$\theta(f_0)$ for $\sigma_A(f_0)$	3.0	2.5	2.0	1.78	1.58
Log $\theta(f_0)$ for $\sigma_{\log HV}(f_0)$	0.48	0.40	0.30	0.25	0.20

RAVENNA – n. 5

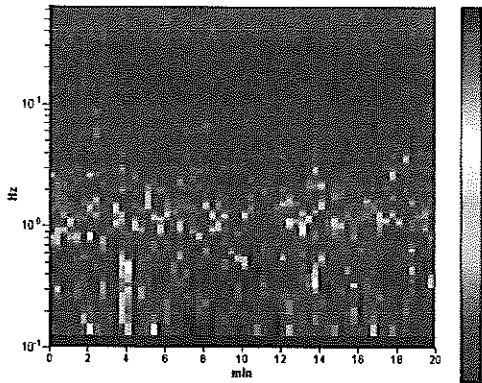
Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
GPS data not available

Trace length: 0h20'00". Analysis performed on the entire trace.  
Sampling frequency: 128 Hz  
Window size: 20 s  
Smoothing window: Triangular window  
Smoothing: 10%

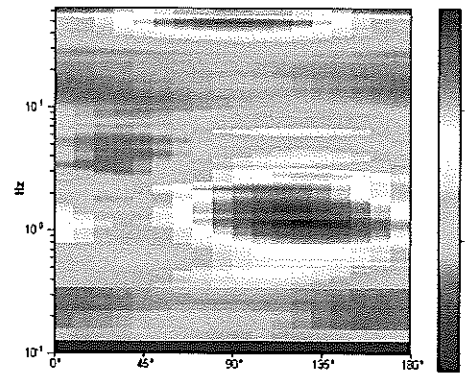
HORIZONTAL TO VERTICAL SPECTRAL RATIO



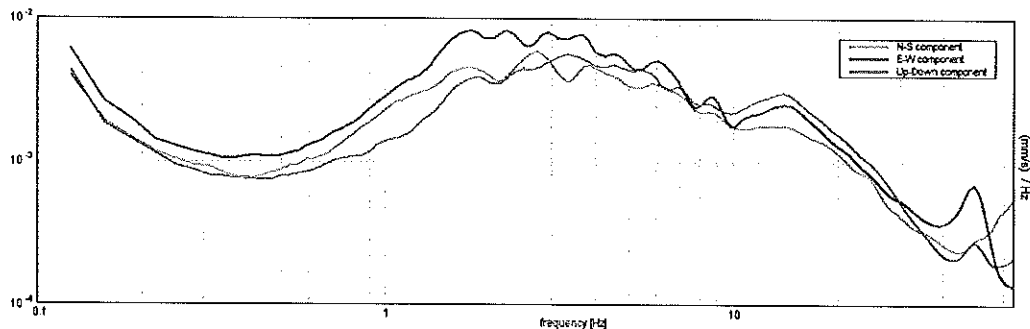
H/V TIME HISTORY



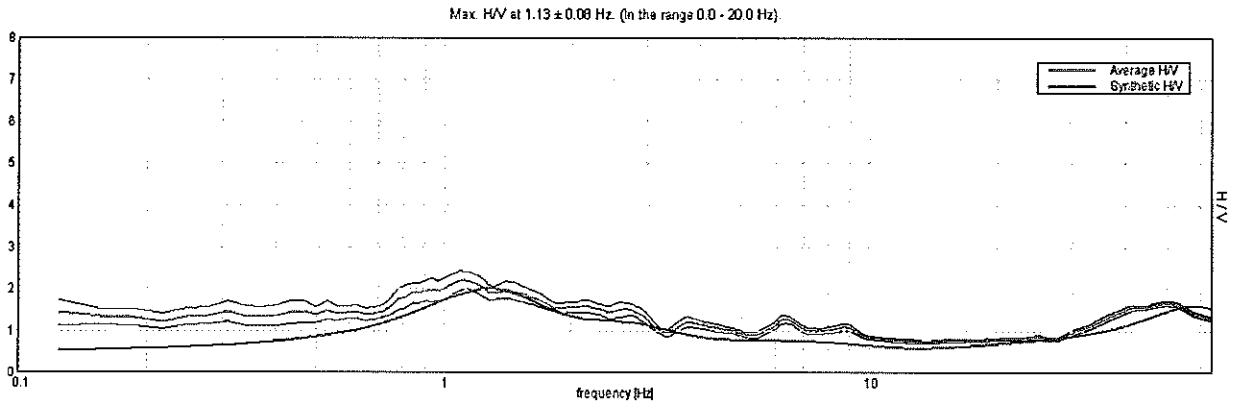
DIRECTIONAL HV



SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC HV



Depth at the bottom of the layer

Thickness [m]

Vs [m/s]

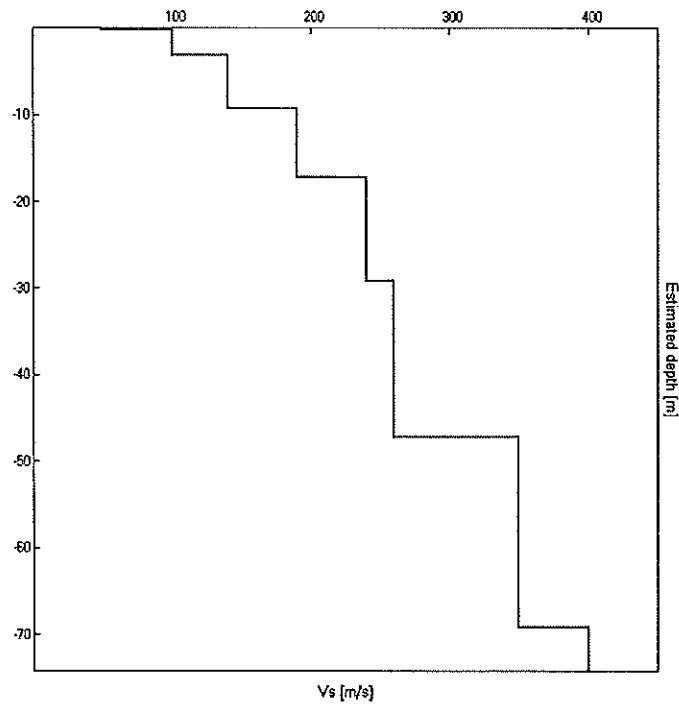
[m]

0.20  
3.20  
9.20  
17.20  
29.20  
47.20  
69.20  
inf.

0.20  
3.00  
6.00  
8.00  
12.00  
18.00  
22.00  
inf.

50  
100  
140  
190  
240  
260  
350  
400

Vs(0.0-30.0)=174m/s



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

**Max. H/V at 1.13 ± 0.08 Hz. (in the range 0.0 - 20.0 Hz).**

<b>Criteria for a reliable HVSR curve</b> [All 3 should be fulfilled]			
$f_0 > 10 / L_w$	1.13 > 0.50	OK	
$n_c(f_0) > 200$	1350.0 > 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 55 times	OK	
<b>Criteria for a clear HVSR peak</b> [At least 5 out of 6 should be fulfilled]			
Exists $f^-$ in $[f_0/4, f_0] \mid A_{HV}(f^-) < A_0 / 2$			NO
Exists $f^+$ in $[f_0, 4f_0] \mid A_{HV}(f^+) < A_0 / 2$	3.156 Hz	OK	
$A_0 > 2$	2.20 > 2	OK	
$f_{\text{peak}}[A_{HV}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.03432  < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	0.0386 < 0.1125	OK	
$\sigma_A(f_0) < \theta(f_0)$	0.1015 < 1.78	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
$\sigma_f$	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 $f_0$
$A_{HV}(f)$	H/V curve amplitude at frequency $f$
$f^-$	frequency between $f_0/4$ and $f_0$ for which $A_{HV}(f^-) < A_0/2$
$f^+$	frequency between $f_0$ and $4f_0$ for which $A_{HV}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{HV}(f)$ , $\sigma_A(f)$ is the factor by which the mean $A_{HV}(f)$ curve should be multiplied or divided
$\sigma_{\log HV}(f)$	standard deviation of $\log A_{HV}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

Threshold values for $\sigma_f$ 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 $\sigma_{\log HV}(f_0)$	0.48	0.40	0.30	0.25	0.20



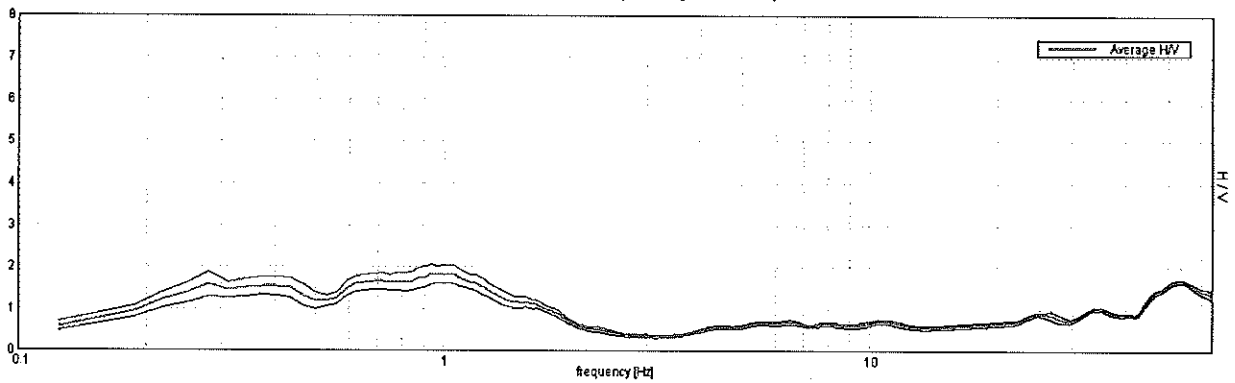
RAVENNA – n. 6

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
 GPS data not available

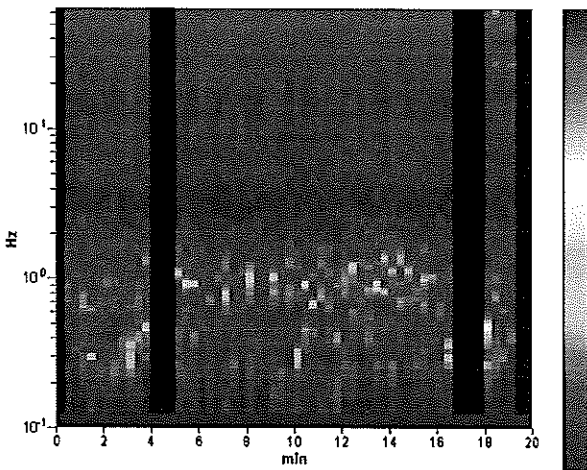
Trace length: 0h20'00". Analyzed 83% trace (manual window selection)  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

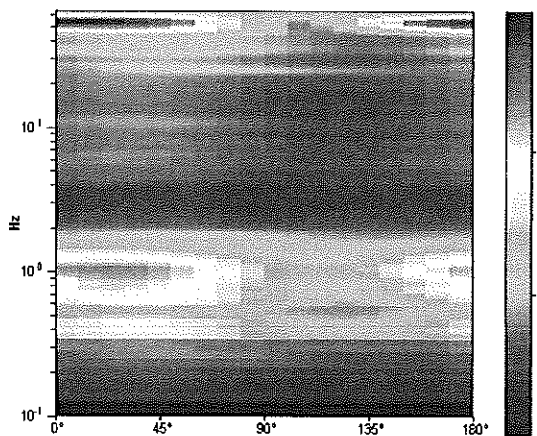
Max. H/V at 0.94 ± 0.11 Hz. (in the range 0.0 - 20.0 Hz).



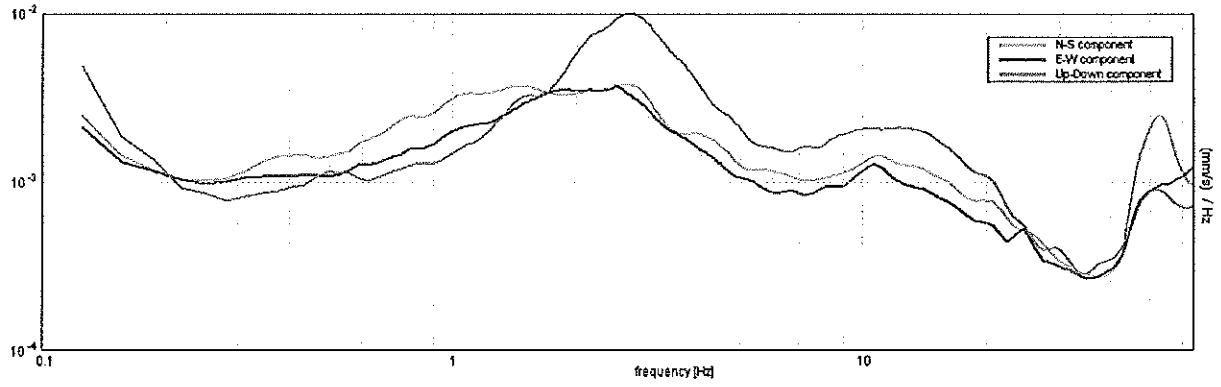
H/V TIME HISTORY



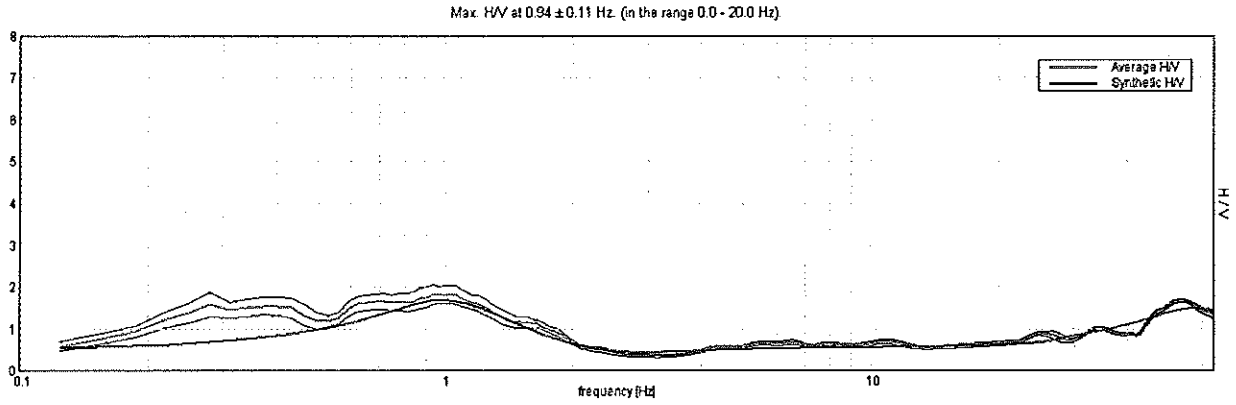
DIRECTIONAL H/V



SINGLE COMPONENT SPECTRA

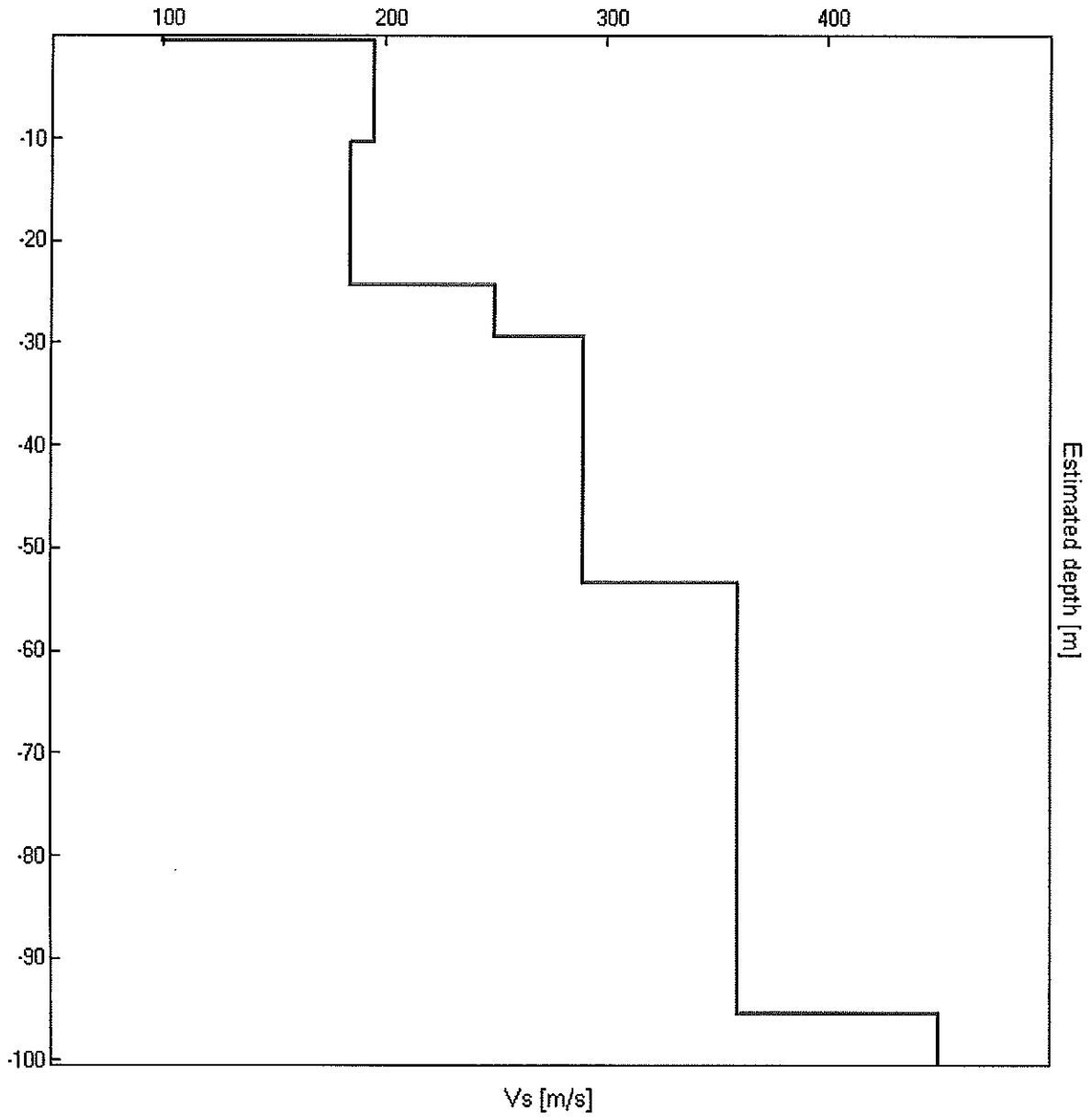


EXPERIMENTAL VS. SYNTHETIC HV



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.40	0.40	100
10.40	10.00	195
24.40	14.00	185
29.40	5.00	250
53.40	24.00	290
95.40	42.00	360
inf.	inf.	450

Vs(0.0-30.0)=196m/s



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

Max. H/V at  $0.94 \pm 0.11$  Hz. (in the range 0.0 - 20.0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$0.94 > 0.50$	OK	
$n_c(f_0) > 200$	$937.5 > 200$	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 46 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0]$   $A_{HV}(f^-) < A_0 / 2$			NO
Exists $f^+$ in $[f_0, 4f_0]$   $A_{HV}(f^+) < A_0 / 2$	1.844 Hz	OK	
$A_0 > 2$	$1.83 > 2$		NO
$f_{\text{peak}}[A_{HV}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.06033  < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	$0.05656 < 0.14063$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.1158 < 2.0$	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
$\sigma_f$	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 $f_0$
$A_{HV}(f)$	H/V curve amplitude at frequency $f$
$f^-$	frequency between $f_0/4$ and $f_0$ for which $A_{HV}(f^-) < A_0/2$
$f^+$	frequency between $f_0$ and $4f_0$ for which $A_{HV}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{HV}(f)$ , $\sigma_A(f)$ is the factor by which the mean $A_{HV}(f)$ curve should be multiplied or divided
$\sigma_{\log HV}(f)$	standard deviation of $\log A_{HV}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

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

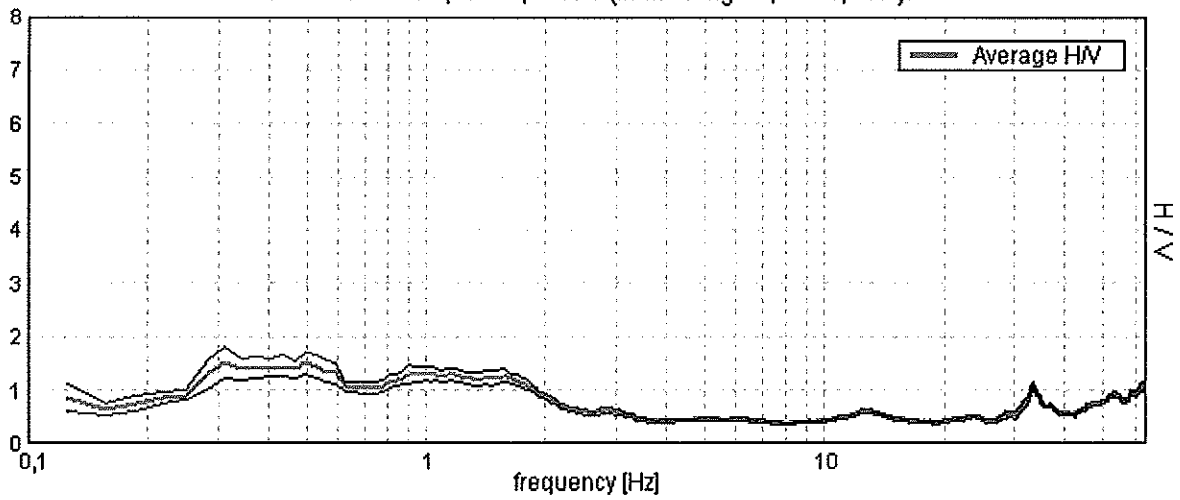
Freq.range [Hz]	< 0.2	0.2 - 0.5	0.5 - 1.0	1.0 - 2.0	> 2.0
$\varepsilon(f_0)$ [Hz]	$0.25 f_0$	$0.2 f_0$	$0.15 f_0$	$0.10 f_0$	$0.05 f_0$
$\theta(f_0)$ for $\sigma_A(f_0)$	3.0	2.5	2.0	1.78	1.58
Log $\theta(f_0)$ for $\sigma_{\log HV}(f_0)$	0.48	0.40	0.30	0.25	0.20

RAVENNA – n. 7

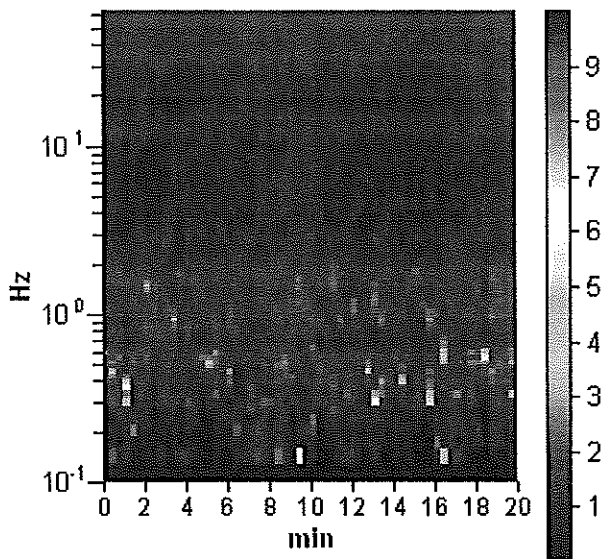
GPS data not available

Trace length: 0h20'00". Analysis performed on the entire trace.  
Sampling frequency: 128 Hz  
Window size: 20 s  
Smoothing window: Triangular window  
Smoothing: 10%

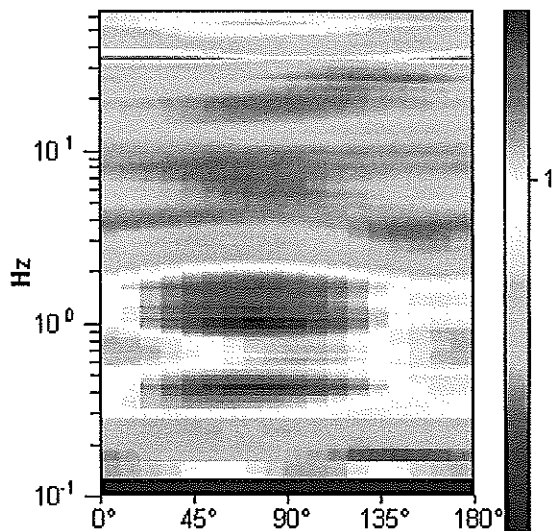
HORIZONTAL TO VERTICAL SPECTRAL RATIO  
Max. HVSR at 0,31 ± 0,02 Hz. (in the range 0,0 - 64,0 Hz).



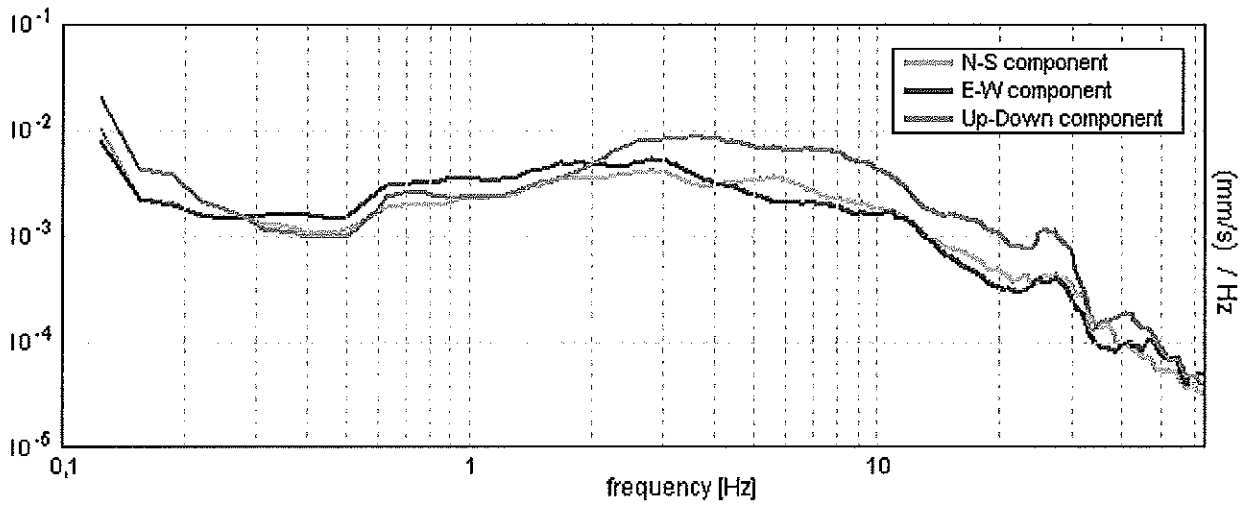
HV TIME HISTORY



DIRECTIONAL HV

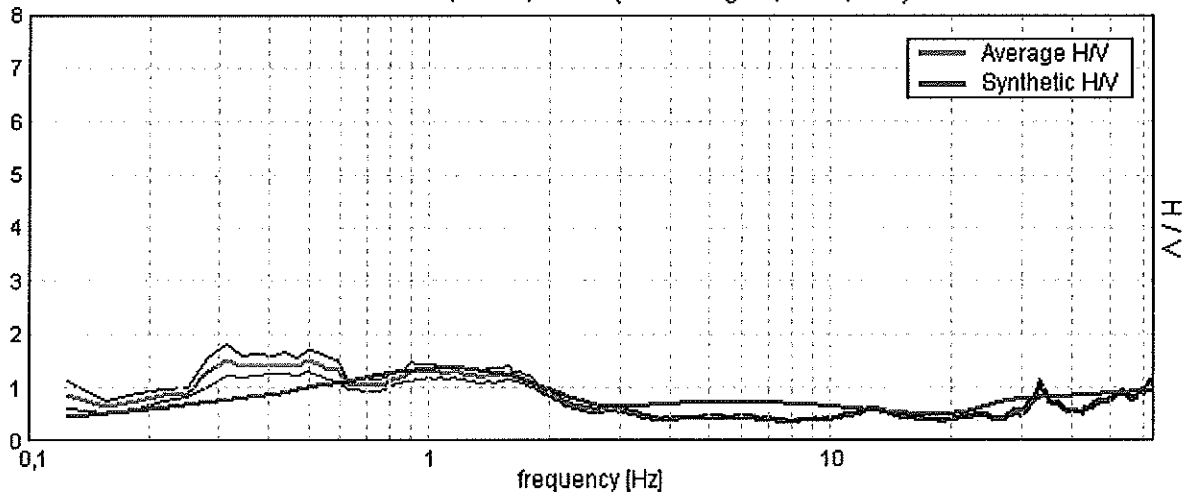


SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V

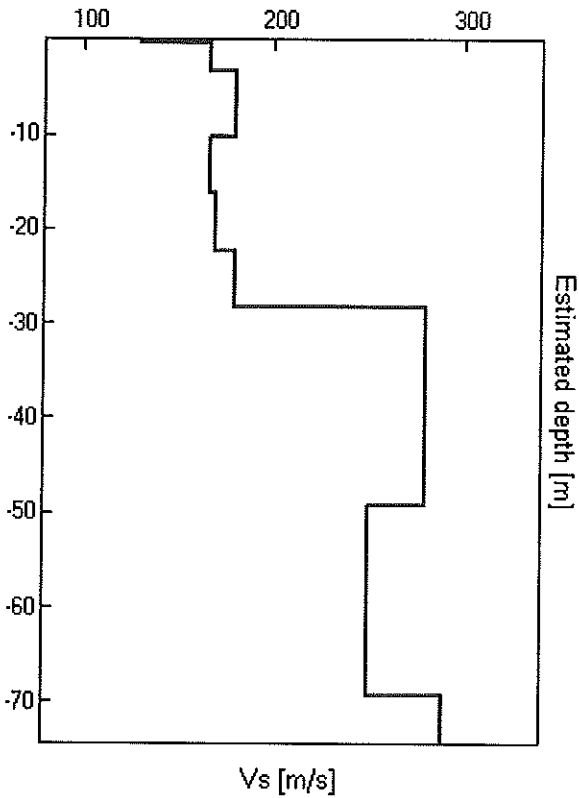
Max. HVSR at  $0,31 \pm 0,02$  Hz. (in the range 0,0 - 64,0 Hz).



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0,30	0,30	130
3,30	3,00	167
10,30	7,00	180
16,30	6,00	167
22,30	6,00	170
28,30	6,00	180
49,30	21,00	280
69,30	20,00	250
inf.	inf.	290

Vs30=177 m/s





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

**Max. HVSR at  $0,31 \pm 0,02$  Hz. (in the range 0,0 - 64,0 Hz).**

<b>Criteria for a reliable HVSR curve</b> [All 3 should be fulfilled]			
$f_0 > 10 / L_w$	$0,31 > 0,50$		<b>NO</b>
$n_c(f_0) > 200$	$375,0 > 200$	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 16 times	OK	
<b>Criteria for a clear HVSR peak</b> [At least 5 out of 6 should be fulfilled]			
Exists $f^-$ in $[f_0/4, f_0] \mid A_{H/V}(f^-) < A_0 / 2$	$0,188 \text{ Hz}$	OK	
Exists $f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0 / 2$			<b>NO</b>
$A_0 > 2$	$1,51 > 2$		<b>NO</b>
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0,03902  < 0,05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0,01219 < 0,0625$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0,1474 < 2,5$	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
$\sigma_f$	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 $\sigma_f$ 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

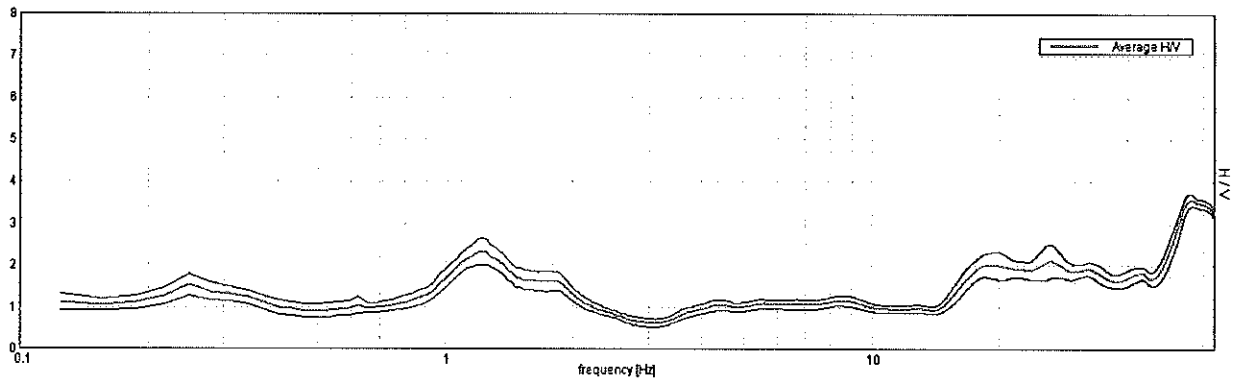
**RAVENNA – n. 8**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
 GPS data not available

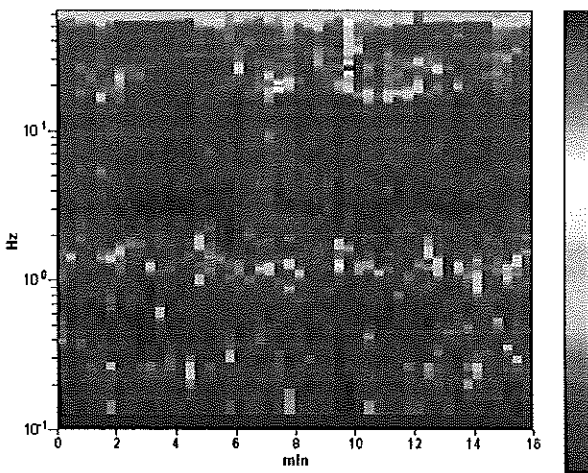
Trace length: 0h16'00". Analysis performed on the entire trace.  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 10%

**HORIZONTAL TO VERTICAL SPECTRAL RATIO**

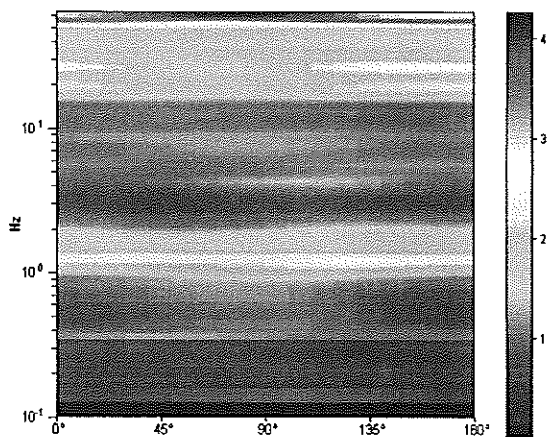
Max. HV at 56.53 ± 1.05 Hz. (in the range 0.0 - 64.0 Hz)



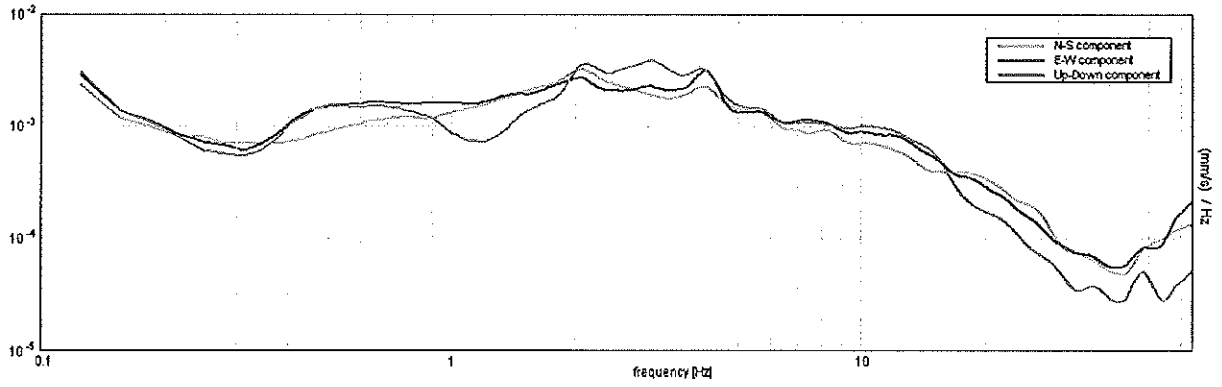
**H/V TIME HISTORY**



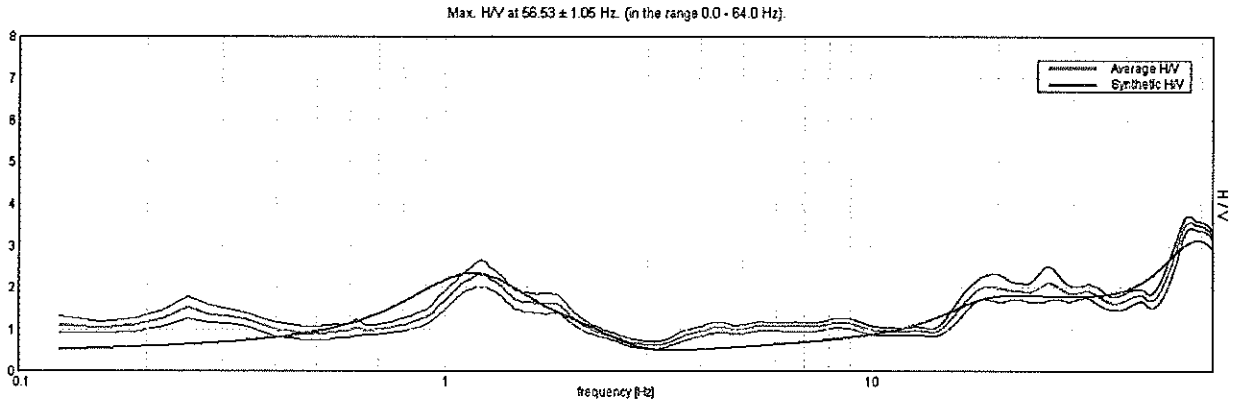
**DIRECTIONAL H/V**



SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



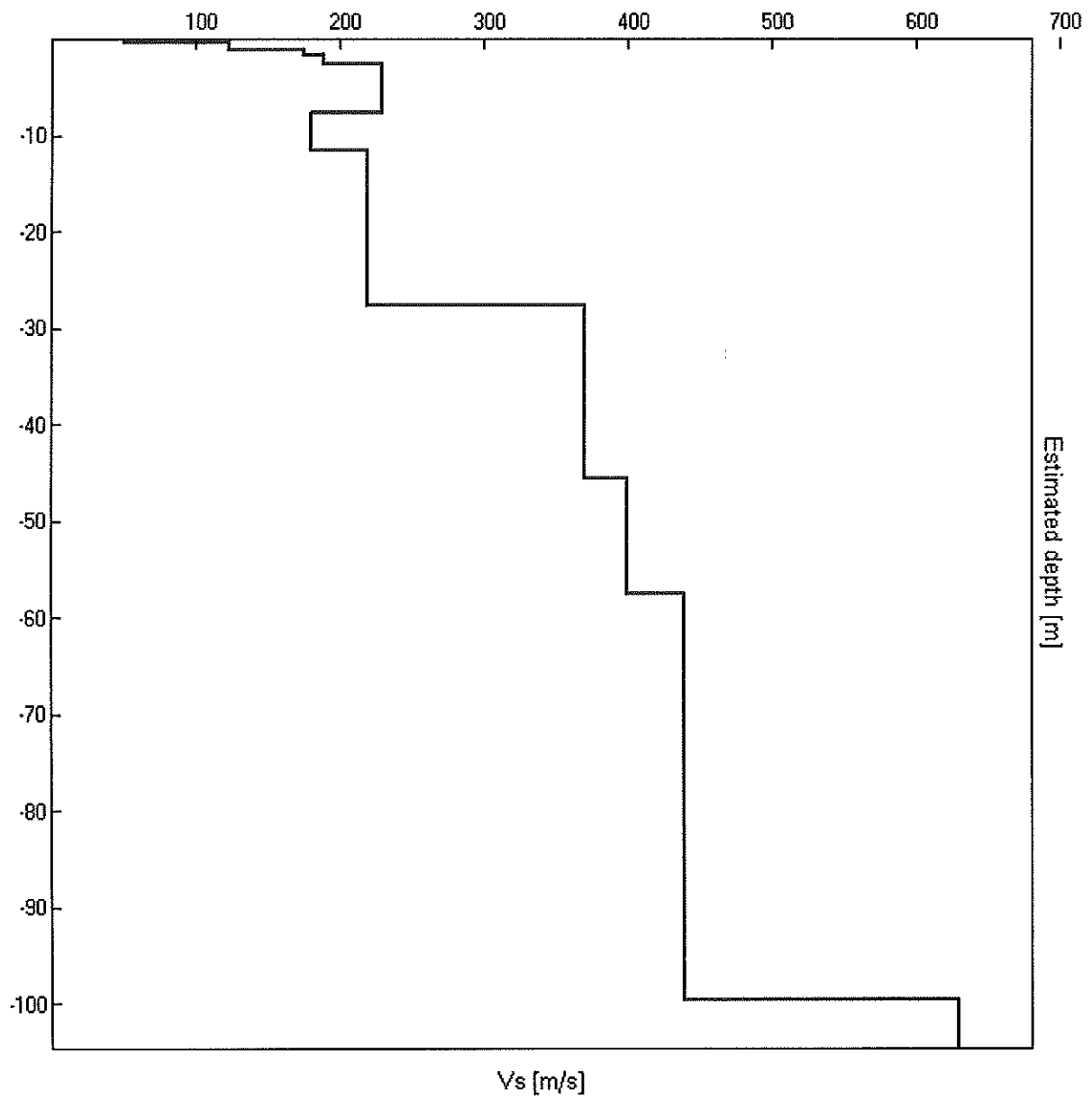
Depth at the bottom of the layer  
 [m]

Thickness [m]

Vs [m/s]

0.23	0.23	50
1.03	0.80	123
1.53	0.50	175
2.53	1.00	189
7.53	5.00	230
11.53	4.00	180
27.53	16.00	220
45.53	18.00	370
57.53	12.00	400
99.53	42.00	440
inf.	inf.	630

Vs(0.0-30.0)=210m/s



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

Max. H/V at 56.53 ± 1.05 Hz. (in the range 0.0 - 64.0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	56.53 > 0.50	OK	
$n_c(f_0) > 200$	54270.0 > 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 1144 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0] \mid A_{HV}(f^-) < A_0 / 2$	47.156 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0] \mid A_{HV}(f^+) < A_0 / 2$			NO
$A_0 > 2$	3.56 > 2	OK	
$f_{\text{peak}}[A_{HV}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00911  < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	0.51472 < 2.82656	OK	
$\sigma_A(f_0) < \theta(f_0)$	0.0706 < 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
$\sigma_f$	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 $f_0$
$A_{HV}(f)$	H/V curve amplitude at frequency $f$
$f^-$	frequency between $f_0/4$ and $f_0$ for which $A_{HV}(f^-) < A_0/2$
$f^+$	frequency between $f_0$ and $4f_0$ for which $A_{HV}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{HV}(f)$ , $\sigma_A(f)$ is the factor by which the mean $A_{HV}(f)$ curve should be multiplied or divided
$\sigma_{\log HV}(f)$	standard deviation of $\log A_{HV}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

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

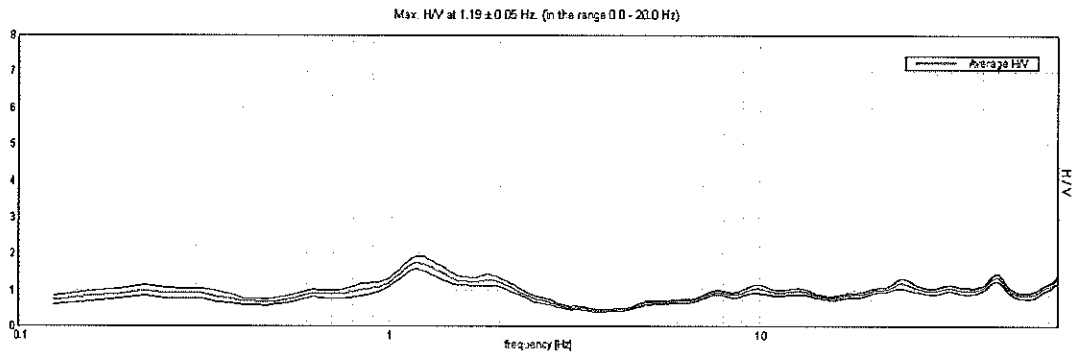
Freq. range [Hz]	< 0.2	0.2 – 0.5	0.5 – 1.0	1.0 – 2.0	> 2.0
$\varepsilon(f_0)$ [Hz]	0.25 $f_0$	0.2 $f_0$	0.15 $f_0$	0.10 $f_0$	0.05 $f_0$
$\theta(f_0)$ for $\sigma_A(f_0)$	3.0	2.5	2.0	1.78	1.58
Log $\theta(f_0)$ for $\sigma_{\log HV}(f_0)$	0.48	0.40	0.30	0.25	0.20

**RAVENNA – n. 9**

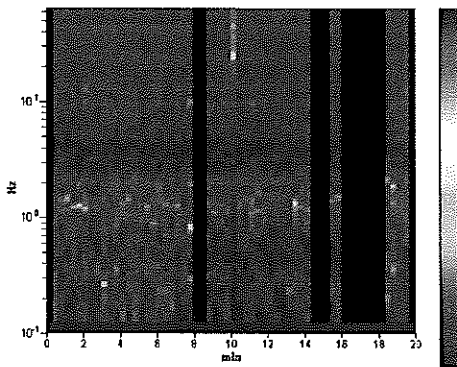
Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
 GPS data not available

Trace length: 0h20'00". Analyzed 77% trace (manual window selection)  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 10%

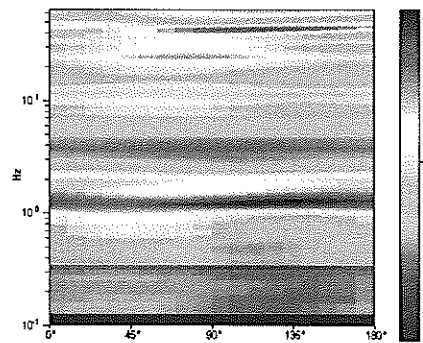
**HORIZONTAL TO VERTICAL SPECTRAL RATIO**



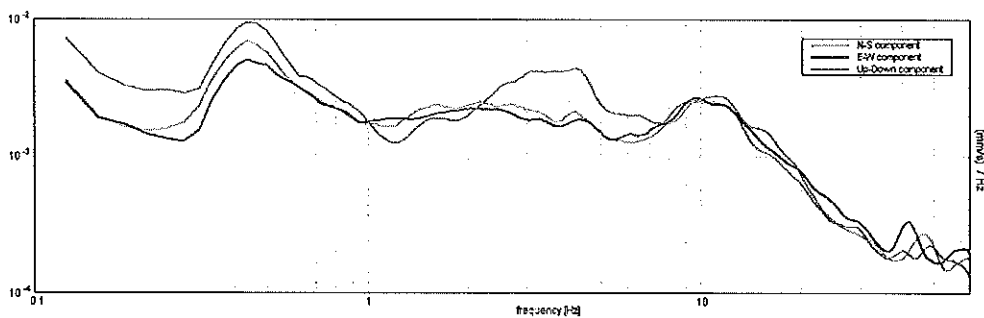
**H/V TIME HISTORY**



**DIRECTIONAL H/V**

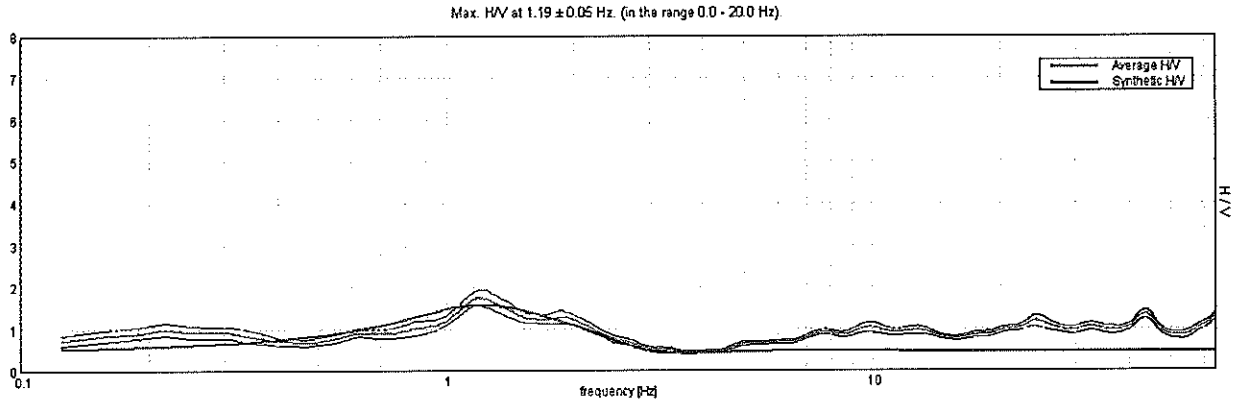


**SINGLE COMPONENT SPECTRA**



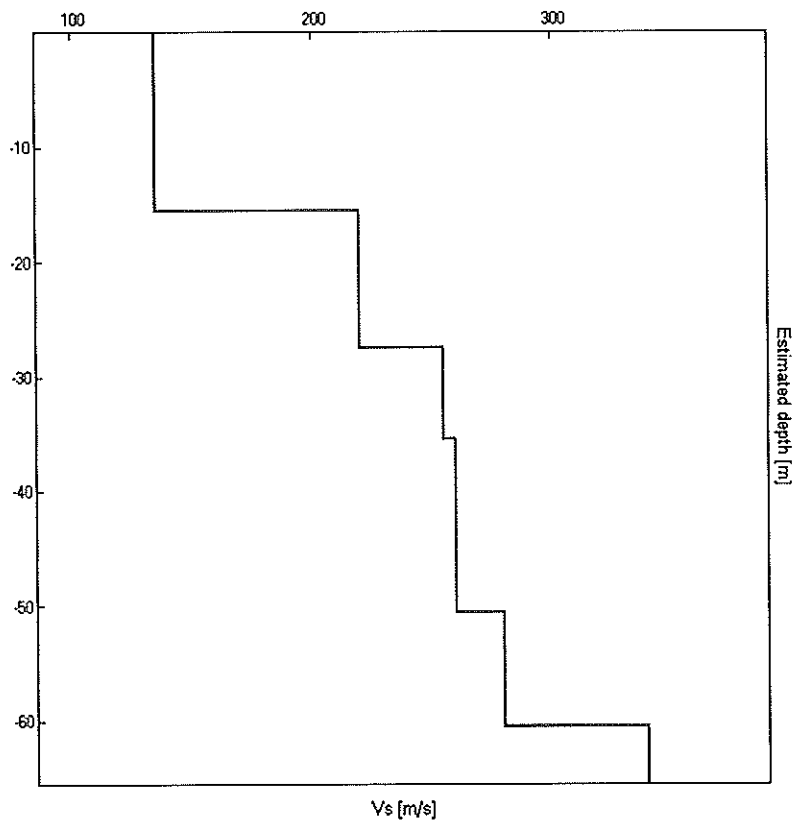


EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
15.50	15.50	135
27.50	12.00	220
35.50	8.00	255
50.50	15.00	260
60.50	10.00	280
inf.	inf.	340

Vs(0.0-30.0)=167m/s



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

Max. H/V at 1.19 ± 0.05 Hz. (in the range 0.0 - 20.0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	1.19 > 0.50	OK	
$n_c(f_0) > 200$	1092.5 > 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 58 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0]$   $A_{HV}(f^-) < A_0 / 2$	0.594 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0]$   $A_{HV}(f^+) < A_0 / 2$	2.344 Hz	OK	
$A_0 > 2$	1.75 > 2		NO
$f_{\text{peak}}[A_{HV}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.01946  < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.02311 < 0.11875$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.0856 < 1.78$	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
$\sigma_f$	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 $f_0$
$A_{HV}(f)$	H/V curve amplitude at frequency $f$
$f^-$	frequency between $f_0/4$ and $f_0$ for which $A_{HV}(f^-) < A_0/2$
$f^+$	frequency between $f_0$ and $4f_0$ for which $A_{HV}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{HV}(f)$ , $\sigma_A(f)$ is the factor by which the mean $A_{HV}(f)$ curve should be multiplied or divided
$\sigma_{\log HV}(f)$	standard deviation of $\log A_{HV}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

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

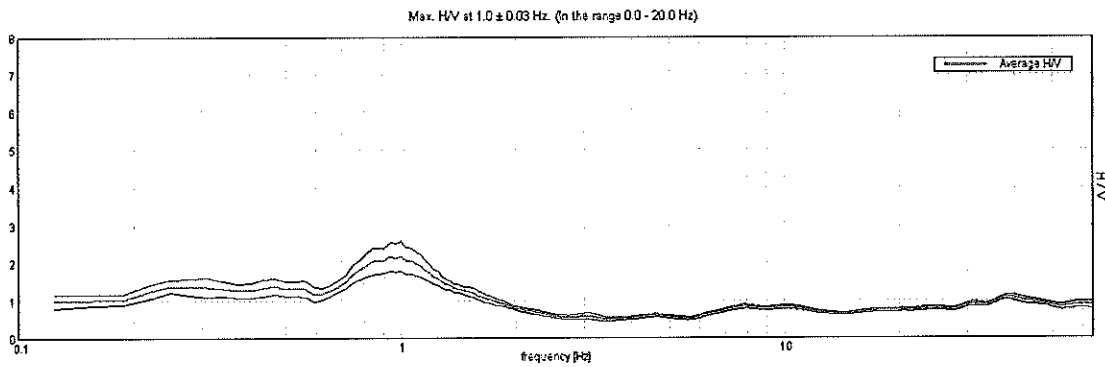
Freq.range [Hz]	< 0.2	0.2 – 0.5	0.5 – 1.0	1.0 – 2.0	> 2.0
$\varepsilon(f_0)$ [Hz]	$0.25 f_0$	$0.2 f_0$	$0.15 f_0$	$0.10 f_0$	$0.05 f_0$
$\theta(f_0)$ for $\sigma_A(f_0)$	3.0	2.5	2.0	1.78	1.58
Log $\theta(f_0)$ for $\sigma_{\log HV}(f_0)$	0.48	0.40	0.30	0.25	0.20

**RAVENNA – n. 10**

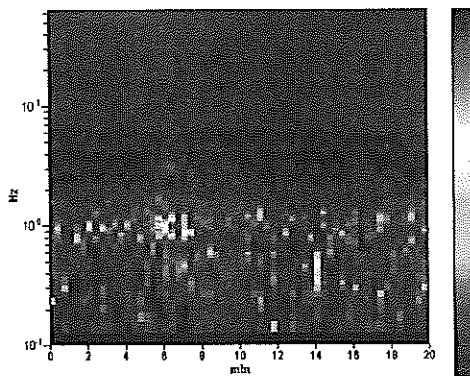
Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
 GPS data not available

Trace length: 0h20'00". Analysis performed on the entire trace.  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 10%

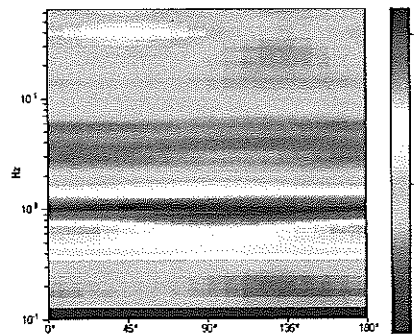
**HORIZONTAL TO VERTICAL SPECTRAL RATIO**



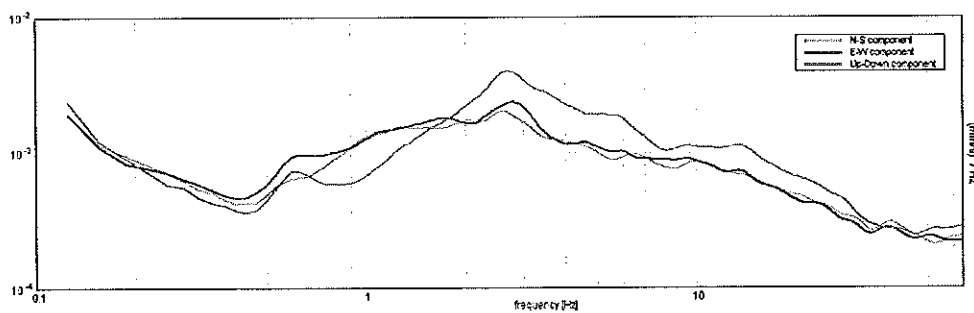
**H/V TIME HISTORY**



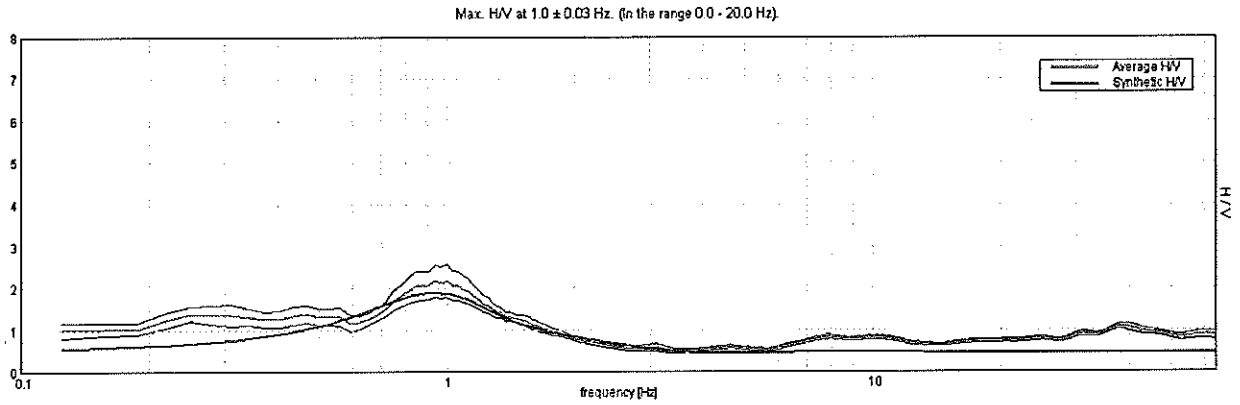
**DIRECTIONAL HV**



**SINGLE COMPONENT SPECTRA**



EXPERIMENTAL VS. SYNTHETIC HV



Depth at the bottom of the layer

Thickness [m]

Vs [m/s]

[m]

13.00

13.00

130

34.00

21.00

195

65.00

31.00

270

83.00

18.00

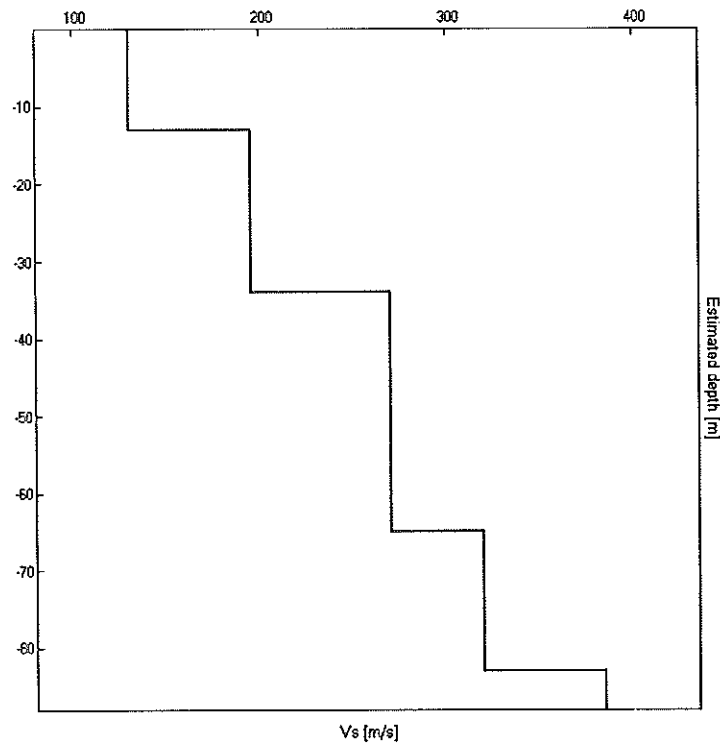
320

inf.

inf.

385

Vs(0.0-30.0)=160m/s



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

Max. H/V at 1.0 ± 0.03 Hz. (in the range 0.0 - 20.0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	1.00 > 0.50	OK	
$n_c(f_0) > 200$	1200.0 > 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 49 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0]$   $A_{HV}(f^-) < A_0 / 2$			NO
Exists $f^+$ in $[f_0, 4f_0]$   $A_{HV}(f^+) < A_0 / 2$	1.656 Hz	OK	
$A_0 > 2$	2.17 > 2	OK	
$f_{\text{peak}}[A_{HV}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	0.01618  < 0.05	OK	
$\sigma_f < \varepsilon(f_0)$	0.01618 < 0.1	OK	
$\sigma_A(f_0) < \theta(f_0)$	0.1968 < 1.78	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
$\sigma_f$	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 $f_0$
$A_{HV}(f)$	H/V curve amplitude at frequency $f$
$f^-$	frequency between $f_0/4$ and $f_0$ for which $A_{HV}(f^-) < A_0/2$
$f^+$	frequency between $f_0$ and $4f_0$ for which $A_{HV}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{HV}(f)$ , $\sigma_A(f)$ is the factor by which the mean $A_{HV}(f)$ curve should be multiplied or divided
$\sigma_{\log HV}(f)$	standard deviation of $\log A_{HV}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

Threshold values for  $\sigma_f$  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 $\sigma_{\log HV}(f_0)$	0.48	0.40	0.30	0.25	0.20

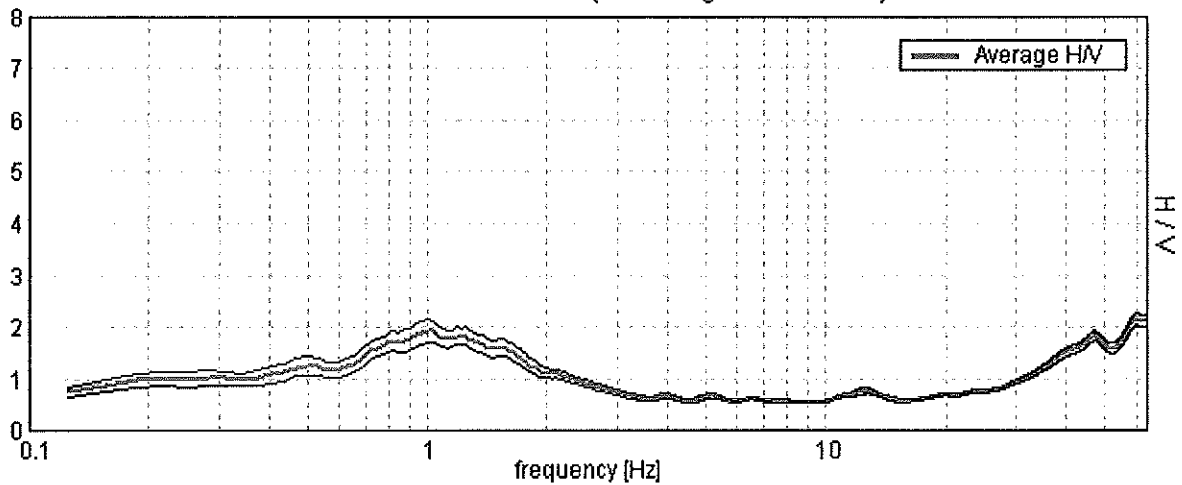
RAVENNA - n. 11

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
GPS data not available

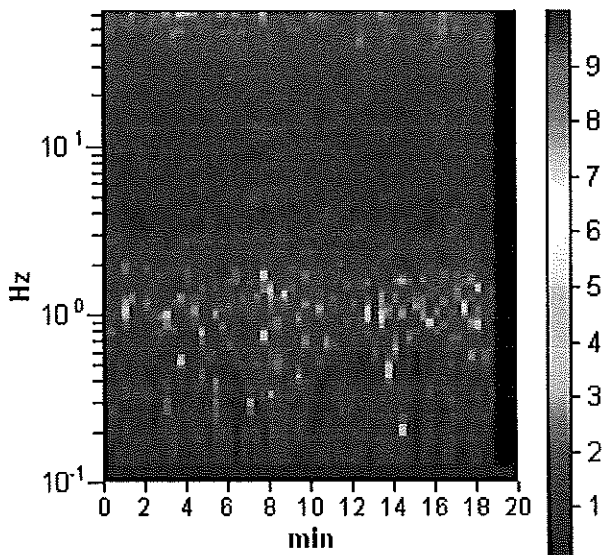
Trace length: 0h20'00". Analyzed 95% trace (manual window selection)  
Sampling frequency: 128 Hz  
Window size: 20 s  
Smoothing window: Triangular window  
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

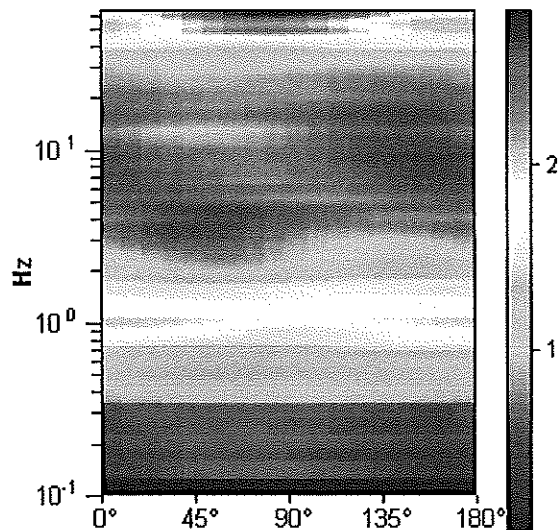
Max. H/V at  $1.0 \pm 0.02$  Hz. (in the range 0.0 - 20.0 Hz).



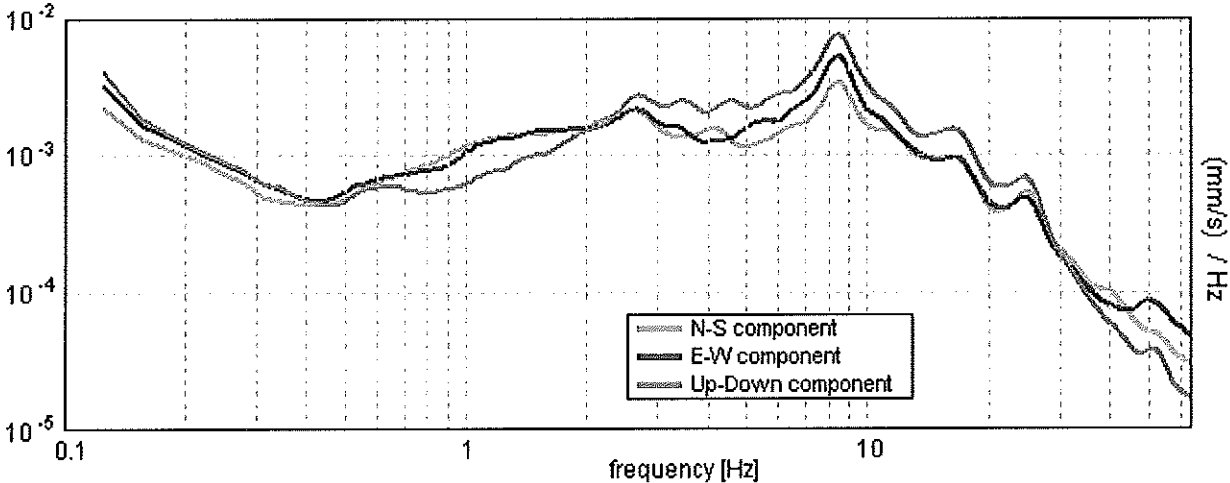
H/V TIME HISTORY



DIRECTIONAL H/V

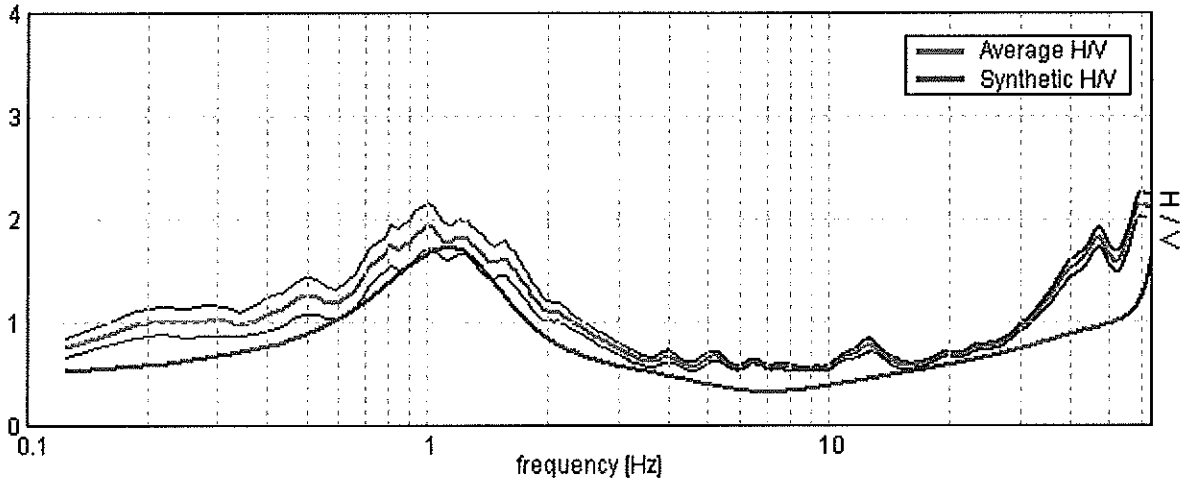


SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V

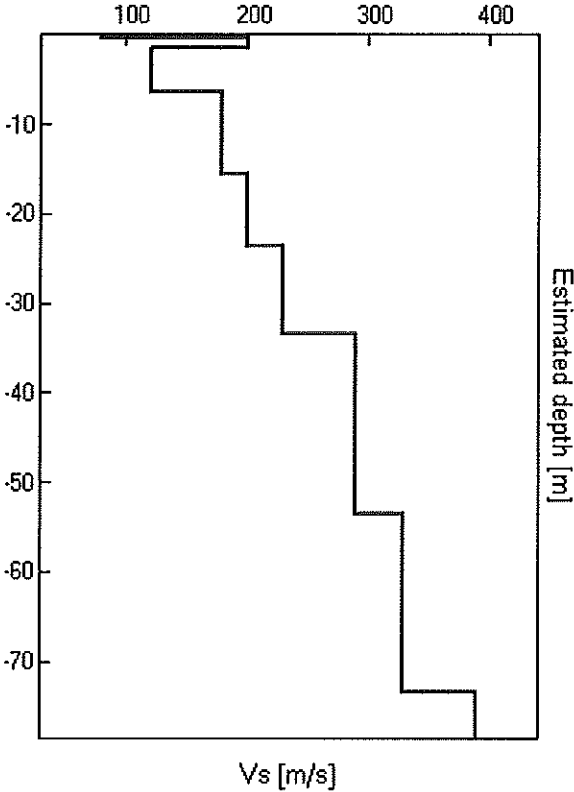
Max. H/V at  $1.0 \pm 0.02$  Hz. (in the range 0.0 - 20.0 Hz).



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.30	0.30	80
1.50	1.20	200
6.50	5.00	120
15.50	9.00	180
23.50	8.00	200
33.50	10.00	230
53.50	20.00	290
73.50	20.00	330
inf.	inf.	390

Vs(0.0-30.0)=177m/s





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

Max. H/V at  $1.0 \pm 0.02$  Hz. (in the range 0.0 - 20.0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$1.00 > 0.50$	OK	
$n_c(f_0) > 200$	$1140.0 > 200$	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 49 times	OK	

**Criteria for a clear HVSR 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 $[f_0, 4f_0]$   $A_{H/V}(f^+) < A_0 / 2$	2.406 Hz	OK	
$A_0 > 2$	1.94 > 2		NO
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.01057  < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.01057 < 0.1$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.1074 < 1.78$	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
$\sigma_f$	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  $\sigma_f$  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

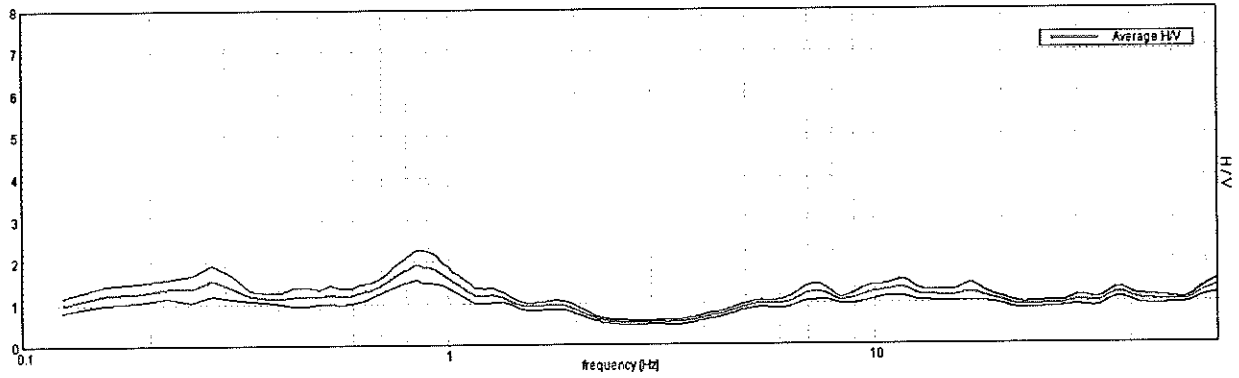
RAVENNA – n. 12

Start recording: 23/09/10 16:06:14 End recording: 23/09/10 16:26:15  
 Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
 GPS data not available

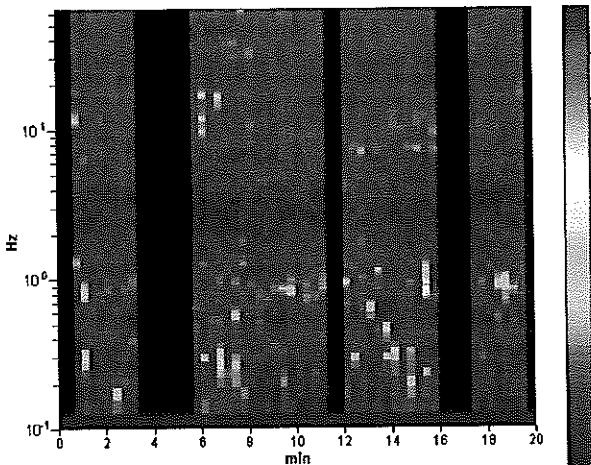
Trace length: 0h20'00". Analyzed 73% trace (manual window selection)  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

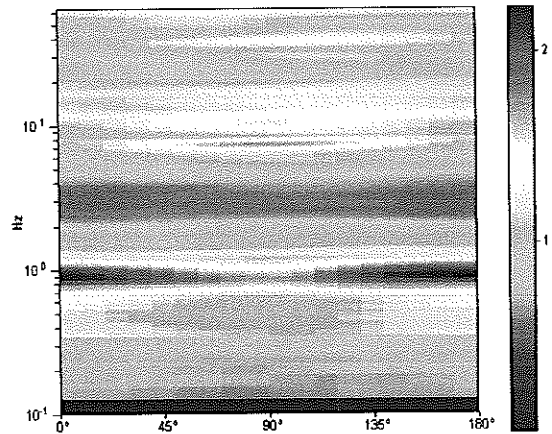
Max. HW at 0.84 ± 0.66 Hz. (in the range 0.0 - 20.0 Hz).



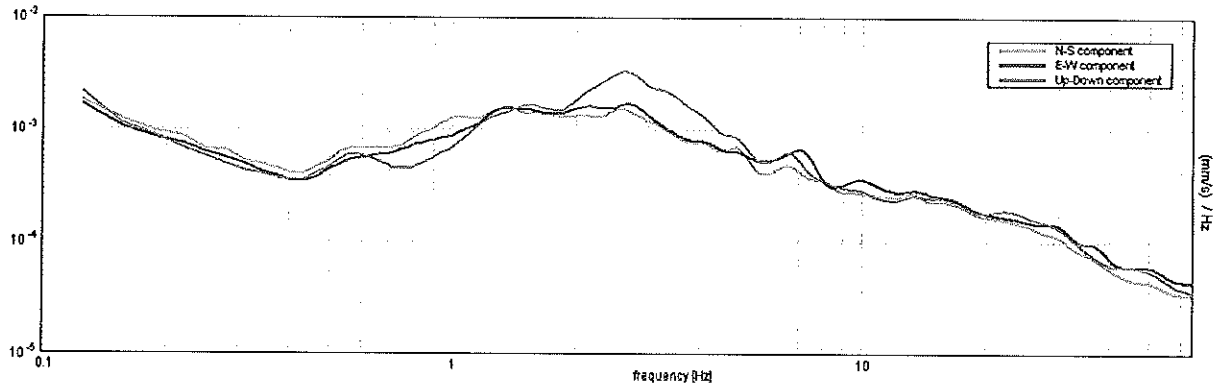
H/V TIME HISTORY



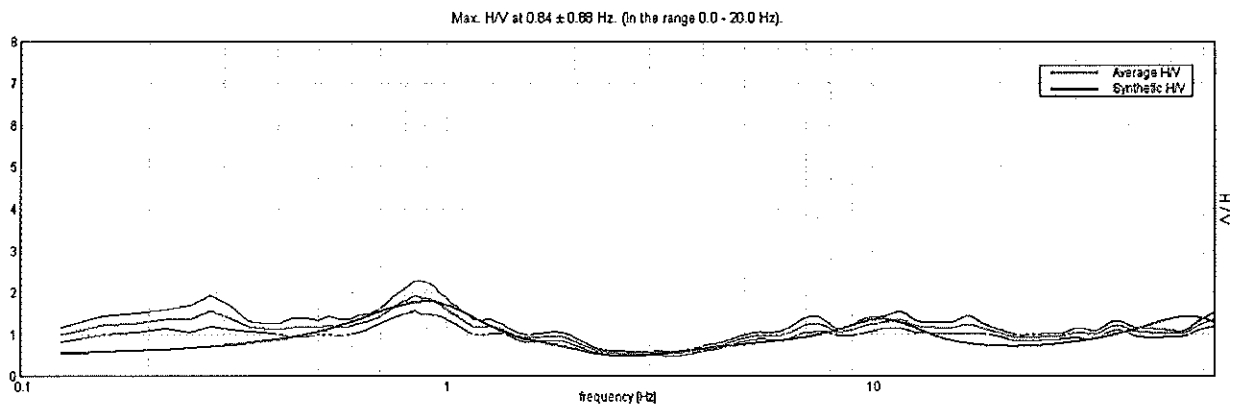
DIRECTIONAL H/V



SINGLE COMPONENT SPECTRA

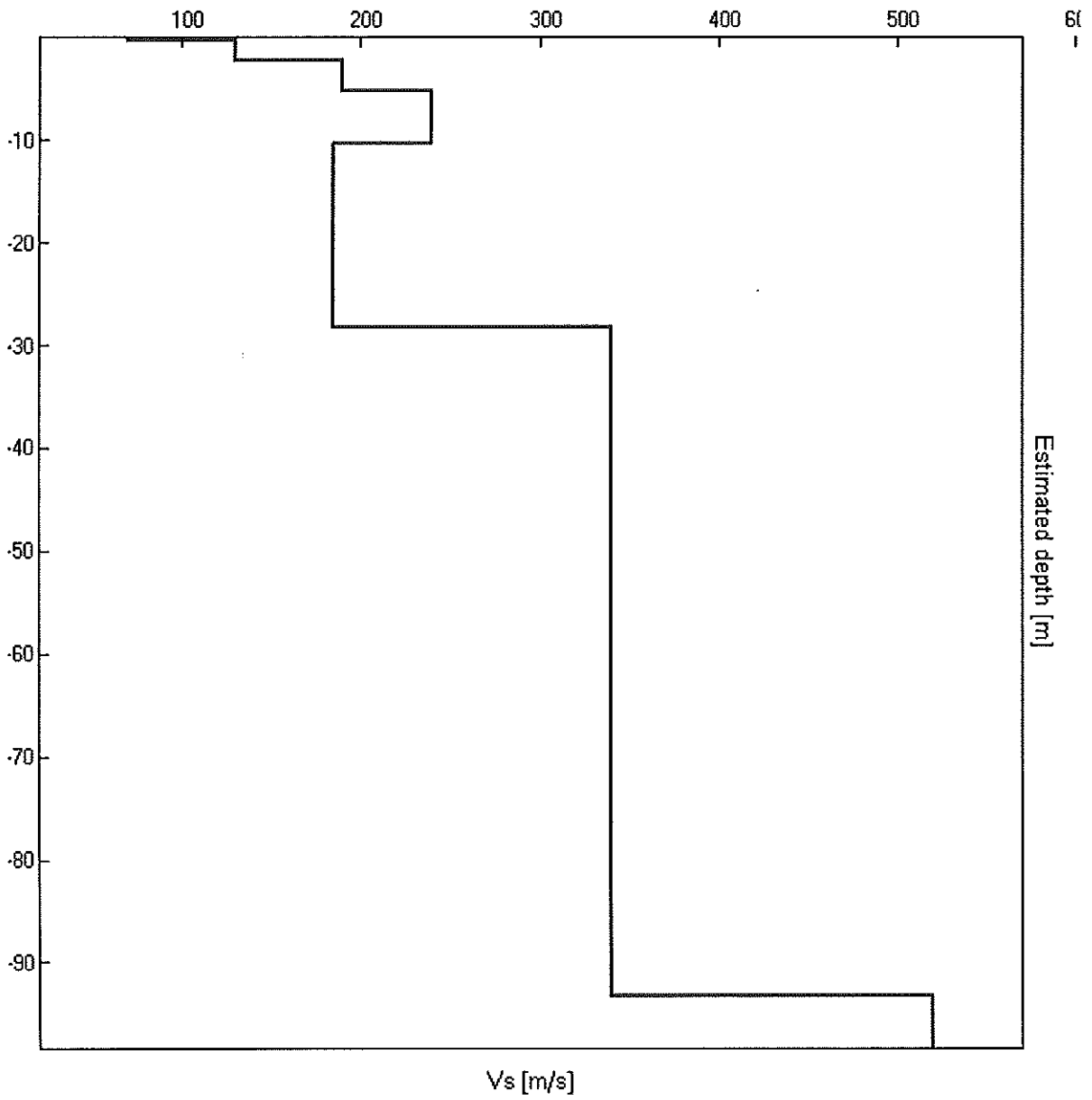


EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.30	0.30	70
2.30	2.00	130
5.30	3.00	190
10.30	5.00	240
28.30	18.00	185
93.30	65.00	340
inf.	inf.	520

Vs(0.0-30.0)=189m/s



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

Max. H/V at  $0.84 \pm 0.88$  Hz. (in the range 0.0 - 20.0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$0.84 > 0.50$	OK	
$n_c(f_0) > 200$	$742.5 > 200$	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 42 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0] \mid A_{H/V}(f^-) < A_0 / 2$			NO
Exists $f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0 / 2$	1.5 Hz	OK	
$A_0 > 2$	$1.92 > 2$		NO
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.50947  < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	$0.42987 < 0.12656$		NO
$\sigma_A(f_0) < \theta(f_0)$	$0.1784 < 2.0$	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
$\sigma_f$	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  $\sigma_f$  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

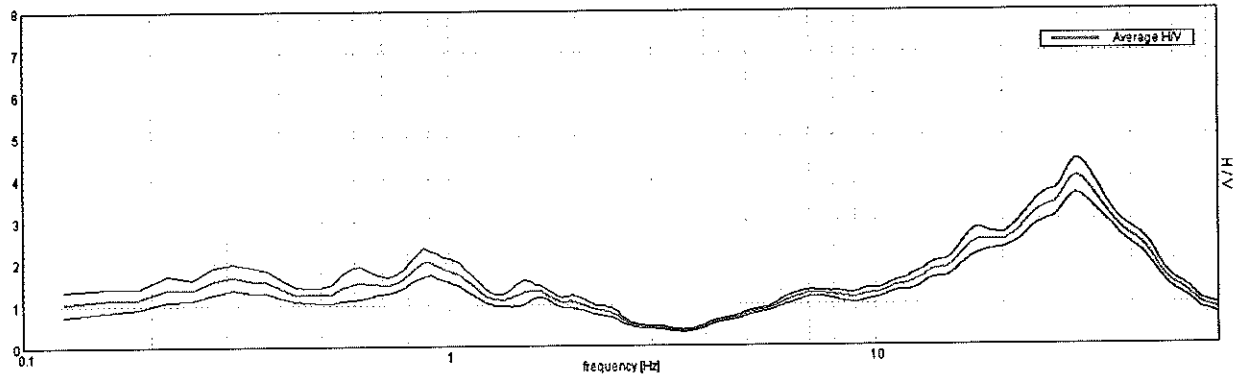
RAVENNA – n. 13

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
GPS data not available

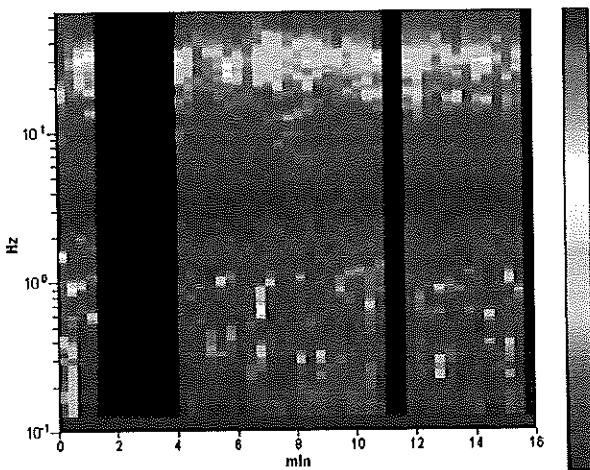
Trace length: 0h16'00". Analyzed 77% trace (manual window selection)  
Sampling frequency: 128 Hz  
Window size: 20 s  
Smoothing window: Triangular window  
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

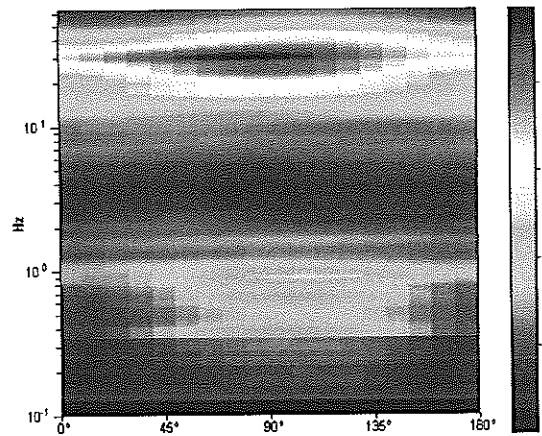
Max. HV at 29.69 ± 2.76 Hz. (in the range 0.0 - 64.0 Hz)



H/V TIME HISTORY

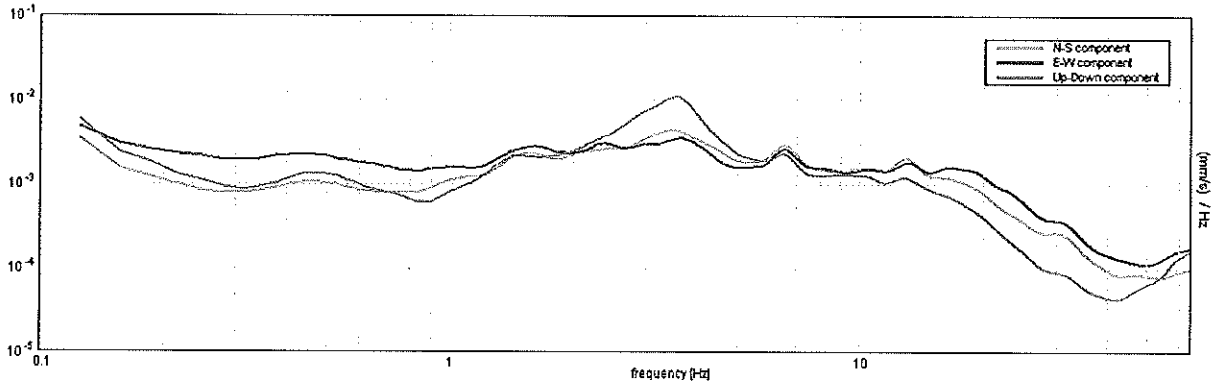


DIRECTIONAL H/V

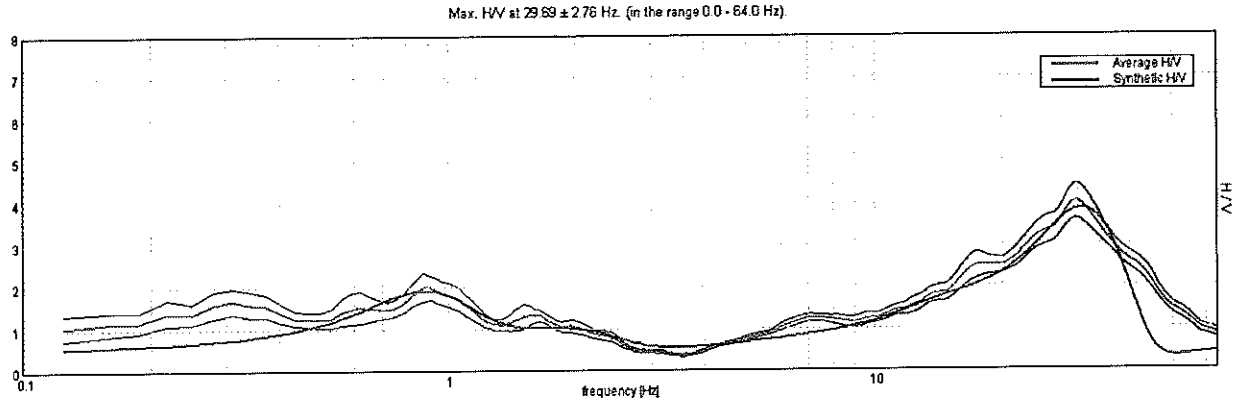




SINGLE COMPONENT SPECTRA

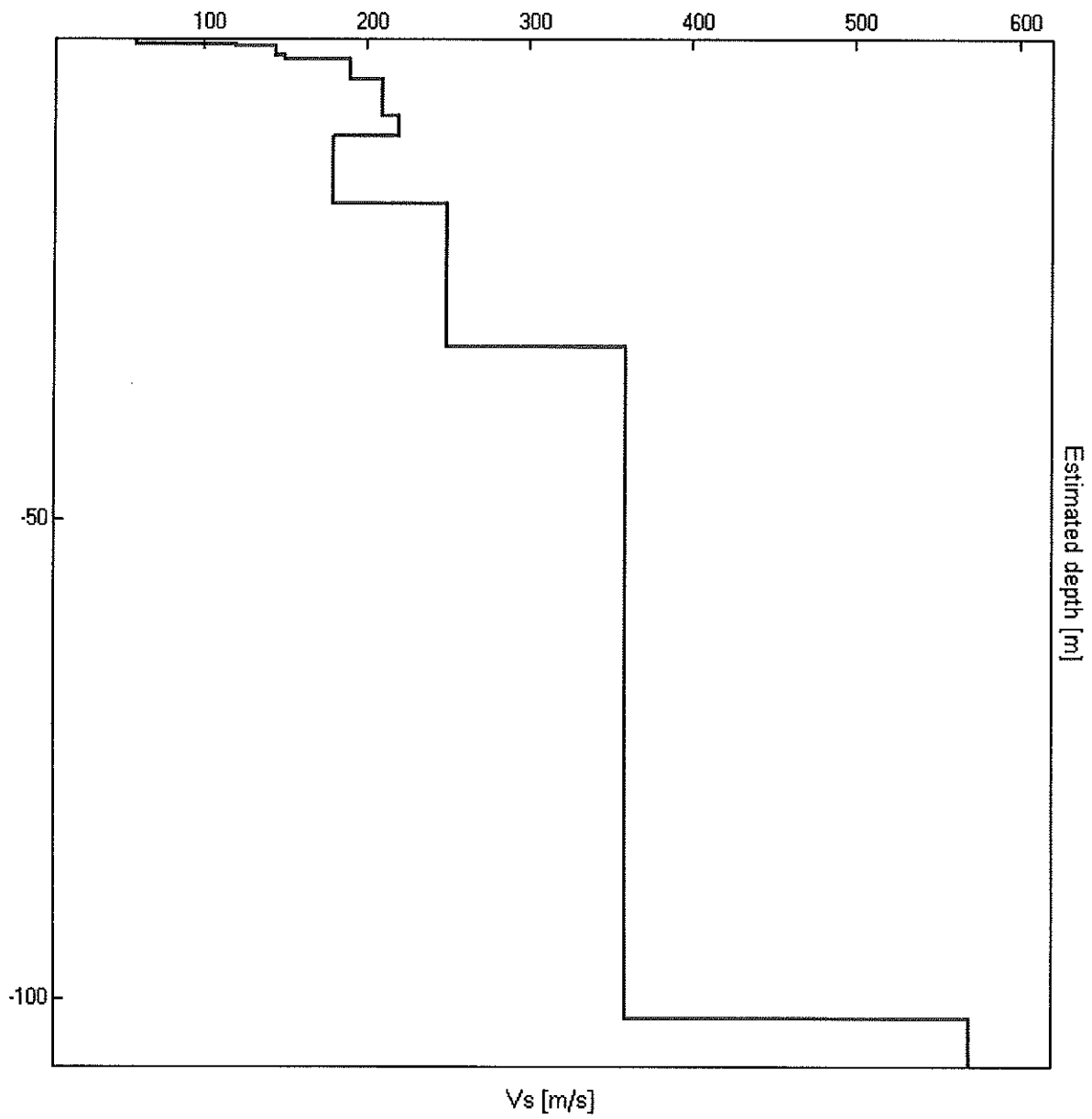


EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.47	0.47	60
0.77	0.30	120
1.57	0.80	145
2.07	0.50	150
4.07	2.00	190
8.07	4.00	210
10.07	2.00	220
17.07	7.00	180
32.07	15.00	250
102.07	70.00	360
inf.	inf.	570

Vs(0.0-30.0)=202m/s



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

**Max. HV at 29.69 ± 2.76 Hz. (in the range 0.0 - 64.0 Hz).**

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	29.69 > 0.50	OK	
$n_c(f_0) > 200$	21968.8 > 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 1426 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0]   A_{HV}(f^-) < A_0 / 2$	15.375 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0]   A_{HV}(f^+) < A_0 / 2$	45.594 Hz	OK	
$A_0 > 2$	4.01 > 2	OK	
$f_{\text{peak}}[A_{HV}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	0.04516  < 0.05	OK	
$\sigma_f < \varepsilon(f_0)$	1.34074 < 1.48438	OK	
$\sigma_A(f_0) < \theta(f_0)$	0.2003 < 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
$\sigma_f$	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 $f_0$
$A_{HV}(f)$	H/V curve amplitude at frequency $f$
$f^-$	frequency between $f_0/4$ and $f_0$ for which $A_{HV}(f^-) < A_0/2$
$f^+$	frequency between $f_0$ and $4f_0$ for which $A_{HV}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{HV}(f)$ , $\sigma_A(f)$ is the factor by which the mean $A_{HV}(f)$ curve should be multiplied or divided
$\sigma_{\log HV}(f)$	standard deviation of $\log A_{HV}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

**Threshold values for  $\sigma_f$  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 $\sigma_{\log HV}(f_0)$	0.48	0.40	0.30	0.25	0.20

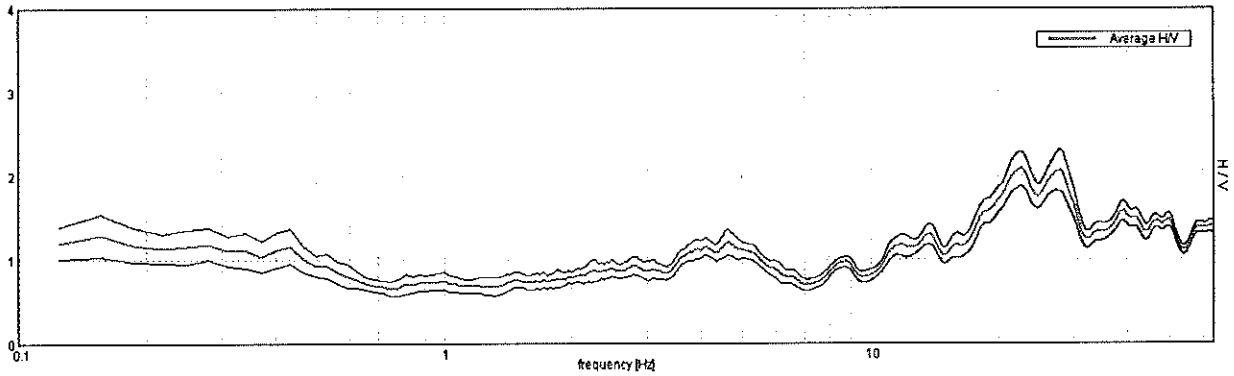
**RAVENNA – n. 14**

Start recording: 19/02/10 18:14:42      End recording: 19/02/10 18:34:43  
 Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
 GPS data not available

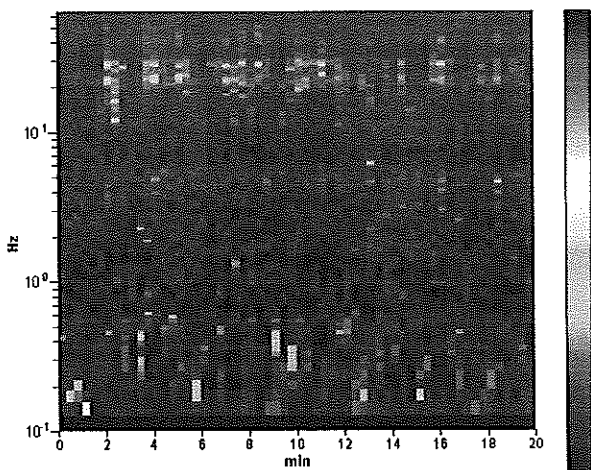
Trace length: 0h20'00".      Analysis performed on the entire trace.  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 5%

**HORIZONTAL TO VERTICAL SPECTRAL RATIO**

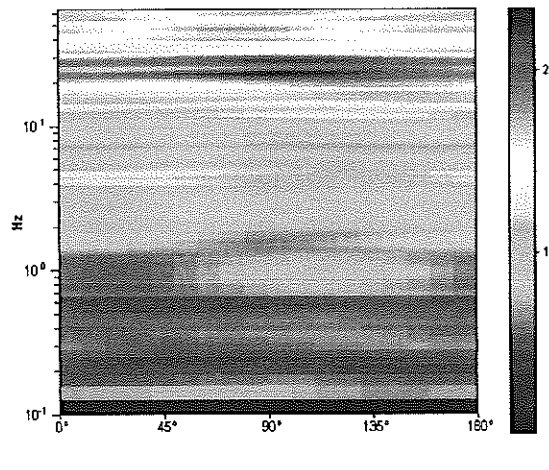
Max. HV at 13.72 ± 2.08 Hz. (in the range 0.0 - 15.0 Hz).



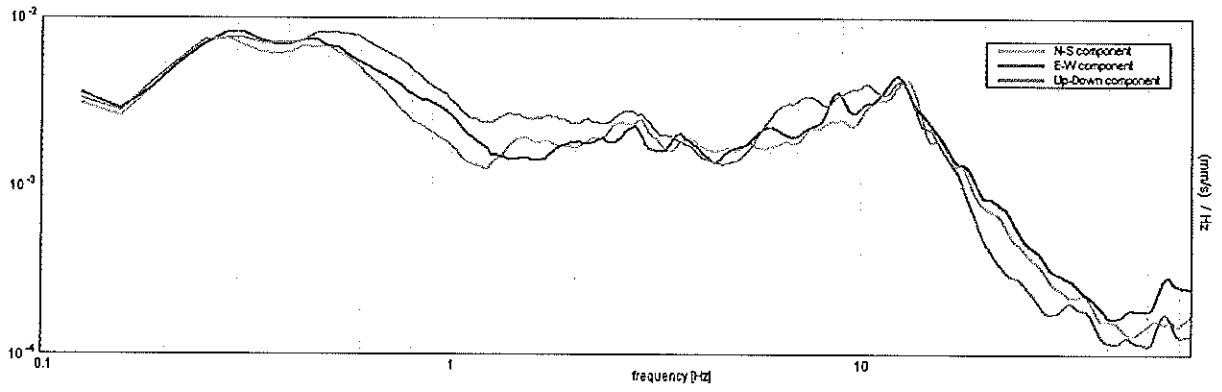
**HV TIME HISTORY**



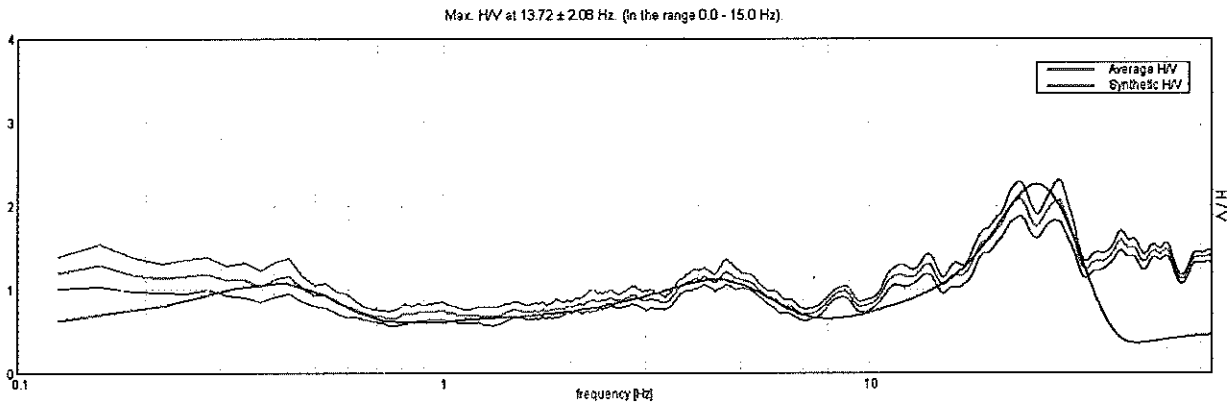
**DIRECTIONAL HV**



SINGLE COMPONENT SPECTRA

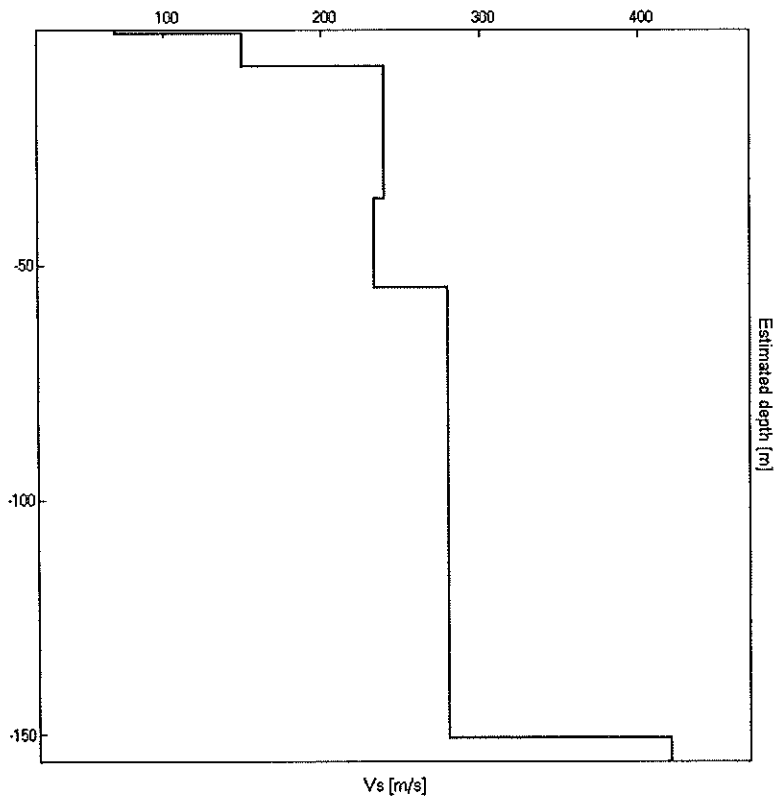


EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.70	0.70	70
7.70	7.00	150
35.70	28.00	240
54.70	19.00	233
150.70	96.00	280
inf.	inf.	420

Vs(0.0-30.0)=201m/s



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

Max. H/V at 13.72 ± 2.08 Hz. (in the range 0.0 - 15.0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	13.72 > 0.50	OK	
$n_c(f_0) > 200$	16462.5 > 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 660 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0]$   $A_{HV}(f^-) < A_0 / 2$			NO
Exists $f^+$ in $[f_0, 4f_0]$   $A_{HV}(f^+) < A_0 / 2$			NO
$A_0 > 2$	1.30 > 2		NO
$f_{\text{peak}}[A_{HV}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.07505  < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	1.02954 < 0.68594		NO
$\sigma_A(f_0) < \theta(f_0)$	0.0598 < 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
$\sigma_f$	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 $f_0$
$A_{HV}(f)$	H/V curve amplitude at frequency $f$
$f^-$	frequency between $f_0/4$ and $f_0$ for which $A_{HV}(f^-) < A_0/2$
$f^+$	frequency between $f_0$ and $4f_0$ for which $A_{HV}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{HV}(f)$ , $\sigma_A(f)$ is the factor by which the mean $A_{HV}(f)$ curve should be multiplied or divided
$\sigma_{\log HV}(f)$	standard deviation of $\log A_{HV}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

Threshold values for  $\sigma_f$  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 $\sigma_{\log HV}(f_0)$	0.48	0.40	0.30	0.25	0.20

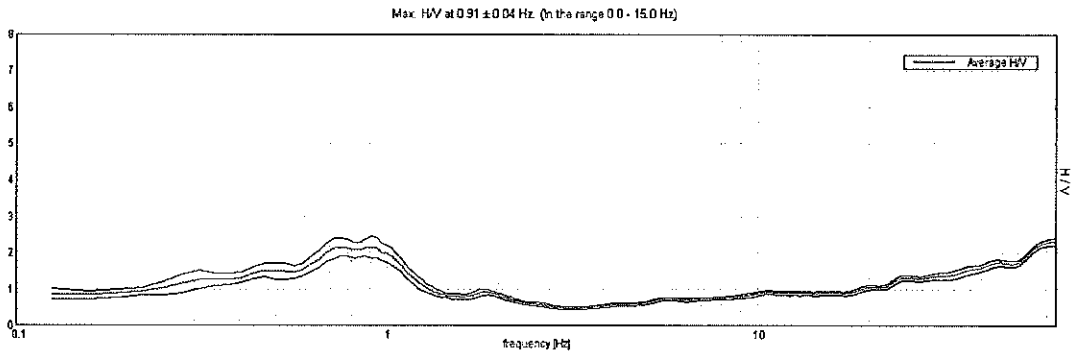


**RAVENNA – n. 15**

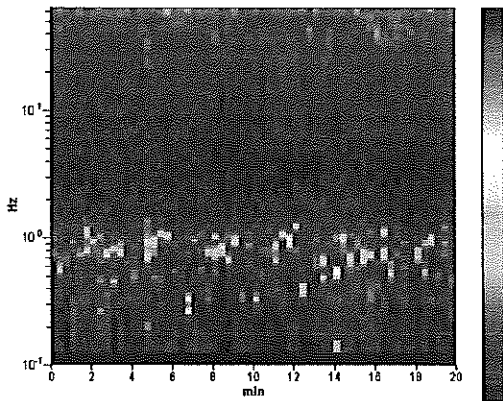
Start recording: 22/06/10 16:53:55      End recording: 22/06/10 17:13:56  
 Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
 GPS data not available

Trace length: 0h20'00".      Analysis performed on the entire trace.  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 10%

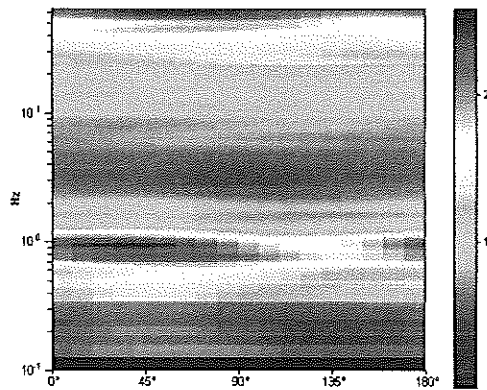
**HORIZONTAL TO VERTICAL SPECTRAL RATIO**



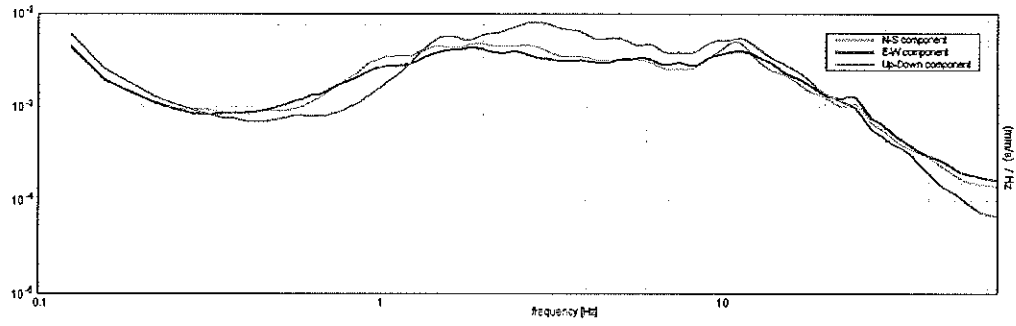
**H/V TIME HISTORY**



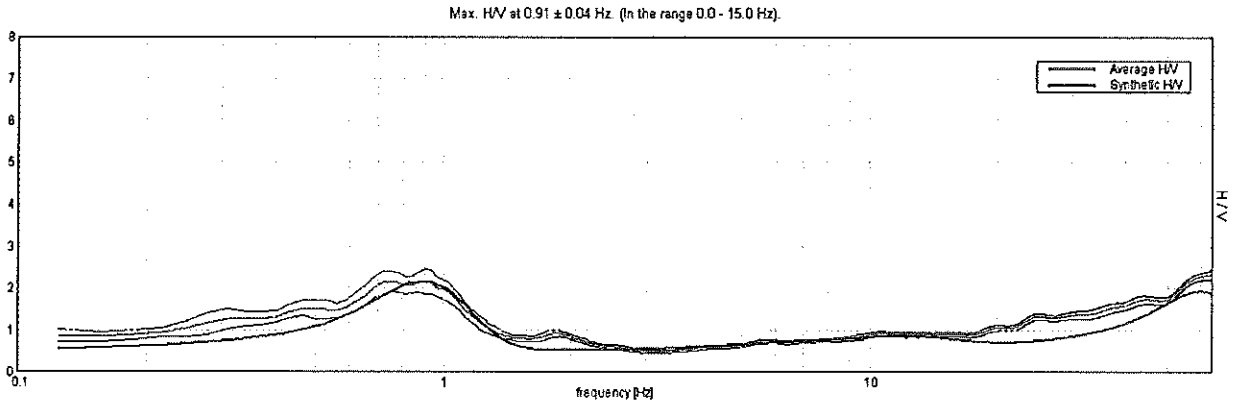
**DIRECTIONAL H/V**



**SINGLE COMPONENT SPECTRA**

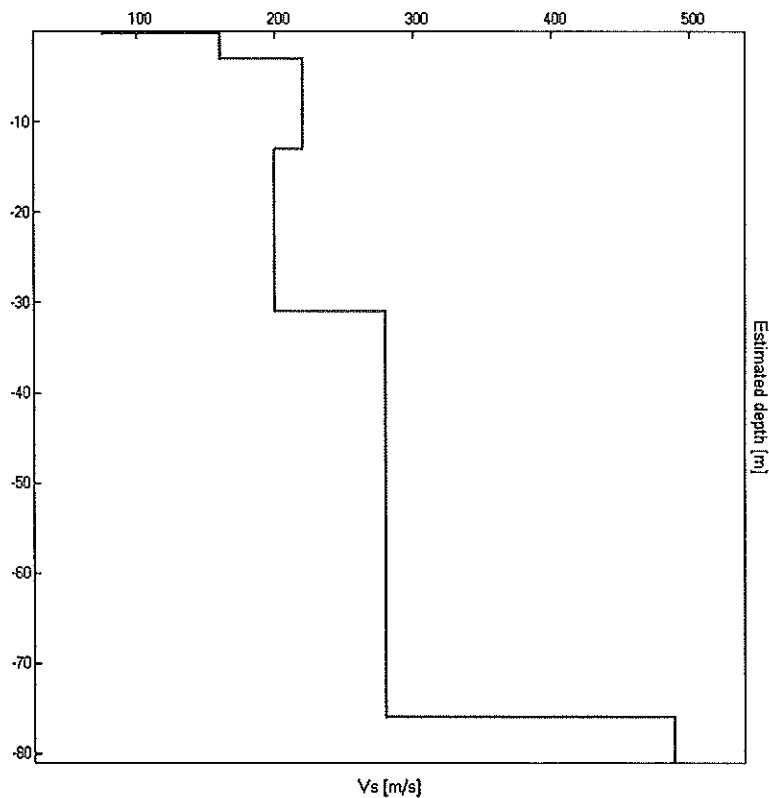


EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.30	0.30	75
3.00	2.70	160
13.00	10.00	220
31.00	18.00	200
76.00	45.00	280
inf.	inf.	490

Vs(0.0-30.0)=198m/s



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

Max. H/V at 0.91 ± 0.04 Hz. (in the range 0.0 - 15.0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	0.91 > 0.50	OK	
$n_c(f_0) > 200$	1087.5 > 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 44 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0] \mid A_{H/V}(f^-) < A_0 / 2$	0.25 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0 / 2$	1.281 Hz	OK	
$A_0 > 2$	2.15 > 2	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.02048  < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	0.01856 < 0.13594	OK	
$\sigma_A(f_0) < \theta(f_0)$	0.148 < 2.0	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
$\sigma_f$	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  $\sigma_f$  and  $\sigma_A(f_0)$

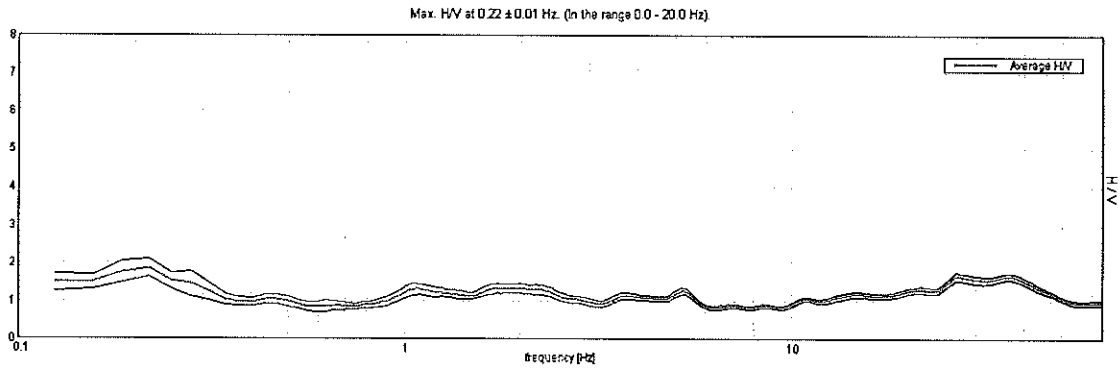
Freq. range [Hz]	< 0.2	0.2 – 0.5	0.5 – 1.0	1.0 – 2.0	> 2.0
$\varepsilon(f_0)$ [Hz]	0.25 $f_0$	0.2 $f_0$	0.15 $f_0$	0.10 $f_0$	0.05 $f_0$
$\theta(f_0)$ for $\sigma_A(f_0)$	3.0	2.5	2.0	1.78	1.58
Log $\theta(f_0)$ for $\sigma_{\log H/V}(f_0)$	0.48	0.40	0.30	0.25	0.20

**RAVENNA - n. 16**

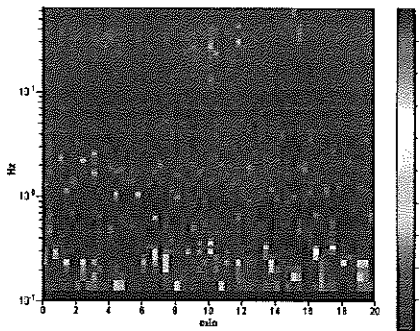
Start recording: 19/10/10 16:21:55      End recording: 19/10/10 16:41:55  
 Channel labels: NORTH SOUTH; EAST WEST; UP DOWN  
 GPS data not available

Trace length: 0h20'00"      Analysis performed on the entire trace.  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 10%

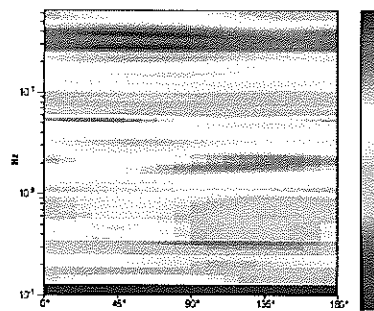
**HORIZONTAL TO VERTICAL SPECTRAL RATIO**



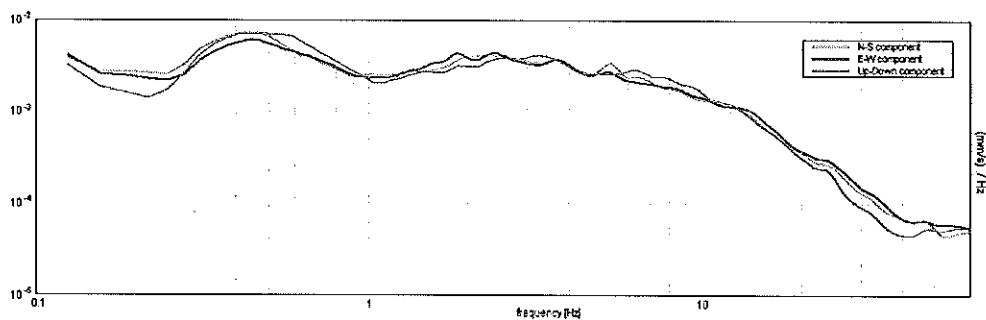
**H/V TIME HISTORY**



**DIRECTIONAL HV**

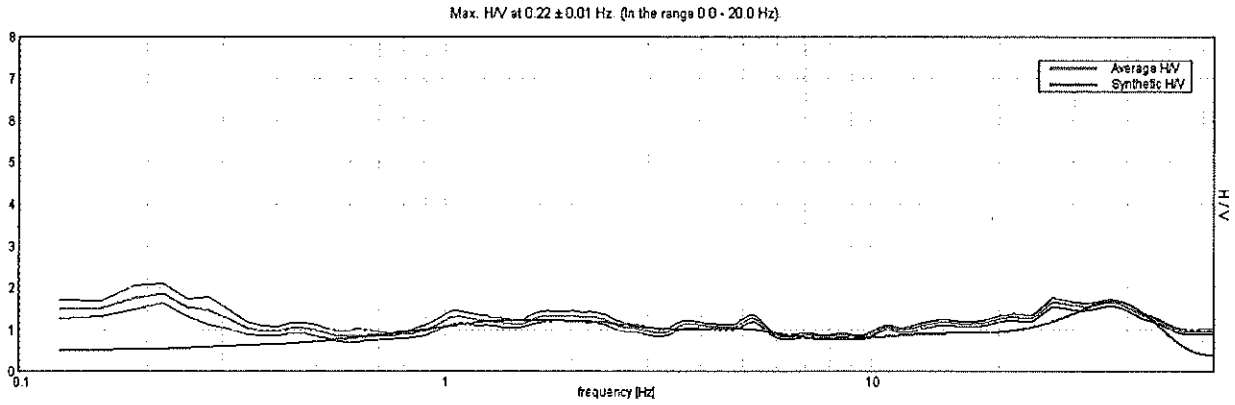


**SINGLE COMPONENT SPECTRA**





EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer

Thickness [m]

Vs [m/s]

[m]

0.40

0.40

60

2.40

2.00

120

8.40

6.00

160

27.40

19.00

240

70.40

43.00

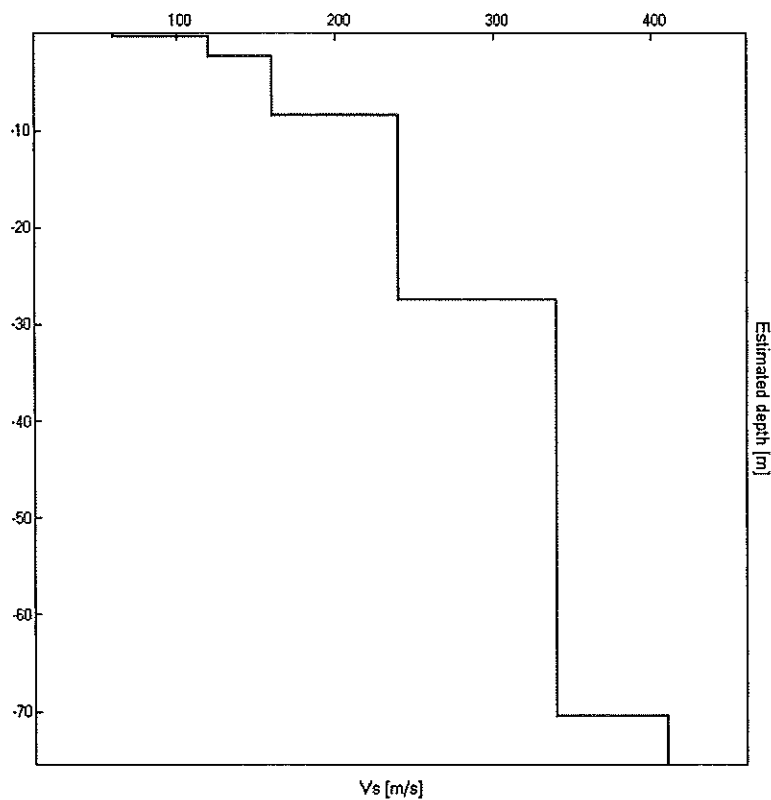
340

inf.

inf.

410

Vs(0.0-30.0)=203m/s



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

Max. H/V at  $0.22 \pm 0.01$  Hz. (in the range 0.0 - 20.0 Hz).

**Criteria for a reliable HVSr curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$0.22 > 0.50$		NO
$n_c(f_0) > 200$	$262.5 > 200$	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 12 times	OK	

**Criteria for a clear HVSr peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0] \mid A_{H/V}(f^-) < A_0 / 2$	0.094 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0 / 2$	0.531 Hz	OK	
$A_0 > 2$	$1.86 > 2$		NO
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.02662  < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.00582 < 0.04375$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.1155 < 2.5$	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
$\sigma_f$	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  $\sigma_f$  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
$\text{Log } \theta(f_0)$ for $\sigma_{\log H/V}(f_0)$	0.48	0.40	0.30	0.25	0.20



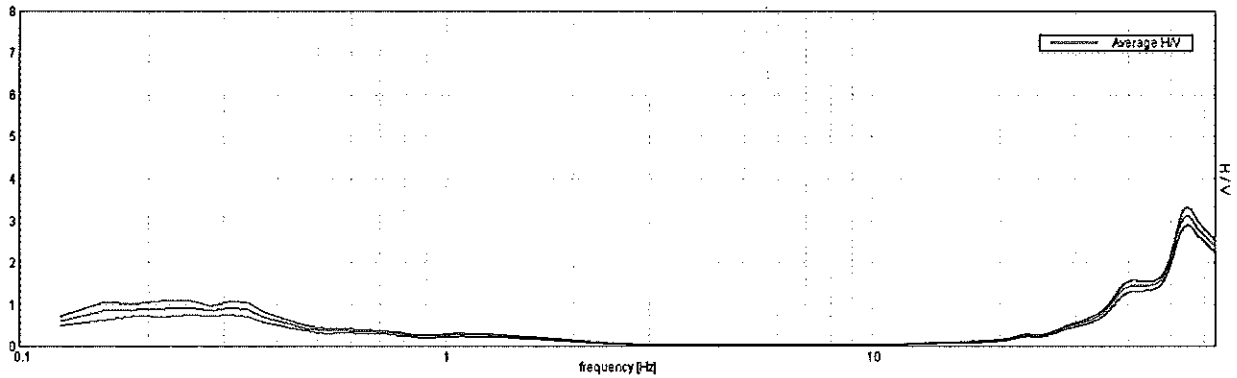
**RAVENNA – n. 17**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
GPS data not available

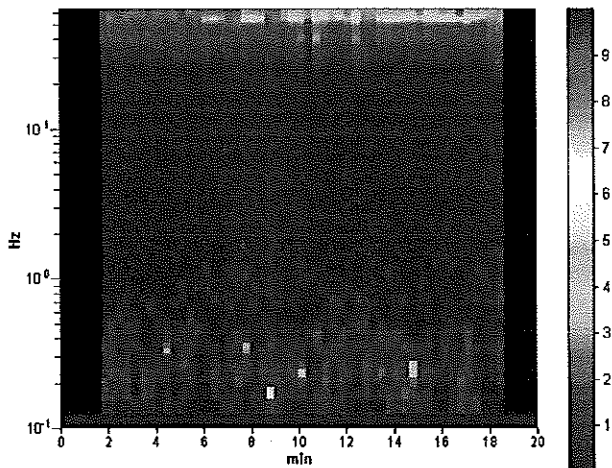
Trace length: 0h20'00". Analyzed 85% trace (manual window selection)  
Sampling frequency: 128 Hz  
Window size: 20 s  
Smoothing window: Triangular window  
Smoothing: 10%

**HORIZONTAL TO VERTICAL SPECTRAL RATIO**

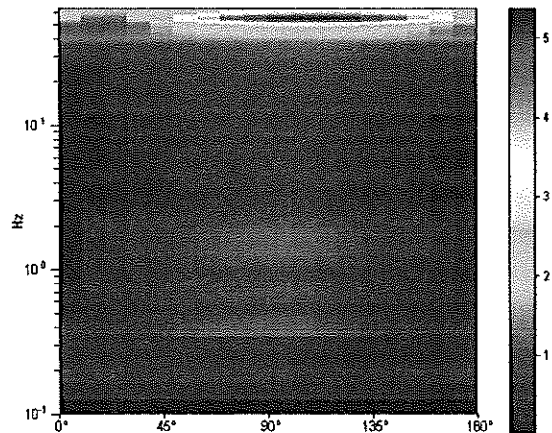
Max. HV at  $0.25 \pm 0.02$  Hz (in the range 0.0 - 20.0 Hz)



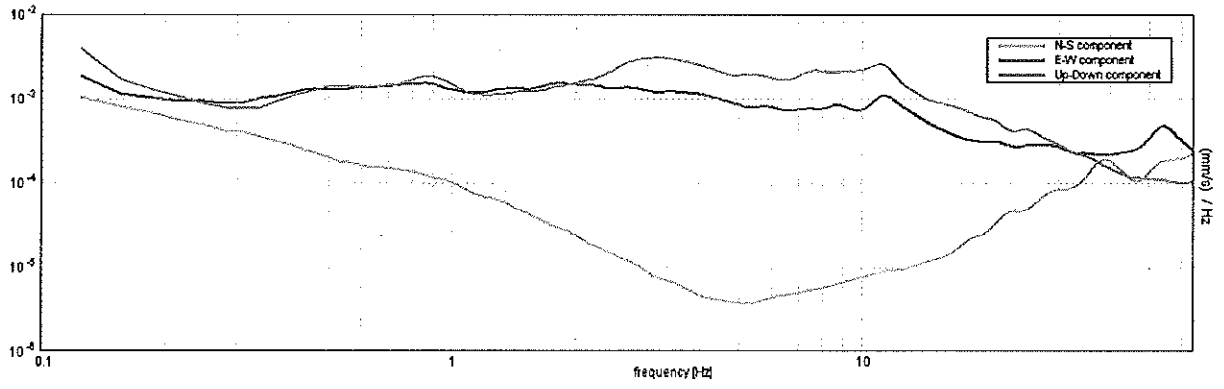
**H/V TIME HISTORY**



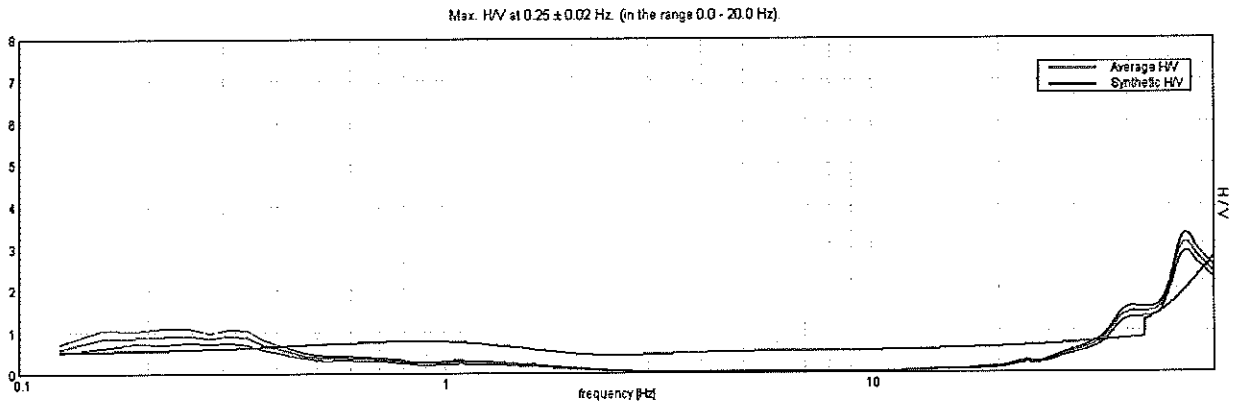
**DIRECTIONAL H/V**



SINGLE COMPONENT SPECTRA

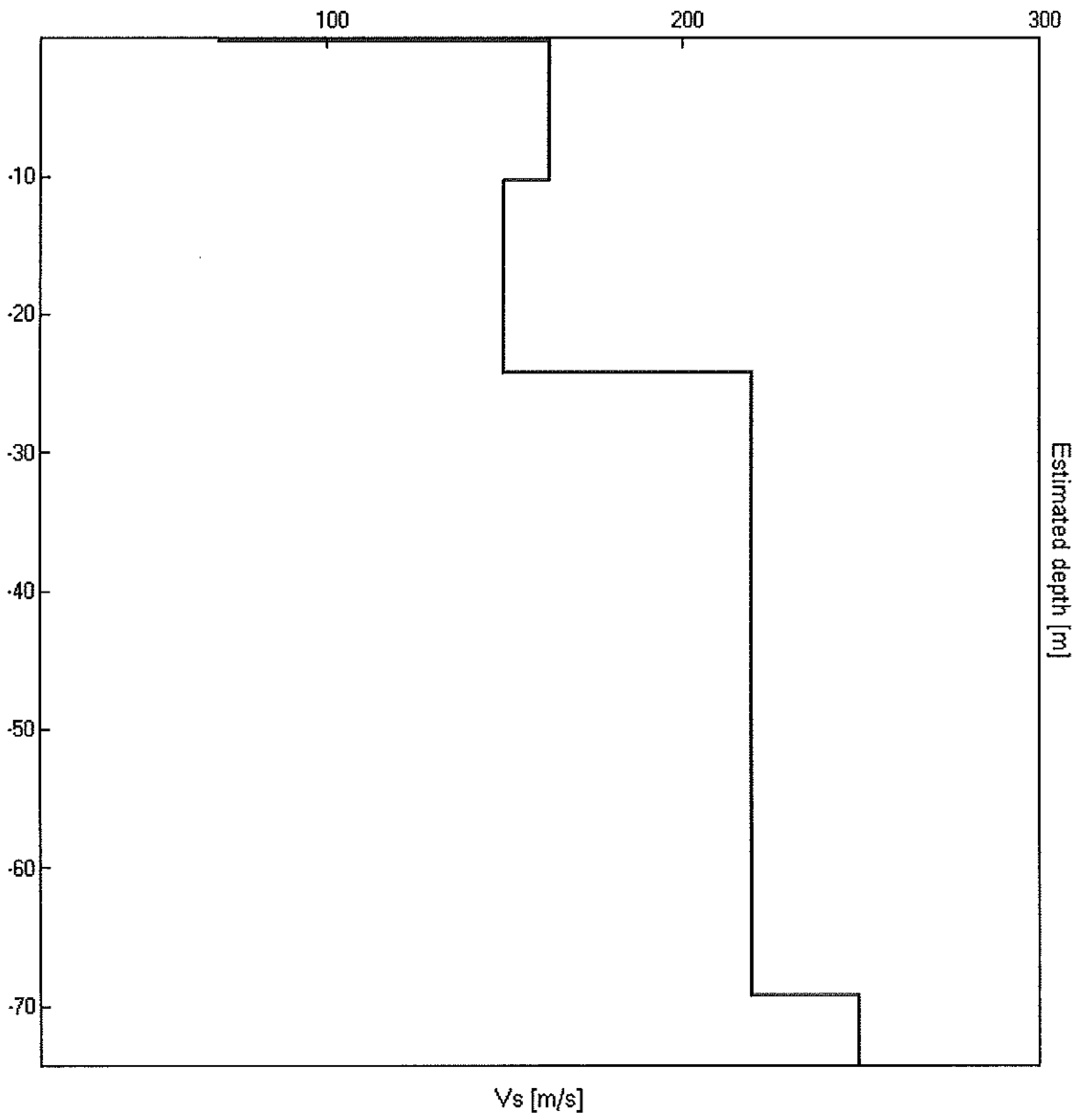


EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.25	0.25	70
10.25	10.00	163
24.25	14.00	150
69.25	45.00	220
inf.	inf.	250

Vs(0.0-30.0)=163m/s



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

Max. H/V at  $0.25 \pm 0.02$  Hz. (in the range 0.0 - 20.0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$0.25 > 0.50$		NO
$n_c(f_0) > 200$	$255.0 > 200$	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 13 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0] \mid A_{HV}(f^-) < A_0 / 2$	0.094 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0] \mid A_{HV}(f^+) < A_0 / 2$	0.469 Hz	OK	
$A_0 > 2$	$0.92 > 2$		NO
$f_{\text{peak}}[A_{HV}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.03279  < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.0082 < 0.05$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.0854 < 2.5$	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
$\sigma_f$	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 $f_0$
$A_{HV}(f)$	H/V curve amplitude at frequency $f$
$f^-$	frequency between $f_0/4$ and $f_0$ for which $A_{HV}(f^-) < A_0/2$
$f^+$	frequency between $f_0$ and $4f_0$ for which $A_{HV}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{HV}(f)$ , $\sigma_A(f)$ is the factor by which the mean $A_{HV}(f)$ curve should be multiplied or divided
$\sigma_{\log HV}(f)$	standard deviation of $\log A_{HV}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

Threshold values for  $\sigma_f$  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 $\sigma_{\log HV}(f_0)$	0.48	0.40	0.30	0.25	0.20

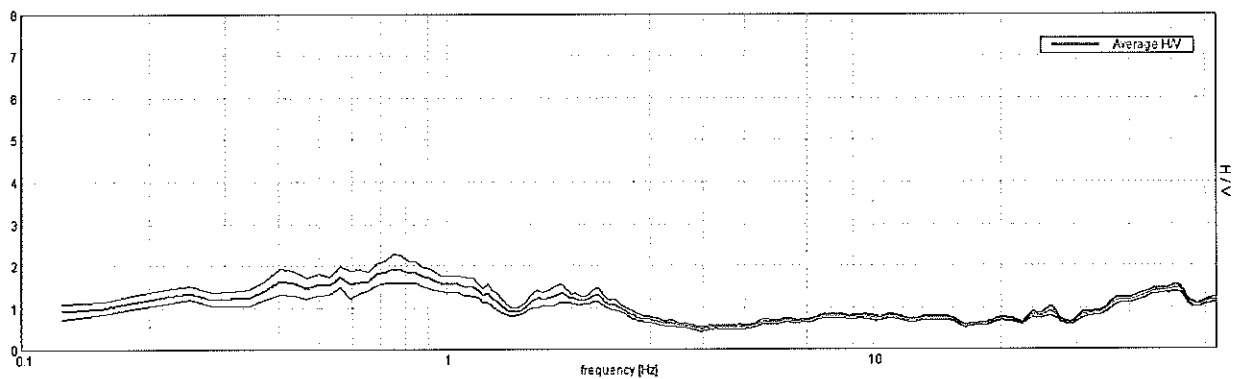
RAVENNA – n. 18

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
GPS data not available

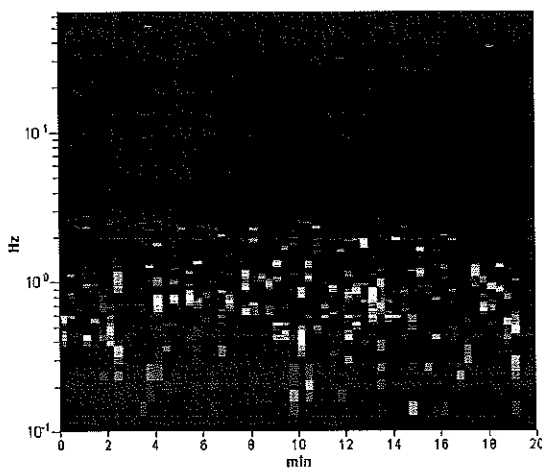
Trace length: 0h20'00". Analyzed 92% trace (manual window selection)  
Sampling frequency: 128 Hz  
Window size: 20 s  
Smoothing window: Triangular window  
Smoothing: 5%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

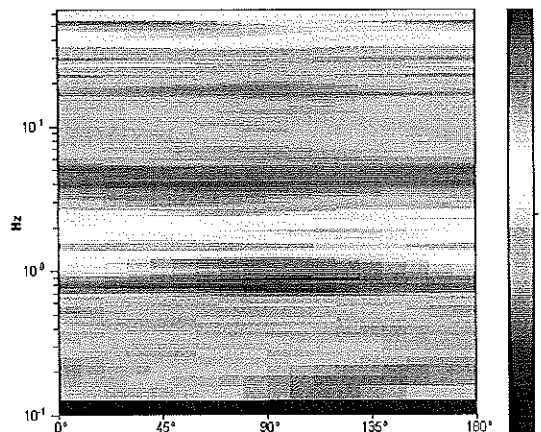
Max. HV at 0.75 ± 0.03 Hz. (in the range 0.0 - 20.0 Hz)



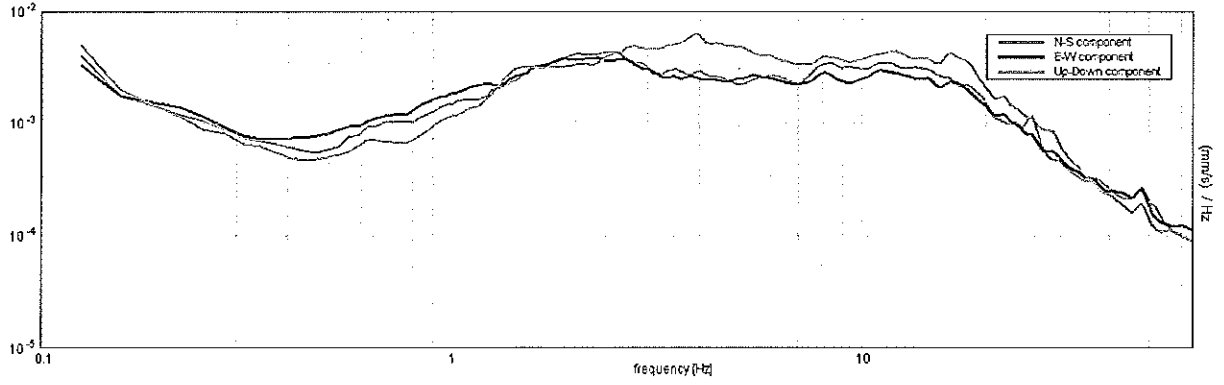
HV TIME HISTORY



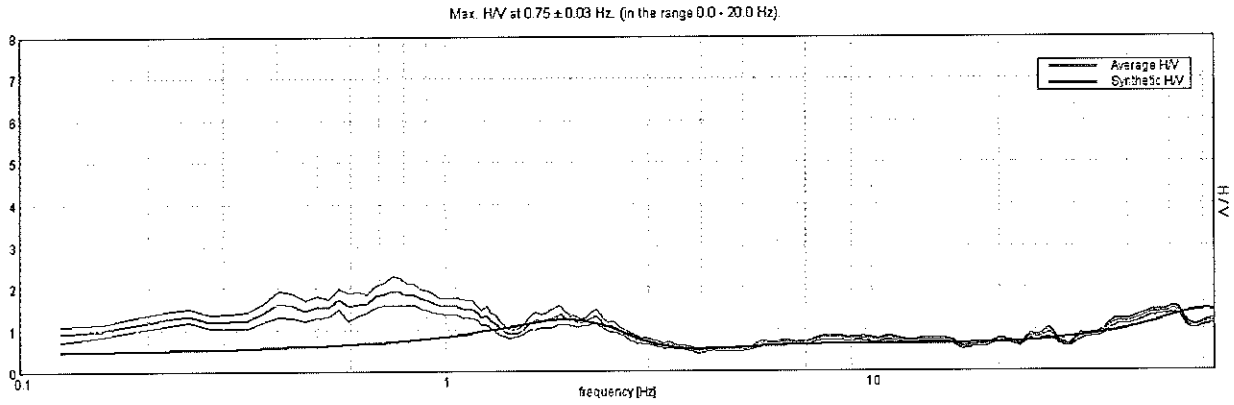
DIRECTIONAL HV



SINGLE COMPONENT SPECTRA



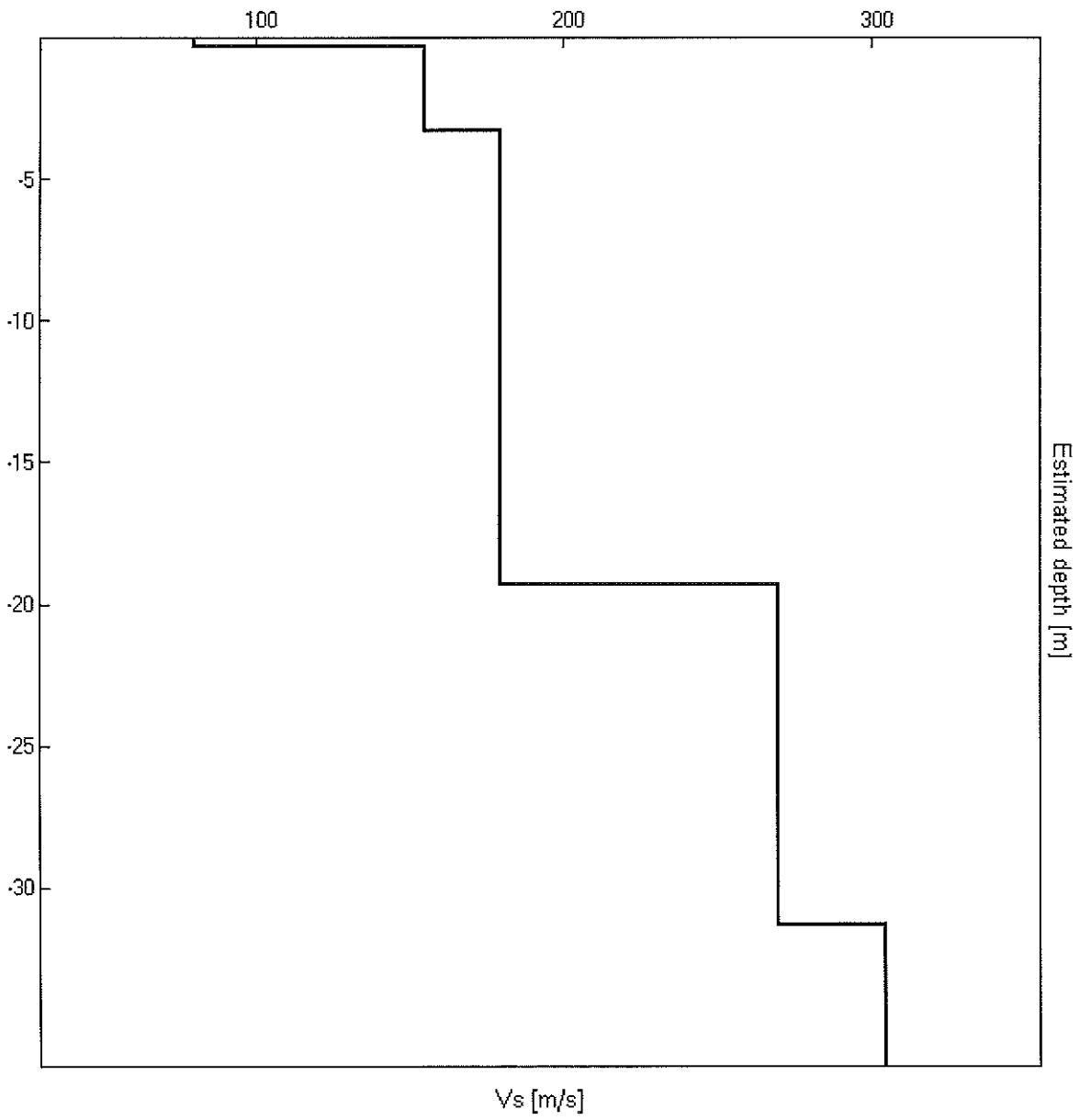
EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.30	0.30	80
3.30	3.00	155
19.30	16.00	180
31.30	12.00	270
inf.	inf.	305

Vs(0.0-30.0)=198m/s





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

**Max. H/V at 0.75 ± 0.03 Hz. (in the range 0.0 - 20.0 Hz).**

**Criteria for a reliable HVSR curve**  
[All 3 should be fulfilled]

$f_0 > 10 / L_w$	0.75 > 0.50	OK	
$n_c(f_0) > 200$	825.0 > 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 37 times	OK	

**Criteria for a clear HVSR 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 $[f_0, 4f_0]$   $A_{H/V}(f^+) < A_0 / 2$	1.406 Hz	OK	
$A_0 > 2$	1.93 > 2		NO
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	0.02299  < 0.05	OK	
$\sigma_f < \varepsilon(f_0)$	0.01724 < 0.1125	OK	
$\sigma_A(f_0) < \theta(f_0)$	0.1696 < 2.0	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
$\sigma_f$	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  $\sigma_f$  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

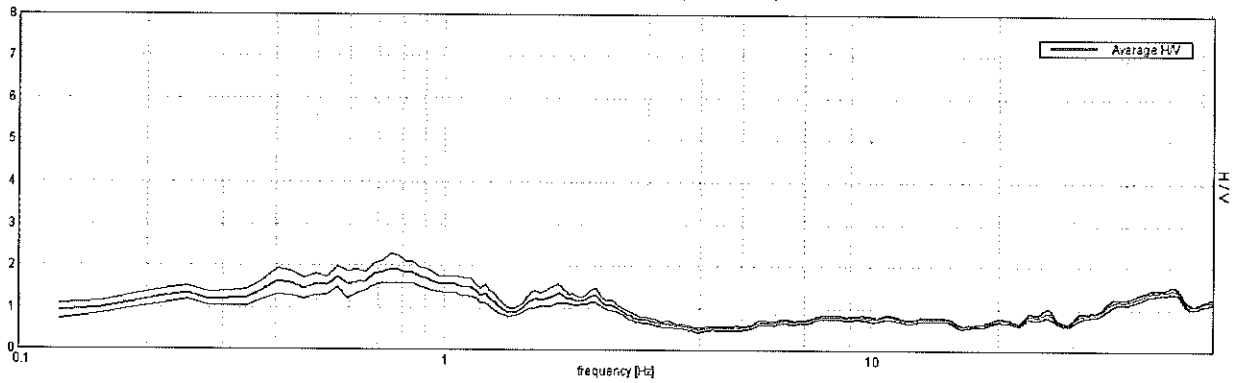
**RAVENNA – n. 18**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
 GPS data not available

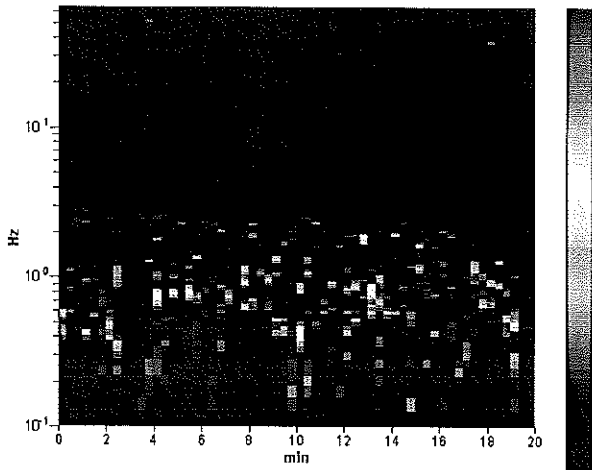
Trace length: 0h20'00". Analyzed 92% trace (manual window selection)  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 5%

**HORIZONTAL TO VERTICAL SPECTRAL RATIO**

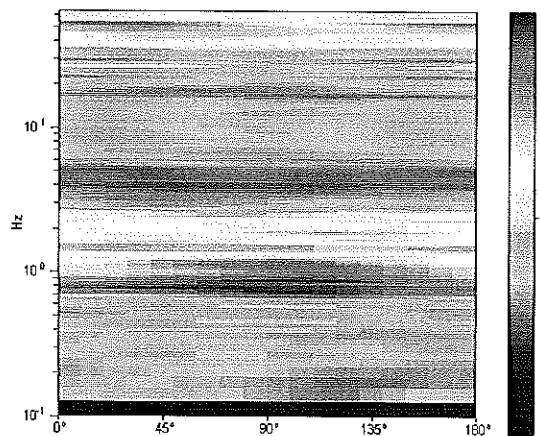
Max. H/V at 0.75 ± 0.03 Hz (in the range 0.0 - 20.0 Hz)



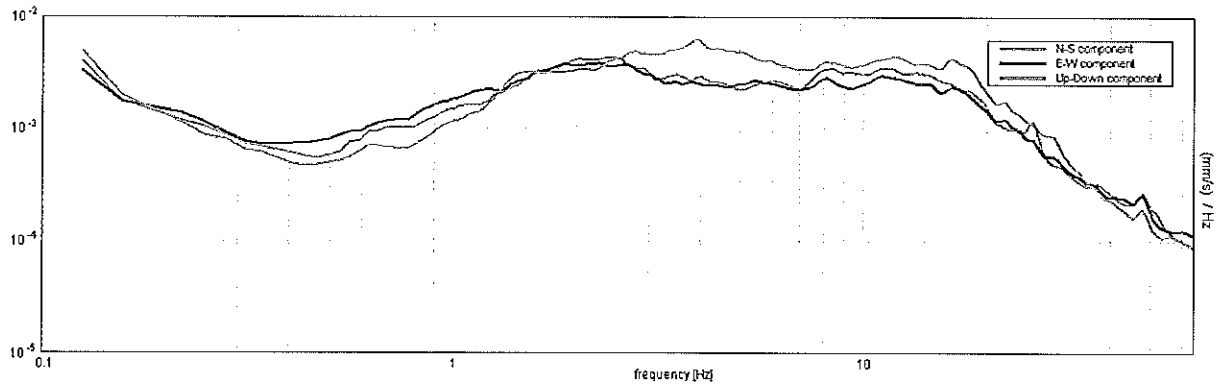
**H/V TIME HISTORY**



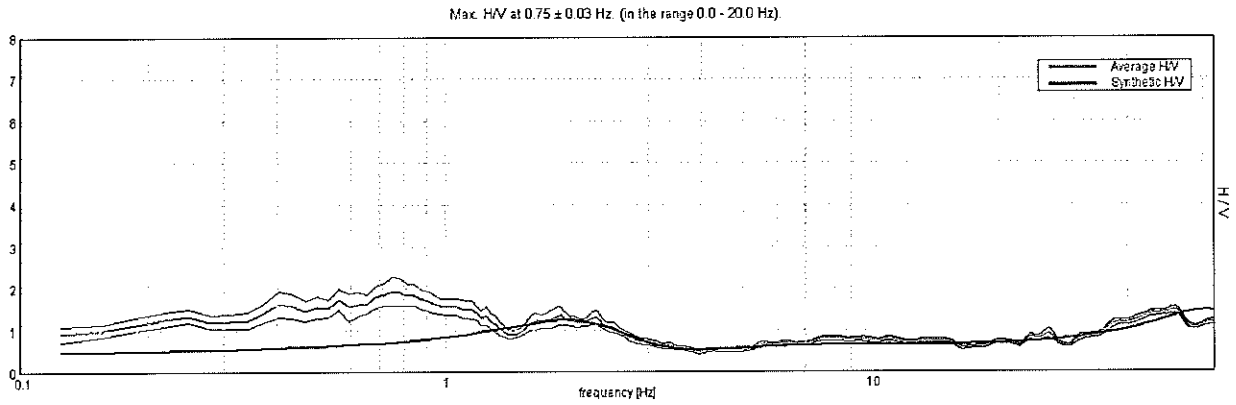
**DIRECTIONAL H/V**



SINGLE COMPONENT SPECTRA

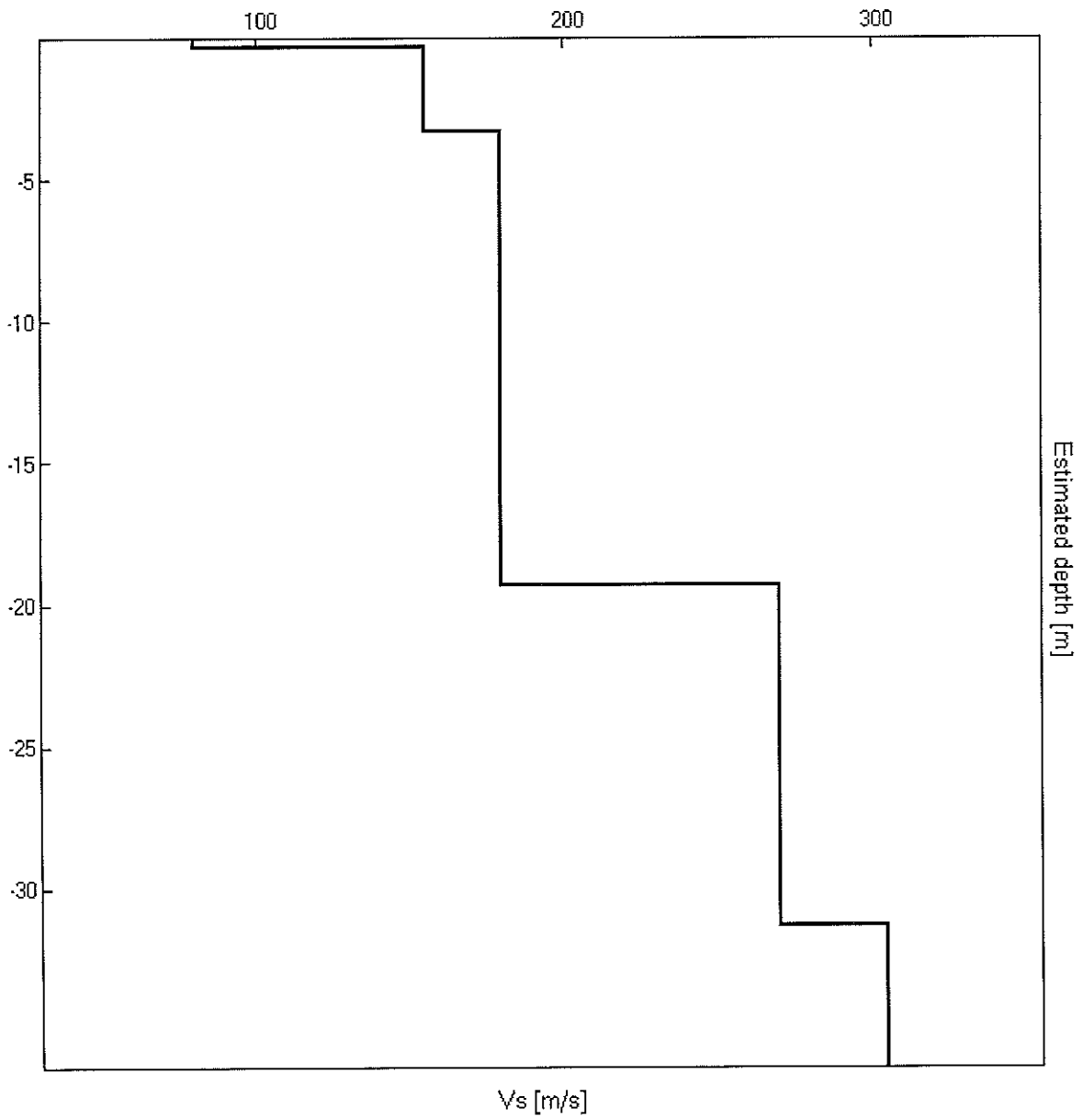


EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.30	0.30	80
3.30	3.00	155
19.30	16.00	180
31.30	12.00	270
inf.	inf.	305

Vs(0.0-30.0)=198m/s



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

Max. H/V at 0.75 ± 0.03 Hz. (in the range 0.0 - 20.0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	0.75 > 0.50	OK	
$n_c(f_0) > 200$	825.0 > 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 37 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0]$   $A_{HV}(f^-) < A_0 / 2$			NO
Exists $f^+$ in $[f_0, 4f_0]$   $A_{HV}(f^+) < A_0 / 2$	1.406 Hz	OK	
$A_0 > 2$	1.93 > 2		NO
$f_{\text{peak}}[A_{HV}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	0.02299  < 0.05	OK	
$\sigma_f < \varepsilon(f_0)$	0.01724 < 0.1125	OK	
$\sigma_A(f_0) < \theta(f_0)$	0.1696 < 2.0	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
$\sigma_f$	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 $f_0$
$A_{HV}(f)$	H/V curve amplitude at frequency $f$
$f^-$	frequency between $f_0/4$ and $f_0$ for which $A_{HV}(f^-) < A_0/2$
$f^+$	frequency between $f_0$ and $4f_0$ for which $A_{HV}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{HV}(f)$ , $\sigma_A(f)$ is the factor by which the mean $A_{HV}(f)$ curve should be multiplied or divided
$\sigma_{\log HV}(f)$	standard deviation of $\log A_{HV}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

Threshold values for  $\sigma_f$  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 $\sigma_{\log HV}(f_0)$	0.48	0.40	0.30	0.25	0.20

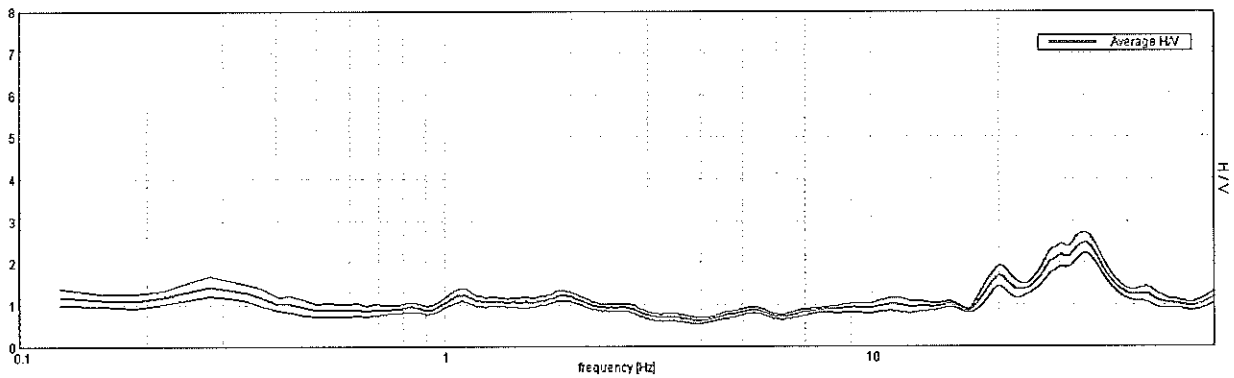
**RAVENNA – n. 19**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
 GPS data not available

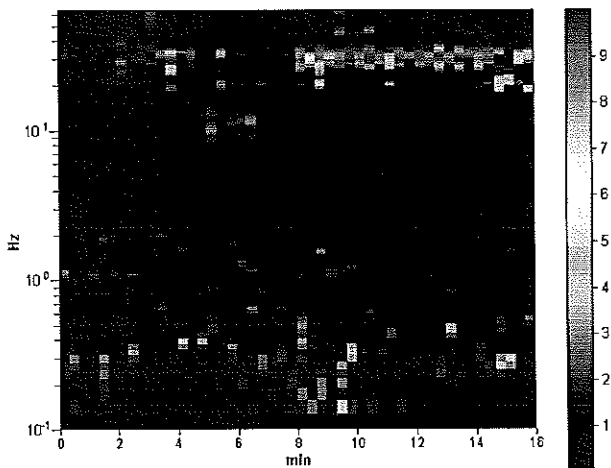
Trace length: 0h16'00". Analysis performed on the entire trace.  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 10%

**HORIZONTAL TO VERTICAL SPECTRAL RATIO**

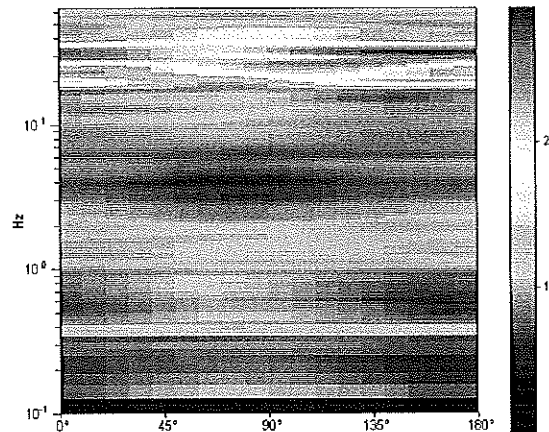
Max. HVV at 31.78 ± 2.64 Hz (in the range 0.0 - 64.0 Hz).



**HV TIME HISTORY**

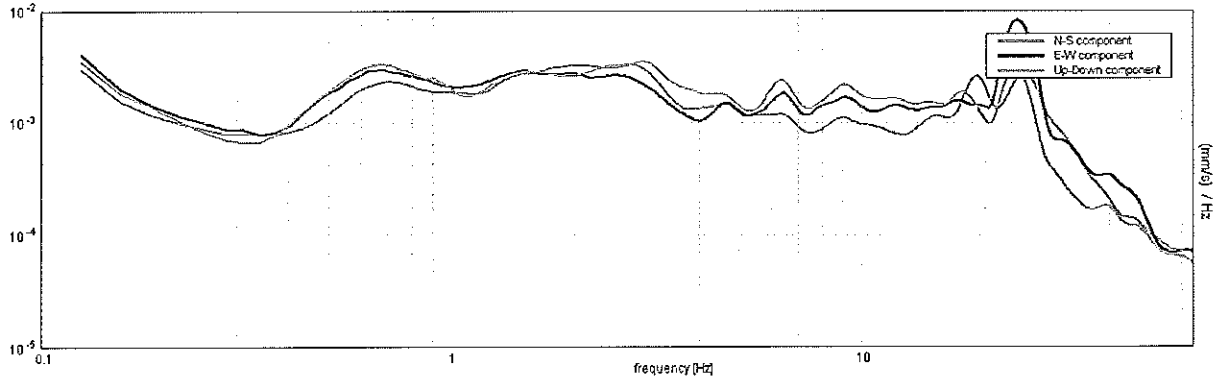


**DIRECTIONAL HV**

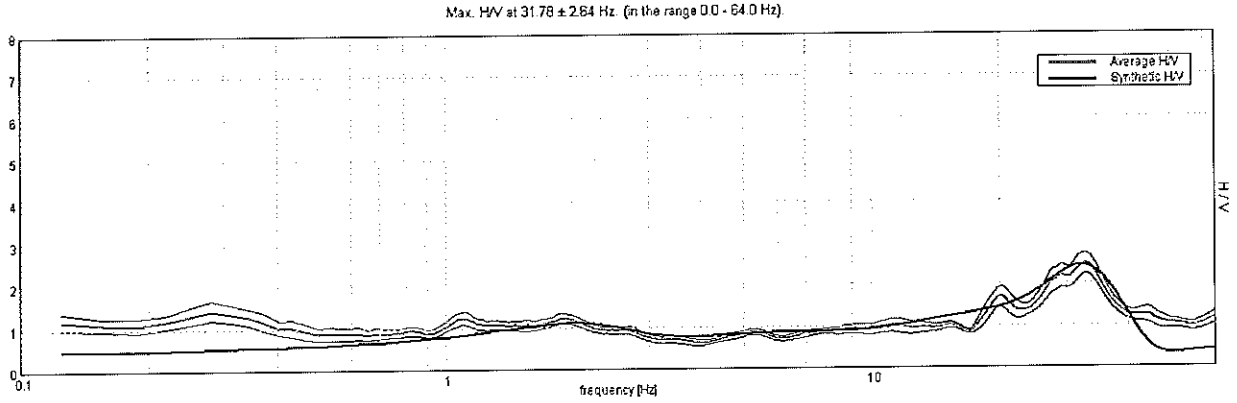




SINGLE COMPONENT SPECTRA

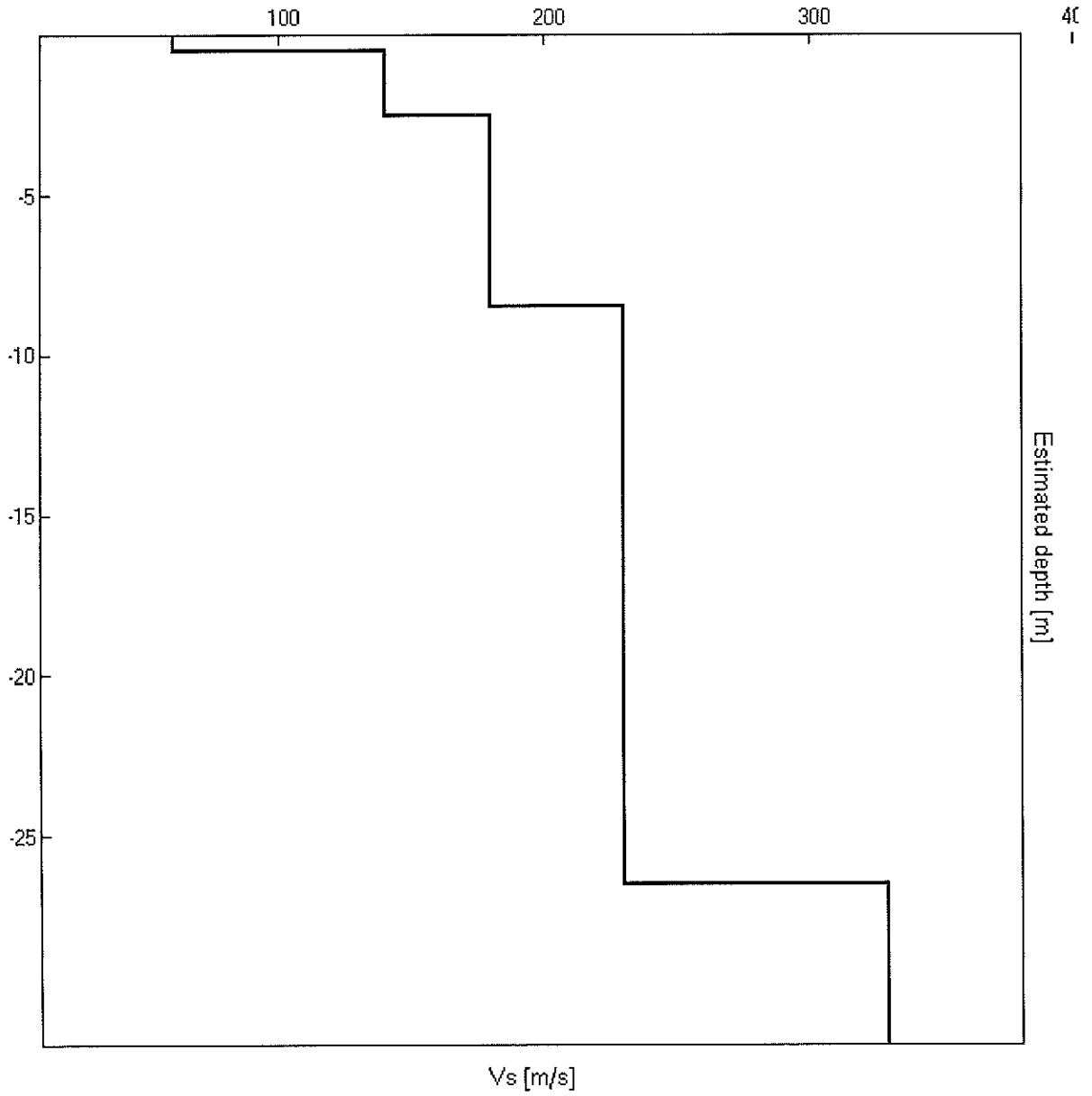


EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.50	0.50	60
2.50	2.00	140
8.50	6.00	180
26.50	18.00	230
inf.	inf.	330

Vs(0.0-30.0)=207m/s



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

Max. H/V at 31.78 ± 2.64 Hz. (in the range 0.0 - 64.0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	31.78 > 0.50	OK	
$n_c(f_0) > 200$	30510.0 > 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 1526 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0]$   $A_{HV}(f^-) < A_0 / 2$	18.375 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0]$   $A_{HV}(f^+) < A_0 / 2$	41.188 Hz	OK	
$A_0 > 2$	2.48 > 2	OK	
$f_{\text{peak}}[A_{HV}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.04092  < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	1.30049 < 1.58906	OK	
$\sigma_A(f_0) < \theta(f_0)$	0.122 < 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
$\sigma_f$	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 $f_0$
$A_{HV}(f)$	H/V curve amplitude at frequency $f$
$f^-$	frequency between $f_0/4$ and $f_0$ for which $A_{HV}(f^-) < A_0/2$
$f^+$	frequency between $f_0$ and $4f_0$ for which $A_{HV}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{HV}(f)$ , $\sigma_A(f)$ is the factor by which the mean $A_{HV}(f)$ curve should be multiplied or divided
$\sigma_{\log HV}(f)$	standard deviation of $\log A_{HV}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

Threshold values for  $\sigma_f$  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 $\sigma_{\log HV}(f_0)$	0.48	0.40	0.30	0.25	0.20

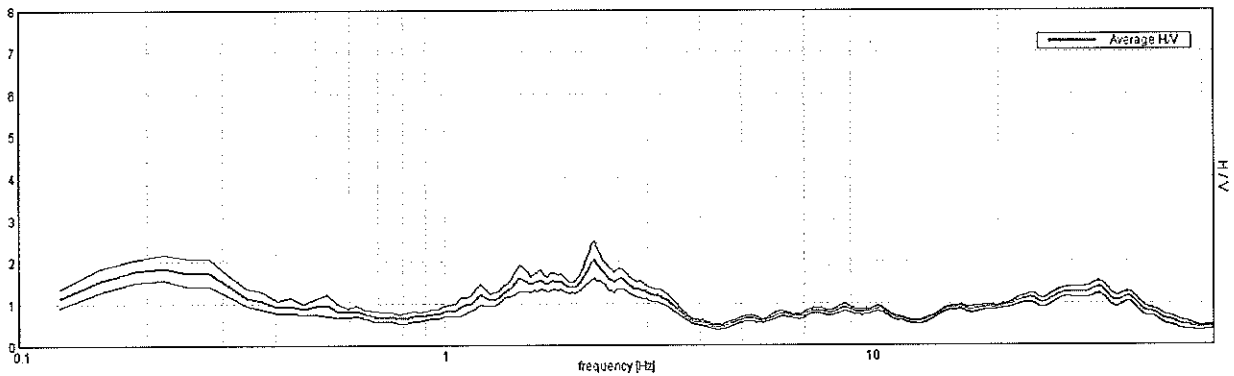
**RAVENNA – n. 20**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
 GPS data not available

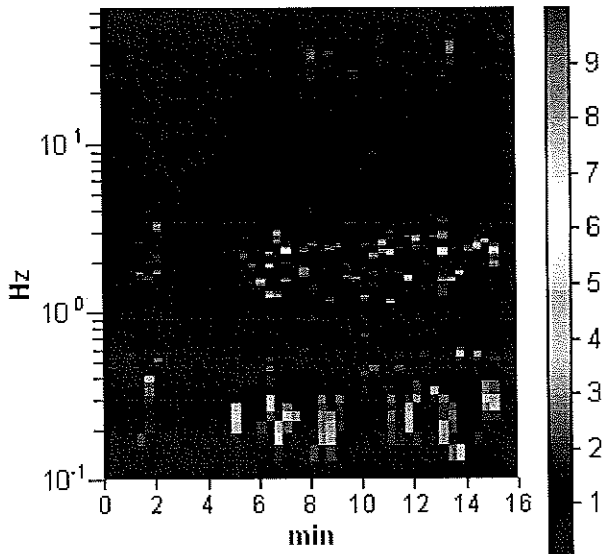
Trace length: 0h16'00". Analyzed 75% trace (manual window selection)  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 5%

**HORIZONTAL TO VERTICAL SPECTRAL RATIO**

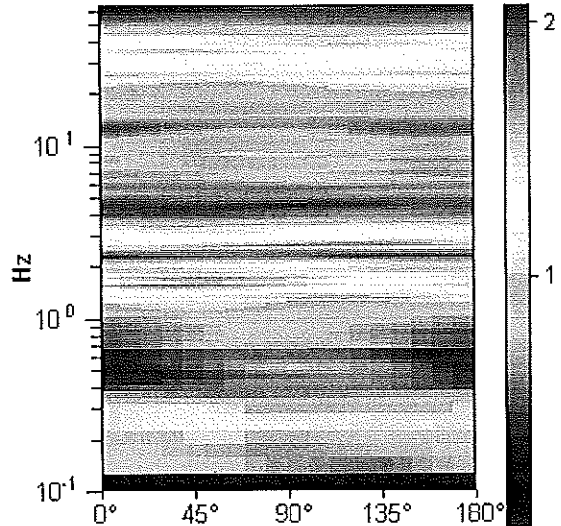
Max. HV at  $2.25 \pm 1.83$  Hz. (in the range 0.0 - 64.0 Hz)



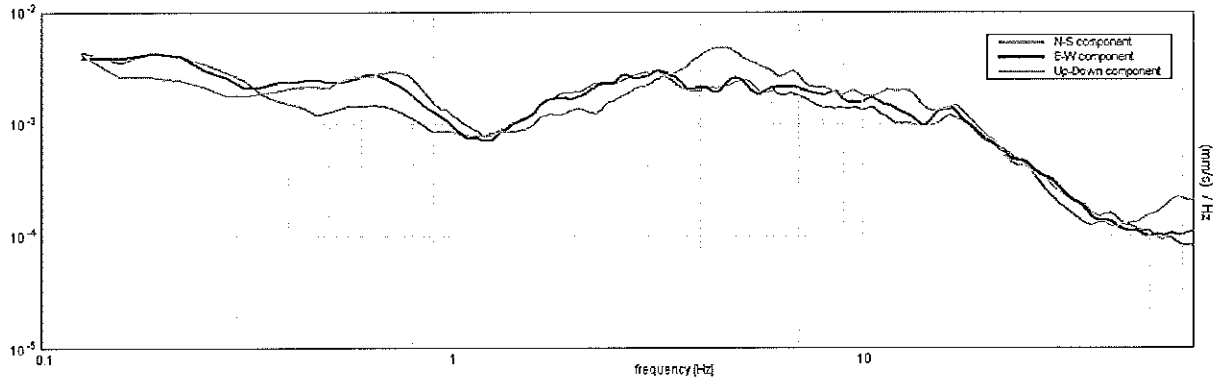
**HV TIME HISTORY**



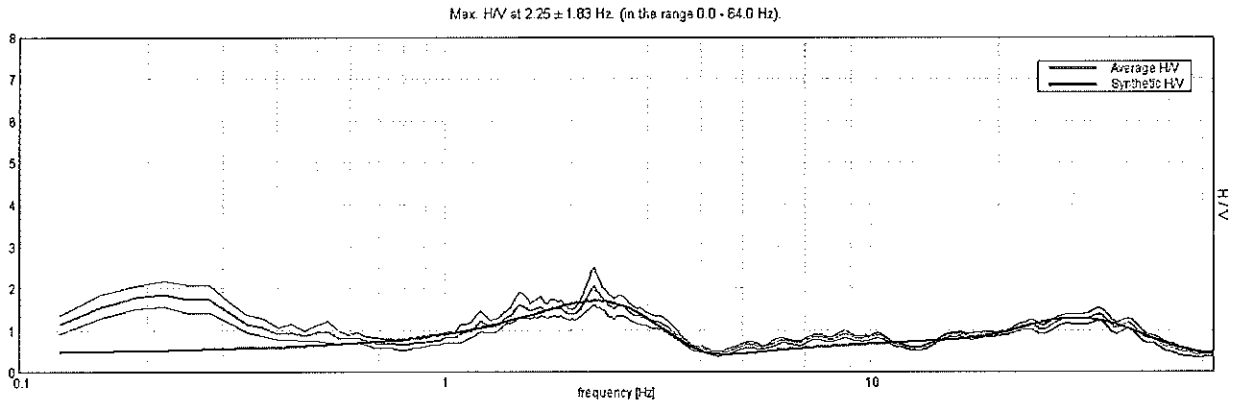
**DIRECTIONAL HV**



SINGLE COMPONENT SPECTRA

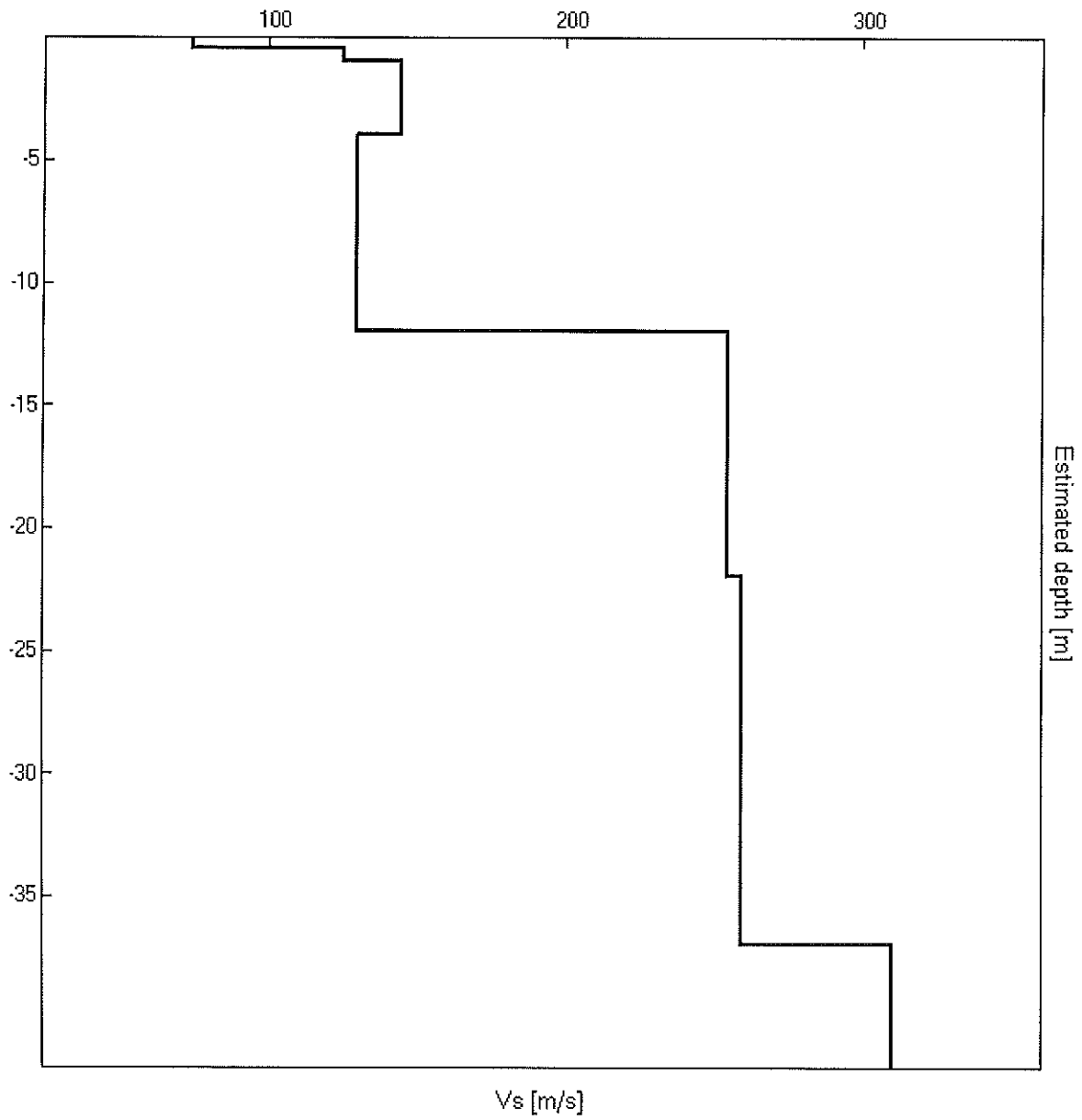


EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.45	0.45	75
0.95	0.50	125
3.95	3.00	145
11.95	8.00	130
21.95	10.00	255
36.95	15.00	260
inf.	inf.	310

Vs(2.0-32.0)=196m/s





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

Max. H/V at  $2.25 \pm 1.83$  Hz. (in the range 0.0 - 64.0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$2.25 > 0.50$	OK	
$n_c(f_0) > 200$	$1620.0 > 200$	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 109 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0]$   $A_{H/V}(f^-) < A_0 / 2$	1.156 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0]$   $A_{H/V}(f^+) < A_0 / 2$	3.406 Hz	OK	
$A_0 > 2$	$2.06 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.39422  < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	$0.887 < 0.1125$		NO
$\sigma_A(f_0) < \theta(f_0)$	$0.2135 < 1.58$	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
$\sigma_f$	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  $\sigma_f$  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

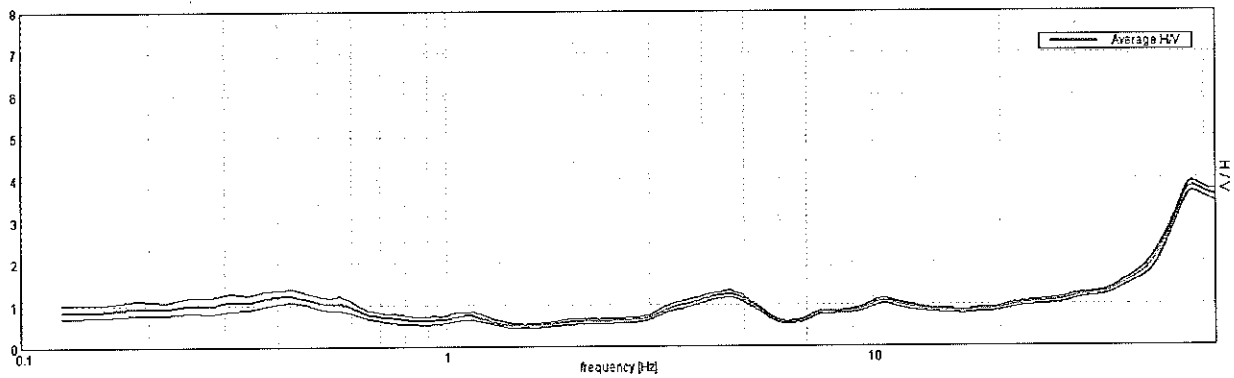
**RAVENNA – n. 21**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
GPS data not available

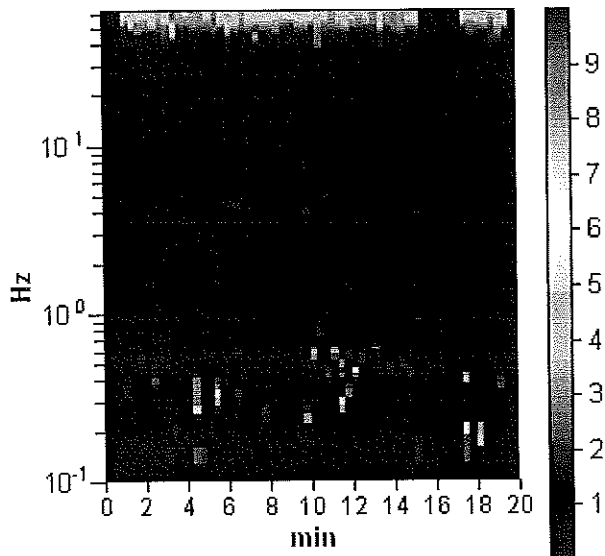
Trace length: 0h20'00". Analyzed 83% trace (manual window selection)  
Sampling frequency: 128 Hz  
Window size: 20 s  
Smoothing window: Triangular window  
Smoothing: 10%

**HORIZONTAL TO VERTICAL SPECTRAL RATIO**

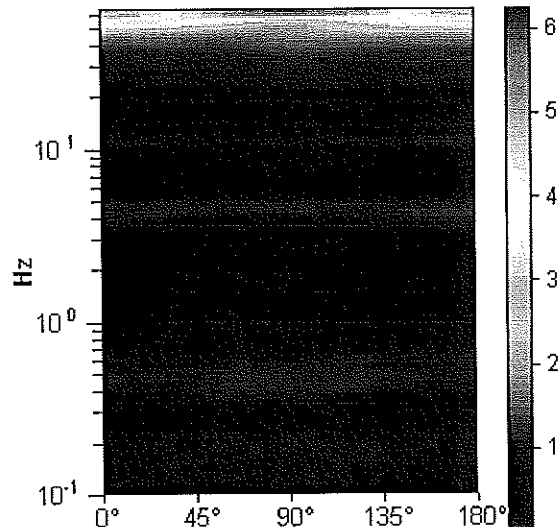
Max. HV at  $4.59 \pm 0.82$  Hz. (in the range 0.0 - 20.0 Hz)



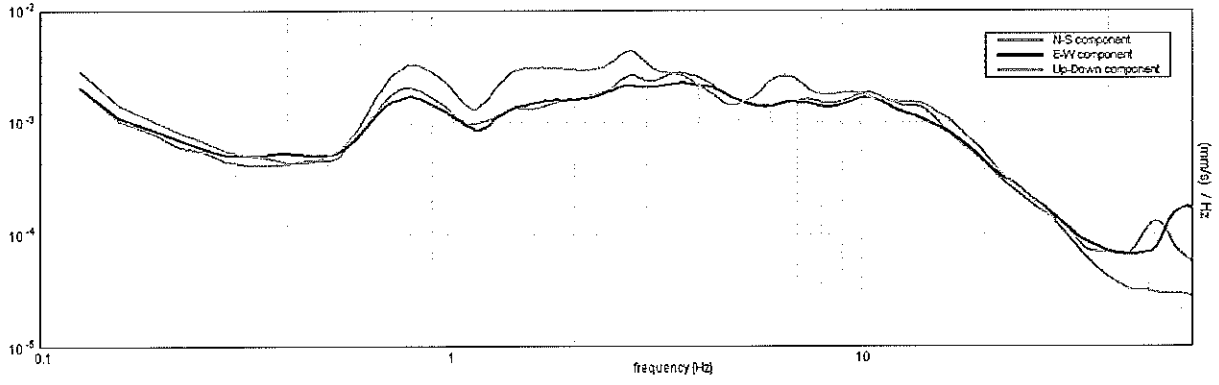
**H/V TIME HISTORY**



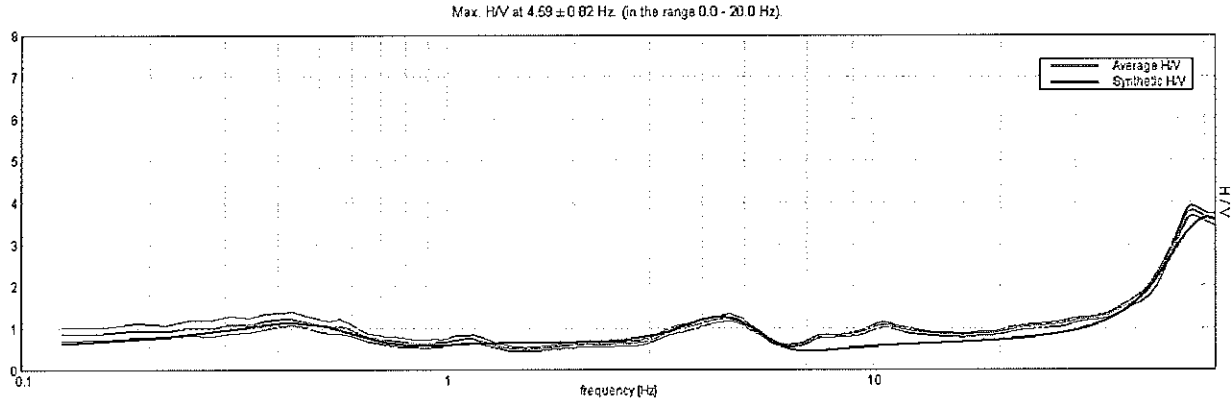
**DIRECTIONAL H/V**



SINGLE COMPONENT SPECTRA

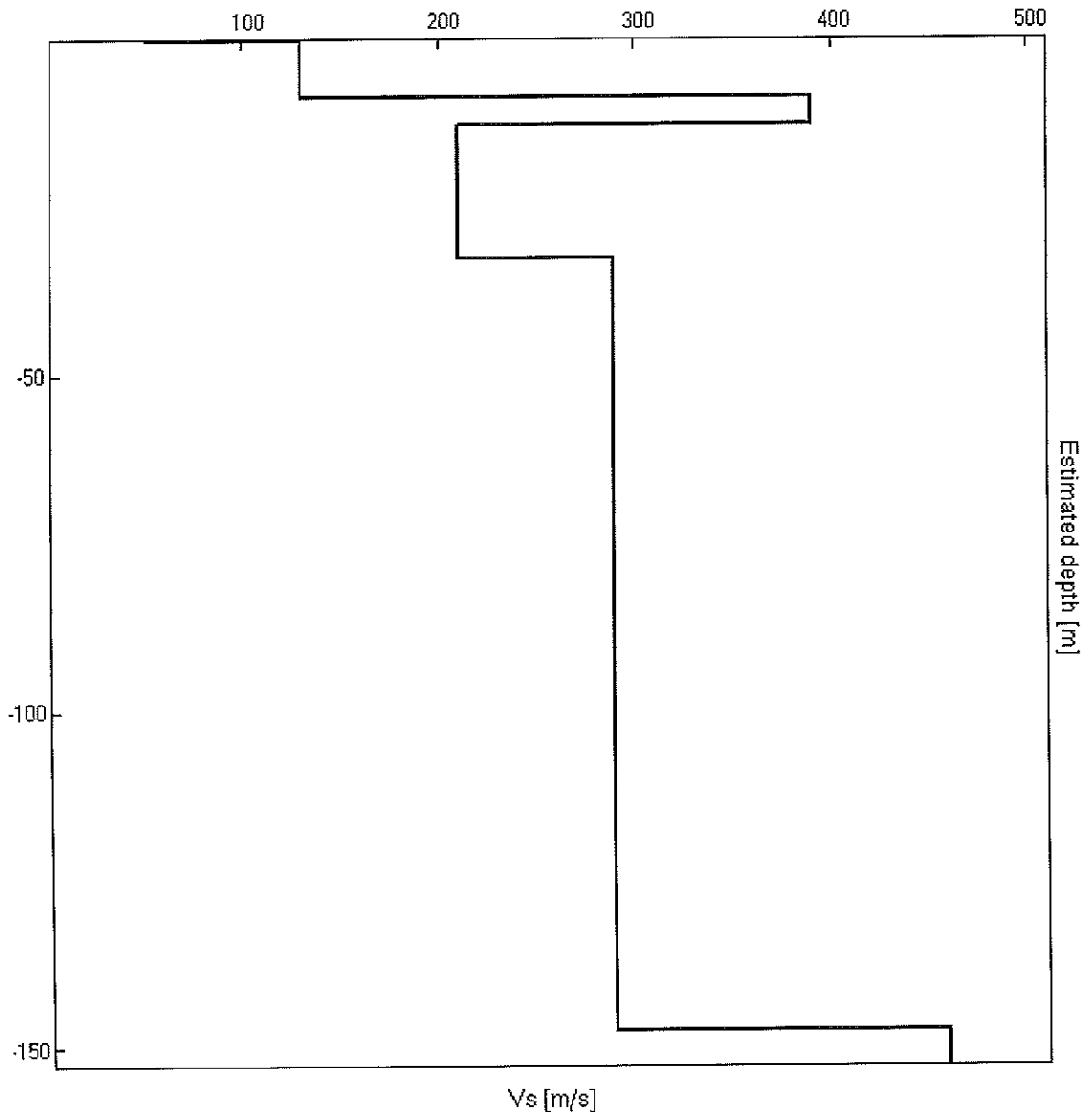


**EXPERIMENTAL VS. SYNTHETIC H/V**



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.22	0.22	52
8.62	8.40	130
12.62	4.00	390
32.62	20.00	210
147.62	115.00	290
inf.	inf.	460

Vs(0.0-30.0)=185m/s



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

Max. H/V at 4.59 ± 0.82 Hz. (in the range 0.0 - 20.0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	4.59 > 0.50	OK	
$n_c(f_0) > 200$	4593.8 > 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 222 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0] \mid A_{H/V}(f^-) < A_0 / 2$	2.563 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0 / 2$	5.969 Hz	OK	
$A_0 > 2$	1.25 > 2		NO
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.08754  < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	0.40213 < 0.22969		NO
$\sigma_A(f_0) < \theta(f_0)$	0.0389 < 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
$\sigma_f$	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  $\sigma_f$  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

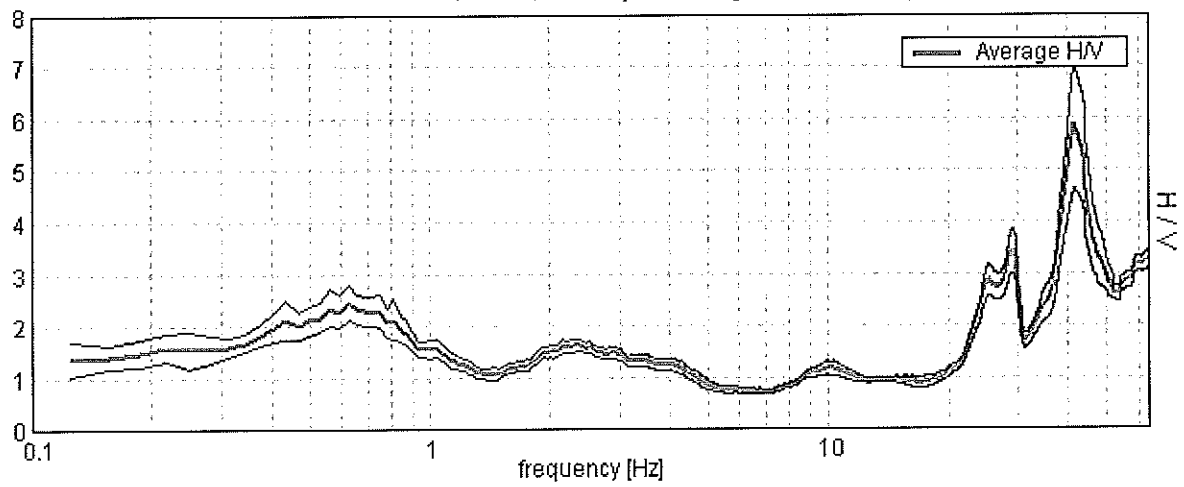
RAVENNA – n. 23

GPS data not available

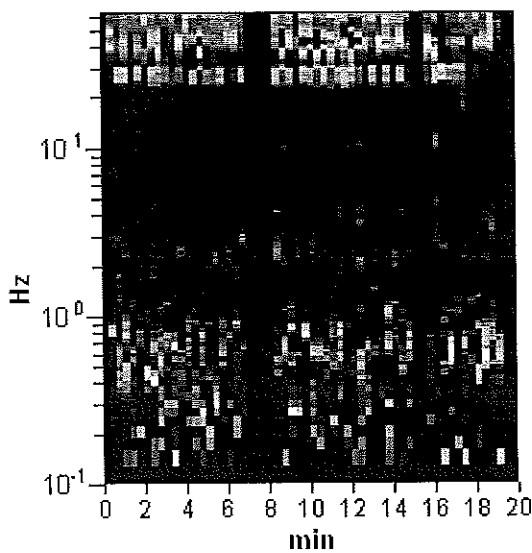
Trace length: 0h20'00". Analyzed 85% trace (manual window selection)  
Sampling frequency: 128 Hz  
Window size: 20 s  
Smoothing window: Triangular window  
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

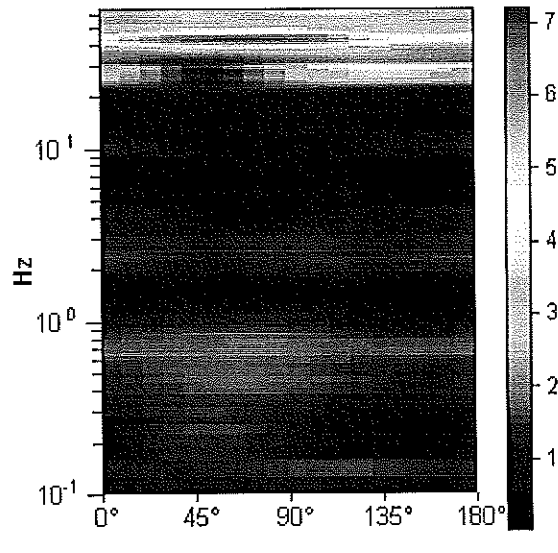
Max. HVSR at  $41,47 \pm 0,33$  Hz. (in the range 0,0 - 64,0 Hz).



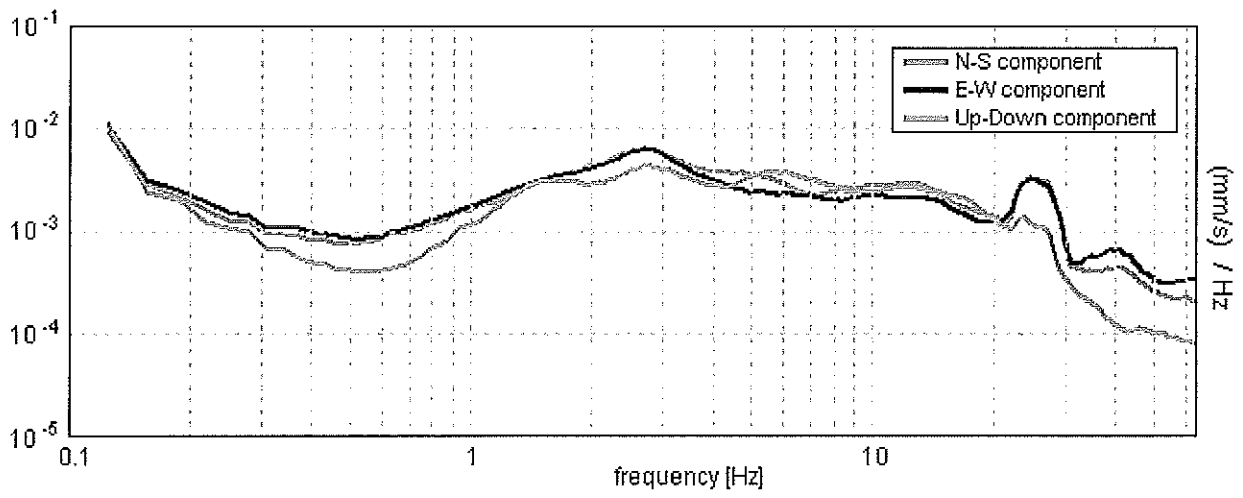
H/V TIME HISTORY



DIRECTIONAL H/V



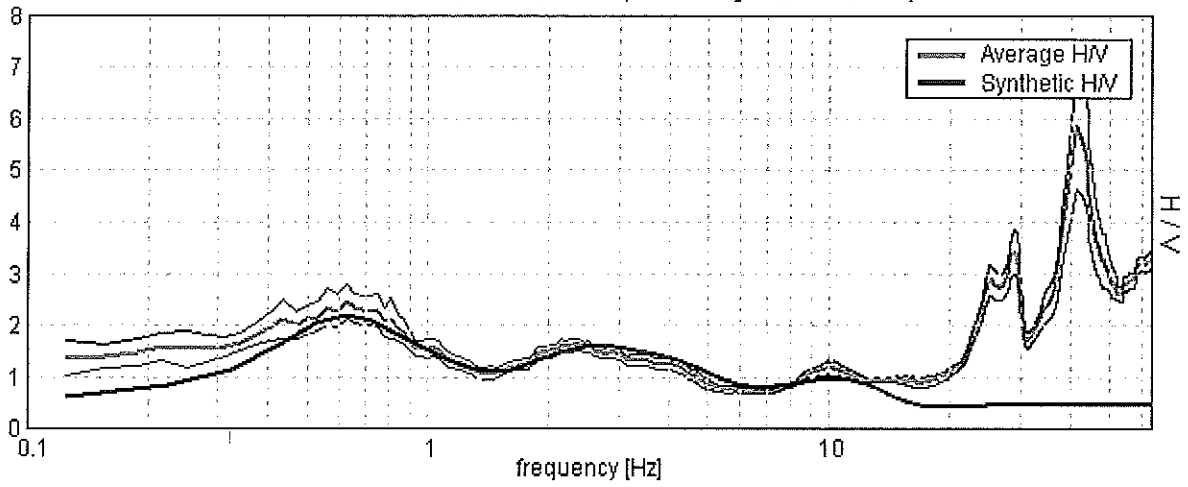
SINGLE COMPONENT SPECTRA





EXPERIMENTAL VS. SYNTHETIC H/V

Max. HYSR at 41,47 ± 0,33 Hz. (in the range 0,0 - 64,0 Hz).



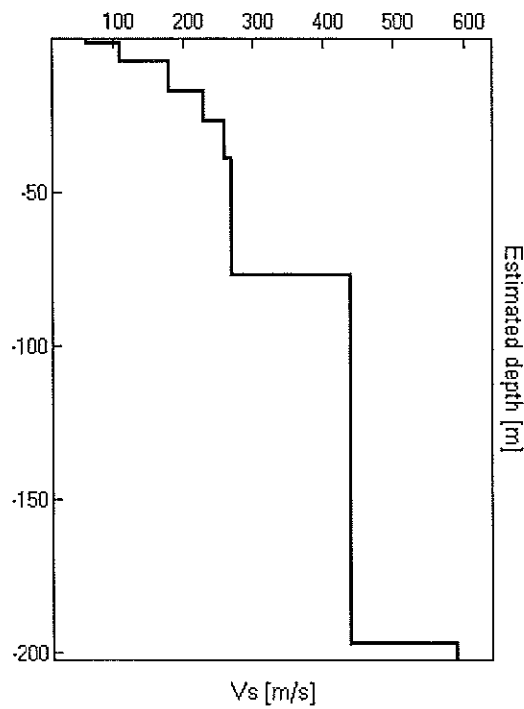
Depth at the bottom of the layer  
[m]

Thickness [m]

Vs [m/s]

1.50	1.50	65
7.00	5.50	110
17.00	10.00	180
27.00	10.00	230
39.00	12.00	260
77.00	38.00	270
197.00	120.00	440
inf.	inf.	590

Vs(0.0-30.0)=163m/s



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

Max. HVSR at 41,47 ± 0,33 Hz. (in the range 0,0 - 64,0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	41.47 > 0.50	OK	
$n_c(f_0) > 200$	42298.1 > 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 1386 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0] \mid A_{H/V}(f^-) < A_0 / 2$	37.031 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0 / 2$	50.25 Hz	OK	
$A_0 > 2$	5.86 > 2	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00394  < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.16319 < 2.07344$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.6008 < 1.58$	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
$\sigma_f$	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  $\sigma_f$  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

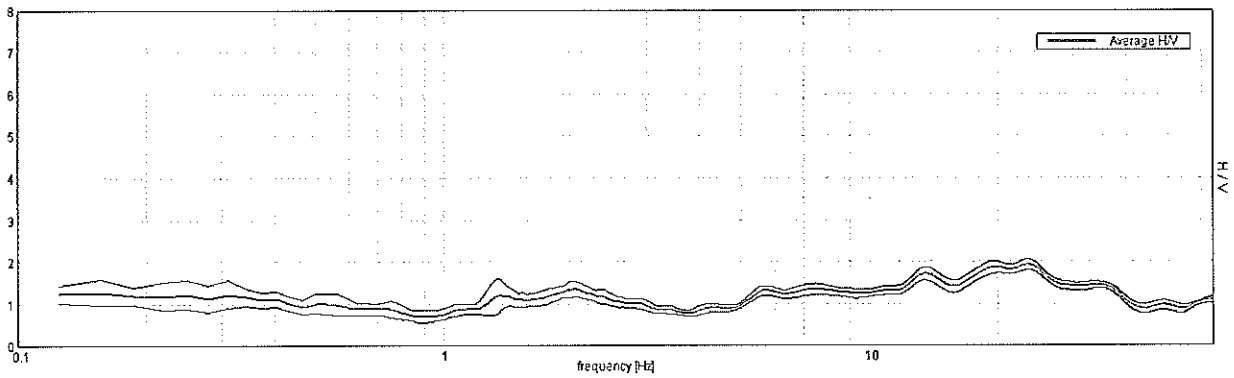
**RAVENNA – n. 23**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
 GPS data not available

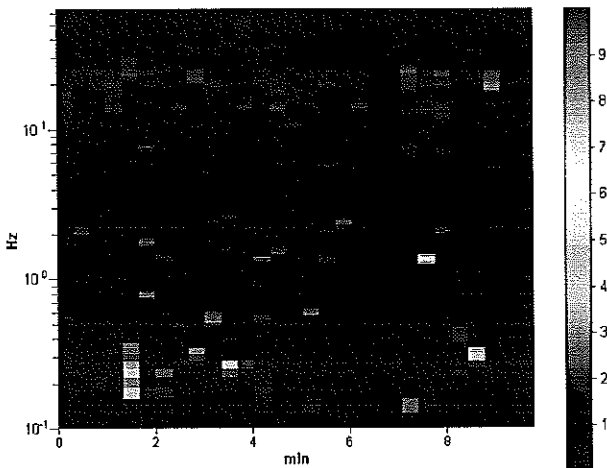
Trace length: 0h09'48". Analyzed 86% trace (manual window selection)  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 10%

**HORIZONTAL TO VERTICAL SPECTRAL RATIO**

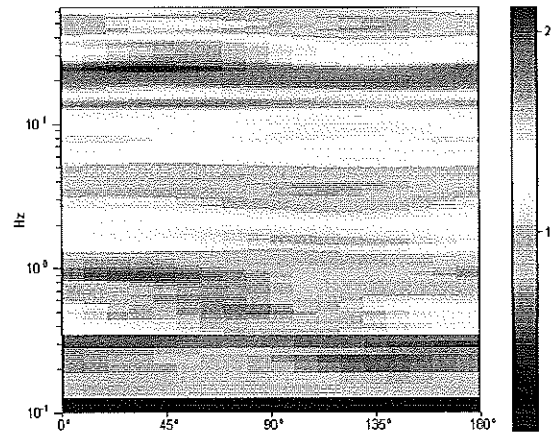
Max. HV at 19.69 ± 0.87 Hz. (in the range 0.0 - 20.0 Hz)



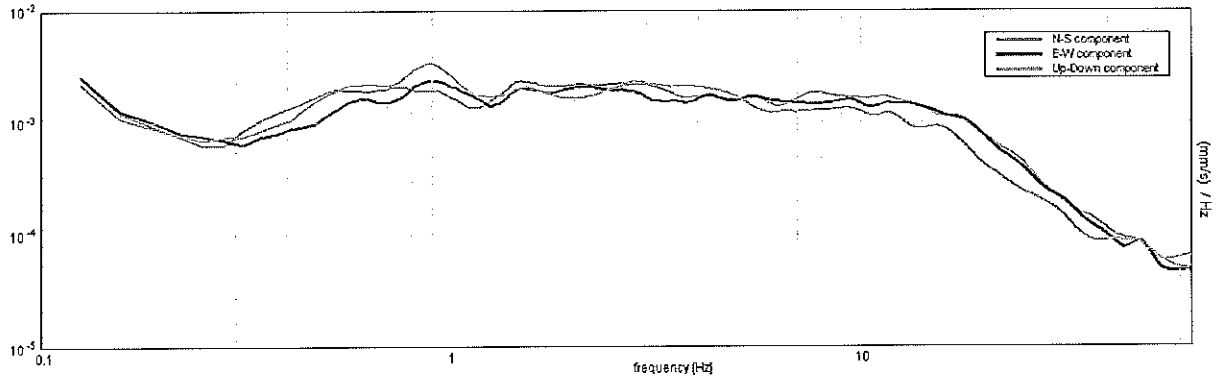
**H/V TIME HISTORY**



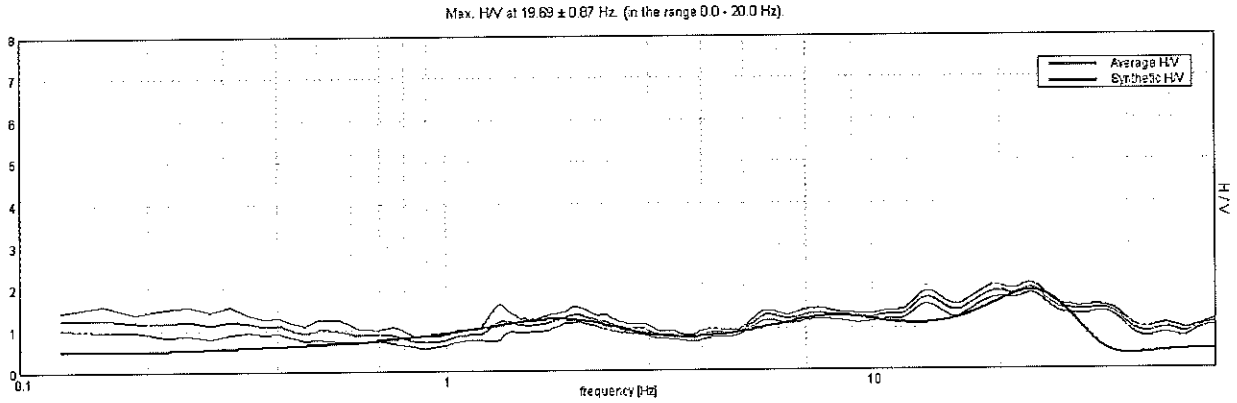
**DIRECTIONAL H/V**



SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer

Thickness [m]

Vs [m/s]

[m]

0.55

0.55

52

2.55

2.00

115

4.55

2.00

145

19.55

15.00

185

39.55

20.00

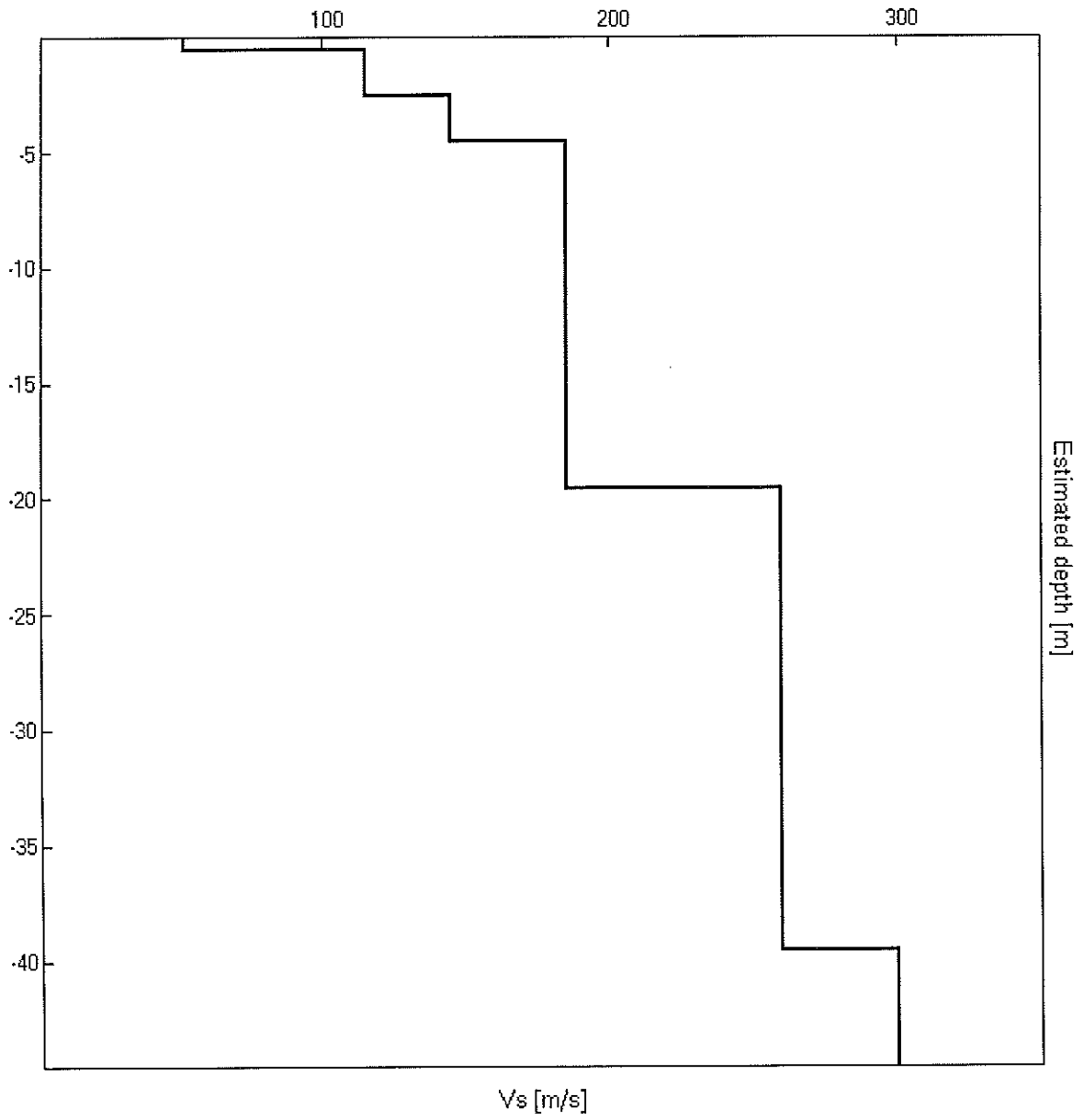
260

inf.

inf.

300

Vs(0.0-30.0)=184m/s



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

**Max. H/V at 19.69 ± 0.87 Hz. (in the range 0.0 - 20.0 Hz).**

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	19.69 > 0.50	OK	
$n_c(f_0) > 200$	9843.8 > 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 946 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0]$   $A_{HV}(f^-) < A_0 / 2$			NO
Exists $f^+$ in $[f_0, 4f_0]$   $A_{HV}(f^+) < A_0 / 2$	41.813 Hz	OK	
$A_0 > 2$	1.87 > 2		NO
$f_{\text{peak}}[A_{HV}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.02105  < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	0.41434 < 0.98438	OK	
$\sigma_A(f_0) < \theta(f_0)$	0.0685 < 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
$\sigma_f$	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 $f_0$
$A_{HV}(f)$	H/V curve amplitude at frequency $f$
$f^-$	frequency between $f_0/4$ and $f_0$ for which $A_{HV}(f^-) < A_0/2$
$f^+$	frequency between $f_0$ and $4f_0$ for which $A_{HV}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{HV}(f)$ , $\sigma_A(f)$ is the factor by which the mean $A_{HV}(f)$ curve should be multiplied or divided
$\sigma_{\log HV}(f)$	standard deviation of $\log A_{HV}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

**Threshold values for  $\sigma_f$  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 $\sigma_{\log HV}(f_0)$	0.48	0.40	0.30	0.25	0.20

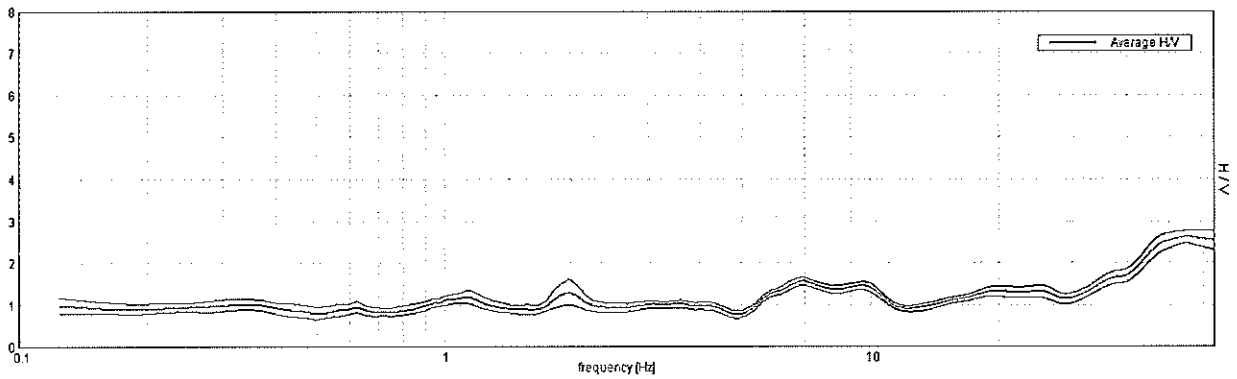
RAVENNA – n. 24

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
GPS data not available

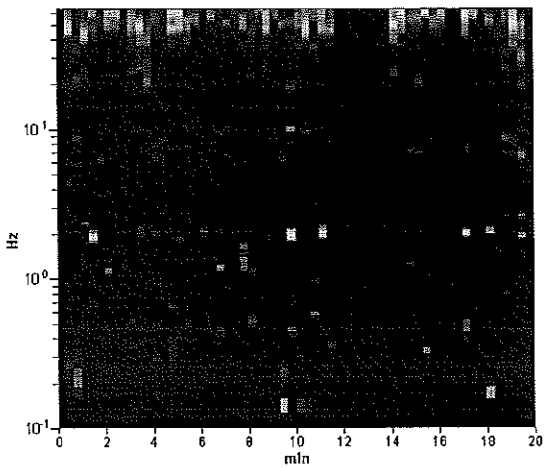
Trace length: 0h20'00". Analyzed 82% trace (manual window selection)  
Sampling frequency: 128 Hz  
Window size: 20 s  
Smoothing window: Triangular window  
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

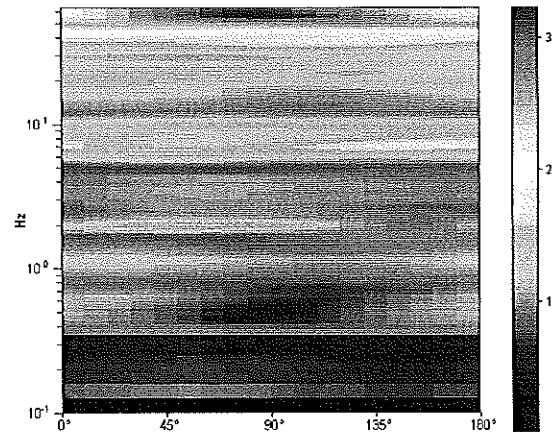
Max. HV at 6.68 ± 0.6 Hz. (in the range 0.0 - 20.0 Hz)



H/V TIME HISTORY

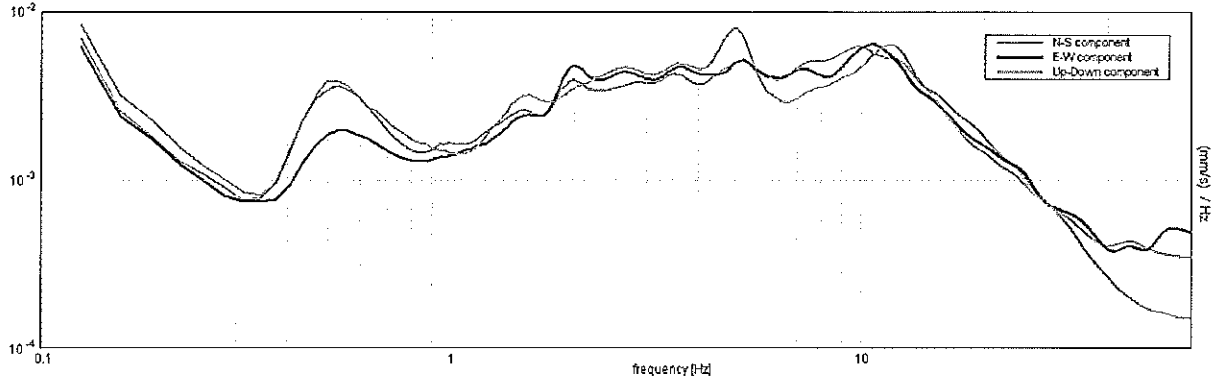


DIRECTIONAL H/V

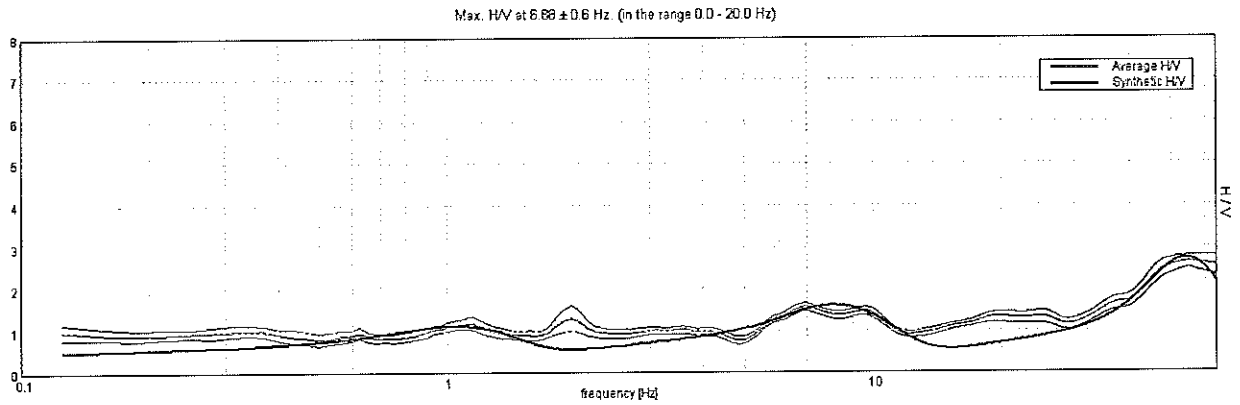




SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer

Thickness [m]

Vs [m/s]

[m]

0.23

0.23

50

3.23

3.00

118

10.23

7.00

220

22.23

12.00

230

28.23

6.00

200

46.23

18.00

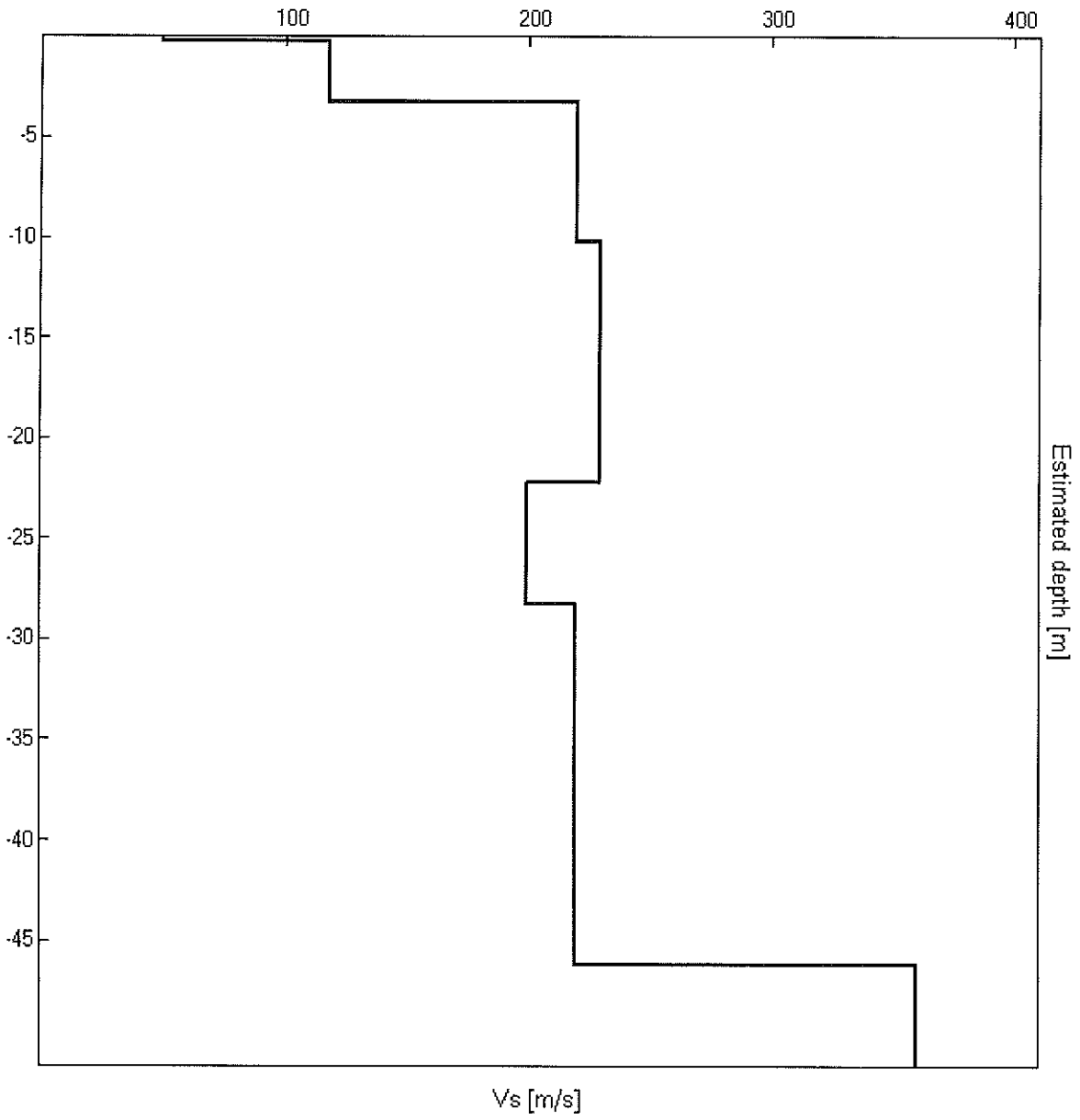
220

inf.

inf.

360

Vs(0.0-30.0)=197m/s



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

**Max. H/V at 6.88 ± 0.6 Hz. (in the range 0.0 - 20.0 Hz).**

<b>Criteria for a reliable HVSR curve</b> [All 3 should be fulfilled]			
$f_0 > 10 / L_w$	6.88 > 0.50	OK	
$n_c(f_0) > 200$	6737.5 > 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 331 times	OK	
<b>Criteria for a clear HVSR peak</b> [At least 5 out of 6 should be fulfilled]			
Exists $f^-$ in $[f_0/4, f_0] \mid A_{H/V}(f^-) < A_0 / 2$	4.969 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0 / 2$			NO
$A_0 > 2$	1.56 > 2		NO
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.04274  < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	0.29383 < 0.34375	OK	
$\sigma_A(f_0) < \theta(f_0)$	0.0469 < 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
$\sigma_f$	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 $\sigma_f$ 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

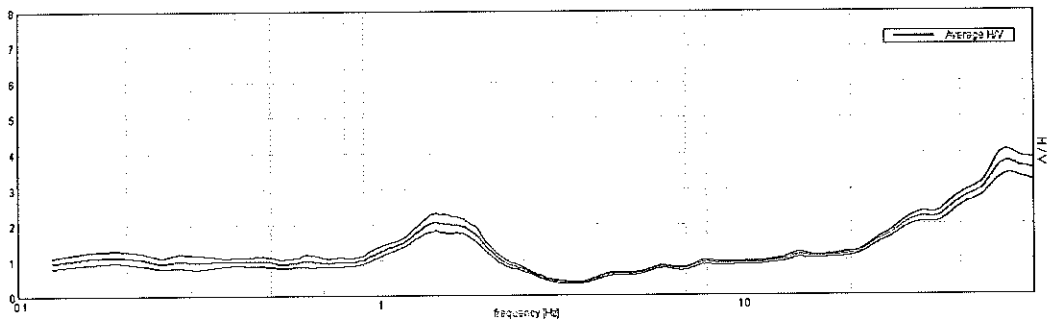
**RAVENNA – n. 25**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
 GPS data not available

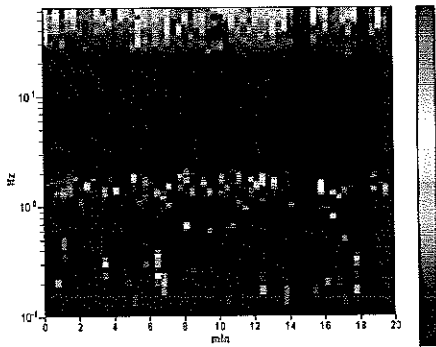
Trace length: 0h20'00". Analyzed 90% trace (manual window selection)  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 10%

**HORIZONTAL TO VERTICAL SPECTRAL RATIO**

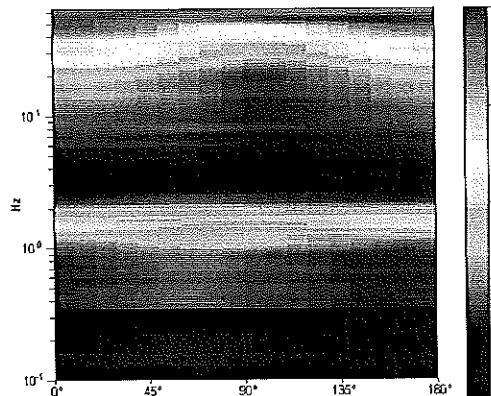
Max HVV at 1.44 ± 0.03 Hz. (in the range 0.0 - 20.0 Hz)



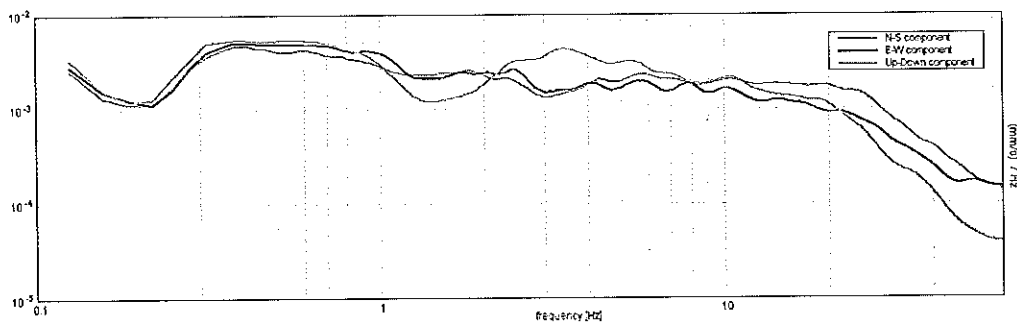
**H/V TIME HISTORY**



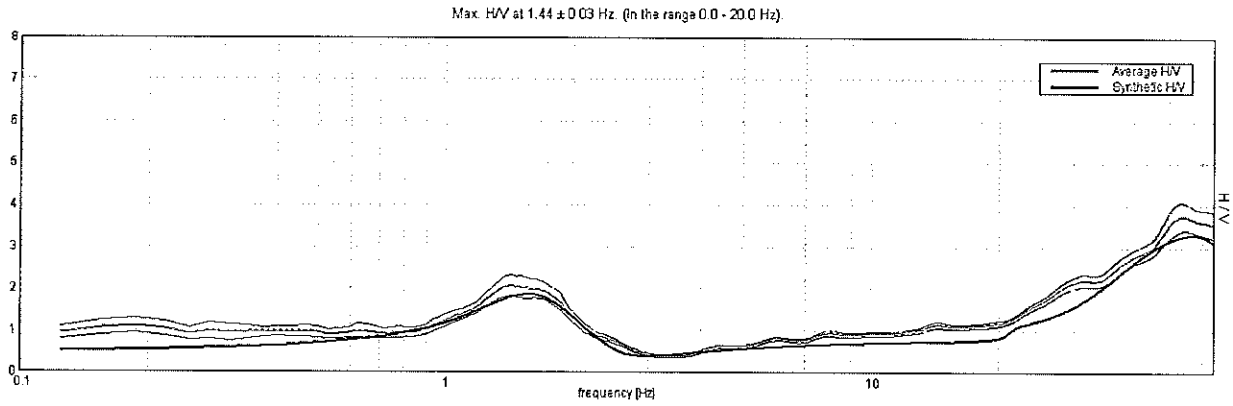
**DIRECTIONAL H/V**



**SINGLE COMPONENT SPECTRA**

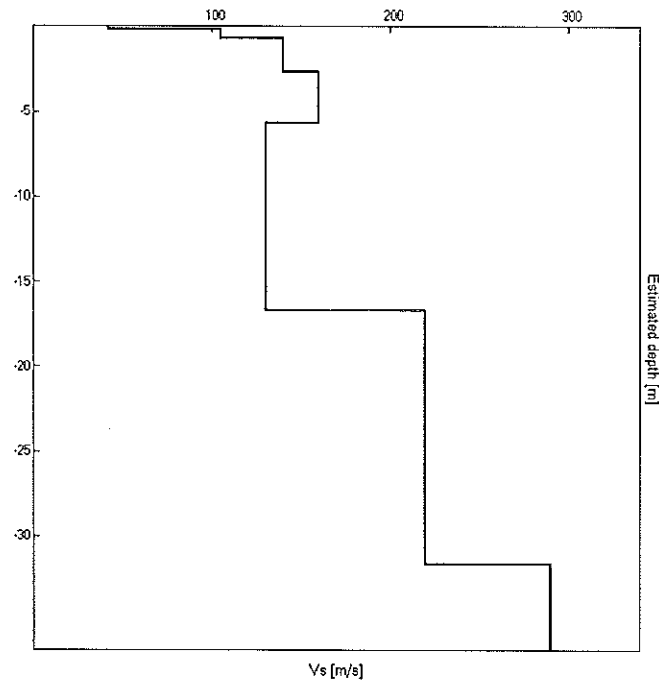


**EXPERIMENTAL VS. SYNTHETIC H/V**



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.18	0.18	42
0.68	0.50	105
2.68	2.00	140
5.68	3.00	160
16.68	11.00	130
31.68	15.00	220
inf.	inf.	290

Vs(0.0-30.0)=160m/s



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

**Max. H/V at 1.44 ± 0.03 Hz. (in the range 0.0 - 20.0 Hz).**

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	1.44 > 0.50	OK	
$n_c(f_0) > 200$	1552.5 > 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 70 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0] \mid A_{HV}(f^-) < A_0 / 2$	0.906 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0] \mid A_{HV}(f^+) < A_0 / 2$	2.156 Hz	OK	
$A_0 > 2$	2.07 > 2	OK	
$f_{\text{peak}}[A_{HV}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.01165  < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	0.01675 < 0.14375	OK	
$\sigma_A(f_0) < \theta(f_0)$	0.1203 < 1.78	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
$\sigma_f$	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 $f_0$
$A_{HV}(f)$	H/V curve amplitude at frequency $f$
$f^-$	frequency between $f_0/4$ and $f_0$ for which $A_{HV}(f^-) < A_0/2$
$f^+$	frequency between $f_0$ and $4f_0$ for which $A_{HV}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{HV}(f)$ , $\sigma_A(f)$ is the factor by which the mean $A_{HV}(f)$ curve should be multiplied or divided
$\sigma_{\log HV}(f)$	standard deviation of $\log A_{HV}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

**Threshold values for  $\sigma_f$  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 $\sigma_{\log HV}(f_0)$	0.48	0.40	0.30	0.25	0.20

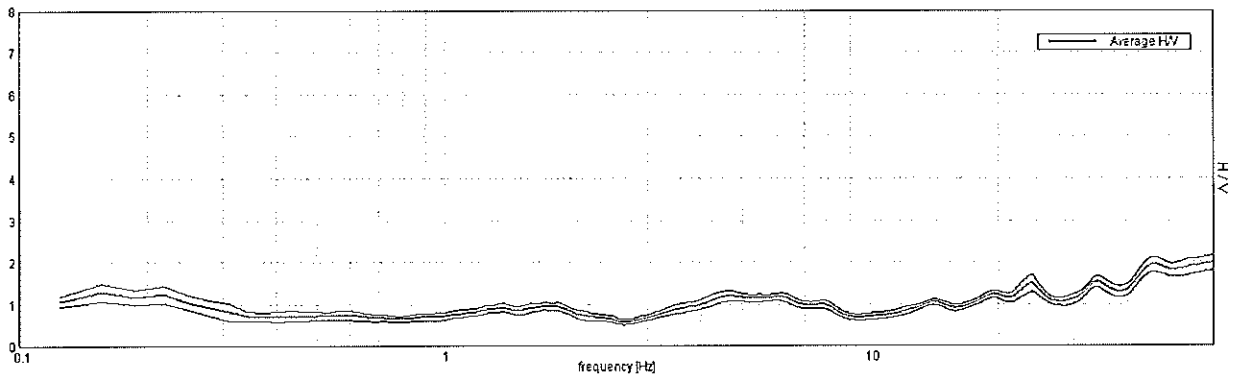
**RAVENNA – n. 26**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
 GPS data not available

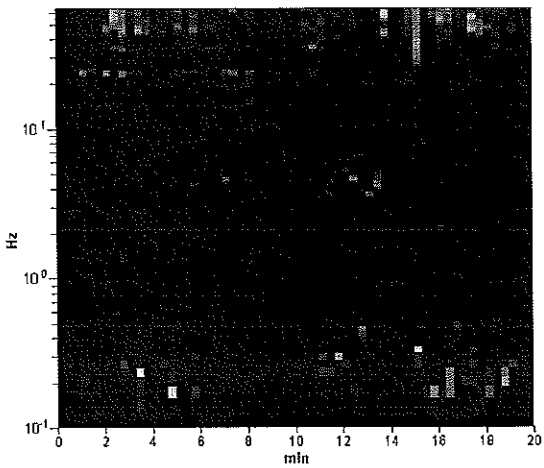
Trace length: 0h20'00". Analyzed 78% trace (manual window selection)  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 10%

**HORIZONTAL TO VERTICAL SPECTRAL RATIO**

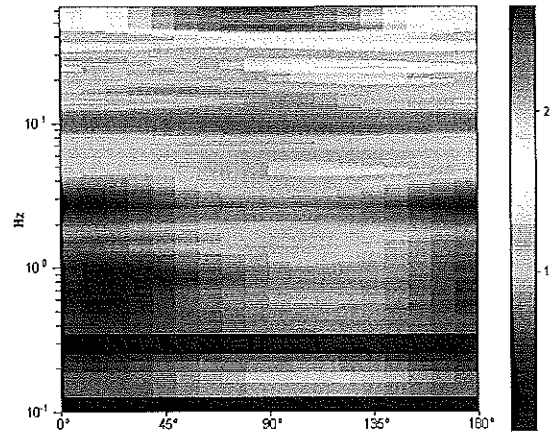
Max. H/V at 0.16 ± 3.93 Hz (in the range 0.0 - 20.0 Hz)



**H/V TIME HISTORY**

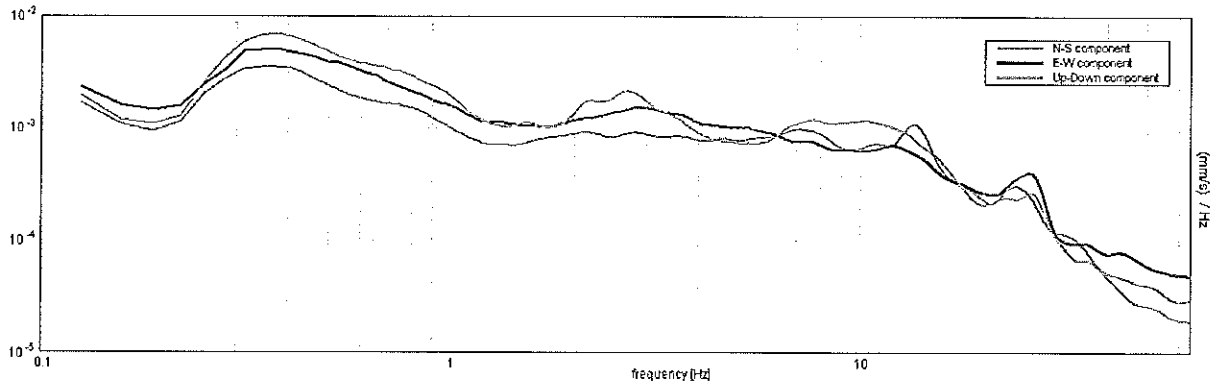


**DIRECTIONAL H/V**

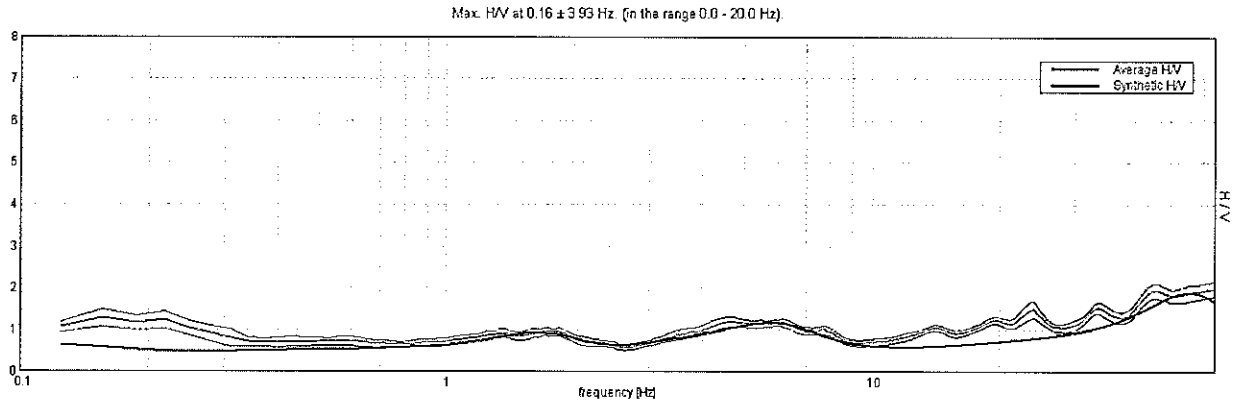




SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



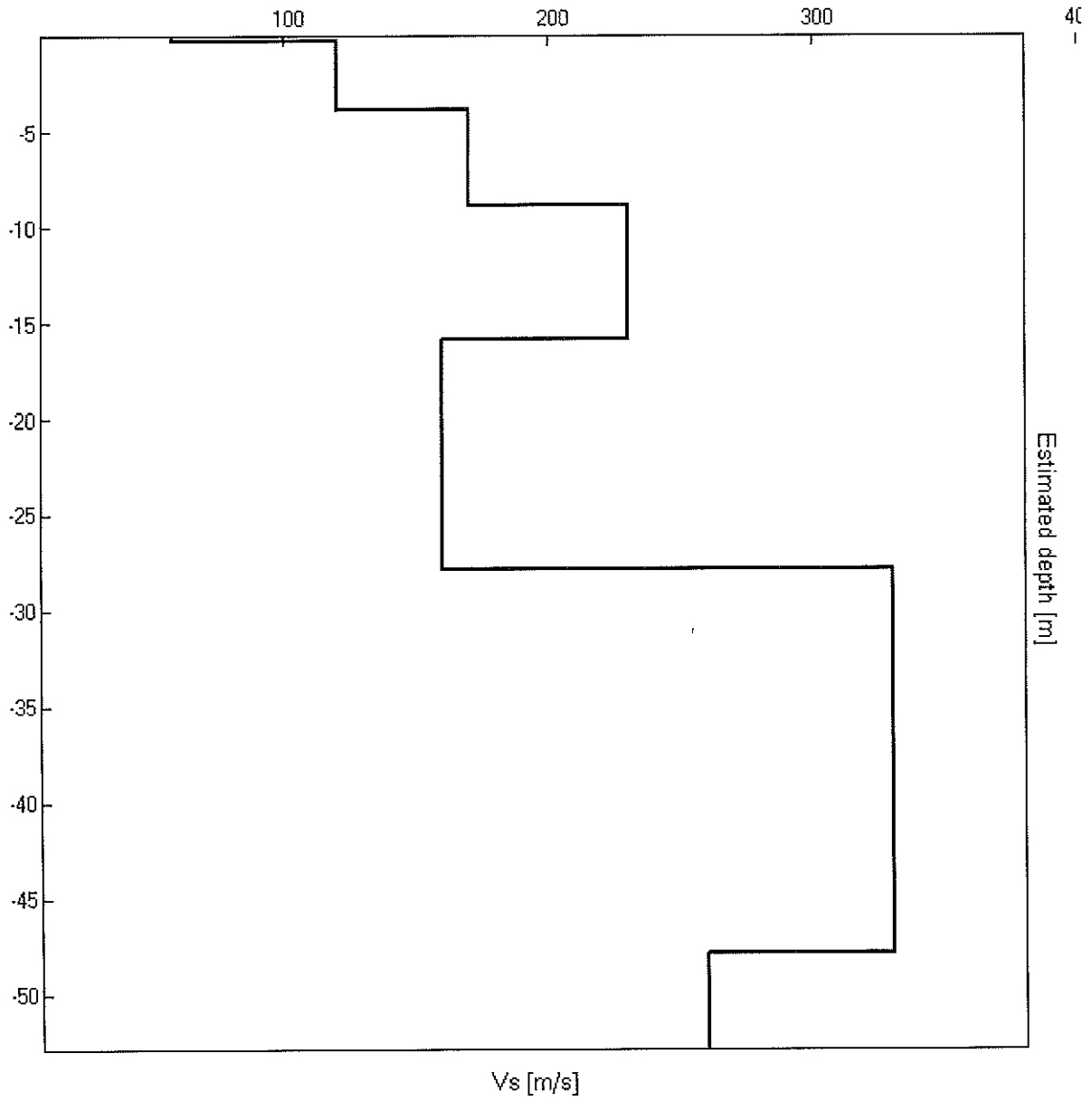
Depth at the bottom of the layer  
 [m]

Thickness [m]

Vs [m/s]

0.25	0.25	58
3.85	3.60	120
8.85	5.00	170
15.85	7.00	230
27.85	12.00	160
47.85	20.00	330
inf.	inf.	260

Vs(0.0-30.0)=171m/s



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

Max. H/V at  $0.16 \pm 3.93$  Hz. (in the range 0.0 - 20.0 Hz).

**Criteria for a reliable HVSR curve**  
[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$0.16 > 0.50$		NO
$n_c(f_0) > 200$	$146.9 > 200$		NO
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$ if $f_0 > 0.5$ Hz $\sigma_A(f) < 3$ for $0.5f_0 < f < 2f_0$ if $f_0 < 0.5$ Hz	Exceeded 0 out of 8 times	OK	

**Criteria for a clear HVSR peak**  
[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0]$   $A_{H/V}(f^-) < A_0 / 2$	0.094 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0]$   $A_{H/V}(f^+) < A_0 / 2$			NO
$A_0 > 2$	$1.28 > 2$		NO
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 12.35853  < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	$1.93102 < 0.03906$		NO
$\sigma_A(f_0) < \theta(f_0)$	$0.1055 < 3.0$	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
$\sigma_f$	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  $\sigma_f$  and  $\sigma_A(f_0)$

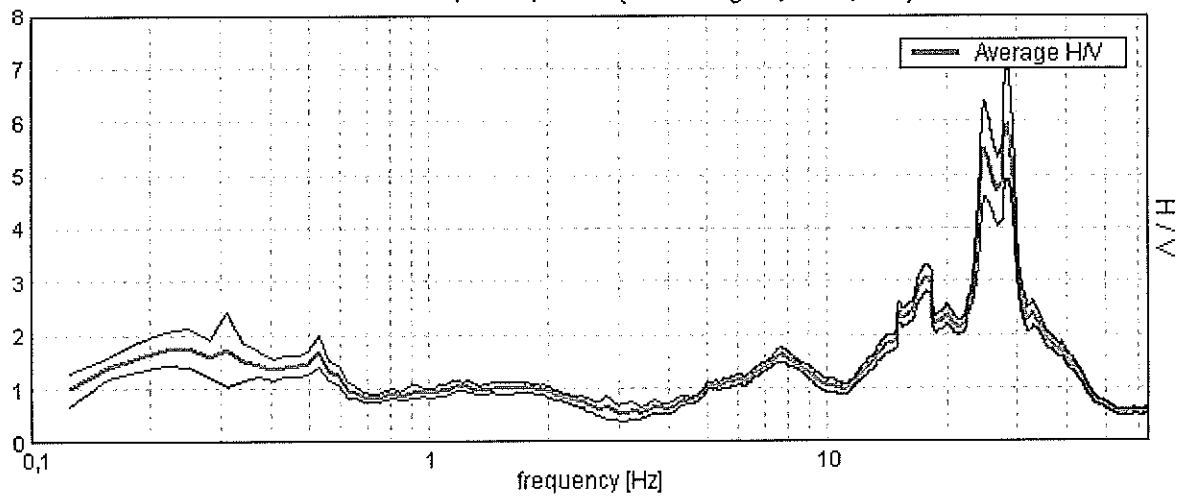
Freq.range [Hz]	< 0.2	0.2 – 0.5	0.5 – 1.0	1.0 – 2.0	> 2.0
$\varepsilon(f_0)$ [Hz]	$0.25 f_0$	$0.2 f_0$	$0.15 f_0$	$0.10 f_0$	$0.05 f_0$
$\theta(f_0)$ for $\sigma_A(f_0)$	3.0	2.5	2.0	1.78	1.58
Log $\theta(f_0)$ for $\sigma_{\log H/V}(f_0)$	0.48	0.40	0.30	0.25	0.20

RAVENNA – n. 27

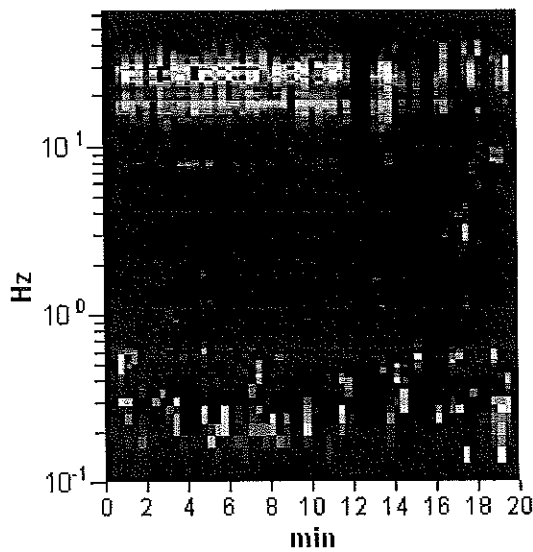
GPS data not available

Trace length: 0h20'00". Analyzed 87% trace (manual window selection)  
Sampling frequency: 128 Hz  
Window size: 20 s  
Smoothing window: Triangular window  
Smoothing: 10%

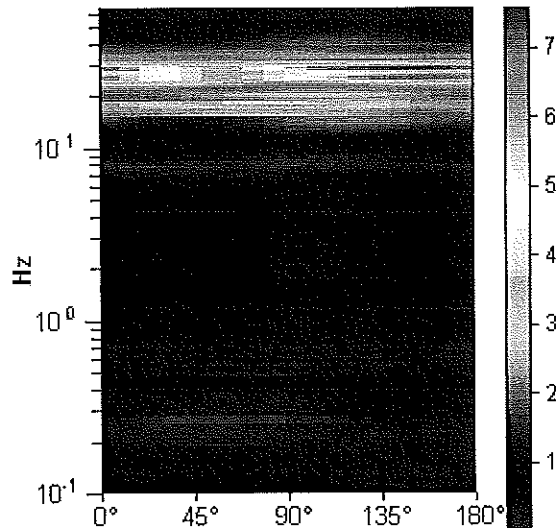
HORIZONTAL TO VERTICAL SPECTRAL RATIO  
Max. HVSR at  $28,28 \pm 1,09$  Hz. (in the range 0,0 - 64,0 Hz).



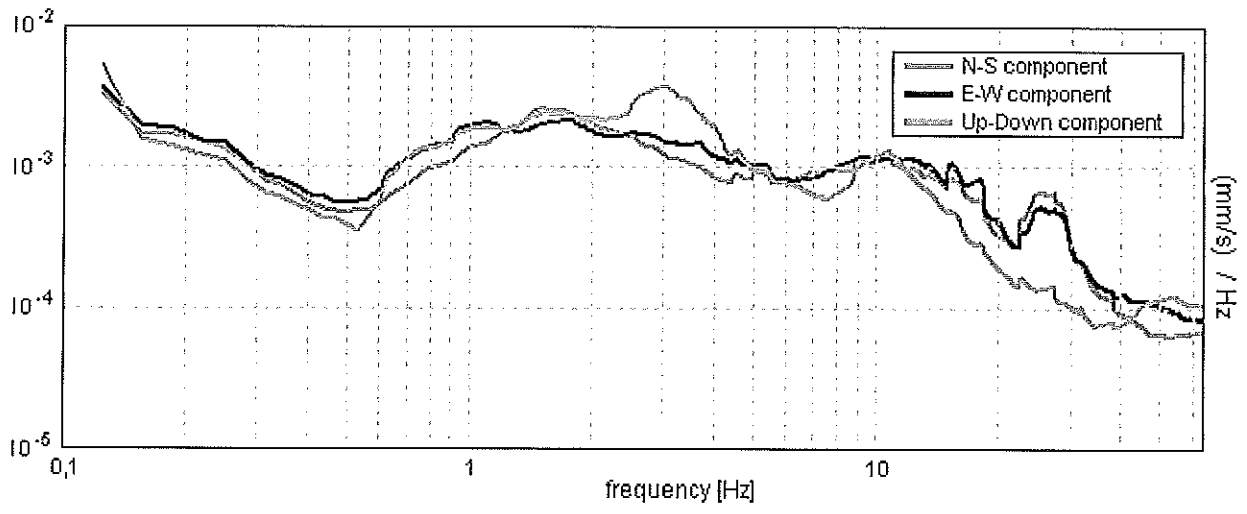
H/V TIME HISTORY



DIRECTIONAL H/V

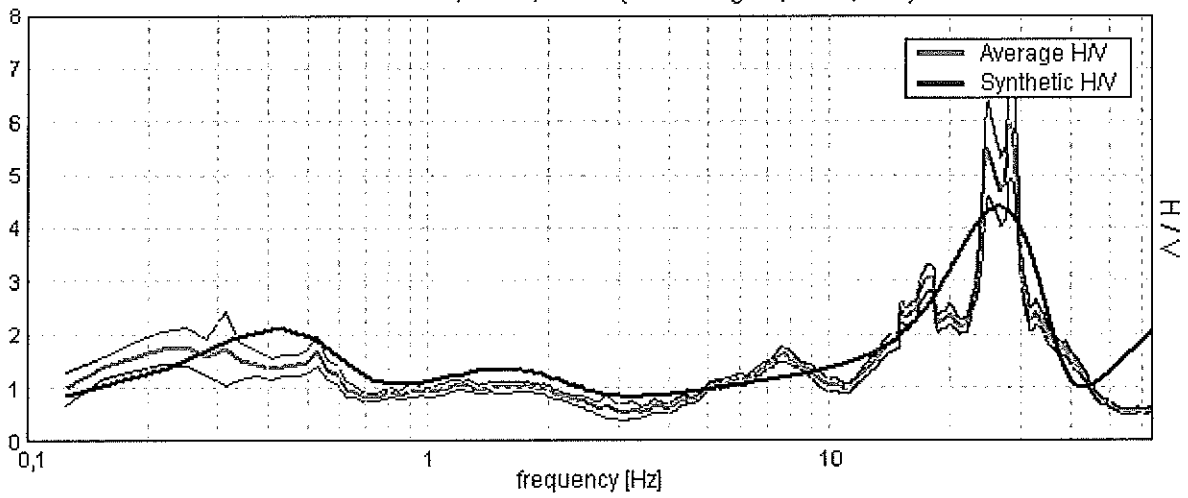


SINGLE COMPONENT SPECTRA



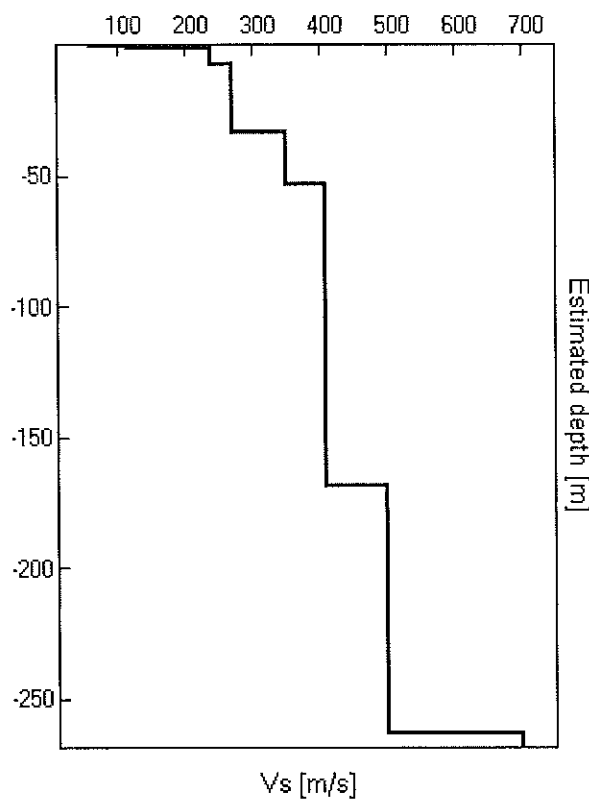
EXPERIMENTAL VS. SYNTHETIC H/V

Max. HVSR at  $28,28 \pm 1,09$  Hz. (in the range 0,0 - 64,0 Hz).



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0,20	0,20	60
1,20	1,00	115
7,20	6,00	240
33,20	26,00	270
53,20	20,00	350
168,20	115,00	410
263,20	95,00	500
inf.	inf.	700

**Vs30 = 247 m/s**



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

Max. HVSR at 28,28 ± 1,09 Hz. (in the range 0,0 - 64,0 Hz).

**Criteria for a reliable HVSR curve**  
[All 3 should be fulfilled]

$f_0 > 10 / L_w$	28,28 > 0,50	OK	
$n_c(f_0) > 200$	29412,5 > 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 1358 times	OK	

**Criteria for a clear HVSR peak**  
[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0]$   $A_{HV}(f^-) < A_0 / 2$	23,313 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0]$   $A_{HV}(f^+) < A_0 / 2$	30,406 Hz	OK	
$A_0 > 2$	5,95 > 2	OK	
$f_{\text{peak}}[A_{HV}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0,01905  < 0,05$	OK	
$\sigma_f < \varepsilon(f_0)$	0,53879 < 1,41406	OK	
$\sigma_A(f_0) < \theta(f_0)$	0,5099 < 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
$\sigma_f$	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 $f_0$
$A_{HV}(f)$	H/V curve amplitude at frequency $f$
$f^-$	frequency between $f_0/4$ and $f_0$ for which $A_{HV}(f^-) < A_0/2$
$f^+$	frequency between $f_0$ and $4f_0$ for which $A_{HV}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{HV}(f)$ , $\sigma_A(f)$ is the factor by which the mean $A_{HV}(f)$ curve should be multiplied or divided
$\sigma_{\log HV}(f)$	standard deviation of $\log A_{HV}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

Threshold values for  $\sigma_f$  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 $\sigma_{\log HV}(f_0)$	0.48	0.40	0.30	0.25	0.20



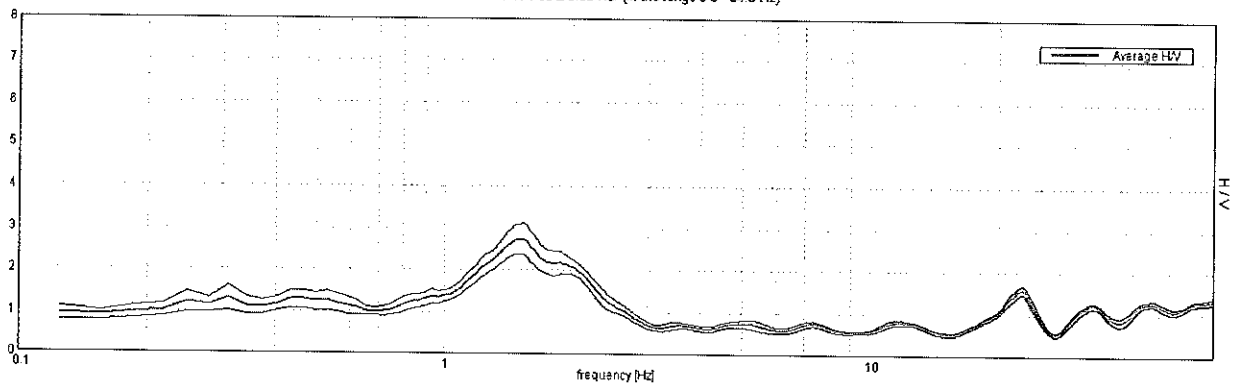
RAVENNA – n. 28

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
 GPS data not available

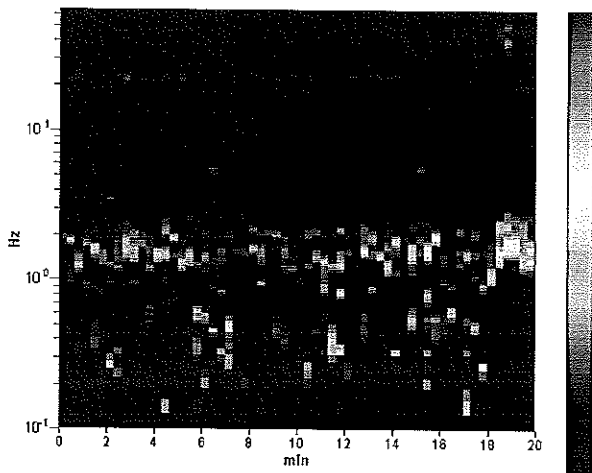
Trace length: 0h20'00". Analysis performed on the entire trace.  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

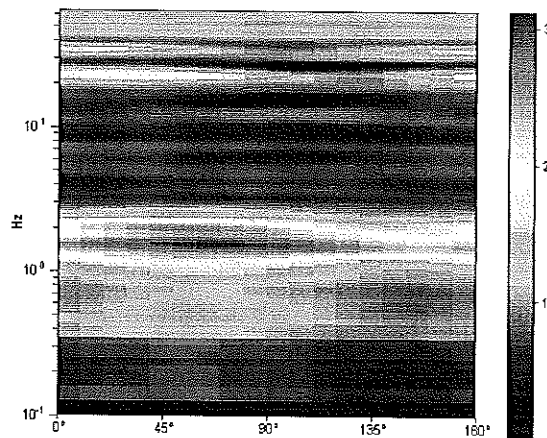
Max. HV at 1.63 ± 0.03 Hz. (in the range 0.0 - 64.0 Hz)



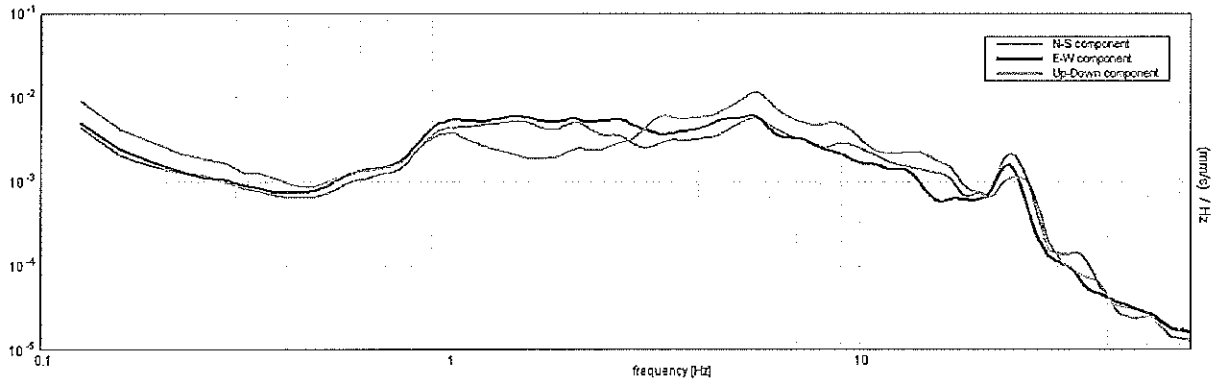
H/V TIME HISTORY



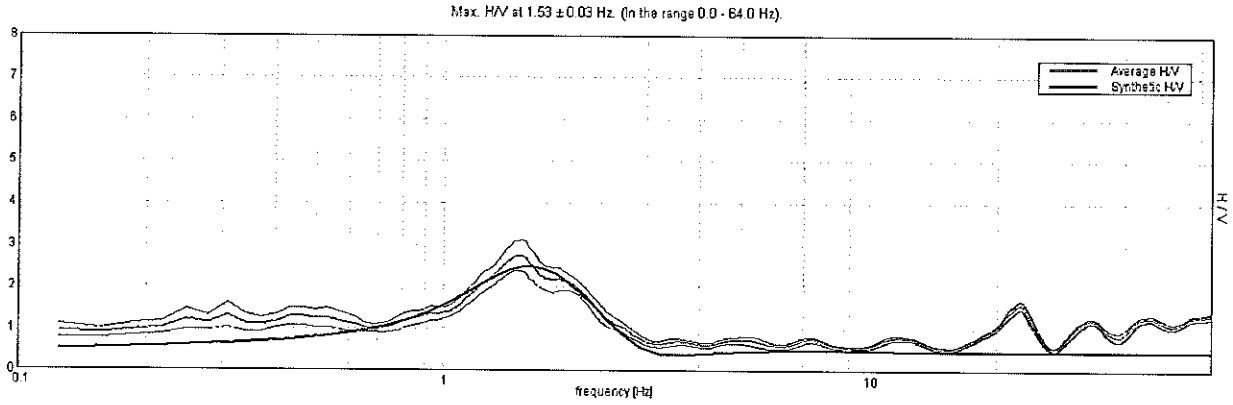
DIRECTIONAL H/V



SINGLE COMPONENT SPECTRA

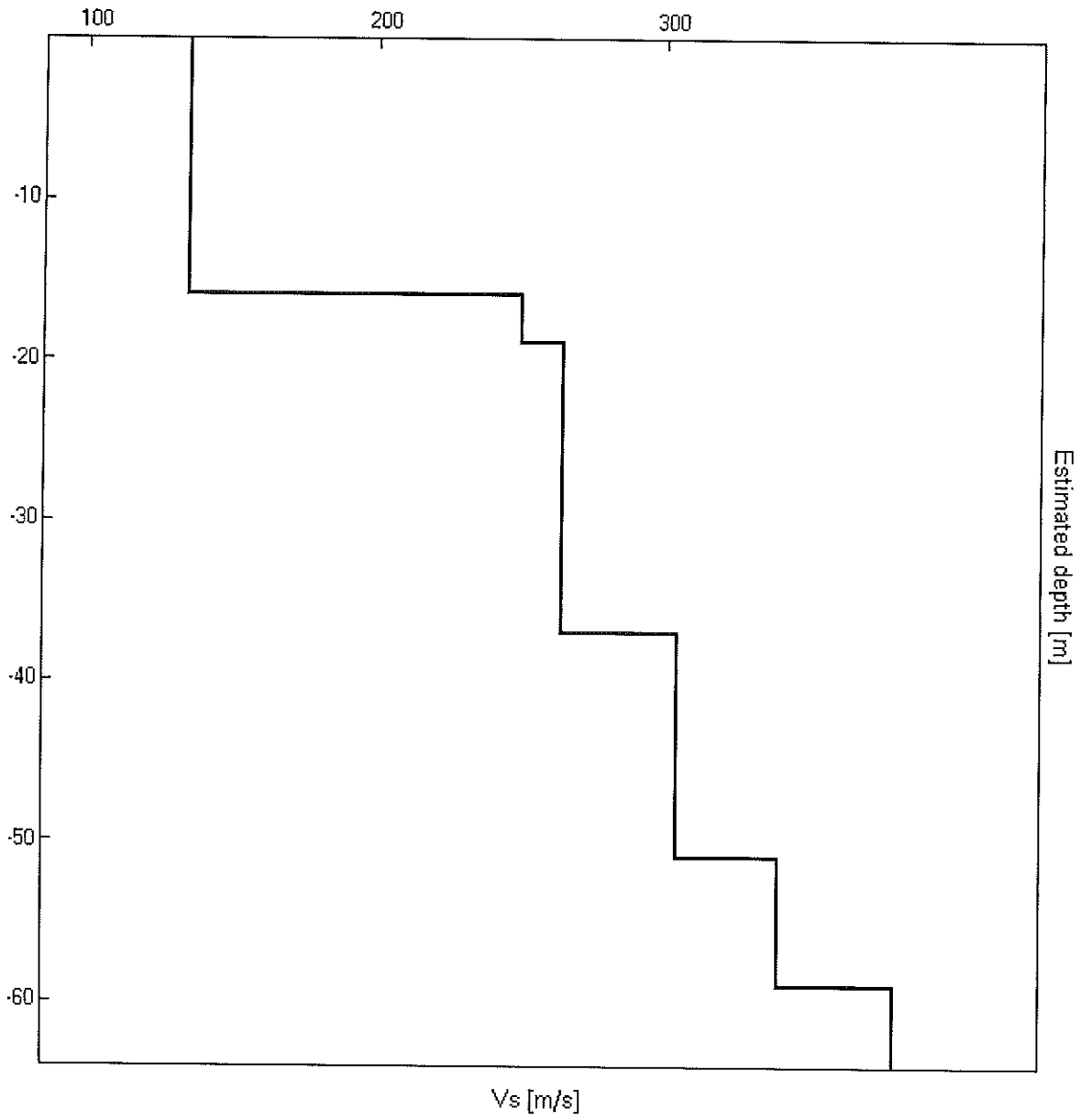


EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
16.00	16.00	135
19.00	3.00	250
37.00	18.00	265
51.00	14.00	305
59.00	8.00	340
inf.	inf.	380

Vs(0.0-30.0)=174m/s



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

Max. H/V at  $1.53 \pm 0.03$  Hz. (in the range 0.0 - 64.0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$1.53 > 0.50$	OK	
$n_c(f_0) > 200$	$1837.5 > 200$	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 74 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0]$   $A_{HV}(f^-) < A_0 / 2$	0.969 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0]$   $A_{HV}(f^+) < A_0 / 2$	2.344 Hz	OK	
$A_0 > 2$	$2.74 > 2$	OK	
$f_{\text{peak}}[A_{HV}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.01024  < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.01568 < 0.15313$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.1856 < 1.78$	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
$\sigma_f$	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 $f_0$
$A_{HV}(f)$	H/V curve amplitude at frequency $f$
$f^-$	frequency between $f_0/4$ and $f_0$ for which $A_{HV}(f^-) < A_0/2$
$f^+$	frequency between $f_0$ and $4f_0$ for which $A_{HV}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{HV}(f)$ , $\sigma_A(f)$ is the factor by which the mean $A_{HV}(f)$ curve should be multiplied or divided
$\sigma_{\log HV}(f)$	standard deviation of $\log A_{HV}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

Threshold values for  $\sigma_f$  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 $\sigma_{\log HV}(f_0)$	0.48	0.40	0.30	0.25	0.20

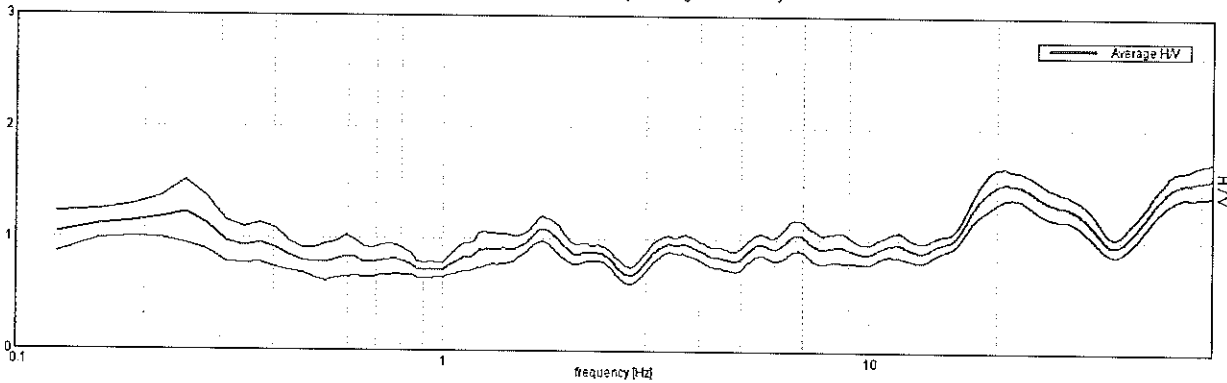
**RAVENNA – n. 29**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
 GPS data not available

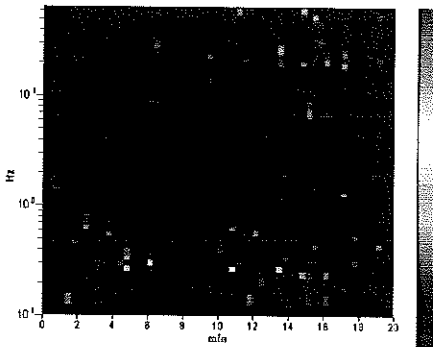
Trace length: 0h20'00". Analyzed 63% trace (manual window selection)  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 10%

**HORIZONTAL TO VERTICAL SPECTRAL RATIO**

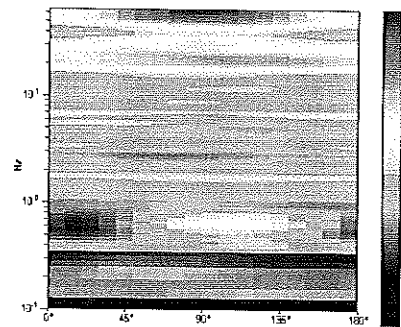
Max. HV at 19.97 ± 1.62 Hz. (in the range 0.0 - 20.0 Hz).



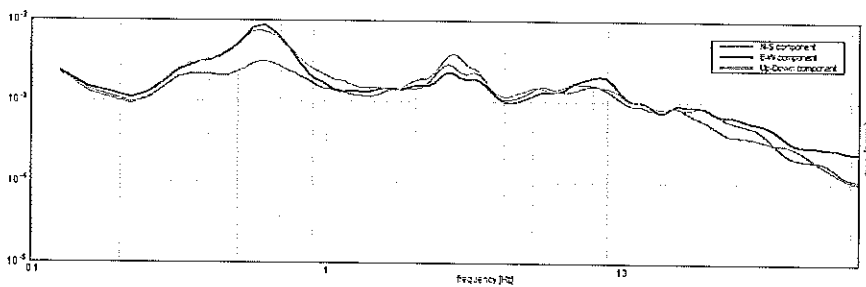
**H/V TIME HISTORY**



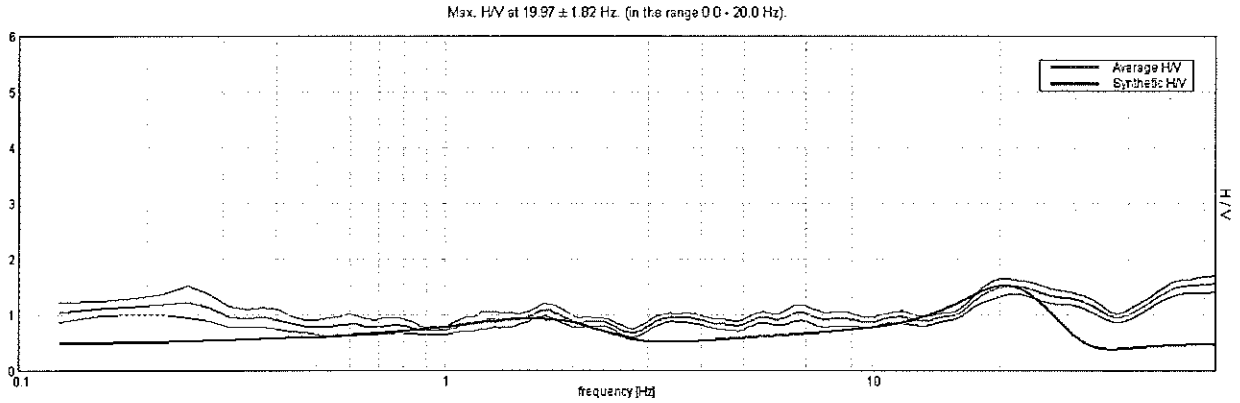
**DIRECTIONAL H/V**



**SINGLE COMPONENT SPECTRA**

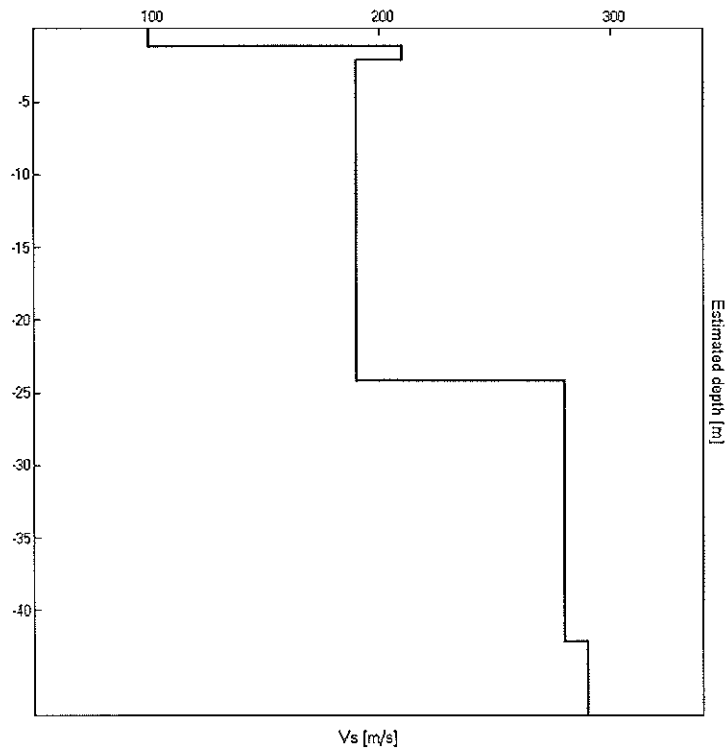


**EXPERIMENTAL VS. SYNTHETIC HV**



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
1.20	1.20	100
2.20	1.00	210
24.20	22.00	190
42.20	18.00	280
inf.	inf.	290

Vs(0.0-30.0)=196m/s



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

**Max. H/V at 19.97 ± 1.82 Hz. (in the range 0.0 - 20.0 Hz).**

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	19.97 > 0.50	OK	
$n_c(f_0) > 200$	15176.3 > 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 960 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0] \mid A_{H/V}(f^-) < A_0 / 2$			NO
Exists $f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0 / 2$			NO
$A_0 > 2$	1.49 > 2		NO
$f_{\text{peak}} [A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.04427  < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	0.88398 < 0.99844	OK	
$\sigma_A(f_0) < \theta(f_0)$	0.0761 < 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
$\sigma_f$	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  $\sigma_f$  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

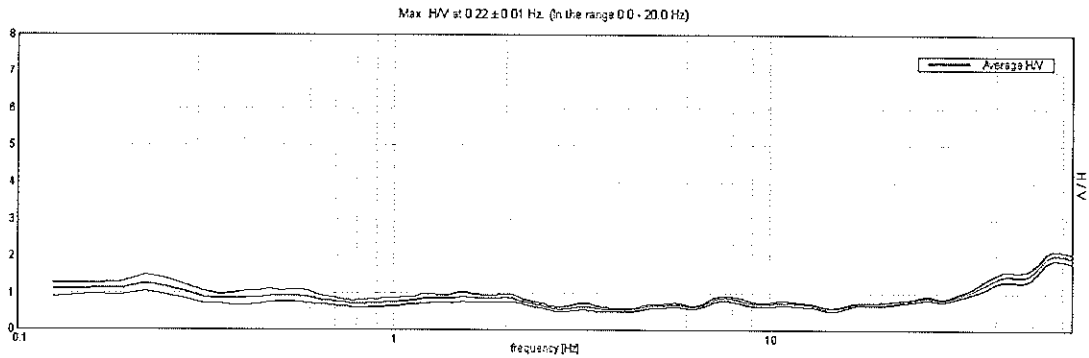


RAVENNA – n. 30

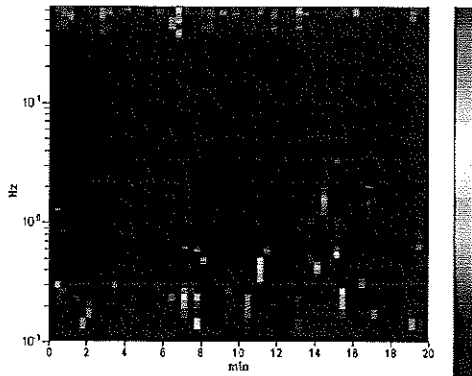
Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
GPS data not available

Trace length: 0h20'00". Analyzed 83% trace (manual window selection)  
Sampling frequency: 128 Hz  
Window size: 20 s  
Smoothing window: Triangular window  
Smoothing: 10%

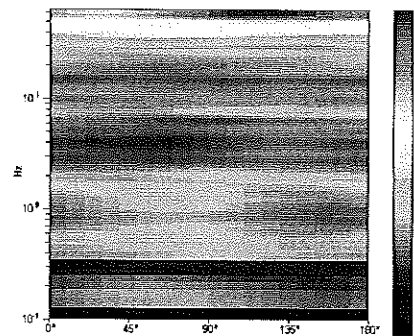
HORIZONTAL TO VERTICAL SPECTRAL RATIO



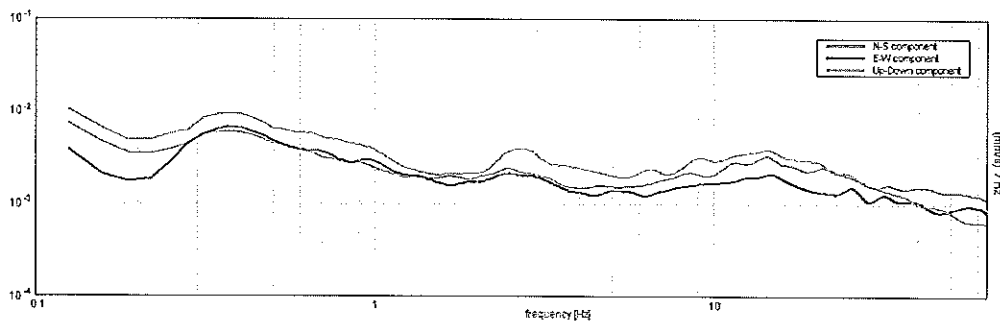
H/V TIME HISTORY



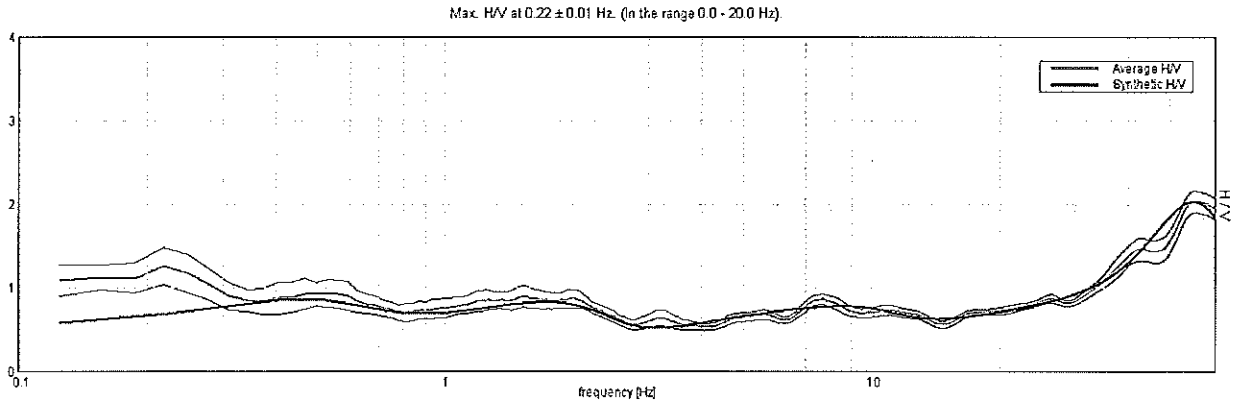
DIRECTIONAL H/V



SINGLE COMPONENT SPECTRA

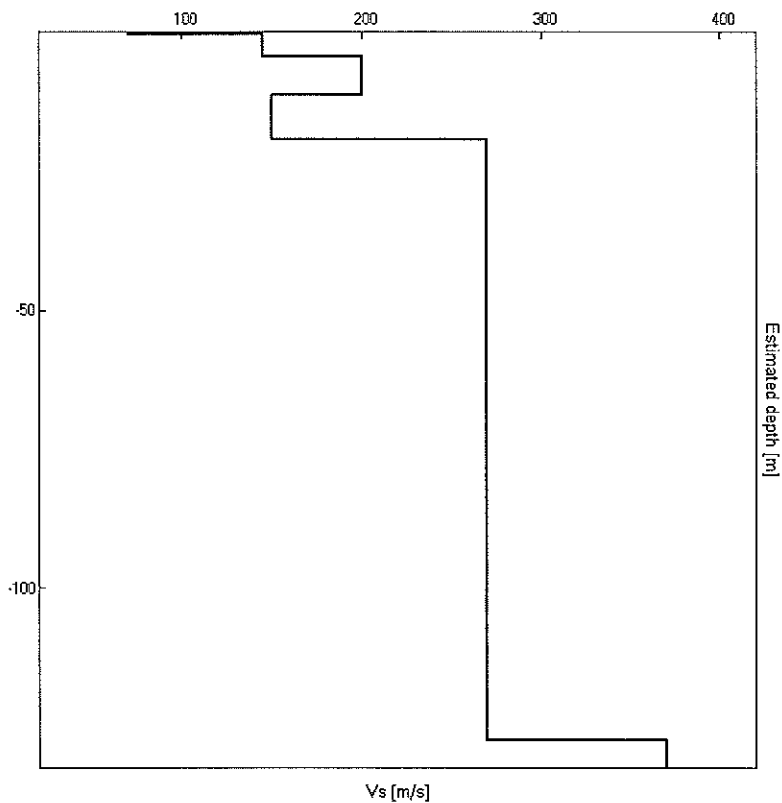


EXPERIMENTAL VS. SYNTHETIC HV



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.30	0.30	70
4.30	4.00	145
11.30	7.00	200
19.30	8.00	150
127.30	108.00	270
inf.	inf.	370

Vs(0.0-30.0)=188m/s



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

Max. H/V at  $0.22 \pm 0.01$  Hz. (in the range 0.0 - 20.0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$0.22 > 0.50$		<b>NO</b>
$n_c(f_0) > 200$	$218.8 > 200$	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 12 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0]$   $A_{HV}(f^-) < A_0 / 2$	0.094 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0]$   $A_{HV}(f^+) < A_0 / 2$			<b>NO</b>
$A_0 > 2$	$1.26 > 2$		<b>NO</b>
$f_{\text{peak}}[A_{HV}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.01178  < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.00258 < 0.04375$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.1103 < 2.5$	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
$\sigma_f$	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 $f_0$
$A_{HV}(f)$	H/V curve amplitude at frequency $f$
$f^-$	frequency between $f_0/4$ and $f_0$ for which $A_{HV}(f^-) < A_0/2$
$f^+$	frequency between $f_0$ and $4f_0$ for which $A_{HV}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{HV}(f)$ , $\sigma_A(f)$ is the factor by which the mean $A_{HV}(f)$ curve should be multiplied or divided
$\sigma_{\log HV}(f)$	standard deviation of $\log A_{HV}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

Threshold values for  $\sigma_f$  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 $\sigma_{\log HV}(f_0)$	0.48	0.40	0.30	0.25	0.20

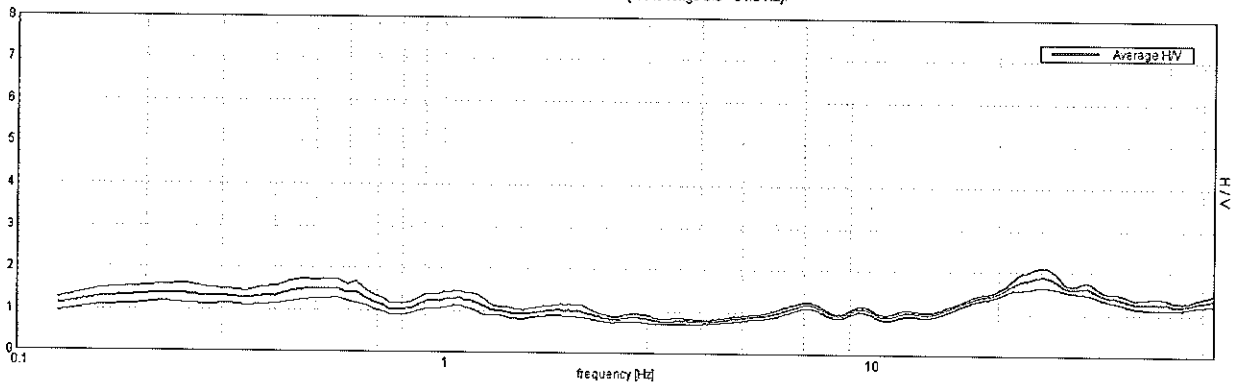
**RAVENNA – n. 31**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
 GPS data not available

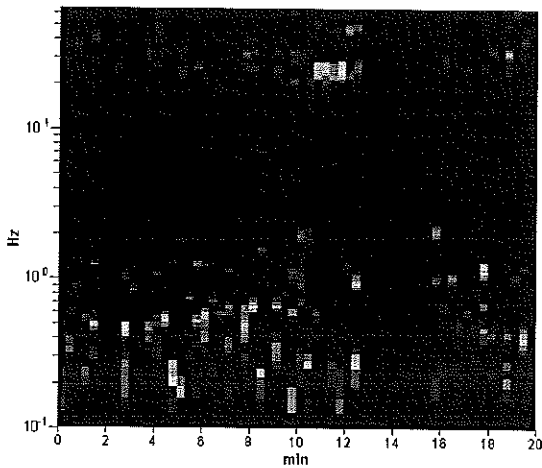
Trace length: 0h20'00". Analyzed 80% trace (manual window selection)  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 10%

**HORIZONTAL TO VERTICAL SPECTRAL RATIO**

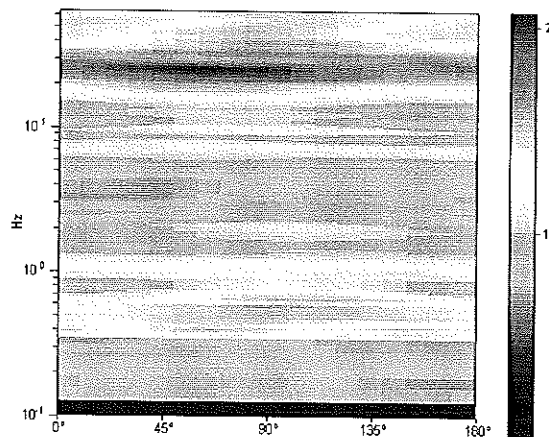
Max. HV at 25.28 ± 5.71 Hz. (in the range 0.0 - 64.0 Hz)



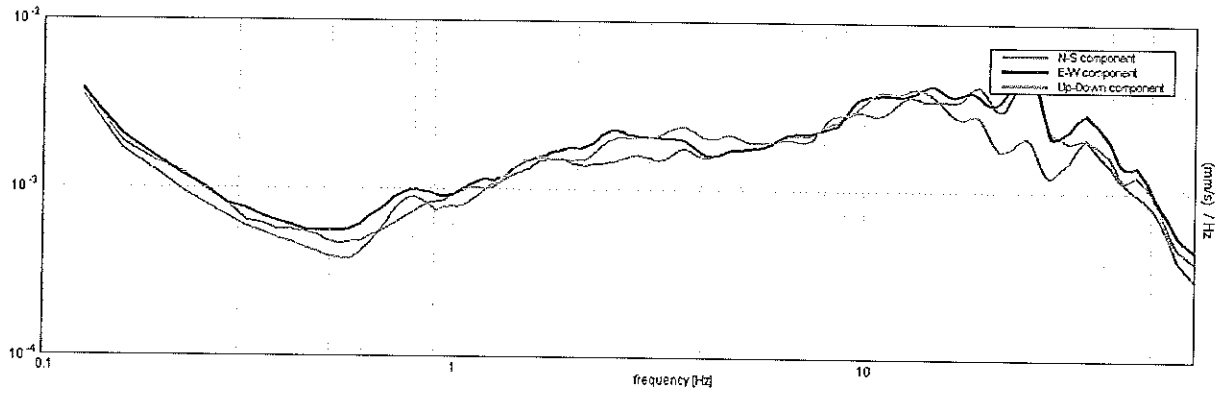
**H/V TIME HISTORY**



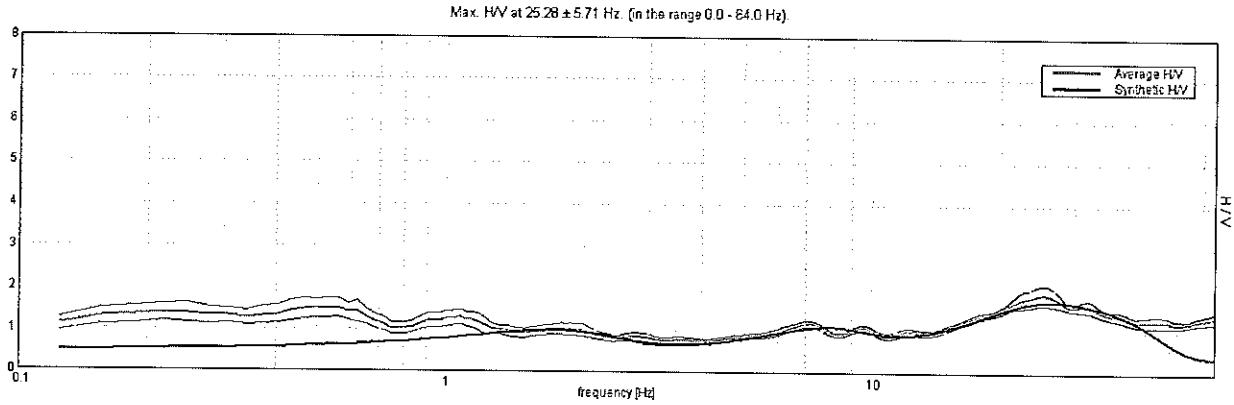
**DIRECTIONAL H/V**



SINGLE COMPONENT SPECTRA

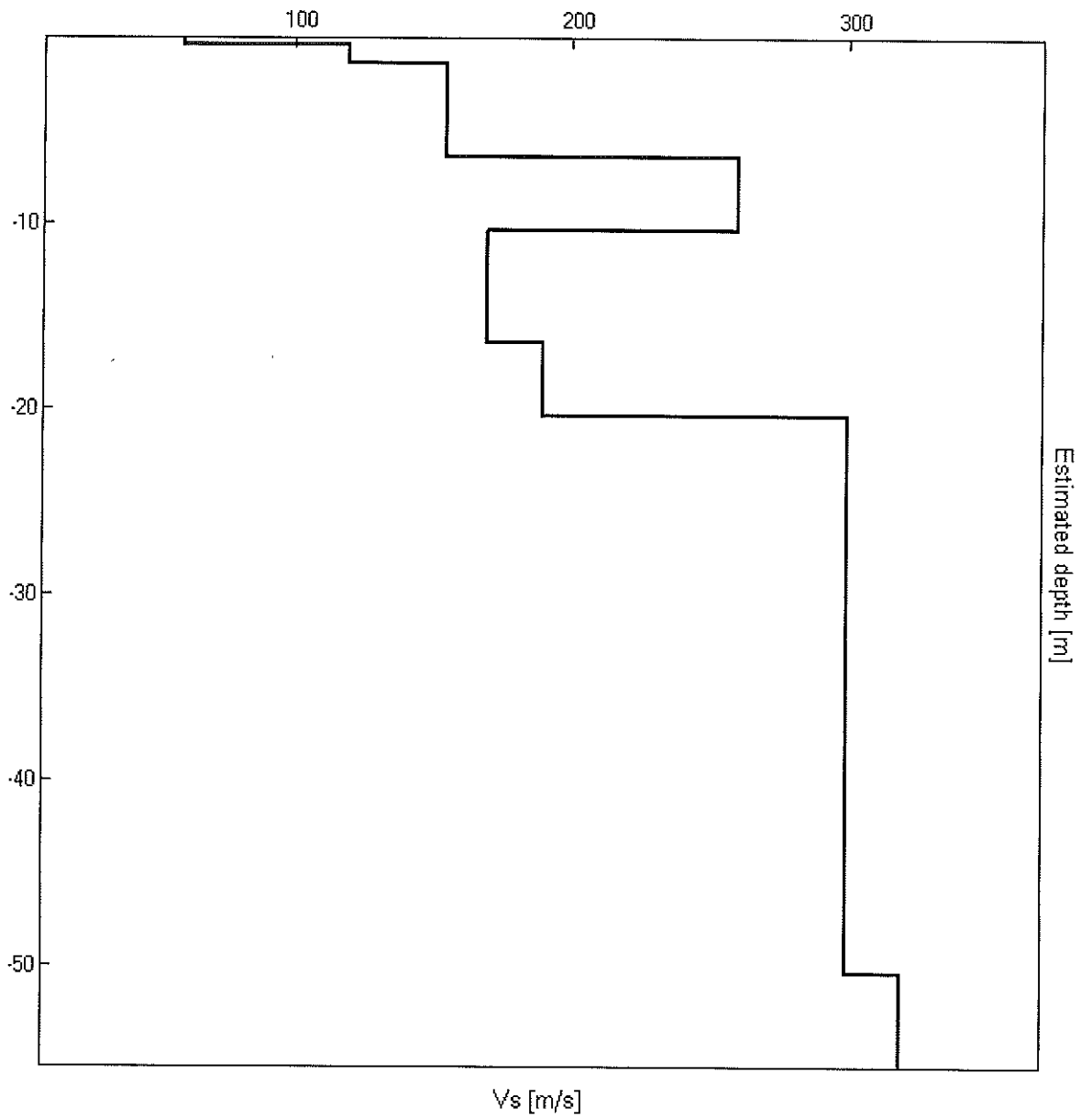


EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.40	0.40	60
1.40	1.00	120
6.40	5.00	155
10.40	4.00	260
16.40	6.00	170
20.40	4.00	190
50.40	30.00	300
inf.	inf.	320

Vs(0.0-30.0)=199m/s



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

Max. H/V at 25.28 ± 5.71 Hz. (in the range 0.0 - 64.0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	25.28 > 0.50	OK	
$n_c(f_0) > 200$	24270.0 > 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 1214 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0] \mid A_{H/V}(f^-) < A_0 / 2$	11.469 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0 / 2$			NO
$A_0 > 2$	1.88 > 2		NO
$f_{\text{peak}} [A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.11101  < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	2.80654 < 1.26406		NO
$\sigma_A(f_0) < \theta(f_0)$	0.1155 < 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
$\sigma_f$	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  $\sigma_f$  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



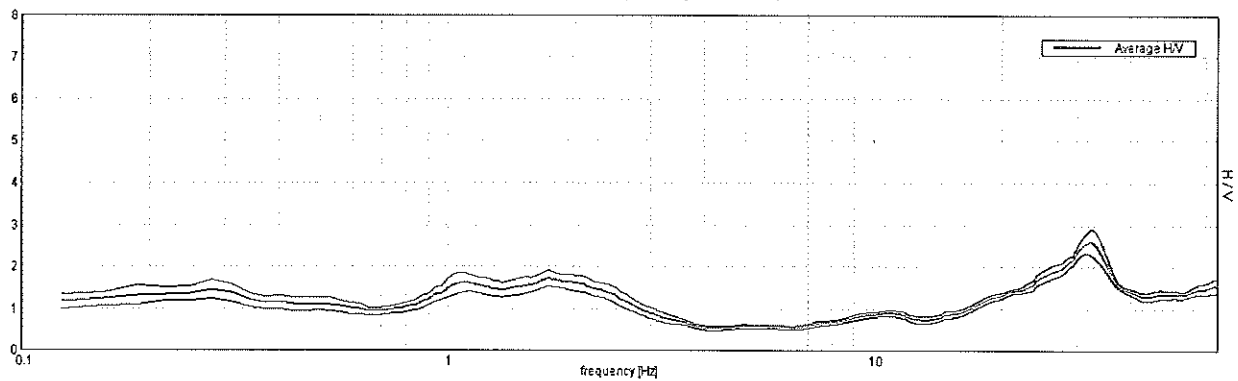
RAVENNA – n. 32

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
GPS data not available

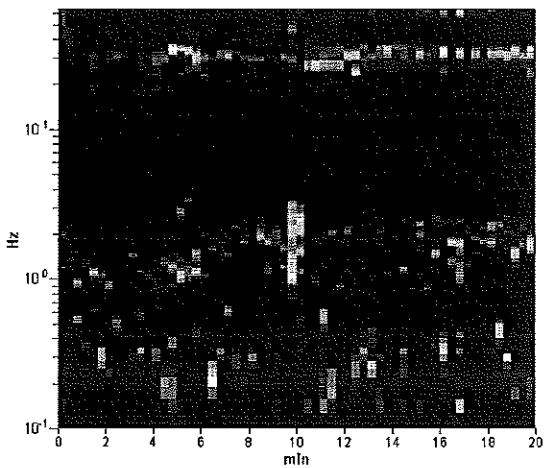
Trace length: 0h20'00". Analysis performed on the entire trace.  
Sampling frequency: 128 Hz  
Window size: 20 s  
Smoothing window: Triangular window  
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

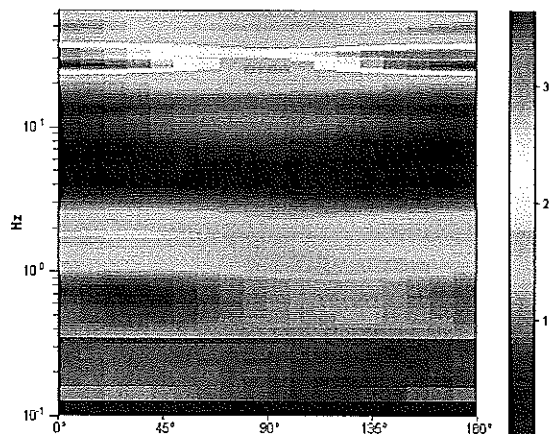
Max. HV at 1.72 ± 0.16 Hz (in the range 0.0 - 20.0 Hz)



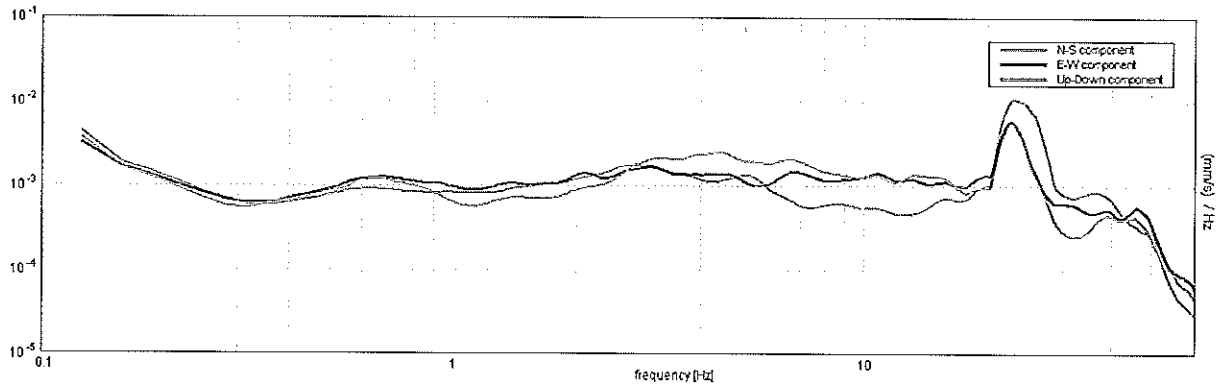
H/V TIME HISTORY



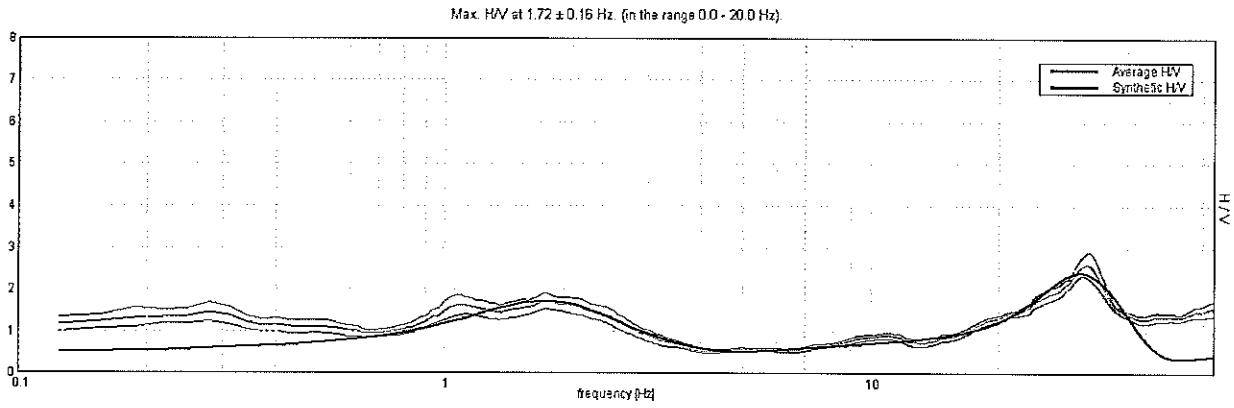
DIRECTIONAL H/V



SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC HV

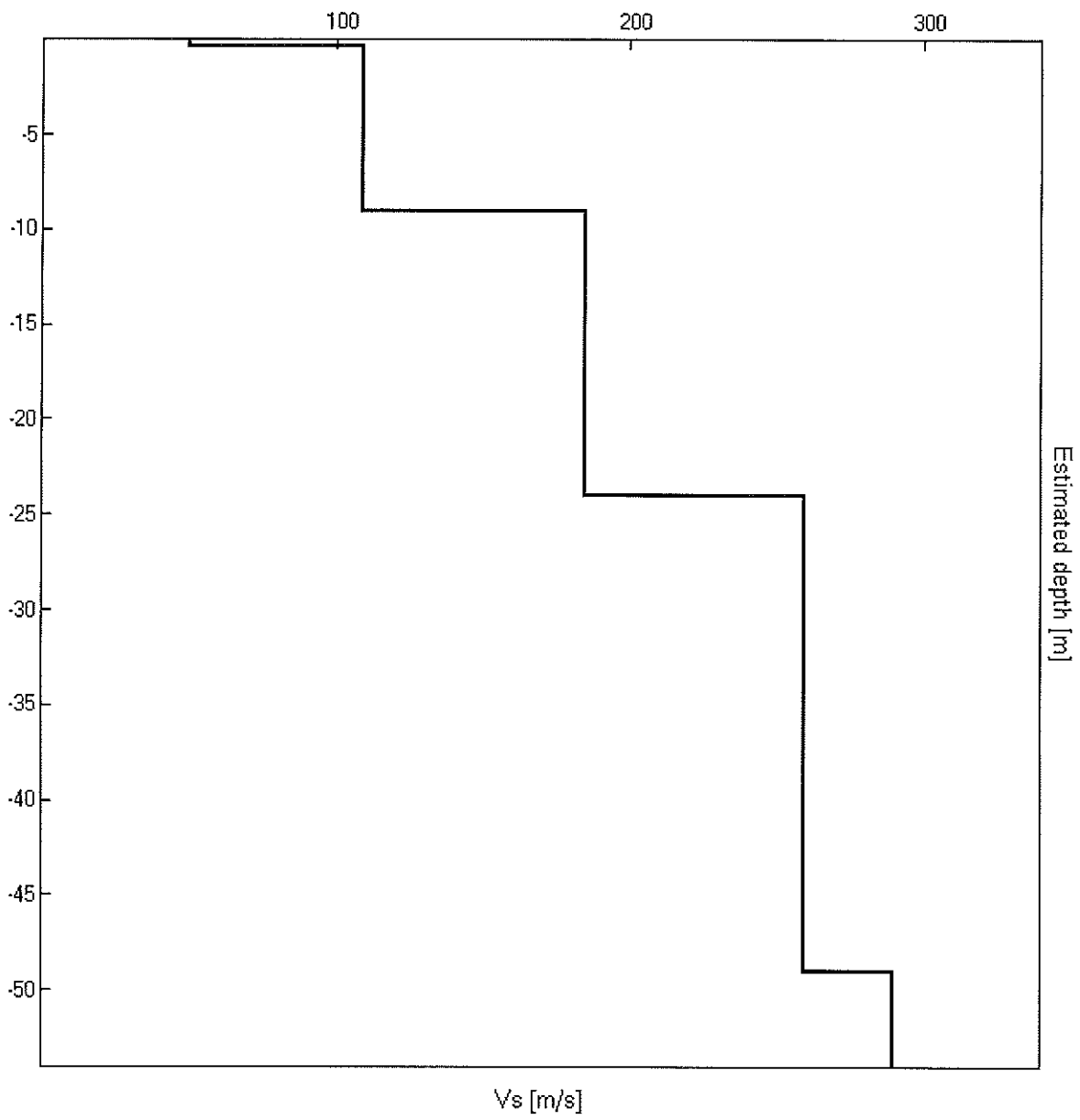


Depth at the bottom of the layer [m]
0.40
9.00
24.00
49.00
inf.

Thickness [m]
0.40
8.60
15.00
25.00
inf.

Vs [m/s]
50
109
185
260
290

Vs(0.0-30.0)=157m/s



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

**Max. H/V at 1.72 ± 0.16 Hz. (in the range 0.0 - 20.0 Hz).**

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	1.72 > 0.50	OK	
$n_c(f_0) > 200$	2062.5 > 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 84 times	OK	

**Criteria for a clear HVSR 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 $[f_0, 4f_0]$   $A_{H/V}(f^+) < A_0 / 2$	3.094 Hz	OK	
$A_0 > 2$	1.72 > 2		NO
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.0451  < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.07752 < 0.17188$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.0957 < 1.78$	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
$\sigma_f$	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  $\sigma_f$  and  $\sigma_A(f_0)$**

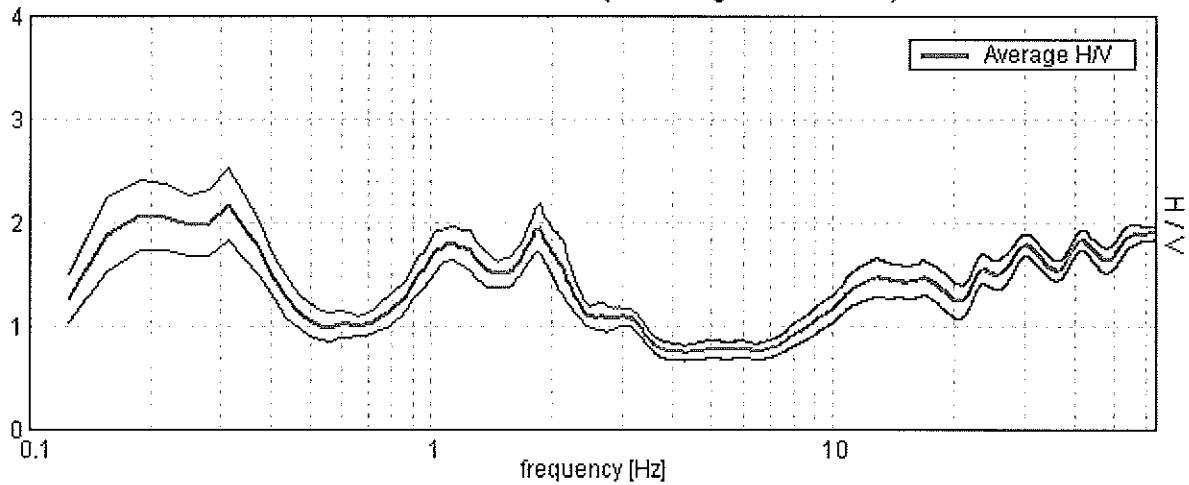
Freq. range [Hz]	< 0.2	0.2 - 0.5	0.5 - 1.0	1.0 - 2.0	> 2.0
$\varepsilon(f_0)$ [Hz]	$0.25 f_0$	$0.2 f_0$	$0.15 f_0$	$0.10 f_0$	$0.05 f_0$
$\theta(f_0)$ for $\sigma_A(f_0)$	3.0	2.5	2.0	1.78	1.58
Log $\theta(f_0)$ for $\sigma_{\log H/V}(f_0)$	0.48	0.40	0.30	0.25	0.20

RAVENNA - n. 33

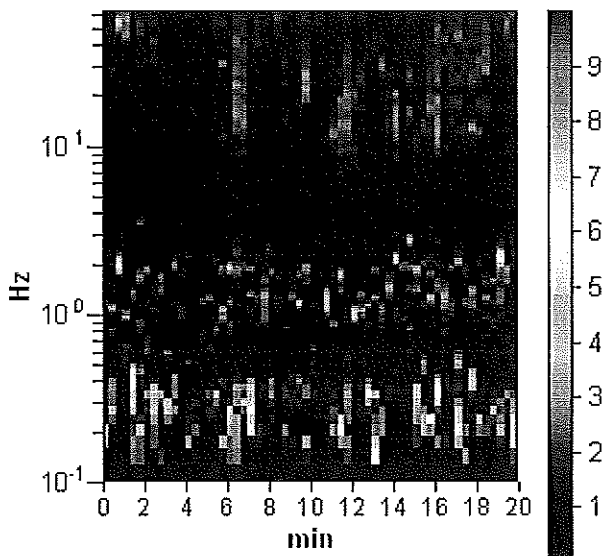
Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
GPS data not available

Trace length: 0h20'00". Analysis performed on the entire trace.  
Sampling frequency: 128 Hz  
Window size: 20 s  
Smoothing window: Triangular window  
Smoothing: 10%

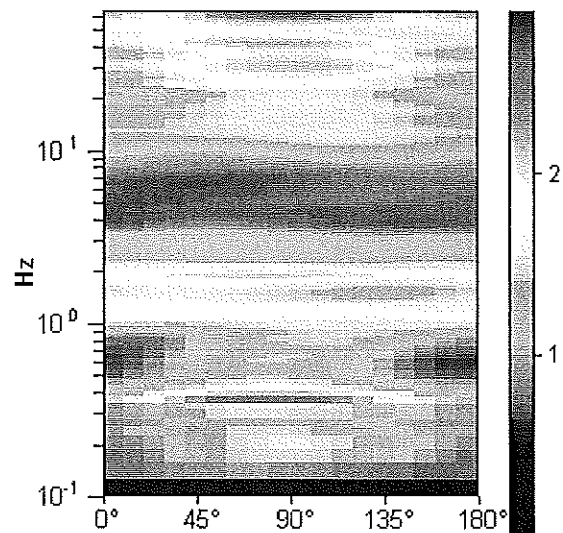
HORIZONTAL TO VERTICAL SPECTRAL RATIO  
Max. H/V at  $0.31 \pm 0.08$  Hz. (in the range 0.0 - 20.0 Hz).



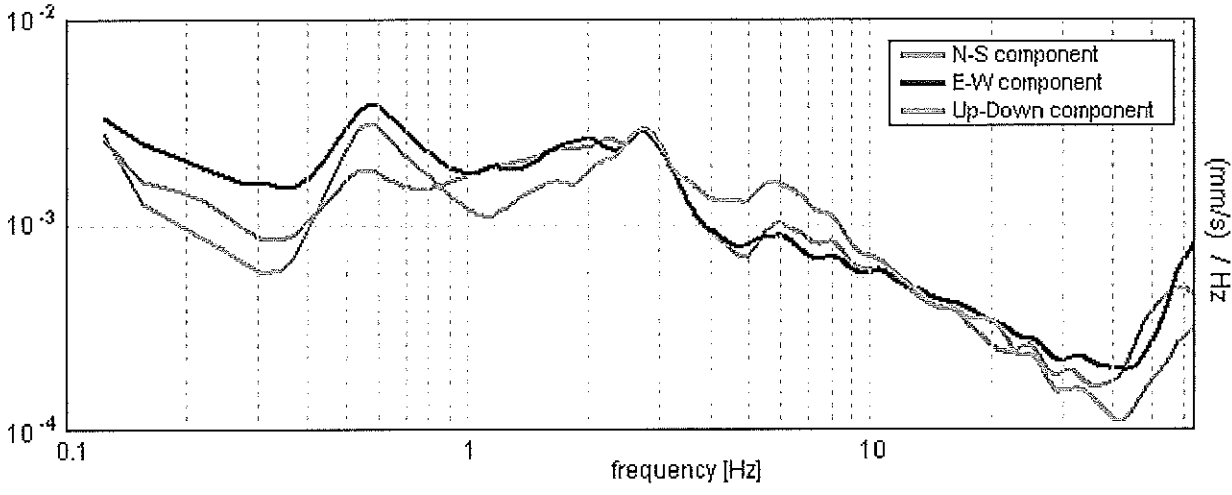
H/V TIME HISTORY



DIRECTIONAL H/V

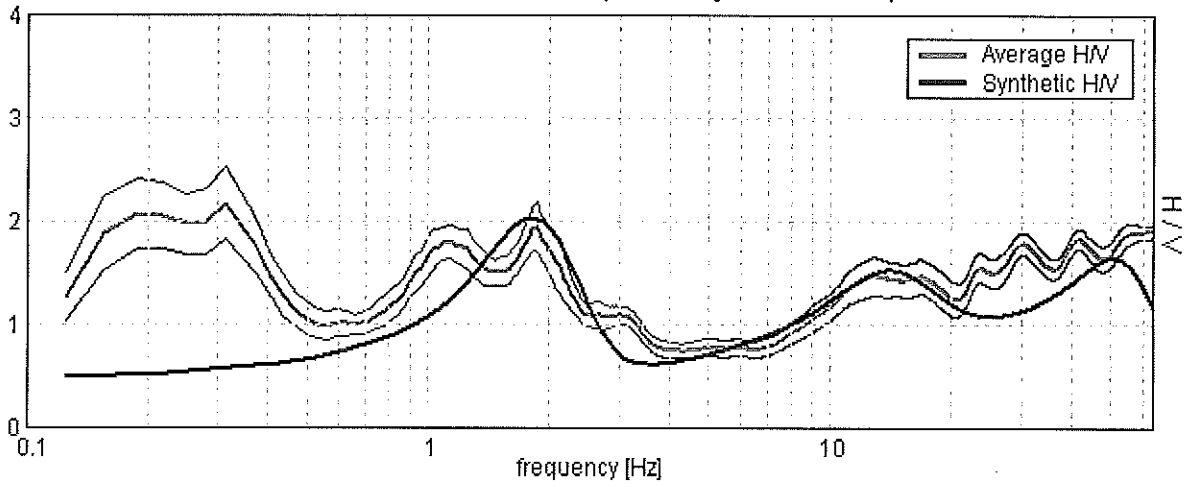


SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V

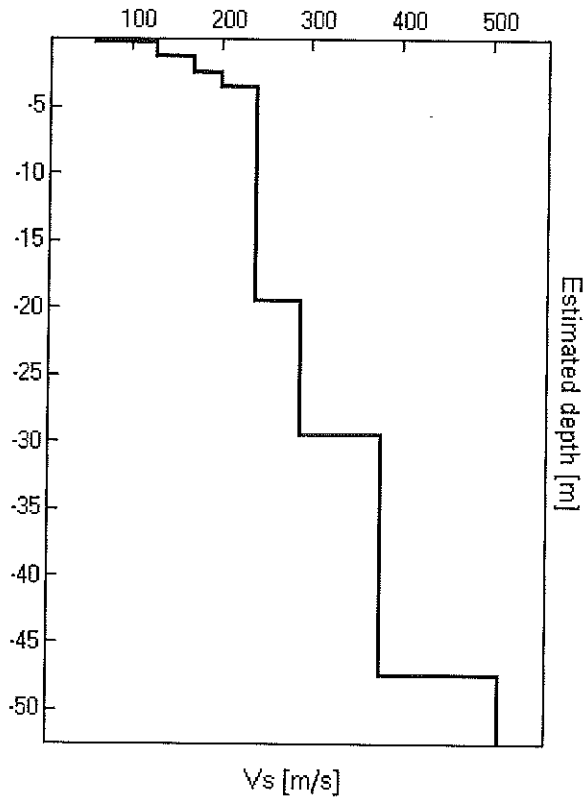
Max. H/V at  $0.31 \pm 0.08$  Hz. (in the range 0.0 - 20.0 Hz).



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.30	0.30	62
1.30	1.00	130
2.50	1.20	170
3.50	1.00	200
19.50	16.00	240
29.50	10.00	290
47.50	18.00	380
inf.	inf.	510

Vs(0.0-30.0)=236m/s





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

Max. H/V at  $0.31 \pm 0.08$  Hz. (in the range 0.0 - 20.0 Hz).

**Criteria for a reliable HVSR curve**  
[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$0.31 > 0.50$		NO
$n_c(f_0) > 200$	$375.0 > 200$	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 16 times	OK	

**Criteria for a clear HVSR peak**  
[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0] \mid A_{H/V}(f^-) < A_0 / 2$	0.094 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0 / 2$	0.5 Hz	OK	
$A_0 > 2$	$2.18 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.12496  < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	$0.03905 < 0.0625$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.1743 < 2.5$	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
$\sigma_f$	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  $\sigma_f$  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

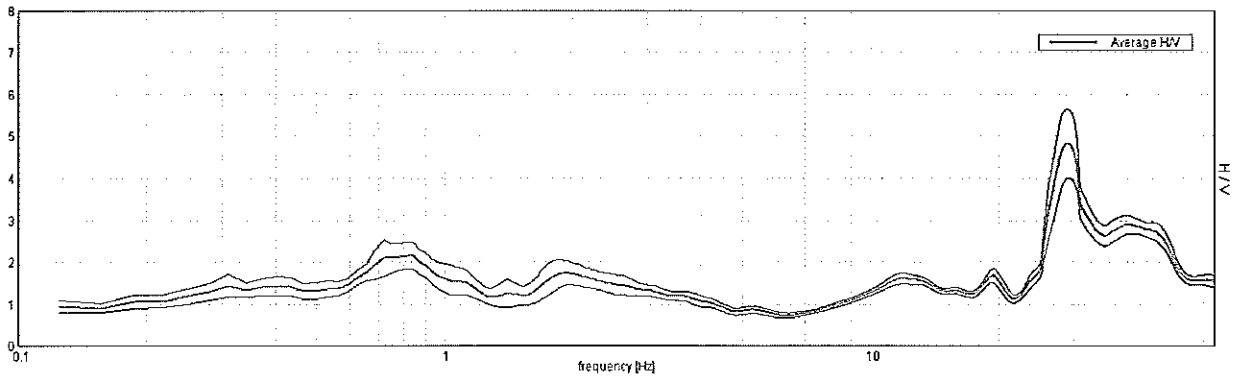
RAVENNA – n. 34

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
 GPS data not available

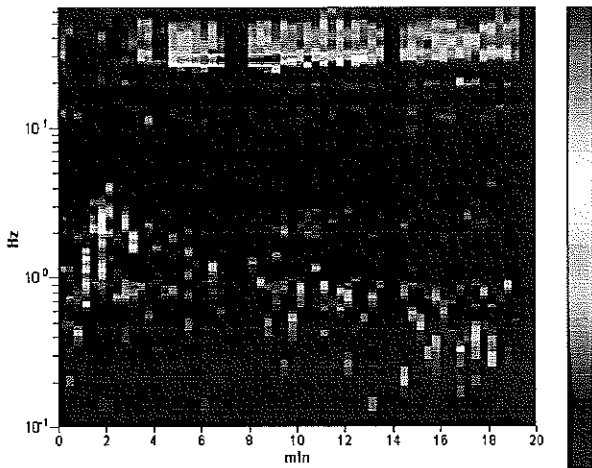
Trace length: 0h20'00". Analyzed 88% trace (manual window selection)  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

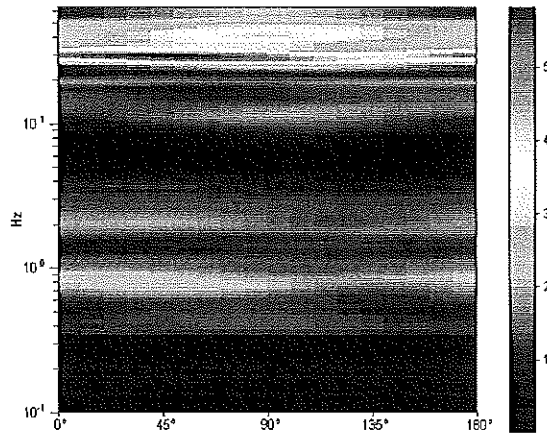
Max. H/V at 29.0 ± 4.05 Hz (in the range 0.0 - 64.0 Hz)



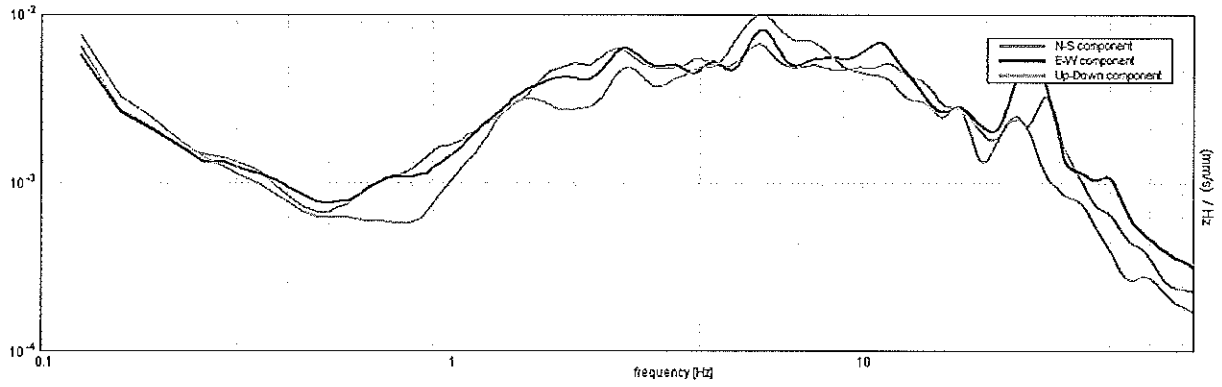
H/V TIME HISTORY



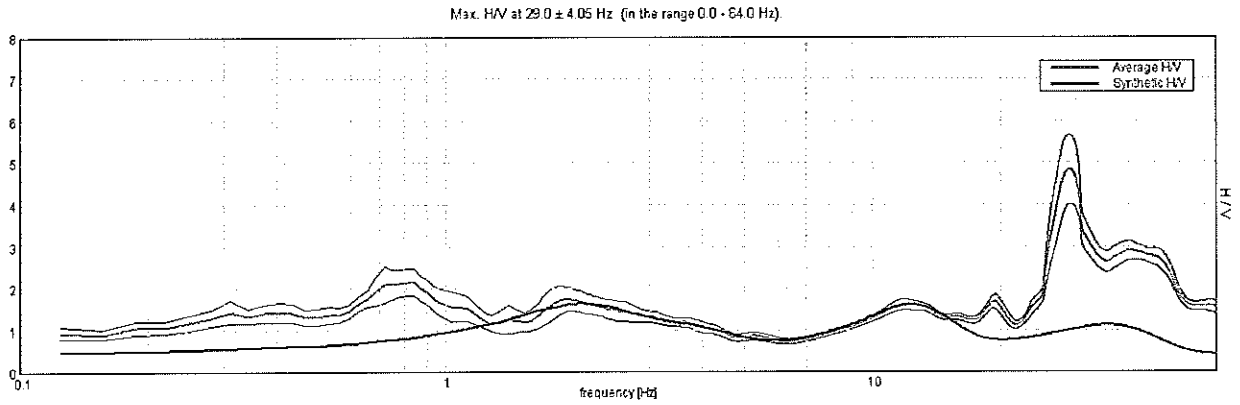
DIRECTIONAL H/V



SINGLE COMPONENT SPECTRA

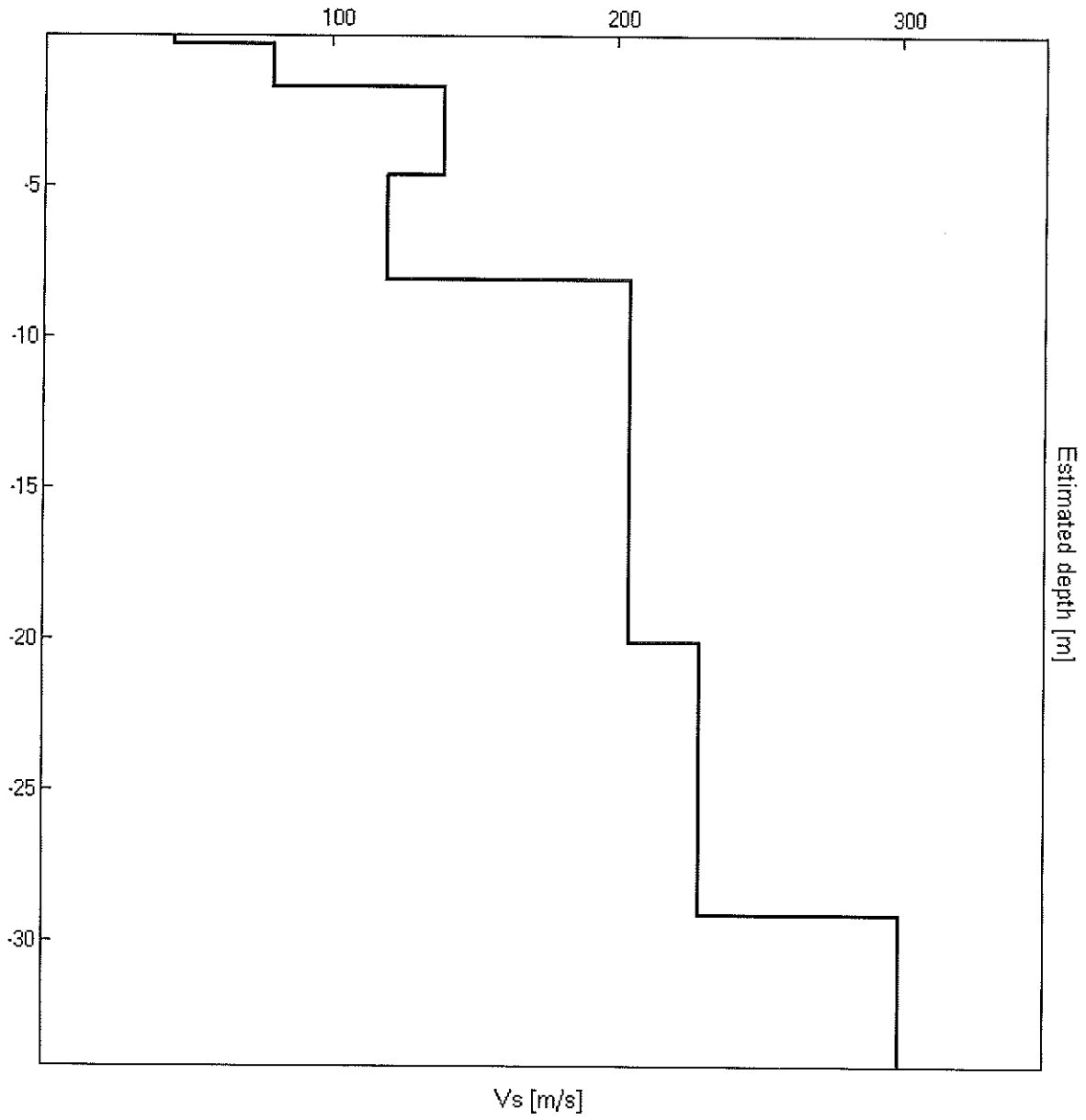


**EXPERIMENTAL VS. SYNTHETIC H/V**



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.30	0.30	45
1.70	1.40	80
4.60	2.90	140
8.10	3.50	120
20.10	12.00	205
29.10	9.00	230
inf.	inf.	300

Vs(0.0-30.0)=172m/s



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

Max. H/V at 29.0 ± 4.05 Hz. (in the range 0.0 - 64.0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	29.00 > 0.50	OK	
$n_c(f_0) > 200$	30740.0 > 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 1393 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0] \mid A_{HV}(f^-) < A_0 / 2$	25.469 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0] \mid A_{HV}(f^+) < A_0 / 2$	49.531 Hz	OK	
$A_0 > 2$	4.83 > 2	OK	
$f_{\text{peak}}[A_{HV}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.06886  < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	1.99686 < 1.45		NO
$\sigma_A(f_0) < \theta(f_0)$	0.4047 < 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
$\sigma_f$	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 $f_0$
$A_{HV}(f)$	H/V curve amplitude at frequency $f$
$f^-$	frequency between $f_0/4$ and $f_0$ for which $A_{HV}(f^-) < A_0/2$
$f^+$	frequency between $f_0$ and $4f_0$ for which $A_{HV}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{HV}(f)$ , $\sigma_A(f)$ is the factor by which the mean $A_{HV}(f)$ curve should be multiplied or divided
$\sigma_{\log HV}(f)$	standard deviation of $\log A_{HV}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

**Threshold values for  $\sigma_f$  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 $\sigma_{\log HV}(f_0)$	0.48	0.40	0.30	0.25	0.20

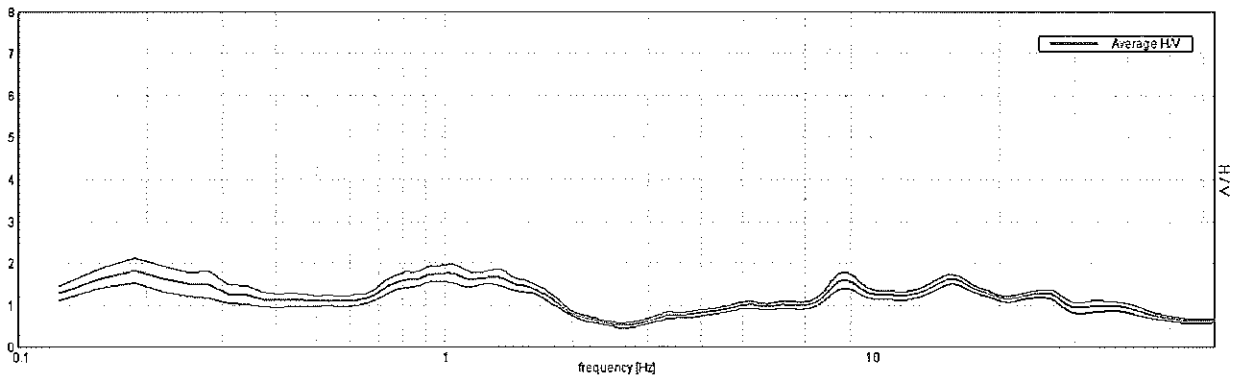
**RAVENNA - n. 35**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
 GPS data not available

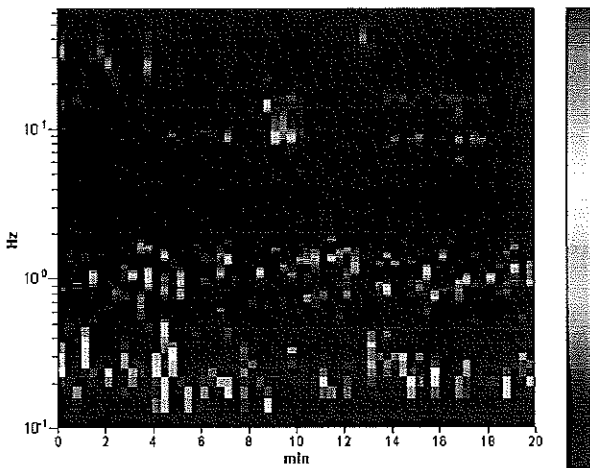
Trace length: 0h20'00". Analysis performed on the entire trace.  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 10%

**HORIZONTAL TO VERTICAL SPECTRAL RATIO**

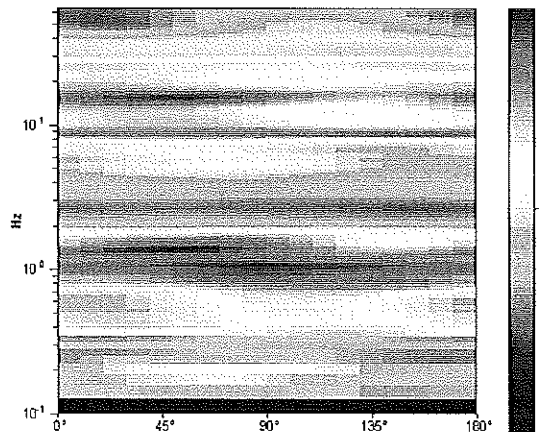
Max. H/V at 0.19 ± 0.14 Hz (in the range 0.0 - 20.0 Hz)



**H/V TIME HISTORY**

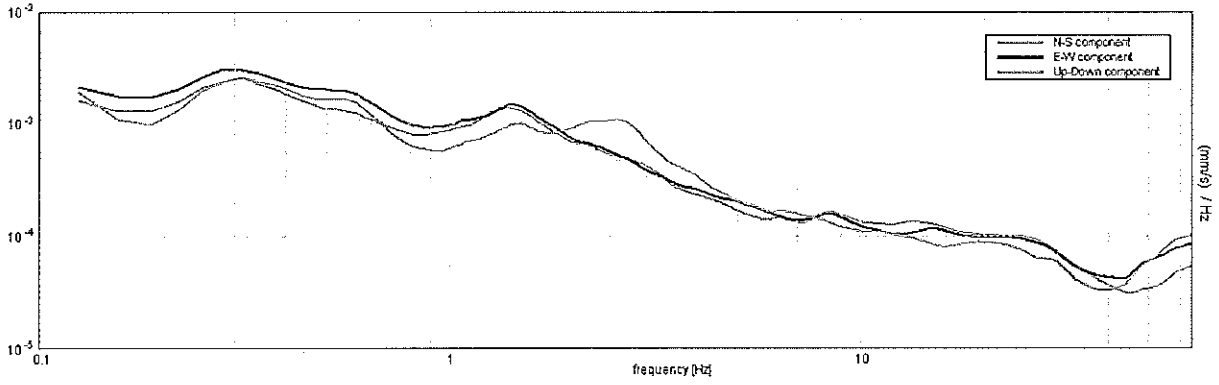


**DIRECTIONAL H/V**

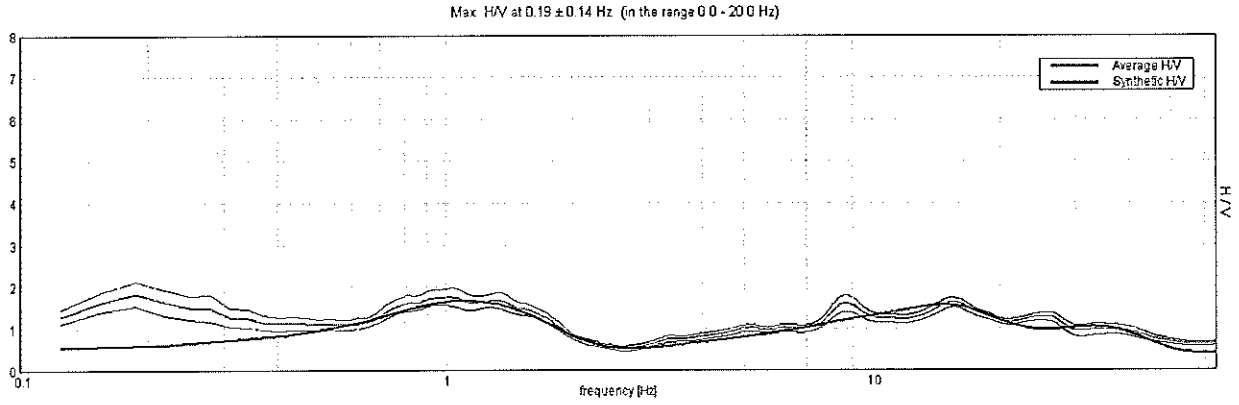




SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



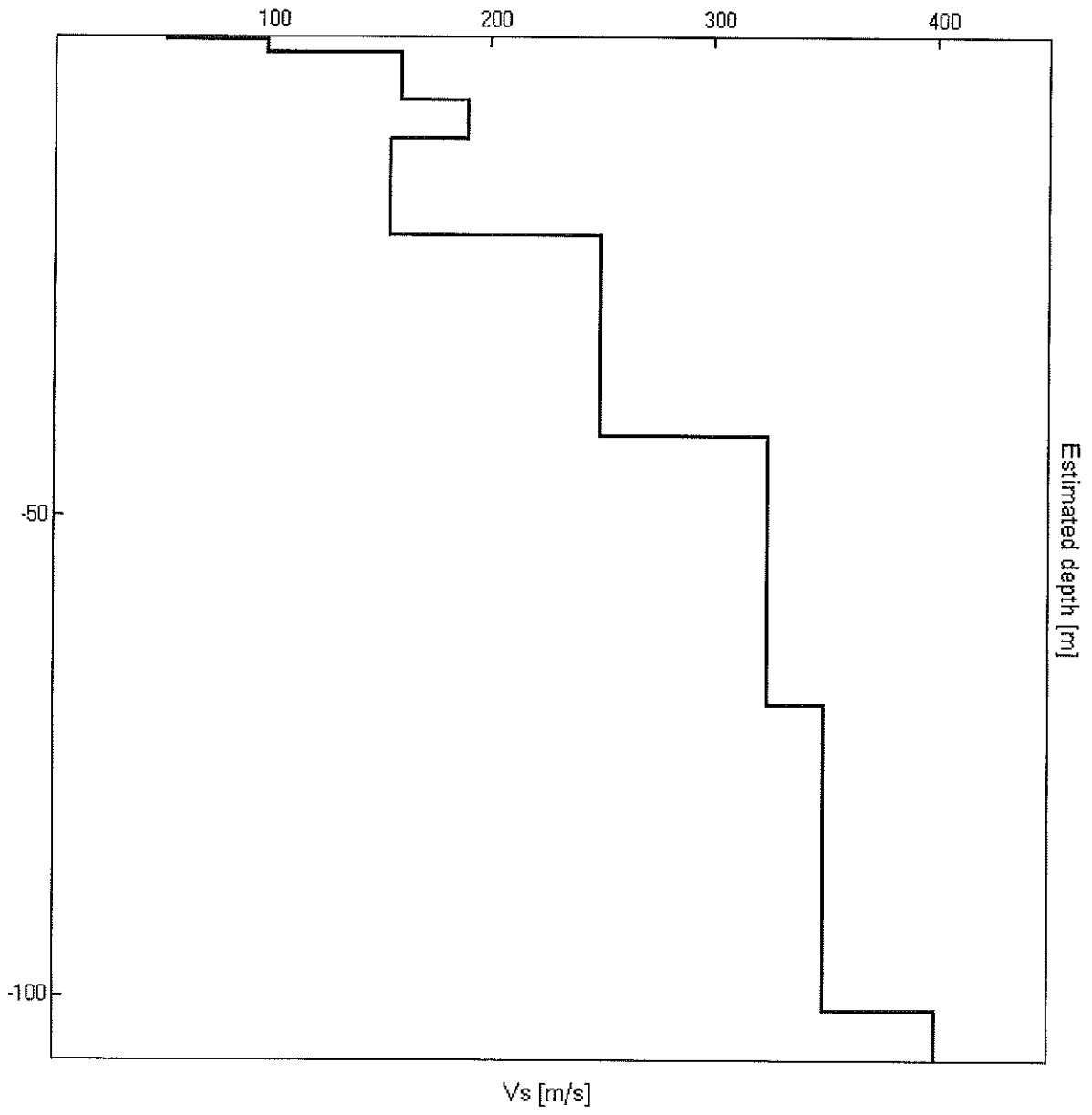
Depth at the bottom of the layer

Thickness [m]

Vs [m/s]

Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.40	0.40	55
1.70	1.30	100
6.70	5.00	160
10.70	4.00	190
20.70	10.00	155
41.70	21.00	250
69.70	28.00	325
101.70	32.00	350
inf.	inf.	400

Vs(0.0-30.0)=172m/s



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

Max. H/V at 0.19 ± 0.14 Hz. (in the range 0.0 - 20.0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	0.19 > 0.50		NO
$n_c(f_0) > 200$	225.0 > 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 10 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0]$   $A_{HV}(f^-) < A_0 / 2$	0.094 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0]$   $A_{HV}(f^+) < A_0 / 2$			NO
$A_0 > 2$	1.83 > 2		NO
$f_{\text{peak}}[A_{HV}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.36701  < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	0.06882 < 0.04688		NO
$\sigma_A(f_0) < \theta(f_0)$	0.142 < 3.0	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
$\sigma_f$	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 $f_0$
$A_{HV}(f)$	H/V curve amplitude at frequency $f$
$f^-$	frequency between $f_0/4$ and $f_0$ for which $A_{HV}(f^-) < A_0/2$
$f^+$	frequency between $f_0$ and $4f_0$ for which $A_{HV}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{HV}(f)$ , $\sigma_A(f)$ is the factor by which the mean $A_{HV}(f)$ curve should be multiplied or divided
$\sigma_{\log HV}(f)$	standard deviation of $\log A_{HV}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

Threshold values for  $\sigma_f$  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 $\sigma_{\log HV}(f_0)$	0.48	0.40	0.30	0.25	0.20

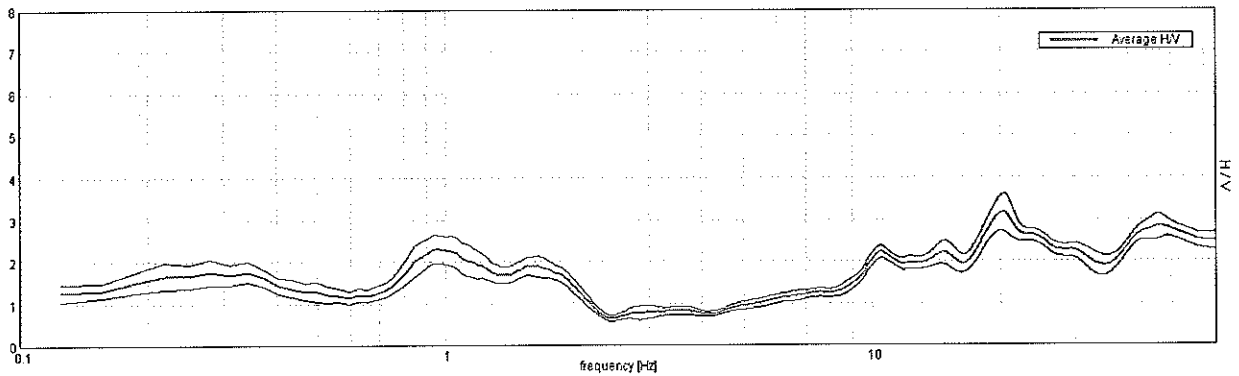
RAVENNA – n. 36

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
 GPS data not available

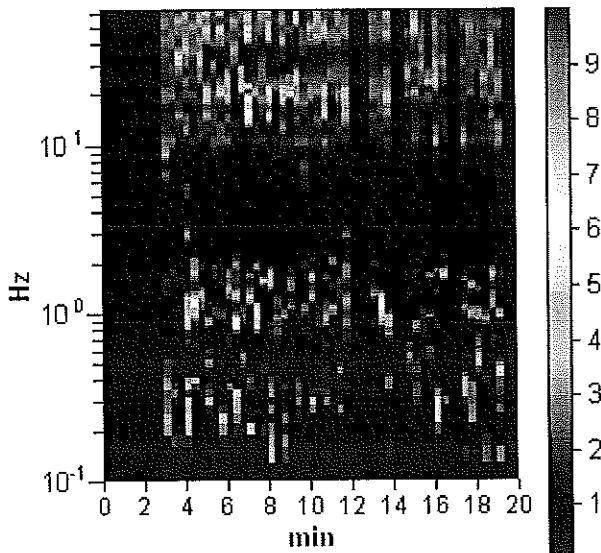
Trace length: 0h20'00". Analyzed 70% trace (manual window selection)  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

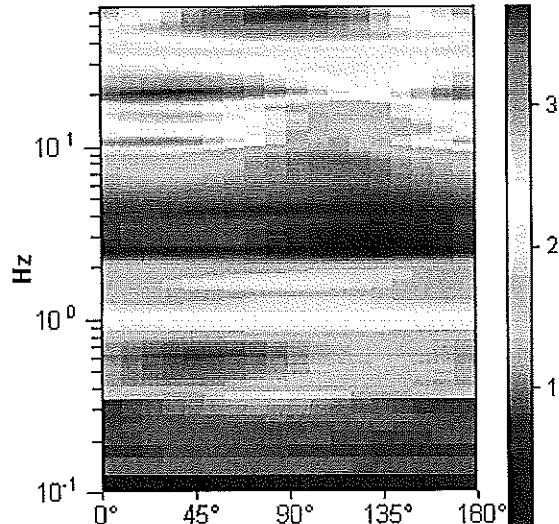
Max. HV at 19.97 ± 2.15 Hz. (in the range 0.0 - 20.0 Hz)



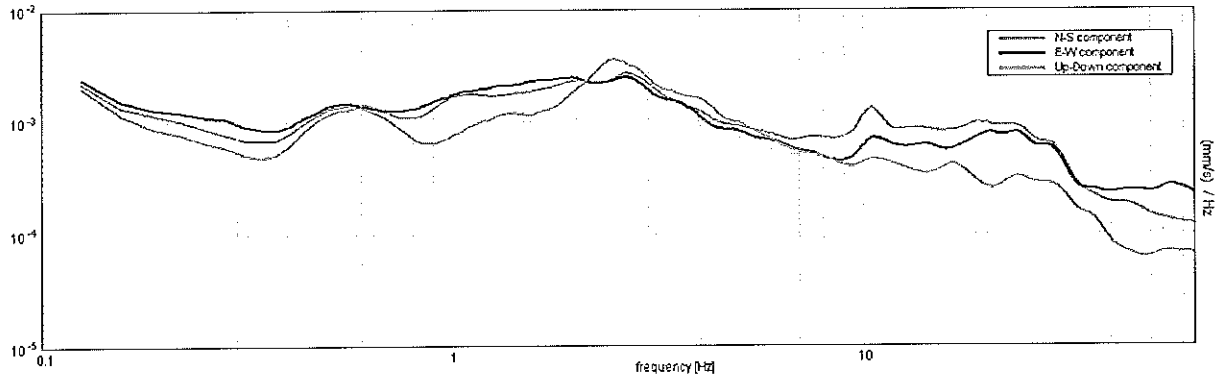
H/V TIME HISTORY



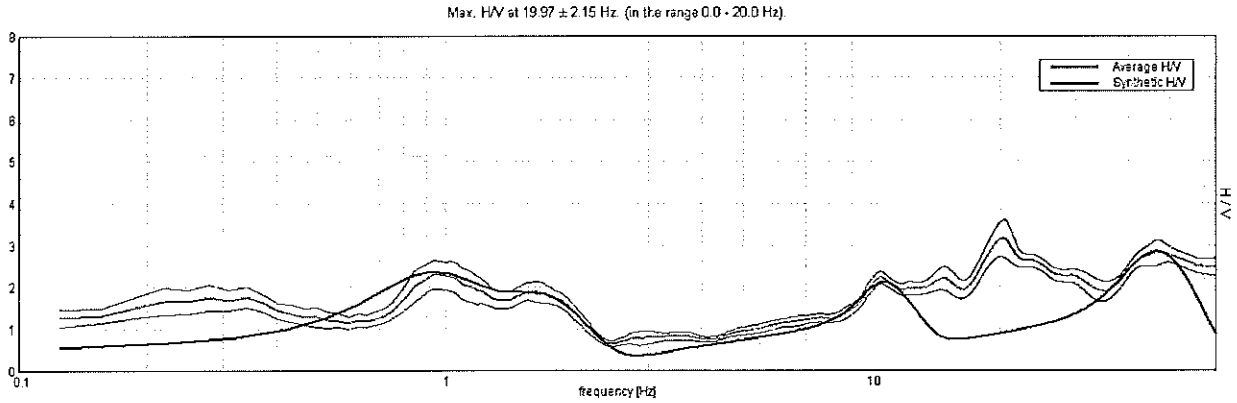
DIRECTIONAL HV



SINGLE COMPONENT SPECTRA

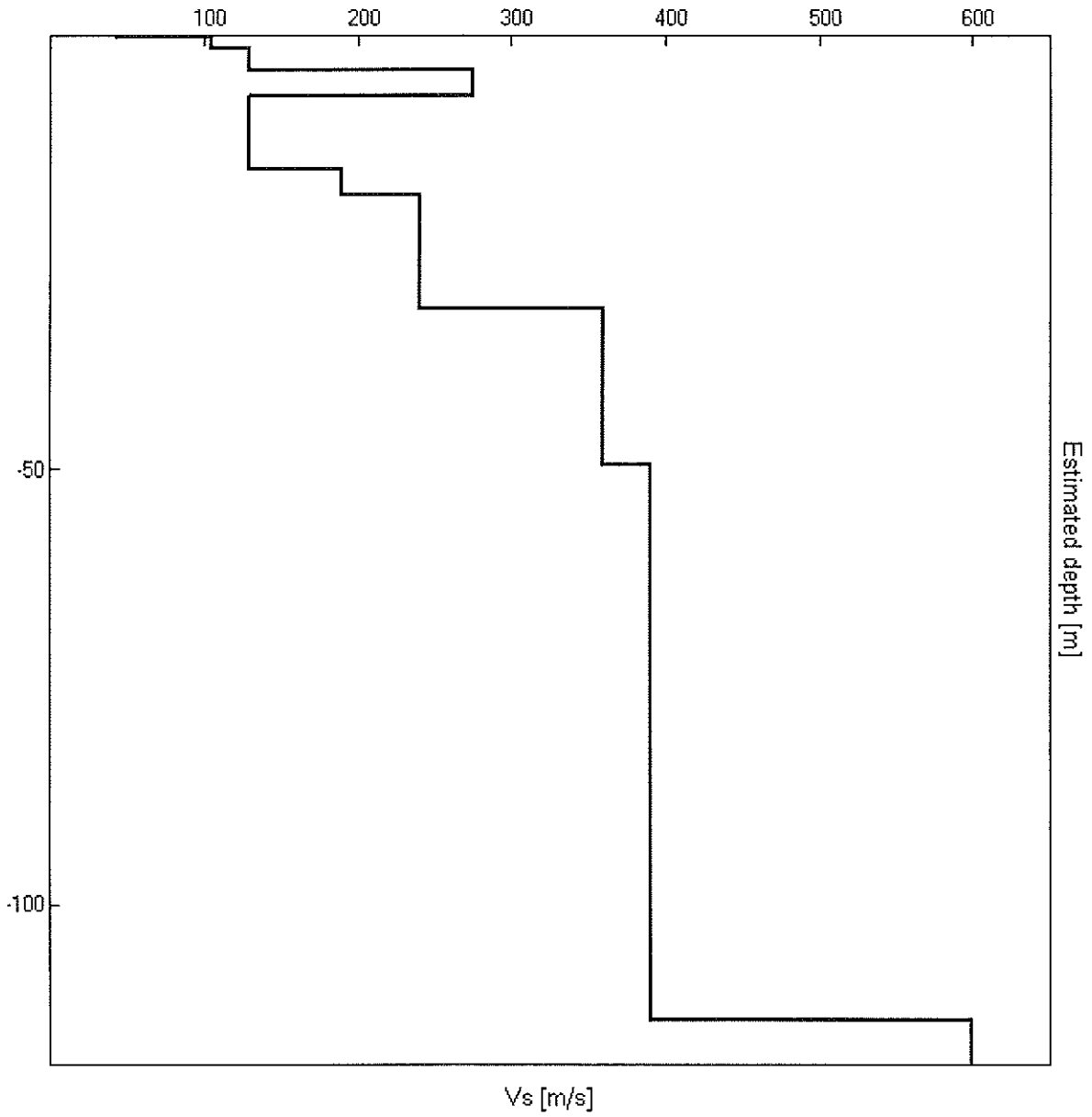


EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.24	0.24	43
1.44	1.20	105
3.94	2.50	130
6.94	3.00	275
15.44	8.50	130
18.44	3.00	190
31.44	13.00	240
49.44	18.00	360
113.44	64.00	390
inf.	inf.	600

Vs(0.0-30.0)=170m/s





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

Max. H/V at  $19.97 \pm 2.15$  Hz. (in the range 0.0 - 20.0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$19.97 > 0.50$	OK	
$n_c(f_0) > 200$	$16773.8 > 200$	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 960 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0]$   $A_{HV}(f^-) < A_0 / 2$	9.219 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0]$   $A_{HV}(f^+) < A_0 / 2$			NO
$A_0 > 2$	$3.13 > 2$	OK	
$f_{\text{peak}}[A_{HV}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.05262  < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	$1.05066 < 0.99844$		NO
$\sigma_A(f_0) < \theta(f_0)$	$0.2038 < 1.58$	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
$\sigma_f$	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 $f_0$
$A_{HV}(f)$	H/V curve amplitude at frequency $f$
$f^-$	frequency between $f_0/4$ and $f_0$ for which $A_{HV}(f^-) < A_0/2$
$f^+$	frequency between $f_0$ and $4f_0$ for which $A_{HV}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{HV}(f)$ , $\sigma_A(f)$ is the factor by which the mean $A_{HV}(f)$ curve should be multiplied or divided
$\sigma_{\log HV}(f)$	standard deviation of $\log A_{HV}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

Threshold values for  $\sigma_f$  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 $\sigma_{\log HV}(f_0)$	0.48	0.40	0.30	0.25	0.20

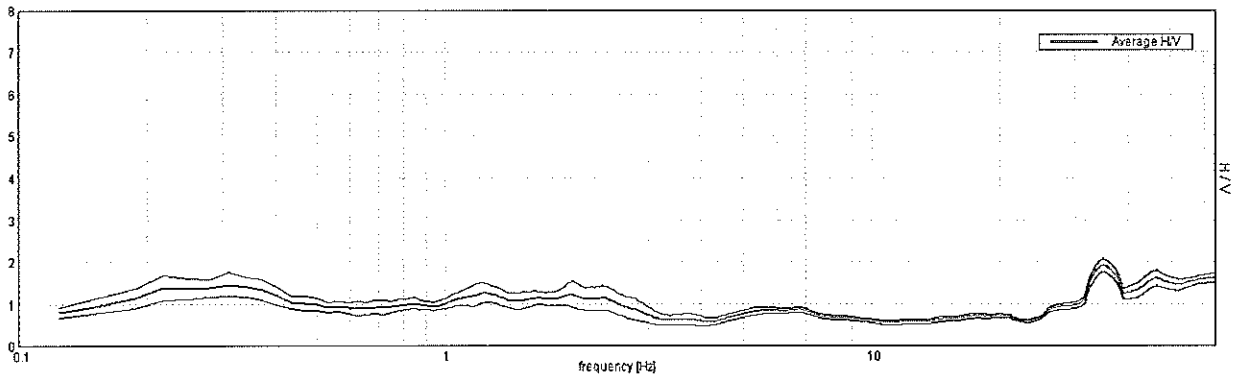
**CASALBORSETTI - VIA DELLE ROSE 18-20, BROGNARA TR 1**

Start recording: 18/11/09 16:09:18      End recording: 18/11/09 16:29:19  
 Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN  
 GPS data not available

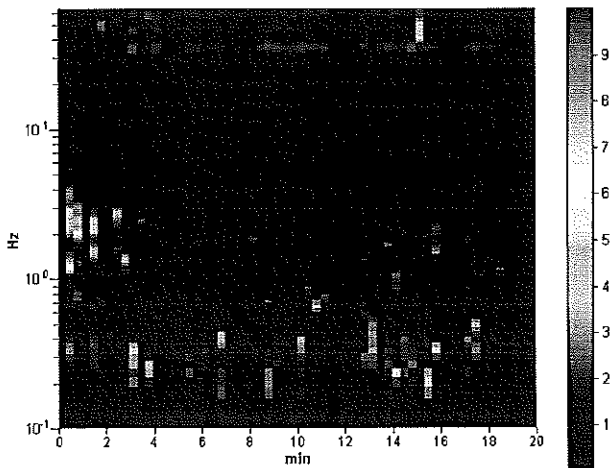
Trace length: 0h20'00".      Analyzed 72% trace (manual window selection)  
 Sampling frequency: 128 Hz  
 Window size: 20 s  
 Smoothing window: Triangular window  
 Smoothing: 10%

**HORIZONTAL TO VERTICAL SPECTRAL RATIO**

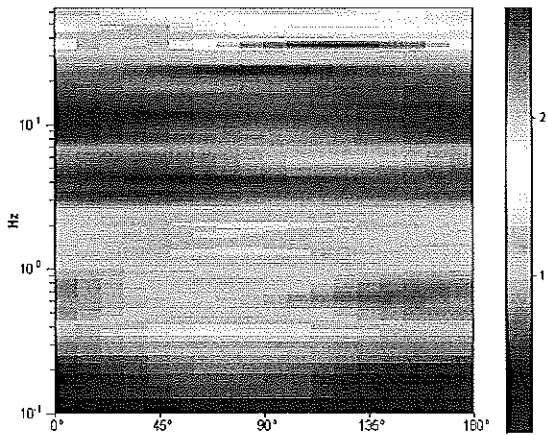
Max. HV at 0.31 ± 0.44 Hz. (in the range 0.0 - 20.0 Hz)



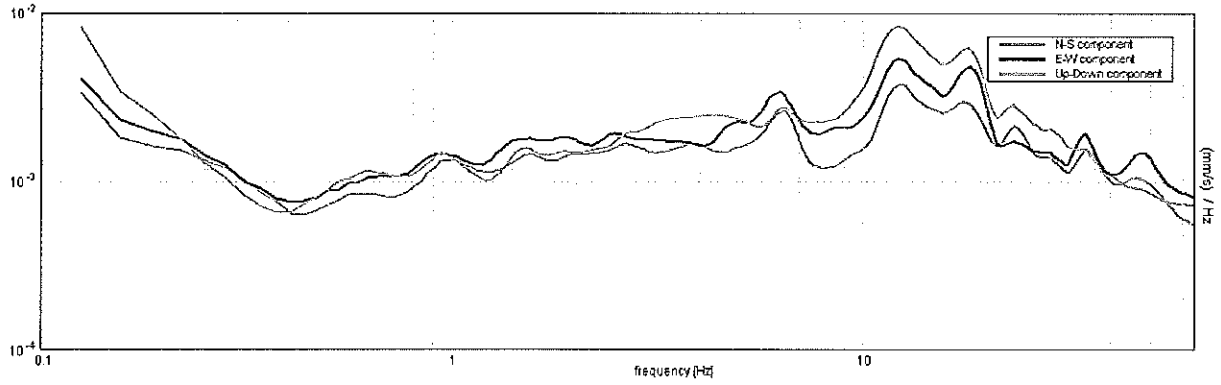
**H/V TIME HISTORY**



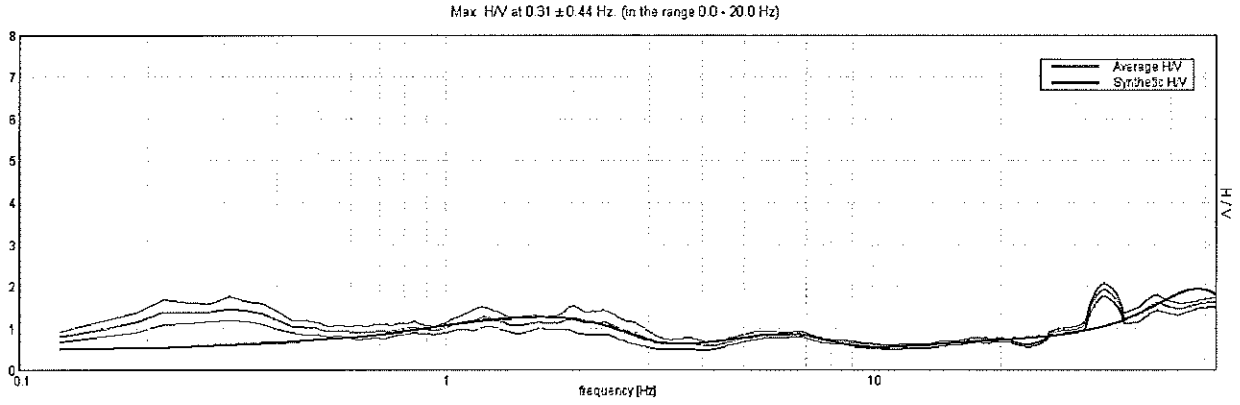
**DIRECTIONAL H/V**



SINGLE COMPONENT SPECTRA

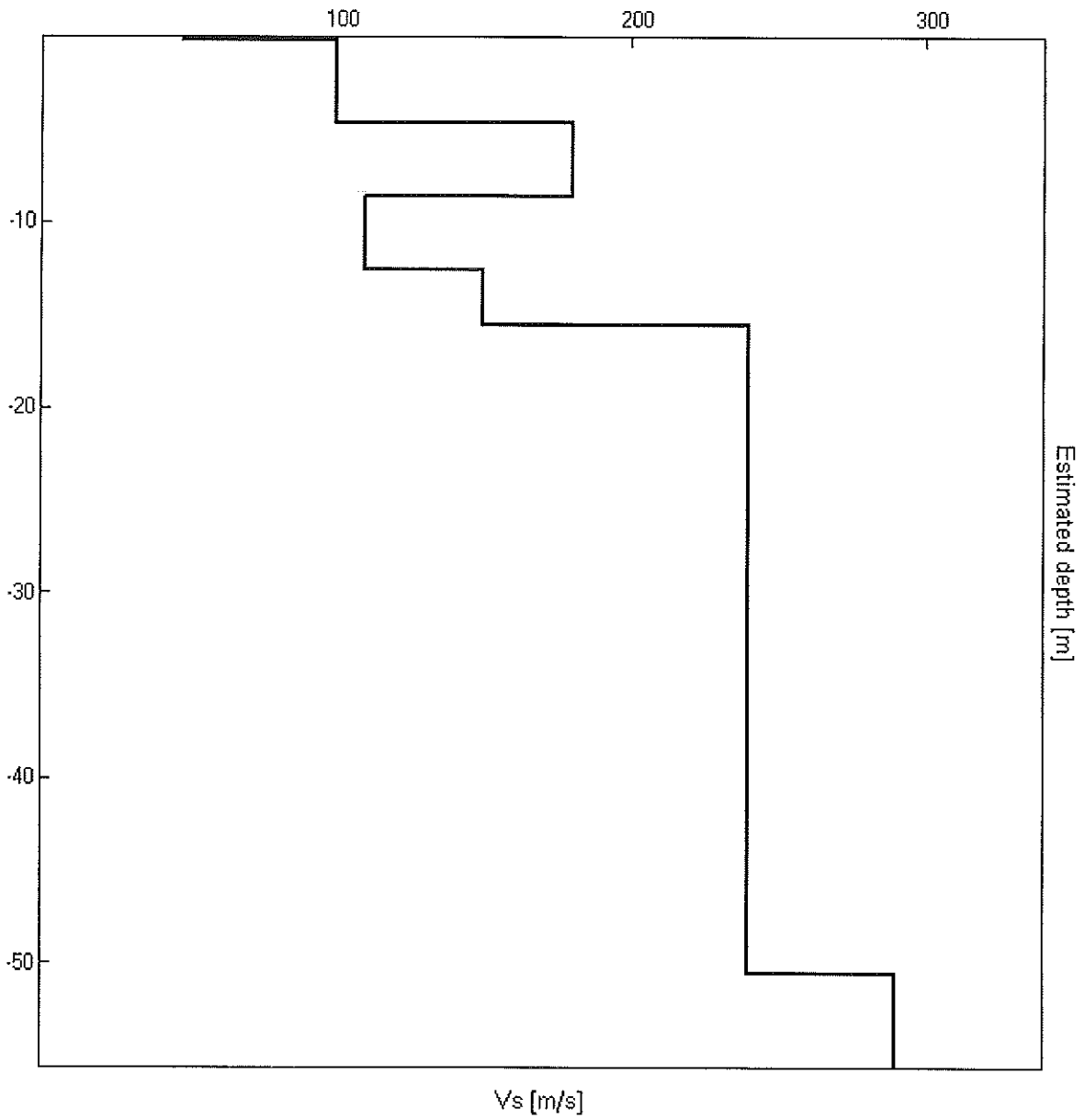


EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.20	0.20	48
4.60	4.40	100
8.60	4.00	180
12.60	4.00	110
15.60	3.00	150
50.60	35.00	240
inf.	inf.	290

Vs(0.0-30.0)=161m/s



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

Max. H/V at  $0.31 \pm 0.44$  Hz. (in the range 0.0 - 20.0 Hz).

**Criteria for a reliable HVSR curve**

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$0.31 > 0.50$		NO
$n_c(f_0) > 200$	$268.8 > 200$	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 16 times	OK	

**Criteria for a clear HVSR peak**

[At least 5 out of 6 should be fulfilled]

Exists $f^-$ in $[f_0/4, f_0]$   $A_{HV}(f^-) < A_0 / 2$	0.094 Hz	OK	
Exists $f^+$ in $[f_0, 4f_0]$   $A_{HV}(f^+) < A_0 / 2$			NO
$A_0 > 2$	$1.47 > 2$		NO
$f_{\text{peak}}[A_{HV}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.6878  < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	$0.21494 < 0.0625$		NO
$\sigma_A(f_0) < \theta(f_0)$	$0.1401 < 2.5$	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
$\sigma_f$	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 $f_0$
$A_{HV}(f)$	H/V curve amplitude at frequency $f$
$f^-$	frequency between $f_0/4$ and $f_0$ for which $A_{HV}(f^-) < A_0/2$
$f^+$	frequency between $f_0$ and $4f_0$ for which $A_{HV}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{HV}(f)$ , $\sigma_A(f)$ is the factor by which the mean $A_{HV}(f)$ curve should be multiplied or divided
$\sigma_{\log HV}(f)$	standard deviation of $\log A_{HV}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

Threshold values for  $\sigma_f$  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 $\sigma_{\log HV}(f_0)$	0.48	0.40	0.30	0.25	0.20