



APPROFONDIMENTI TEMATICI DELLA GEOLOGIA E DELLA SISMICA

Relazione tecnica

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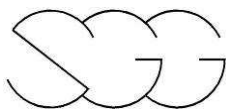
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ELENCO TAVOLE

Elaborati conoscitivi

Tavola GEO.1 - Carta delle aree potenzialmente soggette ad effetti locali

Tavola GEO.2 - Carta del tetto delle ghiaie

Tavola GEO.3 - Planimetria delle indagini

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Tavola GEO.8 - Carta dei livelli di approfondimento

1 - INTRODUZIONE

Nel presente rapporto sono illustrati i risultati dell'indagine di microzonazione sismica eseguita per conto del Comune di Formigine (MO).



Figura 1 – Indagine effettuata presso un parco nel territorio di Formigine

Lo scopo della prospezione è stato quello di identificare e ricostruire, sulla base delle loro caratteristiche fisiche e meccaniche, i rapporti geometrici degli strati di terreno (definizione della profondità del bedrock sismico e dello spessore del deposito di copertura), i profili di Velocità delle onde superficiali ed il computo del valore di V_{s30} e di V_{sH} . A tal scopo sono state realizzate su tutto il territorio comunale n°29 prove MASW.

Ad integrazione e completamento di tali prove sono state eseguite n° 12 prove penetrometriche, oltre alla rielaborazione di altre prove penetrometriche ricavate da database comunali.

Nella presente relazione sono illustrate in particolar modo le metodologie esecutive ed interpretative delle misure geofisiche ed i risultati di tutte le indagini dirette ed indirette.

2 - INDAGINI SVOLTE

Le indagini svolte si sono sviluppate con due metodologie diverse e identificabili come indagini dirette (prove penetrometriche) e come indagini indirette (prove geofisiche Masw e misure HVSr).

La prospezione geofisica è stata eseguita nei giorni compresi tra il 7 ed il 18 Ottobre 2010, mentre la campagna penetrometrica si è svolta nei giorni del 28 e 29 Ottobre 2010. L'ubicazione complessiva delle indagini è riportata in dettaglio nell'elaborato nella tavola GEO.3 "*Planimetria delle indagini*".

Le indagini dirette si sono sviluppate su **12 prove penetrometriche con tecnica mista CPT e DPSH**.

L'indagine geofisica si è svolta attraverso l'esecuzione di **29 prove MASW per l'acquisizione delle onde superficiali di Rayleigh**.

Inoltre su alcuni dei siti delle prove penetrometriche ed in altri settori sono state eseguite delle **misure HVSr** a stazione singola.



Figura 2 – Misura HVSr

In totale sono stati quindi eseguiti:

- n°29 acquisizioni di onde superficiali di Rayleigh (Masw).
- n°12 prove penetrometriche
- n°45 misure HVSr a stazione singola.

3 - STRUMENTAZIONI IMPIEGATE

Per l'esecuzione delle indagini sono state utilizzate le seguenti strumentazioni ed attrezzature:

n°	Strumentazione	COD. IDENT.
1	sismografo GEOMETRICS "GEODE" 24 ch- 24 bit	SGG-SI-52
1	notebook HP per registrazione dei dati di campagna con MULTIPLEGEODEOPTIMSOFTWARE (MGOS)	
24	geofoni verticali con frequenza pari a 4,5 Hz	SGG-SI-61
1	cavo geofonico GEOSPACE con 24 take-out spaziate di 5 metri	SGG-SI-39h
1	hammer switch per dispositivo time-break	
1	massa battente da 5 kg	
	cavi e prolunghe per il dispositivo di time-break e per il collegamento GEODE-notebook	
1	tromografo MICROMED SpA "TROMINO ENGY PLUS"	SGG-SI-65
	Penetrometro Statico/Dinamico montato su carro cingolato Pagani Mod. TG63/200, con Cella di Carico da 200KN e Maglio da 63,5KG.	

II

Tutti gli strumenti di misura impiegati, in riferimento con il "calendario di taratura" afferente al "sistema di qualità" in uso presso questo studio, sono periodicamente tarati presso il LABORATORIO CE.TA.CE. di Calenzano, della CESVIT S.p.A., ed accreditato SIT n°56 (Servizio di Taratura in Italia).

4 - FINALITÀ DELLE INDAGINI

Le finalità complessive delle indagini possono così essere sinteticamente riassunte:

- *definire il modello geologico del sottosuolo (profondità del bedrock sismico e spessore della copertura) in riferimento alla velocità delle onde S*
- *computo della V_{s30} e V_{sH}*
- *redazione della carta di microzonazione sismica*
- *computo dei fattori di amplificazione sismica espressi sia in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0) sia in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi.*

Inoltre, a corredo di quanto sopra e rielaborando i dati di amplificazione con gli elementi dei periodi fondamentali dei terreni, un'ulteriore finalità è stata quella di realizzare una carta di zonizzazione e prescrizione per il territorio comunale ai fini sismici.

5 – ESECUZIONE DEI RILIEVI

Prove penetrometriche CPT - DPSH

Le prove penetrometriche sono state realizzate con la duplice finalità di individuare il tetto delle ghiaie ed anche per fornire ulteriori elementi geologici e geotecnici alle conoscenze già in possesso sull'area comunale.

Le prove sono state collocate in coincidenza o in prossimità delle aree interessate da nuove urbanizzazioni. In taluni casi sono state rielaborate alcune delle numerose prove penetrometriche già realizzate nel territorio comunale. Nella presente nota non verranno descritte le modalità esecutive della singola prova penetrometrica, ma è opportuno ricordare che le varie prove sono state eseguite inizialmente con le modalità statiche (CPT) e successivamente, al momento dell'individuazione delle ghiaie, con la modalità dinamica (DPSH). Entrambe le metodologie sono state eseguite fino a raggiungere la massima profondità di avanzamento (rifiuto).

Prove Multi-channel Analysis of Surface Waves ("MASW")

Al fine di caratterizzare la risposta sismica del sito in esame è stata effettuata una serie di acquisizioni MASW (Multi-channel Analysis of Surface Waves, analisi della dispersione delle onde di Rayleigh da misure di sismica attiva – e.g. Park et al., 1999) utili a definire il profilo verticale della VS (velocità di propagazione delle onde di taglio).

Nel loro insieme, le procedure adottate sono state eseguite in accordo alle norme tecniche per le costruzioni del DM 14 gennaio 2008 (ex DM 14/09/2005). Queste, in buona misura, fanno risalire la stima dell'effetto di sito alle caratteristiche del profilo di velocità delle onde di taglio (VS).

La classificazione dei terreni è stata quindi svolta sulla base del valore della V_{sH} e della V_{s30} (il valore medio ponderato della VS nei primi 30m di profondità) definita dalla relazione:

$$V_{S_{30}} = \frac{30}{\sum_{i=1, N} \frac{h_i}{V_i}} \quad \text{eq. (1)}$$

in cui V_{s_i} e h_i sono rispettivamente la velocità delle onde di taglio e lo spessore dell'i-esimo strato

Lo scopo della prova MASW è quello di ricostruire il profilo di rigidezza del sito tramite la misura della velocità di propagazione delle onde di superficie di Rayleigh con un successivo processo d'inversione, attraverso il quale è fornita una stima indiretta della distribuzione delle V_s (velocità di propagazione delle onde di taglio).

L'acquisizione è avvenuta tramite sismografo a 24 canali collegato a geofoni verticali a frequenza propria di 4.5Hz (spaziatura tra geofoni 2m, 2s di acquisizione, offset minimi di 2, 10 e 20 m).

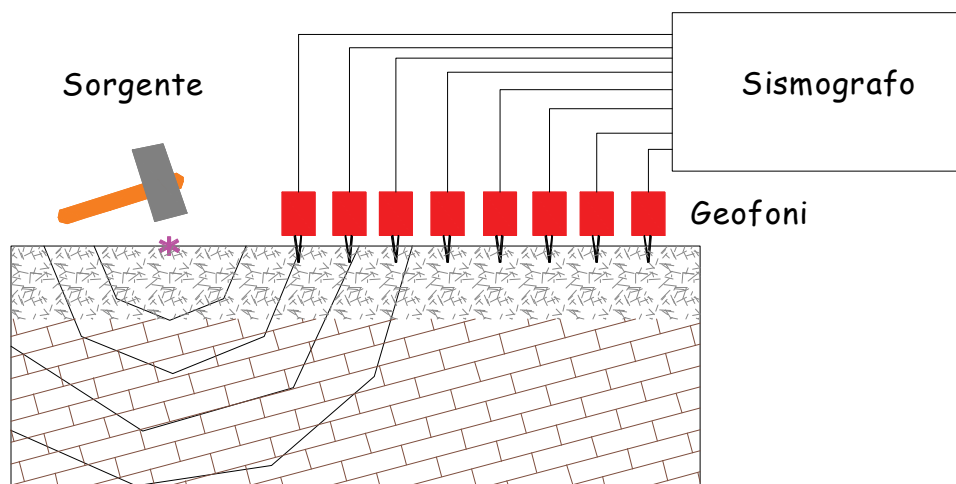


Figura 3. Stendimento sismico

La prova consiste nel produrre in un punto sulla superficie del terreno, in corrispondenza del sito da investigare, una sollecitazione dinamica verticale in un determinato campo di frequenze e nel registrare tramite uno stendimento lineare di sensori (fig. 3) le vibrazioni prodotte, sempre in corrispondenza della superficie, a distanze note e prefissate.

Curva HVSR

La tecnica HVSR (Horizontal to Vertical Spectral Ratios) è basata sulla misura dei rapporti medi fra le ampiezze spettrali delle componenti orizzontali e verticale del rumore sismico ambientale. Le frequenze di risonanza corrispondono ai massimi della funzione che rappresenta rapporti spettrali medi in funzione della frequenza (funzione H/V). L'ampiezza di questi massimi è proporzionale (anche se non linearmente) all'entità del contrasto di impedenza sismica esistente

L'idea di base è quella secondo cui il rapporto H/V consente in media di eliminare il ruolo delle variazioni di intensità delle sorgenti nel corso della registrazione mettendo in evidenza il ruolo della struttura. Sperimentalmente si vede che, in presenza di un campo d'onde diffuso, la forma della funzione (e in particolare la posizione dei suoi valori massimi) risulta con buona approssimazione stabile nel tempo e fortemente correlata con le caratteristiche del sottosuolo al di sotto del sito di misura.

In particolare, in presenza di forti variazioni nel profilo di velocità delle onde S nel sottosuolo (legate per esempio alla transizione fra sedimenti soffici e basamento rigido), la funzione H/V mostra dei massimi marcati in corrispondenza della frequenza di risonanza f_r relativa a quella configurazione strutturale (con f_r circa uguale al rapporto fra la velocità media delle onde S fino alla profondità del salto di velocità e il quadruplo di questa profondità). Si osserva anche una certa correlazione (fortemente non lineare) fra l'entità della variazione di velocità responsabile del fenomeni di risonanza e l'ampiezza del massimo della funzione H/V (maggiore è il contrasto di impedenza sismica, maggiore è l'entità del massimo).

La struttura del campo d'onde presente nel terreno (rumore sismico ambientale, microtremore, rumore sismico o seismic noise) è condizionata dalle caratteristiche delle sorgenti che lo determinano (siano esse naturali o antropiche) e dalle proprietà meccaniche dei terreni. Infatti, ciascuna sorgente genera un treno d'onde che raggiunge il punto di misura con caratteristiche che dipendono dall'entità delle sollecitazioni nelle componenti orizzontali e verticali del moto e dalle modalità di propagazione fra la sorgente e il sito in funzione dei fenomeni di riflessione, rifrazione e diffrazione che hanno luogo in

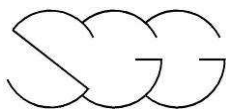
corrispondenza di variazioni delle proprietà meccaniche dei terreni nel sottosuolo. In genere, nel campo di rumore ambientale, saranno presenti sia onde di volume (P e S in quantità variabili) che onde superficiali (Love e Rayleigh).

Se si considera un intervallo di tempo opportunamente lungo (dell'ordine delle decine di minuti), le proprietà medie di un campo d'onde sismiche generato da una molteplicità di sorgenti differenti, distribuite casualmente attorno a un punto di misura, tendono ad avere un andamento che non dipende dalle singole sorgenti che hanno generato il campo, ma solo dalle proprietà del mezzo in cui le onde si propagano e dal livello energetico medio dell'attività antropica o naturale.

In particolare, si può immaginare che, in media, le componenti orizzontali e verticali del moto del suolo tendano a essere sollecitate in modo equivalente, con un'ampiezza media pari al livello medio del rumore in quell'intervallo temporale. In questa ipotesi, i rapporti fra le ampiezze verticali e orizzontali del moto (H/V) saranno statisticamente indipendenti dalle caratteristiche delle sorgenti (dato che le ampiezze delle sollecitazioni sul piano orizzontale e verticale sono mediamente le stesse) e saranno condizionate dai soli effetti di propagazione ovvero dalle caratteristiche del mezzo interessato dal moto sismico. Queste ultime influenzeranno l'ampiezza relativa delle diverse fasi sismiche (onde P, S, Rayleigh e Love) e le direzioni di emergenza delle onde al punto di misura.

Si può dimostrare che la frequenza di risonanza v_0 di una copertura sedimentaria di spessore H sovrapposta a un basamento rigido e in condizioni di stratificazione piana è data dal rapporto fra la velocità media delle onde S nel sedimento (V_s) e 4 volte lo spessore H ($v_0 = V_s/4H$). Utilizzando questa relazione è possibile risalire dalla frequenza di risonanza misurata allo spessore della copertura una volta nota la velocità delle onde di taglio o, viceversa a questa ultima se lo spessore H è noto.

Studi teorici mostrano che se il rumore è effettivamente dominato da onde di volume emergenti da direzioni sub-verticali, l'andamento e l'ampiezza della funzione H/V riflettono quelle della funzione di risposta del deposito sedimentario analizzato. In caso contrario si vede che l'ampiezza dei massimi della funzione H/V è correlata (ma non linearmente) all'entità del contrasto di



impedenza sismica presente alla base della copertura.

L'assenza di massimi della funzione H/V suggerisce l'assenza di fenomeni di amplificazione sismica dovuti a fenomeni di risonanza.

Le registrazioni di microtremori sono state effettuate con il tromografo digitale TROMINO ENGY PLUS (specifiche tecniche su www.tromino.it), strumento appositamente progettato per questo scopo.

6 – ANALISI DELLA DISPERSIONE DELLE ONDE SUPERFICIALI

Il metodo “MASW” consente di eseguire un’analisi dei dati sismici in modo tale da poter ricavare il profilo verticale della velocità delle onde S.

La metodologia MASW permette altresì di definire il parametro V_{s30} , utile per la classificazione dei terreni nelle categorie di suolo da utilizzare in seguito per la descrizione dell’azione sismica in sito.

Si ricorda che il valore del parametro V_{s30} della prova MASW è riportato, per convenzione, al centro del relativo stendimento geofonico.

Per l’interpretazione dei dati sperimentali è stato utilizzato uno specifico programma (winMASW Professional Version 4.1).

Il profilo verticale di V_s è ottenuto tramite l’inversione (considerando tanto il modo fondamentale che quelli superiori) delle curve di dispersione delle onde di Rayleigh.

La procedura si sviluppa in due fasi:

- Determinazione dello spettro della velocità sulla quale si identifica la curva di dispersione
- Inversione della curva di dispersione attraverso l’utilizzo di algoritmi genetici.

L’elaborazione del segnale consiste inizialmente nel calcolo dello spettro di velocità dei dati sismici acquisiti in campagna (fig. 4).

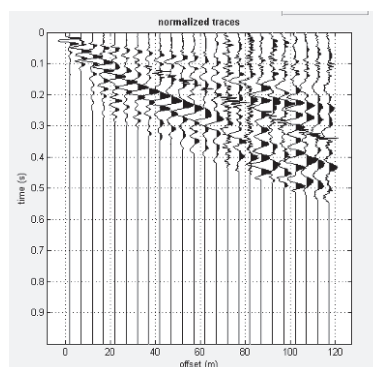


Figura 4: dati di campagna

Sullo spettro di velocità calcolato (fig. 5) è eseguito un “picking” della curva di dispersione (soprassegno con cerchietti) individuando un insieme di punti che appartengono ad un certo modo (in questo caso al modo fondamentale) di propagazione dell’onda superficiale di Rayleigh.

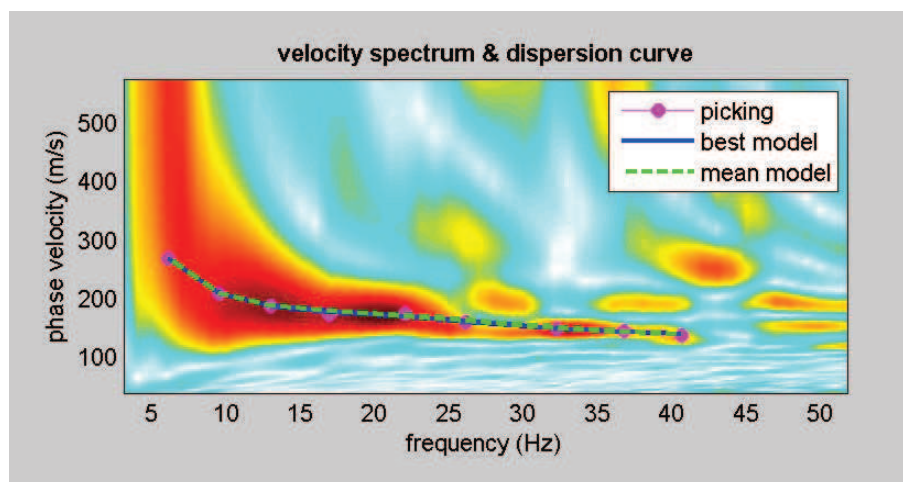


Figura 5: esempio di spettro di velocità tratto dalla prova MASW e relativo picking

Allo scopo di ottenere una prima valutazione del possibile modello del terreno è altresì effettuata una modellazione diretta del terreno tramite il calcolo di una curva di dispersione appartenente ad un modello a quattro strati, i cui valori di V_s e degli spessori sono definiti sulla base di osservazioni desunte e dalla tomografia sismica a rifrazione e delle stratigrafie delle prove penetrometriche.

Successivamente per ottenere il profilo verticale di V_s è eseguita l’inversione della curva di dispersione precedentemente “piccata”. Tale inversione è eseguita tramite l’utilizzo di algoritmi genetici che consentono di ottenere soluzioni affidabili ed una stima dell’attendibilità del modello ricavato in termini di deviazione standard.

L’operazione di inversione è ottimizzata definendo uno spazio di ricerca i cui confini sono definiti da valori di V_s e spessori all’interno dei quali si cerca la soluzione. Tali assunzioni sono fatte sulla base delle conoscenze geologiche

del sito e delle informazioni derivate dalla sismica a rifrazione e delle prove penetrometriche.

Una volta fissati i limiti minimi e massimi dello spazio di ricerca, sono quindi impostati i parametri genetici che definiscono sia il numero di individui (ossia il numero di modelli che costituiscono la popolazione che si evolverà verso soluzioni sempre migliori) sia il numero di generazioni al passare delle quali sono esplorati modelli sempre migliori.

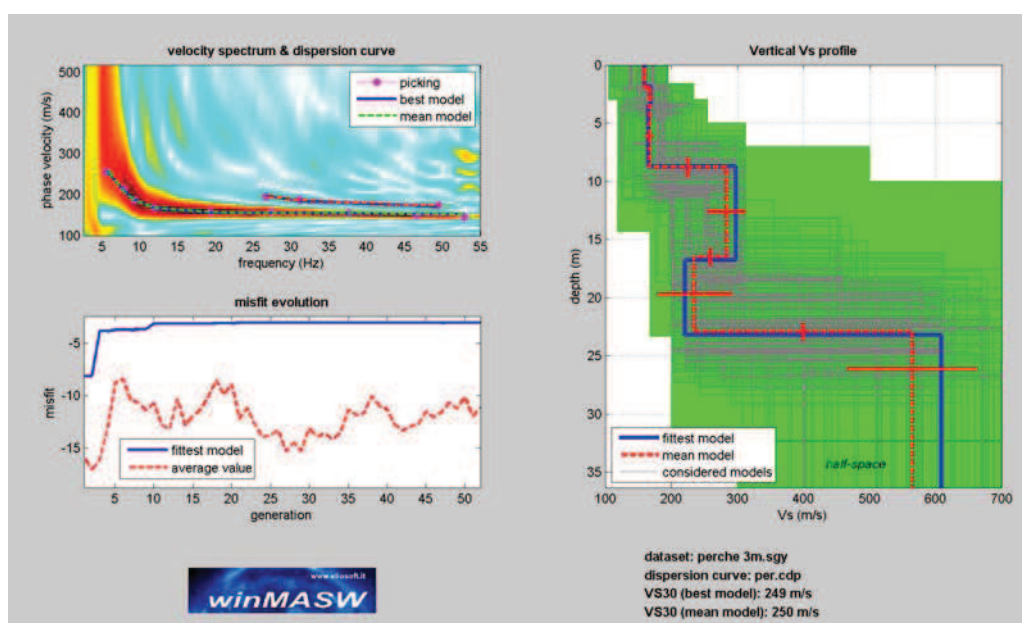


Figura 6: Esempio di risultati dell'inversione della curva di dispersione determinata tramite analisi dei dati MASW. In alto a sinistra: spettro osservato, curve di dispersione piccate e curve del modello individuato dall'inversione. Sulla destra il profilo verticale VS identificato (modello "migliore" e medio sono tipicamente analoghi). In basso a sinistra l'evolversi del modello al passare delle "generazioni" utile per la valutazione dei valori di deviazione standard tra il modello medio e quello migliore ai fini di verificare l'accettabilità del modello ottenuto (l'algoritmo utilizzato per l'inversione delle curve di dispersione appartiene alla classe degli Algoritmi Genetici – Dal Moro et al., 2007).

L'analisi dei dati attraverso l'uso di algoritmi genetici porta in ultima analisi alla definizione del profilo verticale della Vs (fig. 6) in funzione della profondità con associato il valore del Vs₃₀.

7 - ANALISI ED UTILIZZO DEI RAPPORTI SPETTRALI

La misura della funzione H/V è stata effettuata tramite l'acquisizione del rumore sismico ambientale in un punto per un tempo di venti minuti. Questa durata ha lo scopo di garantire la misura del campo di rumore generato da una molteplicità di sorgenti dalle diverse direzioni dello spazio.

La misura è stata effettuata utilizzando un sistema di acquisizione tri-direzionale caratterizzato da sufficiente sensibilità.

I risultati di ogni analisi presentati in questo lavoro sono stati ottenuti con il software GRILLA, che permette di determinare i rapporti medi fra le componenti spettrali del rumore misurate sul piano orizzontale e verticale. A questo scopo, la serie di rumore ambientale è stata suddivisa in una serie di finestre temporali di uguale durata (finestre di 20 secondi) per ciascuna delle quali è stato determinato lo spettro del moto. Su ciascuna di queste finestre viene calcolato lo spettro di ampiezza del segnale nelle tre componenti. In questa fase è stata applicato un sistema di lisciamento (smoothing) triangolare del 10% adottato per la determinazione dello spettro.

Dopo un opportuno lisciamento, le ordinate spettrali del moto sul piano orizzontale, ottenute mediando opportunamente i valori ottenuti nelle due direzioni principali, sono state divise per quelle ottenute nella direzione verticale.

L'andamento dei rapporti spettrali è stato quindi ottenuto mediando i valori ottenuti per le diverse finestre temporali considerate. Per definire la qualità delle misure sono state anche valutate le variazioni temporali e azimutali dei rapporti spettrali nel corso della sessione di misura e fatta una stima del relativo intervallo di confidenza.

Di seguito sarà brevemente descritta la procedura di analisi seguita:

- Ciascuna delle tracce è suddivisa in segmenti o finestre di 20 secondi.
- In ogni finestra e per ciascuna delle tracce viene eseguita:
 - un'analisi preliminare: eliminazione di trend lineari (detrend) e tapering delle estremità.
 - la trasformata di Fourier (FFT)
 - il lisciamento degli spettri con finestra triangolare ampia una frazione

della frequenza centrale (in questo lavoro generalmente il 10%).

- Le ampiezze spettrali delle componenti orizzontali vengono mediate in modo geometrico, e vengono calcolati i rapporti HVSR (f), in ciascuna finestra temporale.
- Si calcolano i rapporti HVSR medi ed il relativo intervallo di confidenza al 95%. Alla frequenza di risonanza viene associata una stima dell'incertezza sperimentale.

Lo spettro relativo alla componente orizzontale viene ottenuto effettuando la media (solitamente geometrica) delle due componenti spettrali del rumore sul piano orizzontale. La combinazione delle stime ottenute nelle diverse finestre temporali viene poi utilizzata per costruire la funzione H/V finale e stimare il relativo intervallo di confidenza. In particolare, la funzione H/V è ottenuta facendo la media dei valori delle funzioni H/V calcolate in ogni finestra temporale.

Per verificare se le misure sono state effettuate in condizioni ottimali per i fini geognostici (campo d'onde diffuso), oltre alla stima della curva H/V, risulta quindi utile valutare l'eventuale presenza di fenomeni direzionali (eterogeneità del campo di rumore) e la stabilità nel tempo della funzione H/V durante la misura (stazionarietà). In presenza di un campo di rumore diffuso il valore della funzione H/V non deve cambiare nel tempo o al variare della direzione.

Al contrario, la presenza di sorgenti dominanti o il cattivo posizionamento dello strumento (basculamento) si manifesta come una variazione direzionale e/o temporale dei rapporti H/V.

Sperimentalmente, l'analisi di qualità della misura può essere effettuata confrontando le ampiezze spettrali medie del rumore misurato lungo le due componenti orizzontali, oppure calcolare diversi valori della funzione H/V di volta in volta proiettando lungo direzioni differenti le ampiezze spettrali ottenute sul piano orizzontale (Figura 7). La stazionarietà nel tempo, invece, può essere valutata rappresentando in funzione del tempo le funzioni H/V ottenute nelle diverse finestre temporali considerate (Figura 7).

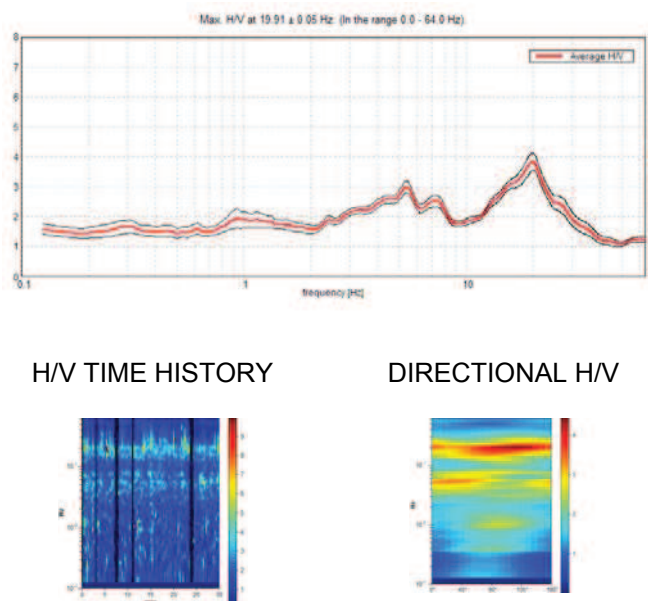


Figura 7: Esempio di risultati delle analisi di rumore sismico relative a una corretta misura H/V. In alto sono riportati i valori del rapporto spettrale H/V in funzione della frequenza con il relativo intervallo di confidenza al 95%. Sono anche indicati i valori delle frequenze corrispondenti ai massimi della funzione H/V. In basso a sinistra è riportato l'andamento nel tempo (ascissa) dei valori H/V (colori) in funzione della frequenza (ordinata): il grafico ha lo scopo di valutare la stabilità nel tempo della curva H/V. In basso a destra sono invece riportati i valori della funzione H/V (colore) in funzione della frequenza (in ordinata) al variare della direzione del segnale (ascissa): il grafico serve a valutare la direzionalità del segnale registrato.

Ai fini dell'affidabilità e della chiarezza del massimo della funzione H/V, infine è effettuata una analisi secondo i criteri determinati nell'ambito del progetto europeo SESAME per l'eliminazione di massimi spuri della funzione H/V, la cui presenza è frutto delle caratteristiche del campo d'onde sismiche e non della struttura locale del sottosuolo (Figura 8).

Max. H/V at 19.91 ± 0.05 Hz. (in the range 0.0 - 64.0 Hz).			
Criteria for a reliable HVSR curve [All 3 should be fulfilled]			
$f_0 > 10 / L_w$	19.91 > 0.50	OK	
$n_c(f_0) > 200$	33044.4 > 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 956 times	OK	
Criteria for a clear HVSR peak [At least 5 out of 6 should be fulfilled]			

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	10.875 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	29.969 Hz	OK	
$A_0 > 2$	$3.84 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00121 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.02401 < 0.99531$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.1455 < 1.58$	OK	

L_w	window length				
n_w	number of windows used in the analysis				
$n_c = L_w n_w f_0$	number of significant cycles				
f	current frequency				
f_0	H/V peak frequency				
σ_f	standard deviation of H/V peak frequency				
$\varepsilon(f_0)$	threshold value for the stability condition $\sigma_f < \varepsilon(f_0)$				
A_0	H/V peak amplitude at frequency f_0				
$A_{H/V}(f)$	H/V curve amplitude at frequency f				
f^-	frequency between $f_0/4$ and f_0 for which $A_{H/V}(f^-) < A_0/2$				
f^+	frequency between f_0 and $4f_0$ for which $A_{H/V}(f^+) < A_0/2$				
$\sigma_A(f)$	standard deviation of $A_{H/V}(f)$, $\sigma_A(f)$ is the factor by which the mean $A_{H/V}(f)$ curve should be multiplied or divided				
$\sigma_{\log H/V}(f)$	standard deviation of $\log A_{H/V}(f)$ curve				
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$				
Threshold values for σ_f and $\sigma_A(f_0)$					
Freq.range [Hz]	< 0.2	0.2 – 0.5	0.5 – 1.0	1.0 – 2.0	> 2.0
$\varepsilon(f_0)$ [Hz]	0.25 f_0	0.2 f_0	0.15 f_0	0.10 f_0	0.05 f_0
$\theta(f_0)$ for $\sigma_A(f_0)$	3.0	2.5	2.0	1.78	1.58
Log $\theta(f_0)$ for $\sigma_{\log H/V}(f_0)$	0.48	0.40	0.30	0.25	0.20

Figura 8: Esempificazione dei criteri da rispettare per l'ottenimento di una realistica curva HVSR.

Infine, un buon indicatore della qualità del picco H/V può essere ottenuto dall'esame degli spettri singoli. Infatti, massimi fisicamente significativi sono generalmente associati a valori di ampiezza spettrale minima sulla componente verticale. La curva sottostante può essere considerata come un esempio di picco H/V chiaro e fisicamente significativo (fig: 9).

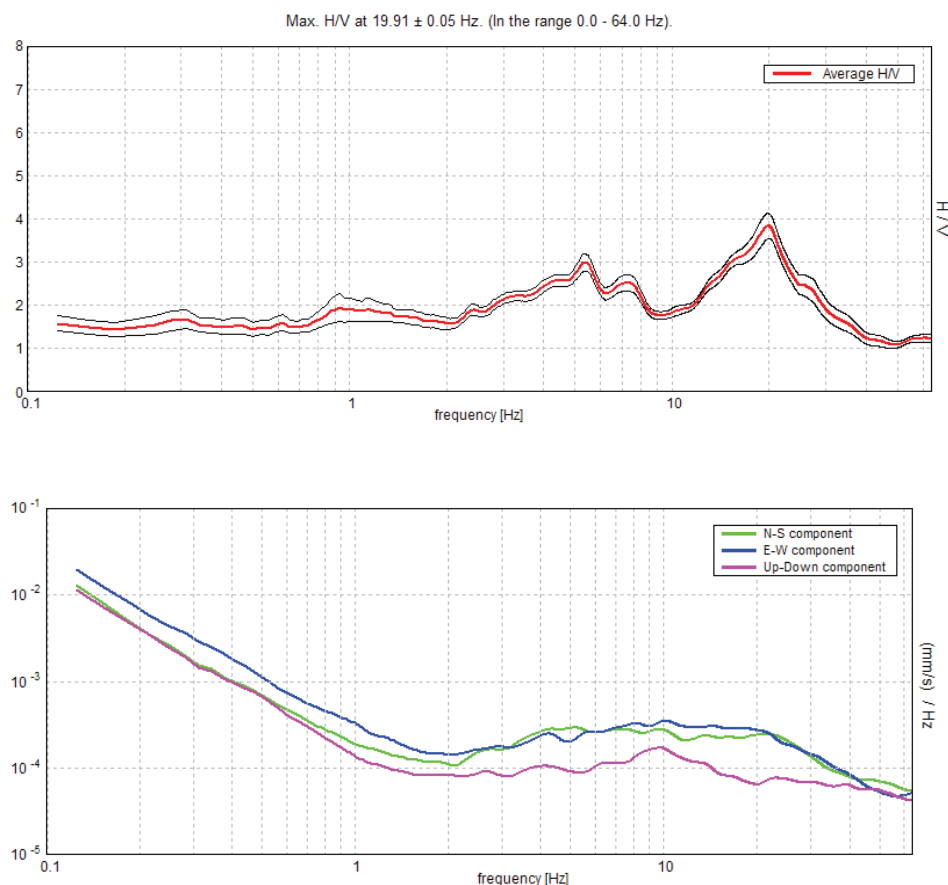


Figura 9: Esempio di andamento degli spettri relativi a una corretta misura H/V nella quale viene identificato un picco fisicamente significativo. Nella figura superiore è riportato l'andamento della curva H/V (curva rossa) e il relativo intervallo di confidenza (curve nere). Nella figura in basso sono riportati gli andamenti degli spettri di ampiezza del rumore sulla componente verticale (curva magenta) e sulle componenti orizzontali (curve verde e blu).

Dopo aver descritto l'analisi della curva H/V passiamo a descrivere l'utilizzo specifico che ne è stato fatto in tale studio. Come già ricordato, un picco chiaro e netto indica un buon contrasto di impedenza sismica; di conseguenza, un passaggio litologico significativo ad un litotipo avente spessori consistenti e che quindi può essere considerato sismicamente come il substrato.

Questo è individuabile nel settore occidentale (indicato come "Area Secchia") della Tav. GEO.4 "Carta del periodo fondamentale di vibrazione". Al

contrario, nel rimanente settore orientale, si evidenziano numerose prove in cui non si ha un picco significativo sulla curva H/V. Ciò, sta ad indicare che non vi è generalmente un contrasto di impedenza significativo e perciò se ne deduce che il pur presente contatto tra i sedimenti limoso-sabbiosi e le sottostanti ghiaie non rappresentano un contrasto tale da essere visualizzato nella curva H/V. In questo caso le ghiaie non hanno spessori considerevoli e non possono essere considerate sismicamente come il sub-strato; da ciò è escluso solamente il settore meridionale dell'area (Torrenti appenninici minori) che proprio in riferimento ai valori delle frequenze sulla curva H/V, può essere assimilato al settore occidentale.

Quindi, attraverso le misure HVSR e le relative curve H/V che ne derivano, è possibile individuare un litotipo che, almeno dal punto di vista sismico, può essere considerato come il sub-strato. Questa conoscenza sul sub-strato sismico ci permette di poter scegliere, per le varie zone del territorio comunale, le varie tabelle da utilizzare per la determinazione dei fattori di amplificazione, secondo quanto stabilito nell'Atto di Indirizzo e Coordinamento Tecnico n. 112/2007.

8 - ANALISI DEI RISULTATI

In appendice sono riportati i risultati delle prove Masw illustrando il dato di campagna acquisito, lo spettro di velocità calcolato, la curva di dispersione piccata, le curve del modello individuato dall'inversione ed il profilo verticale di V_s .

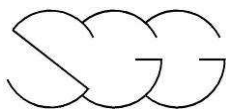
Sulla base del profilo di velocità delle onde S è fornito il valore del parametro di V_{s30} o di V_{sH} in funzione dell'esistenza o meno di un sub-strato profondo o relativamente superficiale.

Il calcolo dei **fattori di amplificazione sismica** delle aree individuate, sono stati effettuati secondo quanto stabilito nell'Atto di Indirizzo e Coordinamento Tecnico n. 112/2007, ovvero utilizzando le metodologie concordate dal servizio preposto dalla Regione Emilia Romagna.

Il territorio comunale di Formigine, come configurazione geologica e morfologica dovrebbe essere collocato, in riferimento alla legge regionale, come pianura padana. In realtà, nel settore centro-occidentale ed in quello sud-orientale, la presenza dei litotipi ghiaiosi (Tav. GEO.2 "Carta del tetto delle ghiaie") aventi consistenti spessori, fa sì che tale litotipo possa essere assimilato dal punto di vista sismico al sub-strato. In conseguenza di ciò, essendo le ghiaie presenti entro una profondità massima di 10 m dal piano campagna, dovremmo utilizzare le tabelle relative ad "Appennino e Margine Appenninico-Padano", nella quale sono riportati i vari fattori di amplificazione per le diverse profondità a partire da V_{s5} ,... V_{s10} ecc.

La rimanente parte centro-orientale del territorio comunale, così come risulta in prima analisi e come confermato dalle misure HVRs, è considerata parte della "Pianura Padana e Costa Adriatica" ed in particolare come Pianura 1 dove il substrato è inferiore ai 100 metri.

Nello specifico per il computo dei fattori di amplificazione sono state utilizzate le tabelle dell'allegato A2 contenute nell'atto sopra citato, facendo riferimento in particolare per il comune di Formigine, ai valori riferiti per gli Ambiti qui di seguito riportati:



Appennino e Margine Appenninico – Padano

In caso di substrato marino caratterizzato da $V_s < 800$ m/s

F.A. P.G.A.

V_{sH}	200	250	300	350	400	450	500	600	700	800
5	2.0	1.7	1.5	1.4	1.3	1.2	1.2	1.2	1.1	1.0
10	2.3	2.0	1.8	1.6	1.5	1.4	1.3	1.2	1.1	1.0
15	2.5	2.2	1.9	1.8	1.6	1.5	1.4	1.2	1.1	1.0

F.A. INTENSITA' SPETTRALE $0.1s < T_0 < 0.5s$

V_{sH}	200	250	300	350	400	450	500	600	700	800
5	1.7	1.5	1.4	1.4	1.4	1.3	1.3	1.2	1.1	1.0
10	2.2	1.9	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1.0
15	2.6	2.2	1.9	1.7	1.6	1.5	1.4	1.2	1.1	1.0

F.A. INTENSITA' SPETTRALE $0.5s < T_0 < 1.0s$

V_{sH}	200	250	300	350	400	450	500	600	700	800
5	1.4	1.4	1.4	1.4	1.4	1.3	1.3	1.2	1.1	1.0
10	1.6	1.5	1.4	1.4	1.4	1.3	1.3	1.3	1.1	1.0
15	1.9	1.7	1.5	1.4	1.4	1.4	1.3	1.3	1.2	1.0

Pianura Padana e Costa Adriatica

In ambito di pianura caratterizzato da profilo stratigrafico costituito da presenza di potenti orizzonti di ghiaie (anche decine di metri) e da alternanze di sabbie e peliti, con substrato poco profondo (<100 m da p.c.) – PIANURA 1

F.A. P.G.A.

V_{s30}	200	250	300	350	400	450	500	600	700	800
F.A.	1.7	1.7	1.6	1.6	1.6	1.5	1.4	1.2	1.0	1.0

F.A. INTENSITA' SPETTRALE $0.1s < T_0 < 0.5s$

V_{s30}	200	250	300	350	400	450	500	600	700	800
F.A.	1.9	1.9	1.8	1.8	1.7	1.6	1.5	1.3	1.1	1.0

F.A. INTENSITA' SPETTRALE $0.5s < T_0 < 1.0s$

V_{s30}	200	250	300	350	400	450	500	600	700	800
F.A.	2.6	2.5	2.4	2.1	1.9	1.7	1.6	1.4	1.1	1.0

9 - MICROZONAZIONE SISMICA DI I° LIVELLO

Lo studio di microzonazione sismica eseguito nel Comune di Formigine ha prodotto, per ciò che riguarda il I° Livello, la realizzazione della “Carta delle aree potenzialmente soggette ad effetti locali” (Tav. GEO.1) legata essenzialmente agli aspetti litologici del territorio comunale. Inoltre è stata prodotta la già citata “Carta del tetto delle ghiaie” (Tav. GEO.2) che deriva da una precedente carta comunale opportunamente integrata con i risultati delle prove penetrometriche attualmente eseguite.

10 - MICROZONAZIONE SISMICA DI II° LIVELLO

Dopo aver realizzato lo studio del I° livello e per alcuni aspetti in contemporanea allo stesso, è stata eseguita la microzonazione di II° livello.

Prima di presentare direttamente i risultati di tale studio è necessario ricordare che le varie indagini eseguite sono sintetizzate nella “Planimetria delle indagini” (Tav. GEO.3) e che una parte di queste (misure HVSR) hanno permesso di redigere una tavola propedeutica alle successive e cioè la “Carta del periodo fondamentale di vibrazione” (Tav. GEO.4).

Lo studio di microzonazione sismica di II° livello del comune di Formigine ha portato, infine, alla realizzazione delle carte dei **fattori di amplificazione** espressi sia in termini di **P.G.A.** sia in termini di **Intensità di Housner**.

Per la redazione delle carte di microzonazione è stato necessario in un primo momento suddividere l'intera area comunale nei vari ambiti di appartenenza come stabilito nell'Atto di Indirizzo e Coordinamento Tecnico n. 112/2007. Tale suddivisione, già descritta in precedenza, ha portato all'individuazione di due ambiti (fig 10) facenti parte uno del settore dell' **“Appennino e Margine Appenninico – Padano”** (con substrato marino affiorante caratterizzato da velocità delle onde S minore di 800 m/s) ed uno della **Pianura Padana e Costa Adriatica** (Pianura 1).

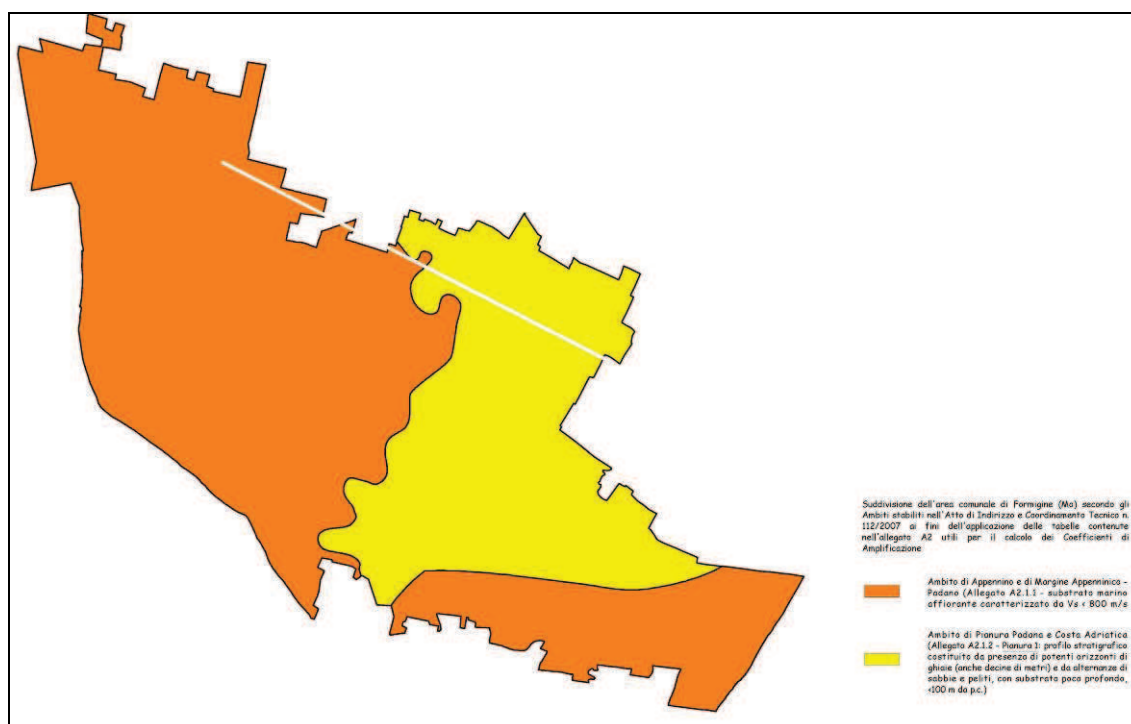
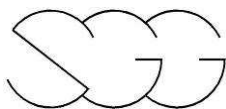


Figura 10: Individuazione degli ambiti per il comune di Formigine

Una volta effettuata questa suddivisione in ambiti, si è provveduto a definire i fattori di amplificazione sismica, per ciascuna area individuata, tramite l'applicazione delle tabelle in funzione dei valori di V_{sH} e V_{s30} ottenuti elaborando i dati delle prove MASW eseguite su tutto il territorio comunale. Questi fattori sono stati espressi sia in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0) (Tav. GEO.5) sia in termini di Intensità di Housner per intervalli di tempo compresi tra $0.1s < T_0 < 0.5s$ (Tav. GEO.6) e $0.5s < T_0 < 1.0s$ (Tav. GEO.7).

Il risultato finale è constatato pertanto nella produzione di tre carte di microzonazione, dove tramite campitura in colori diversi, i valori dei fattori di amplificazione sismica sono stati estesi su tutto il territorio comunale.

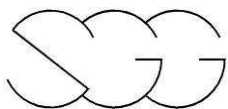
Al termine del secondo livello dello studio di microzonazione sismica viene redatta la "Carta dei livelli di approfondimento" (Tav. GEO.8) nella quale



vengono evidenziate le zone soggette ad un eventuale approfondimento di III° livello. Si fa presente che per la redazione della stessa, si è tenuto conto degli elementi emersi con le varie indagini eseguite ed in particolare della “Carta delle aree potenzialmente soggette ad effetti locali” (Tav. GEO.1).

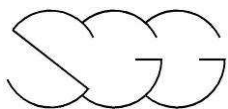
Nell’elaborato “Carta dei livelli di approfondimento” è stata perciò identificata un’area che necessita l’approfondimento di III° livello per problematiche legate alla liquefazione.

Dr. Geol. Antonio Maria Baldi



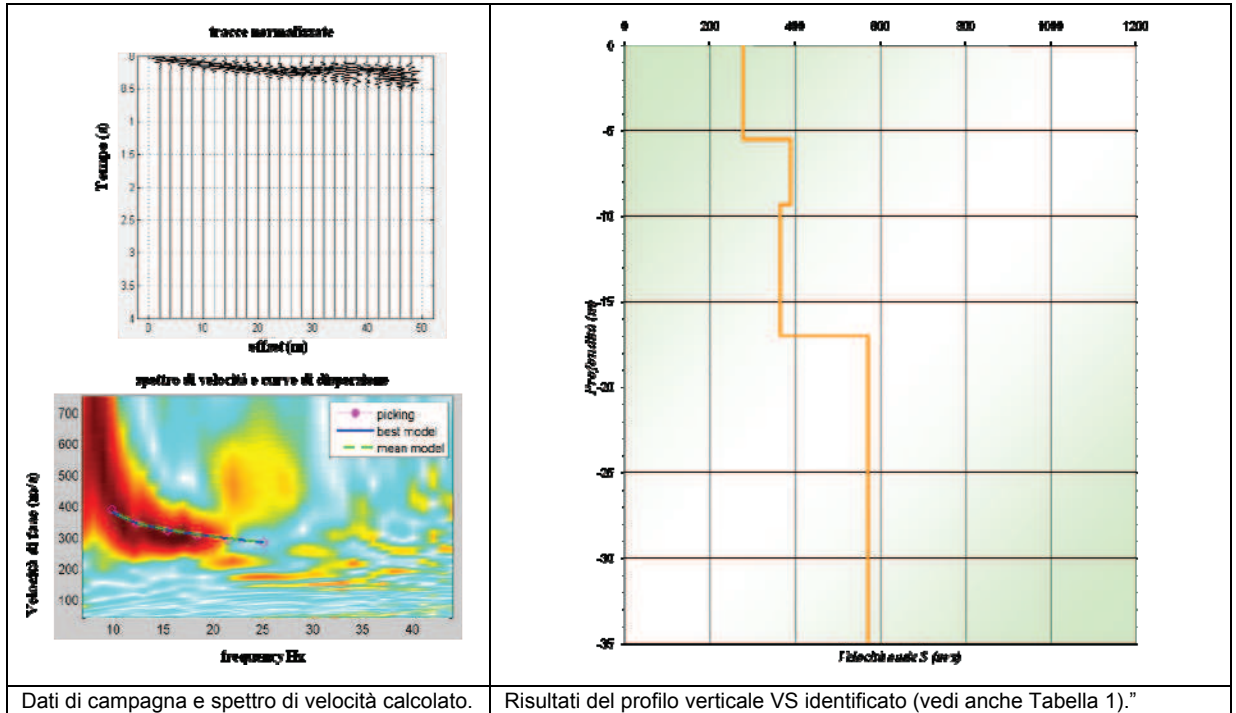
Appendice 1

- | | |
|--------------------------------|----------|
| - Prove Masw | Pag. 27 |
| - Misure HVSR | Pag. 57 |
| - Prove penetrometriche | Pag. 182 |



PROVE MASW

Masw 1:



Spessore (m)	V_s (m/s)
5.5	277
3.8	389
7.7	364
semispazio	570

Tab. 1. Modello medio individuato (V_{s30} dal p.c.: **408 m/s**).

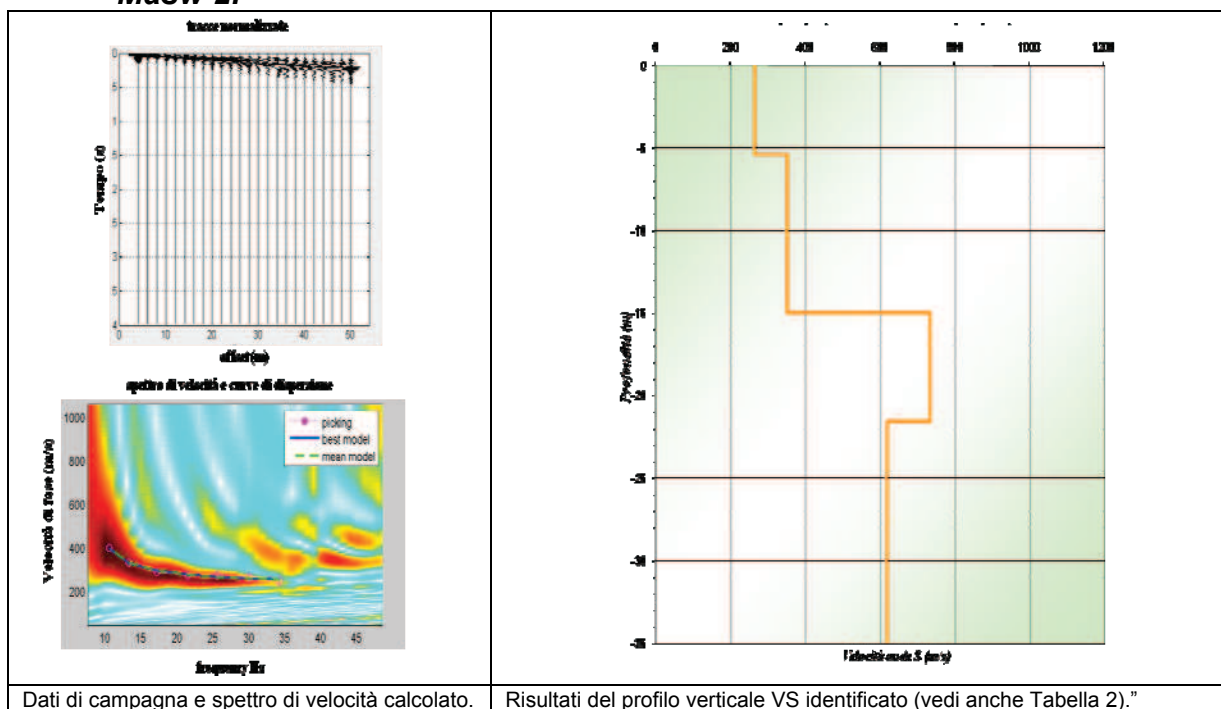
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
F.A. P.G.A. = 1.6
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$\text{F.A. INTENSITA' SPETTRALE } 0.1s < T_0 < 0.5s = 1.7$$

$$\text{F.A. INTENSITA' SPETTRALE } 0.5s < T_0 < 1.0s = 1.9$$

Masw 2:



Spessore (m)	V_s (m/s)
5.4	264
9.6	351
6.6	733
semispazio	618

Tab. 2. Modello medio individuato (V_{s30} dal p.c.: 426 m/s).

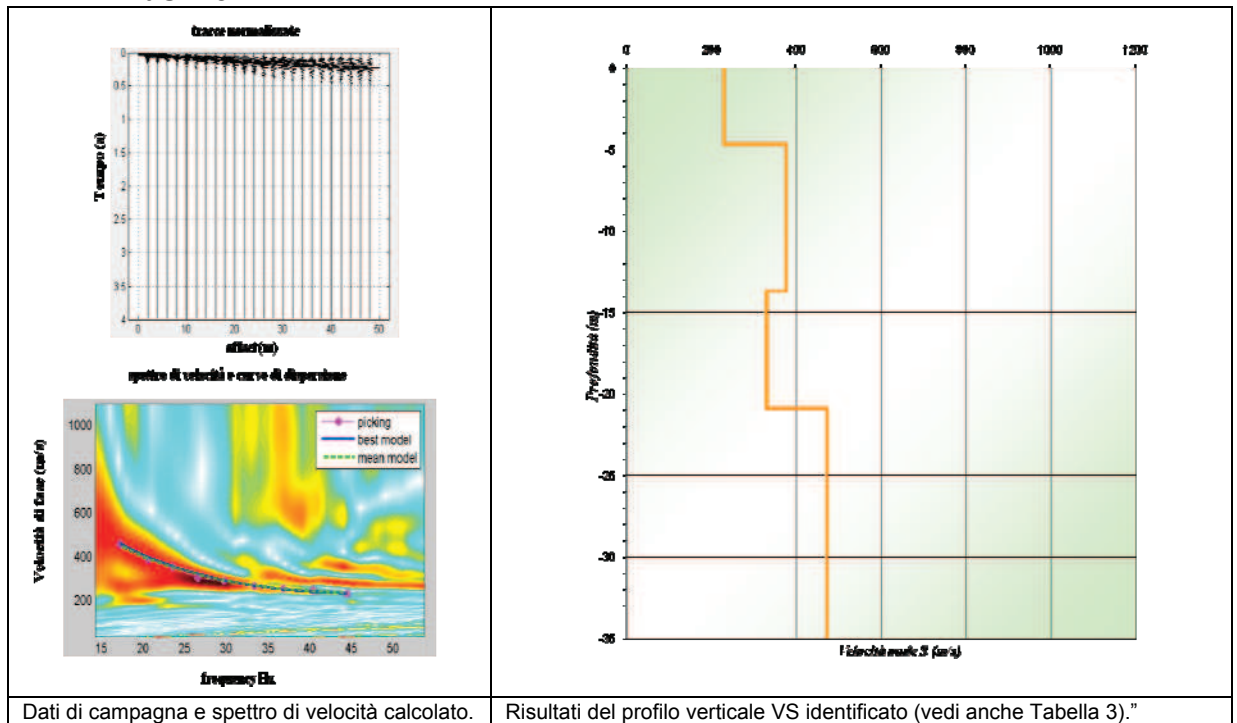
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
 $F.A. P.G.A. = 1.6$
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.7$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.9$$

Masw 3:



Spessore (m)	V_s (m/s)
4.7	229
9.0	376
7.2	330
semispazio	472

Tab. 3. Modello medio individuato (V_{s30} dal p.c.: **351 m/s**).

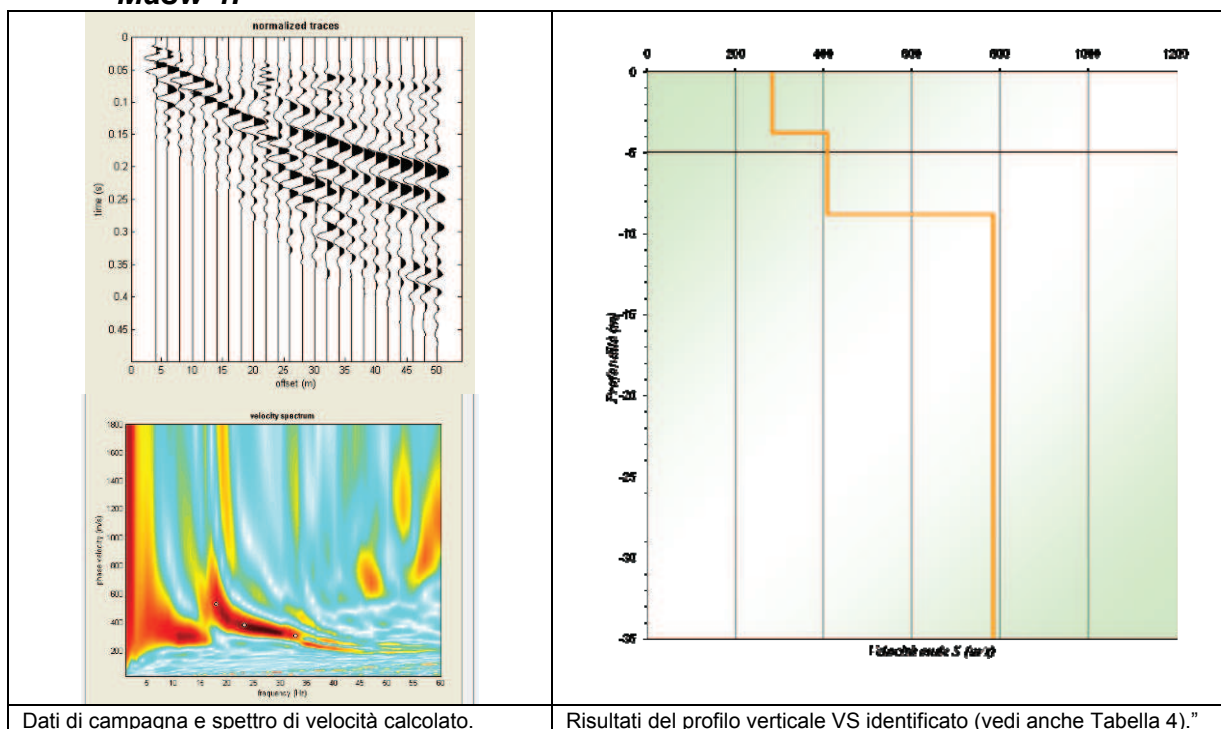
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
F.A. P.G.A. = 1.6
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.8$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 2.1$$

Masw 4:



Spessore (m)	Vs (m/s)
3.8	284
5.0	409
semispazio	785

Tab. 4. Modello medio individuato (Vs₃₀ dal p.c.: **570 m/s**).

Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA₀):

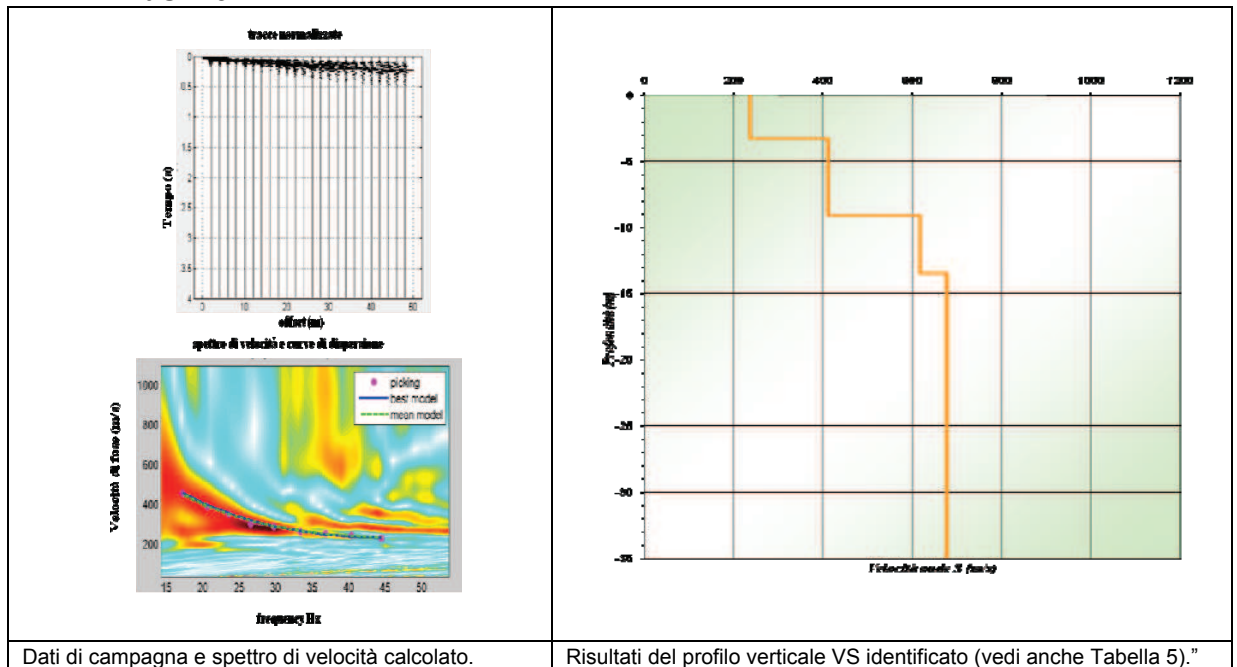
$$F.A. P.G.A. = 1.4$$

- in termini di rapporto di Intensità di Housner (SI/SI₀) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.5$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.6$$

Masw 5:



Spessore (m)	V_s (m/s)
3.3	237
5.8	412
4.4	619
semispazio	678

Tab. 5. Modello medio individuato (V_{s30} dal p.c.: 505 m/s).

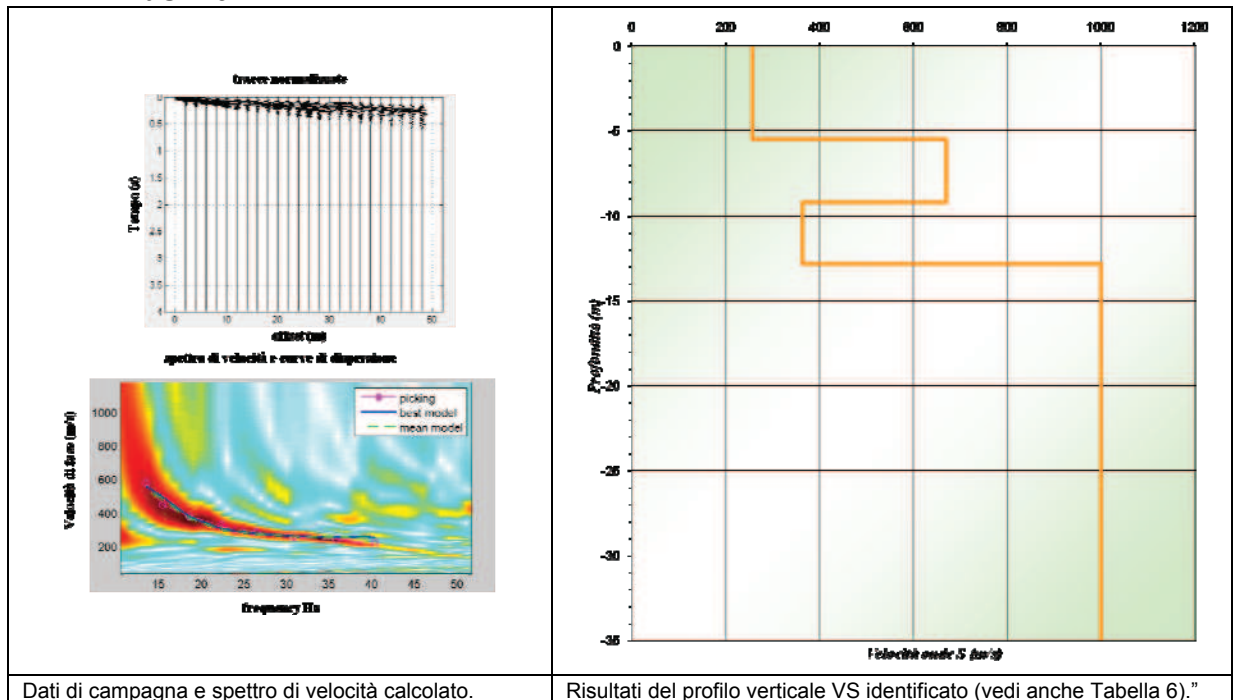
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
 $F.A. P.G.A. = 1.4$
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.5$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.6$$

Masw 6:



Spessore (m)	V_s (m/s)
5.5	257
3.7	671
3.6	364
semispazio	1000

Tab. 6. Modello medio individuato (V_{s30} dal p.c.: **521 m/s**).

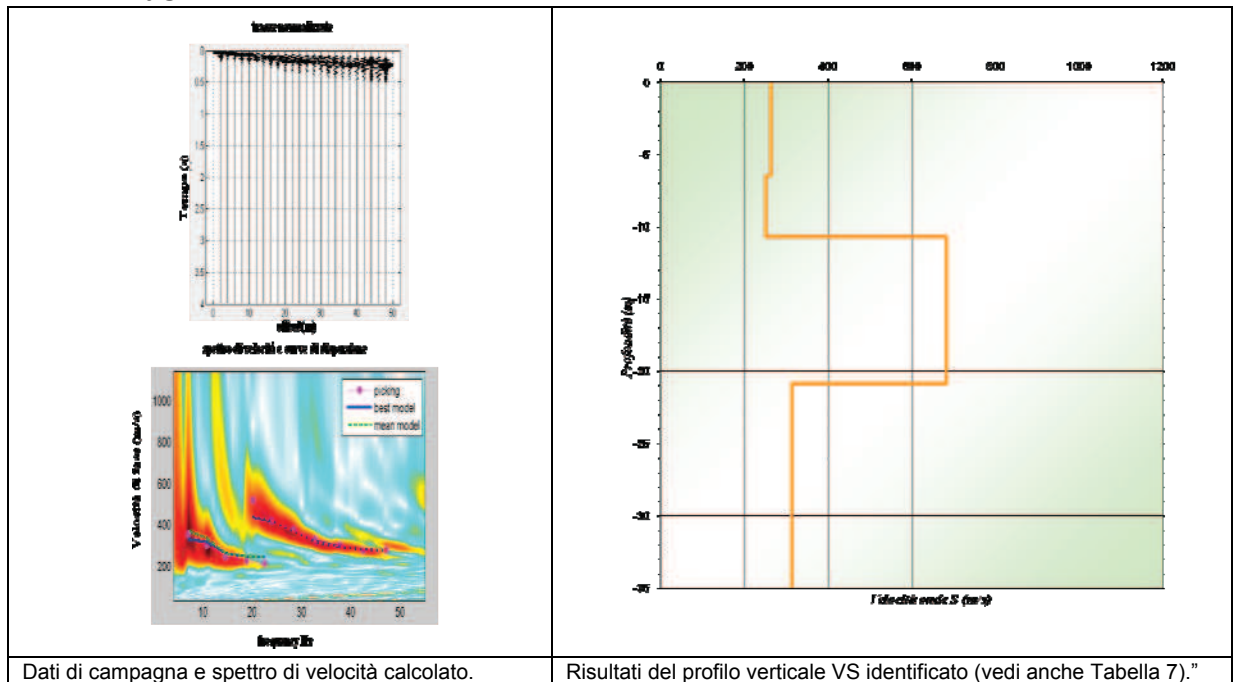
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
F.A. P.G.A. = 1.4
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.5$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.6$$

Masw 7:



Spessore (m)	V_s (m/s)
6.5	263
4.2	250
10.2	682
semispazio	313

Tab. 7. Modello medio individuato (V_{s30} dal p.c.: **351 m/s**).

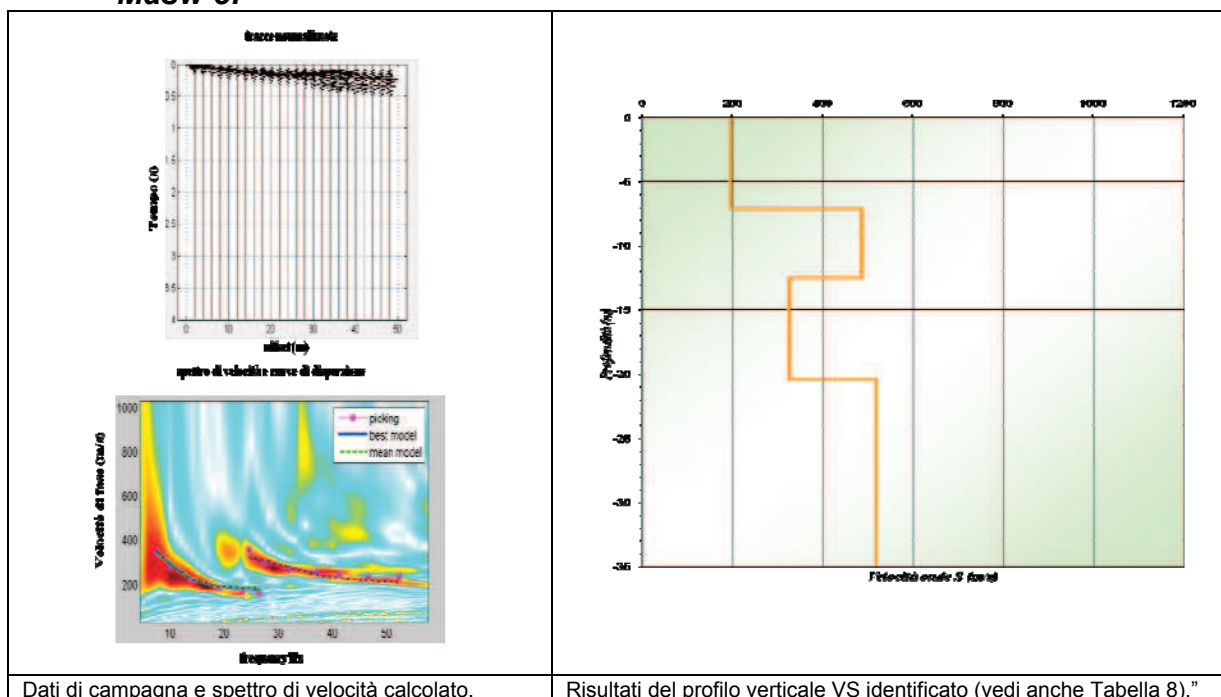
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
F.A. P.G.A. = 1.6
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$\text{F.A. INTENSITA' SPETTRALE } 0.1s < T_0 < 0.5s = \mathbf{1.8}$$

$$\text{F.A. INTENSITA' SPETTRALE } 0.5s < T_0 < 1.0s = \mathbf{2.1}$$

Masw 8:



Spessore (m)	Vs (m/s)
7.1	196
5.4	485
7.9	326
semispazio	518

Tab. 8. Modello medio individuato (V_{S30} dal p.c.: **333 m/s**).

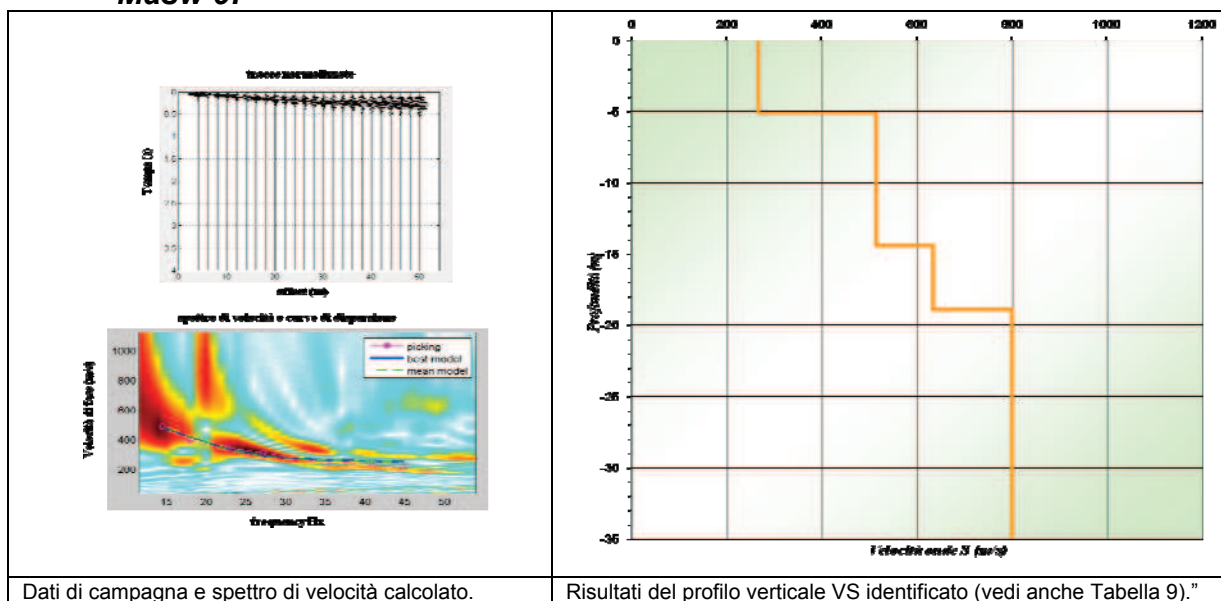
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
F.A. P.G.A. = 1.6
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.8$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 2.4$$

Masw 9:



Spessore (m)	V_s (m/s)
5.1	265
9.3	514
4.5	633
semispazio	799

Tab. 9. Modello medio individuato (V_{s8} dal p.c.: 321 m/s).

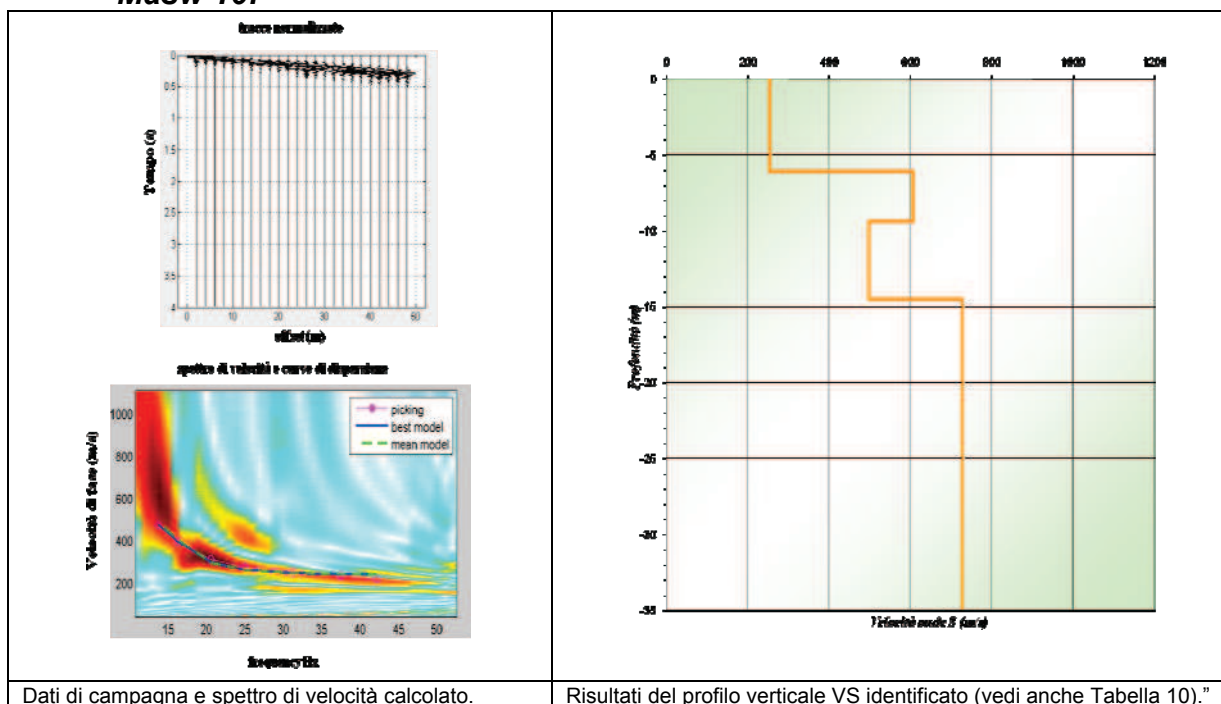
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
 $F.A. P.G.A. = 2.0$
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.9$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.5$$

Masw 10:



Spessore (m)	V_s (m/s)
6.1	255
3.3	608
5.1	499
semispazio	729

Tab. 10. Modello medio individuato (V_{s6} dal p.c.: 255 m/s).

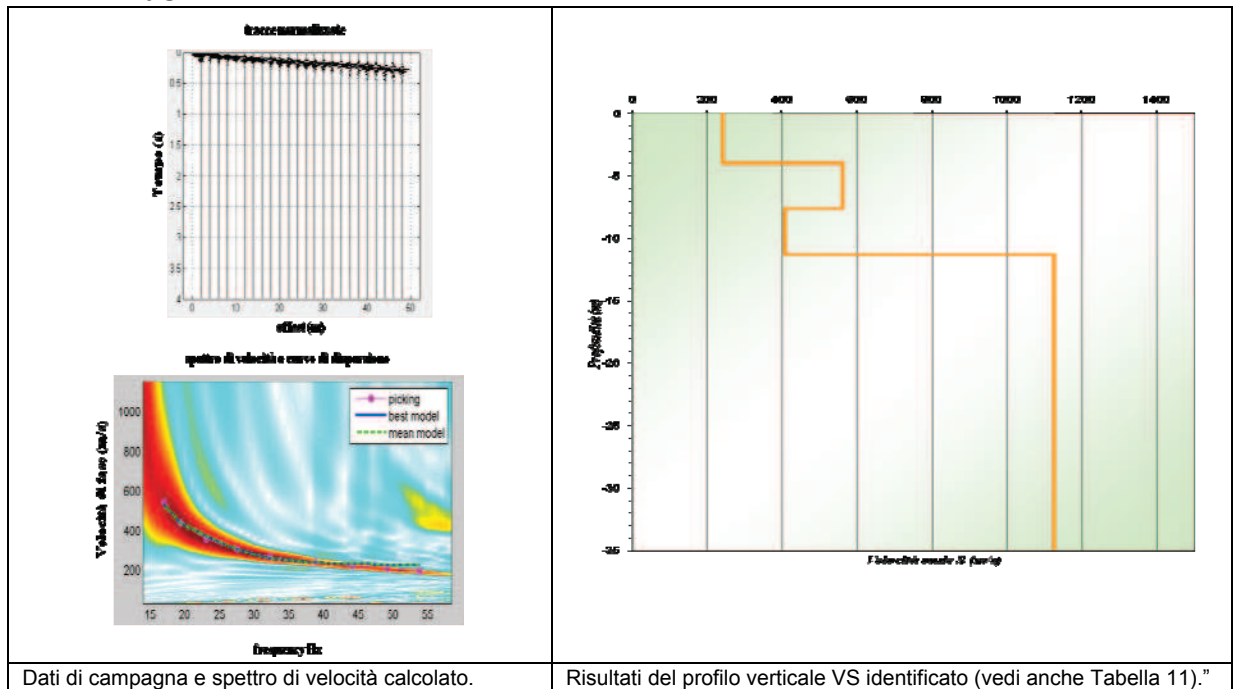
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
 $F.A. P.G.A. = 2.0$
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.9$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.5$$

Masw 11:



Spessore (m)	V_s (m/s)
3.1	241
6.0	561
3.6	407
semispazio	1126

Tab. 11. Modello medio individuato (V_{s3} dal p.c.: 241 m/s).

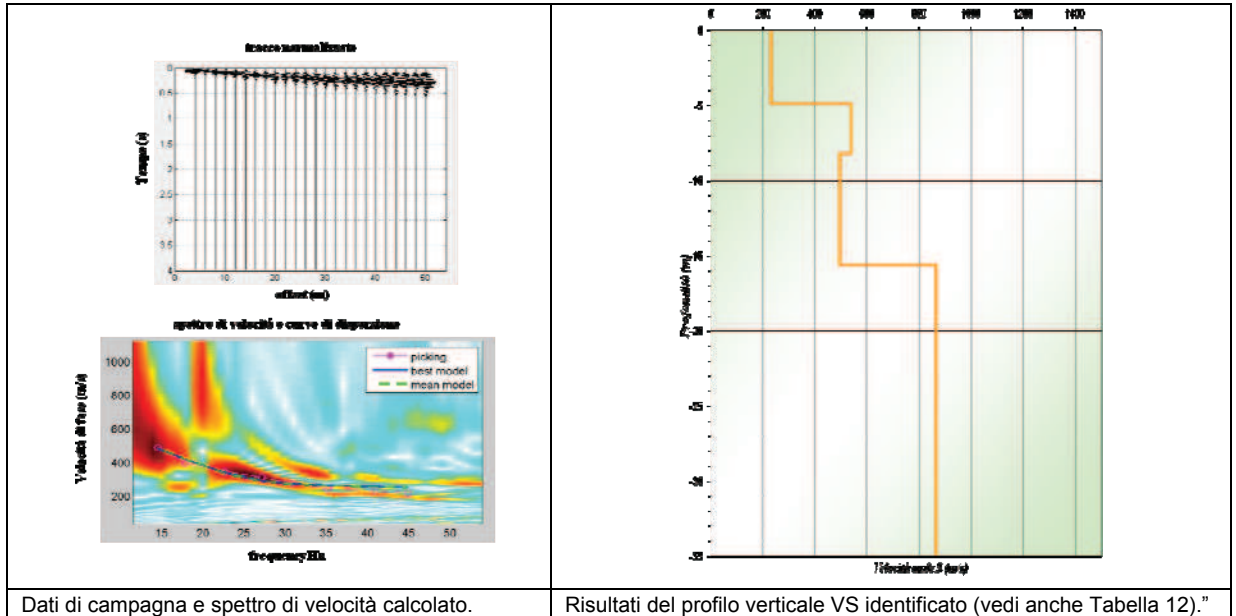
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
 $F.A. P.G.A. = 2.0$
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.7$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.4$$

Masw 12:



Spessore (m)	V_s (m/s)
4.9	232
3.3	540
7.4	496
semispazio	865

Tab. 12. Modello medio individuato (V_{s3} dal p.c.: 232 m/s).

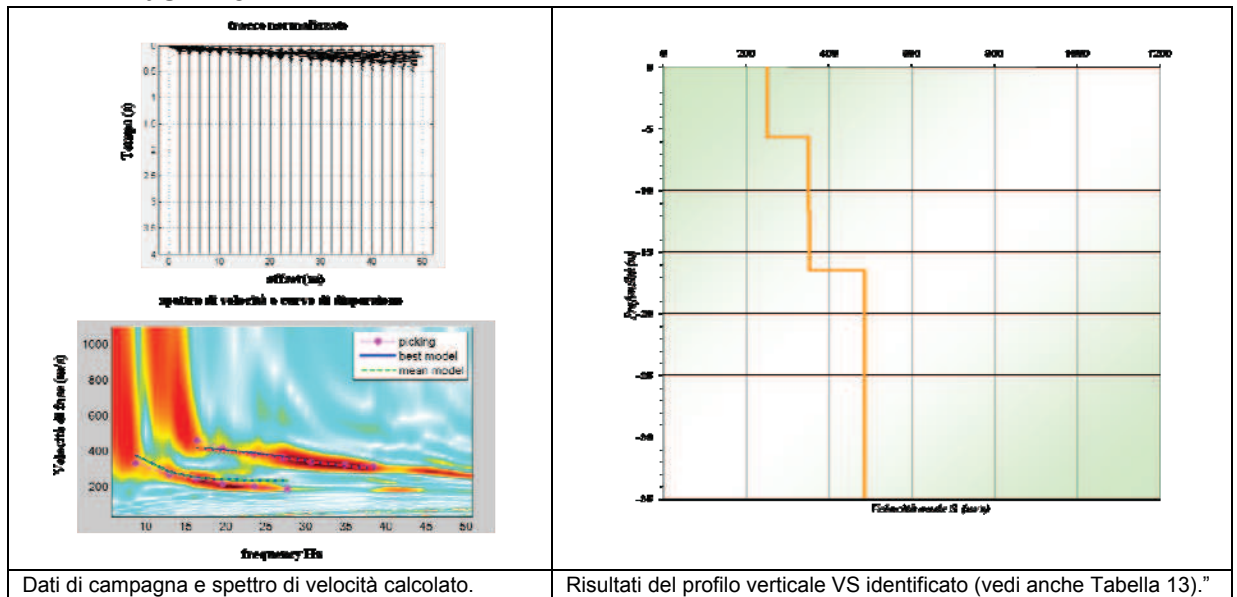
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
 $F.A. P.G.A. = 2.0$
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.7$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.4$$

Masw 13:



Spessore (m)	V_s (m/s)
5.7	250
6.0	350
4.8	353
semispazio	485

Tab. 13. Modello medio individuato (V_{s8} dal p.c.: 272 m/s).

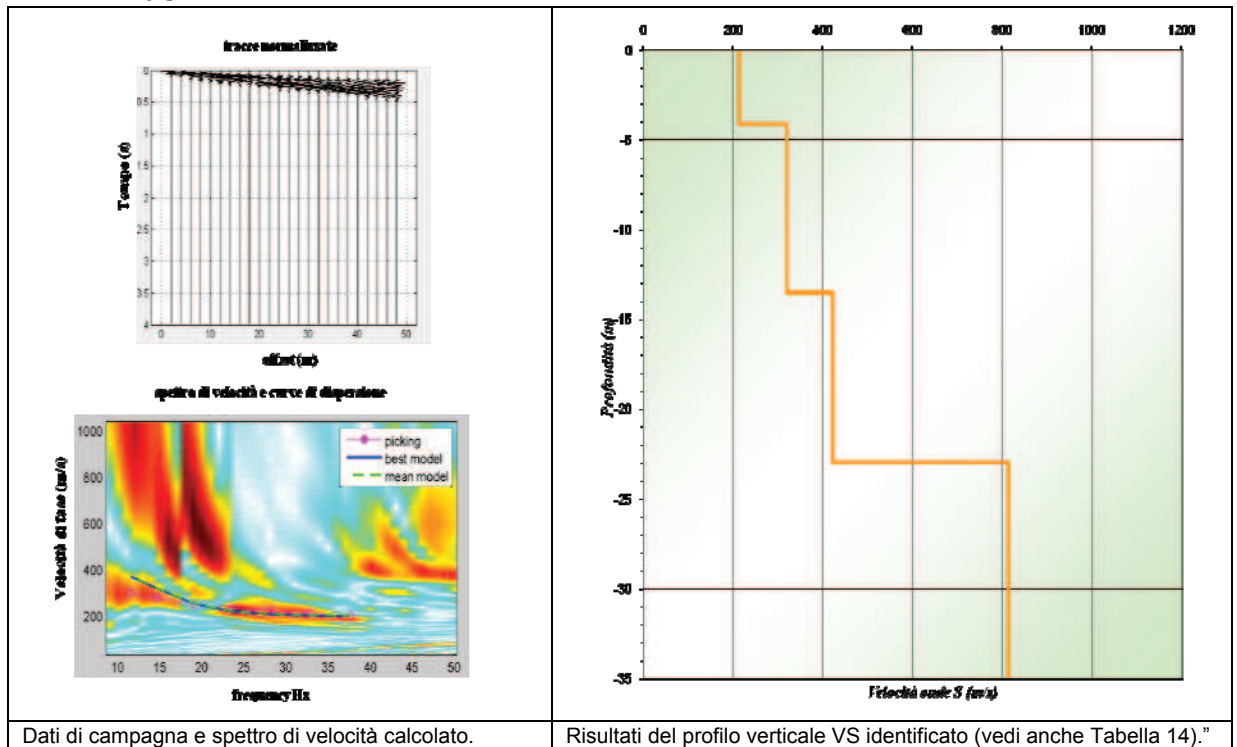
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
 $F.A. P.G.A. = 2.0$
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.9$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.5$$

Masw 14:



Spessore (m)	V_s (m/s)
4.1	214
9.4	321
9.5	422
semispazio	814

Tab. 14. Modello medio individuato (V_{s5} dal p.c.: 228 m/s).

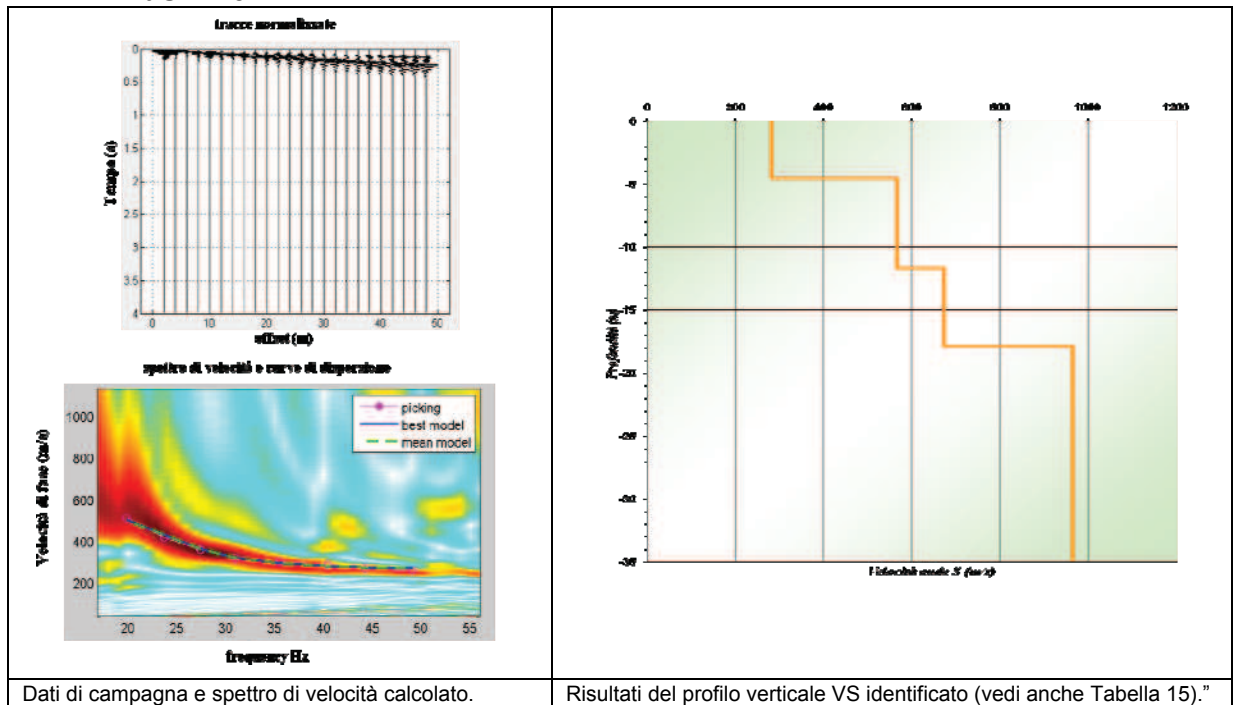
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
 $F.A. P.G.A. = 2.0$
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.7$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.4$$

Masw 15:



Spessore (m)	V_s (m/s)
4.7	283
7.0	567
6.2	674
semispazio	965

Tab. 15. Modello medio individuato (V_{s5} dal p.c.: 292 m/s).

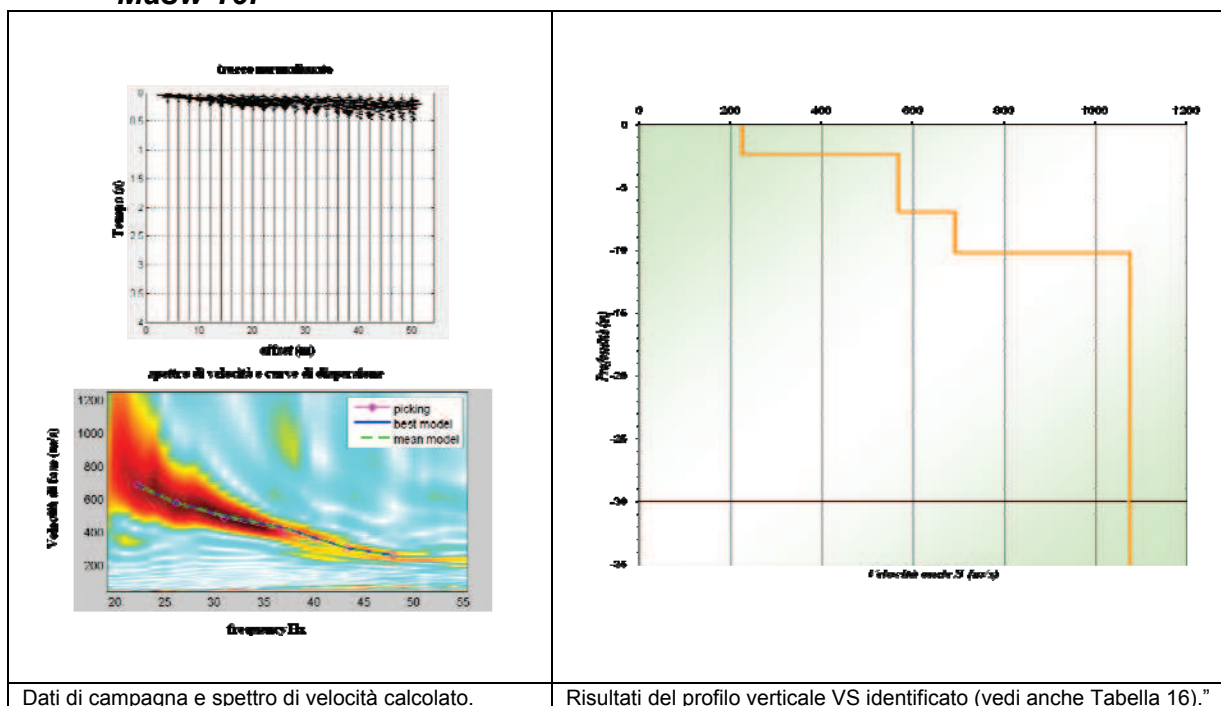
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
 $F.A. P.G.A. = 1.7$
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.5$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.4$$

Masw 16:



Spessore (m)	Vs (m/s)
2.4	225
4.6	567
3.2	692
semispazio	1075

Tab. 16. Modello medio individuato (V_{s2} dal p.c.: 225 m/s).

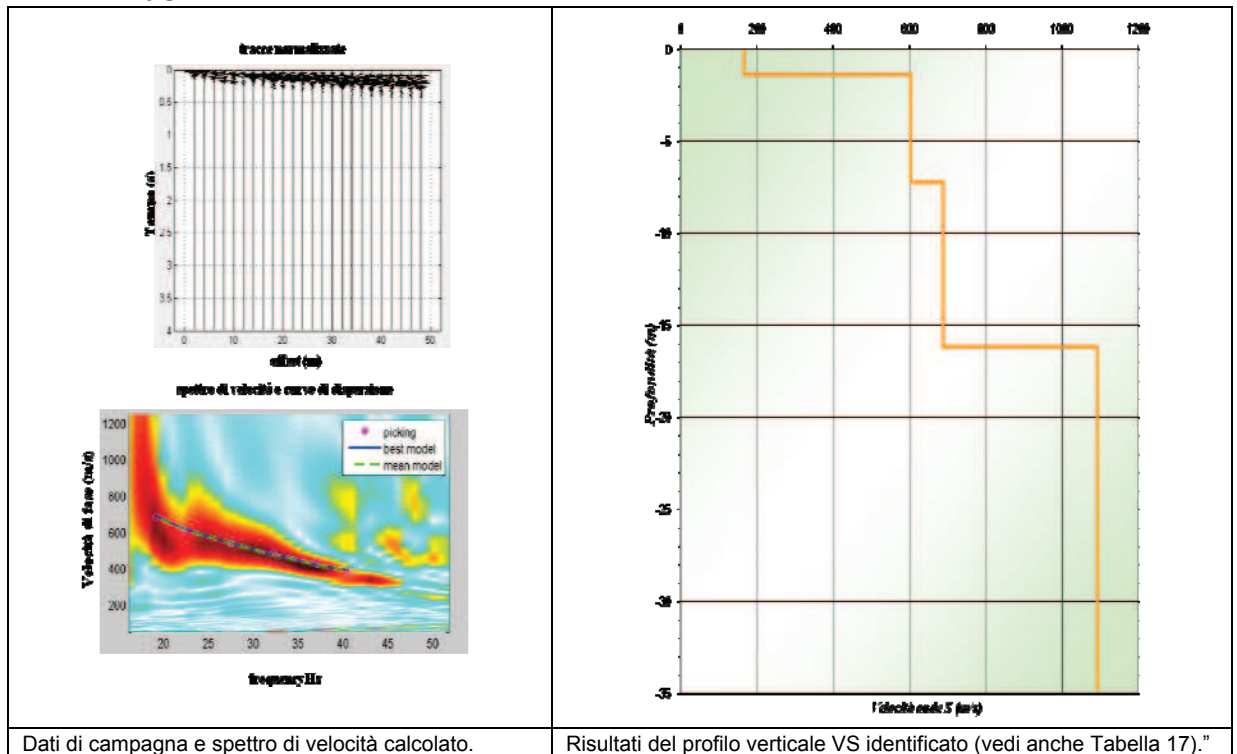
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
 $F.A. P.G.A. = 2.0$
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.7$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.4$$

Masw 17:



Spessore (m)	V_s (m/s)
1.2	166
5.8	602
9.0	688
semispazio	1093

Tab. 17. Modello medio individuato (V_{s1} dal p.c.: **166 m/s**).

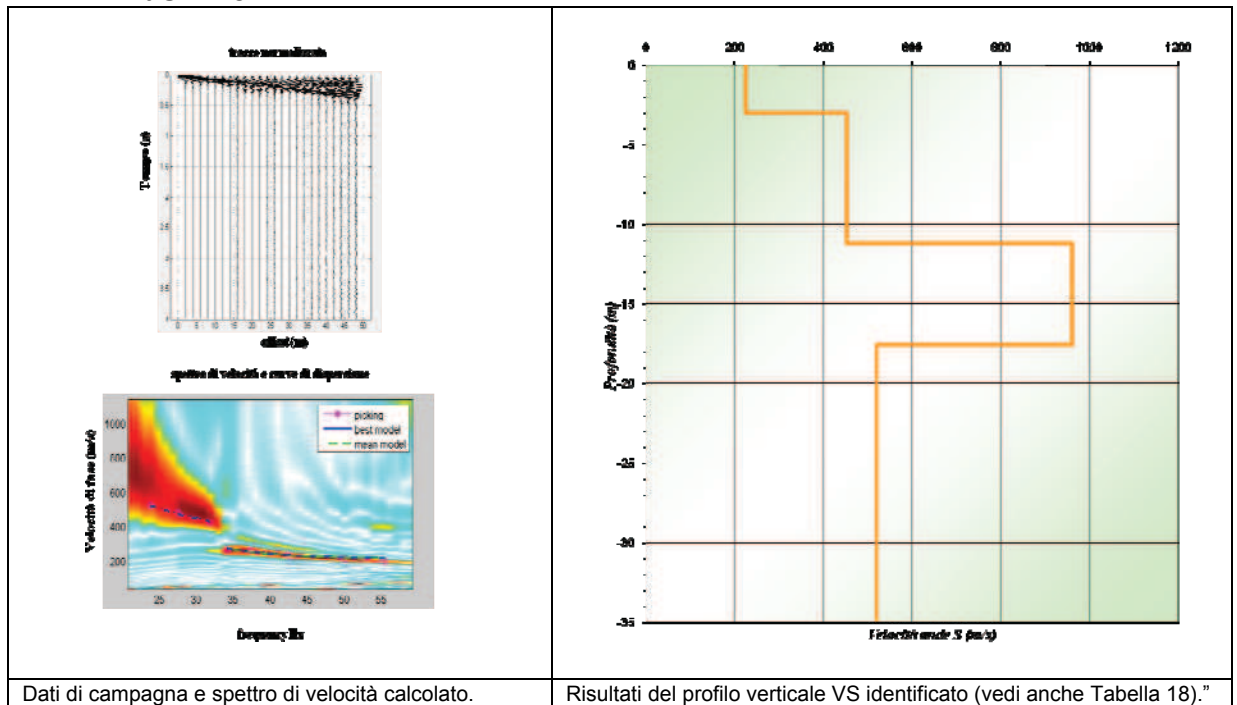
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
 $F.A. P.G.A. = 2.0$
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.7$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.4$$

Masw 18:



Spessore (m)	V_s (m/s)
3.0	225
8.2	453
6.4	961
semispazio	521

Tab. 18. Modello medio individuato (V_{s3} dal p.c.: 225 m/s).

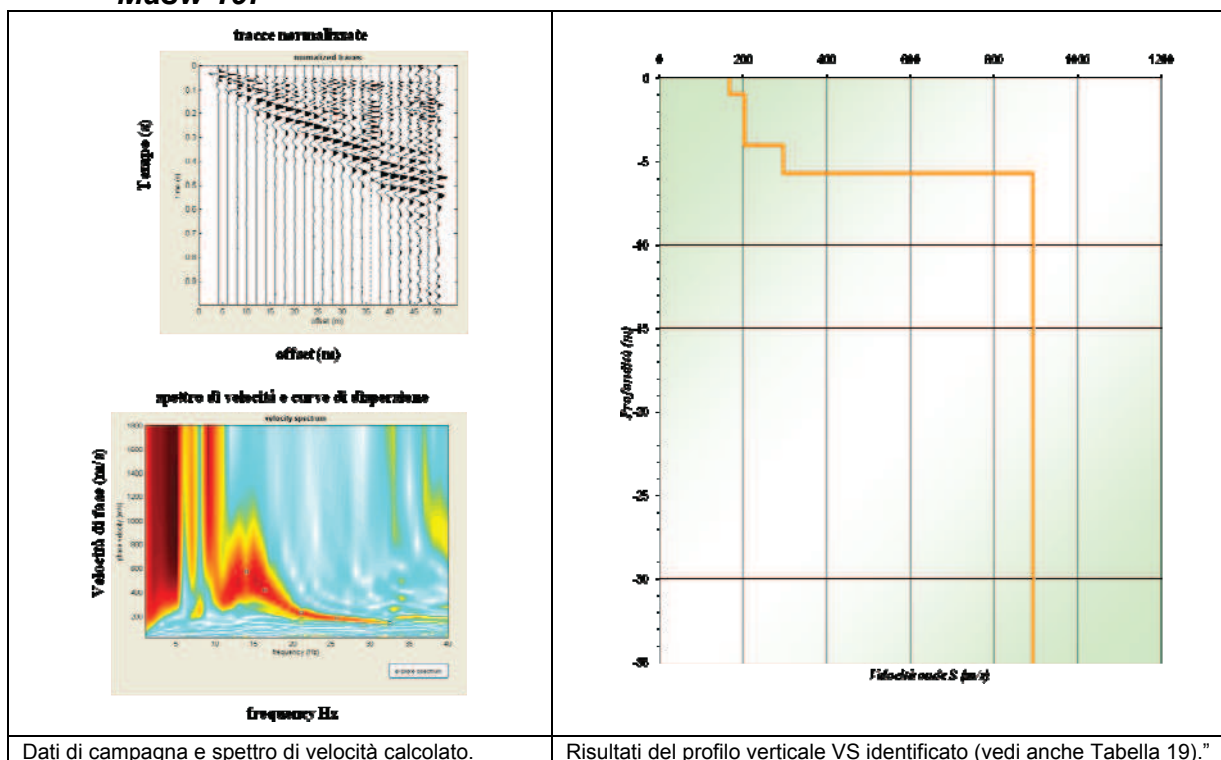
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
 $F.A. P.G.A. = 2.0$
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.7$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.4$$

Masw 19:



Spessore (m)	V_s (m/s)
1.0	167
3.0	203
1.7	296
semispazio	893

Tab. 19. Modello medio individuato (V_{s5} dal p.c.: 207 m/s).

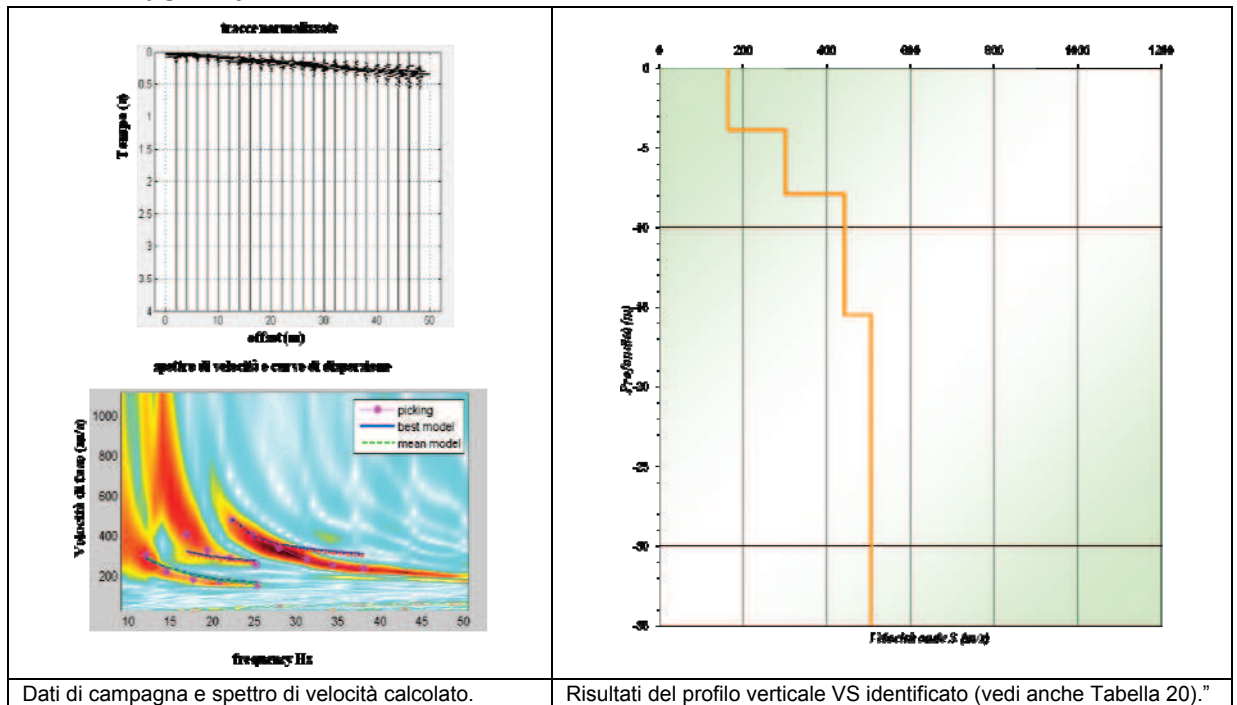
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
 $F.A. P.G.A. = 2.0$
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.7$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.4$$

Masw 20:



Spessore (m)	V_s (m/s)
3.9	165
4.0	301
7.6	443
semispazio	506

Tab. 20. Modello medio individuato (V_{s3} dal p.c.: **165 m/s**).

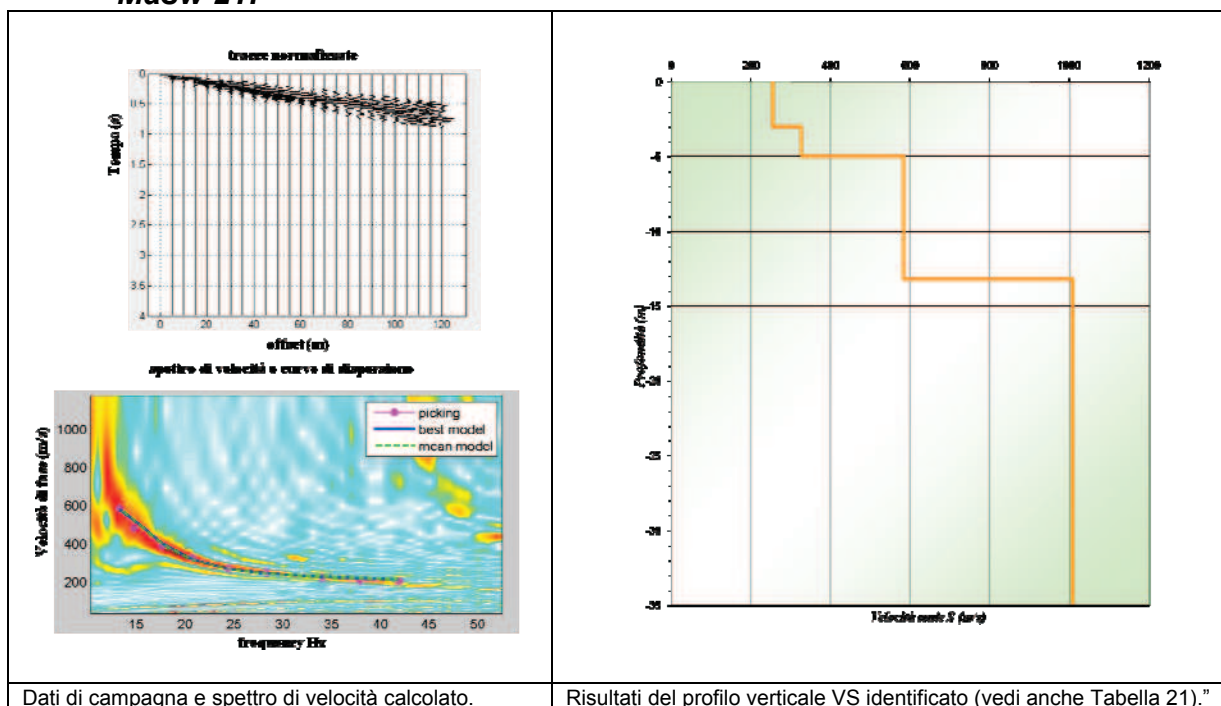
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
F.A. P.G.A. = 2.0
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.7$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.4$$

Masw 21:



Spessore (m)	V_s (m/s)
3.0	256
2.0	327
8.2	583
semispazio	1008

Tab. 21. Modello medio individuato (V_{s4} dal p.c.: 271 m/s).

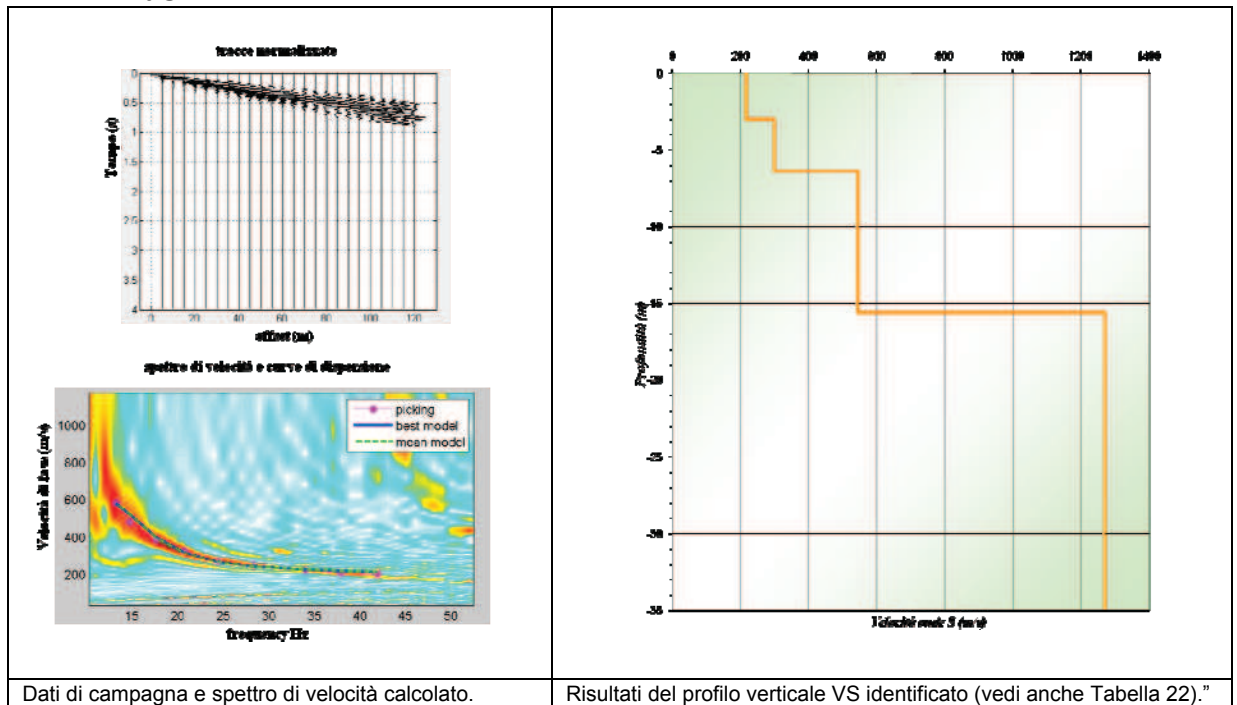
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
 $F.A. P.G.A. = 1.7$
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.5$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.4$$

Masw 22:



Spessore (m)	V_s (m/s)
3.0	217
3.4	300
9.2	544
semispazio	1270

Tab. 22. Modello medio individuato (V_{s6} dal p.c.: 258 m/s).

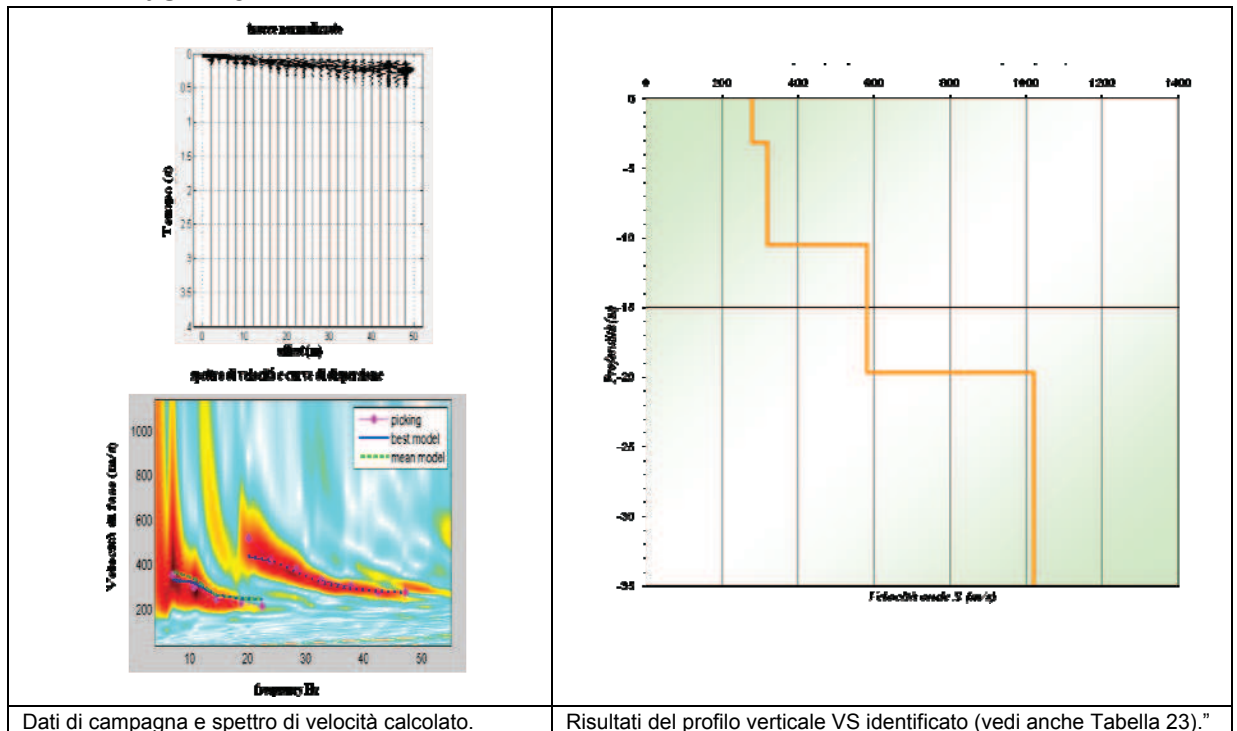
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
 $F.A. P.G.A. = 2.0$
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.9$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.5$$

Masw 23:



Dati di campagna e spettro di velocità calcolato.

Risultati del profilo verticale VS identificato (vedi anche Tabella 23)."

Spessore (m)	V_s (m/s)
3.2	279
7.3	320
9.2	582
semispazio	1021

Tab. 23. Modello medio individuato (V_{s3} dal p.c.: **279 m/s**).

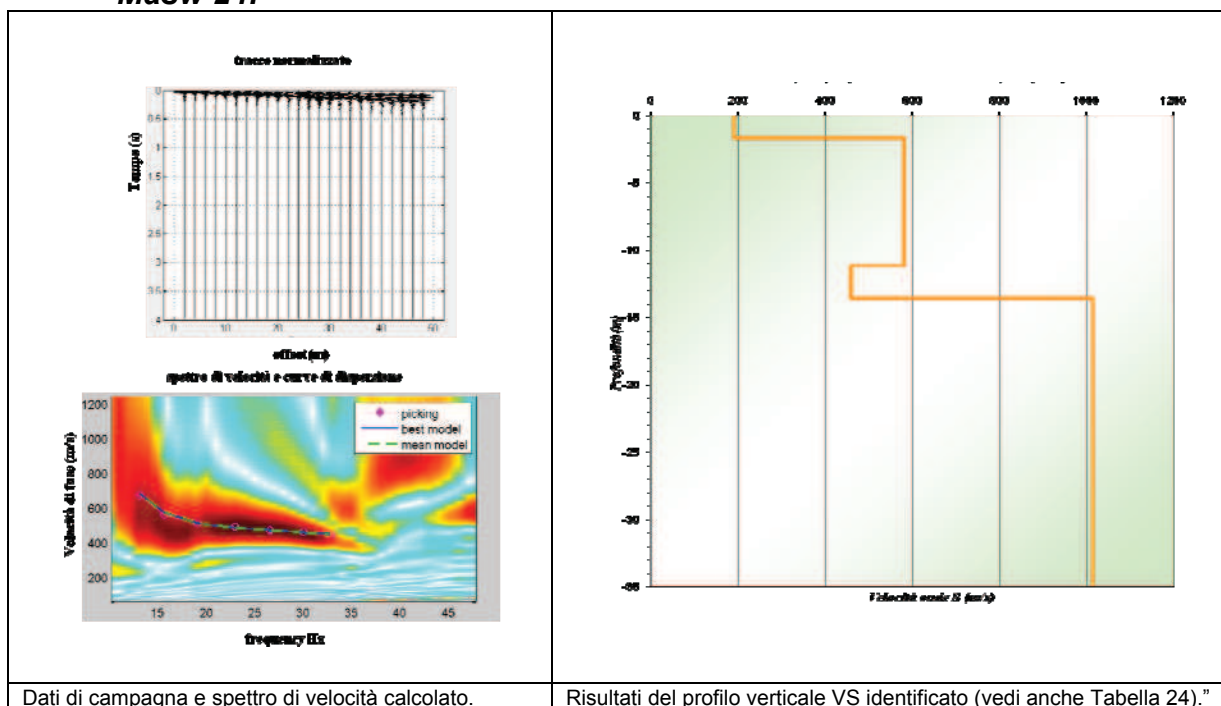
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
 $F.A. P.G.A. = 1.7$
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.5$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.4$$

Masw 24:



Spessore (m)	V_s (m/s)
1.7	190
9.5	581
2.4	458
semispazio	1013

Tab. 24. Modello medio individuato (V_{s1} dal p.c.: 190 m/s).

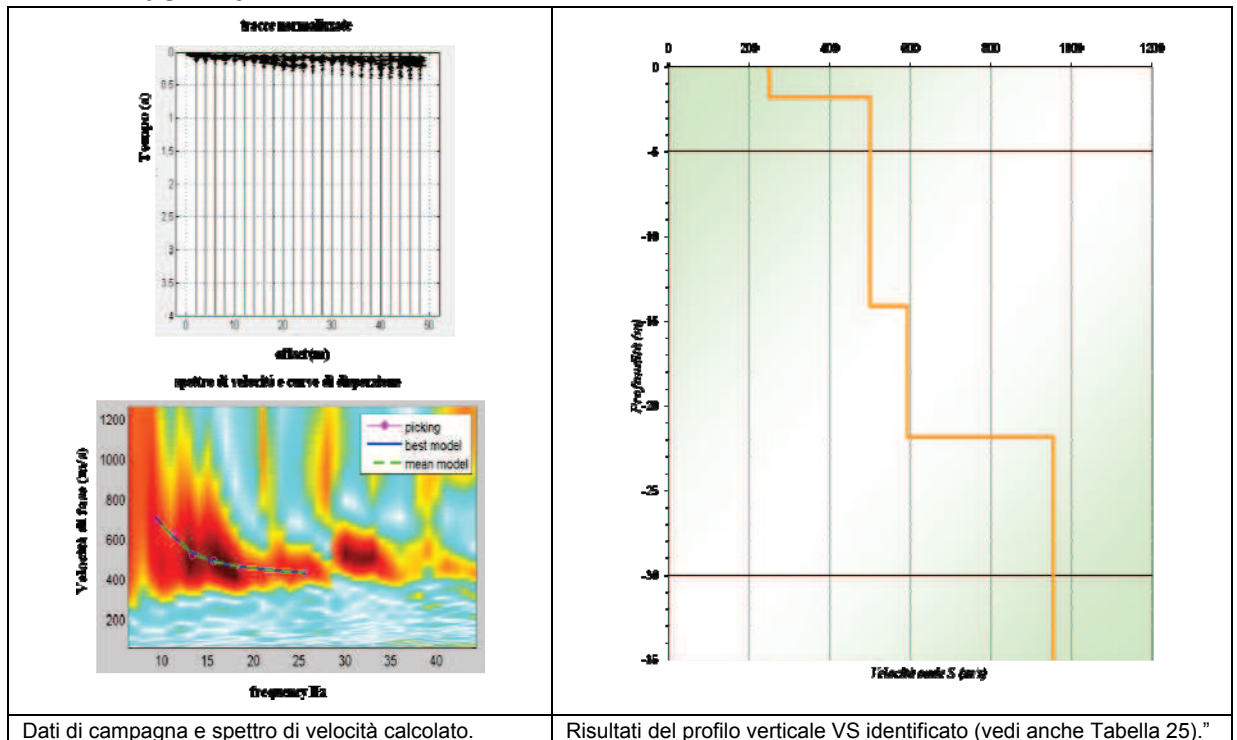
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
 $F.A. P.G.A. = 2.0$
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.7$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.4$$

Masw 25:



Dati di campagna e spettro di velocità calcolato.

Risultati del profilo verticale VS identificato (vedi anche Tabella 25)."

Spessore (m)	Vs (m/s)
1.7	190
9.5	581
2.4	458
semispazio	1013

Tab. 25. Modello medio individuato (V_{s2} dal p.c.: 250 m/s).

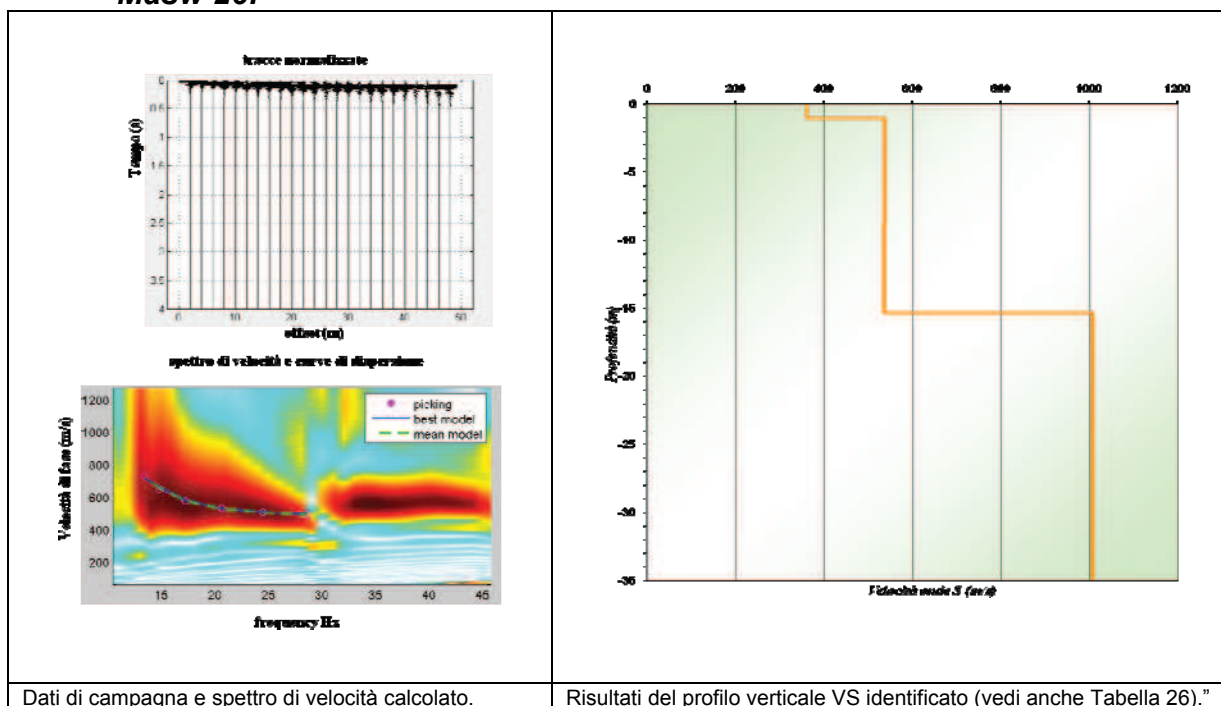
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
 $F.A. P.G.A. = 1.7$
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.5$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.4$$

Masw 26:



Spessore (m)	V_s (m/s)
1.1	361
7.8	537
6.5	535
semispazio	1006

Tab. 26. Modello medio individuato (V_{s1} dal p.c.: 361 m/s).

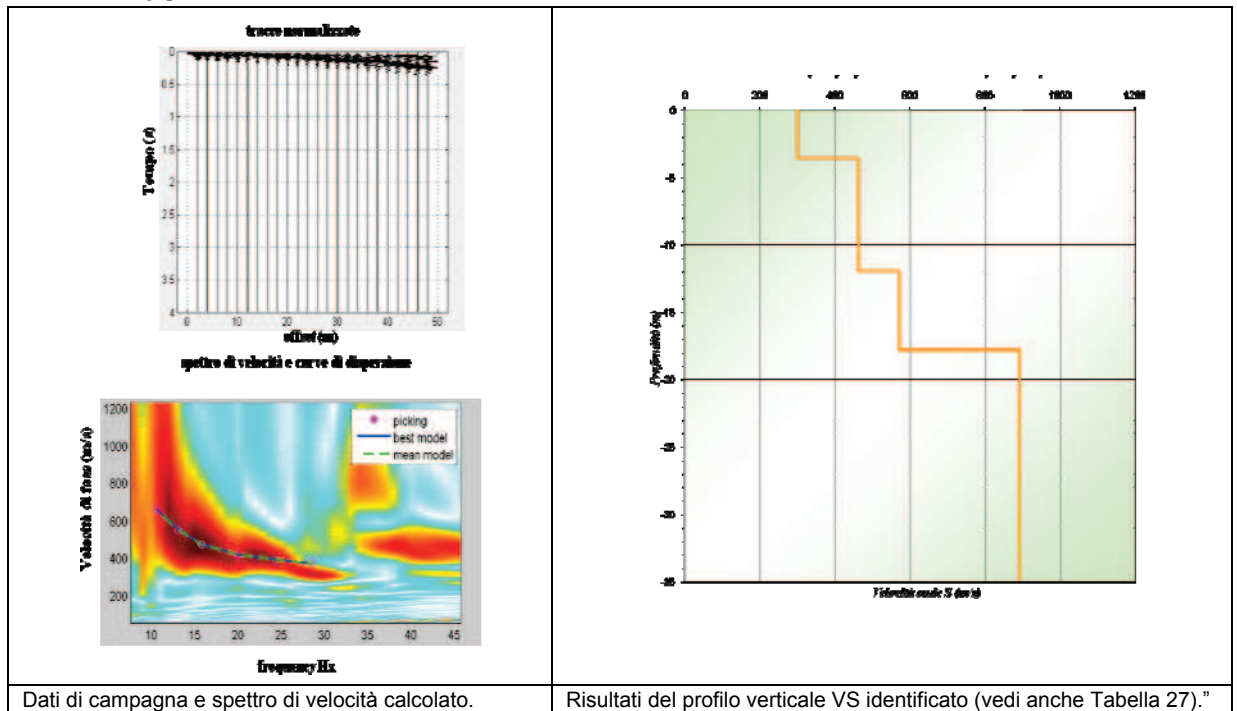
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
 $F.A. P.G.A. = 1.4$
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.4$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.4$$

Masw 27:



Spessore (m)	Vs (m/s)
3.6	300
8.3	462
5.9	572
semispazio	891

Tab. 27. Modello medio individuato (V_{s3} dal p.c.: 300 m/s).

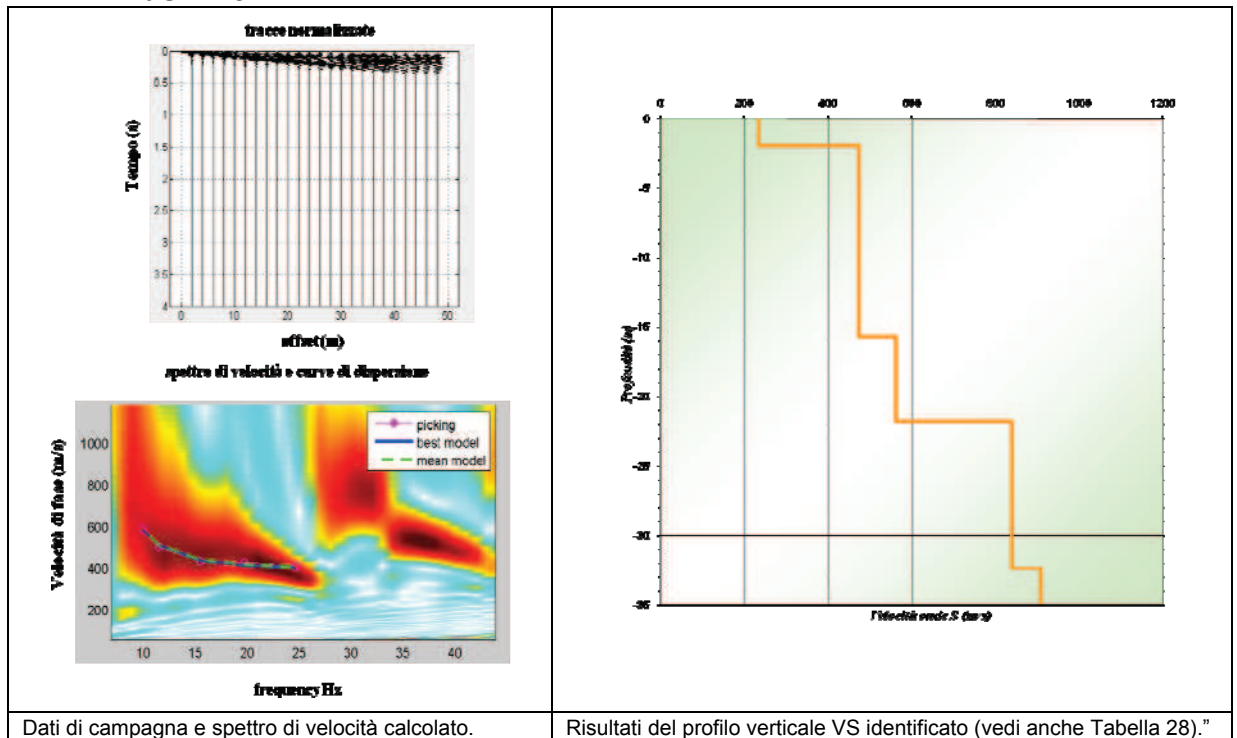
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
 $F.A. P.G.A. = 1.5$
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.4$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.4$$

Masw 28:



Spessore (m)	V_s (m/s)
2.0	235
13.7	473
6.1	542
10.6	839
semispazio	907

Tab. 28. Modello medio individuato (V_{s2} dal p.c.: 235 m/s).

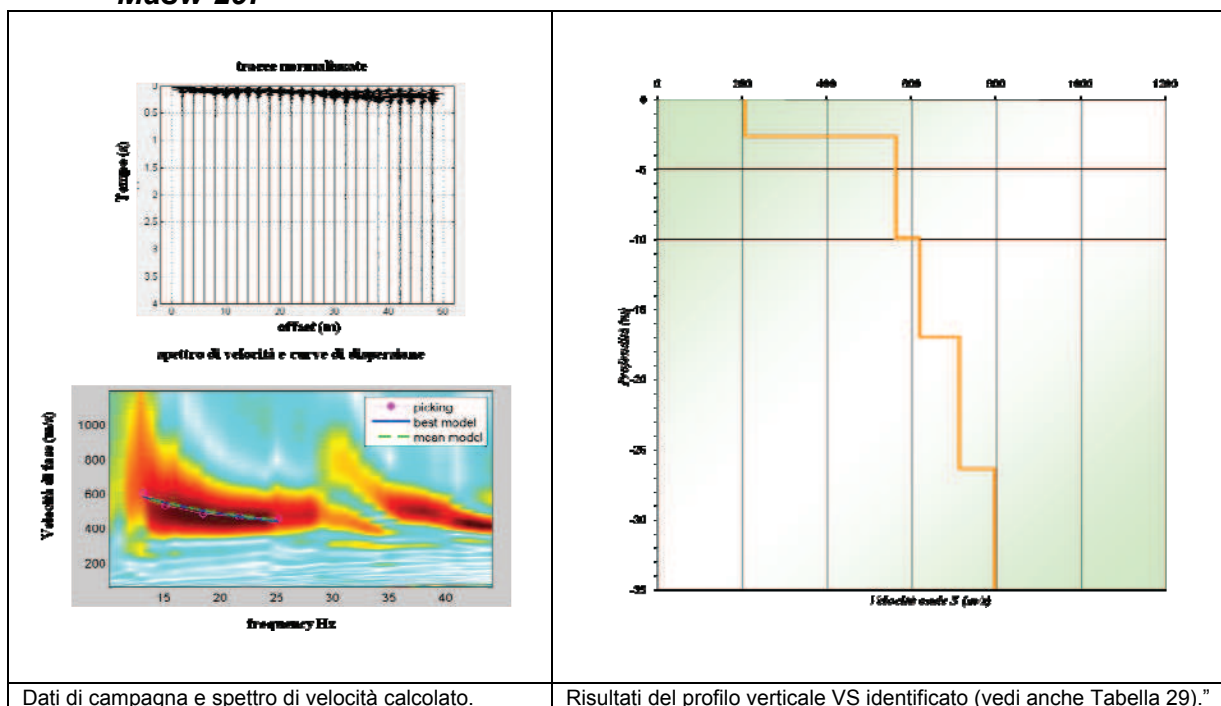
Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
 $F.A. P.G.A. = 2.0$
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.7$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.4$$

Masw 29:



Spessore (m)	Vs (m/s)
2.6	206
7.3	562
7.1	619
9.4	712
semispazio	796

Tab. 29. Modello medio individuato (V_{s2} dal p.c.: 206 m/s).

Per questo sito i coefficienti di amplificazione sismica (F.A.) risultano essere:

- in termini di rapporto di accelerazione massima orizzontale (PGA/PGA_0):
 $F.A. P.G.A. = 2.0$
- in termini di rapporto di Intensità di Housner (SI/SI_0) per prefissati intervalli di periodi:

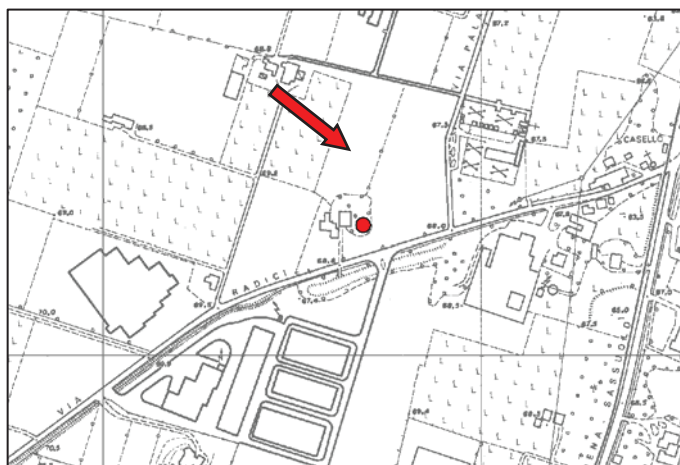
$$F.A. INTENSITA' SPETTRALE 0.1s < T_0 < 0.5s = 1.7$$

$$F.A. INTENSITA' SPETTRALE 0.5s < T_0 < 1.0s = 1.4$$

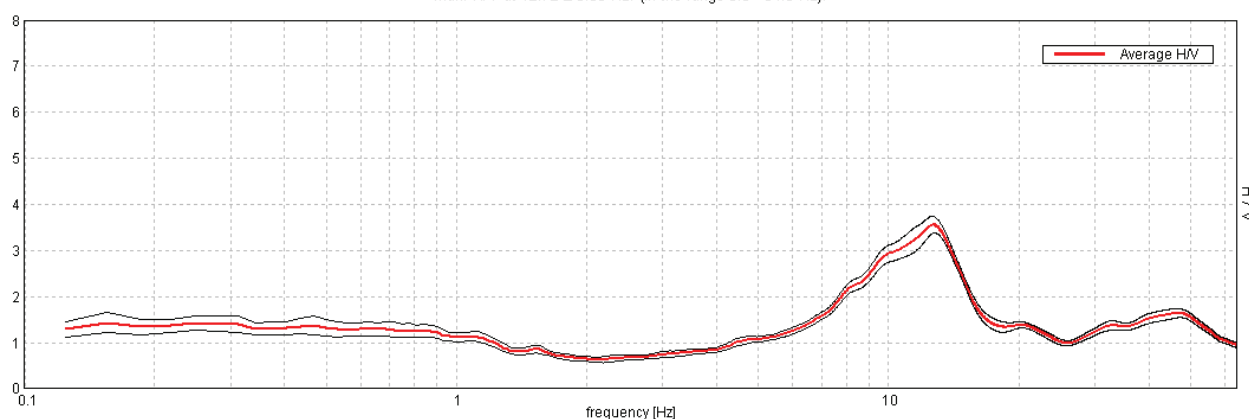
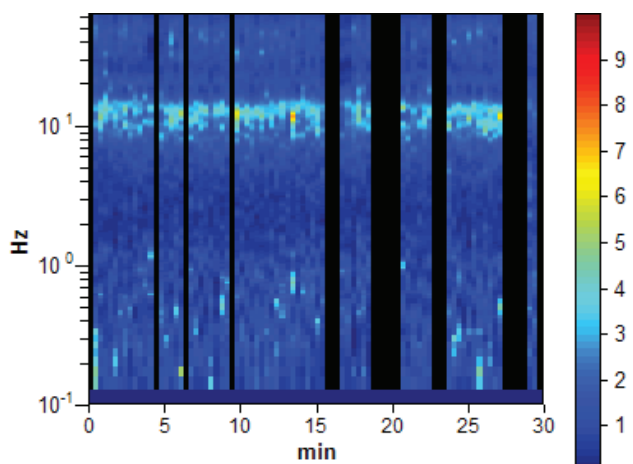
PROVE HVSR

PROVA 1
CASINALBO - VIA RADICI IN PIANO, 371
FORMIGINE

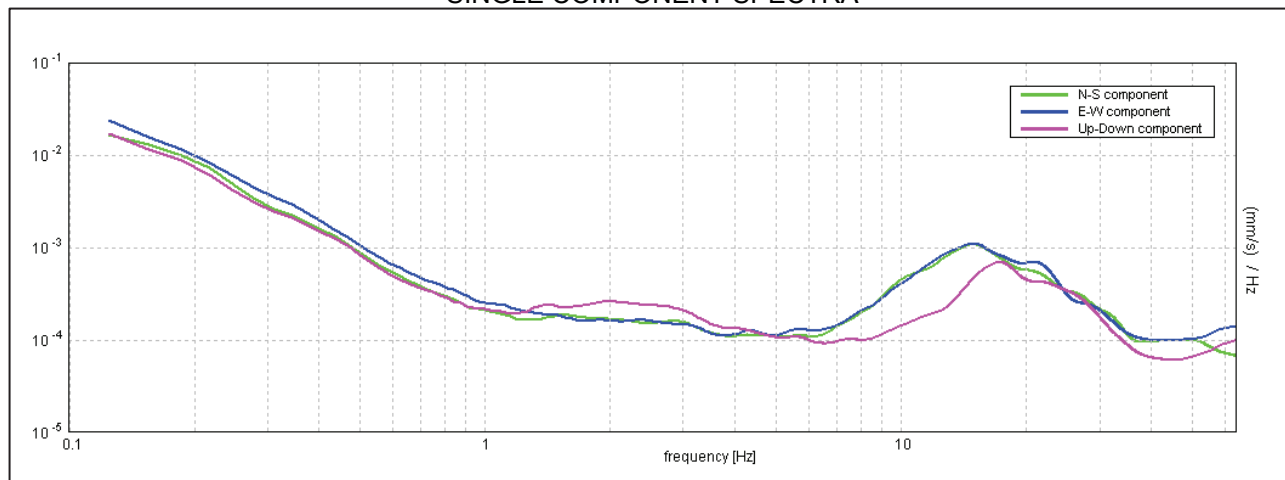
Channel labels: NORTH SOUTH;
EAST WEST ; UP DOWN
COORDINATE GAUSS-BOAGA:
1646845; 4939174
Trace length: 0h30'00".
Analyzed 76% trace
(manual window selection)
Sampling frequency: 128 Hz
Window size: 20 s
Smoothing window: Triangular window
Smoothing: 10%


HORIZONTAL TO VERTICAL SPECTRAL RATIO

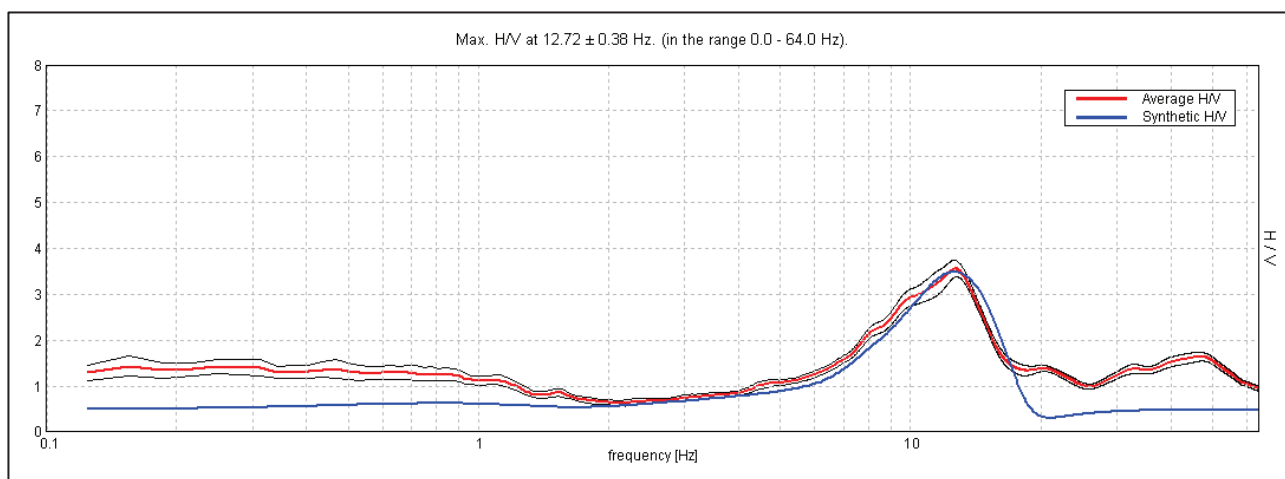
Max. H/V at 12.72 ± 0.38 Hz. (in the range 0.0 - 64.0 Hz).


H/V TIME HISTORY


SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
3.30	3.30	165
11.30	8.00	415
47.30	36.00	480
81.30	34.00	390
91.30	10.00	530
95.30	4.00	420
inf.	inf.	550

Vs(0.0-30.0)=383m/s

Max. H/V at 12.72 ± 0.38 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$12.72 > 0.50$	OK	
$n_c(f_0) > 200$	$17297.5 > 200$	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 612 times	OK	

Criteria for a clear HVSR peak

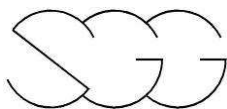
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	7.438 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	15.969 Hz	OK	
$A_0 > 2$	$3.56 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.01471 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.18706 < 0.63594$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.0893 < 1.58$	OK	

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

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

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

**PROVA 2****CASINALBO - VIA COPERNICO****FORMIGINE**

Channel labels: NORTH SOUTH;

EAST WEST ; UP DOWN

COORDINATE GAUSS-BOAGA: 1646742; 4938740

Trace length: 0h30'00".

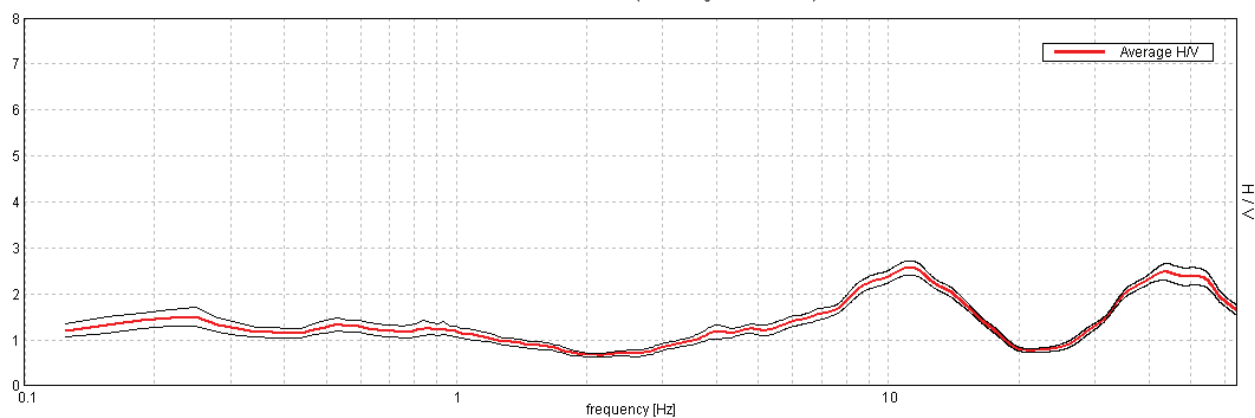
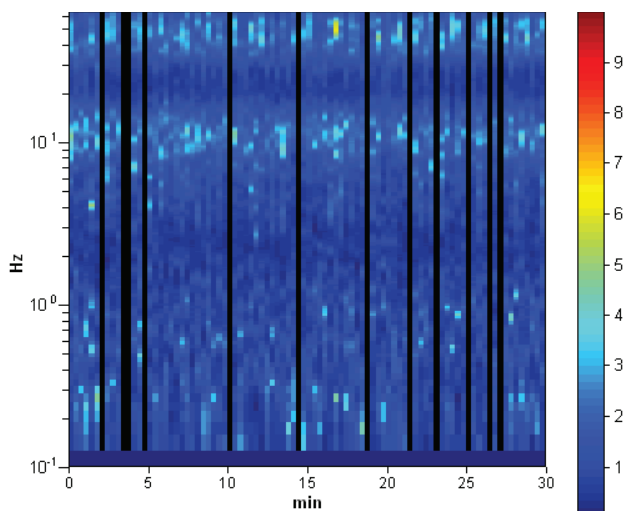
Analyzed 87% trace (manual window selection)

Sampling frequency: 128 Hz

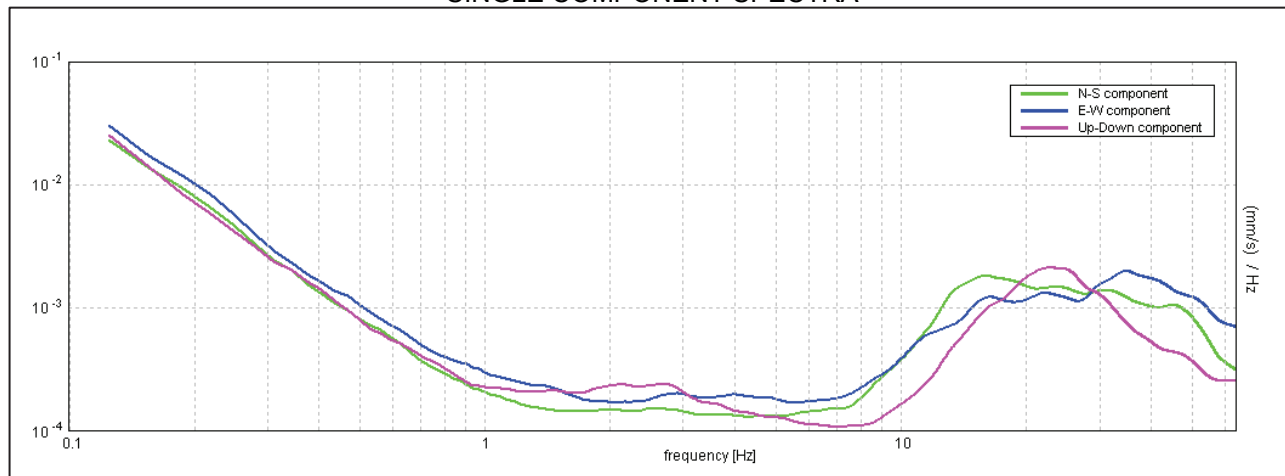
Window size: 20 s

Smoothing window: Triangular window

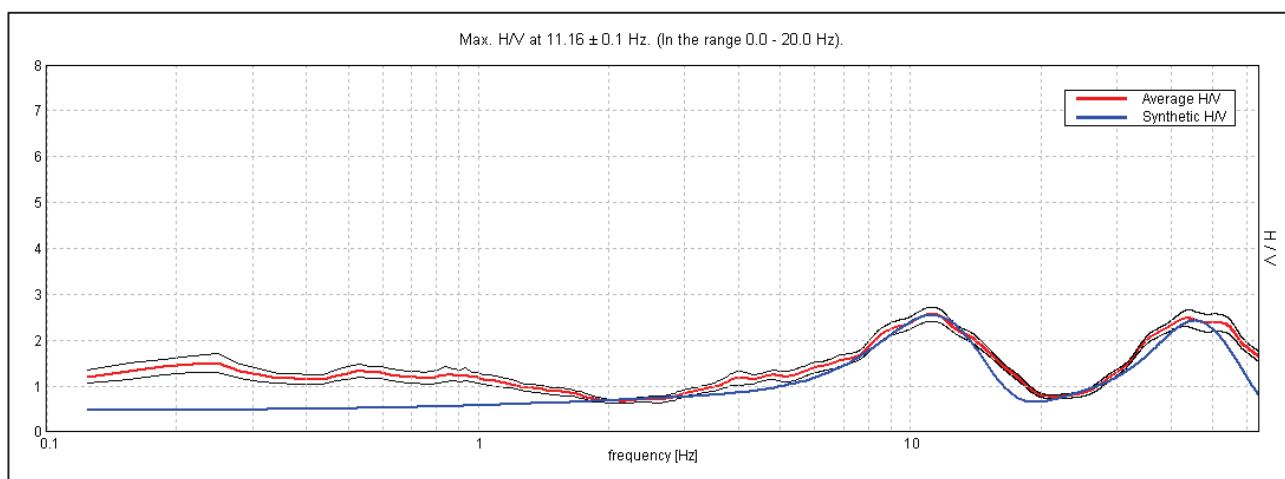
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIOMax. H/V at 11.16 ± 0.1 Hz. (In the range 0.0 - 20.0 Hz).**H/V TIME HISTORY**

SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.55	0.55	100
4.95	4.40	230
14.95	10.00	480
52.95	38.00	540
inf.	inf.	600

Vs(0.0-30.0)=409m/s

Max. H/V at 11.16 ± 0.1 Hz. (in the range 0.0 - 20.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$11.16 > 0.50$	OK	
$n_c(f_0) > 200$	$17403.8 > 200$	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 536 times	OK	

Criteria for a clear HVSR peak

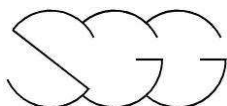
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	5.531 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	17.156 Hz	OK	
$A_0 > 2$	$2.57 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00464 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.05176 < 0.55781$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.0768 < 1.58$	OK	

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

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

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

**PROVA 3 VIA GIUDO ROSSA 001 FORMIGINE**

Channel labels: NORTH SOUTH; EAST WEST; UP DOWN

COORDINATE GAUSS-BOAGA: 1646437; 4935879

Trace length: 0h30'00".

Analyzed 89% trace (manual window selection)

Sampling frequency: 128 Hz

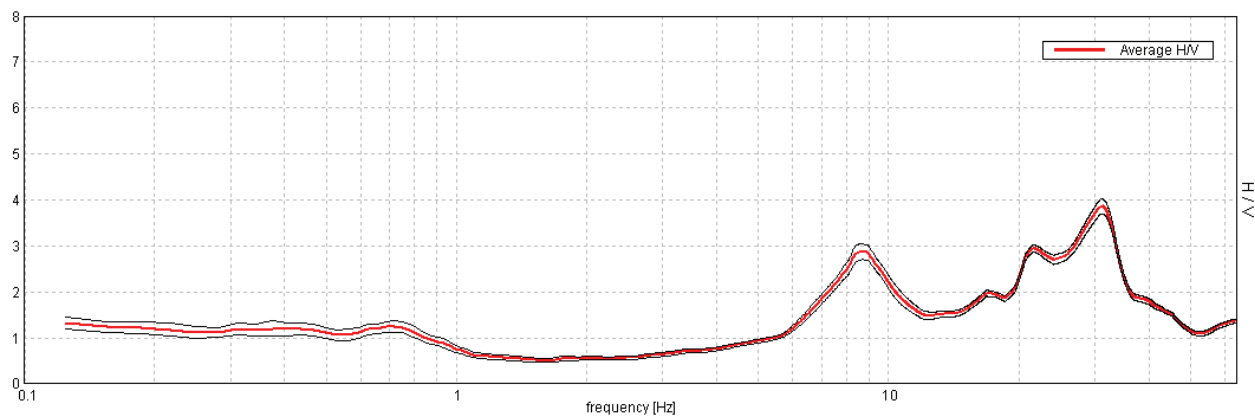
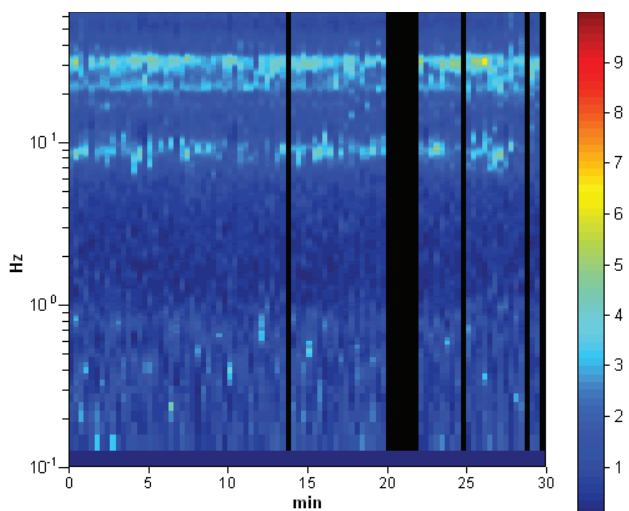
Window size: 20 s

Smoothing window: Triangular window

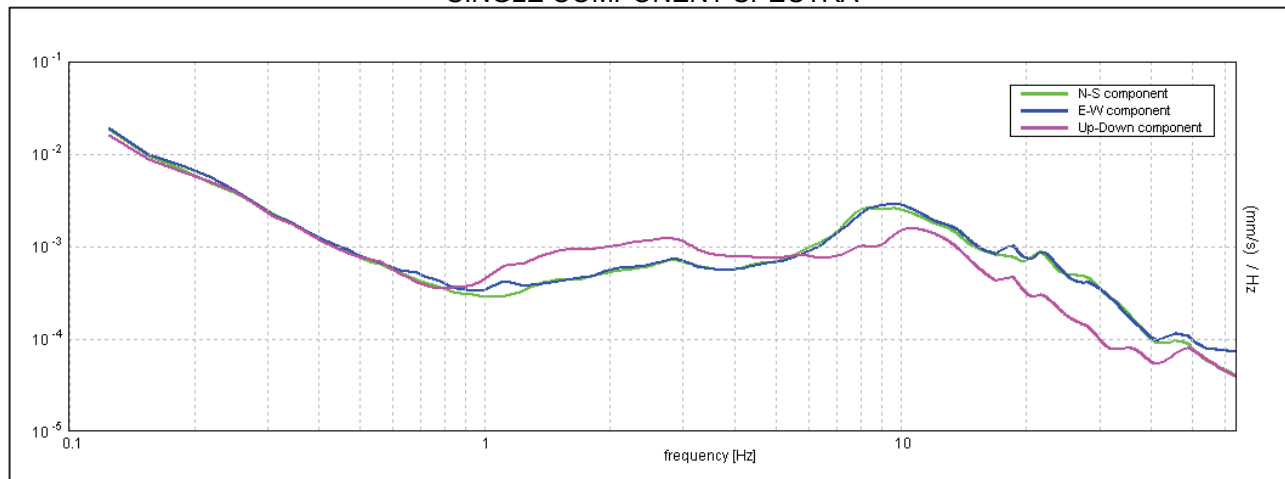
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

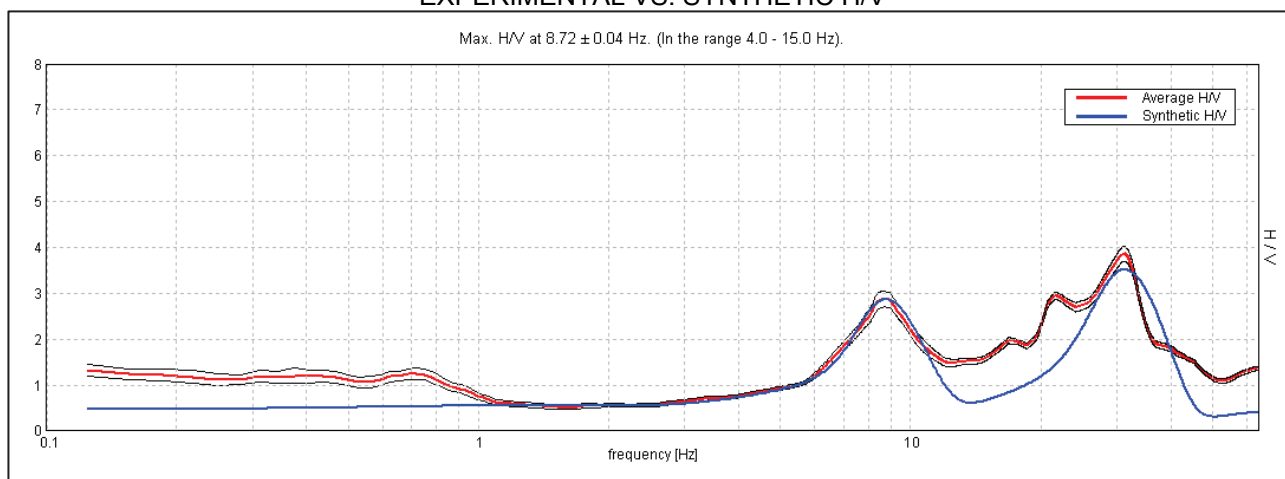
Max. H/V at 8.72 ± 0.04 Hz. (In the range 4.0 - 15.0 Hz).

**H/V TIME HISTORY**

SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
1.00	1.00	120
4.80	3.80	300
7.60	2.80	240
23.60	16.00	600
39.60	16.00	500
55.60	16.00	380
inf.	inf.	580

Vs(0.0-30.0)=416m/s

Max. H/V at 8.72 ± 0.04 Hz. (in the range 4.0 - 15.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$8.72 > 0.50$	OK	
$n_c(f_0) > 200$	$13950.0 > 200$	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 420 times	OK	

Criteria for a clear HVSR peak

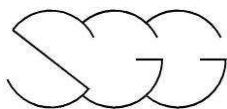
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	6.375 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$			NO
$A_0 > 2$	$2.87 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00209 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.0182 < 0.43594$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.0827 < 1.58$	OK	

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

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

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

**PROVA 4****VIA GUIDO ROSSA 002****FORMIGINE**

Channel labels: NORTH SOUTH;

EAST WEST ; UP DOWN

COORDINATE GAUSS_BOAGA: 1646404, 4935788

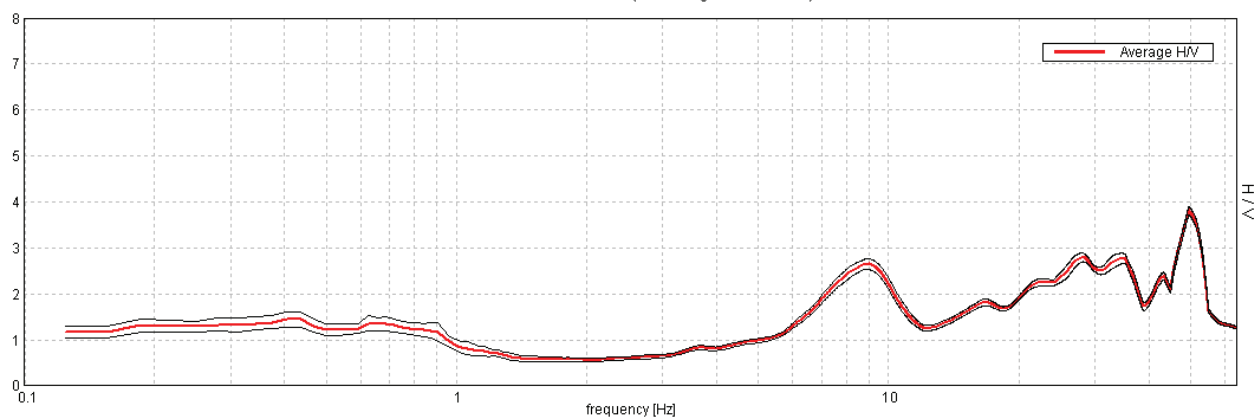
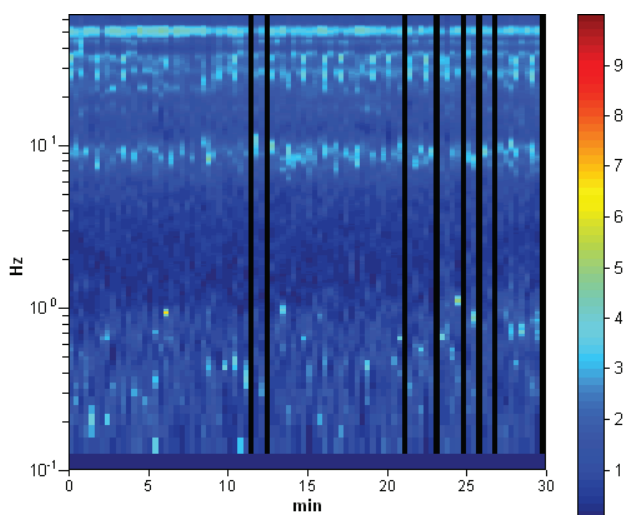
Trace length: 0h30'00". Analyzed 91% trace (manual window selection)

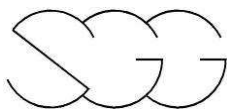
Sampling frequency: 128 Hz

Window size: 20 s

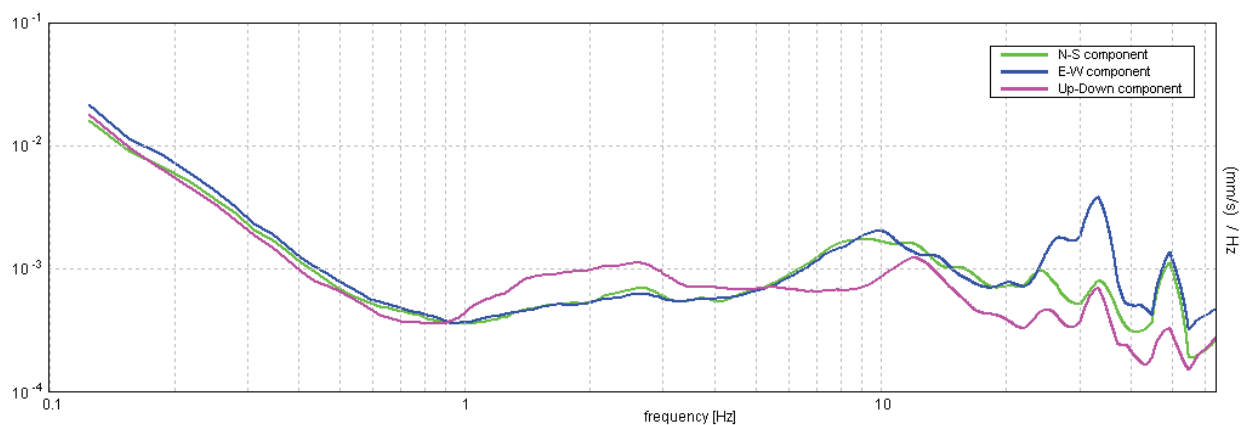
Smoothing window: Triangular window

Smoothing: 10%

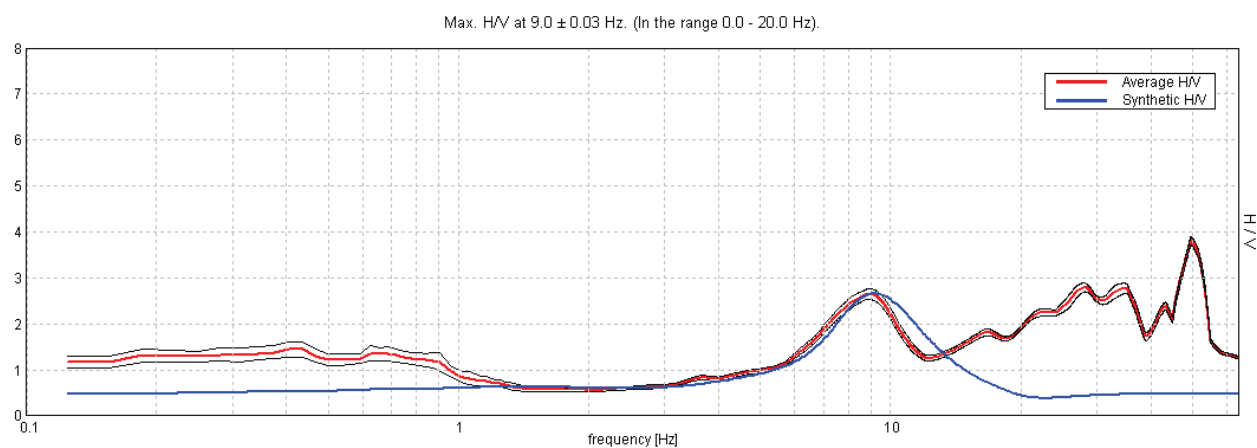
HORIZONTAL TO VERTICAL SPECTRAL RATIOMax. H/V at 9.0 ± 0.03 Hz. (In the range 0.0 - 20.0 Hz).**H/V TIME HISTORY**



SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer

[m]

3.60

6.00

8.20

24.20

40.20

56.20

inf.

Thickness [m]

3.60

2.40

2.20

16.00

16.00

16.00

inf.

Vs [m/s]

180

460

260

550

500

380

600

Vs(0.0-30.0)=403m/s

Max. H/V at 9.0 ± 0.03 Hz. (in the range 0.0 - 20.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$9.00 > 0.50$	OK	
$n_c(f_0) > 200$	$14760.0 > 200$	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 433 times	OK	

Criteria for a clear HVSR peak

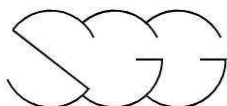
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	6.031 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	11.75 Hz	OK	
$A_0 > 2$	$2.65 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00181 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.0163 < 0.45$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.0602 < 1.58$	OK	

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

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

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

**PROVA 5 CORLO DI FORMIGINE - VIA TIRELLI****FORMIGINE**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN

COORDINATE GAUSS_BOAGA: 1645414, 4938204

Trace length: 0h30'00".

Analyzed 63% trace (manual window selection)

Sampling frequency: 128 Hz

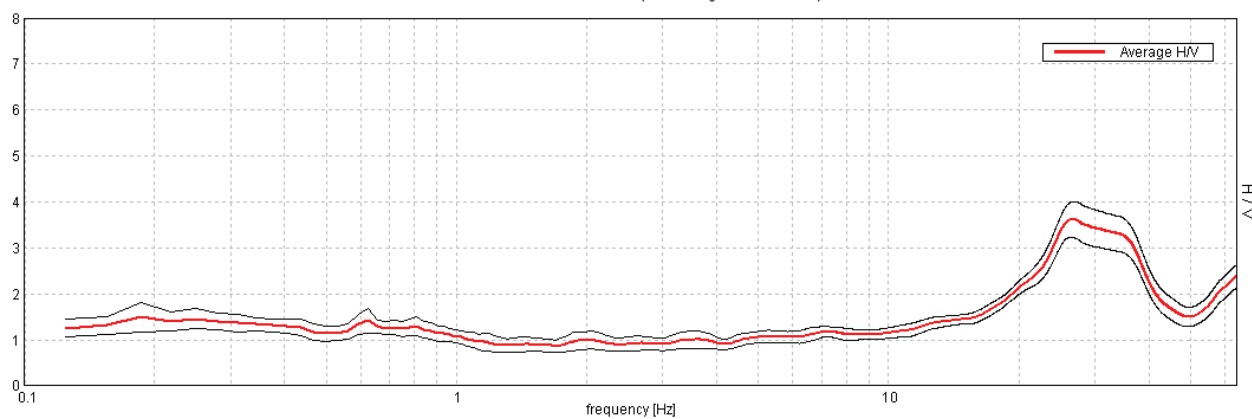
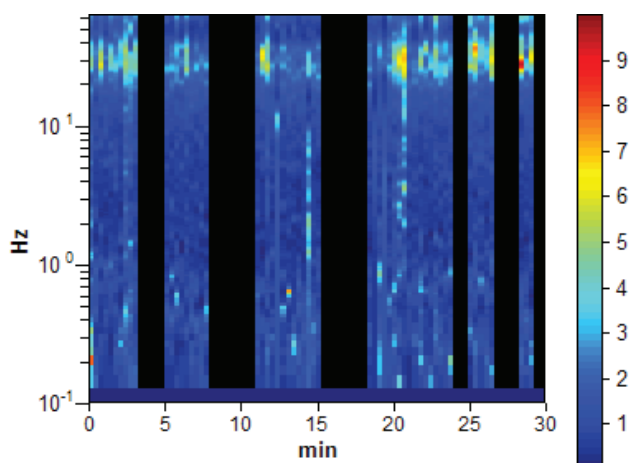
Window size: 20 s

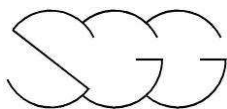
Smoothing window: Triangular window

Smoothing: 10%

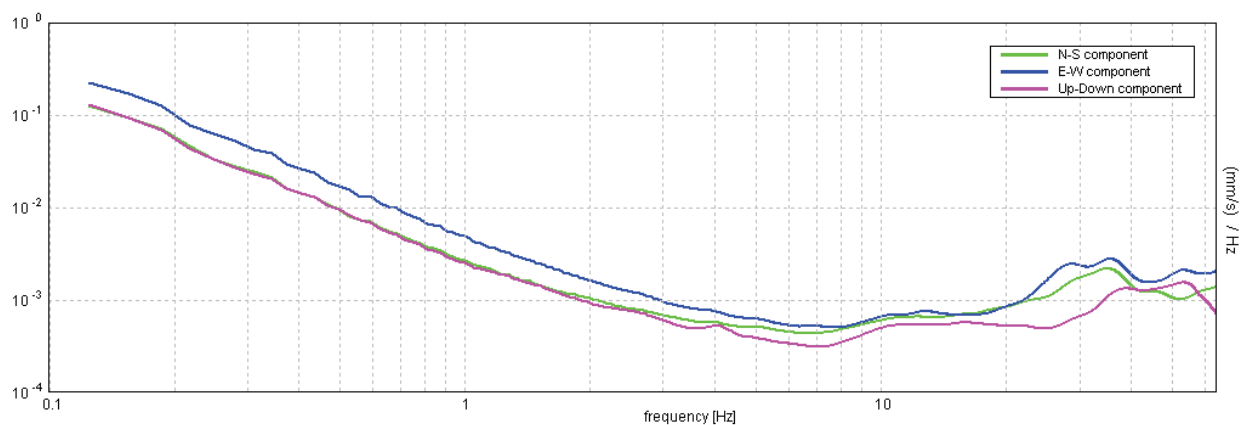
HORIZONTAL TO VERTICAL SPECTRAL RATIO

Max. H/V at 26.56 ± 1.33 Hz. (in the range 0.0 - 64.0 Hz).

**H/V TIME HISTORY**

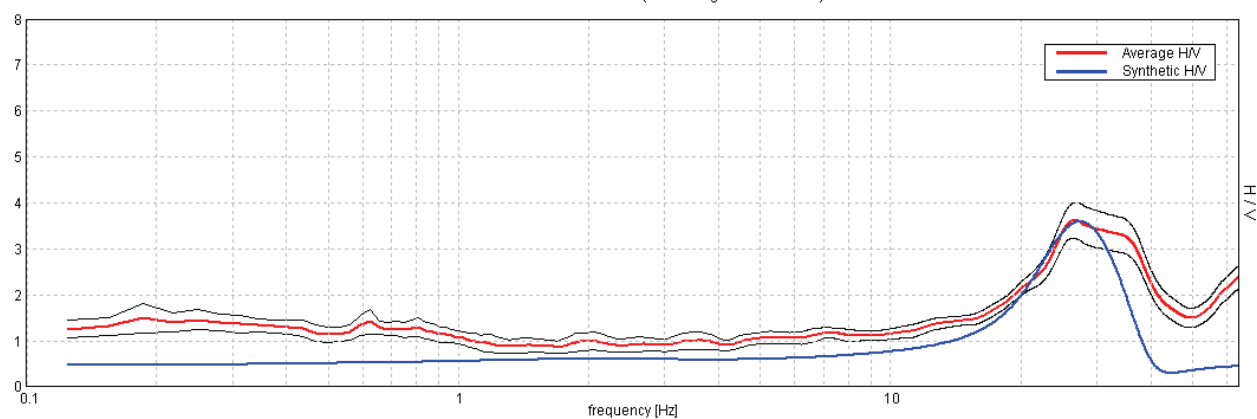


SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V

Max. H/V at 26.56 ± 1.33 Hz. (in the range 0.0 - 64.0 Hz).



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
2.00	2.00	212
32.00	30.00	540
62.00	30.00	580
inf.	inf.	650

$V_s(0.0-30.0)=490\text{m/s}$

Max. H/V at 26.56 ± 1.33 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$26.56 > 0.50$	OK	
$n_c(f_0) > 200$	$30281.3 > 200$	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 1276 times	OK	

Criteria for a clear HVSR peak

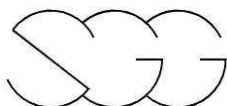
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	18.25 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	43.188 Hz	OK	
$A_0 > 2$	$3.62 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.02468 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.65555 < 1.32813$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.191 < 1.58$	OK	

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

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

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

**PROVA 6 VIA CANTALUPO, FORMIGINE (MO)**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN
COORDINATE GAUSS_BOAGA: 1647684, 4935445

Trace length: 0h20'00". Analyzed 67% trace (manual window selection)

Sampling frequency: 128 Hz

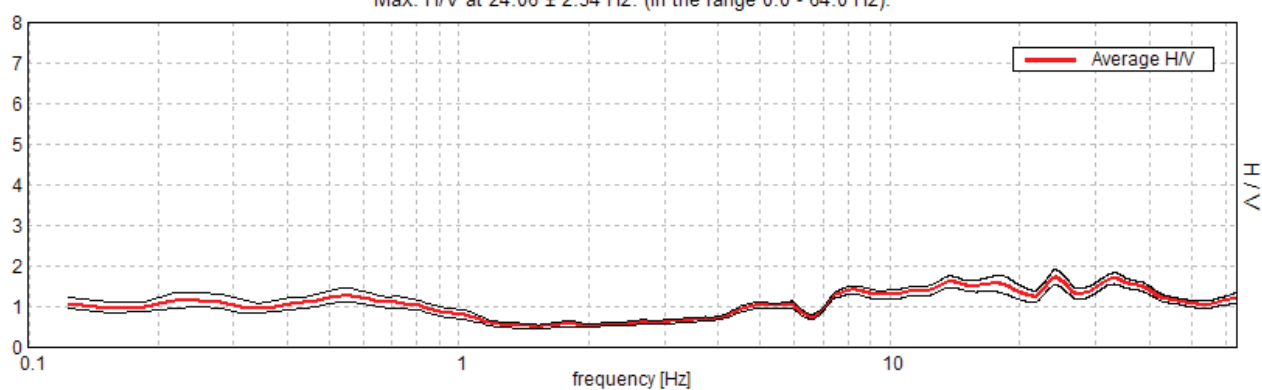
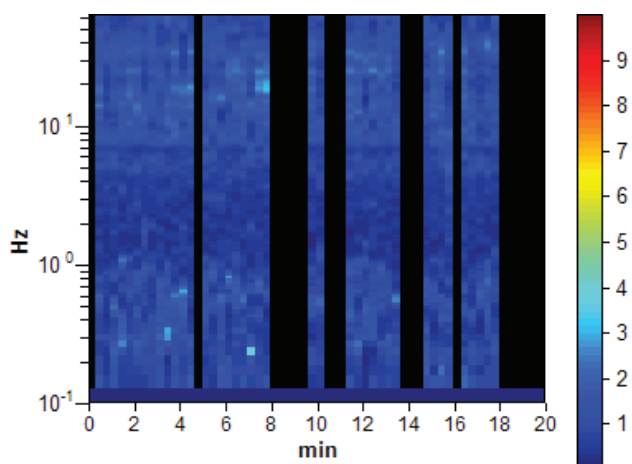
Window size: 20 s

Smoothing window: Triangular window

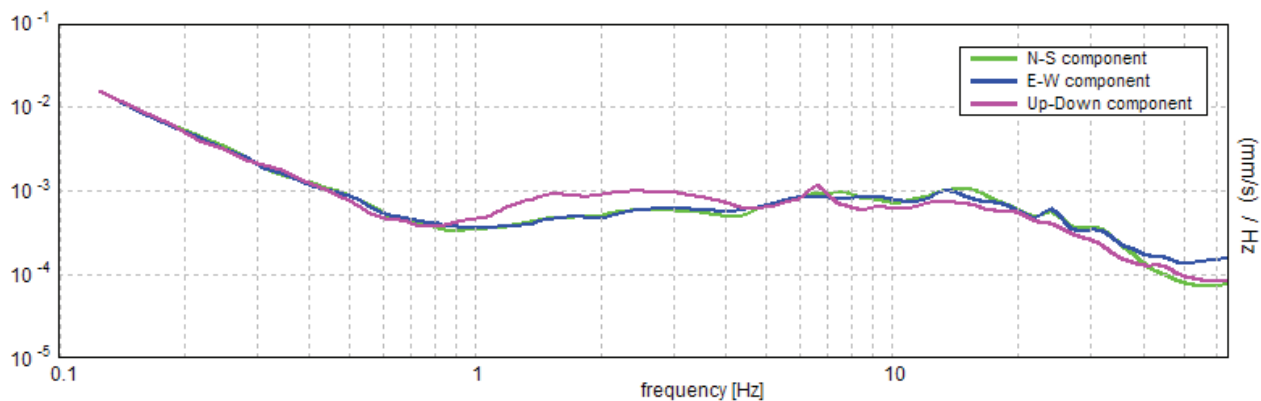
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

Max. H/V at 24.06 ± 2.34 Hz. (in the range 0.0 - 64.0 Hz).

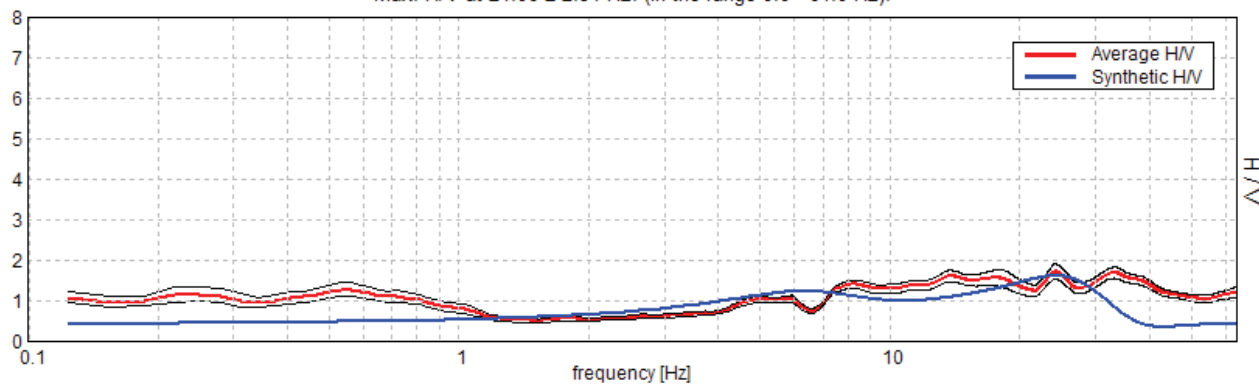
**H/V TIME HISTORY**

SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V

Max. H/V at 24.06 ± 2.34 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	150
5.50	4.00	305
7.50	2.00	350
10.50	3.00	400
15.50	5.00	400
inf.	inf.	530

$V_s(0.0-30.0)=394\text{m/s}$

Max. H/V at 24.06 ± 2.34 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$24.06 > 0.50$	OK	
$n_c(f_0) > 200$	$19250.0 > 200$	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 1156 times	OK	

Criteria for a clear HVSR peak

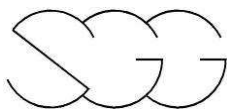
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	6.844 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$			NO
$A_0 > 2$	$1.74 > 2$		NO
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.04743 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$1.14138 < 1.20313$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.0905 < 1.58$	OK	

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

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

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

**PROVA 7****VIA STRADELLA****FORMIGINE**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN

COORDINATE GAUSS_BOAGA: 1648012, 4935922

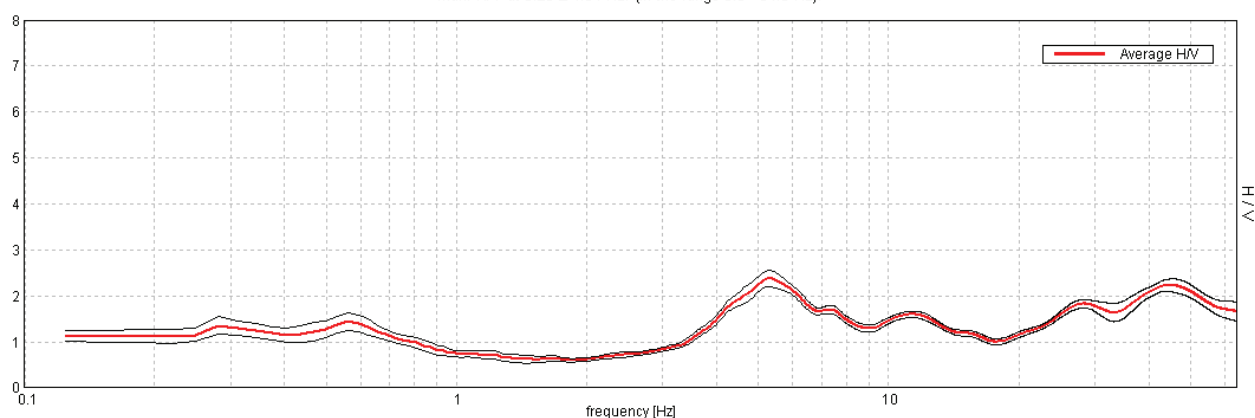
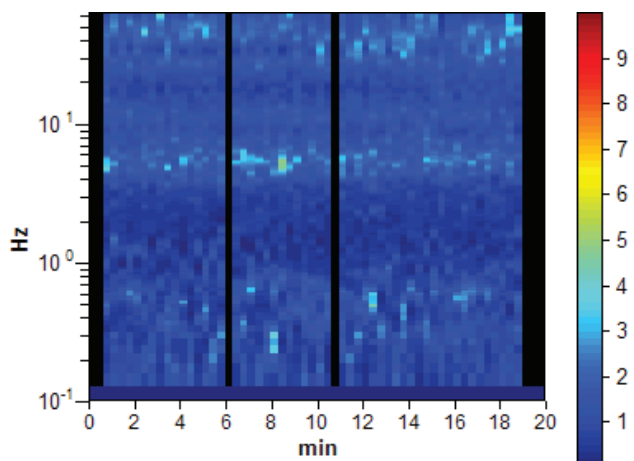
Trace length: 0h20'00". Analyzed 88% trace (manual window selection)

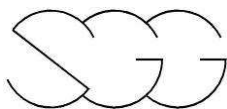
Sampling frequency: 128 Hz

Window size: 20 s

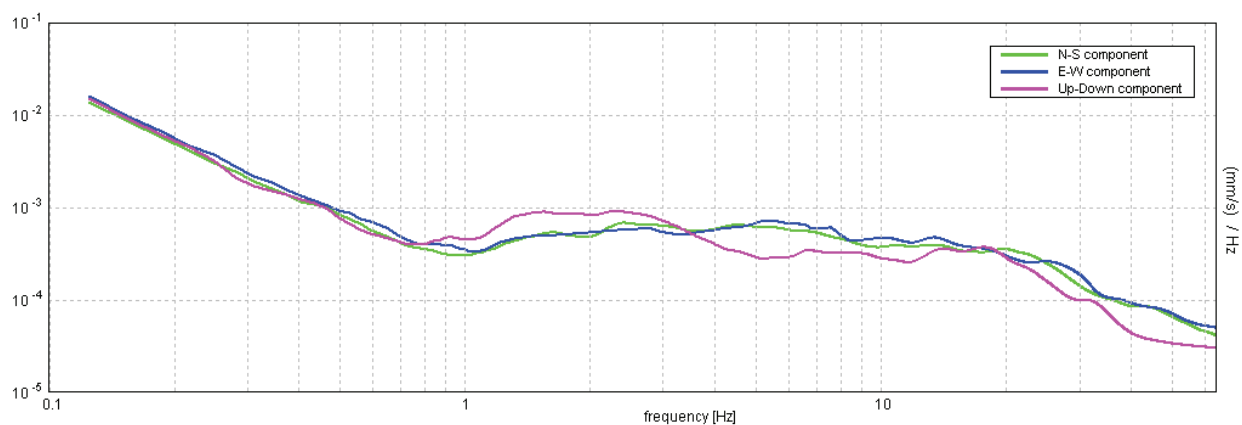
Smoothing window: Triangular window

Smoothing: 10%

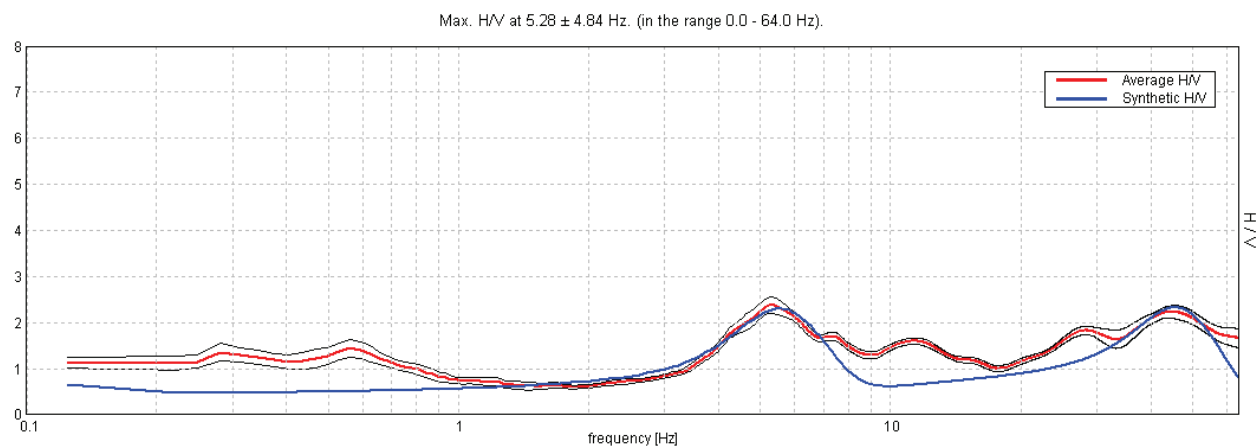
HORIZONTAL TO VERTICAL SPECTRAL RATIOMax. H/V at 5.28 ± 4.84 Hz. (in the range 0.0 - 64.0 Hz).**H/V TIME HISTORY**



SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer
[m]

Thickness [m]

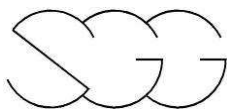
Vs [m/s]

0.55
3.00
7.00
10.00
14.00
29.00
inf.

0.55
2.45
4.00
3.00
4.00
15.00
inf.

100
230
260
300
330
550
500

Vs(0.0-30.0)=362m/s



Max. H/V at 5.28 ± 4.84 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$5.28 > 0.50$	OK	
$n_c(f_0) > 200$	$5598.1 > 200$	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 254 times	OK	

Criteria for a clear HVSR peak

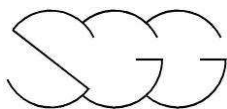
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	3.625 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	14.781 Hz	OK	
$A_0 > 2$	$2.39 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.45251 < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	$2.38981 < 0.26406$		NO
$\sigma_A(f_0) < \theta(f_0)$	$0.0885 < 1.58$	OK	

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

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

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

**PROVA 8****VIA SANT'ONOFRIO****FORMIGINE**

Channel labels: NORTH SOUTH;

EAST WEST ; UP DOWN

COORDINATE GAUSS_BOAGA: 1647947, 4937748

Trace length: 0h20'00".

Analyzed 78% trace (manual window selection)

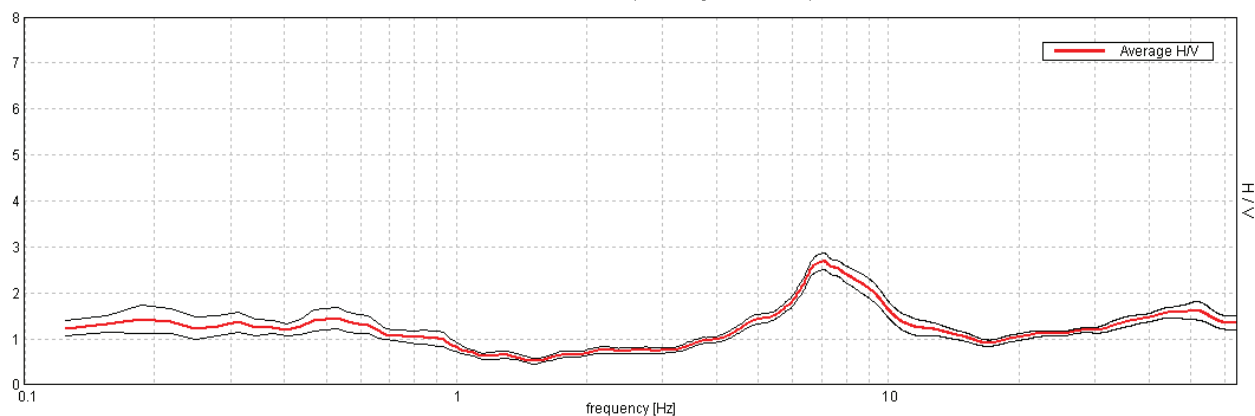
Sampling frequency: 128 Hz

Window size: 20 s

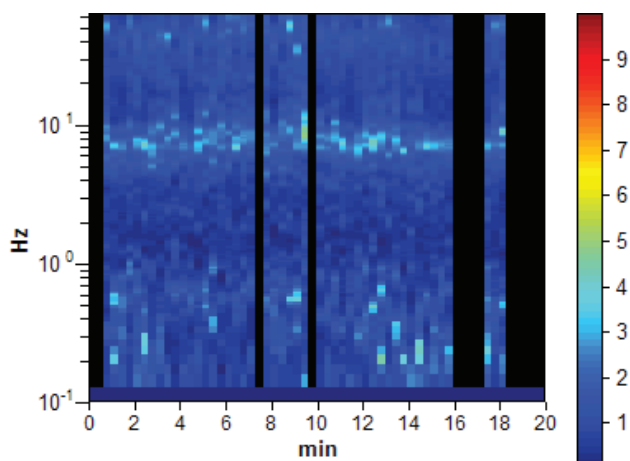
Smoothing window: Triangular window

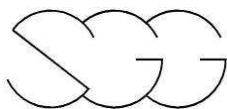
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

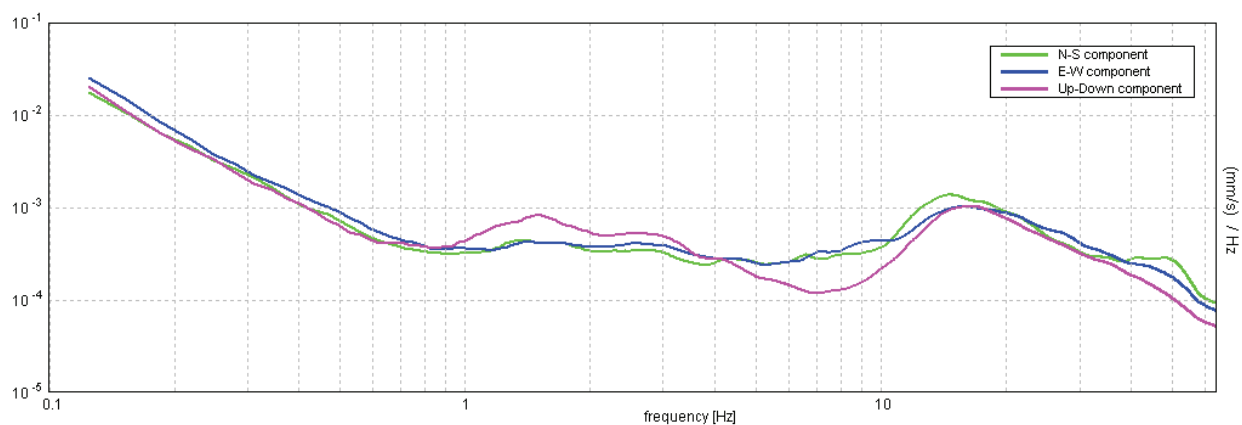
Max. H/V at 7.09 ± 1.9 Hz. (in the range 0.0 - 64.0 Hz).

H/V TIME HISTORY

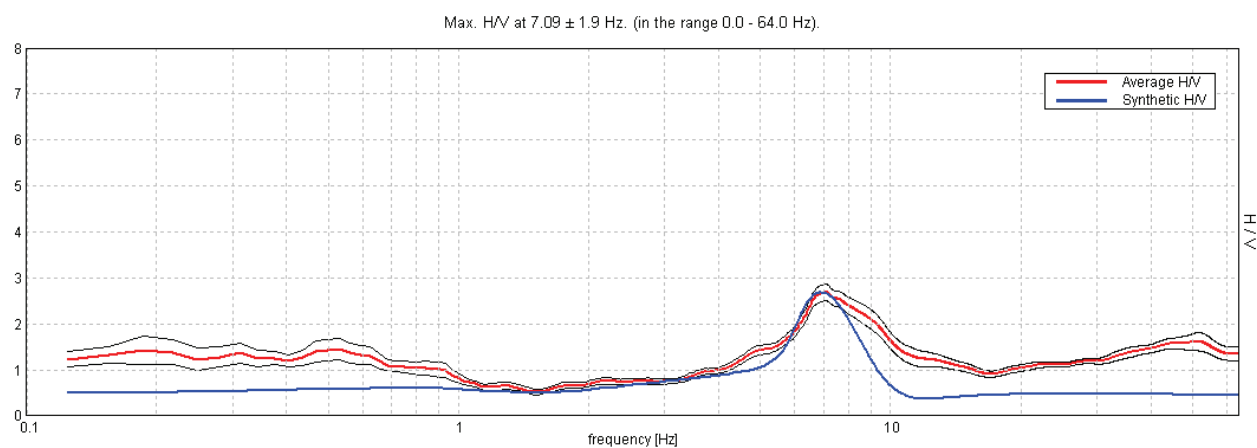




SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer

[m]

9.00

31.00

46.00

96.00

inf.

Thickness [m]

9.00

22.00

15.00

50.00

inf.

Vs [m/s]

255

545

580

395

600

 $V_s(0.0-30.0)=406\text{m/s}$

Max. H/V at 7.09 ± 1.9 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$7.09 > 0.50$	OK	
$n_c(f_0) > 200$	$6668.1 > 200$	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 342 times	OK	

Criteria for a clear HVSR peak

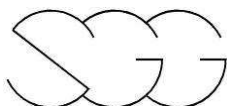
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	4.719 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	10.906 Hz	OK	
$A_0 > 2$	$2.70 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.1315 < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	$0.93285 < 0.35469$		NO
$\sigma_A(f_0) < \theta(f_0)$	$0.089 < 1.58$	OK	

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

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

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

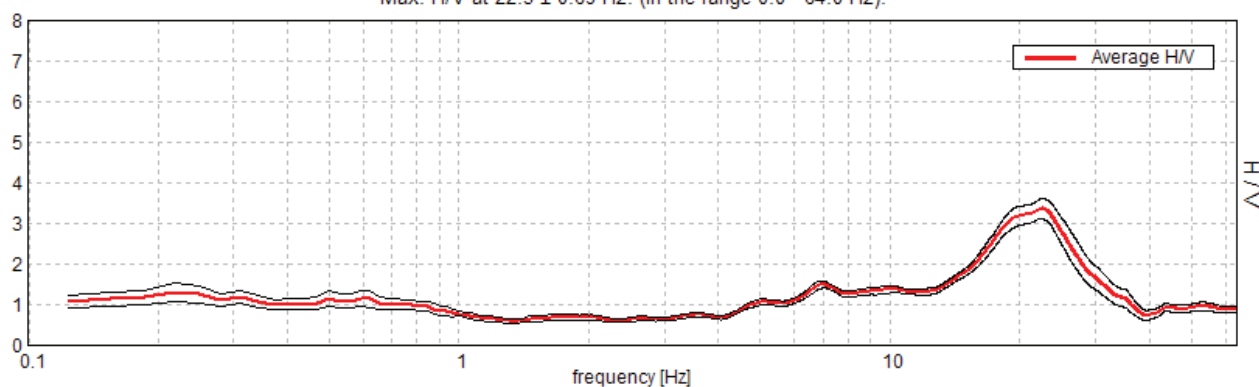
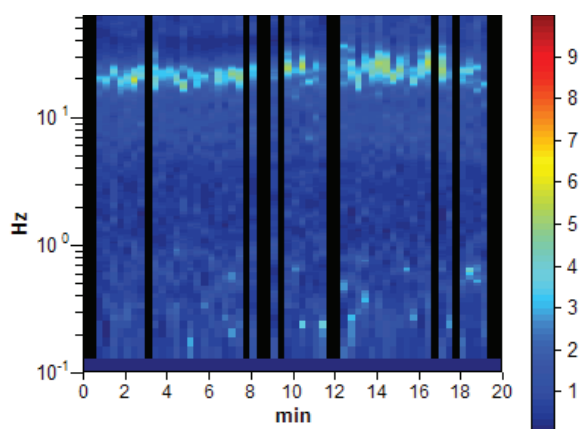
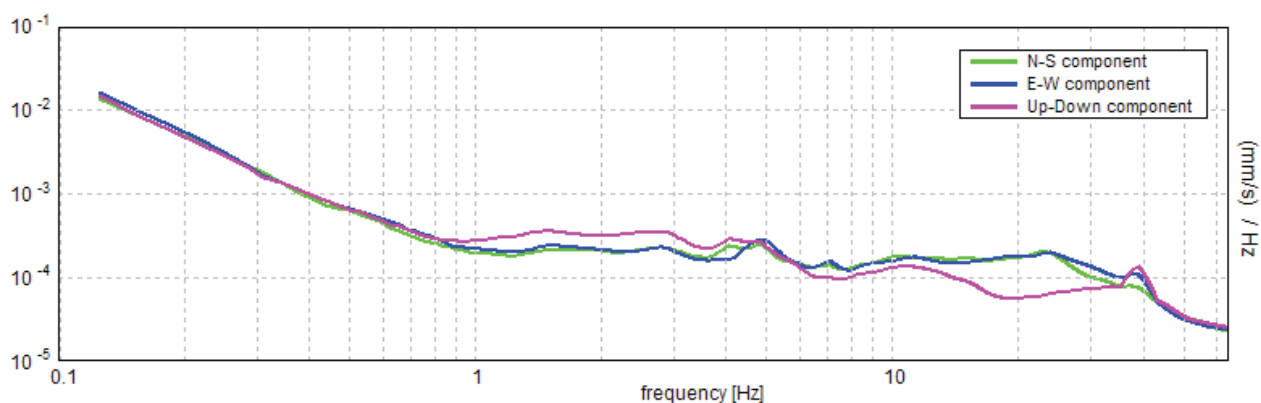
**PROVA 9 VIA MAZZACAVALLLO MAGRETA DI FORMIGINE**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN
COORDINATE GAUSS_BOAGA: 1643559, 4938982

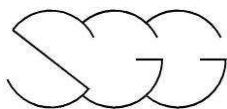
Trace length: 0h20'00". Analyzed 78% trace (manual window selection)
Sampling frequency: 128 Hz
Window size: 20 s
Smoothing window: Triangular window
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

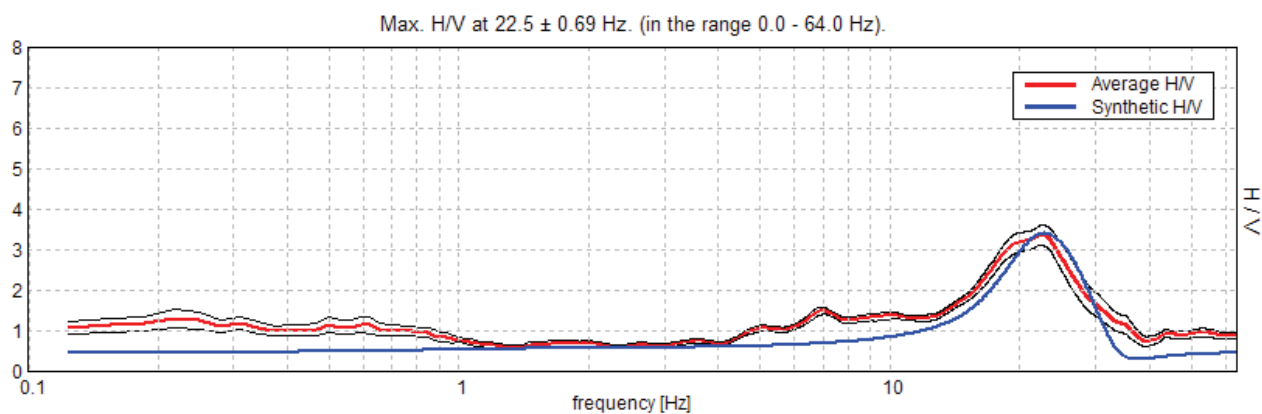
Max. H/V at 22.5 ± 0.69 Hz. (in the range 0.0 - 64.0 Hz).

**H/V TIME HISTORY****SINGLE COMPONENT SPECTRA**

Comune di Formigine (MO)
MICROZONAZIONE SISMICA
Relazione tecnica



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
2.70	2.70	240
33.70	31.00	590
65.70	32.00	650
73.20	7.50	600
83.20	10.00	670
inf.	inf.	700

$V_s(0.0-30.0)=522\text{m/s}$

Max. H/V at 22.5 ± 0.69 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$22.50 > 0.50$	OK	
$n_c(f_0) > 200$	$21150.0 > 200$	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 1081 times	OK	

Criteria for a clear HVSR peak

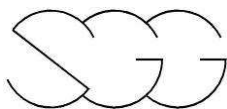
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	14.313 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	29.875 Hz	OK	
$A_0 > 2$	$3.37 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.01514 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.34075 < 1.125$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.1192 < 1.58$	OK	

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

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

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

**PROVA 10****VIA ARRIGO GIUSTI****FORMIGINE (MO)**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN

COORDINATE GAUSS_BOAGA: 1646387, 4936516

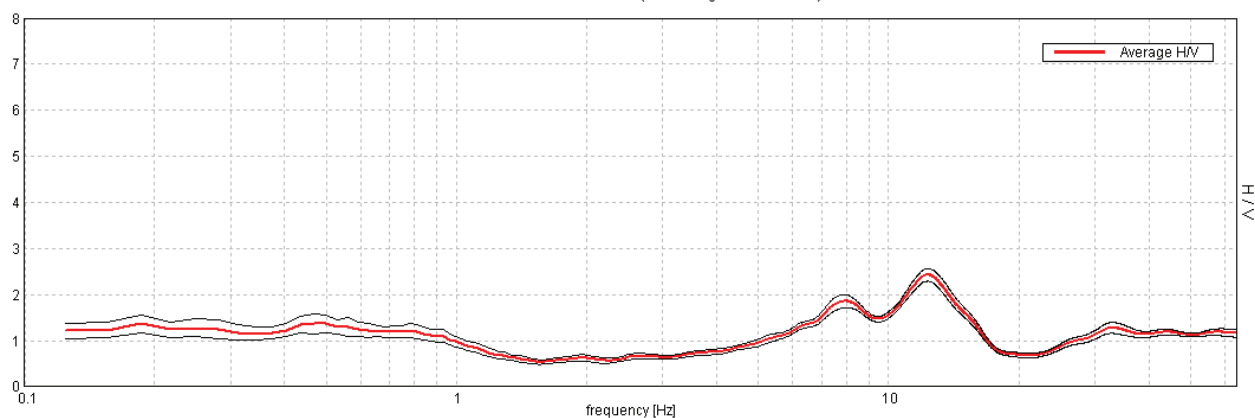
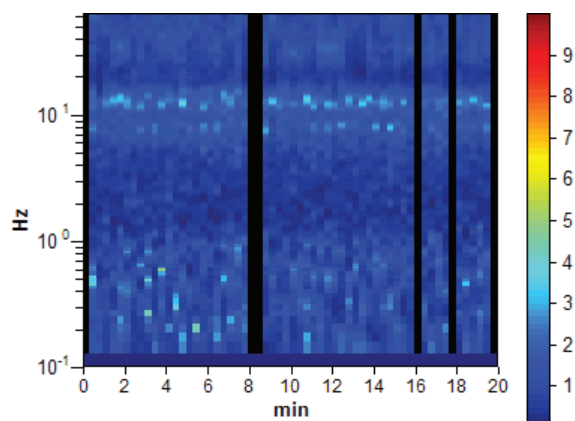
Trace length: 0h20'00". Analyzed 90% trace (manual window selection)

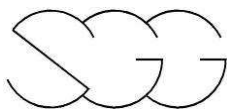
Sampling frequency: 128 Hz

Window size: 20 s

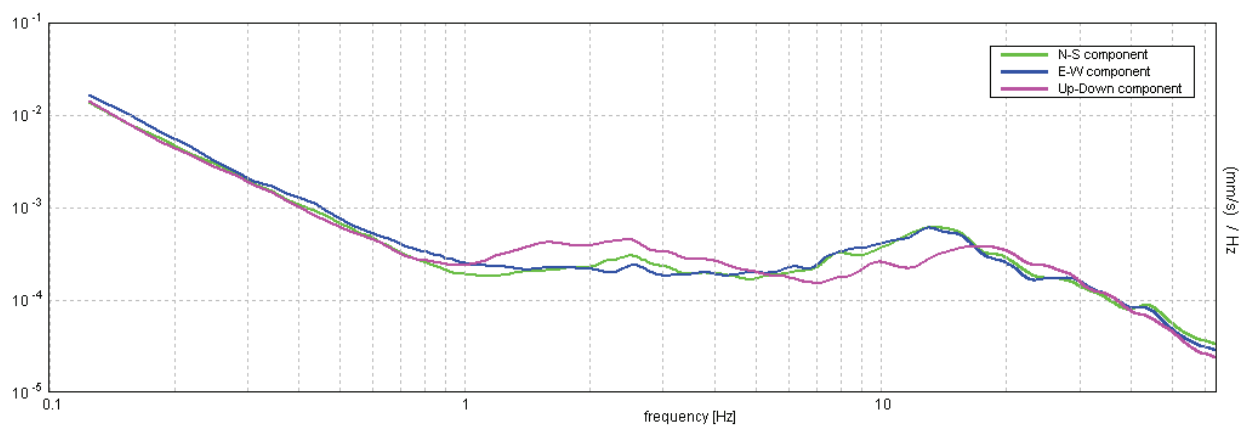
Smoothing window: Triangular window

Smoothing: 10%

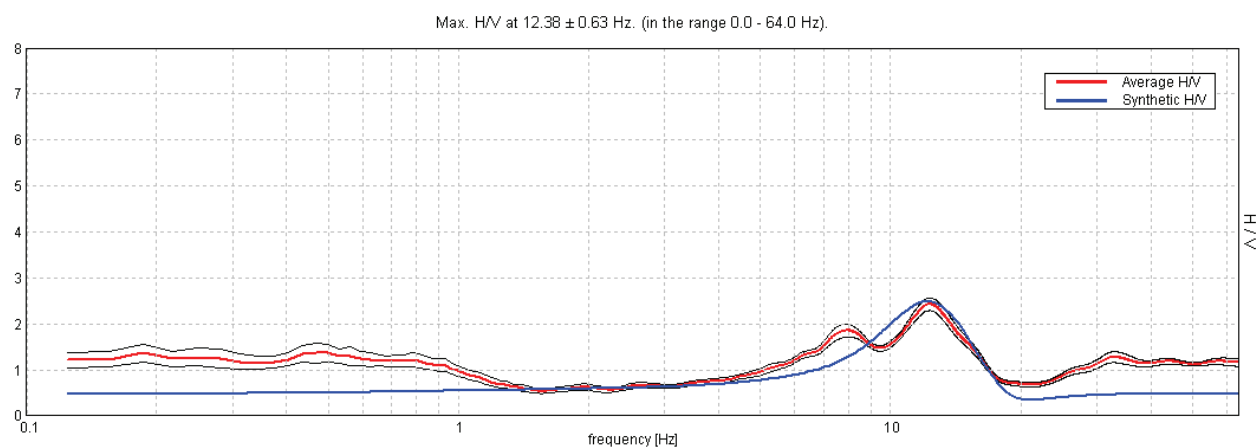
HORIZONTAL TO VERTICAL SPECTRAL RATIOMax. H/V at 12.38 ± 0.63 Hz. (in the range 0.0 - 64.0 Hz).**H/V TIME HISTORY**



SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer

[m]

4.40

34.40

48.40

inf.

Thickness [m]

4.40

30.00

14.00

inf.

Vs [m/s]

218

500

450

530

 $V_s(0.0-30.0)=420\text{m/s}$

Max. H/V at 12.38 ± 0.63 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$12.38 > 0.50$	OK	
$n_c(f_0) > 200$	$13365.0 > 200$	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 595 times	OK	

Criteria for a clear HVSR peak

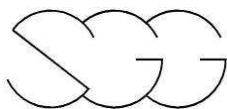
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	5.969 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	16.281 Hz	OK	
$A_0 > 2$	$2.43 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.02524 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.31239 < 0.61875$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.0672 < 1.58$	OK	

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

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

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

**PROVA 11****VIA ACHILLE GRANDI (CIMITERO)****FORMIGINE (MO)**

Channel labels: NORTH SOUTH;

EAST WEST ; UP DOWN

COORDINATE GAUSS_BOAGA:

1646287, 4936828

Trace length: 0h20'00".

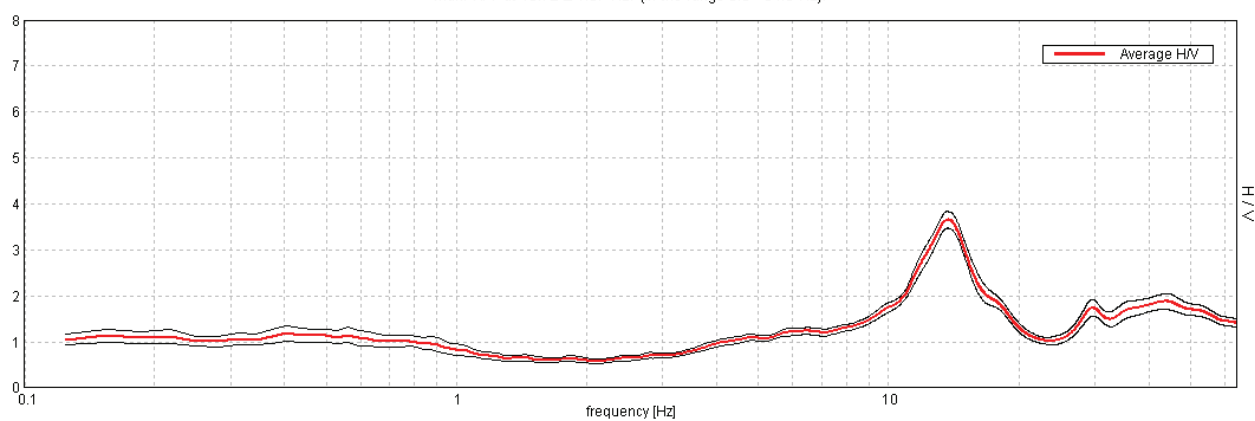
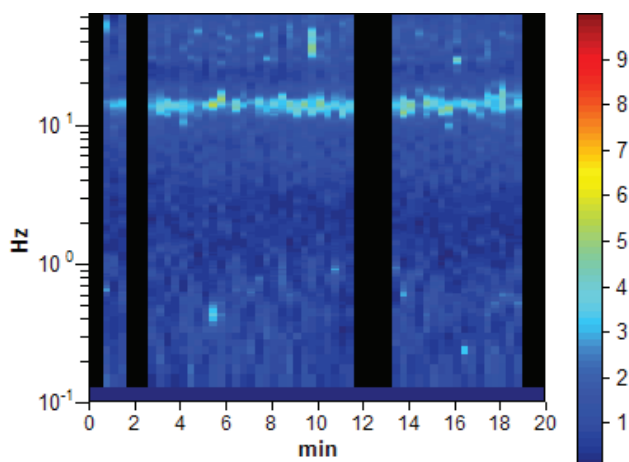
Analyzed 78% trace (manual window selection)

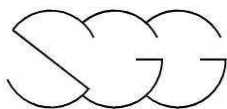
Sampling frequency: 128 Hz

Window size: 20 s

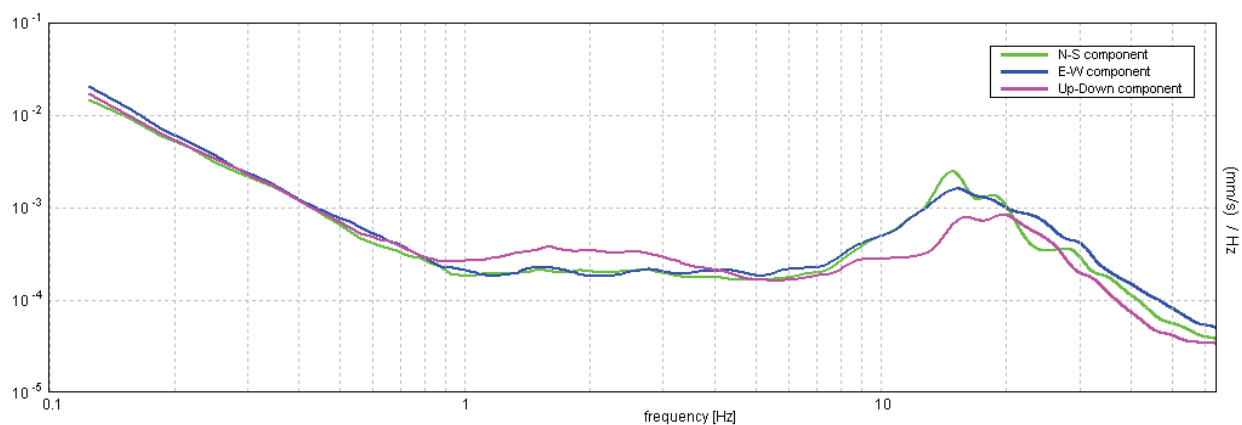
Smoothing window: Triangular window

Smoothing: 10%

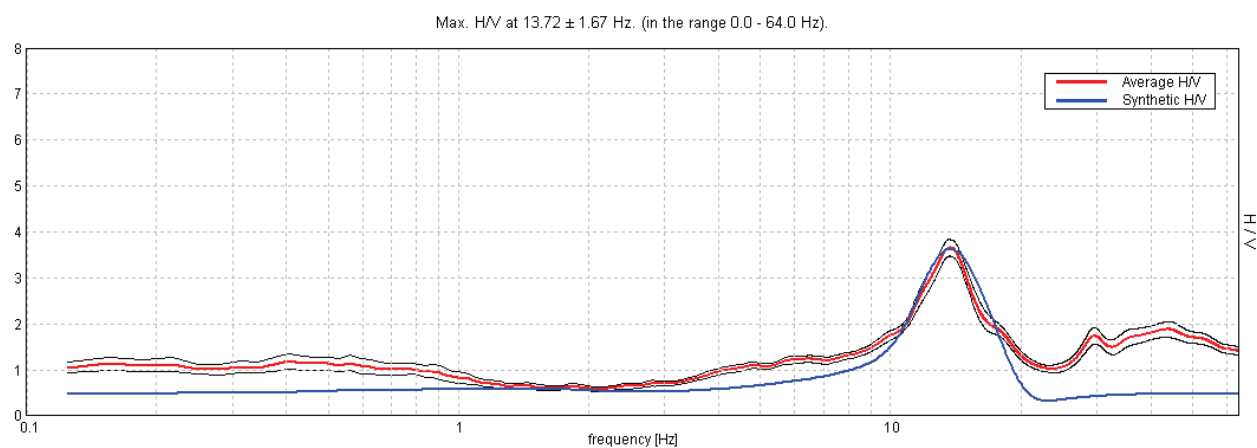
HORIZONTAL TO VERTICAL SPECTRAL RATIOMax. H/V at 13.72 ± 1.67 Hz. (in the range 0.0 - 64.0 Hz).**H/V TIME HISTORY**



SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer

[m]

4.20

22.20

39.20

58.20

68.20

inf.

Thickness [m]

4.20

18.00

17.00

19.00

10.00

inf.

Vs [m/s]

230

555

400

580

420

600

 $V_s(0.0-30.0)=427\text{m/s}$

Max. H/V at 13.72 ± 1.67 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$13.72 > 0.50$	OK	
$n_c(f_0) > 200$	$12895.6 > 200$	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

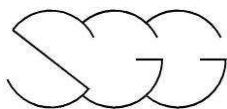
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	10.375 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	18.063 Hz	OK	
$A_0 > 2$	$3.66 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.05967 < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	$0.81854 < 0.68594$		NO
$\sigma_A(f_0) < \theta(f_0)$	$0.0899 < 1.58$	OK	

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

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

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

**PROVA 12 - - VIA MARANELLO (CIMITERO),****COLOMBARO DI FORMIGINE (MO)**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN
COORDINATE GAUSS-BOAGA: 1650015, 4934826

Trace length: 0h20'00". Analyzed 93% trace (manual window selection)

Sampling frequency: 128 Hz

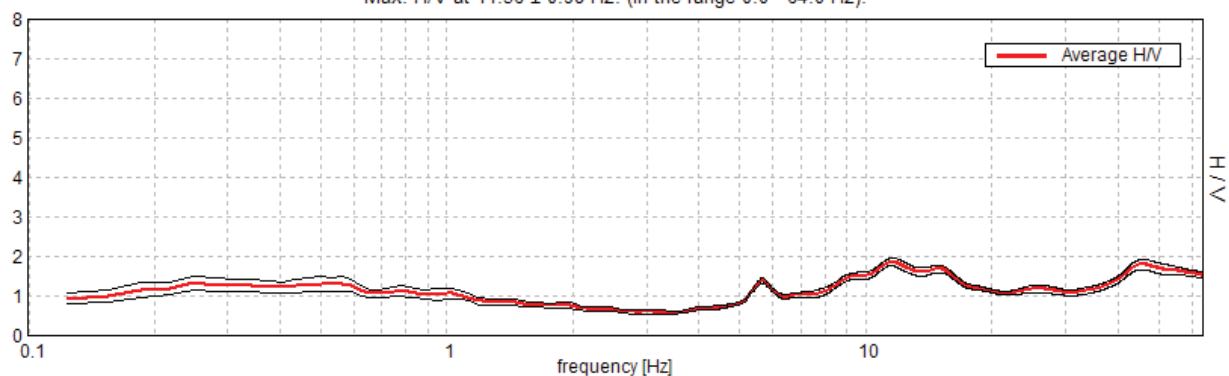
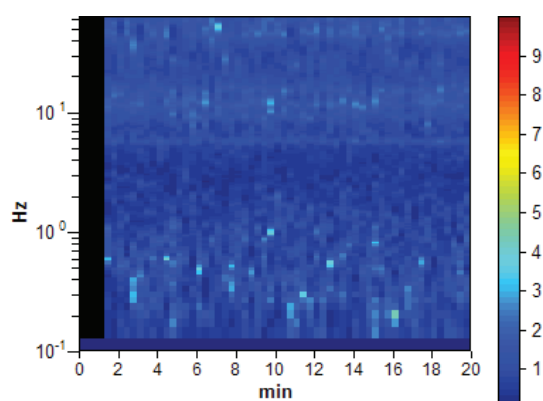
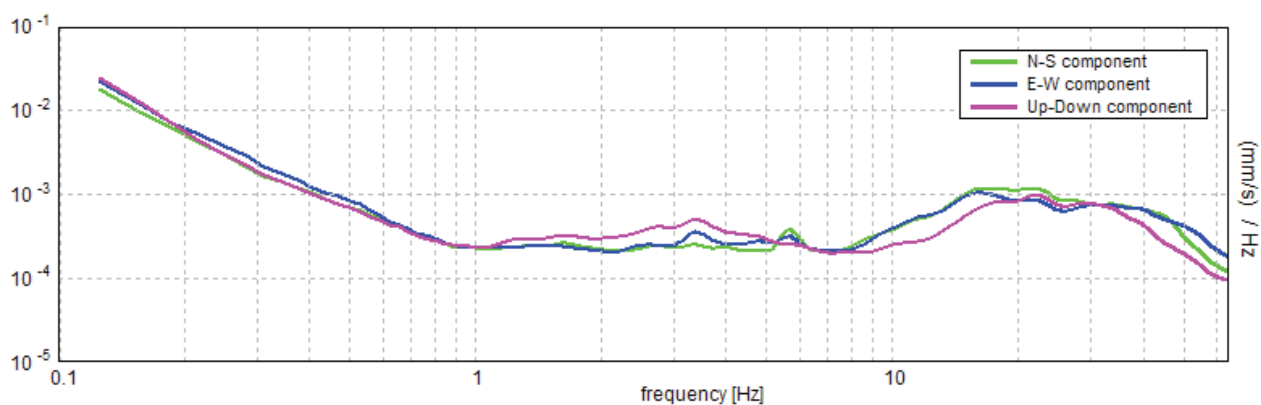
Window size: 20 s

Smoothing window: Triangular window

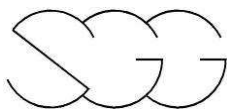
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

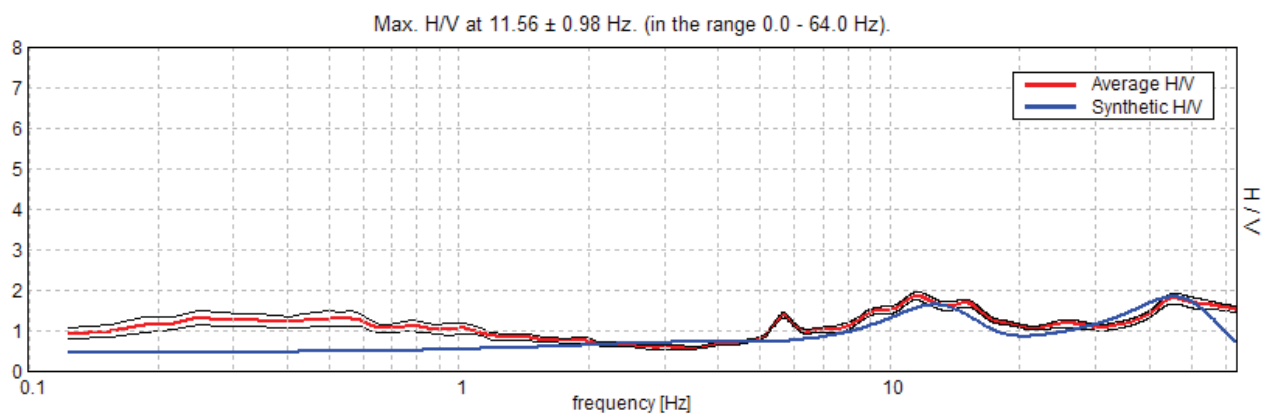
Max. H/V at 11.56 ± 0.98 Hz. (in the range 0.0 - 64.0 Hz).

**H/V TIME HISTORY****SINGLE COMPONENT SPECTRA**

Comune di Formigine (MO)
MICROZONAZIONE SISMICA
Relazione tecnica



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.60	0.60	110
3.10	2.50	240
6.80	3.70	305
11.80	5.00	500
24.80	13.00	370
inf.	inf.	500

$V_s(0.0-30.0)=359\text{m/s}$

Max. H/V at 11.56 ± 0.98 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$11.56 > 0.50$	OK	
$n_c(f_0) > 200$	$12950.0 > 200$	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 556 times	OK	

Criteria for a clear HVSR peak

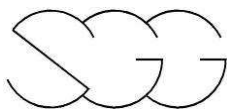
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	5.156 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$			NO
$A_0 > 2$	$1.87 > 2$		NO
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.04186 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.48398 < 0.57813$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.048 < 1.58$	OK	

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

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

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

**PROVA 13****VIA SASSUOLO****FORMIGINE (MO)**

Channel labels: NORTH SOUTH;

EAST WEST ; UP DOWN

COORDINATE GAUSS-BOAGA:

1645679, 4936703

Trace length: 0h20'00".

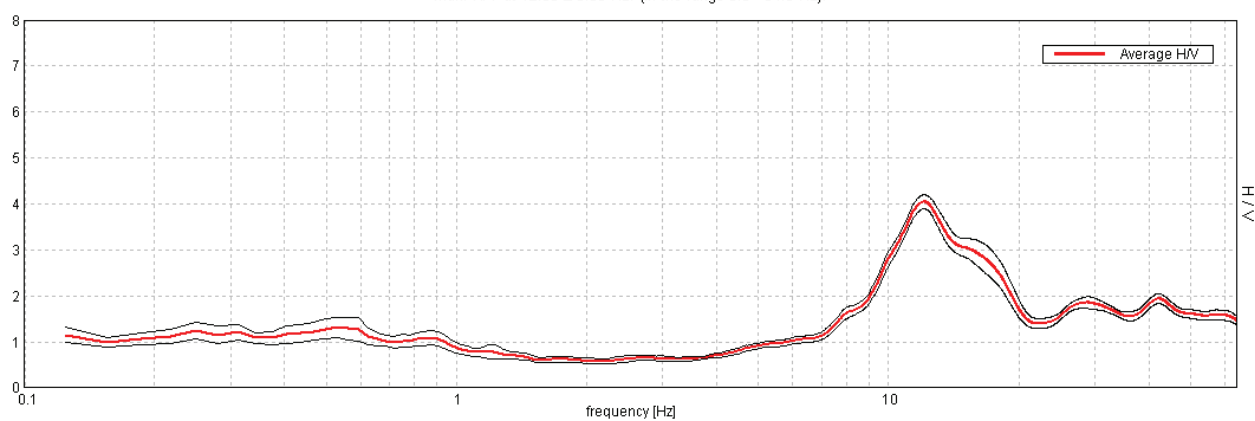
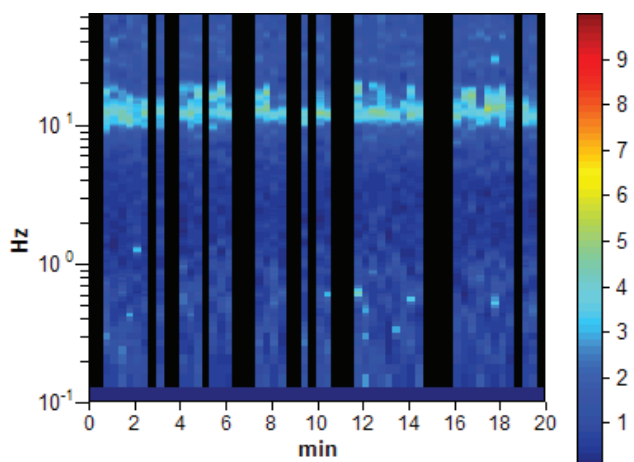
Analyzed 65% trace (manual window selection)

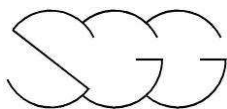
Sampling frequency: 128 Hz

Window size: 20 s

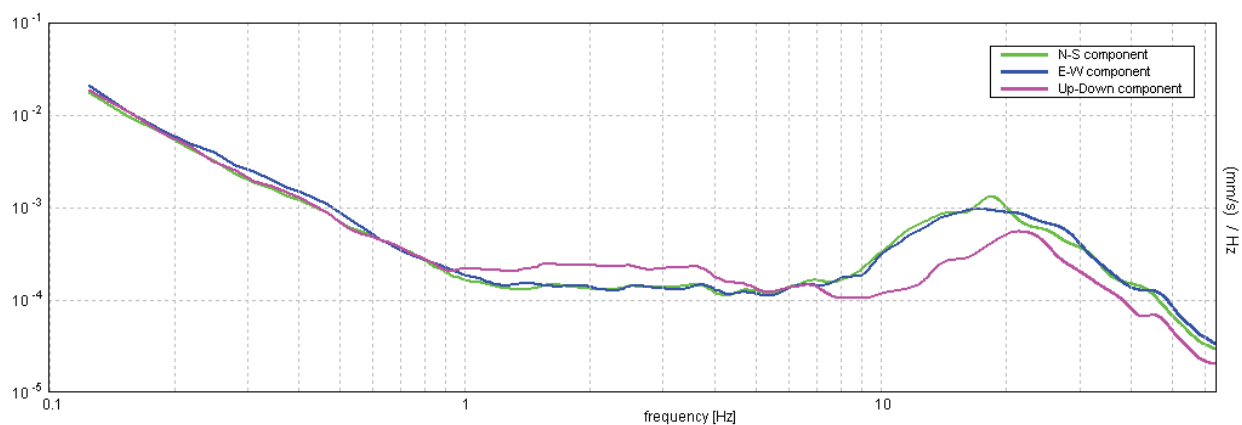
Smoothing window: Triangular window

Smoothing: 10%

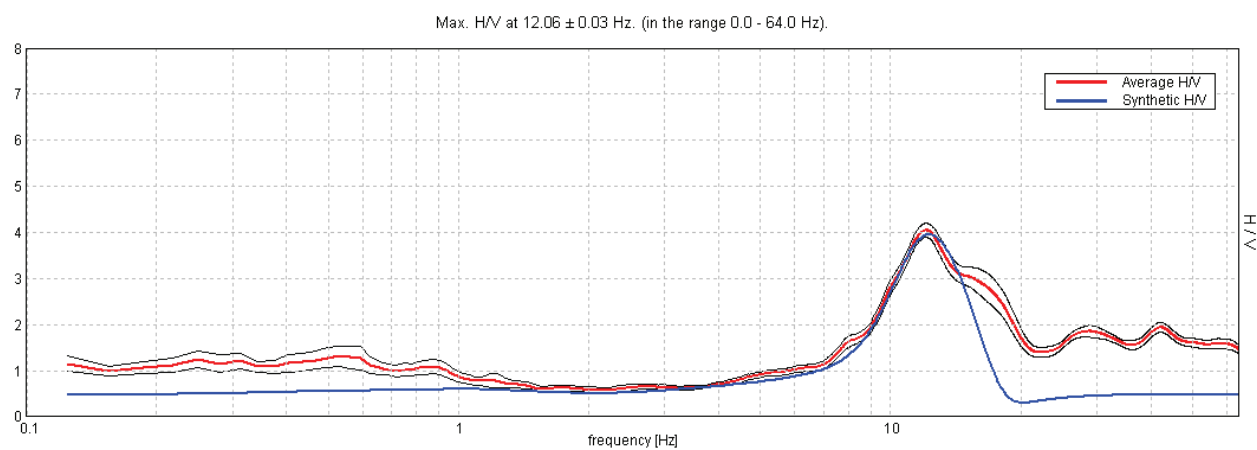
HORIZONTAL TO VERTICAL SPECTRAL RATIOMax. H/V at 12.06 ± 0.03 Hz. (in the range 0.0 - 64.0 Hz).**H/V TIME HISTORY**



SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer
[m]

Thickness [m]

Vs [m/s]

4.40
26.40
34.40
55.40
77.40
inf.

4.40
22.00
8.00
21.00
22.00
inf.

212
535
350
580
380
620

Vs(0.0-30.0)=416m/s

Max. H/V at 12.06 ± 0.03 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$12.06 > 0.50$	OK	
$n_c(f_0) > 200$	$9408.8 > 200$	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 580 times	OK	

Criteria for a clear HVSR peak

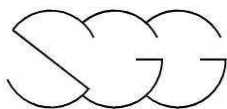
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	9.094 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	19.25 Hz	OK	
$A_0 > 2$	$4.05 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00101 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.01223 < 0.60313$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.0729 < 1.58$	OK	

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

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

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

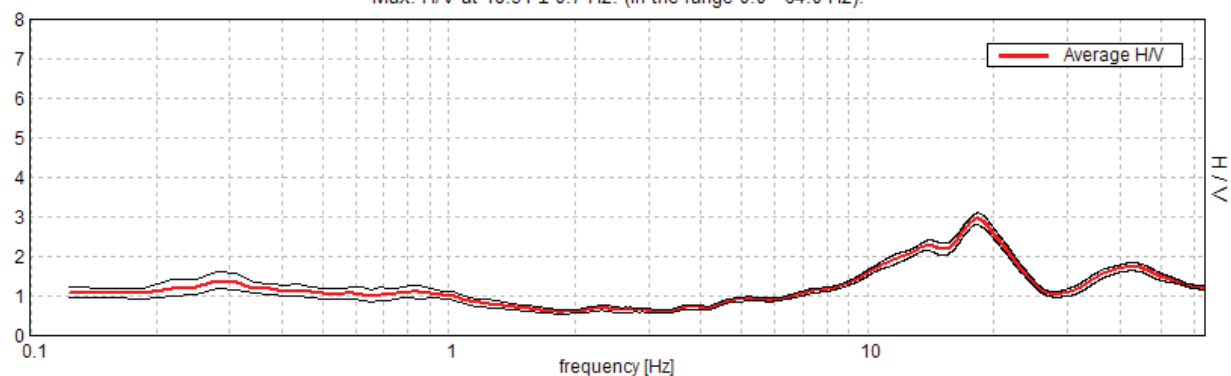
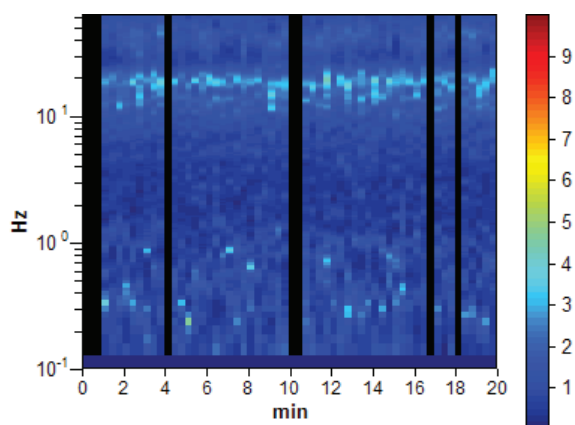
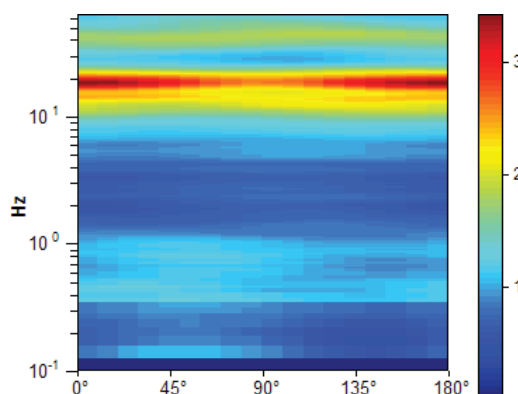
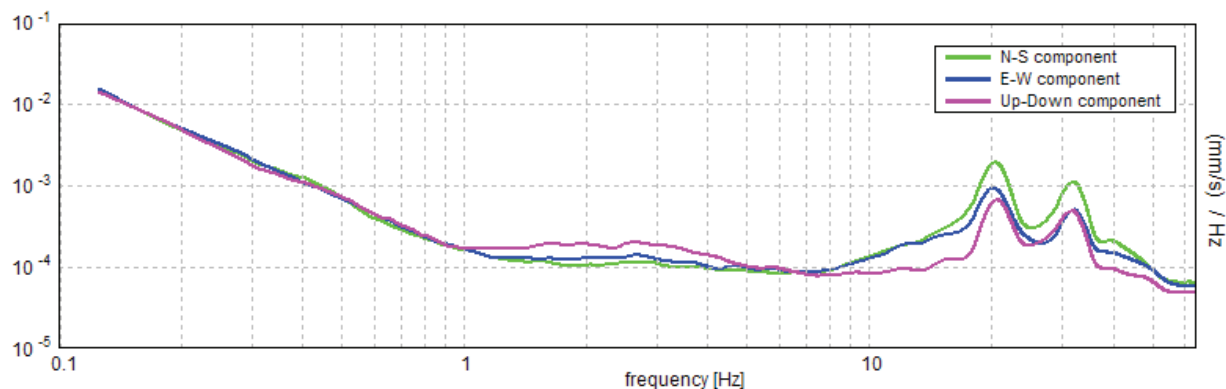
**PROVA 14 VIA ANTONIO GRAMSCI FORMIGINE**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN
COORDINATE GAUSS-BOAGA: 1645876, 4937583

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. H/V at 18.31 ± 0.7 Hz. (In the range 0.0 - 64.0 Hz).

**H/V TIME HISTORY****DIRECTIONAL H/V****SINGLE COMPONENT SPECTRA**

Comune di Formigine (MO)
MICROZONAZIONE SISMICA
Relazione tecnica

Max. H/V at 18.31 ± 0.7 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$18.31 > 0.50$	OK	
$n_c(f_0) > 200$	$19045.0 > 200$	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 880 times	OK	

Criteria for a clear HVSR peak

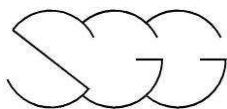
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	9.594 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	24.25 Hz	OK	
$A_0 > 2$	$2.96 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.01895 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.34708 < 0.91563$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.0731 < 1.58$	OK	

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

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

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

**PROVA 15****VIA PODGORA****FORMIGINE (MO)**

Channel labels: NORTH SOUTH;

EAST WEST ; UP DOWN

COORDINATE GAUSS-BOAGA:

1647724, 4940024

Trace length: 0h20'00".

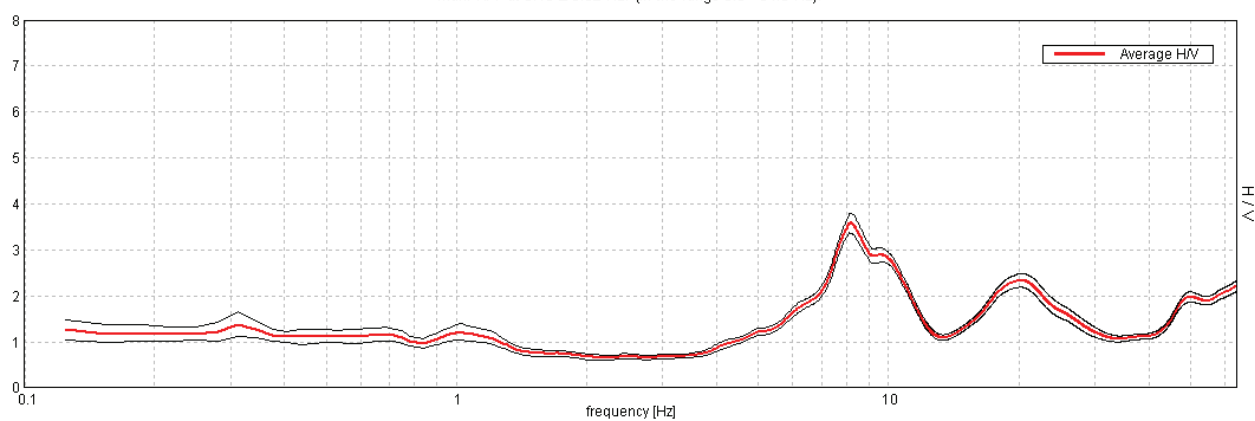
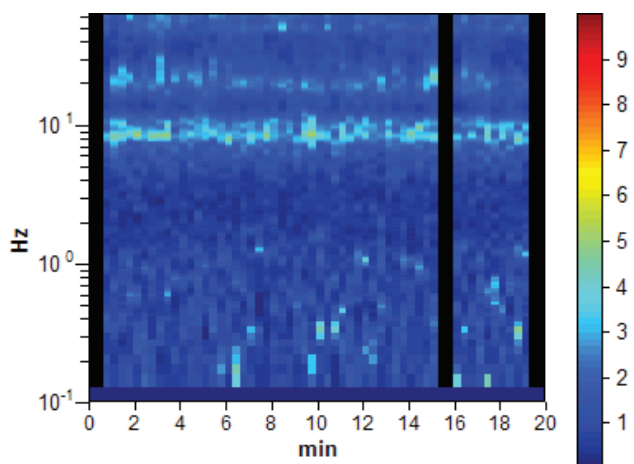
Analyzed 90% trace (manual window selection)

Sampling frequency: 128 Hz

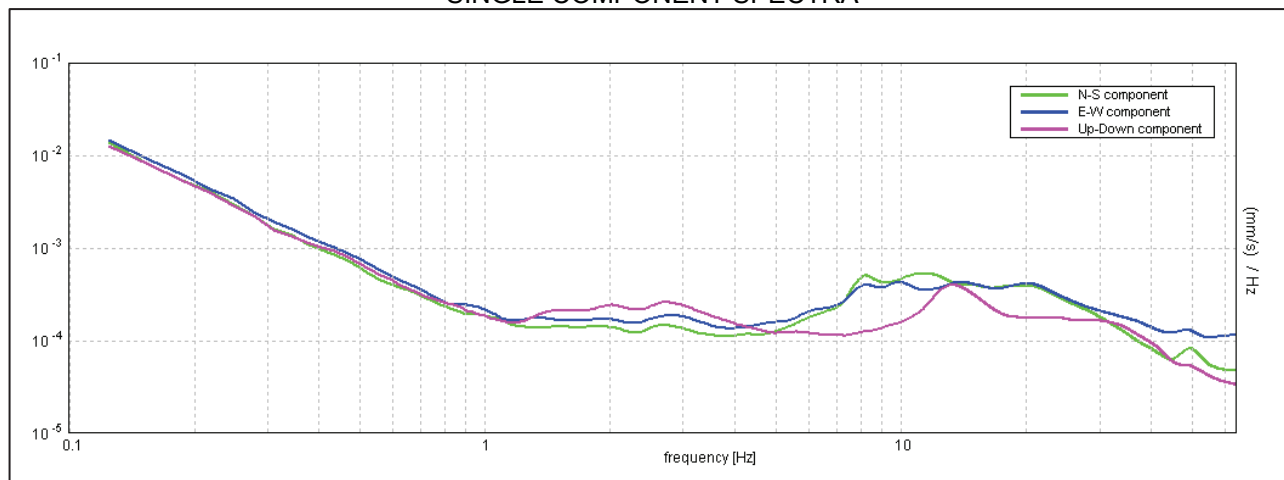
Window size: 20 s

Smoothing window: Triangular window

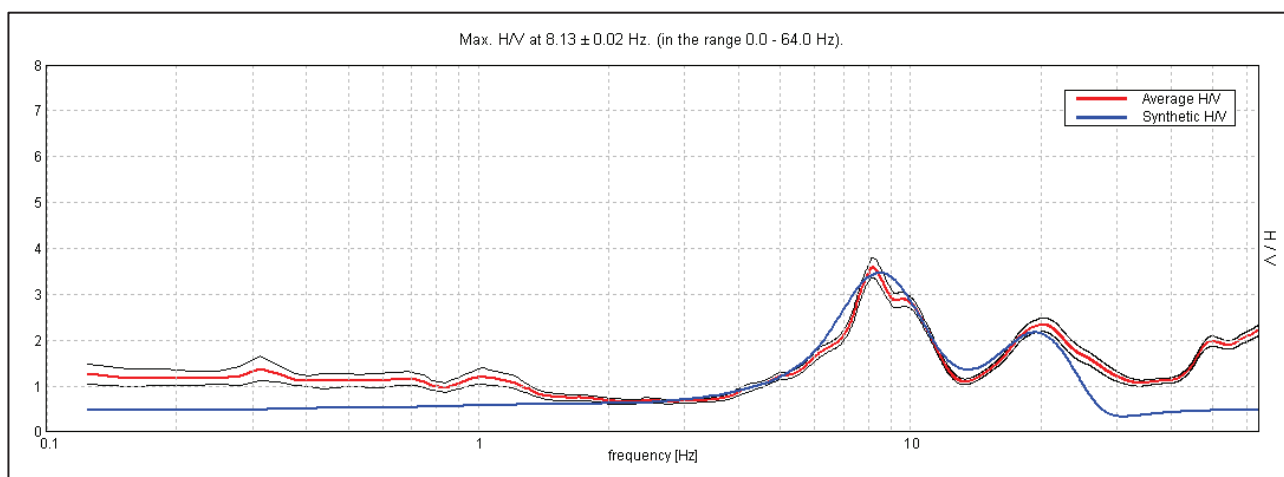
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIOMax. H/V at 8.13 ± 0.02 Hz. (in the range 0.0 - 64.0 Hz).**H/V TIME HISTORY**

SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer

[m]

1.50

7.80

32.80

47.80

inf.

Thickness [m]

1.50

6.30

25.00

15.00

inf.

Vs [m/s]

110

260

490

350

520

Vs(0.0-30.0)=361m/s

Max. H/V at 8.13 ± 0.02 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$8.13 > 0.50$	OK	
$n_c(f_0) > 200$	$8775.0 > 200$	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 391 times	OK	

Criteria for a clear HVSR peak

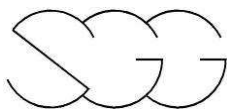
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	6.281 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	11.531 Hz	OK	
$A_0 > 2$	$3.58 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00119 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.00965 < 0.40625$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.1011 < 1.58$	OK	

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

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

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

**PROVA 16****VIA POGGI****COLOMBARONE DI FORMIGINE (MO)**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN
COORDINATE GAUSS-BOAGA: 1643171, 4941449

Trace length: 0h20'00". Analyzed 92% trace (manual window selection)

Sampling frequency: 128 Hz

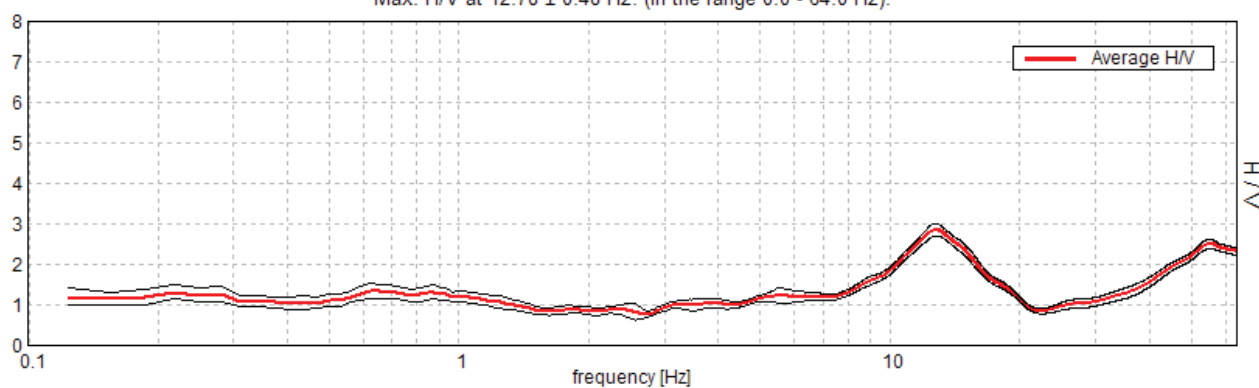
Window size: 20 s

Smoothing window: Triangular window

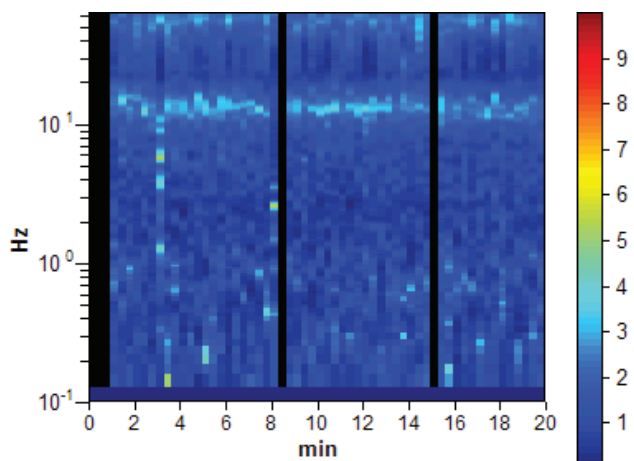
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

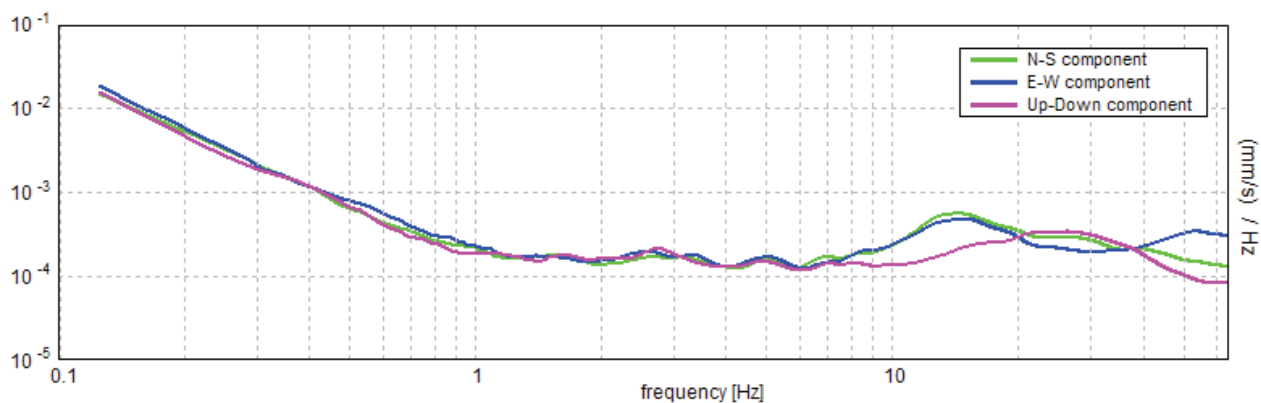
Max. H/V at 12.78 ± 0.48 Hz. (in the range 0.0 - 64.0 Hz).



H/V TIME HISTORY

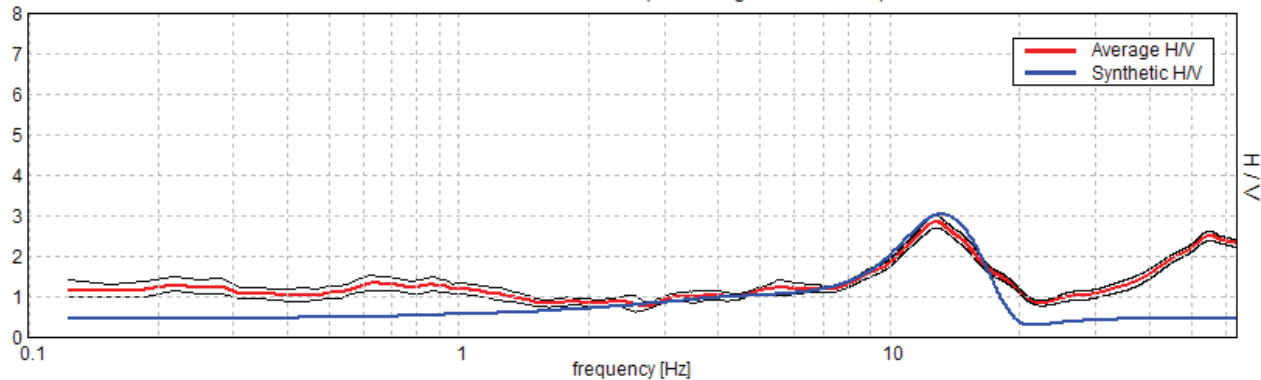


SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V

Max. H/V at 12.78 ± 0.48 Hz. (in the range 0.0 - 64.0 Hz).



Depth at the bottom of the layer
[m]

Thickness [m]

Vs [m/s]

3.50
13.50
23.50
33.50
inf.

3.50
10.00
10.00
10.00
inf.

179
445
500
550
620

Vs(0.0-30.0)=406m/s

Max. H/V at 12.78 ± 0.48 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$12.78 > 0.50$	OK	
$n_c(f_0) > 200$	$14059.4 > 200$	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 614 times	OK	

Criteria for a clear HVSR peak

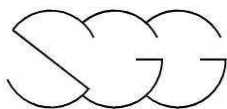
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	8.375 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	18.656 Hz	OK	
$A_0 > 2$	$2.87 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.01845 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.23583 < 0.63906$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.0755 < 1.58$	OK	

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

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

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

**PROVA 17****VIA CÀ DEL VENTO****FORMIGINE**

Channel labels: NORTH SOUTH;

EAST WEST ; UP DOWN

COORDINATE GAUSS-BOAGA:

1649662, 4938581

Trace length: 0h20'00".

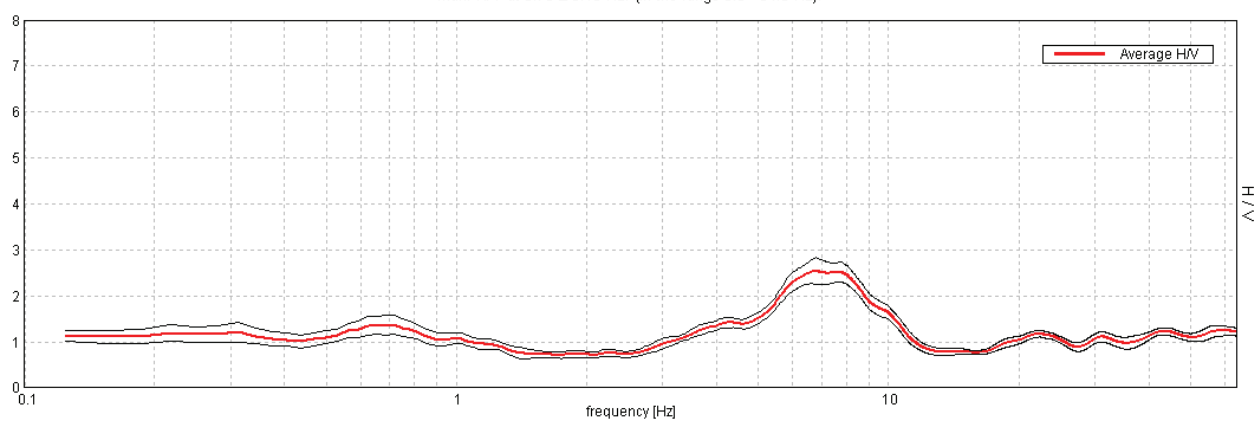
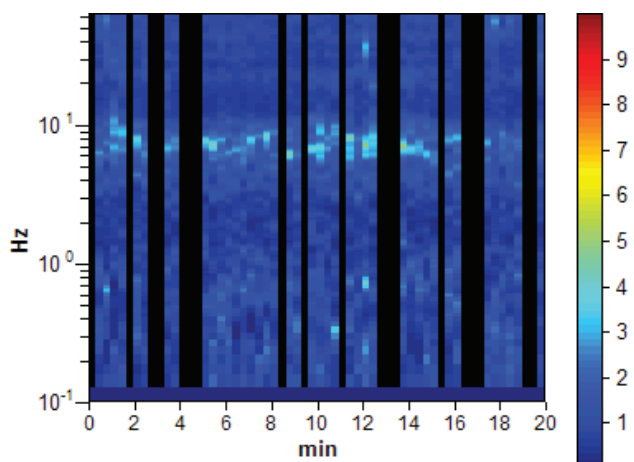
Analyzed 68% trace (manual window selection)

Sampling frequency: 128 Hz

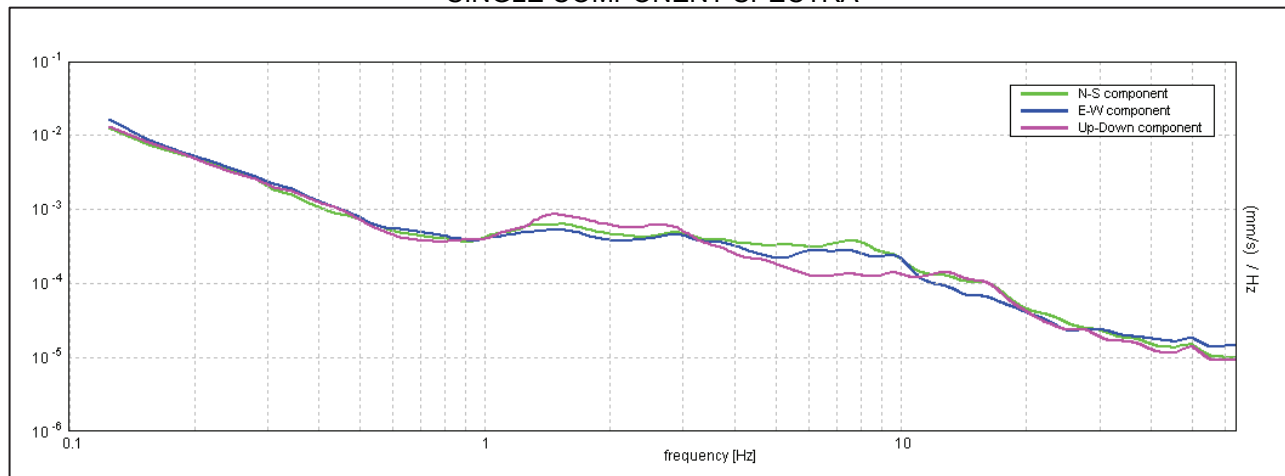
Window size: 20 s

Smoothing window: Triangular window

Smoothing: 10%

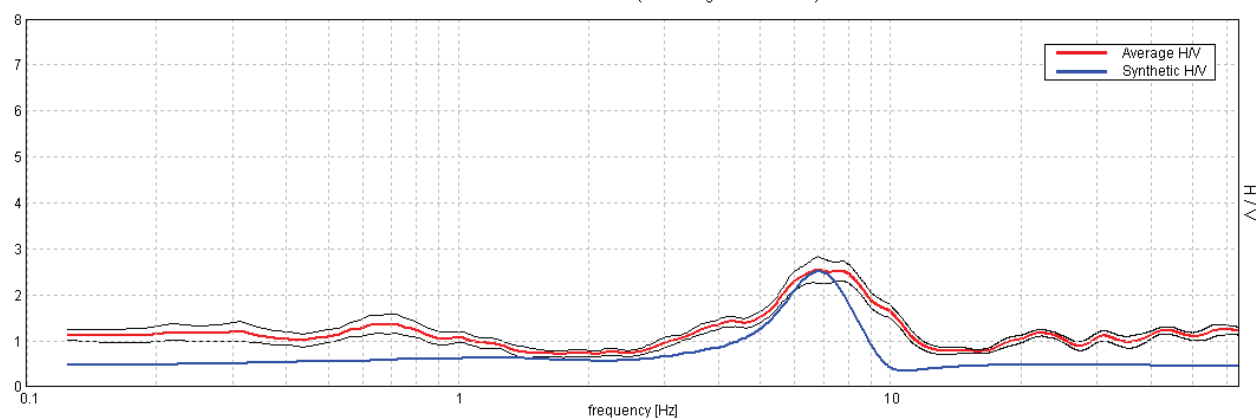
HORIZONTAL TO VERTICAL SPECTRAL RATIOMax. H/V at 6.78 ± 0.16 Hz. (in the range 0.0 - 64.0 Hz).**H/V TIME HISTORY**

SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V

Max. H/V at 6.78 ± 0.16 Hz. (in the range 0.0 - 64.0 Hz).



Depth at the bottom of the layer

[m]

10.40

30.40

50.40

70.40

inf.

Thickness [m]

10.40

20.00

20.00

20.00

inf.

Vs [m/s]

260

610

400

450

600

$V_s(0.0-30.0)=416\text{m/s}$

Max. H/V at 6.78 ± 0.16 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$6.78 > 0.50$	OK	
$n_c(f_0) > 200$	$5560.6 > 200$	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 326 times	OK	

Criteria for a clear HVSR peak

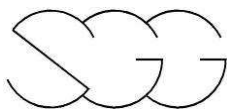
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	3.688 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	10.813 Hz	OK	
$A_0 > 2$	$2.55 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.01168 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.07922 < 0.33906$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.1388 < 1.58$	OK	

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

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

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



PROVA 18--

VIA S. ANTONIO

FORMIGINE

Channel labels: NORTH SOUTH;

EAST WEST ; UP DOWN

COORDINATE GAUSS-BOAGA:

1647453, 4937167

Trace length: 0h20'00".

Analyzed 80% trace (manual window selection)

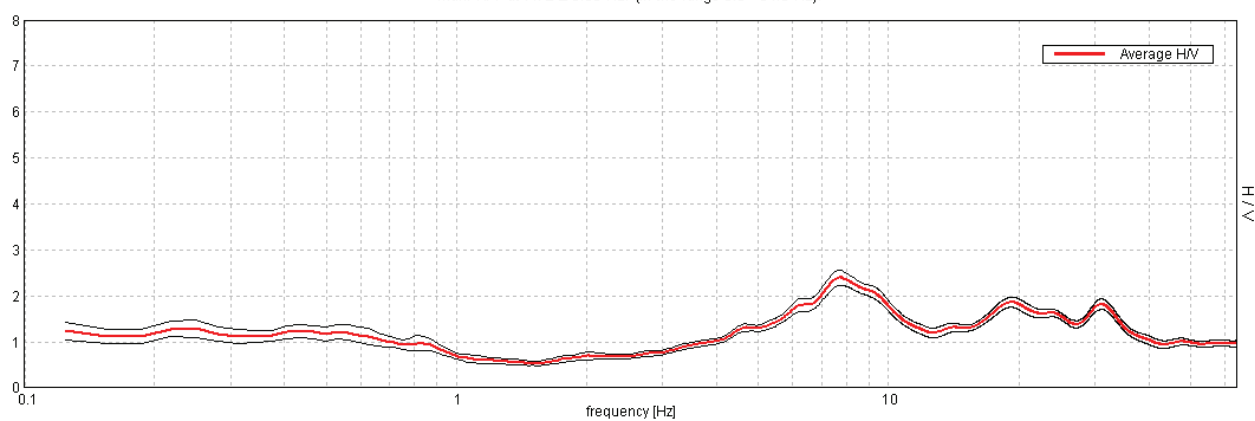
Sampling frequency: 128 Hz

Window size: 20 s

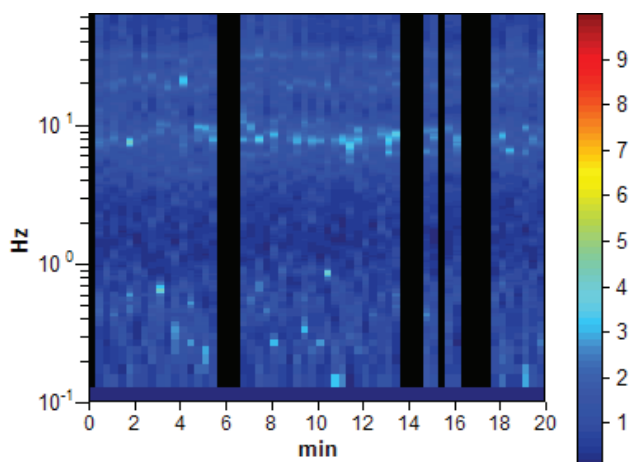
Smoothing window: Triangular window

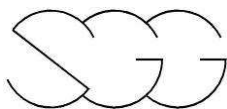
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

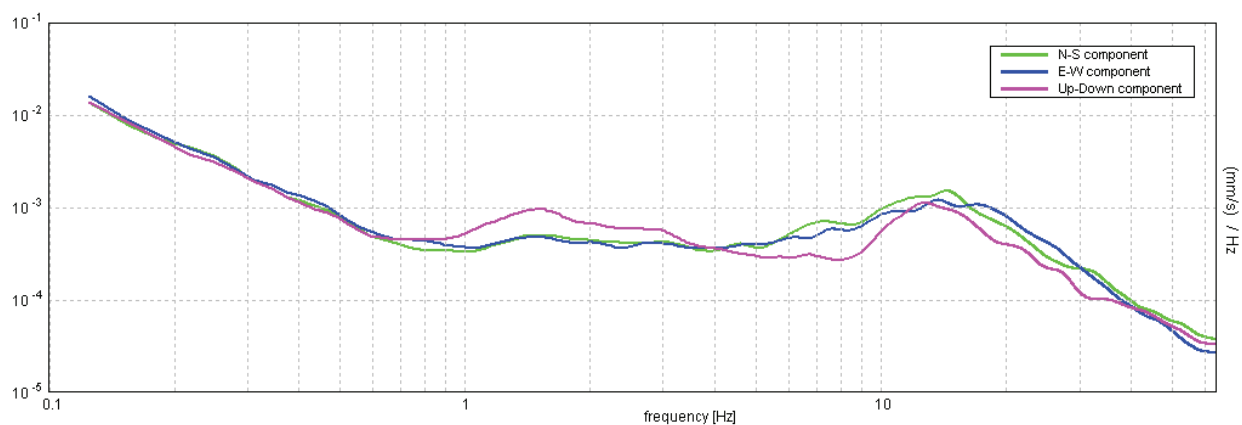
Max. H/V at 7.72 ± 0.05 Hz. (in the range 0.0 - 64.0 Hz).

H/V TIME HISTORY



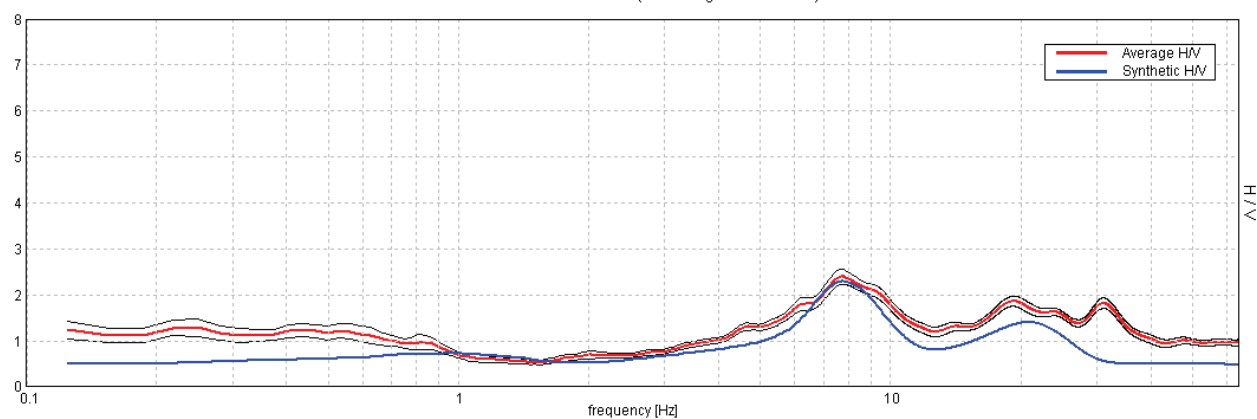


SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V

Max. H/V at 7.72 ± 0.05 Hz. (in the range 0.0 - 64.0 Hz).



Depth at the bottom of the layer

Thickness [m]

Vs [m/s]

[m]

0.80

0.80

135

2.40

1.60

175

4.40

2.00

350

8.00

3.60

240

32.00

24.00

510

82.00

50.00

400

inf.

inf.

600

Vs(0.0-30.0)=380m/s

Max. H/V at 7.72 ± 0.05 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$7.72 > 0.50$	OK	
$n_c(f_0) > 200$	$7410.0 > 200$	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 372 times	OK	

Criteria for a clear HVSR peak

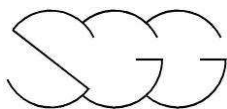
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	4.375 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	12.594 Hz	OK	
$A_0 > 2$	$2.40 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00308 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.02376 < 0.38594$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.0814 < 1.58$	OK	

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

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

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

**PROVA 19****VIA CANALETTO CASE VARINI FORMIGINE (MO)**

Channel labels: NORTH SOUTH; EAST WEST; UP DOWN

COORDINATE GAUSS-BOAGA: 1647971, 4935015

Trace length: 0h20'00".

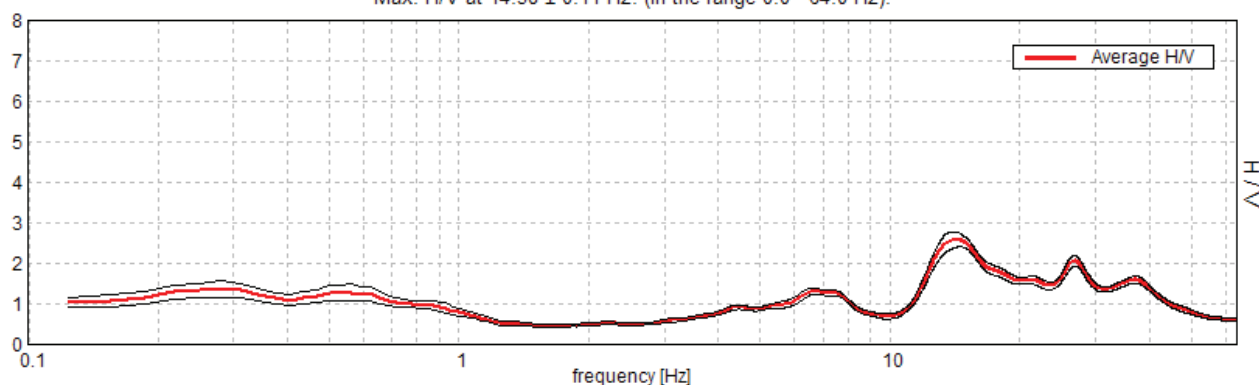
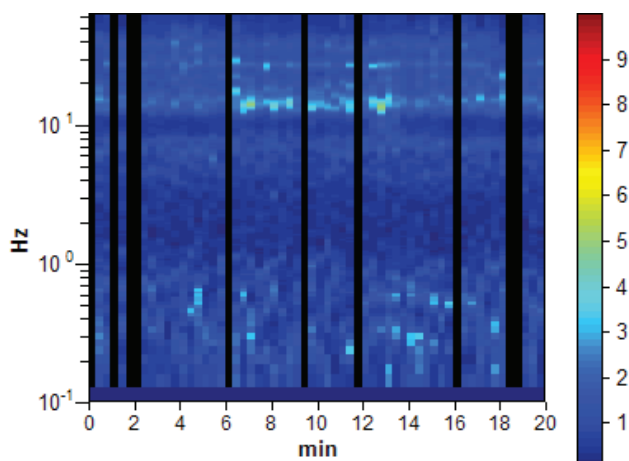
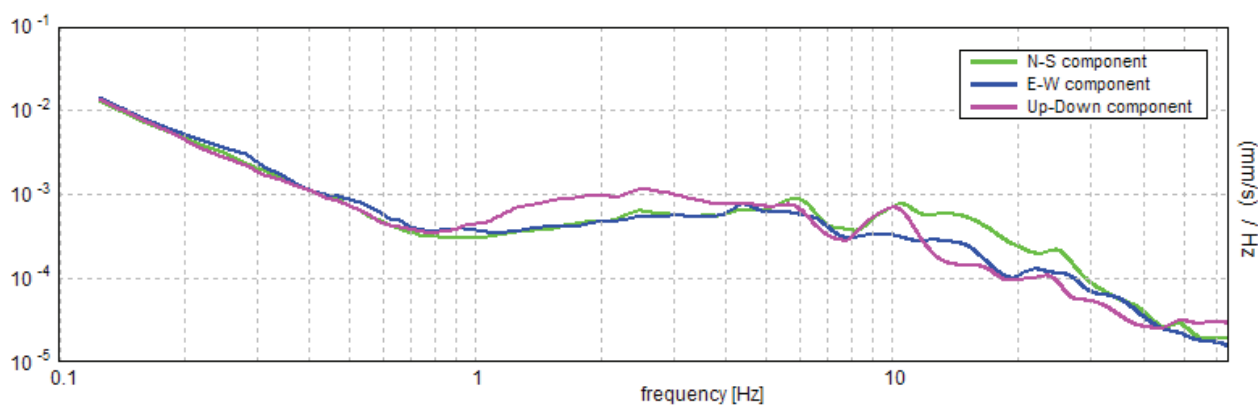
Sampling frequency: 128 Hz

Smoothing window: Triangular window

Analyzed 83% trace (manual window selection)

Window size: 20 s

Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIOMax. H/V at 14.38 ± 0.11 Hz. (in the range 0.0 - 64.0 Hz).**H/V TIME HISTORY****SINGLE COMPONENT SPECTRA**

Max. H/V at 14.38 ± 0.11 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$14.38 > 0.50$	OK	
$n_c(f_0) > 200$	$14375.0 > 200$	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 691 times	OK	

Criteria for a clear HVSR peak

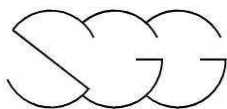
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	11.656 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	41.031 Hz	OK	
$A_0 > 2$	$2.59 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00374 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.05372 < 0.71875$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.0879 < 1.58$	OK	

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

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

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

**PROVA 20 CASE ZOBOLI CASINALBO DI FORMIGINE (MO)**

Channel labels: NORTH SOUTH;

EAST WEST ; UP DOWN

COORDINATE GAUSS-BOAGA:

1648041, 4939653

Trace length: 0h20'00".

Analyzed 77% trace (manual window selection)

Sampling frequency: 128 Hz

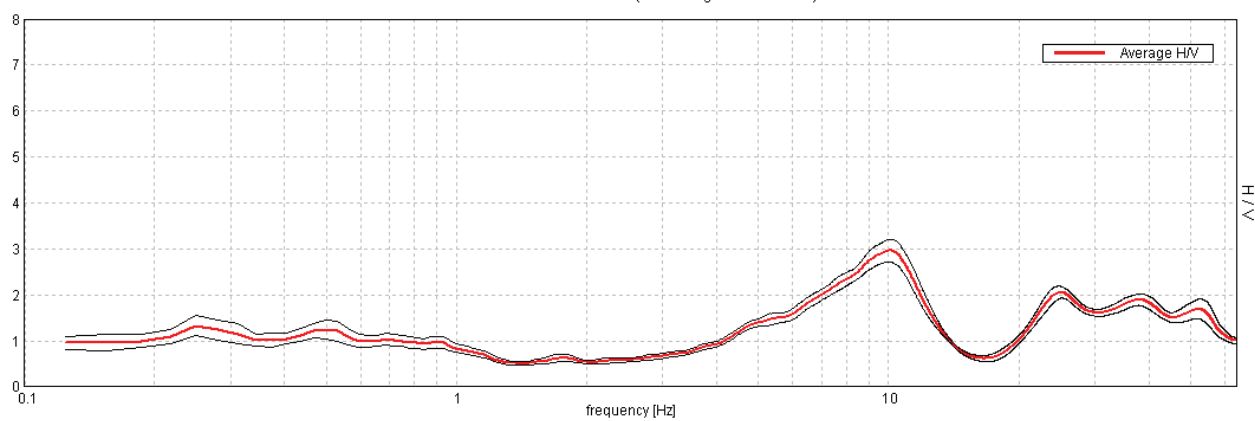
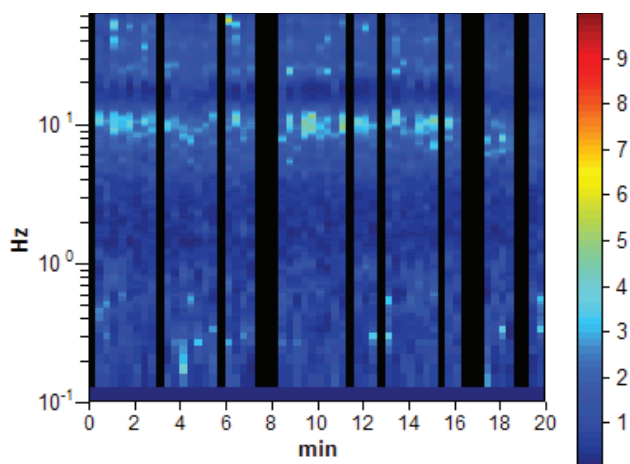
Window size: 20 s

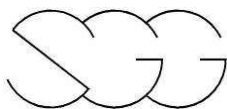
Smoothing window: Triangular window

Smoothing: 10%

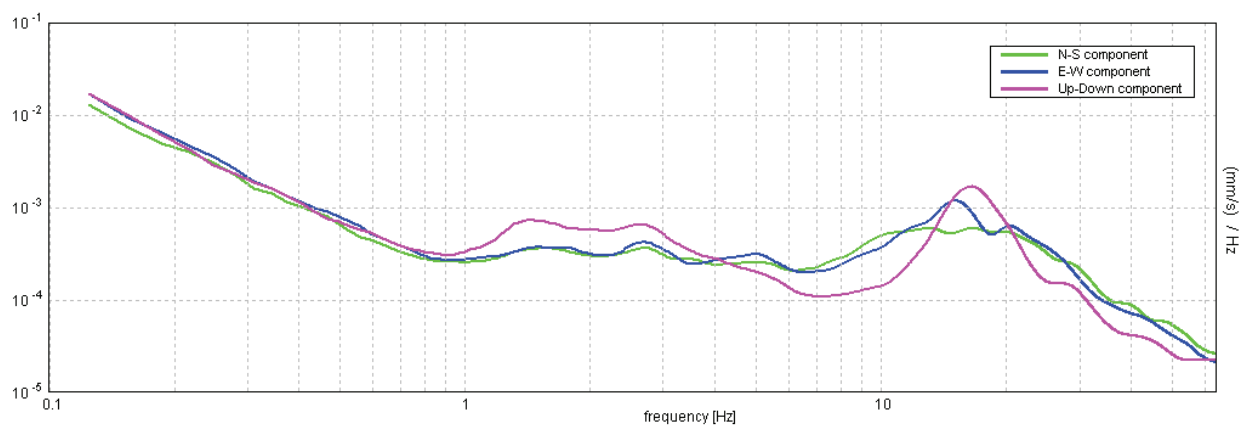
HORIZONTAL TO VERTICAL SPECTRAL RATIO

Max. H/V at 10.0 ± 0.05 Hz. (in the range 0.0 - 64.0 Hz).

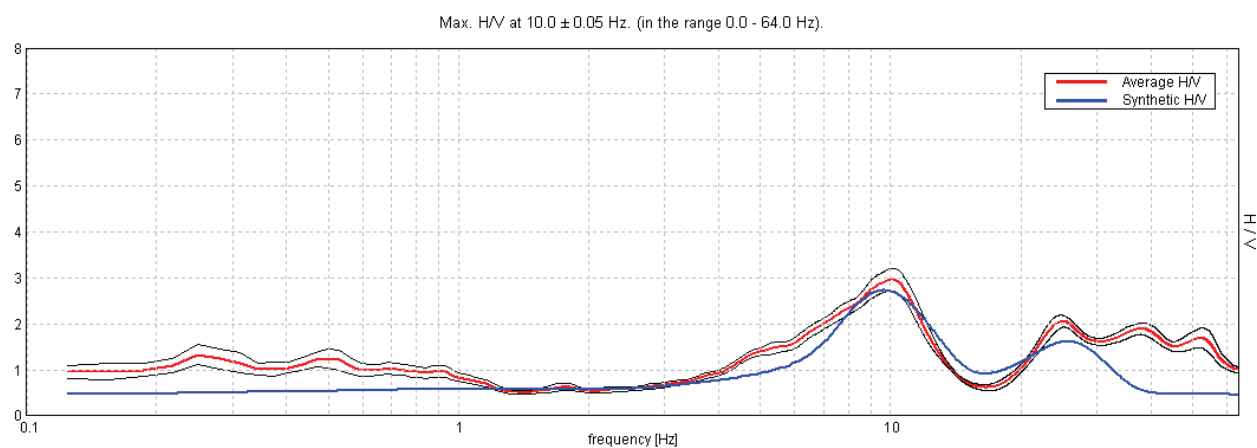
**H/V TIME HISTORY**



SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer

[m]

0.80

2.00

3.40

6.40

21.40

36.40

76.40

inf.

Thickness [m]

0.80

1.20

1.40

3.00

15.00

15.00

40.00

inf.

Vs [m/s]

130

180

365

250

550

580

470

600

 $V_s(0.0-30.0)=424\text{m/s}$

Max. H/V at 10.0 ± 0.05 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$10.00 > 0.50$	OK	
$n_c(f_0) > 200$	$9200.0 > 200$	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 481 times	OK	

Criteria for a clear HVSR peak

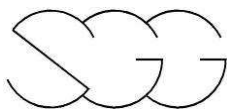
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	5.406 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	12.719 Hz	OK	
$A_0 > 2$	$2.97 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00258 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.02584 < 0.5$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.119 < 1.58$	OK	

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

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

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

**PROVA 21 - VIA BASSA PAOLUCCI****CASINALBO FORMIGINE**

Channel labels: NORTH SOUTH;

EAST WEST ; UP DOWN

COORDINATE GAUSS-BOAGA:

1647976, 4939354

Trace length: 0h20'00".

Analyzed 93% trace (manual window selection)

Sampling frequency: 128 Hz

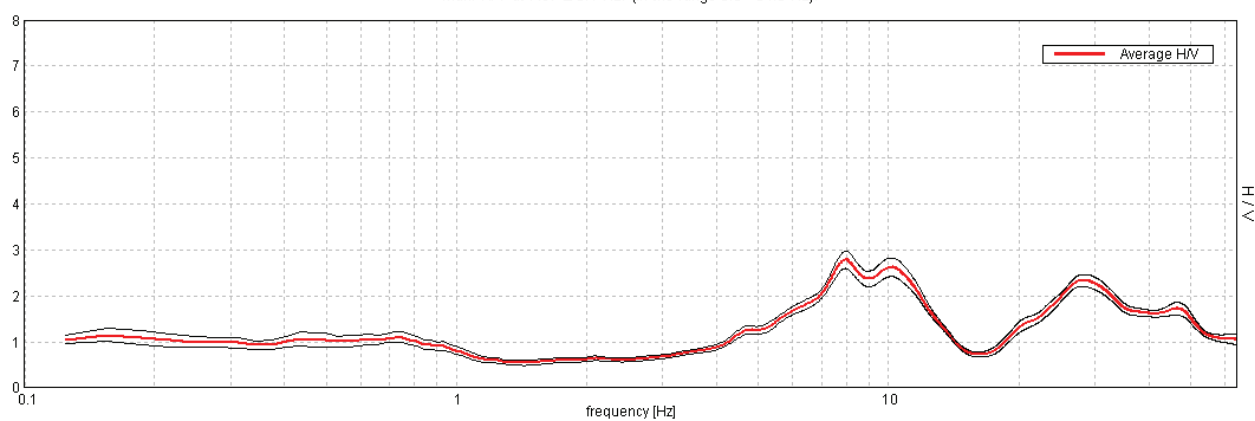
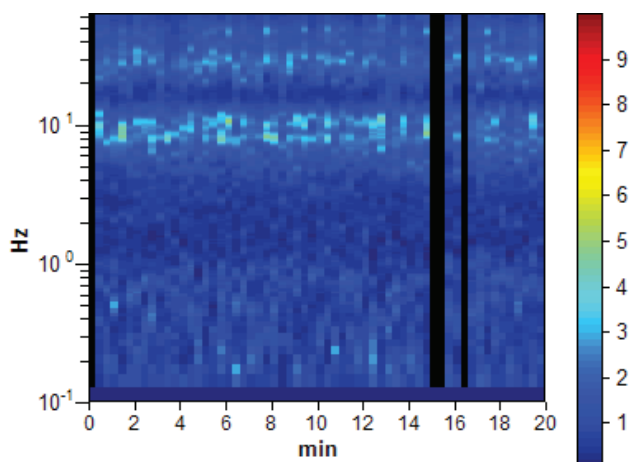
Window size: 20 s

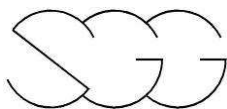
Smoothing window: Triangular window

Smoothing: 10%

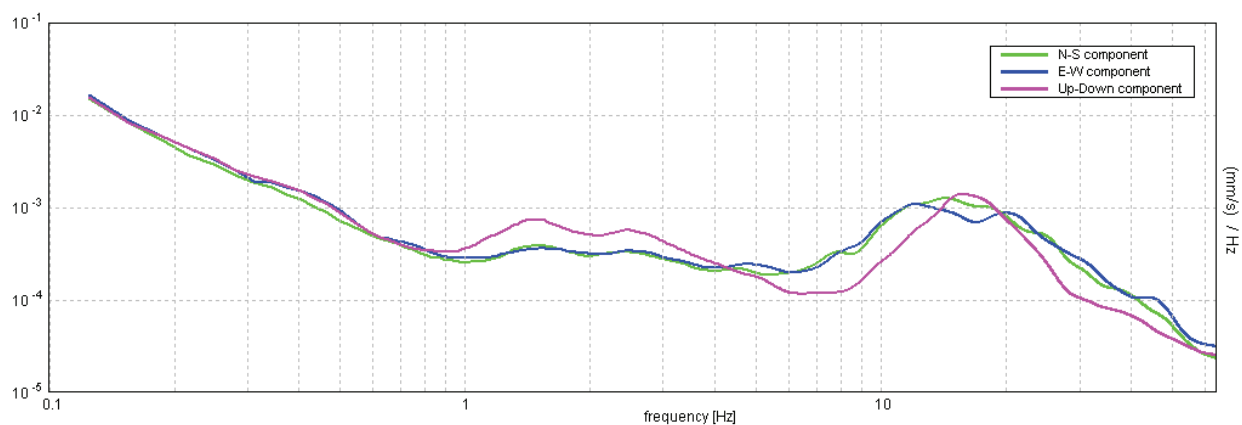
HORIZONTAL TO VERTICAL SPECTRAL RATIO

Max. H/V at 7.97 ± 0.1 Hz. (in the range 0.0 - 64.0 Hz).

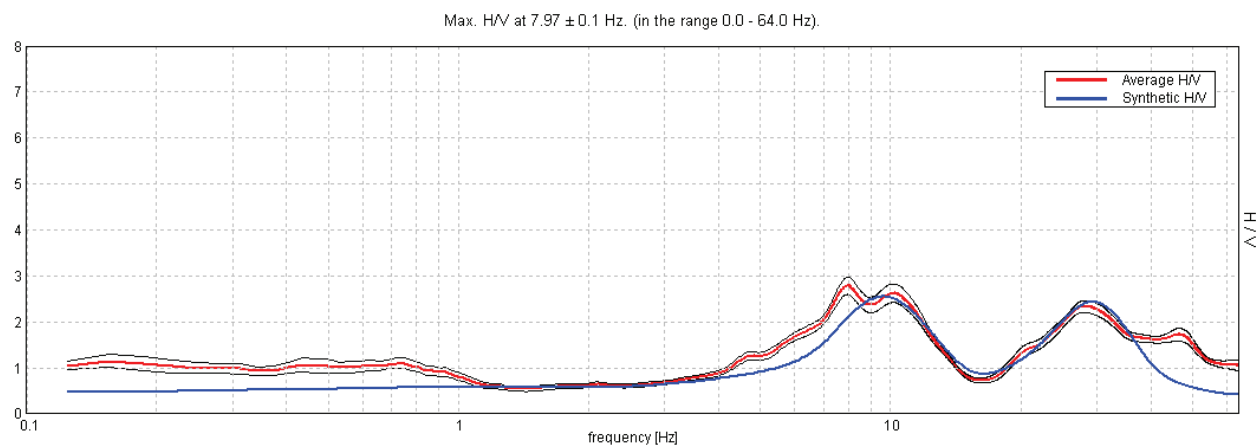
**H/V TIME HISTORY**



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

110

2.00

1.30

200

3.50

1.50

350

6.00

2.50

230

21.00

15.00

540

36.00

15.00

580

76.00

40.00

470

inf.

inf.

600

 $V_s(0.0-30.0)=421\text{m/s}$

Max. H/V at 7.97 ± 0.1 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$7.97 > 0.50$	OK	
$n_c(f_0) > 200$	$8925.0 > 200$	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 384 times	OK	

Criteria for a clear HVSR peak

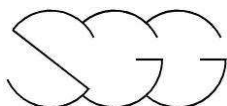
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	5.406 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	13.156 Hz	OK	
$A_0 > 2$	$2.79 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00601 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.04786 < 0.39844$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.0945 < 1.58$	OK	

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

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

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

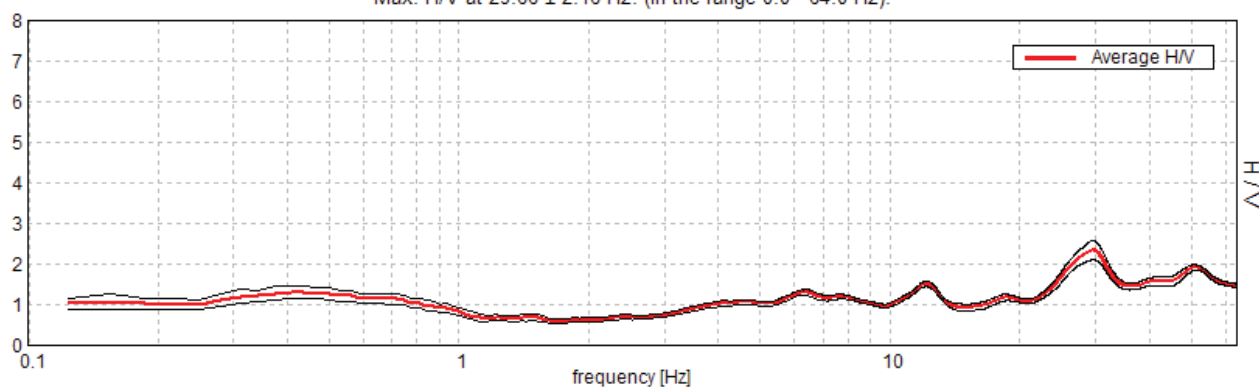
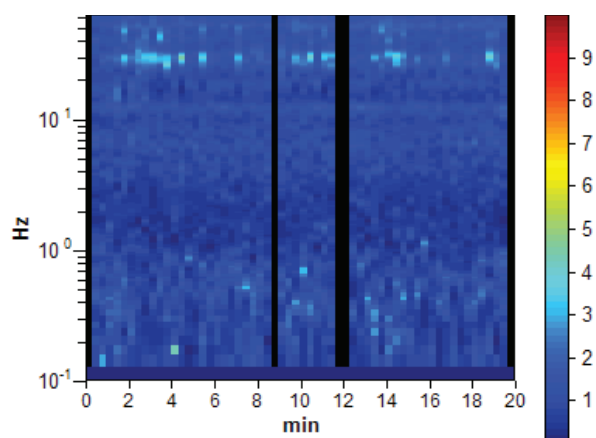
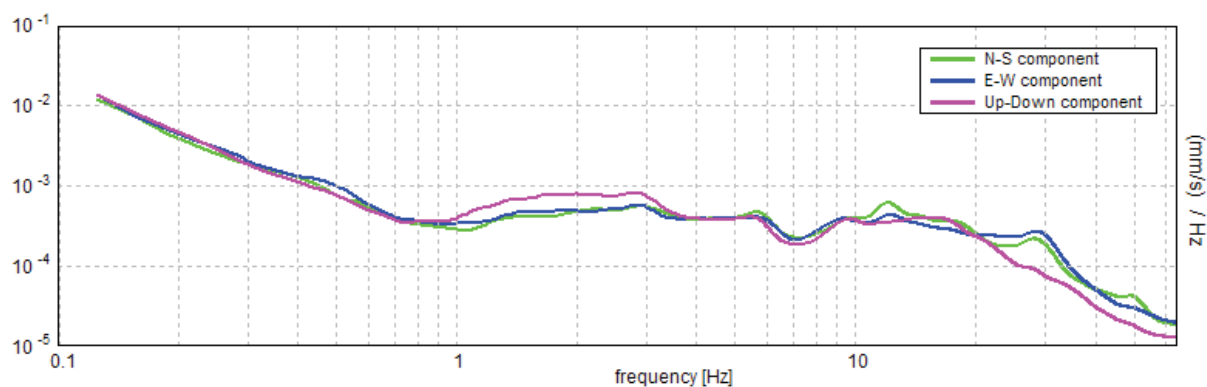
**PROVA 22 VIA SALVIOLA COLOMBARO DI FORMIGINE (MO)**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN
COORDINATE GAUSS-BOAGA: 1648753, 4934910

Trace length: 0h20'00". Analyzed 92% 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 29.66 ± 2.16 Hz. (in the range 0.0 - 64.0 Hz).

**H/V TIME HISTORY****SINGLE COMPONENT SPECTRA**

Comune di Formigine (MO)
MICROZONAZIONE SISMICA
Relazione tecnica

Max. H/V at 29.66 ± 2.16 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$29.66 > 0.50$	OK	
$n_c(f_0) > 200$	$32621.9 > 200$	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 1424 times	OK	

Criteria for a clear HVSR peak

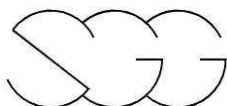
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	22.094 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$			NO
$A_0 > 2$	$2.35 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.03597 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$1.06677 < 1.48281$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.1165 < 1.58$	OK	

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

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

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

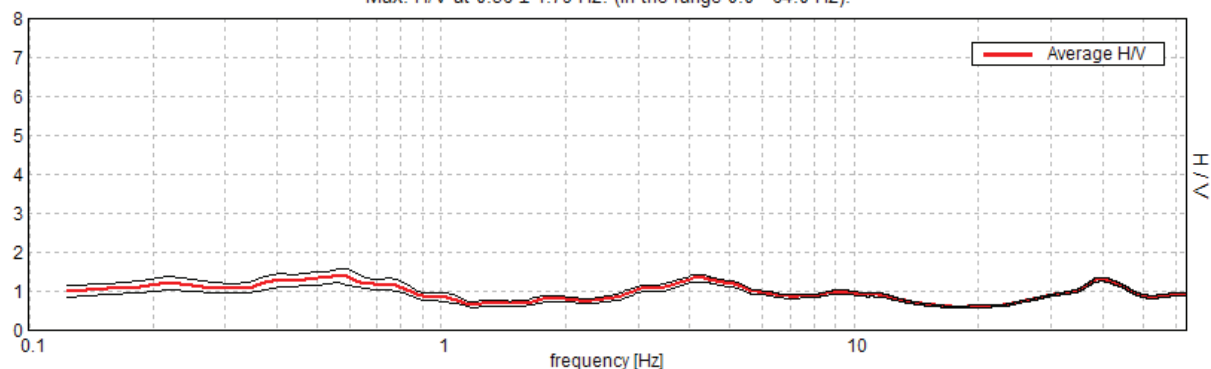
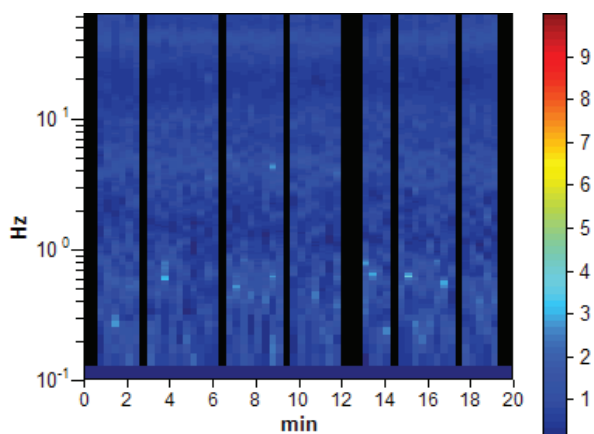
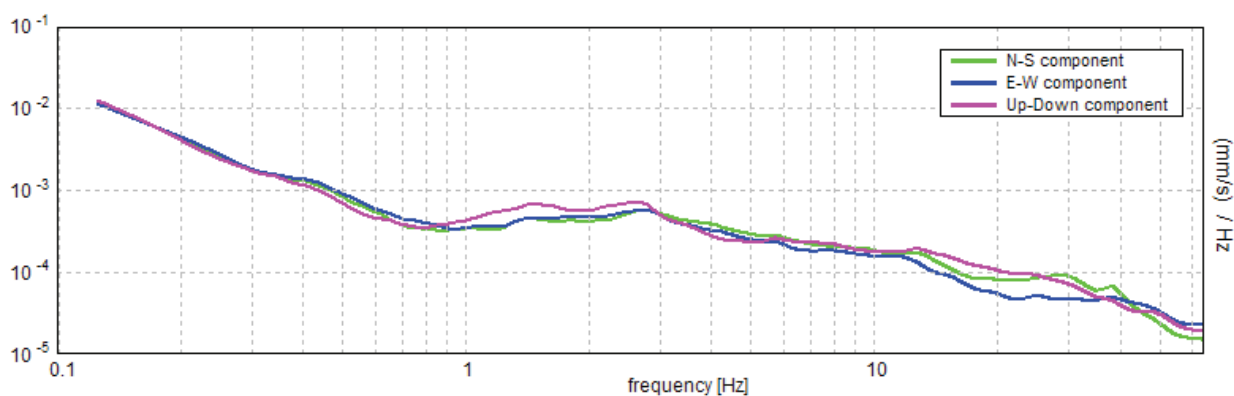
**PROVA 23 VIA VIAZZA DI SOTTO COLOMBARO DI FORMIGINE (MO)**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN
COORDINATE GAUSS-BOAGA: 1649945, 4935542

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. H/V at 0.56 ± 1.79 Hz. (in the range 0.0 - 64.0 Hz).

**H/V TIME HISTORY****SINGLE COMPONENT SPECTRA**

Comune di Formigine (MO)
MICROZONAZIONE SISMICA
Relazione tecnica

Max. H/V at 0.56 ± 1.79 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$0.56 > 0.50$	OK	
$n_c(f_0) > 200$	$540.0 > 200$	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 28 times	OK	

Criteria for a clear HVSR peak

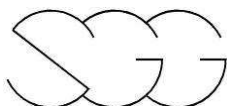
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$			NO
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	1.156 Hz	OK	
$A_0 > 2$	$1.42 > 2$		NO
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 1.56787 < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	$0.88193 < 0.08438$		NO
$\sigma_A(f_0) < \theta(f_0)$	$0.0857 < 2.0$	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
σ_f	standard deviation of H/V peak frequency
$\varepsilon(f_0)$	threshold value for the stability condition $\sigma_f < \varepsilon(f_0)$
A_0	H/V peak amplitude at frequency f_0
$A_{H/V}(f)$	H/V curve amplitude at frequency f
f^-	frequency between $f_0/4$ and f_0 for which $A_{H/V}(f^-) < A_0/2$
f^+	frequency between f_0 and $4f_0$ for which $A_{H/V}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{H/V}(f)$, $\sigma_A(f)$ is the factor by which the mean $A_{H/V}(f)$ curve should be multiplied or divided
$\sigma_{\log H/V}(f)$	standard deviation of $\log A_{H/V}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

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

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

**PROVA 24 VIA RADICI IN PIANO CASINALBO DI FORMIGINE (MO)**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN
COORDINATE GAUSS-BOAGA: 1646804, 4939192

Trace length: 0h20'00". Analyzed 80% trace (manual window selection)

Sampling frequency: 128 Hz

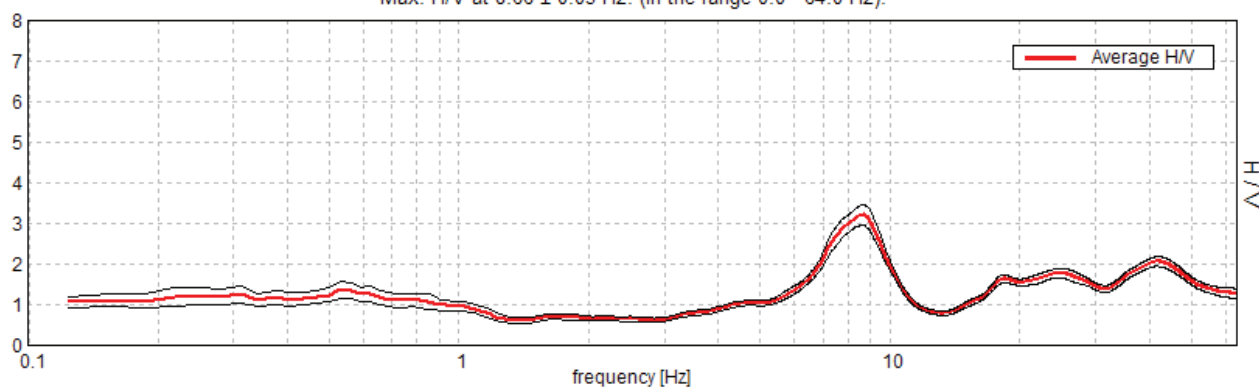
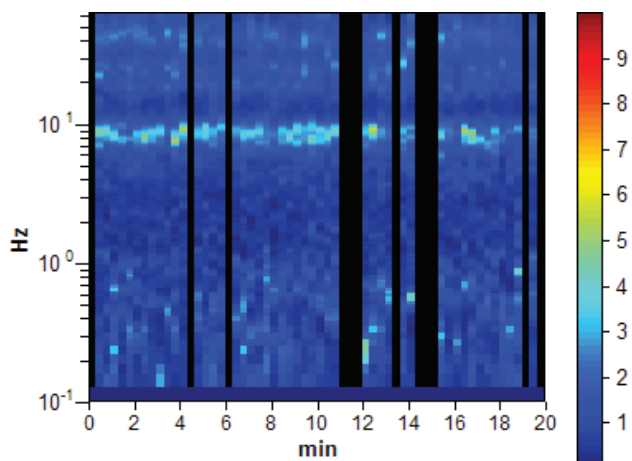
Window size: 20 s

Smoothing window: Triangular window

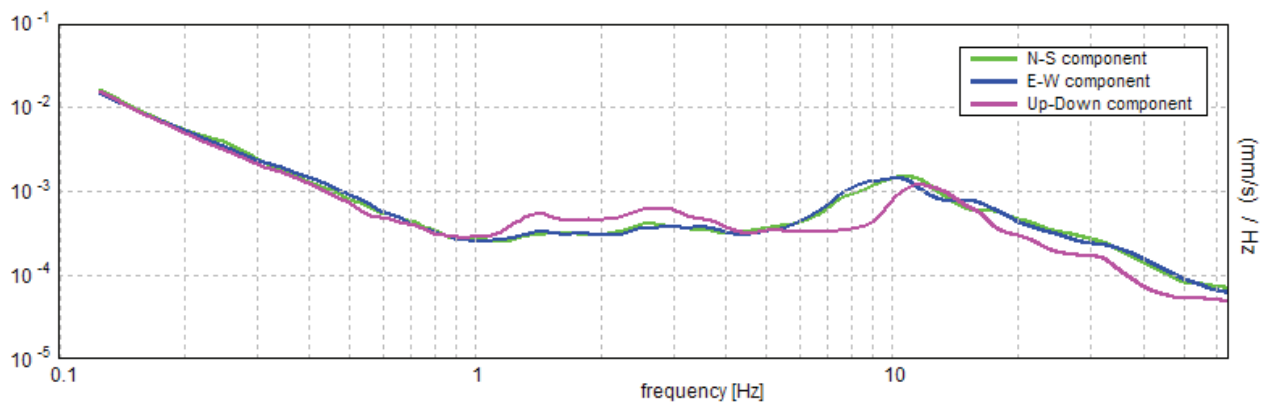
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

Max. H/V at 8.66 ± 0.05 Hz. (In the range 0.0 - 64.0 Hz).

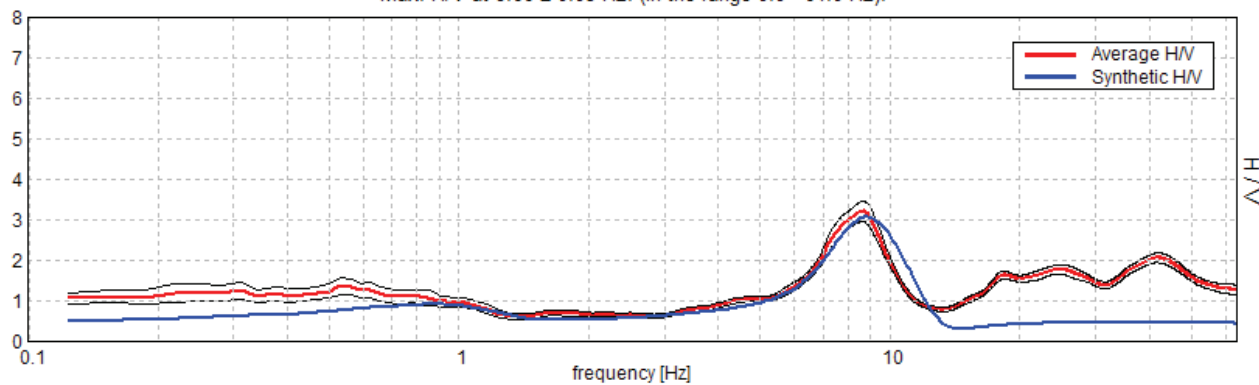
**H/V TIME HISTORY**

SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V

Max. H/V at 8.66 ± 0.05 Hz. (In the range 0.0 - 64.0 Hz).



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
7.00	7.00	242
27.00	20.00	580
57.00	30.00	500
102.00	45.00	550
147.00	45.00	600
inf.	inf.	800

$V_s(0.0-30.0)=432\text{m/s}$

Max. H/V at 8.66 ± 0.05 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$8.66 > 0.50$	OK	
$n_c(f_0) > 200$	$8310.0 > 200$	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 416 times	OK	

Criteria for a clear HVSR peak

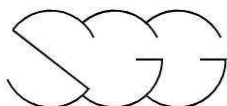
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	6.406 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	10.438 Hz	OK	
$A_0 > 2$	$3.22 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00289 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.02499 < 0.43281$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.1267 < 1.58$	OK	

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

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

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

**PROVA 25 VIA DEL CASONE MAGRETA DI FORMIGINE**

Channel labels: NORTH SOUTH;

EAST WEST ; UP DOWN

COORDINATE GAUSS-BOAGA:

1644042, 4939692

Trace length: 0h20'00".

Analyzed 80% trace (manual window selection)

Sampling frequency: 128 Hz

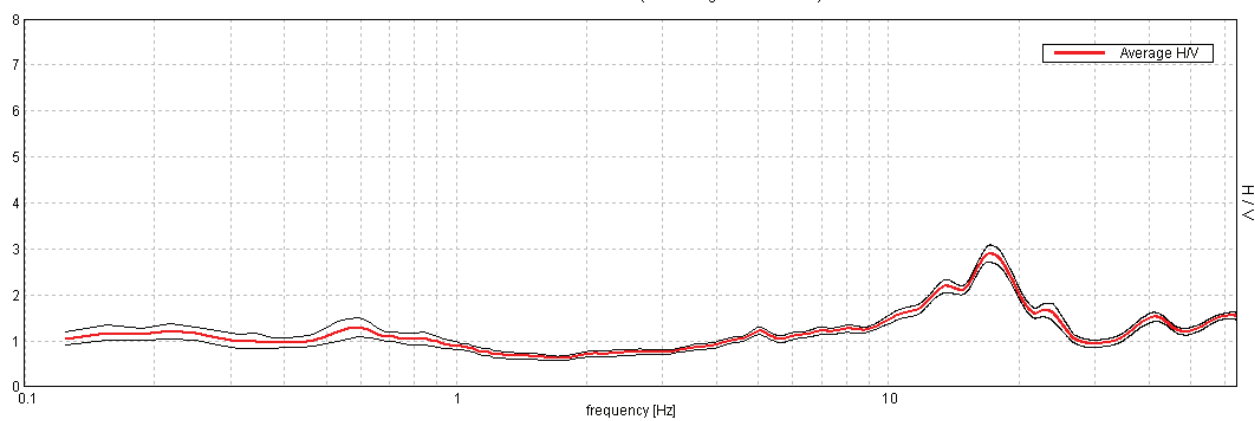
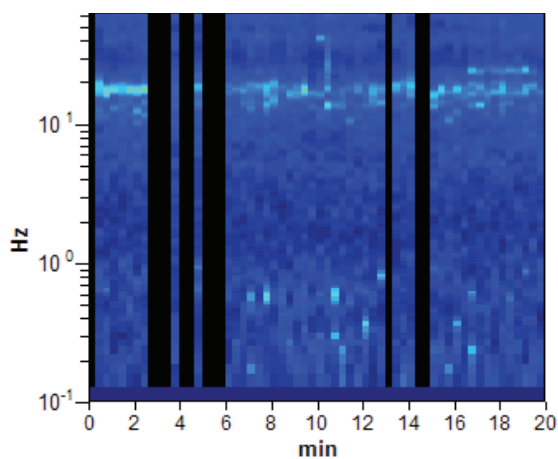
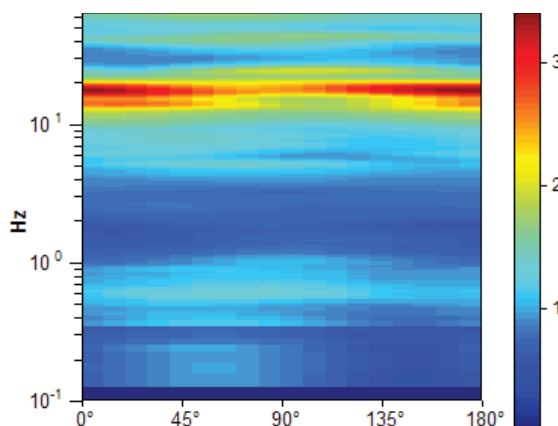
Window size: 20 s

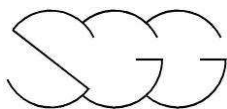
Smoothing window: Triangular window

Smoothing: 10%

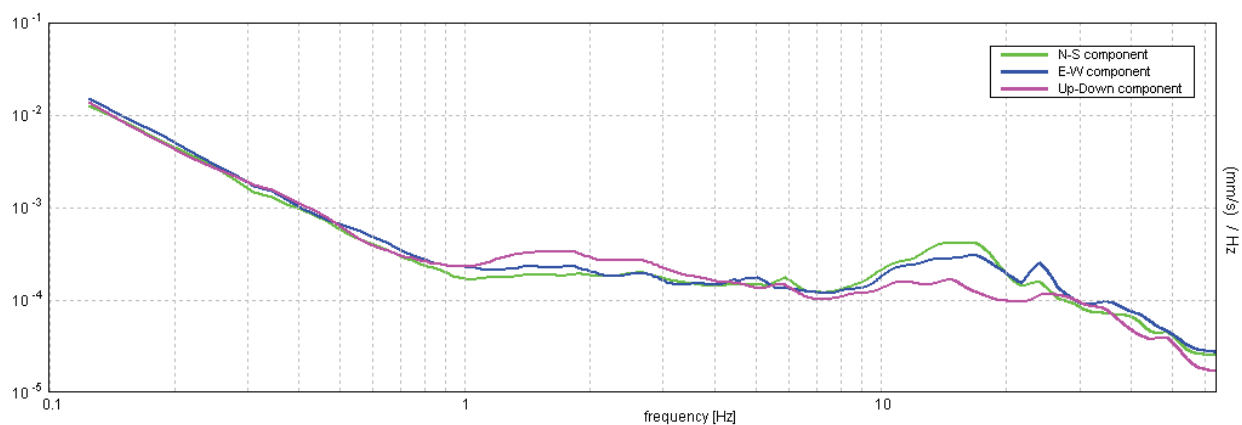
HORIZONTAL TO VERTICAL SPECTRAL RATIO

Max. H/V at 17.19 ± 0.07 Hz. (in the range 0.0 - 64.0 Hz).

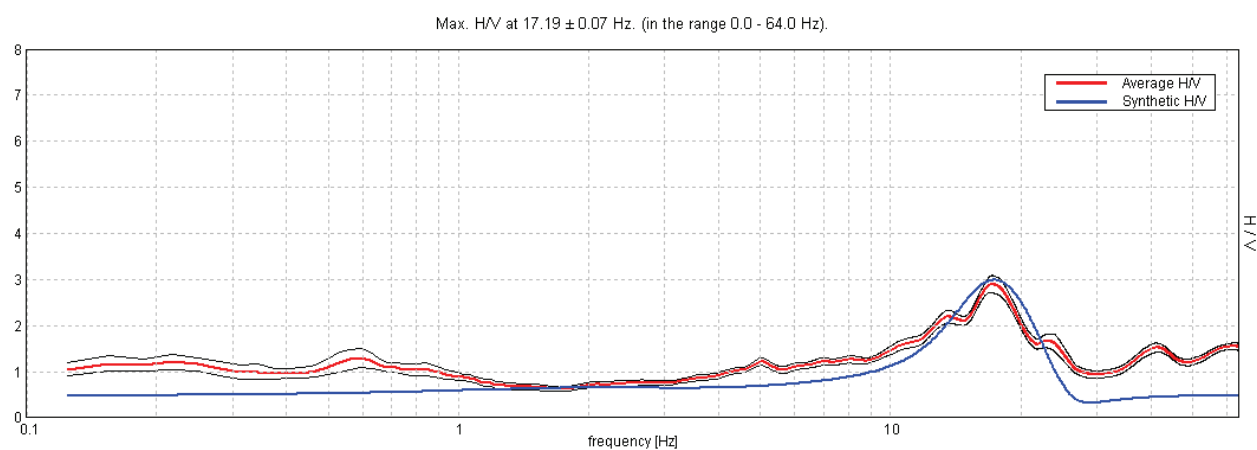
**H/V TIME HISTORY****DIRECTIONAL H/V**



SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer

[m]

3.00

33.00

68.00

inf.

Thickness [m]

3.00

30.00

35.00

inf.

Vs [m/s]

206

500

550

600

 $V_s(0.0-30.0)=438\text{m/s}$

Max. H/V at 17.19 ± 0.07 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$17.19 > 0.50$	OK	
$n_c(f_0) > 200$	$16500.0 > 200$	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 826 times	OK	

Criteria for a clear HVSR peak

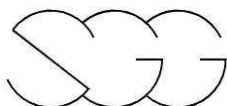
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	9.938 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	24.844 Hz	OK	
$A_0 > 2$	$2.90 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00203 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.03483 < 0.85938$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.0928 < 1.58$	OK	

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

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

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

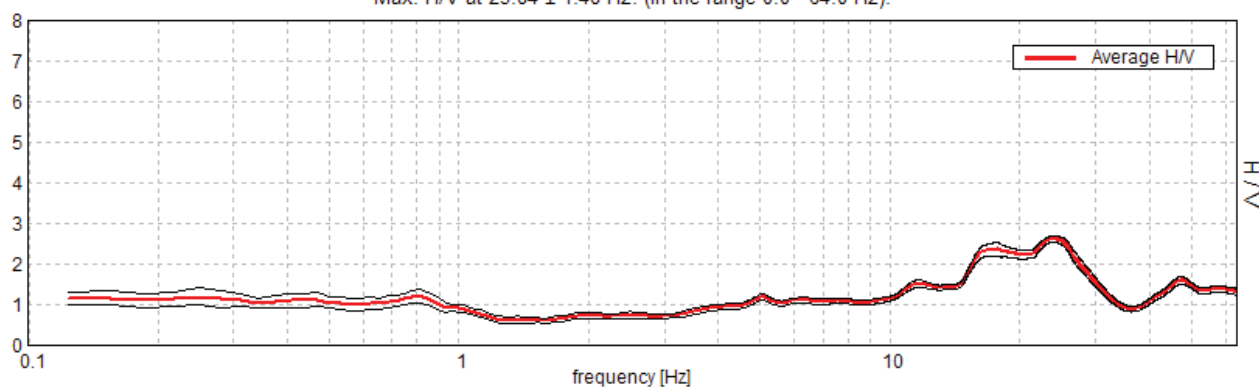
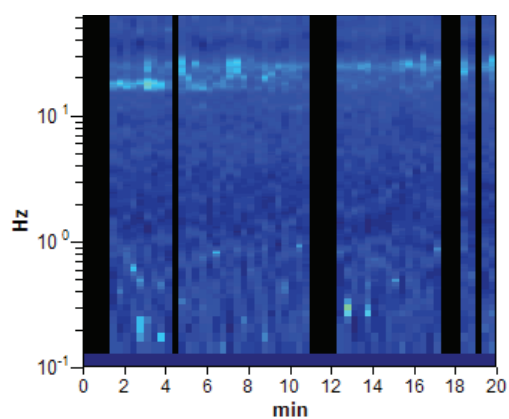
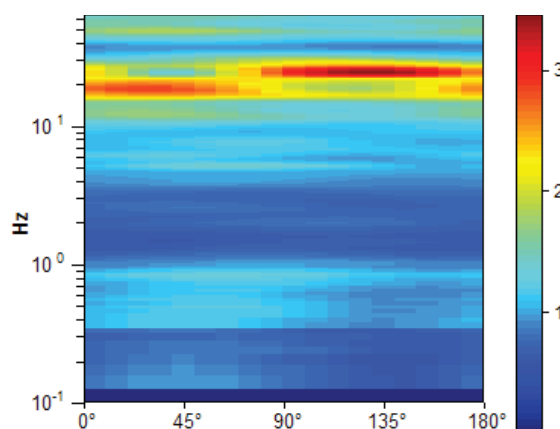
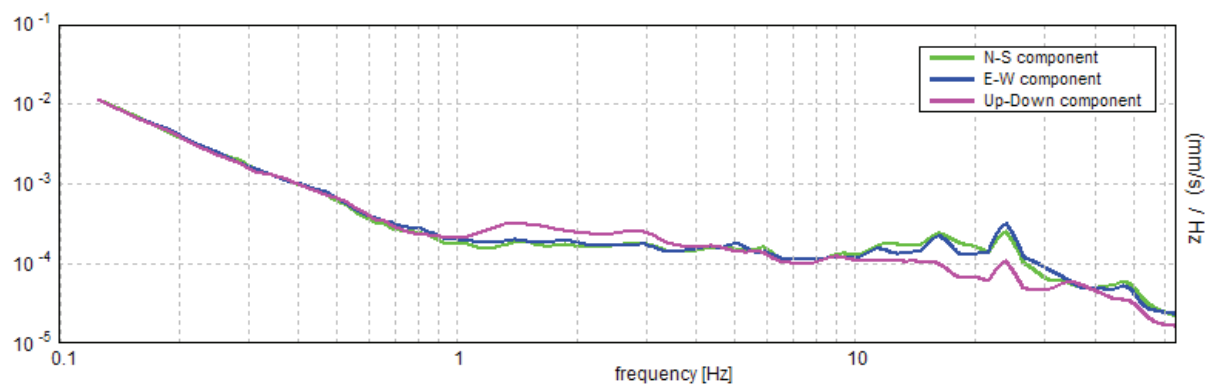
**PROVA 26 VIA DEL CASONE MAGRETA DI FORMIGINE 002**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN
COORDINATE GAUSS-BOAGA: 1643995, 4939669

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 23.84 ± 1.48 Hz. (In the range 0.0 - 64.0 Hz).

**H/V TIME HISTORY****DIRECTIONAL H/V****SINGLE COMPONENT SPECTRA**

Comune di Formigine (MO)
MICROZONAZIONE SISMICA
Relazione tecnica

Max. H/V at 23.84 ± 1.48 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$23.84 > 0.50$	OK	
$n_c(f_0) > 200$	$22413.1 > 200$	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 1146 times	OK	

Criteria for a clear HVSR peak

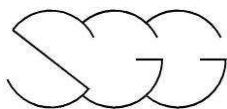
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	10.656 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	31.469 Hz	OK	
$A_0 > 2$	$2.63 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.03052 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.72775 < 1.19219$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.0347 < 1.58$	OK	

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

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

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

**PROVA 27 VIA TOGNOLI****COLOMBARO DI FORMIGINE (MO)**

Channel labels: NORTH SOUTH;

EAST WEST ; UP DOWN

COORDINATE GAUSS-BOAGA:

1648960, 4936975

Trace length: 0h20'00".

Analyzed 75% trace (manual window selection)

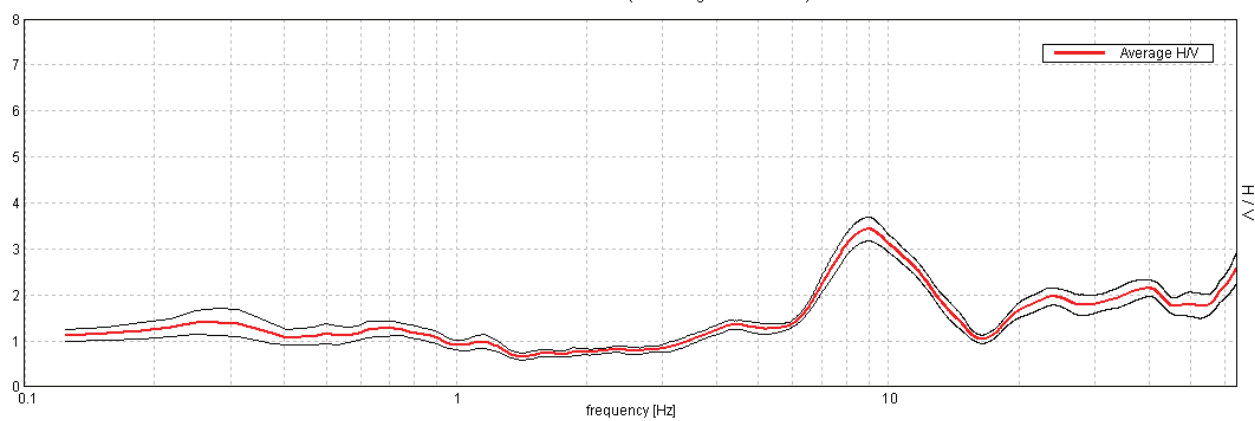
Sampling frequency: 128 Hz

Window size: 20 s

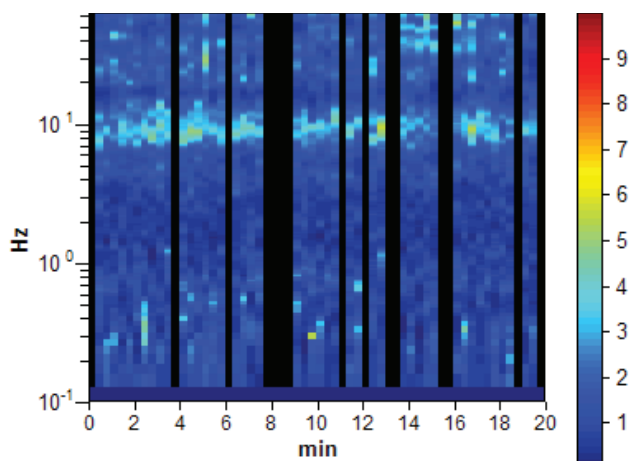
Smoothing window: Triangular window

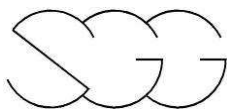
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

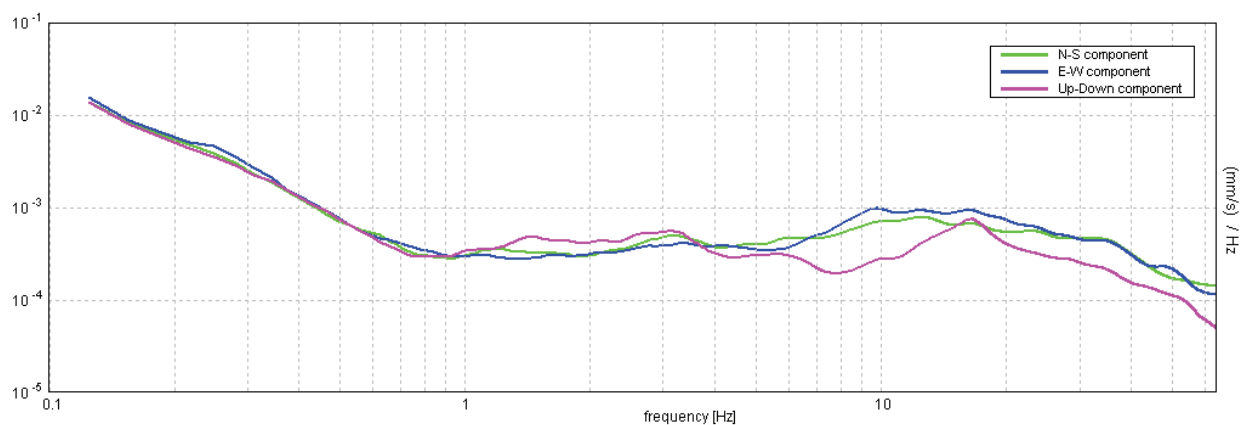
Max. H/V at 9.0 ± 0.1 Hz. (in the range 0.0 - 64.0 Hz).

H/V TIME HISTORY

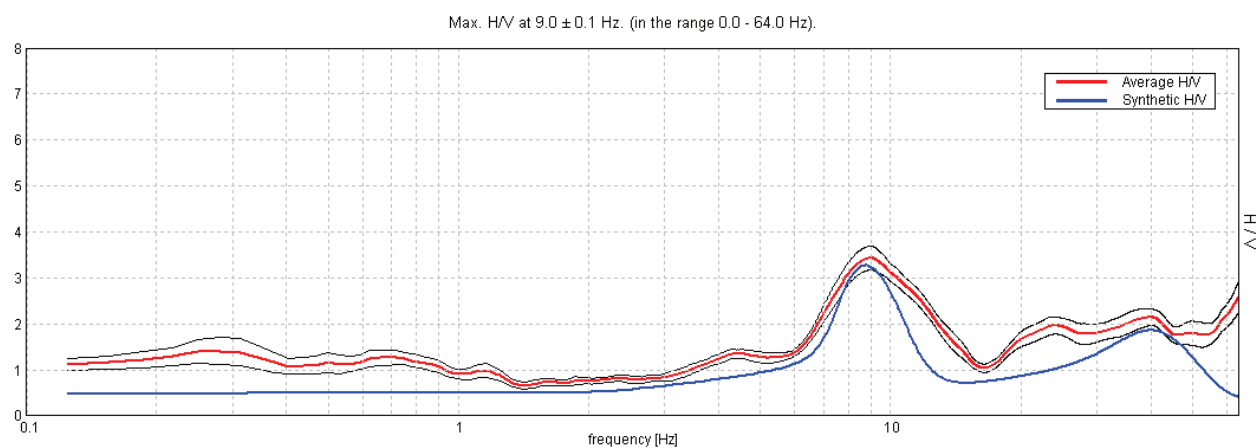




SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer

[m]

Thickness [m]

Vs [m/s]

0.80

0.80

130

4.80

4.00

280

10.00

5.20

350

20.00

10.00

610

35.00

15.00

630

55.00

20.00

400

75.00

20.00

450

inf.

inf.

550

 $V_s(0.0-30.0)=444\text{m/s}$

Max. H/V at 9.0 ± 0.1 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$9.00 > 0.50$	OK	
$n_c(f_0) > 200$	$8100.0 > 200$	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 433 times	OK	

Criteria for a clear HVSR peak

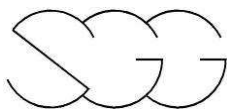
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	6.5 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	13.656 Hz	OK	
$A_0 > 2$	$3.44 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00547 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.04921 < 0.45$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.1283 < 1.58$	OK	

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

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

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

**PROVA 28 VIA VIAZZA DI SOPRA COLOMBARO DI FORMIGINE (MO)**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN
COORDINATE GAUSS-BOAGA: 1649406, 4934760

Trace length: 0h20'00". Analyzed 90% trace (manual window selection)

Sampling frequency: 128 Hz

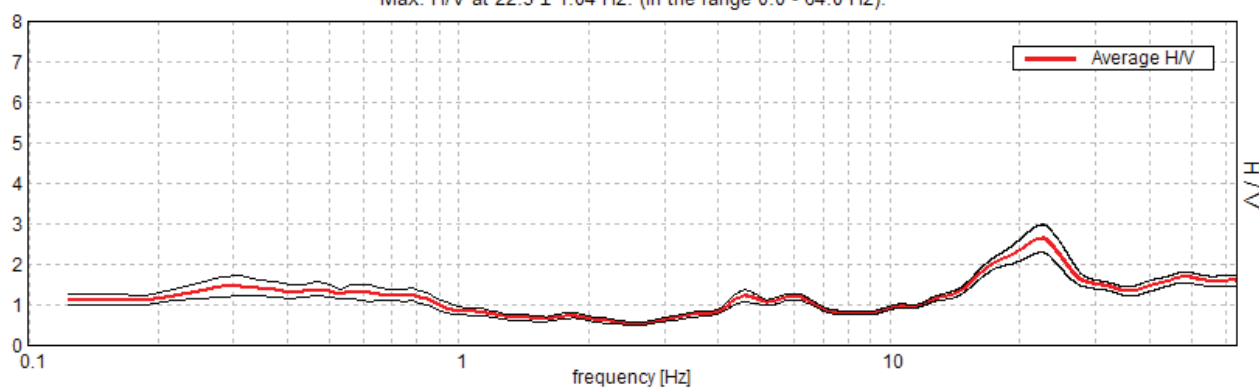
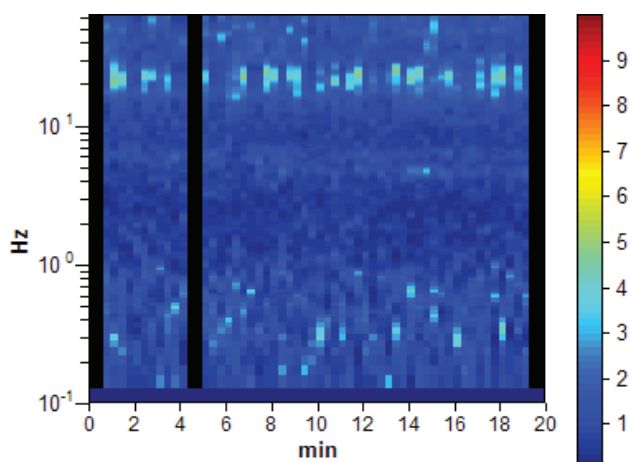
Window size: 20 s

Smoothing window: Triangular window

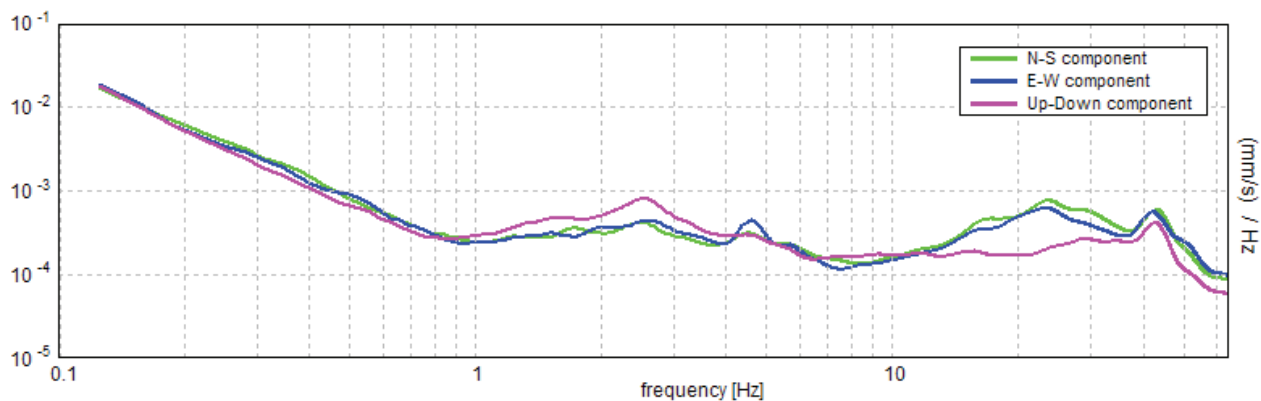
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

Max. H/V at 22.5 ± 1.04 Hz. (in the range 0.0 - 64.0 Hz).

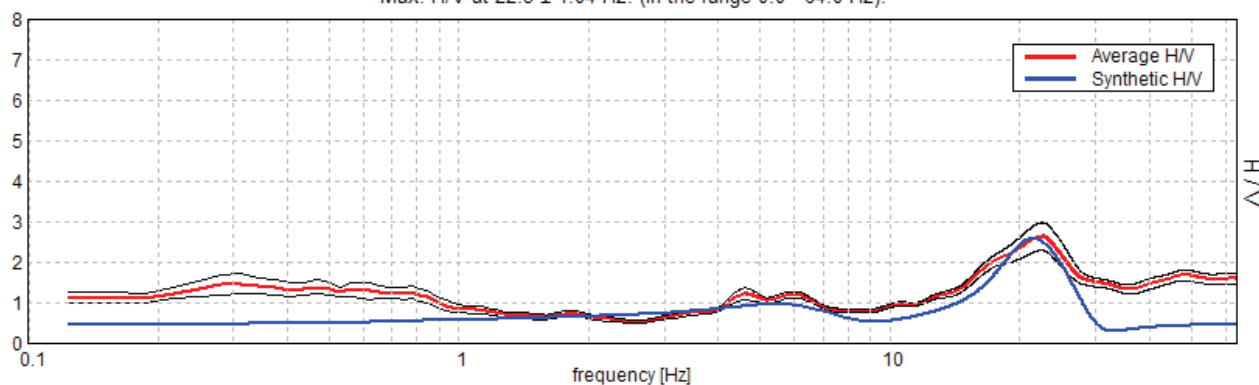
**H/V TIME HISTORY**

SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V

Max. H/V at 22.5 ± 1.04 Hz. (in the range 0.0 - 64.0 Hz).



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
2.20	2.20	165
5.20	3.00	460
11.00	5.80	250
21.00	10.00	550
26.00	5.00	560
31.00	5.00	500
81.00	50.00	550
inf.	inf.	600

Vs(0.0-30.0)=384m/s

Max. H/V at 22.5 ± 1.04 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$22.50 > 0.50$	OK	
$n_c(f_0) > 200$	$24300.0 > 200$	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 1081 times	OK	

Criteria for a clear HVSR peak

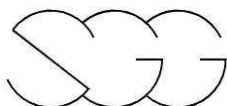
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	14.375 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$			NO
$A_0 > 2$	$2.64 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.02279 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.51288 < 1.125$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.1694 < 1.58$	OK	

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

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

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

**PROVA 29 VIA PALAZZI CASINALBO DI FORMIGINE (MO)**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN
COORDINATE GAUSS-BOAGA:

Trace length: 0h20'00". Analyzed 92% trace (manual window selection)

Sampling frequency: 128 Hz

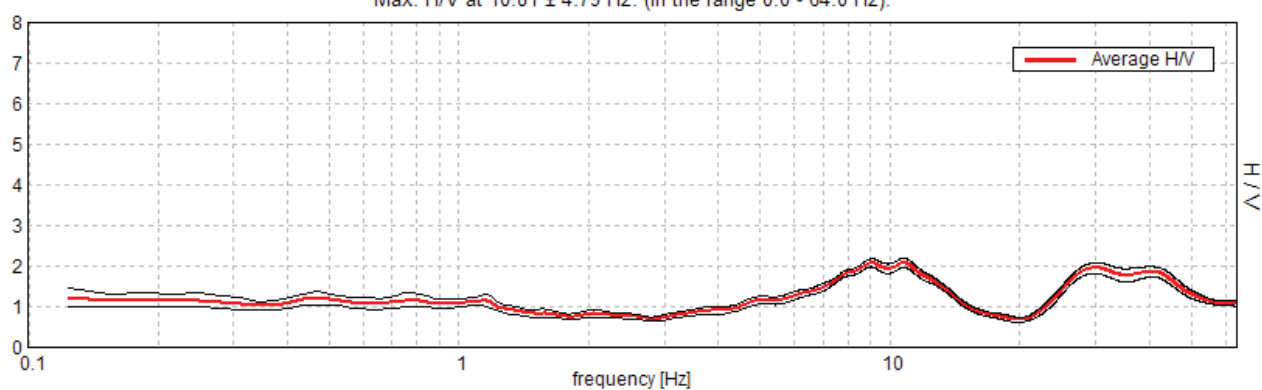
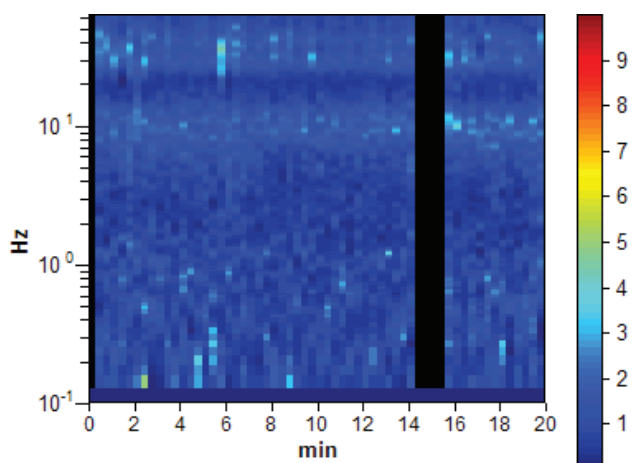
Window size: 20 s

Smoothing window: Triangular window

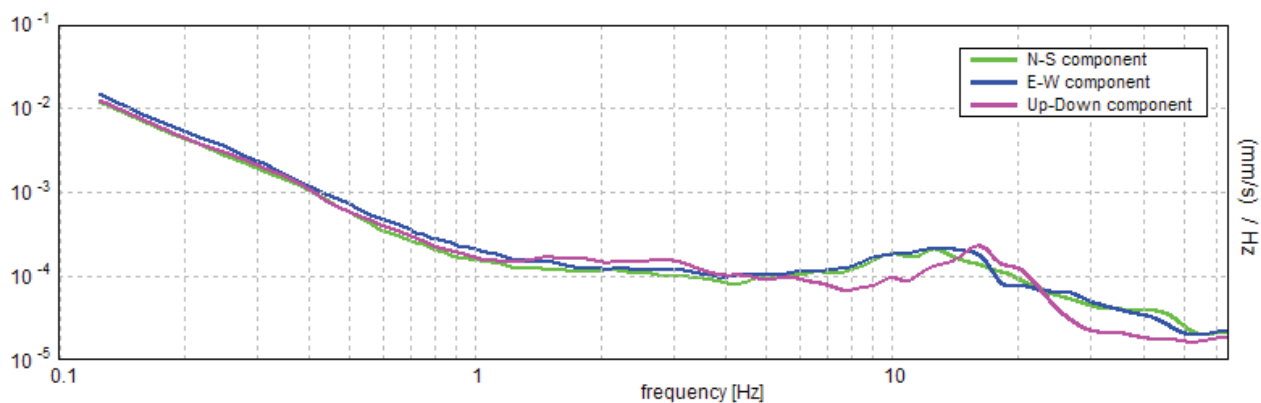
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

Max. H/V at 10.81 ± 4.79 Hz. (in the range 0.0 - 64.0 Hz).

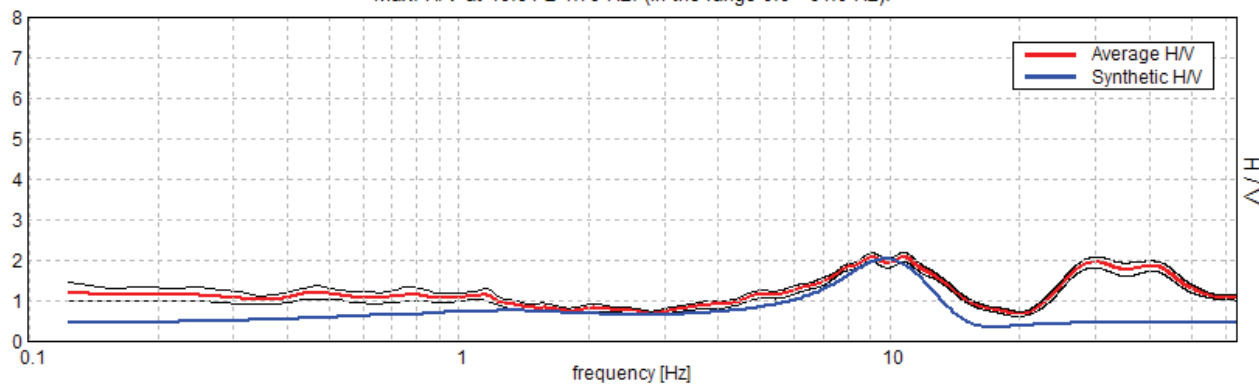
**H/V TIME HISTORY**

SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V

Max. H/V at 10.81 ± 4.79 Hz. (In the range 0.0 - 64.0 Hz).



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
5.30	5.30	216
30.30	25.00	475
40.30	10.00	400
95.30	55.00	550
inf.	inf.	650

$V_s(0.0-30.0)=392m/s$

Max. H/V at 10.81 ± 4.79 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$10.81 > 0.50$	OK	
$n_c(f_0) > 200$	$11893.8 > 200$	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 520 times	OK	

Criteria for a clear HVSR peak

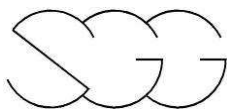
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	4.531 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	15.0 Hz	OK	
$A_0 > 2$	$2.10 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.21904 < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	$2.36832 < 0.54063$		NO
$\sigma_A(f_0) < \theta(f_0)$	$0.0563 < 1.58$	OK	

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

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

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

**PROVA 30 VIA MAZZACAVALLLO****MAGRETA DI FORMIGINE**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN
COORDINATE GAUSS-BOAGA: 1643486, 4939331

Trace length: 0h20'00". Analyzed 87% trace (manual window selection)

Sampling frequency: 128 Hz

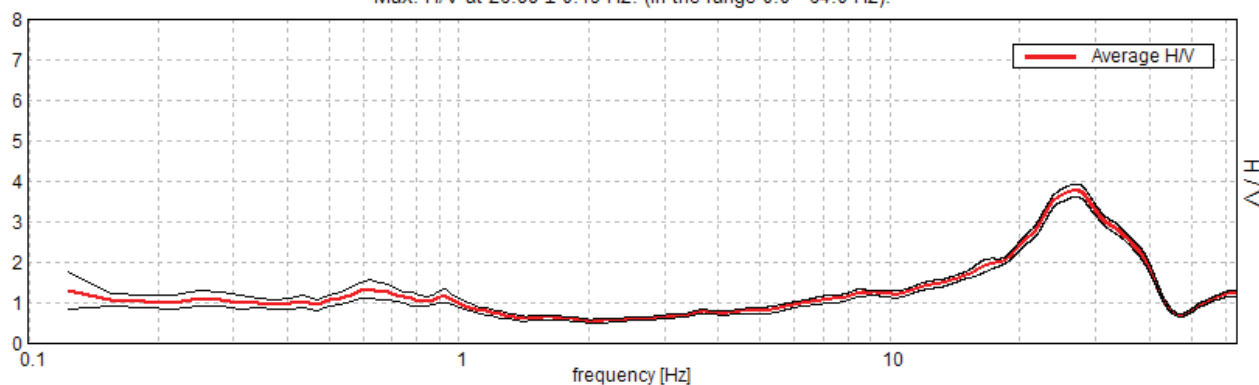
Window size: 20 s

Smoothing window: Triangular window

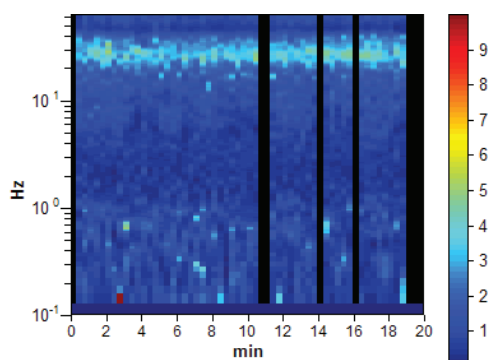
Smoothing: 10%

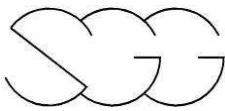
HORIZONTAL TO VERTICAL SPECTRAL RATIO

Max. H/V at 26.88 ± 0.19 Hz. (In the range 0.0 - 64.0 Hz).

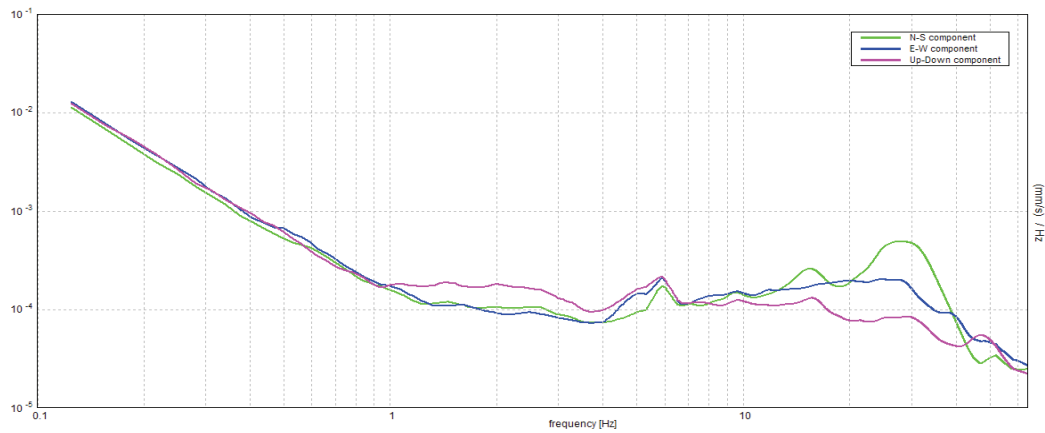


H/V TIME HISTORY

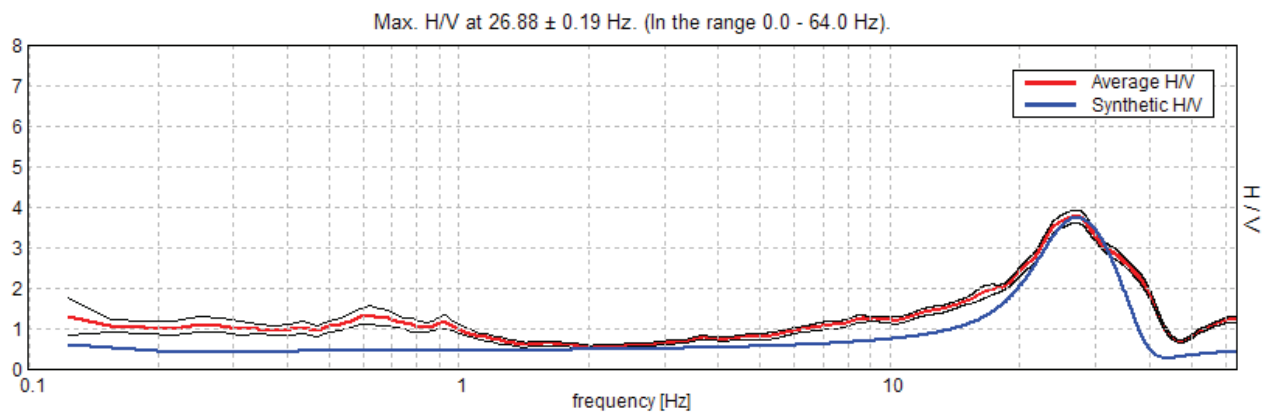




SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer

[m]

2.20

38.20

inf.

Thickness [m]

2.20

36.00

inf.

Vs [m/s]

230

580

600

 $V_s(0.0-30.0)=522\text{m/s}$

Max. H/V at 26.88 ± 0.19 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$26.88 > 0.50$	OK	
$n_c(f_0) > 200$	$27950.0 > 200$	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 1291 times	OK	

Criteria for a clear HVSR peak

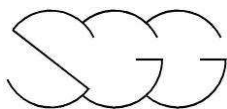
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	16.313 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	39.938 Hz	OK	
$A_0 > 2$	$3.78 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00357 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.09594 < 1.34375$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.0777 < 1.58$	OK	

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

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

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

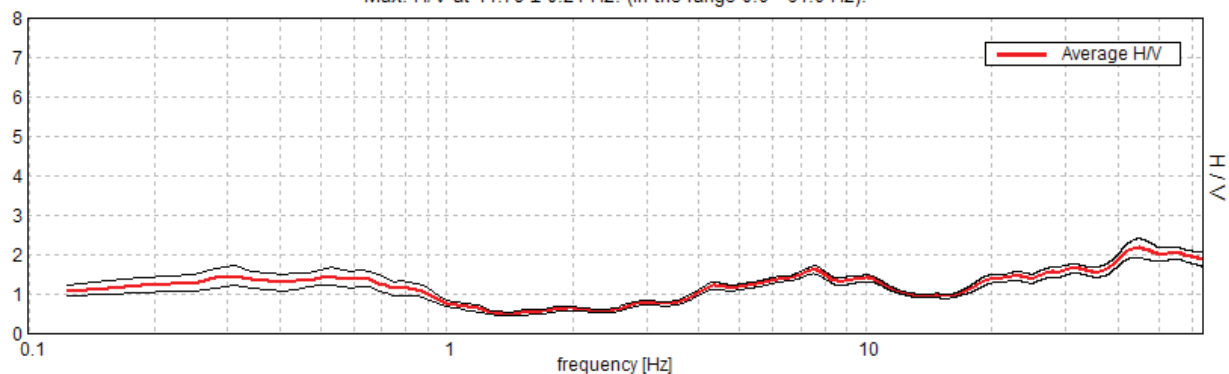
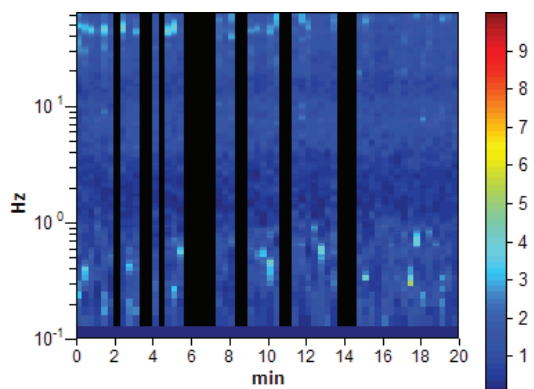
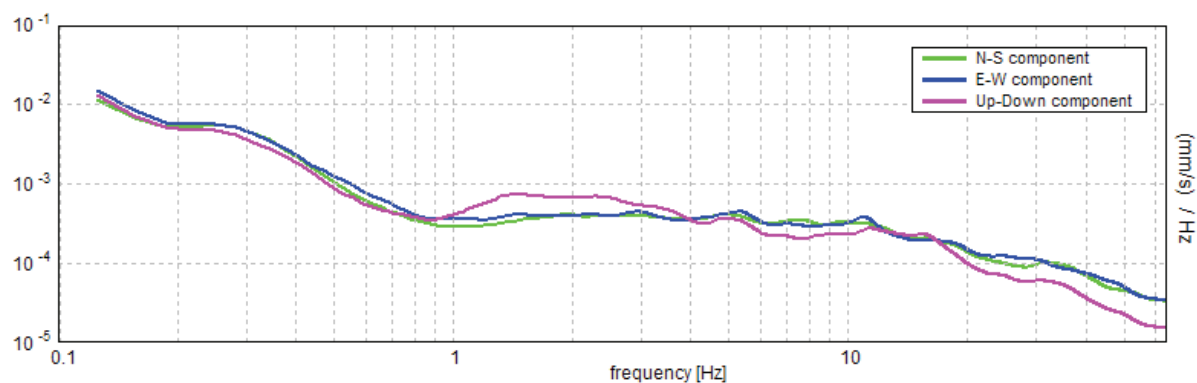
**PROVA 31 VIA SALVIOLA****COLOMBARO DI FORMIGINE**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN
COORDINATE GAUS-BOAGA: 1648933, 4935525

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. H/V at 44.78 ± 0.21 Hz. (in the range 0.0 - 64.0 Hz).

**H/V TIME HISTORY****SINGLE COMPONENT SPECTRA**

Comune di Formigine (MO)
MICROZONAZIONE SISMICA
Relazione tecnica

Max. H/V at 44.78 ± 0.21 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$44.78 > 0.50$	OK	
$n_c(f_0) > 200$	$39407.5 > 200$	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 1332 times	OK	

Criteria for a clear HVSR peak

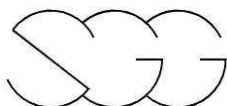
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	17.313 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$			NO
$A_0 > 2$	$2.19 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00227 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.1017 < 2.23906$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.1181 < 1.58$	OK	

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

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

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



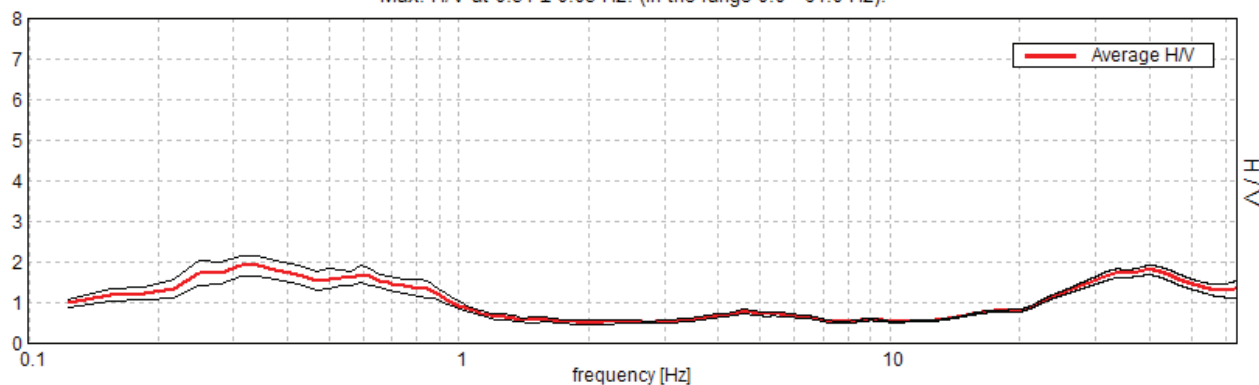
PROVA 32 VIA UGO ABBATI COLOMBARO DI FORMIGINE

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN
COORDINATE GAUSS-BOAGA: 1650963, 4934504

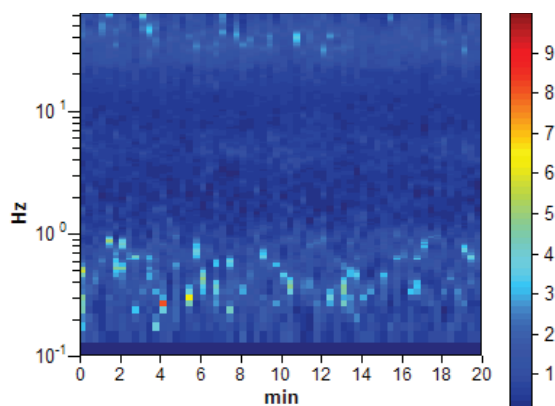
Trace length: 0h20'00". Analysis performed on the entire trace.
Sampling frequency: 128 Hz
Window size: 20 s
Smoothing window: Triangular window
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

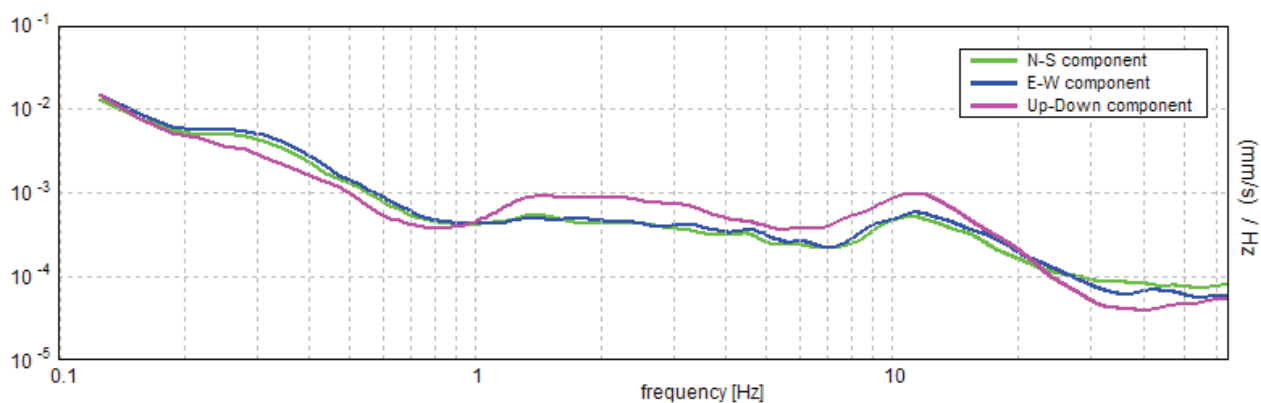
Max. H/V at 0.31 ± 0.03 Hz. (in the range 0.0 - 64.0 Hz).



H/V TIME HISTORY



SINGLE COMPONENT SPECTRA



Comune di Formigine (MO)
MICROZONAZIONE SISMICA
Relazione tecnica

Max. H/V at 0.31 ± 0.03 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$0.31 > 0.50$		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

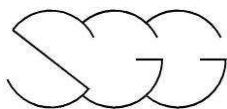
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	0.094 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	1.0 Hz	OK	
$A_0 > 2$	$1.92 > 2$		NO
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.04475 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.01399 < 0.0625$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.1188 < 2.5$	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
σ_f	standard deviation of H/V peak frequency
$\varepsilon(f_0)$	threshold value for the stability condition $\sigma_f < \varepsilon(f_0)$
A_0	H/V peak amplitude at frequency f_0
$A_{H/V}(f)$	H/V curve amplitude at frequency f
f^-	frequency between $f_0/4$ and f_0 for which $A_{H/V}(f^-) < A_0/2$
f^+	frequency between f_0 and $4f_0$ for which $A_{H/V}(f^+) < A_0/2$
$\sigma_A(f)$	standard deviation of $A_{H/V}(f)$, $\sigma_A(f)$ is the factor by which the mean $A_{H/V}(f)$ curve should be multiplied or divided
$\sigma_{\log H/V}(f)$	standard deviation of $\log A_{H/V}(f)$ curve
$\theta(f_0)$	threshold value for the stability condition $\sigma_A(f) < \theta(f_0)$

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

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

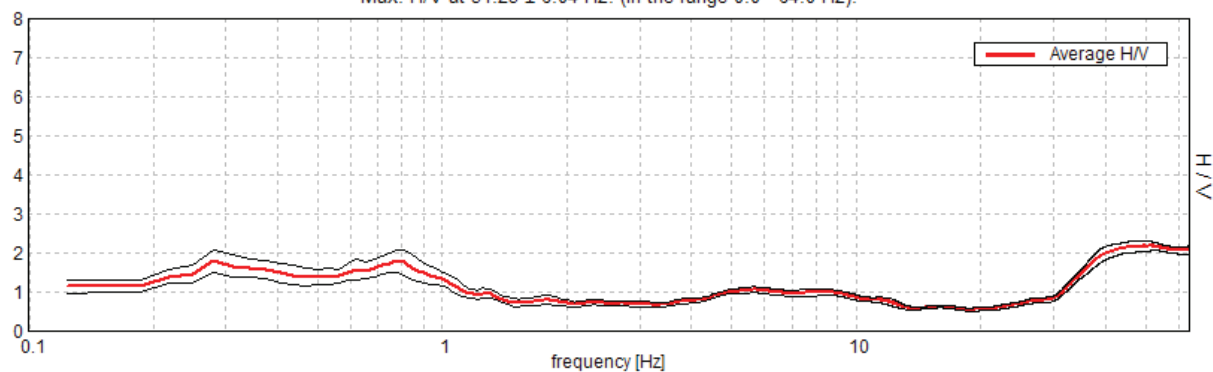
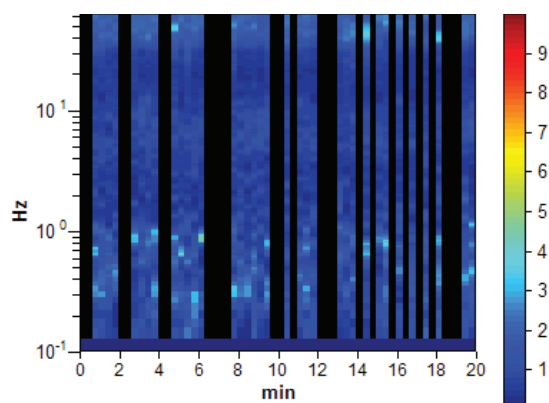
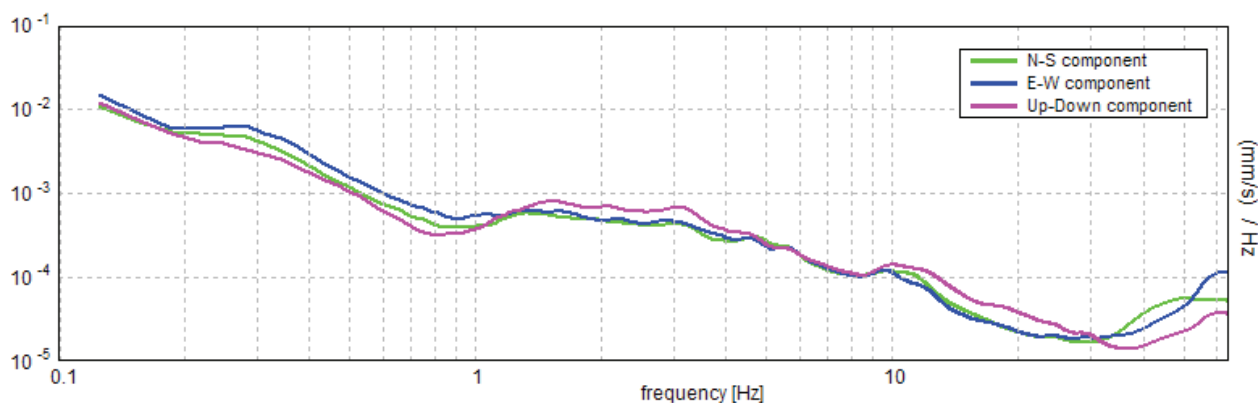
**PROVA 33 LOC. BUTTINELLO DI SOTTO COLOMBARO DI FORMIGINE**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN
COORDINATE GAUSS-BOAGA: 1651735, 4935483

Trace length: 0h20'00". Analyzed 58% 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 51.25 ± 6.04 Hz. (In the range 0.0 - 64.0 Hz).

**H/V TIME HISTORY****SINGLE COMPONENT SPECTRA**

Comune di Formigine (MO)
MICROZONAZIONE SISMICA
Relazione tecnica

Max. H/V at 51.25 ± 6.04 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$51.25 > 0.50$	OK	
$n_c(f_0) > 200$	$35875.0 > 200$	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 1229 times	OK	

Criteria for a clear HVSR peak

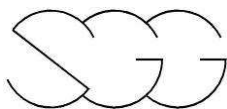
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	32.0 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$			NO
$A_0 > 2$	$2.19 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.05717 < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	$2.93019 < 2.5625$		NO
$\sigma_A(f_0) < \theta(f_0)$	$0.0583 < 1.58$	OK	

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

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

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

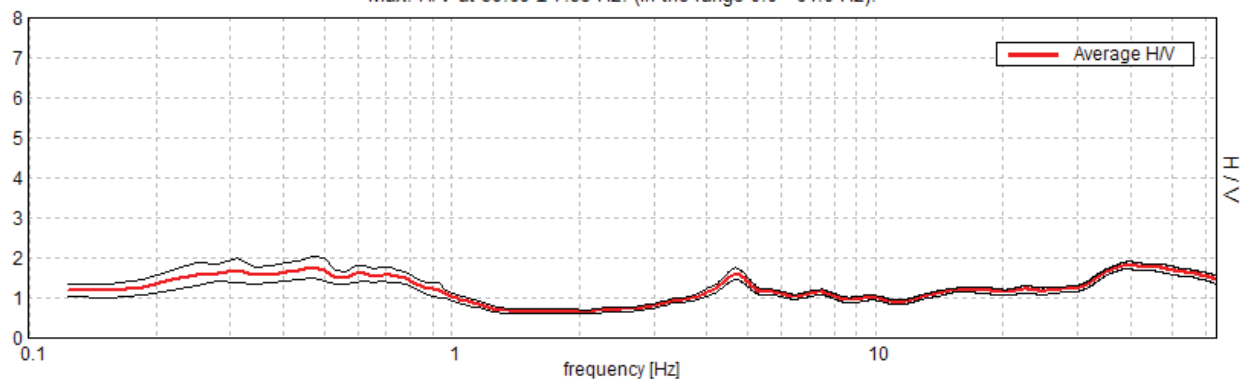
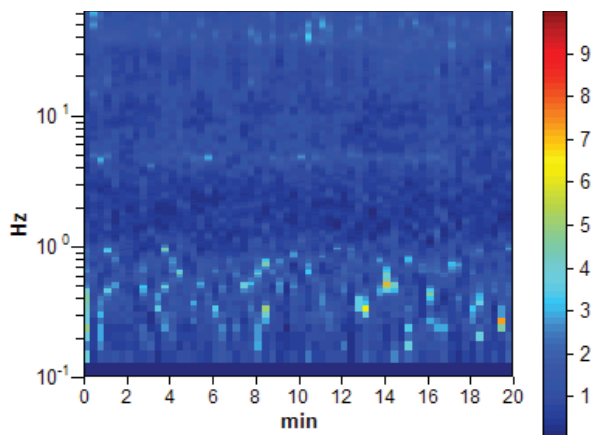
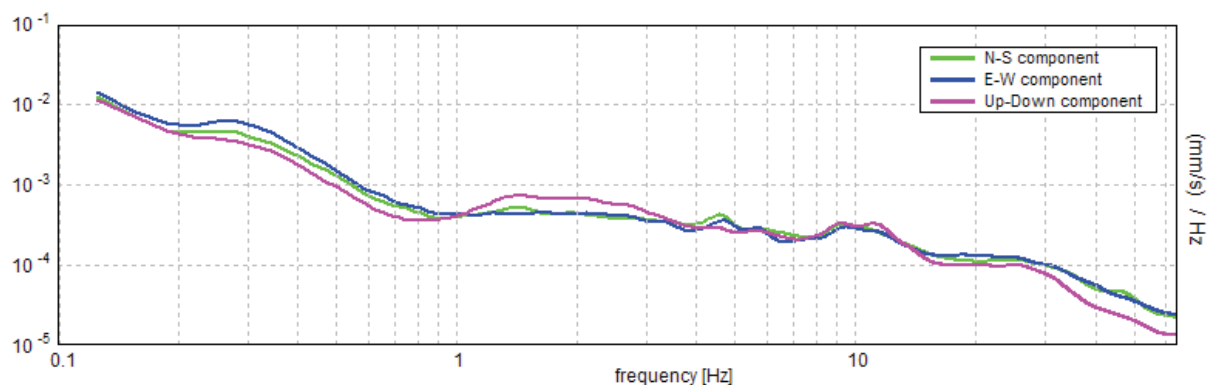
**PROVA 34 LOC. COLMATE COLOMBARO DI FORMIGINE**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN
COORDINATE GAUSS-BOAGA: 1650811, 49354587

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 39.69 ± 7.35 Hz. (in the range 0.0 - 64.0 Hz).

**H/V TIME HISTORY****SINGLE COMPONENT SPECTRA**

Comune di Formigine (MO)
MICROZONAZIONE SISMICA
Relazione tecnica

Max. H/V at 39.69 ± 7.35 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$39.69 > 0.50$	OK	
$n_c(f_0) > 200$	$47625.0 > 200$	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 1414 times	OK	

Criteria for a clear HVSR peak

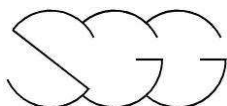
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	11.625 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$			NO
$A_0 > 2$	$1.83 > 2$		NO
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.09183 < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	$3.64433 < 1.98438$		NO
$\sigma_A(f_0) < \theta(f_0)$	$0.0473 < 1.58$	OK	

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

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

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

**PROVA 35 VIA MARANELLO COLOMBARO DI FORMIGINE**

Channel labels: NORTH SOUTH;

EAST WEST ; UP DOWN

COORDINATE GAUSS-BOAGA:

1649615, 4933960

Trace length: 0h20'00".

Analyzed 70% trace (manual window selection)

Sampling frequency: 128 Hz

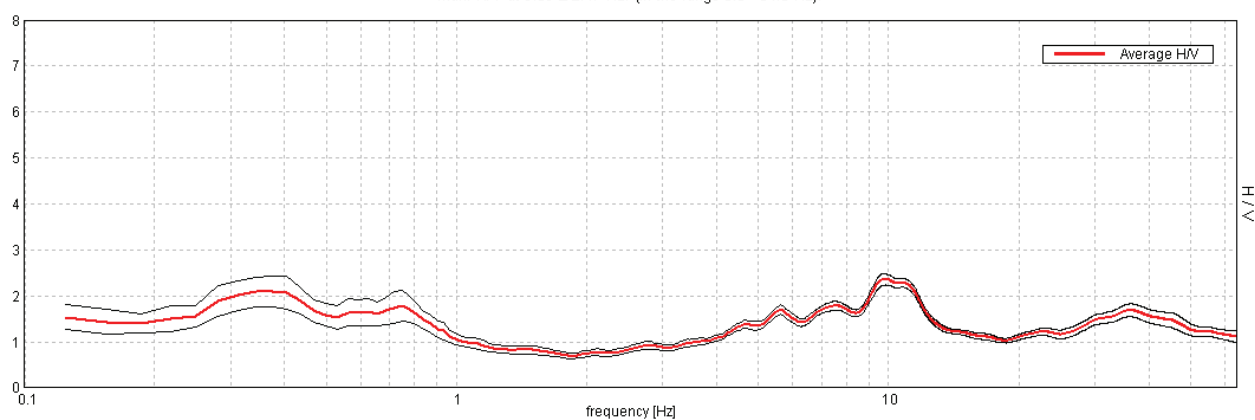
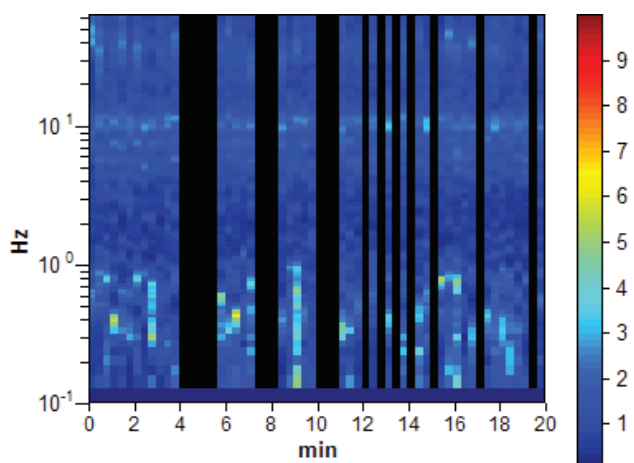
Window size: 20 s

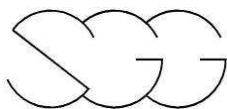
Smoothing window: Triangular window

Smoothing: 10%

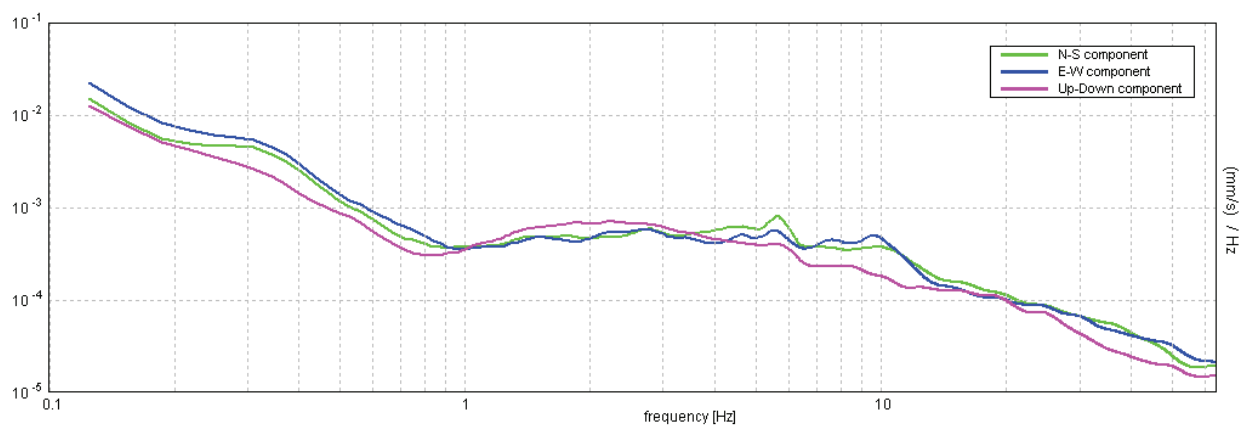
HORIZONTAL TO VERTICAL SPECTRAL RATIO

Max. H/V at 9.69 ± 2.47 Hz. (in the range 0.0 - 64.0 Hz).

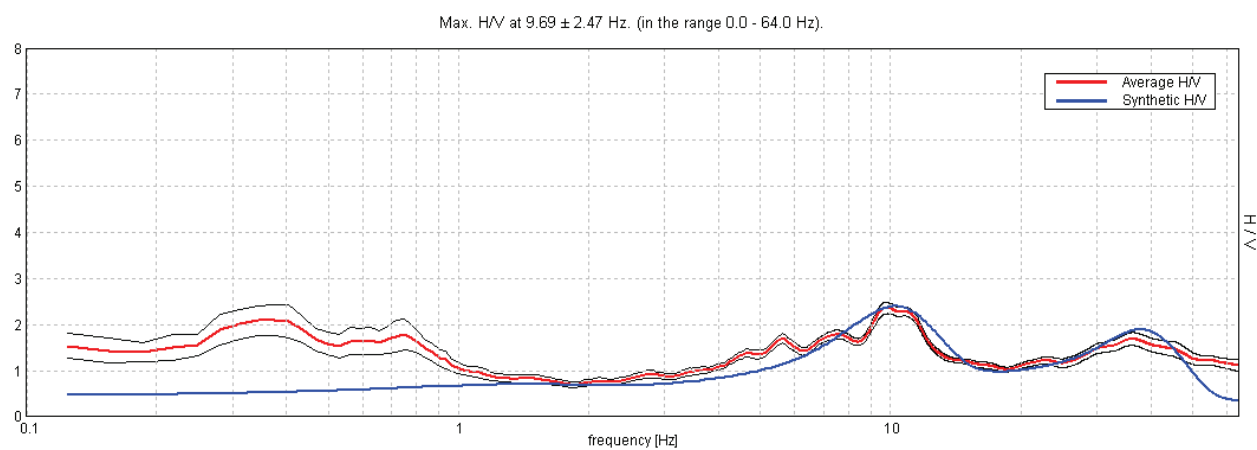
**H/V TIME HISTORY**



SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.60	0.60	90
3.10	2.50	200
7.00	3.90	280
16.00	9.00	455
24.50	8.50	400
28.50	4.00	550
49.00	20.50	430
69.00	20.00	460
inf.	inf.	550

$V_s(0.0-30.0)=353\text{m/s}$

Max. H/V at 9.69 ± 2.47 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$9.69 > 0.50$	OK	
$n_c(f_0) > 200$	$8137.5 > 200$	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 466 times	OK	

Criteria for a clear HVSR peak

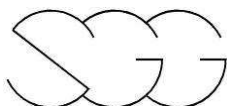
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	4.219 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	15.281 Hz	OK	
$A_0 > 2$	$2.36 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.12456 < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	$1.20663 < 0.48438$		NO
$\sigma_A(f_0) < \theta(f_0)$	$0.062 < 1.58$	OK	

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

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

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



PROVA 36 VIA ERRI BILLÒ CASINALBO DI FORMIGINE

Channel labels: NORTH SOUTH;

EAST WEST ; UP DOWN

COORDINATE GAUSS-BOAGA:

1647644, 4939181

Trace length: 0h20'00".

Analyzed 75% trace (manual window selection)

Sampling frequency: 128 Hz

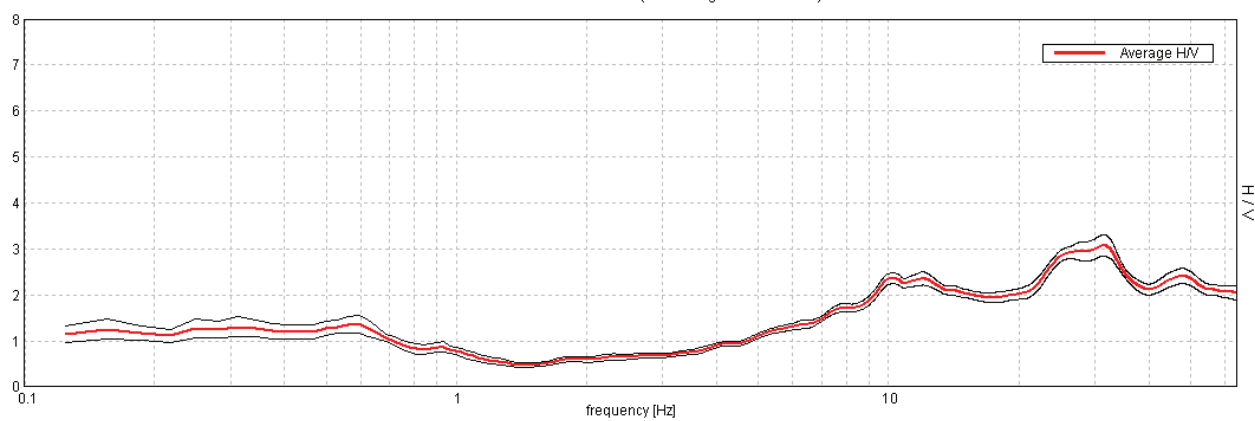
Window size: 20 s

Smoothing window: Triangular window

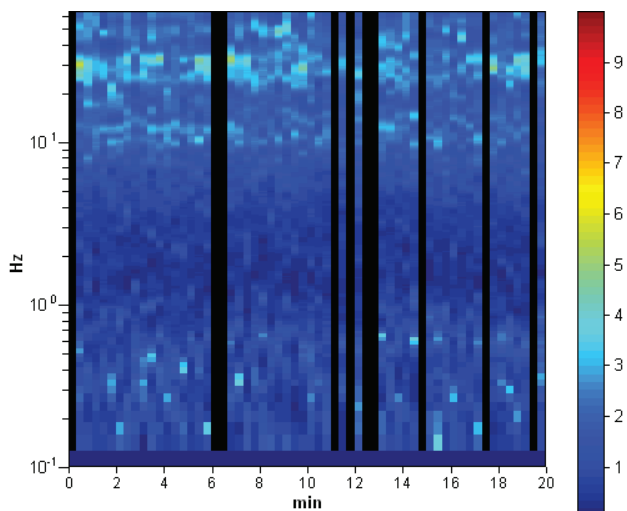
Smoothing: 10%

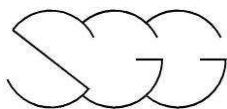
HORIZONTAL TO VERTICAL SPECTRAL RATIO

Max. H/V at 10.31 ± 0.61 Hz. (In the range 0.0 - 15.0 Hz).

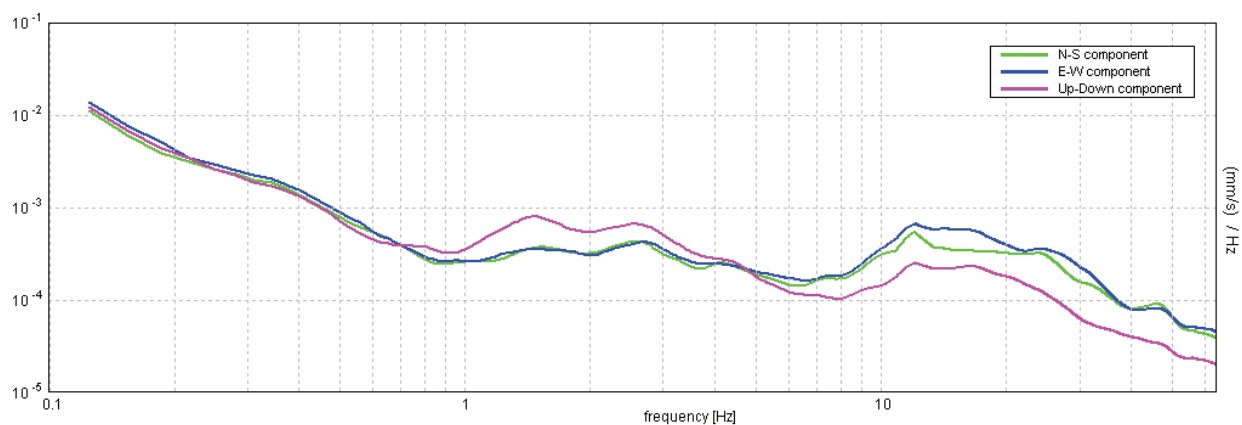


H/V TIME HISTORY

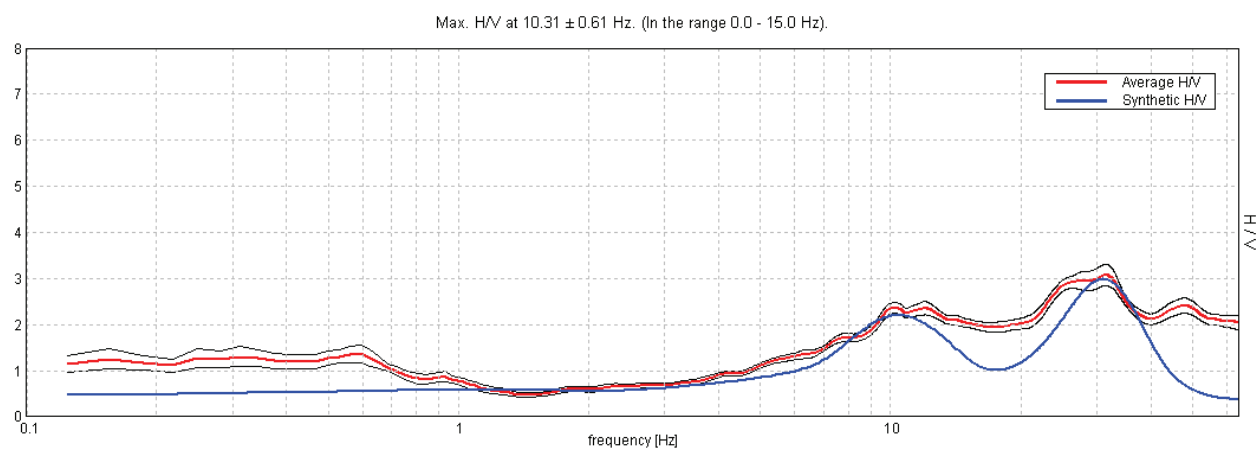




SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer
[m]

Thickness [m]

Vs [m/s]

0.70	0.70	105
2.00	1.30	210
3.50	1.50	350
5.60	2.10	230
20.60	15.00	520
35.60	15.00	550
75.60	40.00	450
inf.	inf.	580

Vs(0.0-30.0)=415m/s

Max. H/V at 10.31 ± 0.61 Hz. (in the range 0.0 - 15.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$10.31 > 0.50$	OK	
$n_c(f_0) > 200$	$10312.5 > 200$	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 496 times	OK	

Criteria for a clear HVSR peak

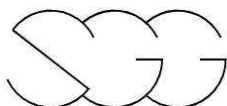
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	5.219 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$			NO
$A_0 > 2$	$2.37 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.02899 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.29895 < 0.51563$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.058 < 1.58$	OK	

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

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

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

**PROVE 37 VIA STRADELLA****CASINALBO DI FORMIGINE**

Start recording: 09/07/09 13:46:42 End recording: 09/07/09 14:06:43

Channel labels: NORTH SOUTH; EAST WEST; UP DOWN

COORDINATE GAUSS-BOAGA: 1648813, 4937747

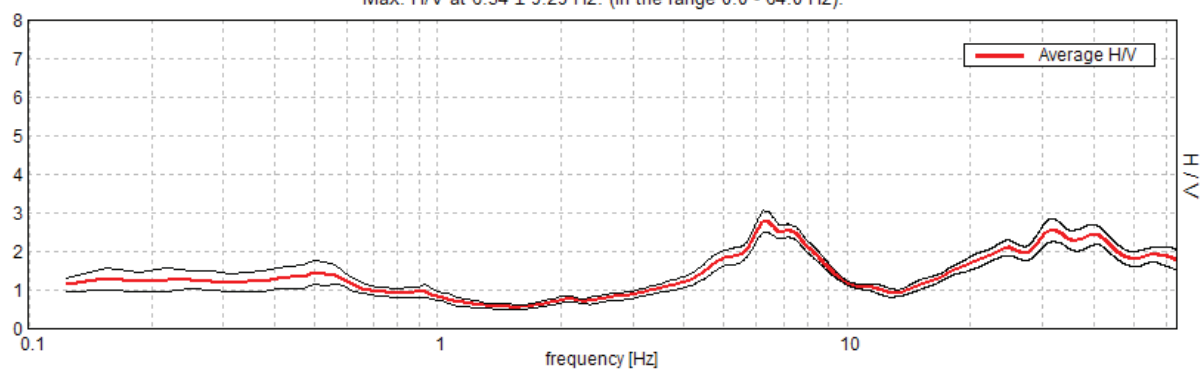
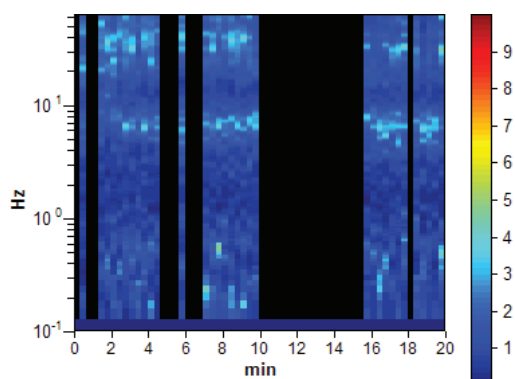
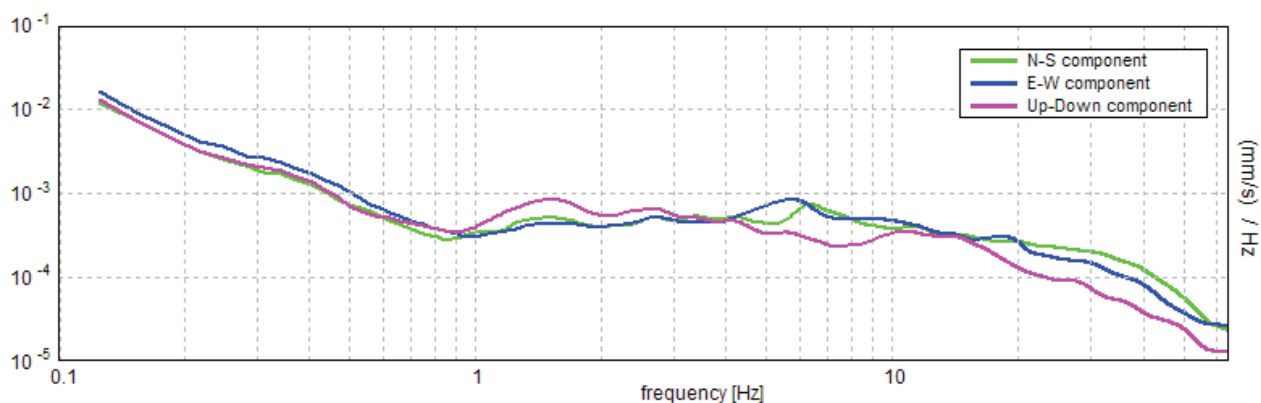
Trace length: 0h20'00". Analyzed 55% trace (manual window selection)

Sampling frequency: 128 Hz

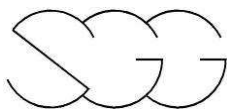
Window size: 20 s

Smoothing window: Triangular window

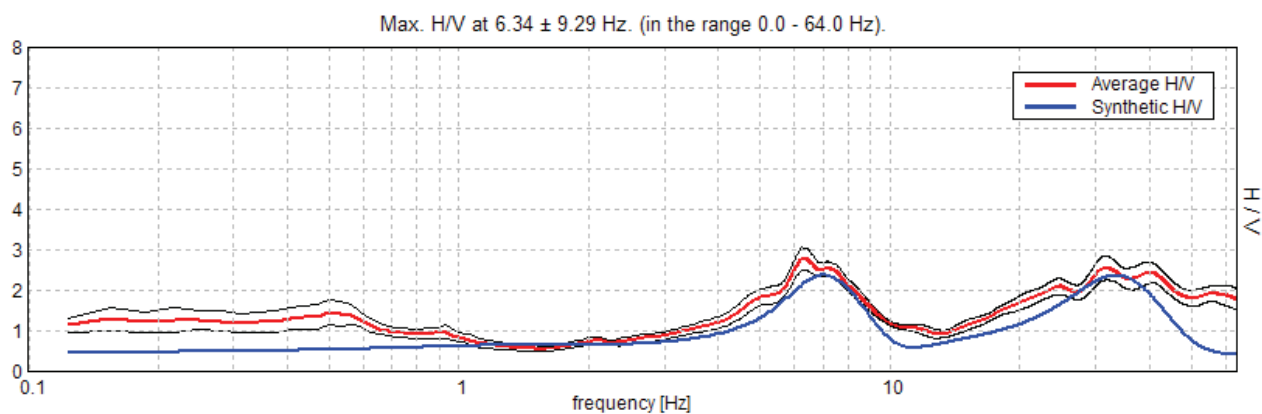
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIOMax. H/V at 6.34 ± 9.29 Hz. (in the range 0.0 - 64.0 Hz).**H/V TIME HISTORY****SINGLE COMPONENT SPECTRA**

Comune di Formigine (MO)
MICROZONAZIONE SISMICA
Relazione tecnica



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.60	0.60	115
1.20	0.60	175
5.70	4.50	280
11.00	5.30	290
17.00	6.00	640
24.00	7.00	580
28.00	4.00	610
35.00	7.00	460
38.50	3.50	600
68.50	30.00	500
inf.	inf.	650

$V_s(0.0-30.0)=398\text{m/s}$

Max. H/V at 6.34 ± 9.29 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$6.34 > 0.50$	OK	
$n_c(f_0) > 200$	$4186.9 > 200$	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 306 times	OK	

Criteria for a clear HVSR peak

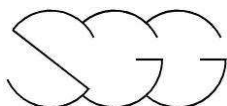
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	4.313 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	9.469 Hz	OK	
$A_0 > 2$	$2.79 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.70797 < 0.05$		NO
$\sigma_f < \varepsilon(f_0)$	$4.4912 < 0.31719$		NO
$\sigma_A(f_0) < \theta(f_0)$	$0.1335 < 1.58$	OK	

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

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

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

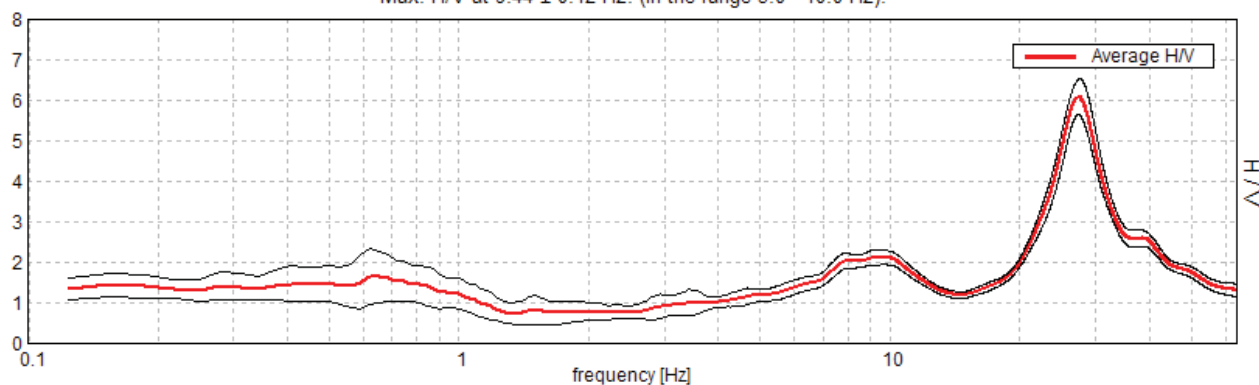
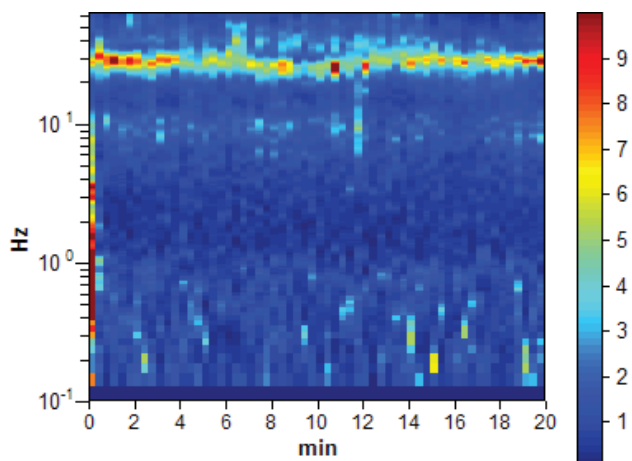
**PROVA 38 VIA SAN ONOFRIO FORMIGINE**

Channel labels: NORTH SOUTH; EAST WEST; UP DOWN
GPS COORDINATE GAUSS-BOAGA: 1648136-4938476

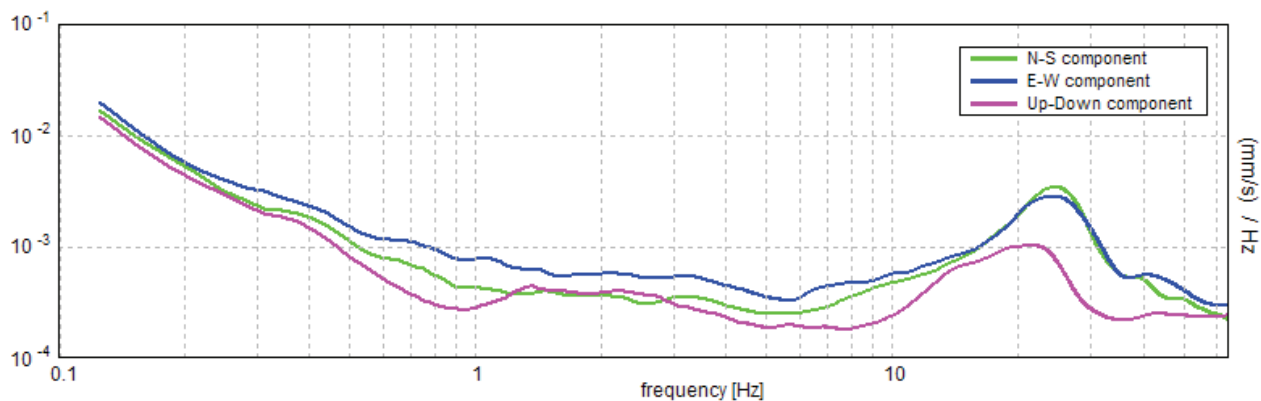
Trace length: 0h20'00". Analysis performed on the entire trace.
Sampling frequency: 128 Hz
Window size: 20 s
Smoothing window: Triangular window
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

Max. H/V at 9.44 ± 0.12 Hz. (In the range 5.0 - 10.0 Hz).

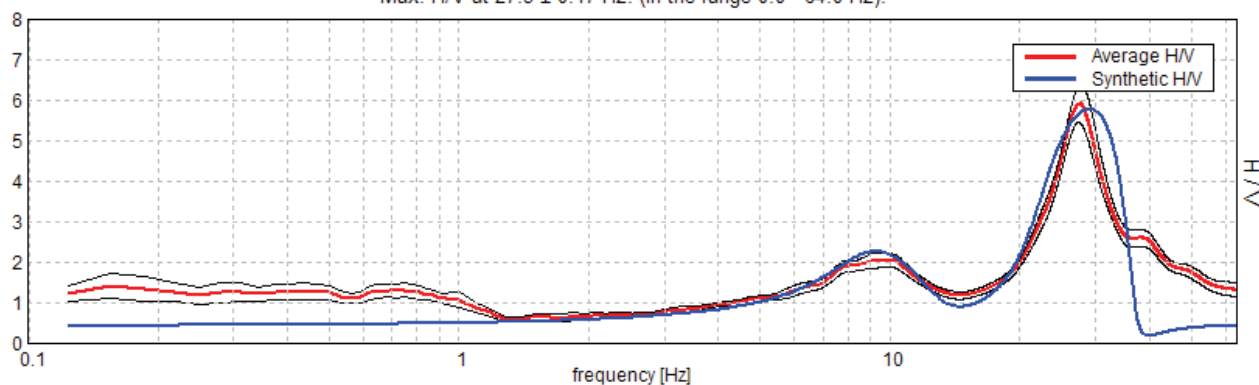
**H/V TIME HISTORY**

SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V

Max. H/V at 27.5 ± 0.17 Hz. (in the range 0.0 - 64.0 Hz).



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
1.10	1.10	105
2.60	1.50	315
8.10	5.50	285
18.10	10.00	570
25.10	7.00	485
29.10	4.00	580
inf.	inf.	550

Vs(0.0-30.0)=400m/s

Max. H/V at 9.44 ± 0.12 Hz. (in the range 5.0 - 10.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$9.44 > 0.50$	OK	
$n_c(f_0) > 200$	$11325.0 > 200$	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 454 times	OK	

Criteria for a clear HVSR peak

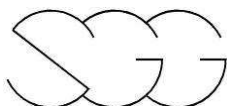
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	4.188 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$			NO
$A_0 > 2$	$2.14 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00637 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.06007 < 0.47188$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.0917 < 1.58$	OK	

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

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

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



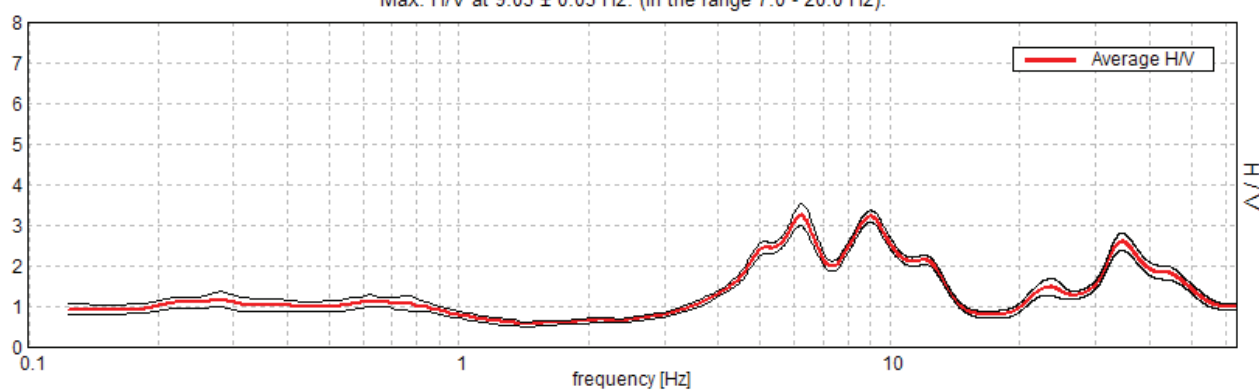
PROVA 39 VIA PIO DONATI

FORMIGINE

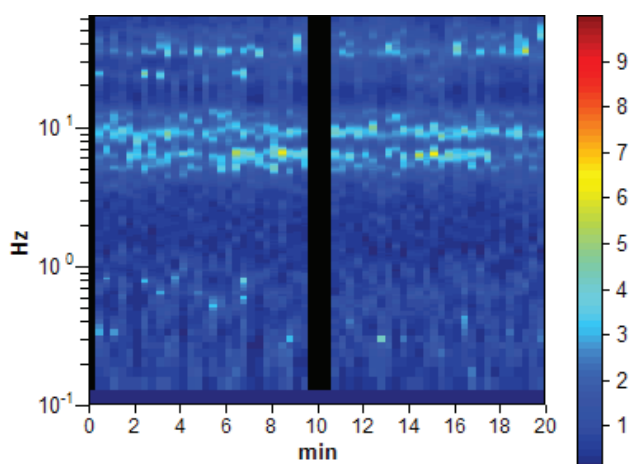
Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN
COORDINATE GAUSS-BOAGA: 1646521, 4937296

Trace length: 0h20'00". Analyzed 93% trace (manual window selection)
Sampling frequency: 128 Hz
Window size: 20 s
Smoothing window: Triangular window
Smoothing: 10%

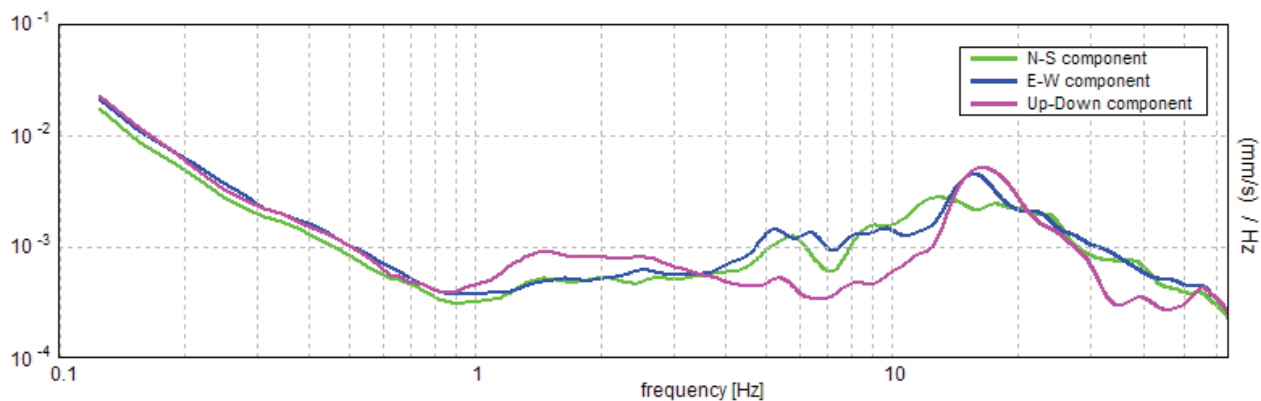
HORIZONTAL TO VERTICAL SPECTRAL RATIO

Max. H/V at 9.03 ± 0.03 Hz. (In the range 7.0 - 20.0 Hz).

H/V TIME HISTORY

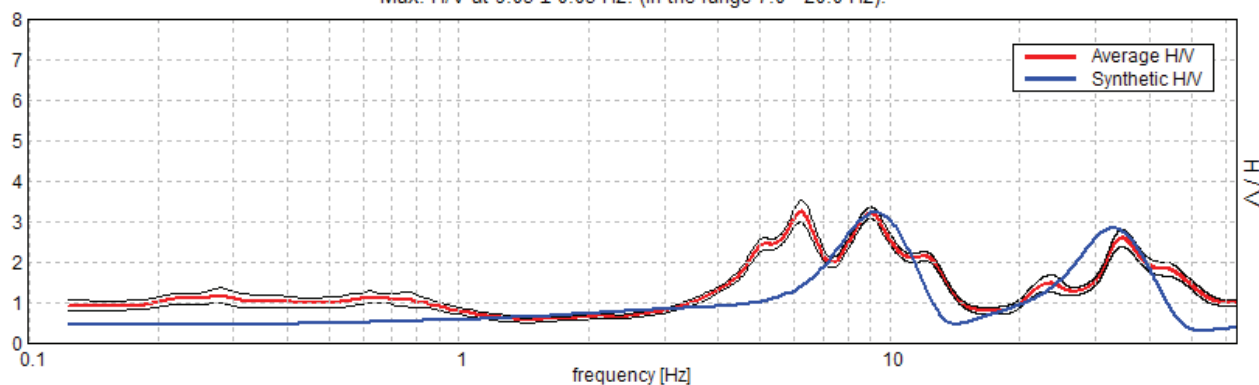


SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V

Max. H/V at 9.03 ± 0.03 Hz. (In the range 7.0 - 20.0 Hz).



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
0.80	0.80	100
2.70	1.90	240
5.70	3.00	190
18.20	12.50	510
28.20	10.00	430
48.20	20.00	560
inf.	inf.	600

$V_s(0.0-30.0)=363\text{m/s}$

Max. H/V at 9.03 ± 0.03 Hz. (in the range 7.0 - 20.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$9.03 > 0.50$	OK	
$n_c(f_0) > 200$	$10115.0 > 200$	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 434 times	OK	

Criteria for a clear HVSR peak

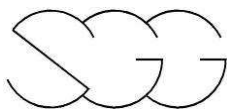
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	4.375 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	13.375 Hz	OK	
$A_0 > 2$	$3.24 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00158 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.01426 < 0.45156$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.071 < 1.58$	OK	

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

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

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

**PROVA 40****VIA GIARDINI FORMIGINE**

Channel labels:

NORTH SOUTH;

EAST WEST ;

UP DOWN

COORDINATE GAUSS-BOAGA: 1646793, 4938022

CTR (elemento scala 1:5.000): 219034

Trace length: 0h20'00".

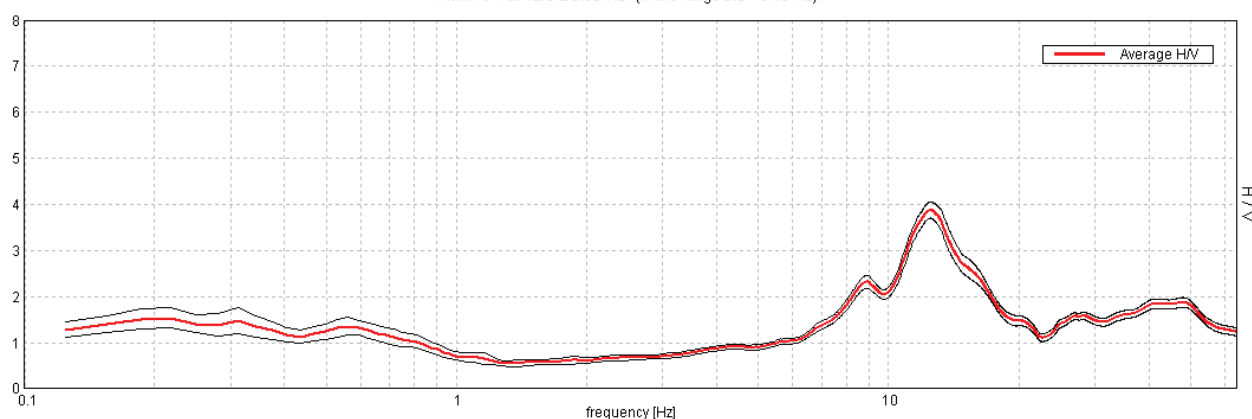
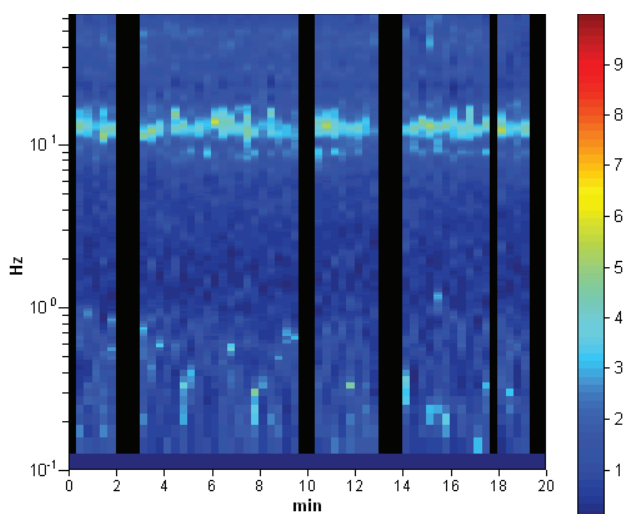
Analyzed 80% trace (manual window selection)

Sampling frequency: 128 Hz

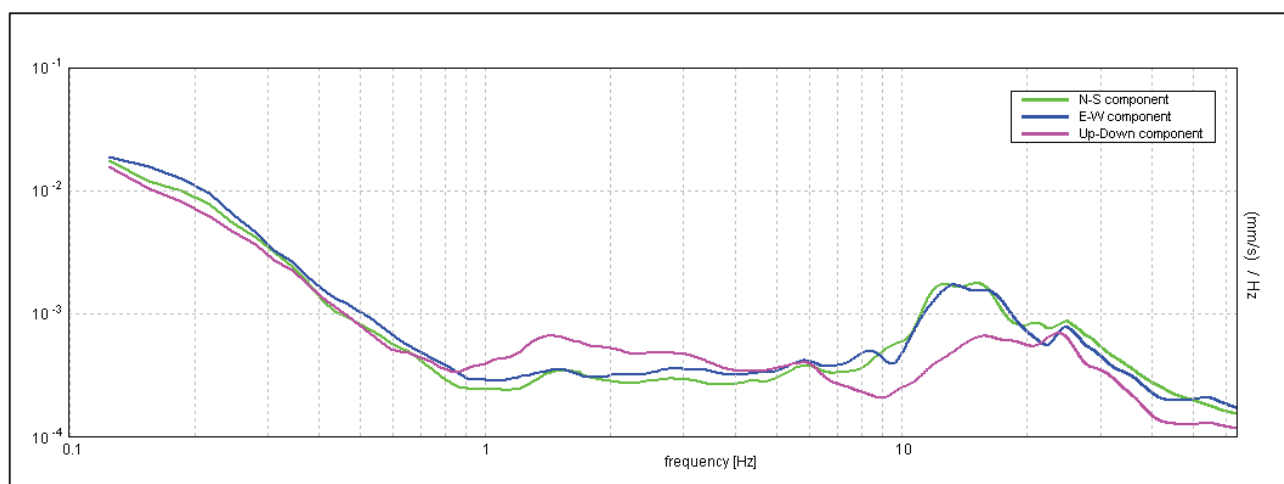
Window size: 20 s

Smoothing window: Triangular window

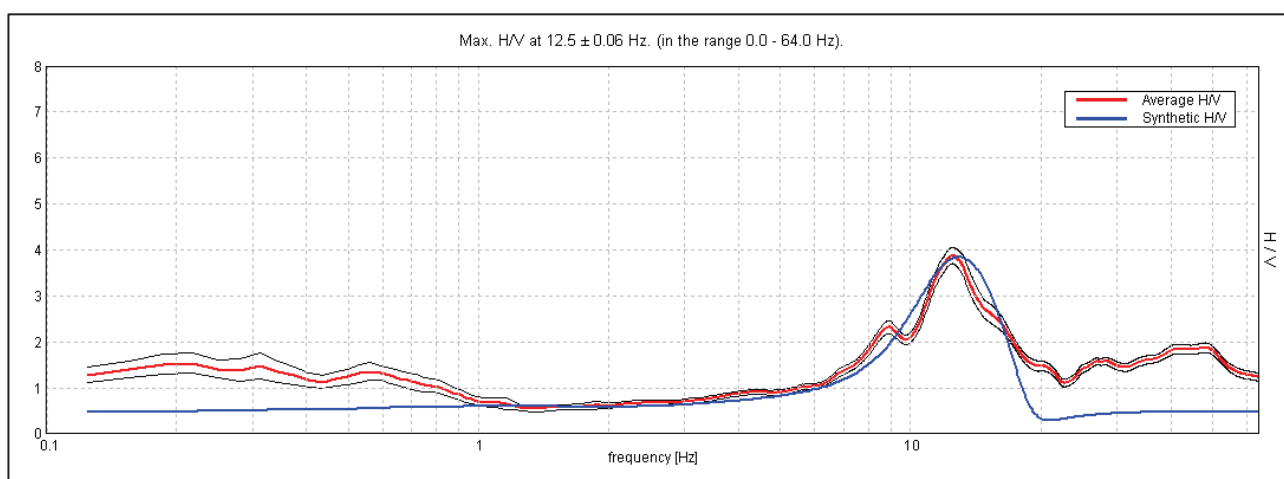
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIOMax. H/V at 12.5 ± 0.06 Hz. (in the range 0.0 - 64.0 Hz).**H/V TIME HISTORY**

SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
3.50	3.50	175
13.50	10.00	453
24.50	11.00	490
40.50	16.00	450
47.00	6.50	500
79.50	32.50	460
87.50	8.00	520
inf.	inf.	550

Vs(0.0-30.0)=391m/s

Max. H/V at 12.5 ± 0.06 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$12.50 > 0.50$	OK	
$n_c(f_0) > 200$	$12000.0 > 200$	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 601 times	OK	

Criteria for a clear HVSR peak

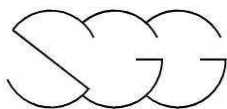
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	8.156 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	17.469 Hz	OK	
$A_0 > 2$	$3.88 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00226 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.02824 < 0.625$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.0865 < 1.58$	OK	

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

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

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



PROVA 41

VIA GIARDINI

FORMIGINE

Channel labels: NORTH SOUTH; EAST WEST; UP DOWN

COORDINATE GAUSS-BOAGA: 1646820, 4938013

Trace length: 0h20'00".

Analyzed 58% trace (manual window selection)

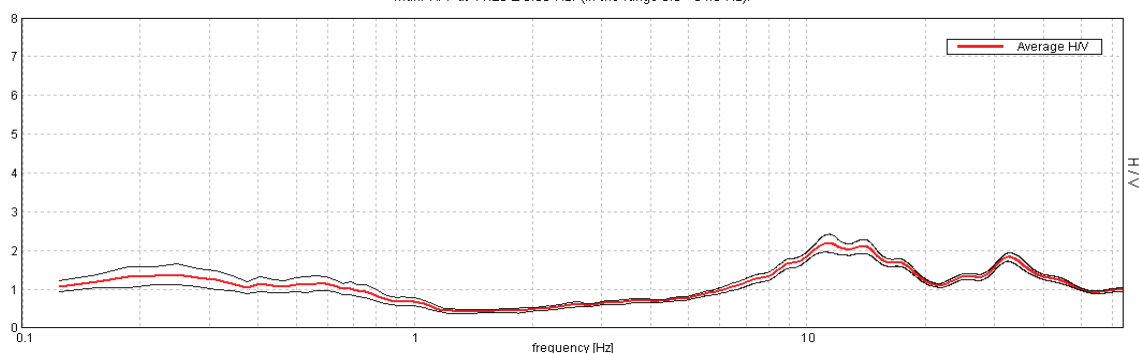
Sampling frequency: 128 Hz

Window size: 20 s

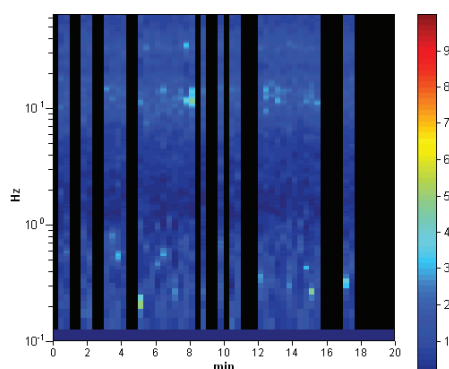
Smoothing window: Triangular window

Smoothing: 10%

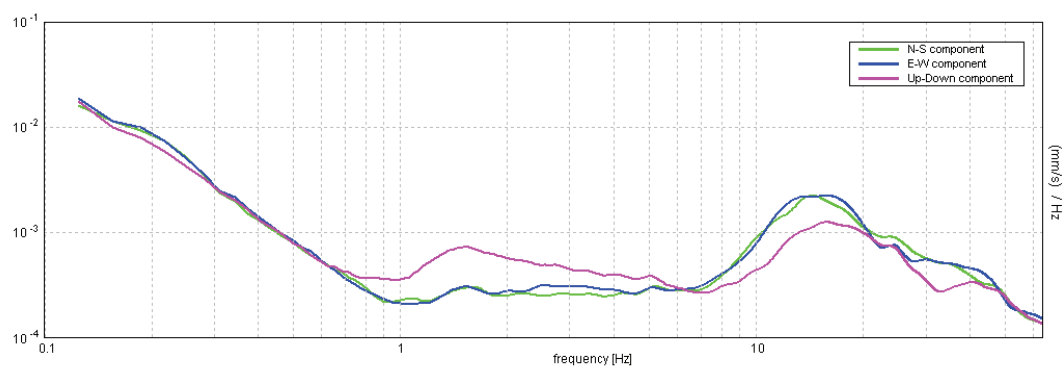
HORIZONTAL TO VERTICAL SPECTRAL RATIO

Max. H/V at 11.25 ± 0.68 Hz. (in the range 0.0 - 64.0 Hz).

H/V TIME HISTORY



SINGLE COMPONENT SPECTRA



Comune di Formigine (MO)
MICROZONAZIONE SISMICA
Relazione tecnica

Max. H/V at 11.25 ± 0.68 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$11.25 > 0.50$	OK	
$n_c(f_0) > 200$	$7875.0 > 200$	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 541 times	OK	

Criteria for a clear HVSR peak

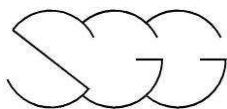
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	6.625 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$			NO
$A_0 > 2$	$2.19 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.02944 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.33125 < 0.5625$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.1115 < 1.58$	OK	

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

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

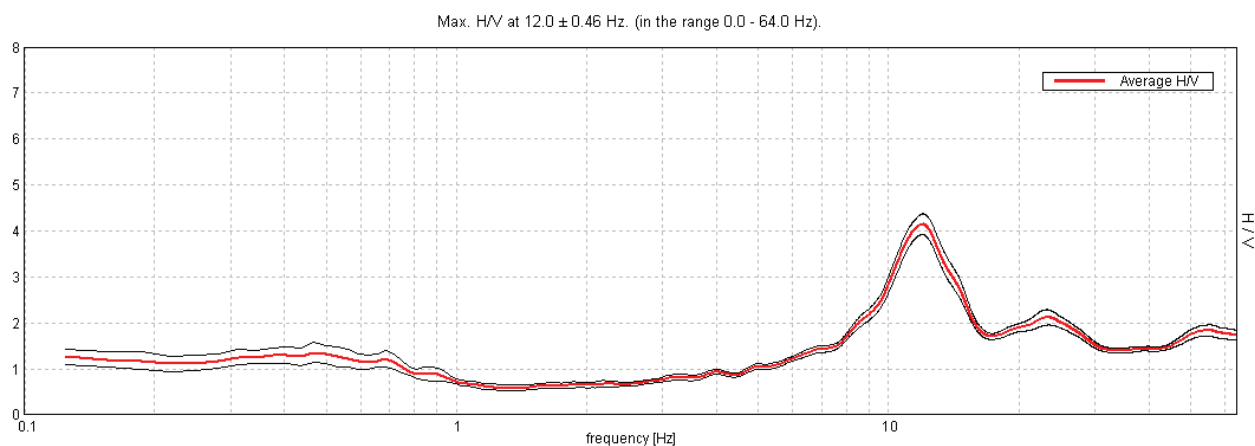
Freq.range [Hz]	< 0.2	0.2 – 0.5	0.5 – 1.0	1.0 – 2.0	> 2.0
$\varepsilon(f_0)$ [Hz]	$0.25 f_0$	$0.2 f_0$	$0.15 f_0$	$0.10 f_0$	$0.05 f_0$
$\theta(f_0)$ for $\sigma_A(f_0)$	3.0	2.5	2.0	1.78	1.58
Log $\theta(f_0)$ for $\sigma_{\log H/V}(f_0)$	0.48	0.40	0.30	0.25	0.20

**PROVA 42 VIA EX-CINEMA ITALIA****FORMIGINE**

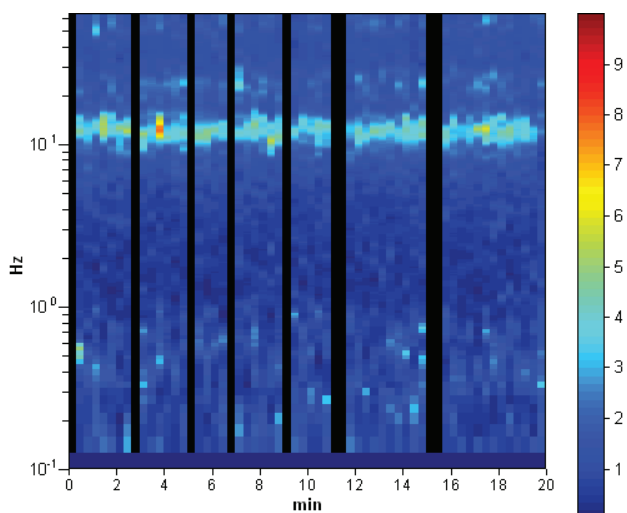
Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN
GPS data not available

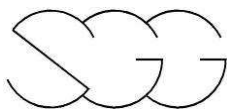
Trace length: 0h20'00". Analyzed 85% trace (manual window selection)
Sampling frequency: 128 Hz
Window size: 20 s
Smoothing window: Triangular window
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

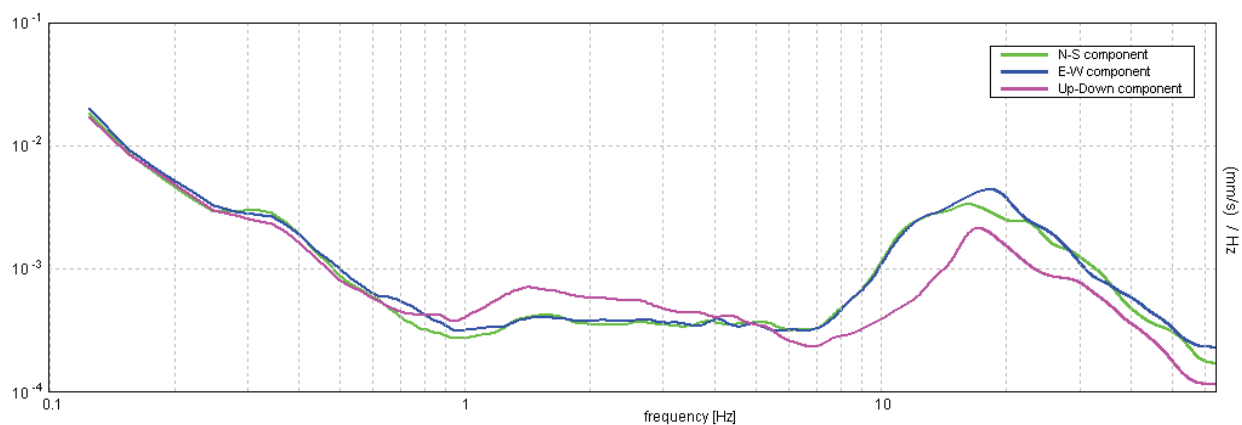


H/V TIME HISTORY

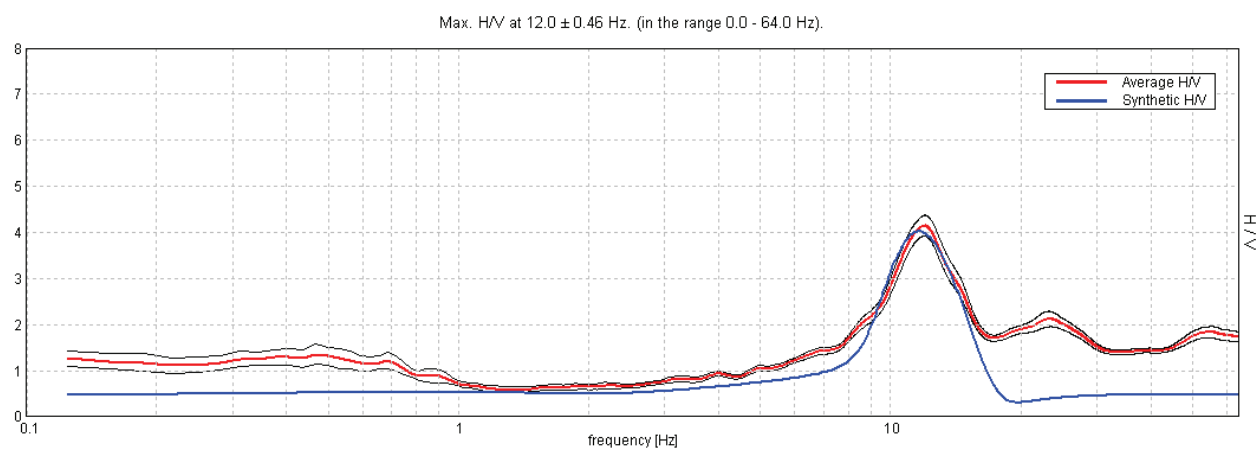




SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer
[m]

4.70
29.70
45.70
85.70
inf.

Thickness [m]

4.70
25.00
16.00
40.00
inf.

Vs [m/s]

220
550
400
480
550

Vs(0.0-30.0)=444m/s

Max. H/V at 12.0 ± 0.46 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$12.00 > 0.50$	OK	
$n_c(f_0) > 200$	$12240.0 > 200$	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 577 times	OK	

Criteria for a clear HVSR peak

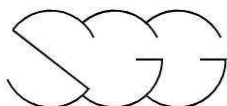
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	8.688 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	15.688 Hz	OK	
$A_0 > 2$	$4.15 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.01879 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.22546 < 0.6$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.1116 < 1.58$	OK	

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

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

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



PROVA 43 VIA MATTEOTTI EX-CINEMA ITALIA FORMIGINE

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN
COORDINATE GAUSS-BOAGA: 1646753, 4937639

Trace length: 0h20'00". Analyzed 85% trace (manual window selection)

Sampling frequency: 128 Hz

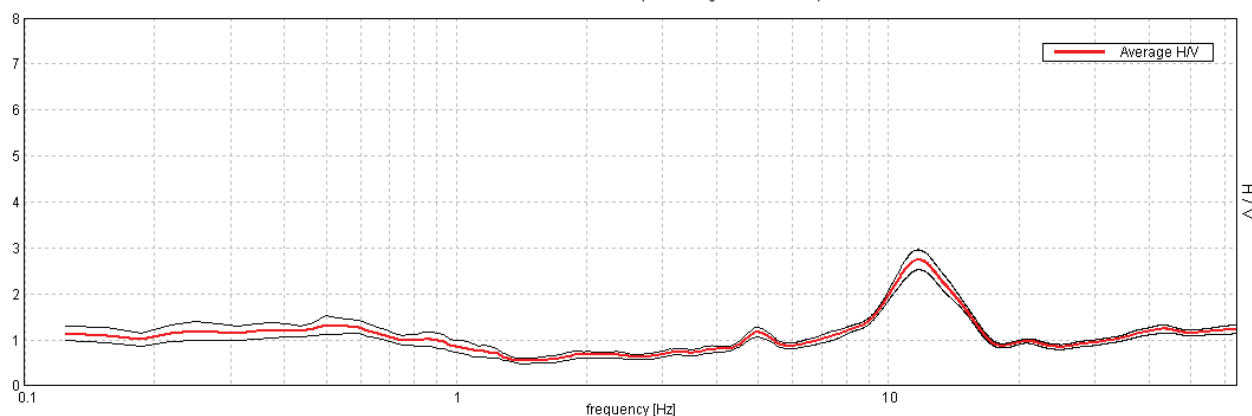
Window size: 20 s

Smoothing window: Triangular window

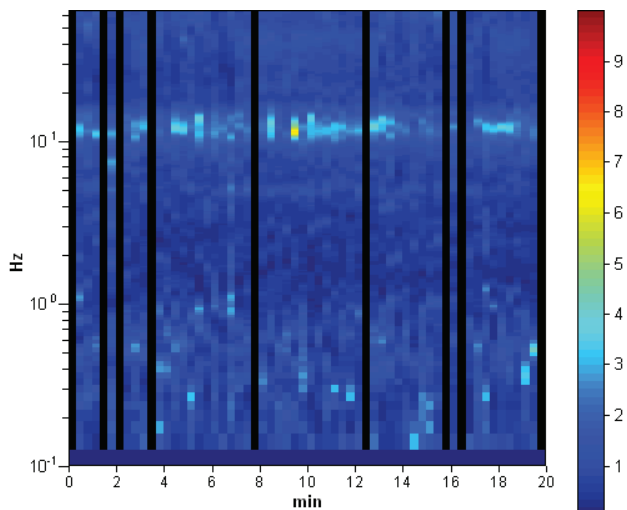
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIO

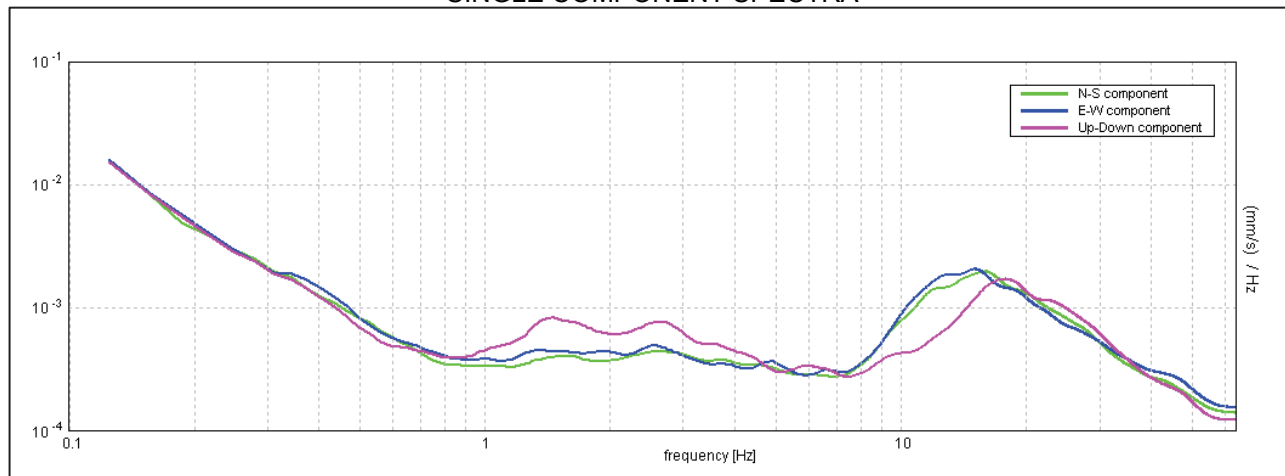
Max. H/V at 11.72 ± 0.07 Hz. (in the range 0.0 - 64.0 Hz).



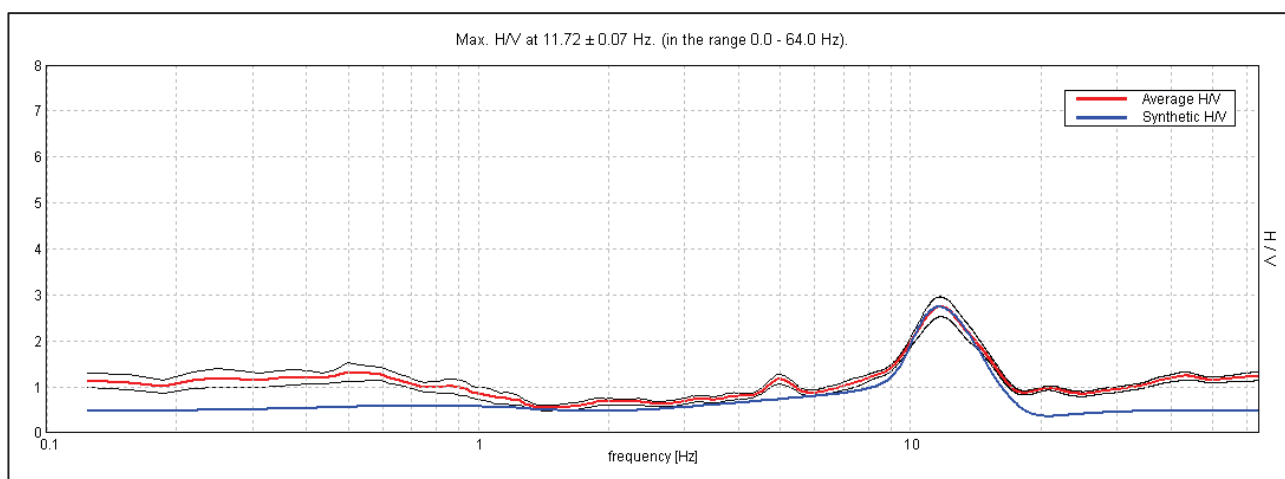
H/V TIME HISTORY



SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
4.60	4.60	225
29.60	25.00	495
45.60	16.00	330
52.10	6.50	520
84.60	32.50	420
inf.	inf.	550

Vs(0.0-30.0)=416m/s

Max. H/V at 11.72 ± 0.07 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$11.72 > 0.50$	OK	
$n_c(f_0) > 200$	$11953.1 > 200$	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 564 times	OK	

Criteria for a clear HVSR peak

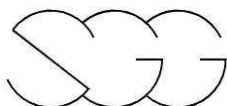
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	8.875 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	15.906 Hz	OK	
$A_0 > 2$	$2.74 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00298 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.03495 < 0.58594$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.1061 < 1.58$	OK	

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

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

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



PROVA 44 VIA CASALI

FORMIGINE

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN

COORDINATE GAUSS-BOAGA: 1646139; 4938752

Trace length: 0h20'00". Analyzed 95% trace (manual window selection)

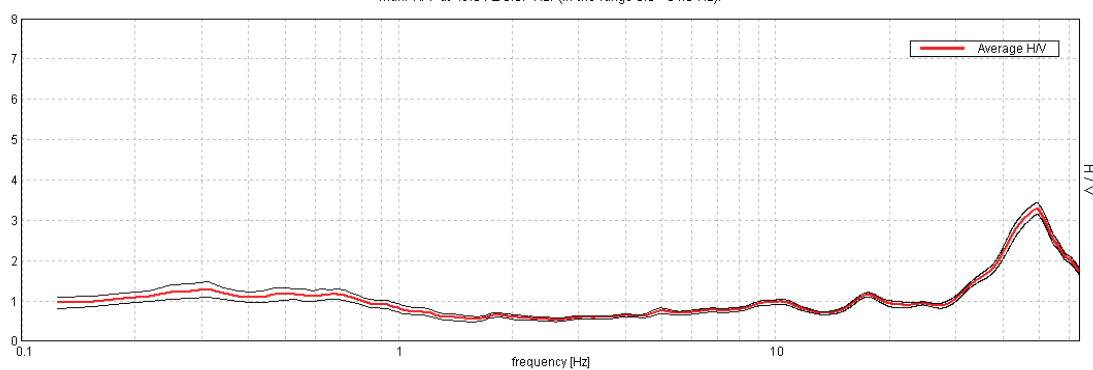
Sampling frequency: 128 Hz

Window size: 20 s

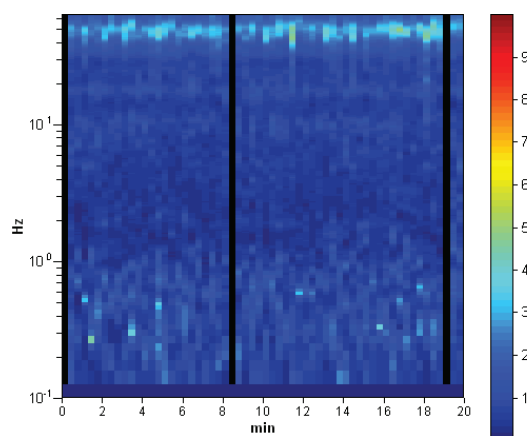
Smoothing window: Triangular window

Smoothing: 10%

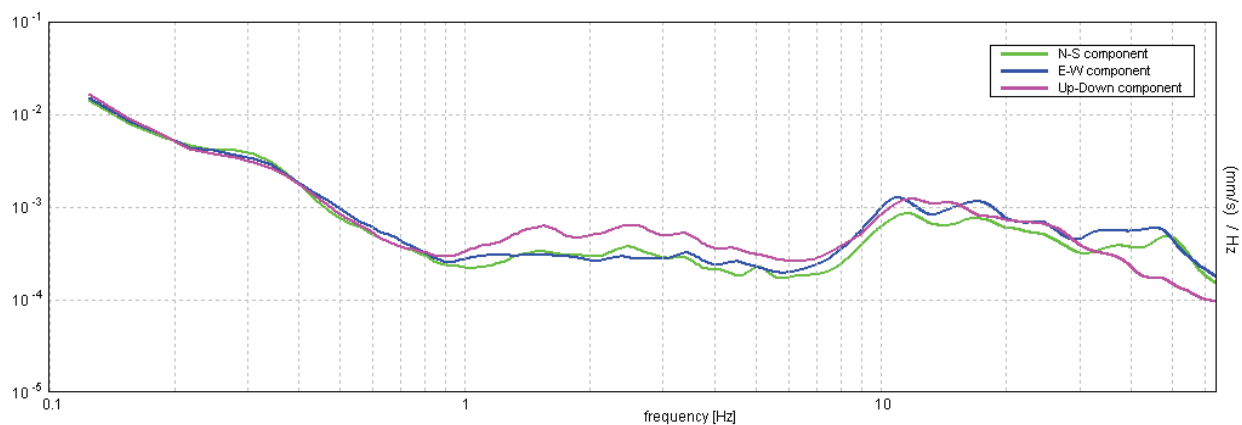
HORIZONTAL TO VERTICAL SPECTRAL RATIO

Max. H/V at 49.34 ± 0.07 Hz. (In the range 0.0 - 64.0 Hz).

H/V TIME HISTORY



SINGLE COMPONENT SPECTRA



Max. H/V at 49.34 ± 0.07 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$49.34 > 0.50$	OK	
$n_c(f_0) > 200$	$56251.9 > 200$	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 1260 times	OK	

Criteria for a clear HVSR peak

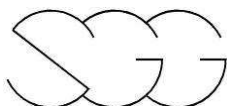
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0] \mid A_{H/V}(f^-) < A_0 / 2$	35.813 Hz	OK	
Exists f^+ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0 / 2$			NO
$A_0 > 2$	$3.29 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00069 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.0339 < 2.46719$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.0707 < 1.58$	OK	

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

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

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

**FORMIGINE 45****VIA CASALI 30****FORMIGINE**

Channel labels: NORTH SOUTH; EAST WEST ; UP DOWN

COORDINATE GAUSS-BOAGA: 1646164, 4938789

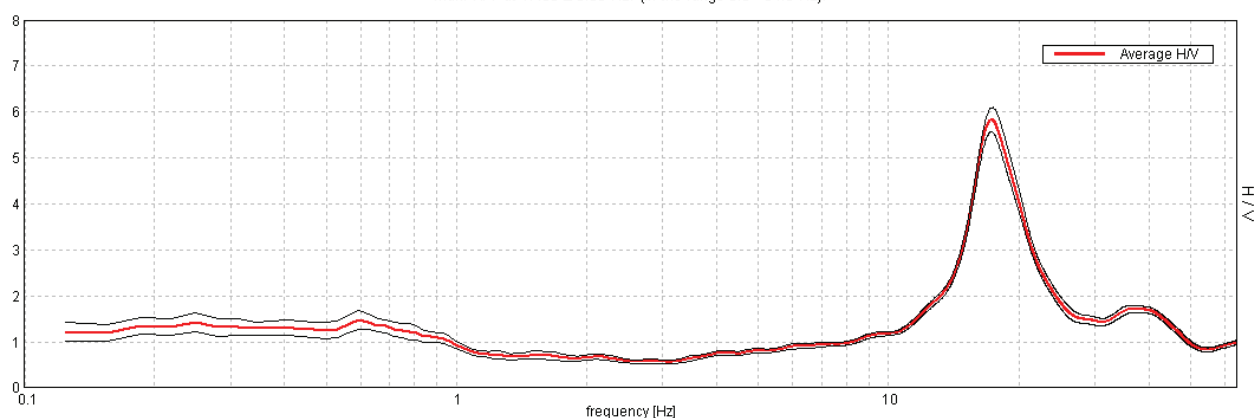
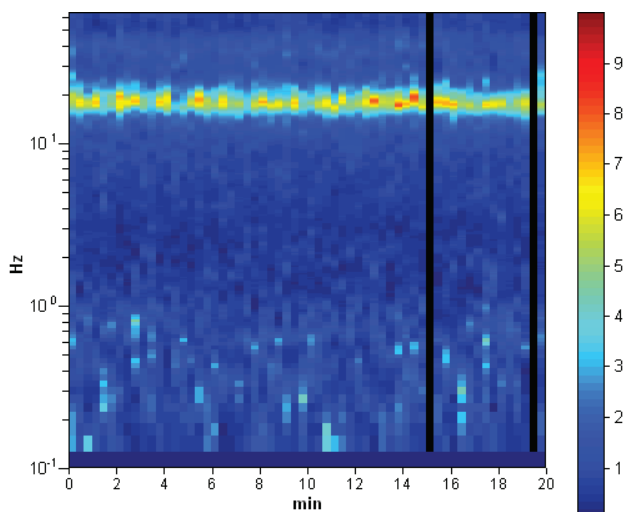
Trace length: 0h20'00". Analyzed 97% trace (manual window selection)

Sampling frequency: 128 Hz

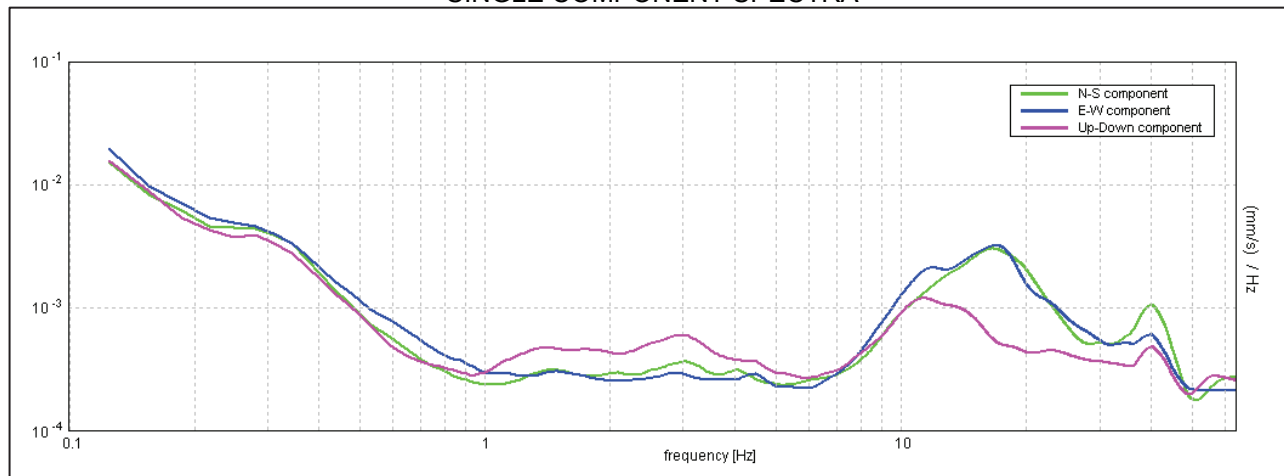
Window size: 20 s

Smoothing window: Triangular window

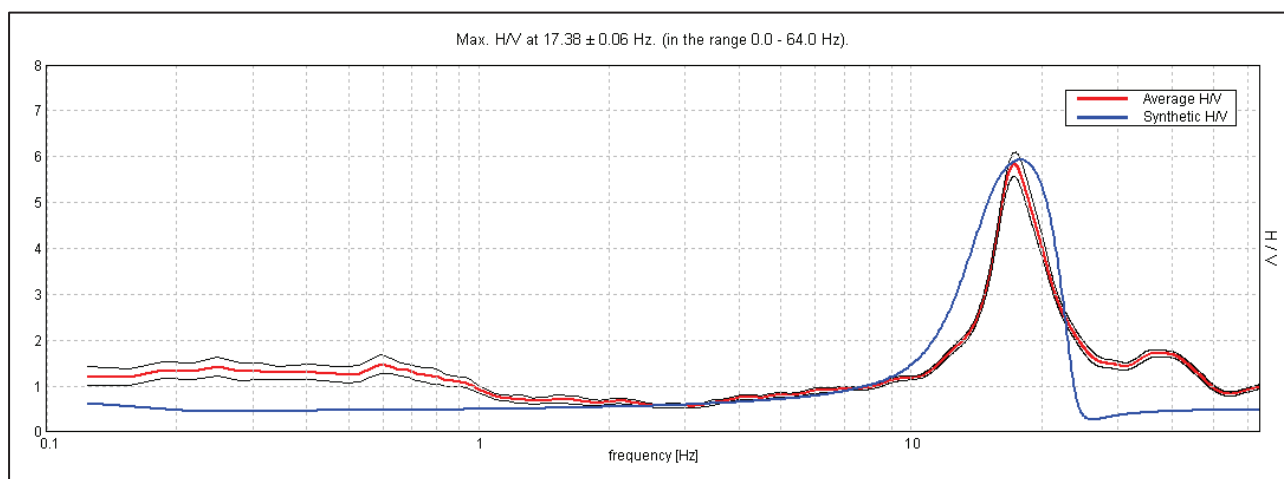
Smoothing: 10%

HORIZONTAL TO VERTICAL SPECTRAL RATIOMax. H/V at 17.38 ± 0.06 Hz. (in the range 0.0 - 64.0 Hz).**H/V TIME HISTORY**

SINGLE COMPONENT SPECTRA



EXPERIMENTAL VS. SYNTHETIC H/V



Depth at the bottom of the layer [m]	Thickness [m]	Vs [m/s]
2.00	2.00	200
3.50	1.50	225
33.50	30.00	575
inf.	inf.	600

Vs(0.0-30.0)=478m/s

Max. H/V at 17.38 ± 0.06 Hz. (in the range 0.0 - 64.0 Hz).

Criteria for a reliable HVSR curve

[All 3 should be fulfilled]

$f_0 > 10 / L_w$	$17.38 > 0.50$	OK	
$n_c(f_0) > 200$	$20155.0 > 200$	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 835 times	OK	

Criteria for a clear HVSR peak

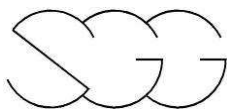
[At least 5 out of 6 should be fulfilled]

Exists f^- in $[f_0/4, f_0]$ $A_{H/V}(f^-) < A_0 / 2$	14.688 Hz	OK	
Exists f^+ in $[f_0, 4f_0]$ $A_{H/V}(f^+) < A_0 / 2$	21.719 Hz	OK	
$A_0 > 2$	$5.83 > 2$	OK	
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	$ 0.00159 < 0.05$	OK	
$\sigma_f < \varepsilon(f_0)$	$0.02761 < 0.86875$	OK	
$\sigma_A(f_0) < \theta(f_0)$	$0.1326 < 1.58$	OK	

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

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

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



PROVE PENETROMETRICHE

PROVA PENETROMETRICA STATICA **LETTURE DI CAMPAGNA / VALORI DI RESISTENZA**

CPT 1

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via A. Fiori
 - resp. cantiere :
 - assist. cantiere :

- data : 28/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

prf	L1	L2	qc	fs	qc/fs	prf	L1	L2	qc	fs	qc/fs
m	-	-	Kg/cm ²	Kg/cm ²	-	m	-	-	Kg/cm ²	Kg/cm ²	-
0,20	9,0	----	9,0	0,47	19,0	4,20	50,0	104,0	50,0	3,60	14,0
0,40	8,0	15,0	8,0	0,40	20,0	4,40	46,0	100,0	46,0	3,27	14,0
0,60	15,0	21,0	15,0	0,80	19,0	4,60	39,0	88,0	39,0	2,80	14,0
0,80	38,0	50,0	38,0	1,53	25,0	4,80	42,0	84,0	42,0	2,67	16,0
1,00	50,0	73,0	50,0	2,93	17,0	5,00	34,0	74,0	34,0	2,07	16,0
1,20	57,0	101,0	57,0	3,27	17,0	5,20	30,0	61,0	30,0	1,87	16,0
1,40	70,0	119,0	70,0	3,93	18,0	5,40	29,0	57,0	29,0	1,73	17,0
1,60	85,0	144,0	85,0	3,33	26,0	5,60	25,0	51,0	25,0	1,33	19,0
1,80	98,0	148,0	98,0	3,33	29,0	5,80	23,0	43,0	23,0	1,27	18,0
2,00	51,0	101,0	51,0	3,47	15,0	6,00	25,0	44,0	25,0	1,33	19,0
2,20	53,0	105,0	53,0	3,60	15,0	6,20	29,0	49,0	29,0	1,80	16,0
2,40	45,0	99,0	45,0	3,13	14,0	6,40	30,0	57,0	30,0	1,93	16,0
2,60	42,0	89,0	42,0	2,93	14,0	6,60	35,0	64,0	35,0	2,27	15,0
2,80	32,0	76,0	32,0	2,27	14,0	6,80	37,0	71,0	37,0	2,33	16,0
3,00	33,0	67,0	33,0	2,33	14,0	7,00	82,0	117,0	82,0	1,47	56,0
3,20	30,0	65,0	30,0	2,13	14,0	7,20	216,0	238,0	216,0	1,67	130,0
3,40	36,0	68,0	36,0	2,60	14,0	7,40	350,0	375,0	350,0	2,33	150,0
3,60	39,0	78,0	39,0	2,80	14,0	7,60	460,0	495,0	460,0	2,67	172,0
3,80	50,0	92,0	50,0	3,60	14,0	7,80	530,0	570,0	530,0	-----	----
4,00	49,0	103,0	49,0	3,60	14,0						

- PENETROMETRO STATICO tipo da 20 t - (con anello allargatore) -
 - COSTANTE DI TRASFORMAZIONE Ct = 10 - Velocità avanzamento punta 2 cm/s
 - punta meccanica tipo Begemann $\phi = 35.7$ mm (area punta 10 cm² - apertura 60°)
 - manicotto laterale (superficie 150 cm²)

PROVA PENETROMETRICA DINAMICA

TABELLE VALORI DI RESISTENZA

DIN 1

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via A. Fiori
 - note : Prova eseguita in continuità con CPT1

- data : 28/10/2010
 - quota inizio : -7.6 m da p.c.a.
 - prof. falda : 0,00 m da quota inizio
 - pagina : 1

Prof.(m)	N(colpi p)	Rpd(kg/cm ²)	N(colpi r)	asta	Prof.(m)	N(colpi p)	Rpd(kg/cm ²)	N(colpi r)	asta
0,00 - 0,20	----	----	----	1	4,20 - 4,40	----	----	----	5
0,20 - 0,40	----	----	----	1	4,40 - 4,60	----	----	----	5
0,40 - 0,60	----	----	----	1	4,60 - 4,80	----	----	----	5
0,60 - 0,80	----	----	----	1	4,80 - 5,00	----	----	----	6
0,80 - 1,00	----	----	----	2	5,00 - 5,20	----	----	----	6
1,00 - 1,20	----	----	----	2	5,20 - 5,40	----	----	----	6
1,20 - 1,40	----	----	----	2	5,40 - 5,60	----	----	----	6
1,40 - 1,60	----	----	----	2	5,60 - 5,80	----	----	----	6
1,60 - 1,80	----	----	----	2	5,80 - 6,00	----	----	----	7
1,80 - 2,00	----	----	----	3	6,00 - 6,20	----	----	----	7
2,00 - 2,20	----	----	----	3	6,20 - 6,40	----	----	----	7
2,20 - 2,40	----	----	----	3	6,40 - 6,60	----	----	----	7
2,40 - 2,60	----	----	----	3	6,60 - 6,80	----	----	----	7
2,60 - 2,80	----	----	----	3	6,80 - 7,00	----	----	----	8
2,80 - 3,00	----	----	----	4	7,00 - 7,20	----	----	----	8
3,00 - 3,20	----	----	----	4	7,20 - 7,40	----	----	----	8
3,20 - 3,40	----	----	----	4	7,40 - 7,60	----	----	----	8
3,40 - 3,60	----	----	----	4	7,60 - 7,80	43	206,4	----	8
3,60 - 3,80	----	----	----	4	7,80 - 8,00	55	251,3	----	9
3,80 - 4,00	----	----	----	5	8,00 - 8,20	62	283,2	----	9
4,00 - 4,20	----	----	----	5					

- PENETROMETRO DINAMICO tipo : **EMILIA (20)**

- M (massa battente)= **63,50** kg - H (altezza caduta)= **0,75** m - A (area punta)= **20,00** cm² - D(diam. punta)= **50,50** mm

- Numero Colpi Punta N = N(**20**) [δ = 20 cm]

- Uso rivestimento / fanghi iniezione : **SI**

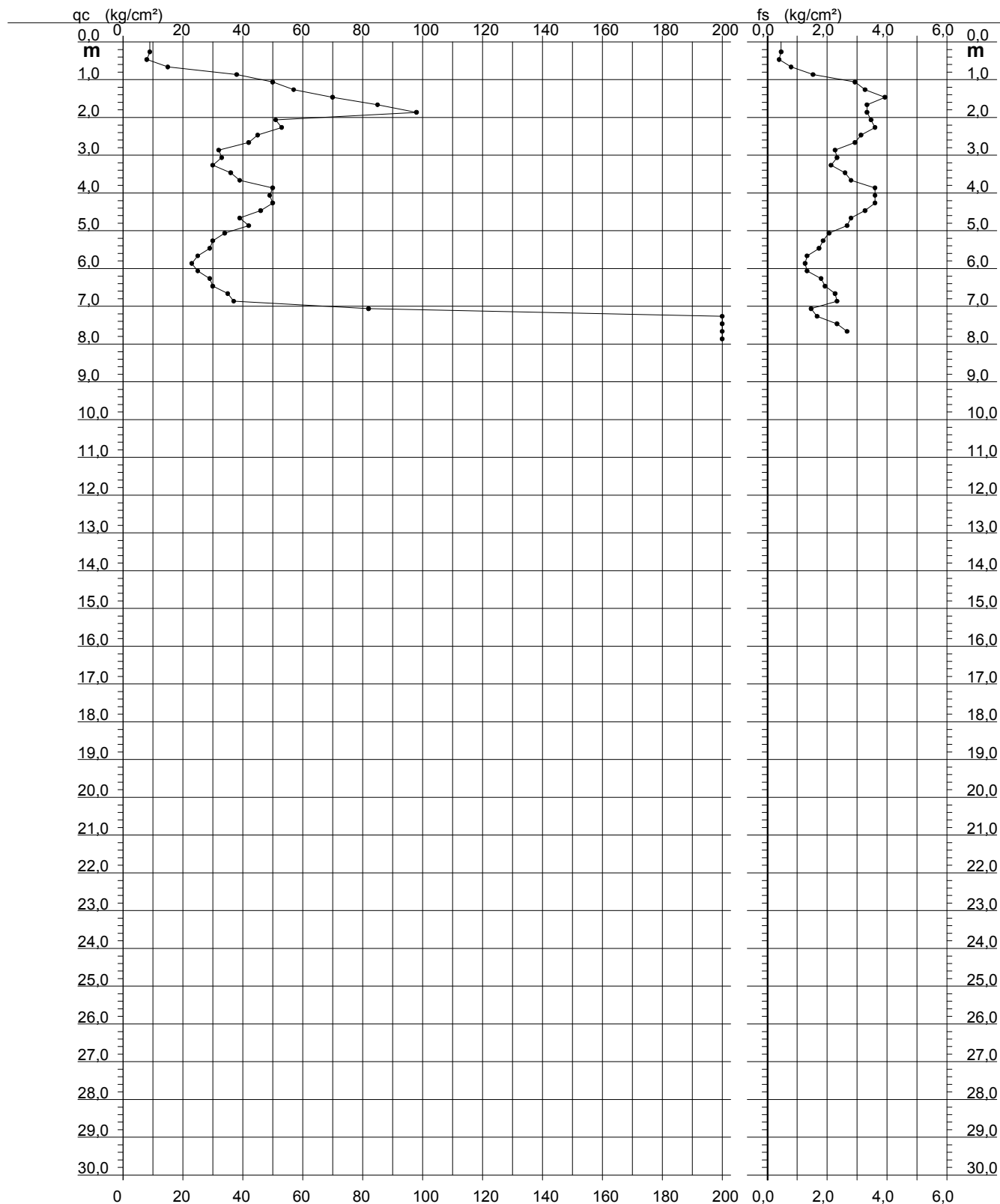
**PROVA PENETROMETRICA STATICA
DIAGRAMMA DI RESISTENZA****CPT 1**

2.0105-PG037

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via A. Fiori
- resp. cantiere :
- assist. cantiere :

- data : 28/10/2010
- quota inizio : Piano Campagna
- falda : Falda non rilevata

- data di emissione :
03/11/2010



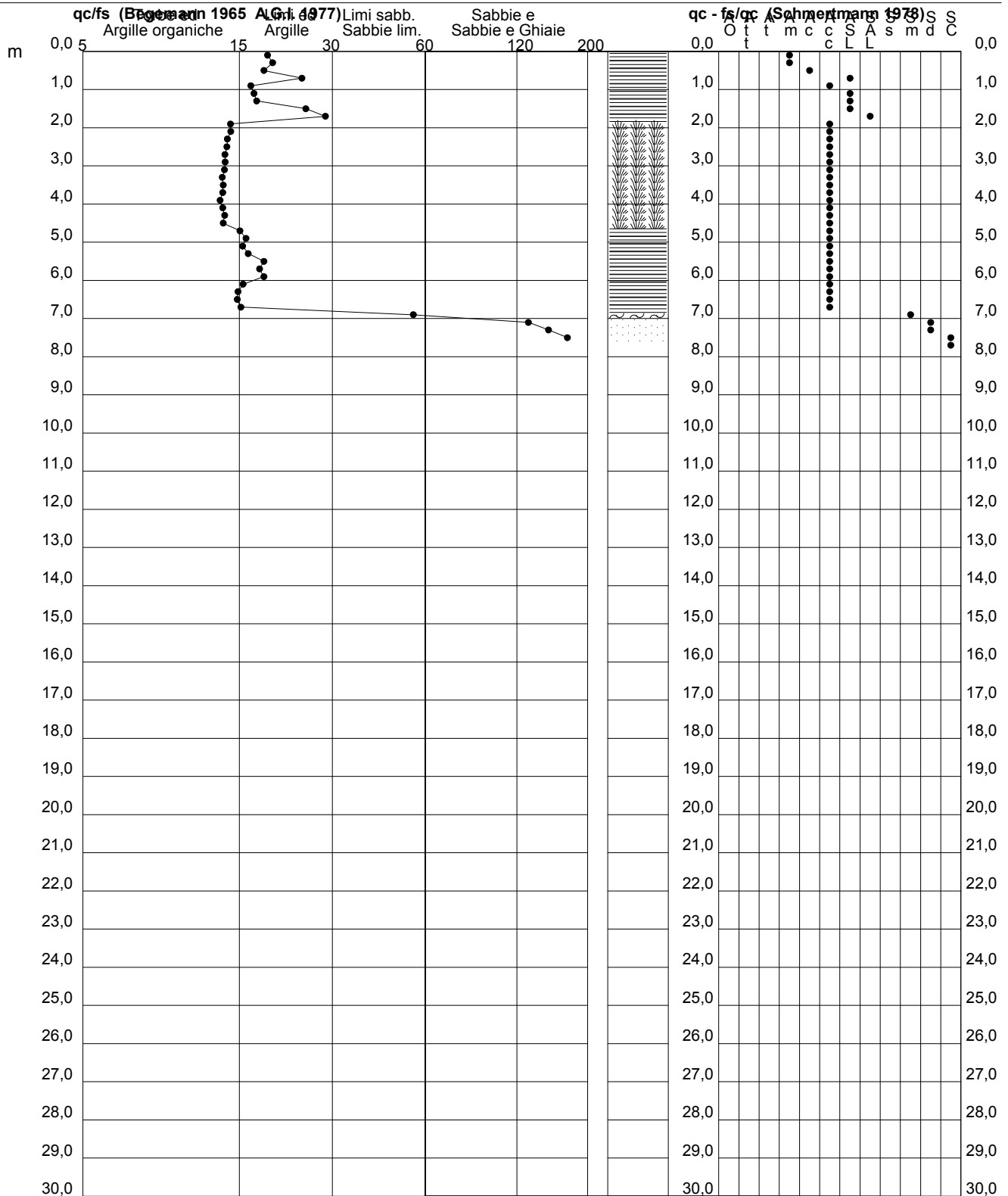
**PROVA PENETROMETRICA STATICA
VALUTAZIONI LITOLOGICHE****CPT 1**

2.0105-PG037

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via A. Fiori
- resp. cantiere :
- assist. cantiere :

- data : 28/10/2010
- quota inizio : Piano Campagna
- falda : Falda non rilevata

- data di emissione : 03/11/2010



PROVA PENETROMETRICA STATICA

TABELLA PARAMETRI GEOTECNICI

CPT 1

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via A. Fiori
 - resp. cantiere :
 - assist. cantiere :

- data : 28/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

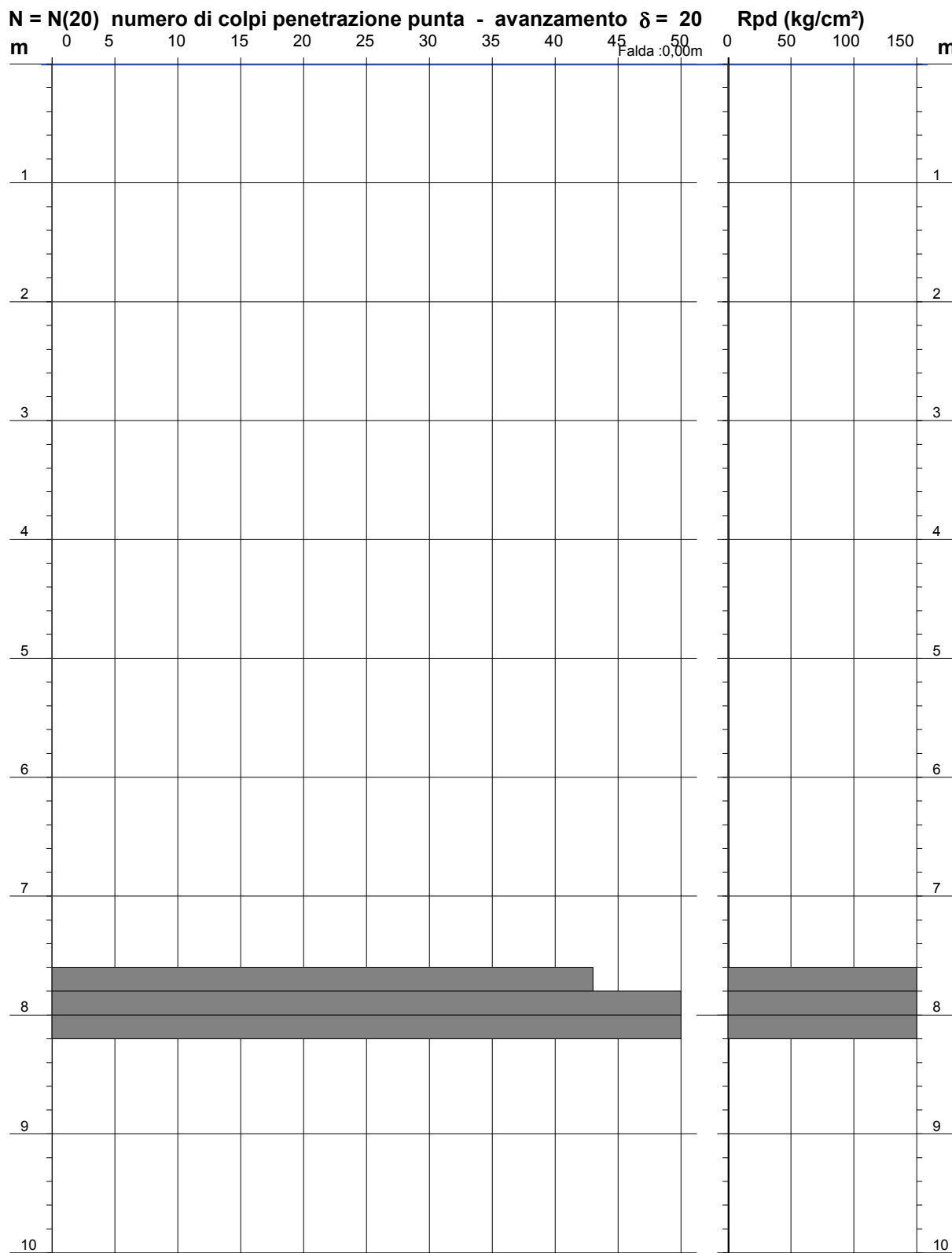
NATURA COESIVA											NATURA GRANULARE										
Prof. m	qc kg/cm²	qc/fs (-)	Natura Litol.	Y' t/m²	p'vo kg/cm²	Cu kg/cm²	OCR (-)	Eu50 kg/cm²	Eu25 kg/cm²	Mo kg/cm²	Dr %	ø1s (°)	ø2s (°)	ø3s (°)	ø4s (°)	ødm (°)	ømy (°)	Amax/g (-)	E'50 kg/cm²	E'25 kg/cm²	Mo
0,20	9	19	2////	1,85	0,04	0,45	99,9	77	115	38	--	--	--	--	--	--	--	--	--	--	--
0,40	8	20	2////	1,85	0,07	0,40	51,7	68	102	35	--	--	--	--	--	--	--	--	--	--	--
0,60	15	19	2////	1,85	0,11	0,67	59,0	113	170	50	--	--	--	--	--	--	--	--	--	--	--
0,80	38	25	4/::	1,85	0,15	1,27	91,9	215	323	114	85	40	41	43	45	41	30	0,207	63	95	114
1,00	50	17	4/::	1,85	0,19	1,67	98,0	283	425	150	89	41	42	44	45	41	31	0,221	83	125	150
1,20	57	17	4/::	1,85	0,22	1,90	91,9	323	485	171	89	41	42	44	45	41	31	0,221	95	143	171
1,40	70	18	4/::	1,85	0,26	2,33	98,0	397	595	210	93	41	42	44	45	41	32	0,232	117	175	210
1,60	85	26	4/::	1,85	0,30	2,83	99,9	482	723	255	96	41	43	44	46	42	33	0,244	142	213	255
1,80	98	29	4/::	1,85	0,33	3,27	99,9	555	833	294	98	42	43	44	46	42	34	0,252	163	245	294
2,00	51	15	4/::	1,85	0,37	1,70	42,2	289	434	153	73	38	40	42	44	39	31	0,168	85	128	153
2,20	53	15	4/::	1,85	0,41	1,77	39,3	300	451	159	72	38	40	42	44	38	31	0,165	88	133	159
2,40	45	14	4/::	1,85	0,44	1,50	28,8	255	383	135	64	37	39	41	43	37	31	0,143	75	113	135
2,60	42	14	4/::	1,85	0,48	1,40	23,9	238	357	126	60	36	38	41	43	36	30	0,131	70	105	126
2,80	32	14	4/::	1,85	0,52	1,07	15,5	181	272	96	49	35	37	39	42	34	29	0,101	53	80	96
3,00	33	14	4/::	1,85	0,55	1,10	14,8	187	281	99	48	35	37	39	42	34	29	0,100	55	83	99
3,20	30	14	4/::	1,85	0,59	1,00	12,1	170	255	90	43	34	36	39	41	33	29	0,088	50	75	90
3,40	36	14	4/::	1,85	0,63	1,20	14,1	204	306	108	48	35	37	39	42	34	30	0,099	60	90	108
3,60	39	14	4/::	1,85	0,67	1,30	14,5	221	332	117	50	35	37	40	42	34	30	0,103	65	98	117
3,80	50	14	4/::	1,85	0,70	1,67	18,5	283	425	150	57	36	38	40	43	35	31	0,122	83	125	150
4,00	49	14	4/::	1,85	0,74	1,63	16,9	278	417	147	55	36	38	40	42	35	31	0,116	82	123	147
4,20	50	14	4/::	1,85	0,78	1,67	16,3	283	425	150	54	36	38	40	42	35	31	0,115	83	125	150
4,40	46	14	4/::	1,85	0,81	1,53	13,9	261	391	138	50	35	37	40	42	34	31	0,105	77	115	138
4,60	39	14	4/::	1,85	0,85	1,30	10,7	221	332	117	44	34	36	39	41	33	30	0,088	65	98	117
4,80	42	16	4/::	1,85	0,89	1,40	11,1	238	357	126	45	34	37	39	42	33	30	0,092	70	105	126
5,00	34	16	4/::	1,85	0,93	1,13	8,1	221	332	102	37	33	36	38	41	31	29	0,073	57	85	102
5,20	30	16	4/::	1,85	0,96	1,00	6,6	247	370	90	32	32	35	38	41	30	29	0,061	50	75	90
5,40	29	17	4/::	1,85	1,00	0,98	6,2	262	393	87	29	32	35	37	40	30	29	0,057	48	73	87
5,60	25	19	4/::	1,85	1,04	0,91	5,3	283	424	75	23	31	34	37	40	29	28	0,045	42	63	75
5,80	23	18	4/::	1,85	1,07	0,87	4,8	298	446	69	20	31	34	36	40	28	28	0,038	38	58	69
6,00	25	19	4/::	1,85	1,11	0,91	4,9	307	461	75	22	31	34	37	40	29	28	0,041	42	63	75
6,20	29	16	4/::	1,85	1,15	0,98	5,2	315	472	87	26	32	34	37	40	29	29	0,050	48	73	87
6,40	30	16	4/::	1,85	1,18	1,00	5,1	326	489	90	26	32	34	37	40	29	29	0,051	50	75	90
6,60	35	15	4/::	1,85	1,22	1,17	5,9	324	486	105	31	32	35	38	40	30	29	0,060	58	88	105
6,80	37	16	4/::	1,85	1,26	1,23	6,1	331	496	111	32	33	35	38	41	30	30	0,062	62	93	111
7,00	82	56	3:::	1,85	1,30	--	--	--	--	--	59	36	38	40	43	34	33	0,127	137	205	246
7,20	216	130	3:::	1,85	1,33	--	--	--	--	--	91	41	42	44	45	39	38	0,228	360	540	648
7,40	350	150	3:::	1,85	1,37	--	--	--	--	--	100	42	43	45	46	41	40	0,258	583	875	1050
7,60	460	172	3:::	1,85	1,41	--	--	--	--	--	100	42	43	45	46	42	40	0,258	767	1150	1380
7,80	530	--	3:::	1,85	1,44	--	--	--	--	--	100	42	43	45	46	43	40	0,258	883	1325	1590

**PROVA PENETROMETRICA DINAMICA
DIAGRAMMA NUMERO COLPI PUNTA - Rpd****DIN 1**

Scala 1: 50

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via A. Fiori
- note : Prova eseguita in continuità con CPT1

- data : 28/10/2010
- quota inizio : -7.6 m da p.c.a.
- prof. falda : 0,00 m da quota inizio
- pagina : 1



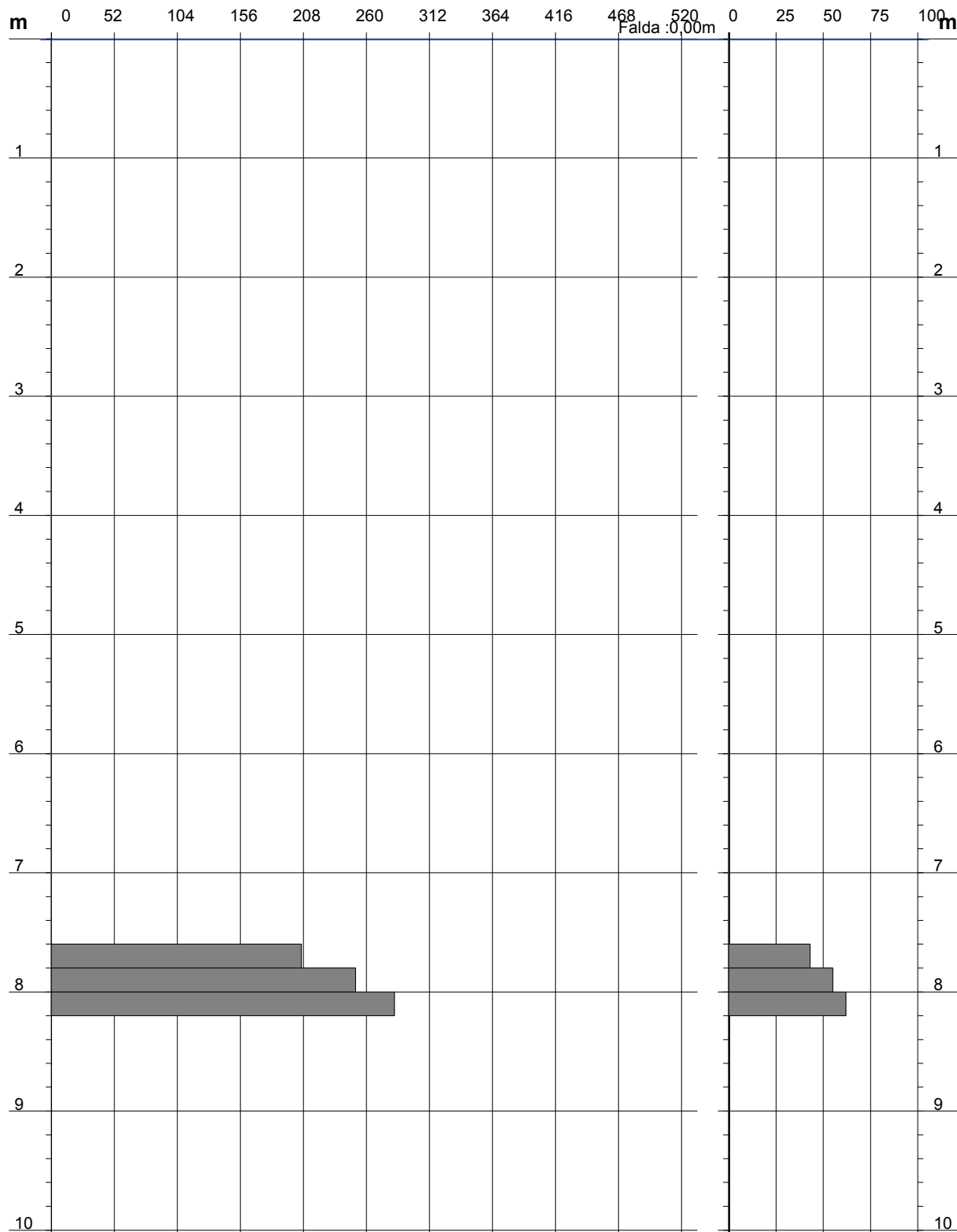
PROVA PENETROMETRICA DINAMICA DIAGRAMMA RESISTENZA DINAMICA PUNTA

DIN 1

Scala 1: 50

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via A. Fiori

- data : 28/10/2010
- quota inizio : -7.6 m da p.c.a.
- prof. falda : 0,00 m da quota inizio

Rpd (kg/cm²) Resistenza dinamica alla punta, formula "Olandese"N = N(20) n° colpi $\delta = 20$ 

PROVA PENETROMETRICA STATICA **LETTURE DI CAMPAGNA / VALORI DI RESISTENZA**

CPT 2

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via A. Fiori
 - resp. cantiere :
 - assist. cantiere :

- data : 28/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

prf	L1	L2	qc	fs	qc/fs	prf	L1	L2	qc	fs	qc/fs
m	-	-	Kg/cm ²	Kg/cm ²	-	m	-	-	Kg/cm ²	Kg/cm ²	-
0,20	18,0	----	18,0	1,00	18,0	4,00	83,0	149,0	83,0	5,60	15,0
0,40	11,0	26,0	11,0	0,67	16,0	4,20	86,0	170,0	86,0	5,87	15,0
0,60	10,0	20,0	10,0	0,60	17,0	4,40	84,0	172,0	84,0	5,80	14,0
0,80	18,0	27,0	18,0	1,07	17,0	4,60	82,0	169,0	82,0	5,60	15,0
1,00	25,0	41,0	25,0	1,33	19,0	4,80	94,0	178,0	94,0	6,13	15,0
1,20	27,0	47,0	27,0	1,53	18,0	5,00	62,0	154,0	62,0	4,40	14,0
1,40	38,0	61,0	38,0	2,13	18,0	5,20	54,0	120,0	54,0	3,80	14,0
1,60	54,0	86,0	54,0	2,73	20,0	5,40	67,0	124,0	67,0	4,67	14,0
1,80	70,0	111,0	70,0	3,33	21,0	5,60	68,0	138,0	68,0	4,67	15,0
2,00	69,0	119,0	69,0	3,27	21,0	5,80	54,0	124,0	54,0	3,80	14,0
2,20	81,0	130,0	81,0	3,87	21,0	6,00	47,0	104,0	47,0	3,33	14,0
2,40	77,0	135,0	77,0	3,67	21,0	6,20	38,0	88,0	38,0	2,67	14,0
2,60	45,0	100,0	45,0	2,67	17,0	6,40	84,0	124,0	84,0	1,73	48,0
2,80	33,0	73,0	33,0	2,20	15,0	6,60	111,0	137,0	111,0	1,93	57,0
3,00	38,0	71,0	38,0	2,60	15,0	6,80	226,0	255,0	226,0	1,80	126,0
3,20	41,0	80,0	41,0	2,87	14,0	7,00	304,0	331,0	304,0	2,33	130,0
3,40	47,0	90,0	47,0	3,33	14,0	7,20	390,0	425,0	390,0	2,67	146,0
3,60	54,0	104,0	54,0	3,80	14,0	7,40	450,0	490,0	450,0	2,67	169,0
3,80	62,0	119,0	62,0	4,40	14,0	7,60	510,0	550,0	510,0	-----	----

- PENETROMETRO STATICO tipo da 20 t - (con anello allargatore) -
 - COSTANTE DI TRASFORMAZIONE Ct = 10 - Velocità avanzamento punta 2 cm/s
 - punta meccanica tipo Begemann $\phi = 35.7$ mm (area punta 10 cm² - apertura 60°)
 - manicotto laterale (superficie 150 cm²)

PROVA PENETROMETRICA DINAMICA TABELLE VALORI DI RESISTENZA

DIN 2

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via A. Fiori
 - note : Prova eseguita in continuità con CPT2

- data : 28/10/2010
 - quota inizio : -7.4 m da p.c.a.
 - prof. falda : 0,00 m da quota inizio
 - pagina : 1

Prof.(m)	N(colpi p)	Rpd(kg/cm ²)	N(colpi r)	asta	Prof.(m)	N(colpi p)	Rpd(kg/cm ²)	N(colpi r)	asta
0,00 - 0,20	----	----	----	1	4,20 - 4,40	----	----	----	5
0,20 - 0,40	----	----	----	1	4,40 - 4,60	----	----	----	5
0,40 - 0,60	----	----	----	1	4,60 - 4,80	----	----	----	5
0,60 - 0,80	----	----	----	1	4,80 - 5,00	----	----	----	6
0,80 - 1,00	----	----	----	2	5,00 - 5,20	----	----	----	6
1,00 - 1,20	----	----	----	2	5,20 - 5,40	----	----	----	6
1,20 - 1,40	----	----	----	2	5,40 - 5,60	----	----	----	6
1,40 - 1,60	----	----	----	2	5,60 - 5,80	----	----	----	6
1,60 - 1,80	----	----	----	2	5,80 - 6,00	----	----	----	7
1,80 - 2,00	----	----	----	3	6,00 - 6,20	----	----	----	7
2,00 - 2,20	----	----	----	3	6,20 - 6,40	----	----	----	7
2,20 - 2,40	----	----	----	3	6,40 - 6,60	----	----	----	7
2,40 - 2,60	----	----	----	3	6,60 - 6,80	----	----	----	7
2,60 - 2,80	----	----	----	3	6,80 - 7,00	----	----	----	8
2,80 - 3,00	----	----	----	4	7,00 - 7,20	----	----	----	8
3,00 - 3,20	----	----	----	4	7,20 - 7,40	----	----	----	8
3,20 - 3,40	----	----	----	4	7,40 - 7,60	54	259,2	----	8
3,40 - 3,60	----	----	----	4	7,60 - 7,80	49	235,2	----	8
3,60 - 3,80	----	----	----	4	7,80 - 8,00	57	260,4	----	9
3,80 - 4,00	----	----	----	5	8,00 - 8,20	65	296,9	----	9
4,00 - 4,20	----	----	----	5					

- PENETROMETRO DINAMICO tipo : **EMILIA (20)**

- M (massa battente)= **63,50** kg - H (altezza caduta)= **0,75** m - A (area punta)= **20,00** cm² - D(diam. punta)= **50,50** mm

- Numero Colpi Punta N = N(**20**) [δ = 20 cm]

- Uso rivestimento / fanghi iniezione : **SI**

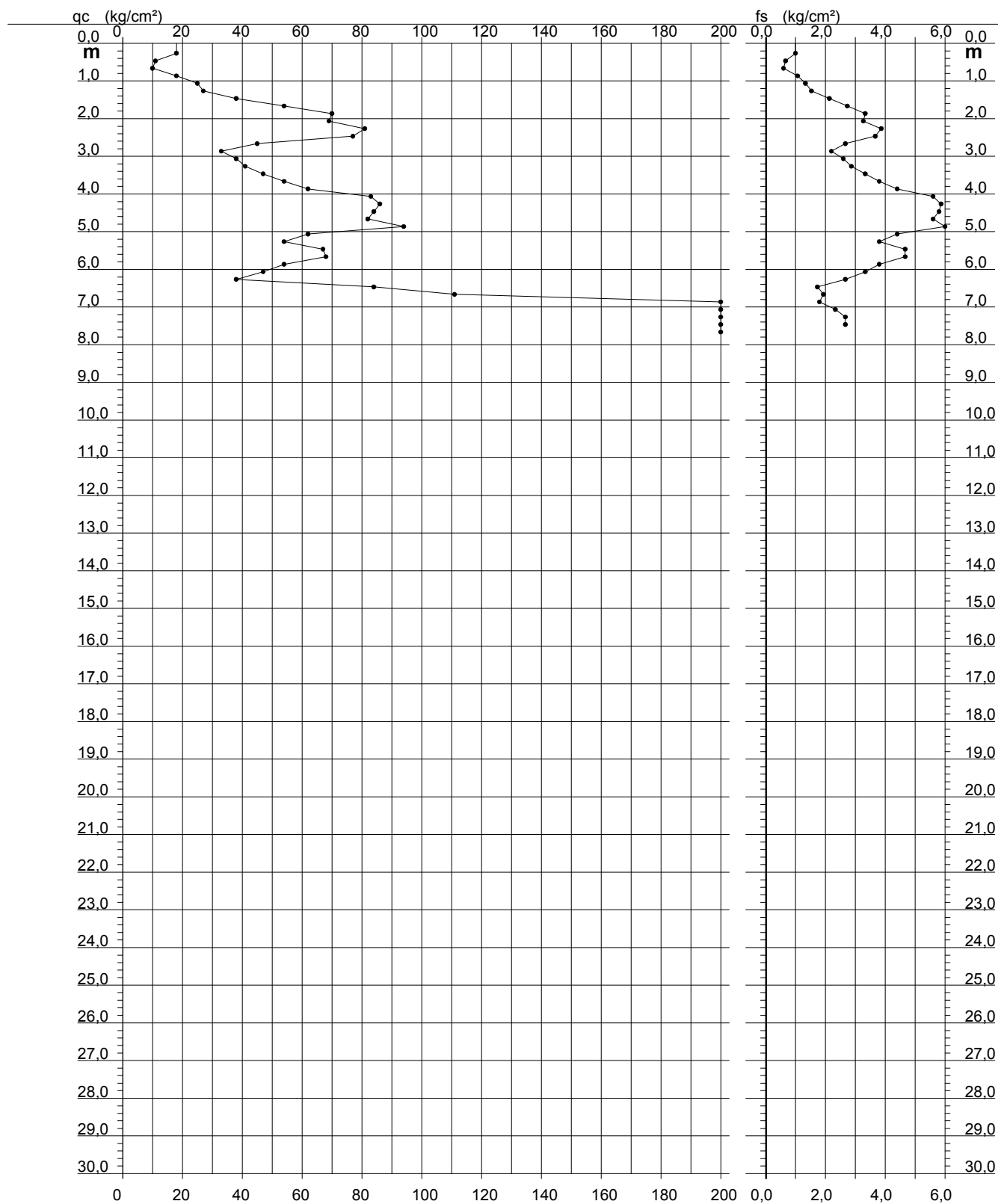
**PROVA PENETROMETRICA STATICA
DIAGRAMMA DI RESISTENZA****CPT 2**

2.0105-PG037

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via A. Fiori
- resp. cantiere :
- assist. cantiere :

- data : 28/10/2010
- quota inizio : Piano Campagna
- falda : Falda non rilevata

- data di emissione :
03/11/2010

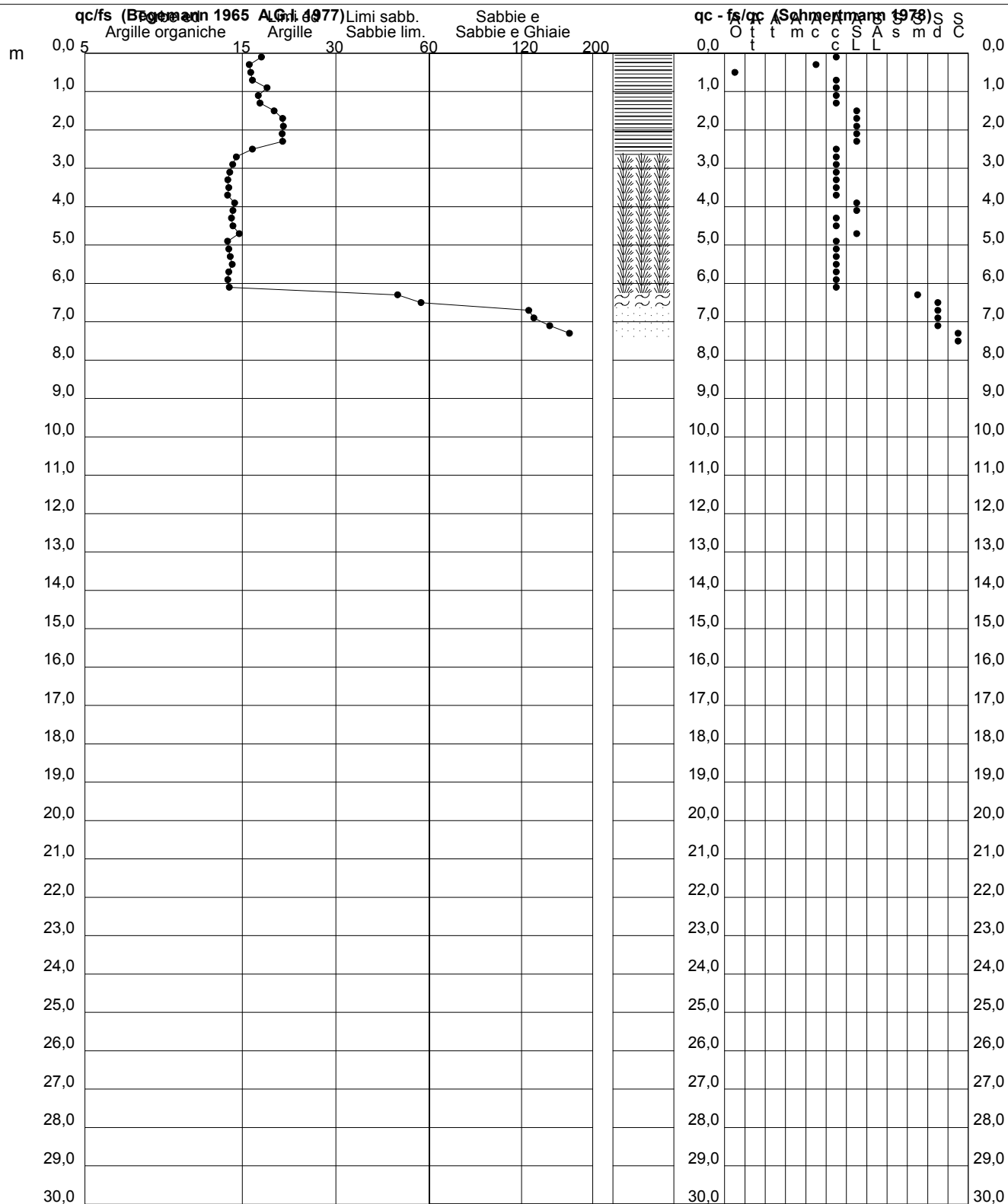


CPT 2

2.0105-PG037

- data : 28/10/2010
- quota inizio : Piano Campagna
- falda : Falda non rilevata

- data di emissione : 03/11/2010



PROVA PENETROMETRICA STATICA **TABELLA PARAMETRI GEOTECNICI**

CPT 2

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via A. Fiori
 - resp. cantiere :
 - assist. cantiere :

- data : 28/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

NATURA COESIVA											NATURA GRANULARE										
Prof. m	qc kg/cm²	qc/fs (-)	Natura Litol.	Y' t/m³	p'vo kg/cm²	Cu kg/cm²	OCR (-)	Eu50 kg/cm²	Eu25 kg/cm²	Mo kg/cm²	Dr %	ø1s (°)	ø2s (°)	ø3s (°)	ø4s (°)	ødm (°)	ømy (°)	Amax/g (-)	E'50 kg/cm²	E'25 kg/cm²	Mo kg/cm²
0,20	18	18	2////	1,85	0,04	0,75	99,9	128	191	56	--	--	--	--	--	--	--	--	--	--	--
0,40	11	16	2////	1,85	0,07	0,54	74,7	91	137	42	--	--	--	--	--	--	--	--	--	--	--
0,60	10	17	2////	1,85	0,11	0,50	41,2	85	128	40	--	--	--	--	--	--	--	--	--	--	--
0,80	18	17	2////	1,85	0,15	0,75	47,7	128	191	56	--	--	--	--	--	--	--	--	--	--	--
1,00	25	19	4:/:	1,85	0,19	0,91	45,9	155	232	75	66	37	39	41	43	38	28	0,146	42	63	75
1,20	27	18	4:/:	1,85	0,22	0,95	38,5	161	242	81	64	37	39	41	43	38	28	0,141	45	68	81
1,40	38	18	4:/:	1,85	0,26	1,27	45,7	215	323	114	72	38	40	42	44	39	30	0,164	63	95	114
1,60	54	20	4:/:	1,85	0,30	1,80	60,0	306	459	162	81	39	41	43	44	40	31	0,192	90	135	162
1,80	70	21	4:/:	1,85	0,33	2,33	71,6	397	595	210	87	40	42	43	45	40	32	0,211	117	175	210
2,00	69	21	4:/:	1,85	0,37	2,30	61,6	391	586	207	83	40	41	43	45	40	32	0,201	115	173	207
2,20	81	21	4:/:	1,85	0,41	2,70	66,8	459	689	243	87	40	42	43	45	40	33	0,212	135	203	243
2,40	77	21	4:/:	1,85	0,44	2,57	56,3	436	655	231	83	40	41	43	45	40	33	0,199	128	193	231
2,60	45	17	4:/:	1,85	0,48	1,50	26,0	255	383	135	62	37	39	41	43	37	31	0,137	75	113	135
2,80	33	15	4:/:	1,85	0,52	1,10	16,1	187	281	99	50	35	37	40	42	34	29	0,104	55	83	99
3,00	38	15	4:/:	1,85	0,55	1,27	17,6	215	323	114	53	35	38	40	42	35	30	0,112	63	95	114
3,20	41	14	4:/:	1,85	0,59	1,37	17,9	232	349	123	54	36	38	40	42	35	30	0,115	68	103	123
3,40	47	14	4:/:	1,85	0,63	1,57	19,6	266	400	141	57	36	38	40	43	35	31	0,123	78	118	141
3,60	54	14	4:/:	1,85	0,67	1,80	21,8	306	459	162	61	37	39	41	43	36	31	0,132	90	135	162
3,80	62	14	4:/:	1,85	0,70	2,07	24,2	351	527	186	64	37	39	41	43	36	32	0,142	103	155	186
4,00	83	15	4:/:	1,85	0,74	2,77	32,6	470	706	249	73	38	40	42	44	38	33	0,168	138	208	249
4,20	86	15	4:/:	1,85	0,78	2,87	32,1	487	731	258	73	38	40	42	44	38	33	0,168	143	215	258
4,40	84	14	4:/:	1,85	0,81	2,80	29,4	476	714	252	71	38	40	42	44	37	33	0,162	140	210	252
4,60	82	15	4:/:	1,85	0,85	2,73	27,0	465	697	246	69	38	40	41	44	37	33	0,156	137	205	246
4,80	94	15	4:/:	1,85	0,89	3,13	30,4	533	799	282	73	38	40	42	44	37	34	0,167	157	235	282
5,00	62	14	4:/:	1,85	0,93	2,07	17,1	351	527	186	57	36	38	40	43	35	32	0,124	103	155	186
5,20	54	14	4:/:	1,85	0,96	1,80	13,7	306	459	162	52	35	37	40	42	34	31	0,108	90	135	162
5,40	67	14	4:/:	1,85	1,00	2,23	17,2	380	570	201	58	36	38	40	43	35	32	0,126	112	168	201
5,60	68	15	4:/:	1,85	1,04	2,27	16,7	385	578	204	58	36	38	40	43	35	32	0,125	113	170	204
5,80	54	14	4:/:	1,85	1,07	1,80	12,0	306	459	162	49	35	37	39	42	33	31	0,102	90	135	162
6,00	47	14	4:/:	1,85	1,11	1,57	9,7	268	403	141	43	34	36	39	41	32	31	0,088	78	118	141
6,20	38	14	4:/:	1,85	1,15	1,27	7,1	286	429	114	35	33	35	38	41	31	30	0,069	63	95	114
6,40	84	48	3:::	1,85	1,18	--	--	--	--	--	62	37	39	41	43	35	33	0,136	140	210	252
6,60	111	57	3:::	1,85	1,22	--	--	--	--	--	71	38	40	42	44	36	34	0,161	185	278	333
6,80	226	126	3:::	1,85	1,26	--	--	--	--	--	94	41	43	44	46	40	39	0,238	377	565	678
7,00	304	130	3:::	1,85	1,30	--	--	--	--	--	100	42	43	45	46	41	40	0,258	507	760	912
7,20	390	146	3:::	1,85	1,33	--	--	--	--	--	100	42	43	45	46	42	40	0,258	650	975	1170
7,40	450	169	3:::	1,85	1,37	--	--	--	--	--	100	42	43	45	46	42	40	0,258	750	1125	1350
7,60	510	--	3:::	1,85	1,41	--	--	--	--	--	100	42	43	45	46	43	40	0,258	850	1275	1530

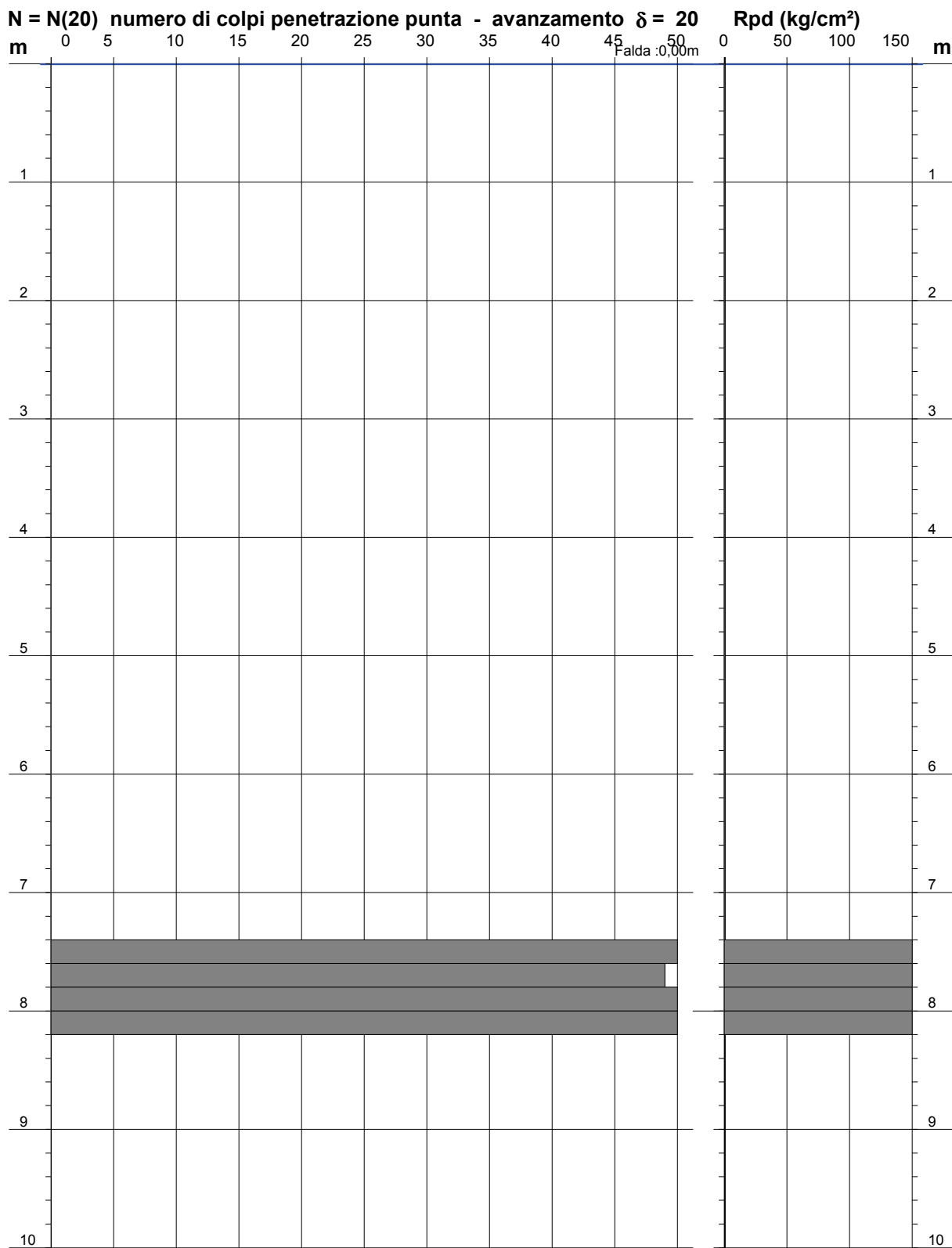
PROVA PENETROMETRICA DINAMICA DIAGRAMMA NUMERO COLPI PUNTA - Rpd

DIN 2

Scala 1: 50

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via A. Fiori
 - note : Prova eseguita in continuità con CPT2

- data : 28/10/2010
 - quota inizio : -7.4 m da p.c.a.
 - prof. falda : 0,00 m da quota inizio
 - pagina : 1



PROVA PENETROMETRICA DINAMICA DIAGRAMMA RESISTENZA DINAMICA PUNTA

DIN 2

Scala 1: 50

- committente : S.G.G. Siena

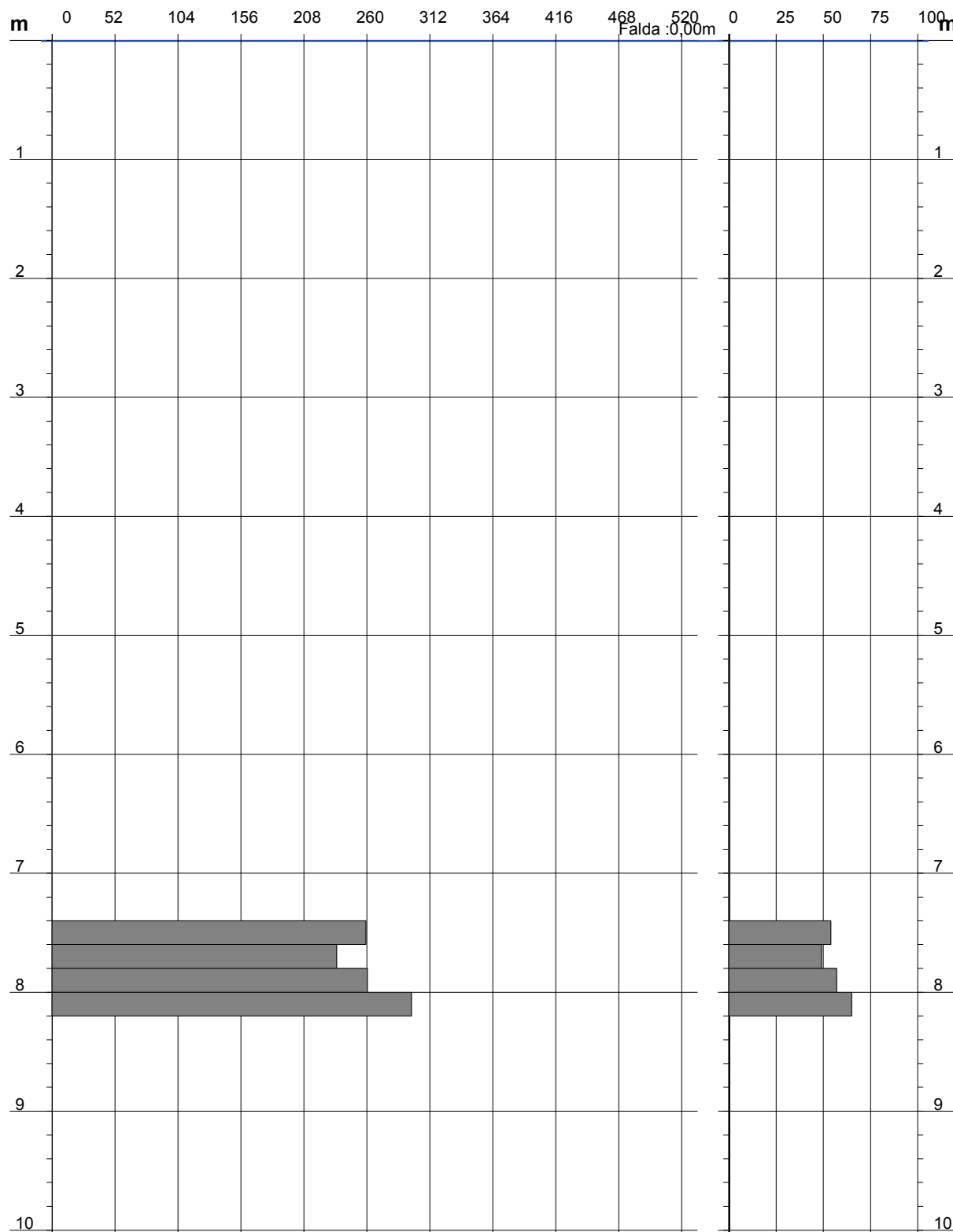
- lavoro :

- località : MO - Formigine, via A. Fiori

- data : 28/10/2010

- quota inizio : -7.4 m da p.c.a.

- prof. falda : 0,00 m da quota inizio

Rpd (kg/cm²) Resistenza dinamica alla punta, formula "Olandese"N = N(20) n° colpi $\delta = 20$ 

PROVA PENETROMETRICA STATICA **LETTURE DI CAMPAGNA / VALORI DI RESISTENZA**

CPT 3

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Turchetto
 - resp. cantiere :
 - assist. cantiere :

- data : 29/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

prf	L1	L2	qc	fs	qc/fs	prf	L1	L2	qc	fs	qc/fs
m	-	-	Kg/cm ²	Kg/cm ²	-	m	-	-	Kg/cm ²	Kg/cm ²	-
0,20	9,0	----	9,0	0,47	19,0	4,60	65,0	110,0	65,0	4,27	15,0
0,40	11,0	18,0	11,0	0,60	18,0	4,80	54,0	118,0	54,0	3,60	15,0
0,60	13,0	22,0	13,0	0,80	16,0	5,00	57,0	111,0	57,0	3,73	15,0
0,80	58,0	70,0	58,0	1,80	32,0	5,20	65,0	121,0	65,0	3,40	19,0
1,00	80,0	107,0	80,0	2,13	37,0	5,40	80,0	131,0	80,0	4,13	19,0
1,20	75,0	107,0	75,0	2,00	38,0	5,60	64,0	126,0	64,0	4,07	16,0
1,40	73,0	103,0	73,0	2,00	36,0	5,80	64,0	125,0	64,0	3,53	18,0
1,60	115,0	145,0	115,0	2,93	39,0	6,00	58,0	111,0	58,0	3,73	16,0
1,80	72,0	116,0	72,0	2,53	28,0	6,20	34,0	90,0	34,0	2,33	15,0
2,00	64,0	102,0	64,0	2,33	27,0	6,40	45,0	80,0	45,0	3,07	15,0
2,20	60,0	95,0	60,0	2,27	26,0	6,60	47,0	93,0	47,0	3,20	15,0
2,40	38,0	72,0	38,0	2,27	17,0	6,80	48,0	96,0	48,0	3,13	15,0
2,60	43,0	77,0	43,0	2,47	17,0	7,00	62,0	109,0	62,0	3,93	16,0
2,80	74,0	111,0	74,0	3,87	19,0	7,20	58,0	117,0	58,0	3,87	15,0
3,00	107,0	165,0	107,0	5,53	19,0	7,40	57,0	115,0	57,0	3,80	15,0
3,20	100,0	183,0	100,0	5,33	19,0	7,60	55,0	112,0	55,0	3,60	15,0
3,40	83,0	163,0	83,0	4,73	18,0	7,80	40,0	94,0	40,0	2,67	15,0
3,60	97,0	168,0	97,0	5,80	17,0	8,00	43,0	83,0	43,0	2,27	19,0
3,80	87,0	174,0	87,0	5,87	15,0	8,20	51,0	85,0	51,0	2,60	20,0
4,00	63,0	151,0	63,0	3,80	17,0	8,40	34,0	73,0	34,0	1,67	20,0
4,20	65,0	122,0	65,0	4,13	16,0	8,60	225,0	250,0	225,0	2,00	112,0
4,40	50,0	112,0	50,0	3,00	17,0	8,80	430,0	460,0	430,0	2,67	161,0
4,60	65,0	110,0	65,0	4,27	15,0	9,00	480,0	520,0	480,0	2,67	180,0
4,80	54,0	118,0	54,0	3,60	15,0	9,20	540,0	580,0	540,0	-----	----

- PENETROMETRO STATICO tipo da 20 t - (con anello allargatore) -
 - COSTANTE DI TRASFORMAZIONE Ct = 10 - Velocità avanzamento punta 2 cm/s
 - punta meccanica tipo Begemann $\phi = 35.7$ mm (area punta 10 cm² - apertura 60°)
 - manicotto laterale (superficie 150 cm²)

PROVA PENETROMETRICA DINAMICA TABELLE VALORI DI RESISTENZA

DIN 3

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via A. Fiori
 - note : Prova eseguita in continuità con CPT3

- data : 29/10/2010
 - quota inizio : -9.0 m da p.c.a.
 - prof. falda : 0,00 m da quota inizio
 - pagina : 1

Prof.(m)	N(colpi p)	Rpd(kg/cm ²)	N(colpi r)	asta	Prof.(m)	N(colpi p)	Rpd(kg/cm ²)	N(colpi r)	asta
0,00 - 0,20	----	----	----	1	4,80 - 5,00	----	----	----	6
0,20 - 0,40	----	----	----	1	5,00 - 5,20	----	----	----	6
0,40 - 0,60	----	----	----	1	5,20 - 5,40	----	----	----	6
0,60 - 0,80	----	----	----	1	5,40 - 5,60	----	----	----	6
0,80 - 1,00	----	----	----	2	5,60 - 5,80	----	----	----	6
1,00 - 1,20	----	----	----	2	5,80 - 6,00	----	----	----	7
1,20 - 1,40	----	----	----	2	6,00 - 6,20	----	----	----	7
1,40 - 1,60	----	----	----	2	6,20 - 6,40	----	----	----	7
1,60 - 1,80	----	----	----	2	6,40 - 6,60	----	----	----	7
1,80 - 2,00	----	----	----	3	6,60 - 6,80	----	----	----	7
2,00 - 2,20	----	----	----	3	6,80 - 7,00	----	----	----	8
2,20 - 2,40	----	----	----	3	7,00 - 7,20	----	----	----	8
2,40 - 2,60	----	----	----	3	7,20 - 7,40	----	----	----	8
2,60 - 2,80	----	----	----	3	7,40 - 7,60	----	----	----	8
2,80 - 3,00	----	----	----	4	7,60 - 7,80	----	----	----	8
3,00 - 3,20	----	----	----	4	7,80 - 8,00	----	----	----	9
3,20 - 3,40	----	----	----	4	8,00 - 8,20	----	----	----	9
3,40 - 3,60	----	----	----	4	8,20 - 8,40	----	----	----	9
3,60 - 3,80	----	----	----	4	8,40 - 8,60	----	----	----	9
3,80 - 4,00	----	----	----	5	8,60 - 8,80	----	----	----	9
4,00 - 4,20	----	----	----	5	8,80 - 9,00	----	----	----	10
4,20 - 4,40	----	----	----	5	9,00 - 9,20	61	265,8	----	10
4,40 - 4,60	----	----	----	5	9,20 - 9,40	68	296,3	----	10
4,60 - 4,80	----	----	----	5					

- PENETROMETRO DINAMICO tipo : **EMILIA (20)**

- M (massa battente)= **63,50** kg - H (altezza caduta)= **0,75** m - A (area punta)= **20,00** cm² - D(diam. punta)= **50,50** mm

- Numero Colpi Punta N = N(**20**) [δ = 20 cm]

- Uso rivestimento / fanghi iniezione : **SI**

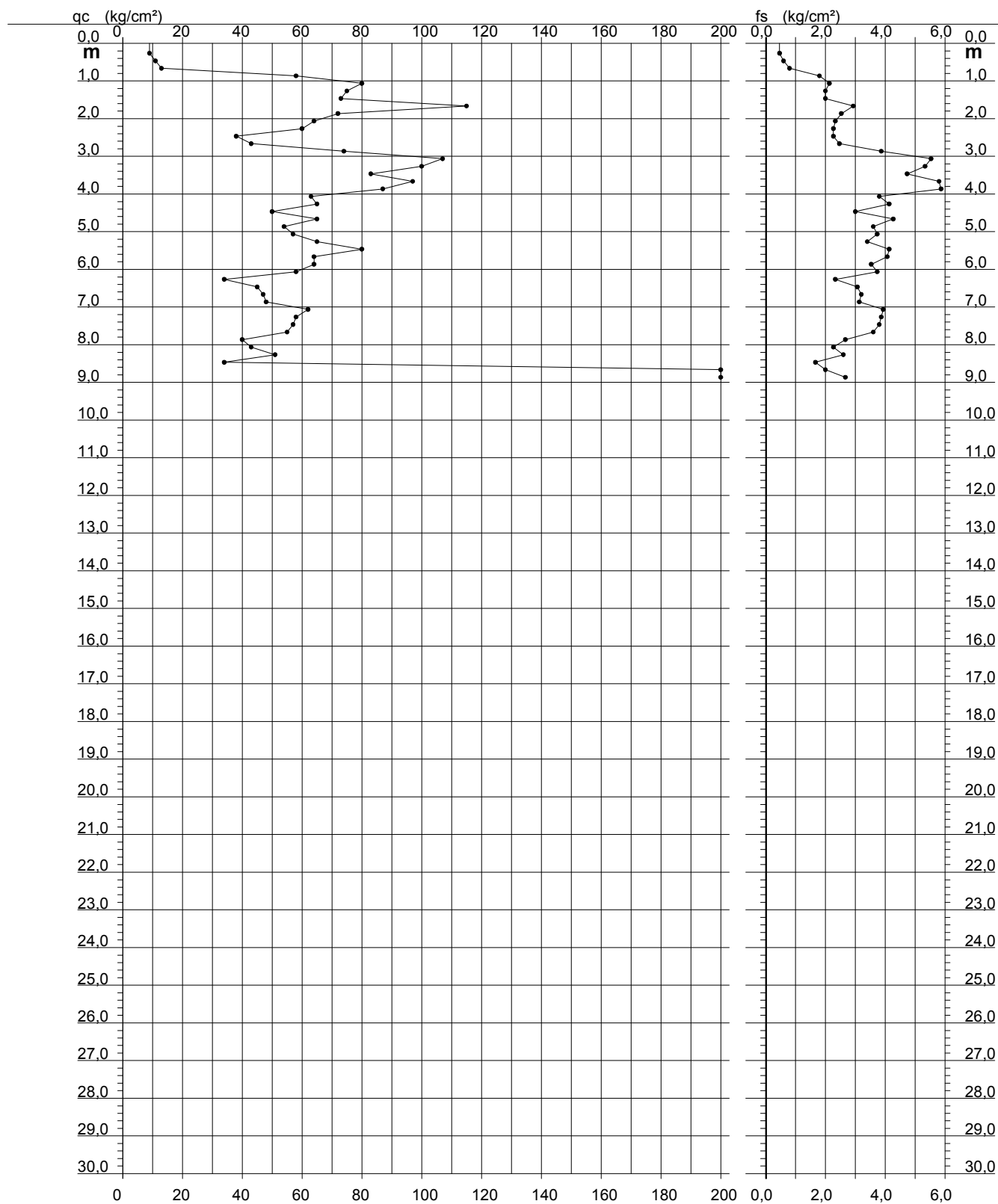
**PROVA PENETROMETRICA STATICA
DIAGRAMMA DI RESISTENZA****CPT 3**

2.0105-PG037

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via Turchetto
- resp. cantiere :
- assist. cantiere :

- data : 29/10/2010
- quota inizio : Piano Campagna
- falda : Falda non rilevata

- data di emissione :
03/11/2010



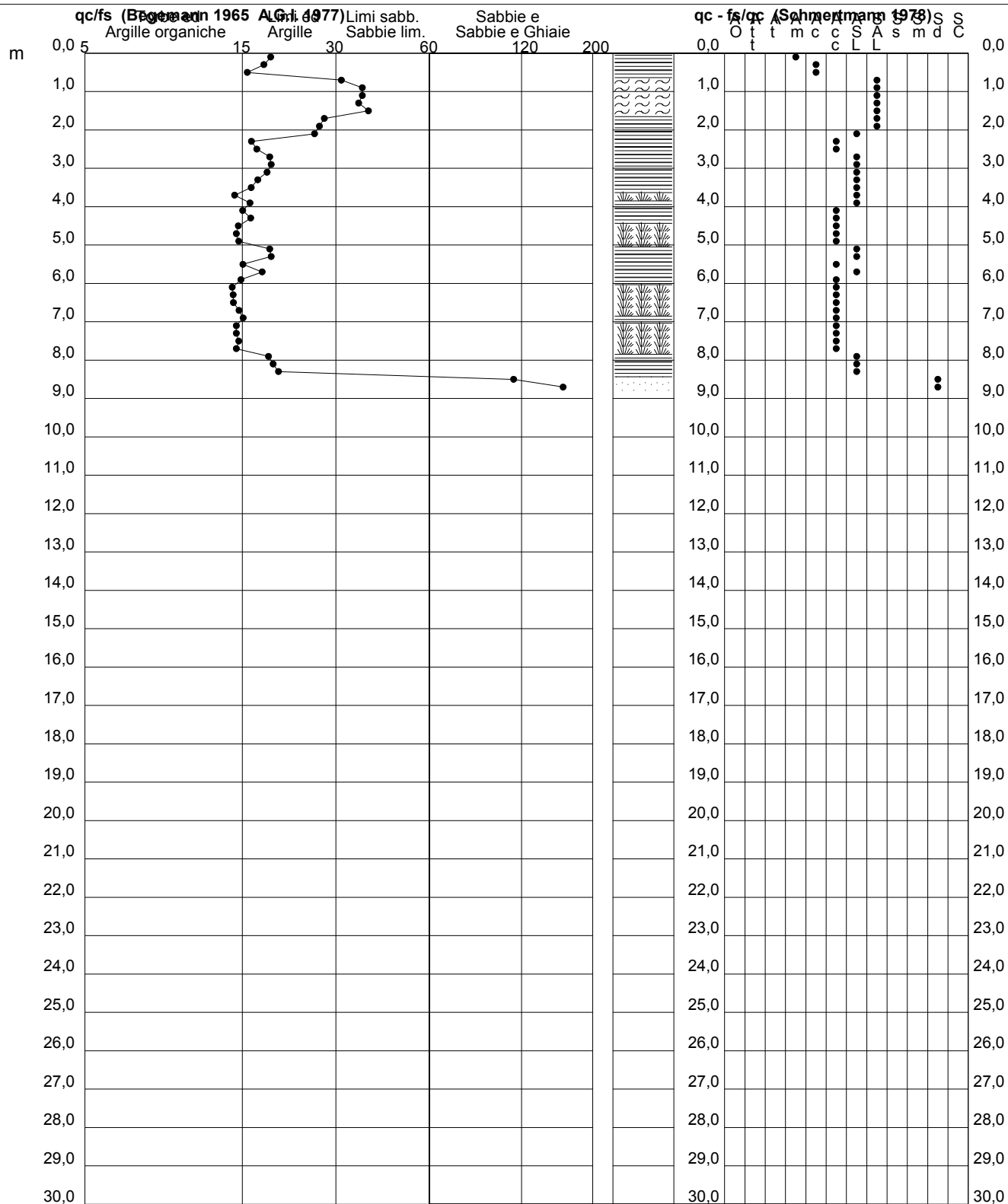
PROVA PENETROMETRICA STATICA VALUTAZIONI LITOLOGICHE

CPT 3

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Turchetto
 - resp. cantiere :
 - assist. cantiere :

- data : 29/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010



PROVA PENETROMETRICA STATICA **TABELLA PARAMETRI GEOTECNICI**

CPT 3

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Turchetto
 - resp. cantiere :
 - assist. cantiere :

- data : 29/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

NATURA COESIVA											NATURA GRANULARE										
Prof. m	qc kg/cm²	qc/fs (-)	Natura Litol.	Y' t/m²	p'vo kg/cm²	Cu kg/cm²	OCR (-)	Eu50 kg/cm²	Eu25 kg/cm²	Mo kg/cm²	Dr %	ø1s (°)	ø2s (°)	ø3s (°)	ø4s (°)	ødm (°)	ømy (°)	Amax/g (-)	E'50 kg/cm²	E'25 kg/cm²	Mo
0,20	9	19	2////	1,85	0,04	0,45	99,9	77	115	38	--	--	--	--	--	--	--	--	--	--	--
0,40	11	18	2////	1,85	0,07	0,54	74,7	91	137	42	--	--	--	--	--	--	--	--	--	--	--
0,60	13	16	2////	1,85	0,11	0,60	52,2	103	154	47	--	--	--	--	--	--	--	--	--	--	--
0,80	58	32	3.....	1,85	0,15	--	--	--	--	--	100	42	43	45	46	43	31	0,258	97	145	174
1,00	80	37	3.....	1,85	0,19	--	--	--	--	--	100	42	43	45	46	43	33	0,258	133	200	240
1,20	75	38	3.....	1,85	0,22	--	--	--	--	--	99	42	43	44	46	42	32	0,254	125	188	225
1,40	73	36	3.....	1,85	0,26	--	--	--	--	--	94	41	43	44	46	42	32	0,237	122	183	219
1,60	115	39	3.....	1,85	0,30	--	--	--	--	--	100	42	43	45	46	43	35	0,258	192	288	345
1,80	72	28	4/./	1,85	0,33	2,40	74,1	408	612	216	88	40	42	43	45	40	32	0,215	120	180	216
2,00	64	27	4/./	1,85	0,37	2,13	56,1	363	544	192	81	39	41	43	44	40	32	0,193	107	160	192
2,20	60	26	4/./	1,85	0,41	2,00	45,9	340	510	180	76	39	40	42	44	39	32	0,179	100	150	180
2,40	38	17	4/./	1,85	0,44	1,27	23,3	215	323	114	59	36	38	40	43	36	30	0,126	63	95	114
2,60	43	17	4/./	1,85	0,48	1,43	24,6	244	366	129	61	37	39	41	43	36	30	0,133	72	108	129
2,80	74	19	4/./	1,85	0,52	2,47	44,2	419	629	222	78	39	41	42	44	39	32	0,183	123	185	222
3,00	107	19	4/./	1,85	0,55	3,57	64,2	606	910	321	89	40	42	43	45	40	34	0,219	178	268	321
3,20	100	19	4/./	1,85	0,59	3,33	54,5	567	850	300	85	40	41	43	45	39	34	0,206	167	250	300
3,40	83	18	4/./	1,85	0,63	2,77	40,0	470	706	249	77	39	40	42	44	38	33	0,180	138	208	249
3,60	97	17	4/./	1,85	0,67	3,23	45,2	550	825	291	81	39	41	43	44	39	34	0,193	162	243	291
3,80	87	15	4/./	1,85	0,70	2,90	36,9	493	740	261	76	39	40	42	44	38	33	0,177	145	218	261
4,00	63	17	4/./	1,85	0,74	2,10	23,1	357	536	189	63	37	39	41	43	36	32	0,140	105	158	189
4,20	65	16	4/./	1,85	0,78	2,17	22,6	368	553	195	63	37	39	41	43	36	32	0,140	108	163	195
4,40	50	17	4/./	1,85	0,81	1,67	15,4	283	425	150	53	35	38	40	42	34	31	0,112	83	125	150
4,60	65	15	4/./	1,85	0,85	2,17	20,2	368	553	195	61	37	39	41	43	35	32	0,134	108	163	195
4,80	54	15	4/./	1,85	0,89	1,80	15,2	306	459	162	54	36	38	40	42	34	31	0,114	90	135	162
5,00	57	15	4/./	1,85	0,93	1,90	15,4	323	485	171	55	36	38	40	42	34	31	0,116	95	143	171
5,20	65	19	4/./	1,85	0,96	2,17	17,3	368	553	195	58	36	38	40	43	35	32	0,125	108	163	195
5,40	80	19	4/./	1,85	1,00	2,67	21,4	453	680	240	64	37	39	41	43	36	33	0,143	133	200	240
5,60	64	16	4/./	1,85	1,04	2,13	15,5	363	544	192	56	36	38	40	42	34	32	0,119	107	160	192
5,80	64	18	4/./	1,85	1,07	2,13	14,8	363	544	192	55	36	38	40	42	34	32	0,117	107	160	192
6,00	58	16	4/./	1,85	1,11	1,93	12,6	329	493	174	51	35	37	40	42	33	31	0,106	97	145	174
6,20	34	15	4/./	1,85	1,15	1,13	6,2	301	451	102	32	32	35	38	41	30	29	0,061	57	85	102
6,40	45	15	4/./	1,85	1,18	1,50	8,4	281	422	135	40	34	36	39	41	32	31	0,081	75	113	135
6,60	47	15	4/./	1,85	1,22	1,57	8,6	290	434	141	41	34	36	39	41	32	31	0,082	78	118	141
6,80	48	15	4/./	1,85	1,26	1,60	8,5	299	448	144	41	34	36	39	41	32	31	0,082	80	120	144
7,00	62	16	4/./	1,85	1,30	2,07	11,3	351	527	186	49	35	37	39	42	33	32	0,102	103	155	186
7,20	58	15	4/./	1,85	1,33	1,93	10,0	329	493	174	46	34	37	39	42	32	31	0,095	97	145	174
7,40	57	15	4/./	1,85	1,37	1,90	9,5	328	492	171	45	34	37	39	42	32	31	0,092	95	143	171
7,60	55	15	4/./	1,85	1,41	1,83	8,7	333	500	165	43	34	36	39	41	32	31	0,087	92	138	165
7,80	40	15	4/./	1,85	1,44	1,33	5,7	388	582	120	32	32	35	38	41	30	30	0,061	67	100	120
8,00	43	19	4/./	1,85	1,48	1,43	6,0	391	587	129	33	33	35	38	41	30	30	0,065	72	108	129
8,20	51	20	4/./	1,85	1,52	1,70	7,2	376	564	153	39	33	36	38	41	31	31	0,077	85	128	153
8,40	34	20	4/./	1,85	1,55	1,13	4,2	434	651	102	24	31	34	37	40	28	29	0,046	57	85	102
8,60	225	112	3.....	1,85	1,59	--	--	--	--	--	89	40	42	43	45	39	39	0,218	375	563	675
8,80	430	161	3.....	1,85	1,63	--	--	--	--	--	100	42	43	45	46	41	40	0,258	717	1075	1290

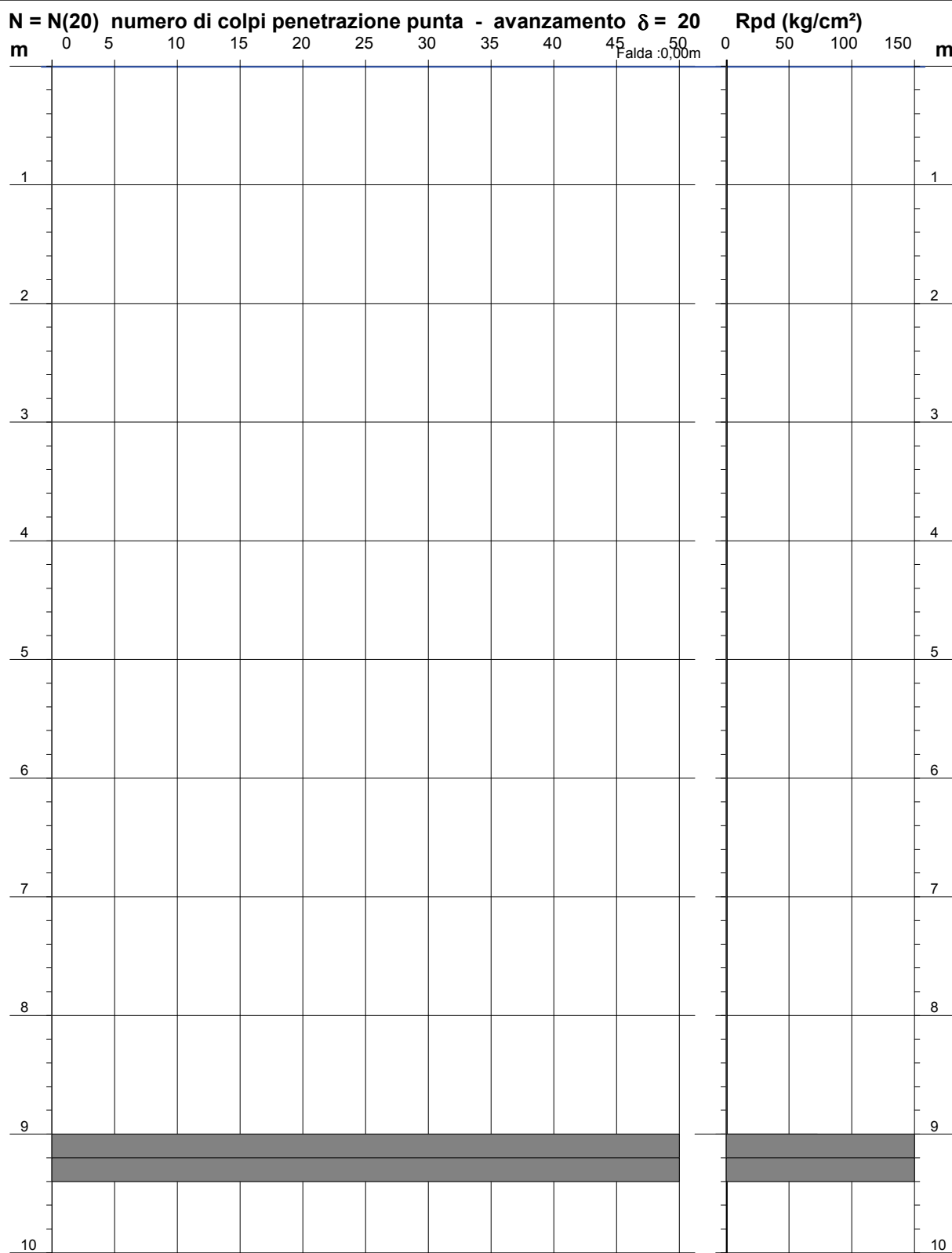
PROVA PENETROMETRICA DINAMICA DIAGRAMMA NUMERO COLPI PUNTA - Rpd

DIN 3

Scala 1: 50

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via A. Fiori
 - note : Prova eseguita in continuità con CPT3

- data : 29/10/2010
 - quota inizio : -9.0 m da p.c.a.
 - prof. falda : 0,00 m da quota inizio
 - pagina : 1



PROVA PENETROMETRICA DINAMICA DIAGRAMMA RESISTENZA DINAMICA PUNTA

DIN 3

Scala 1: 50

- committente : S.G.G. Siena

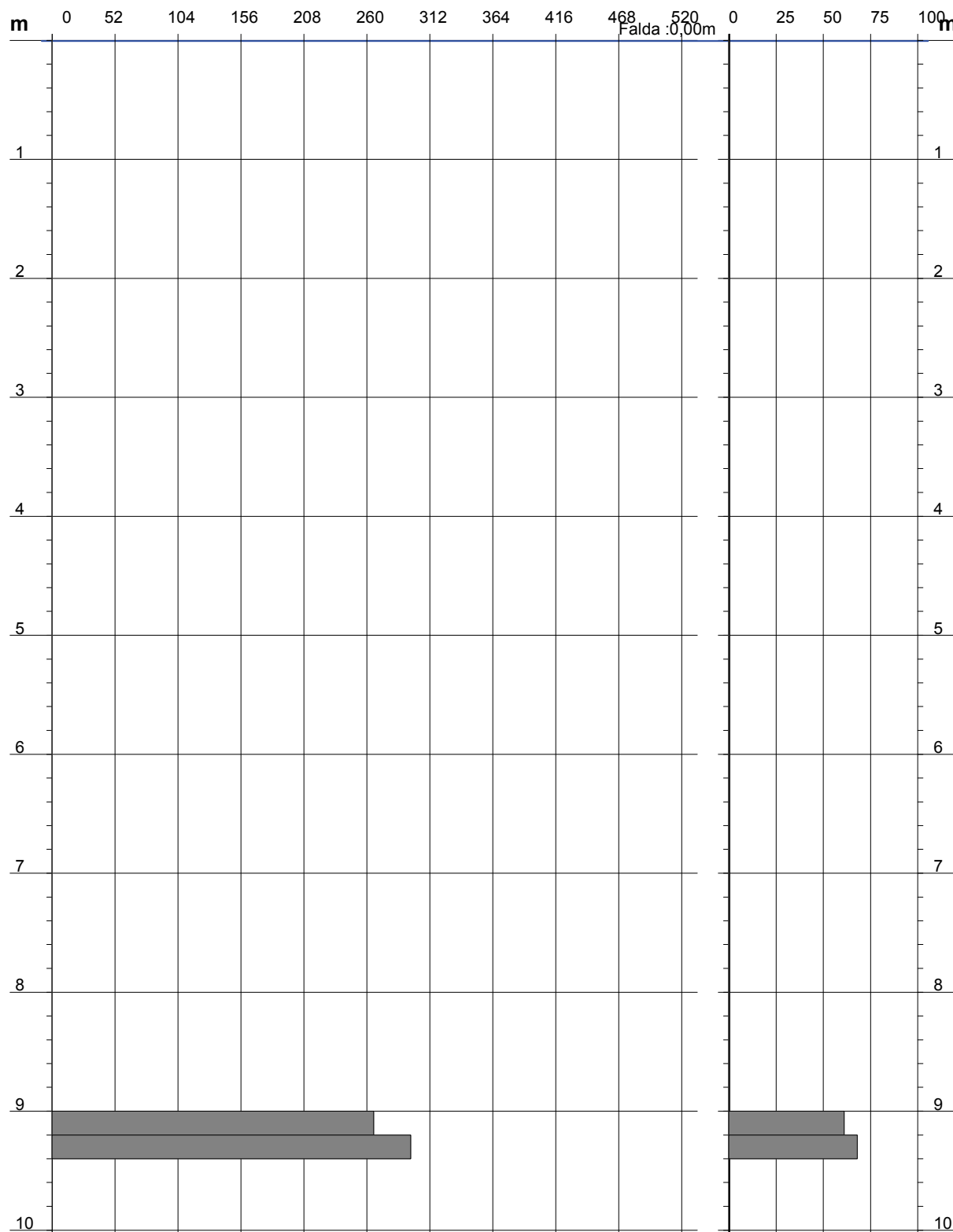
- lavoro :

- località : MO - Formigine, via A. Fiori

- data : 29/10/2010

- quota inizio : -9.0 m da p.c.a.

- prof. falda : 0,00 m da quota inizio

Rpd (kg/cm²) Resistenza dinamica alla punta, formula "Olandese"N = N(20) n° colpi $\delta = 20$ 

PROVA PENETROMETRICA STATICA **LETTURE DI CAMPAGNA / VALORI DI RESISTENZA**

CPT 4

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Vedriani
 - resp. cantiere :
 - assist. cantiere :

- data : 29/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

prf	L1	L2	qc	fs	qc/fs	prf	L1	L2	qc	fs	qc/fs
m	-	-	Kg/cm ²	Kg/cm ²	-	m	-	-	Kg/cm ²	Kg/cm ²	-
0,20	10,0	----	10,0	0,53	19,0	3,80	24,0	49,0	24,0	1,33	18,0
0,40	12,0	20,0	12,0	0,67	18,0	4,00	25,0	45,0	25,0	1,40	18,0
0,60	17,0	27,0	17,0	1,07	16,0	4,20	25,0	46,0	25,0	1,47	17,0
0,80	40,0	56,0	40,0	2,60	15,0	4,40	33,0	55,0	33,0	2,13	15,0
1,00	39,0	78,0	39,0	2,60	15,0	4,60	42,0	74,0	42,0	2,93	14,0
1,20	38,0	77,0	38,0	2,60	15,0	4,80	48,0	92,0	48,0	3,33	14,0
1,40	35,0	74,0	35,0	2,47	14,0	5,00	49,0	99,0	49,0	3,40	14,0
1,60	54,0	91,0	54,0	3,73	14,0	5,20	50,0	101,0	50,0	3,47	14,0
1,80	49,0	105,0	49,0	3,40	14,0	5,40	47,0	99,0	47,0	3,27	14,0
2,00	41,0	92,0	41,0	2,80	15,0	5,60	45,0	94,0	45,0	2,93	15,0
2,20	39,0	81,0	39,0	2,73	14,0	5,80	25,0	69,0	25,0	1,53	16,0
2,40	40,0	81,0	40,0	2,87	14,0	6,00	97,0	120,0	97,0	1,53	63,0
2,60	39,0	82,0	39,0	2,73	14,0	6,20	283,0	306,0	283,0	2,00	142,0
2,80	38,0	79,0	38,0	2,67	14,0	6,40	345,0	375,0	345,0	2,33	148,0
3,00	40,0	80,0	40,0	2,80	14,0	6,60	410,0	445,0	410,0	2,67	154,0
3,20	41,0	83,0	41,0	2,87	14,0	6,80	475,0	515,0	475,0	2,67	178,0
3,40	40,0	83,0	40,0	2,80	14,0	7,00	520,0	560,0	520,0	-----	----
3,60	29,0	71,0	29,0	1,67	17,0						

- PENETROMETRO STATICO tipo da 20 t - (con anello allargatore) -
 - COSTANTE DI TRASFORMAZIONE Ct = 10 - Velocità avanzamento punta 2 cm/s
 - punta meccanica tipo Begemann $\phi = 35.7$ mm (area punta 10 cm² - apertura 60°)
 - manicotto laterale (superficie 150 cm²)

PROVA PENETROMETRICA DINAMICA TABELLE VALORI DI RESISTENZA

DIN 4

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via A. Fiori
 - note : Prova eseguita in continuità con CPT4

- data : 29/10/2010
 - quota inizio : -6.8 m da p.c.a.
 - prof. falda : 0,00 m da quota inizio
 - pagina : 1

Prof.(m)	N(colpi p)	Rpd(kg/cm ²)	N(colpi r)	asta	Prof.(m)	N(colpi p)	Rpd(kg/cm ²)	N(colpi r)	asta
0,00 - 0,20	----	----	----	1	4,00 - 4,20	----	----	----	5
0,20 - 0,40	----	----	----	1	4,20 - 4,40	----	----	----	5
0,40 - 0,60	----	----	----	1	4,40 - 4,60	----	----	----	5
0,60 - 0,80	----	----	----	1	4,60 - 4,80	----	----	----	5
0,80 - 1,00	----	----	----	2	4,80 - 5,00	----	----	----	6
1,00 - 1,20	----	----	----	2	5,00 - 5,20	----	----	----	6
1,20 - 1,40	----	----	----	2	5,20 - 5,40	----	----	----	6
1,40 - 1,60	----	----	----	2	5,40 - 5,60	----	----	----	6
1,60 - 1,80	----	----	----	2	5,60 - 5,80	----	----	----	6
1,80 - 2,00	----	----	----	3	5,80 - 6,00	----	----	----	7
2,00 - 2,20	----	----	----	3	6,00 - 6,20	----	----	----	7
2,20 - 2,40	----	----	----	3	6,20 - 6,40	----	----	----	7
2,40 - 2,60	----	----	----	3	6,40 - 6,60	----	----	----	7
2,60 - 2,80	----	----	----	3	6,60 - 6,80	----	----	----	7
2,80 - 3,00	----	----	----	4	6,80 - 7,00	49	235,2	----	8
3,00 - 3,20	----	----	----	4	7,00 - 7,20	57	273,6	----	8
3,20 - 3,40	----	----	----	4	7,20 - 7,40	52	249,6	----	8
3,40 - 3,60	----	----	----	4	7,40 - 7,60	46	220,8	----	8
3,60 - 3,80	----	----	----	4	7,60 - 7,80	65	312,0	----	8
3,80 - 4,00	----	----	----	5					

- PENETROMETRO DINAMICO tipo : **EMILIA (20)**

- M (massa battente)= **63,50** kg - H (altezza caduta)= **0,75** m - A (area punta)= **20,00** cm² - D(diam. punta)= **50,50** mm

- Numero Colpi Punta N = N(**20**) [δ = 20 cm]

- Uso rivestimento / fanghi iniezione : **SI**

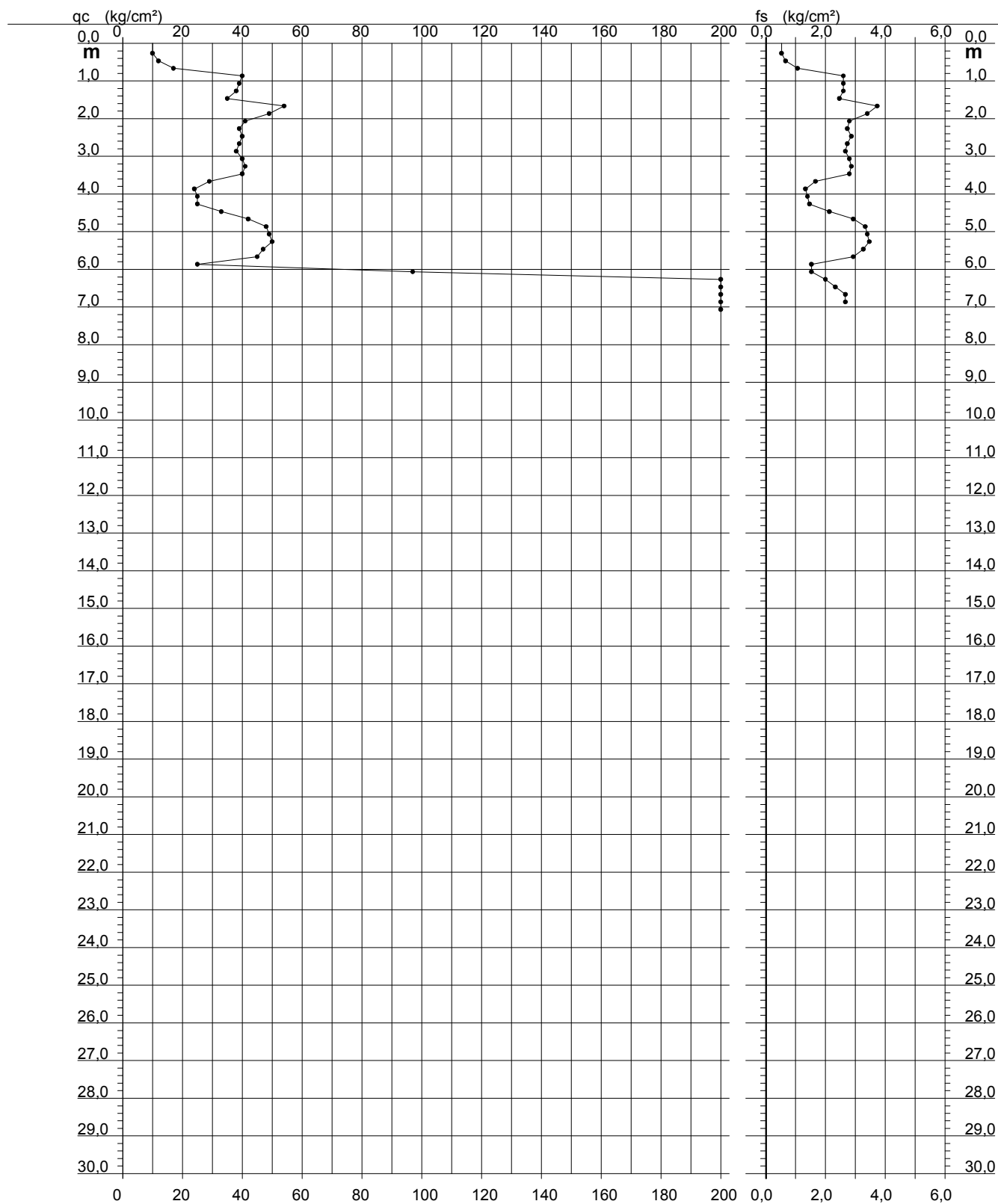
**PROVA PENETROMETRICA STATICA
DIAGRAMMA DI RESISTENZA****CPT 4**

2.0105-PG037

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via Vedriani
- resp. cantiere :
- assist. cantiere :

- data : 29/10/2010
- quota inizio : Piano Campagna
- falda : Falda non rilevata

- data di emissione :
03/11/2010



PROVA PENETROMETRICA STATICA VALUTAZIONI LITOLOGICHE

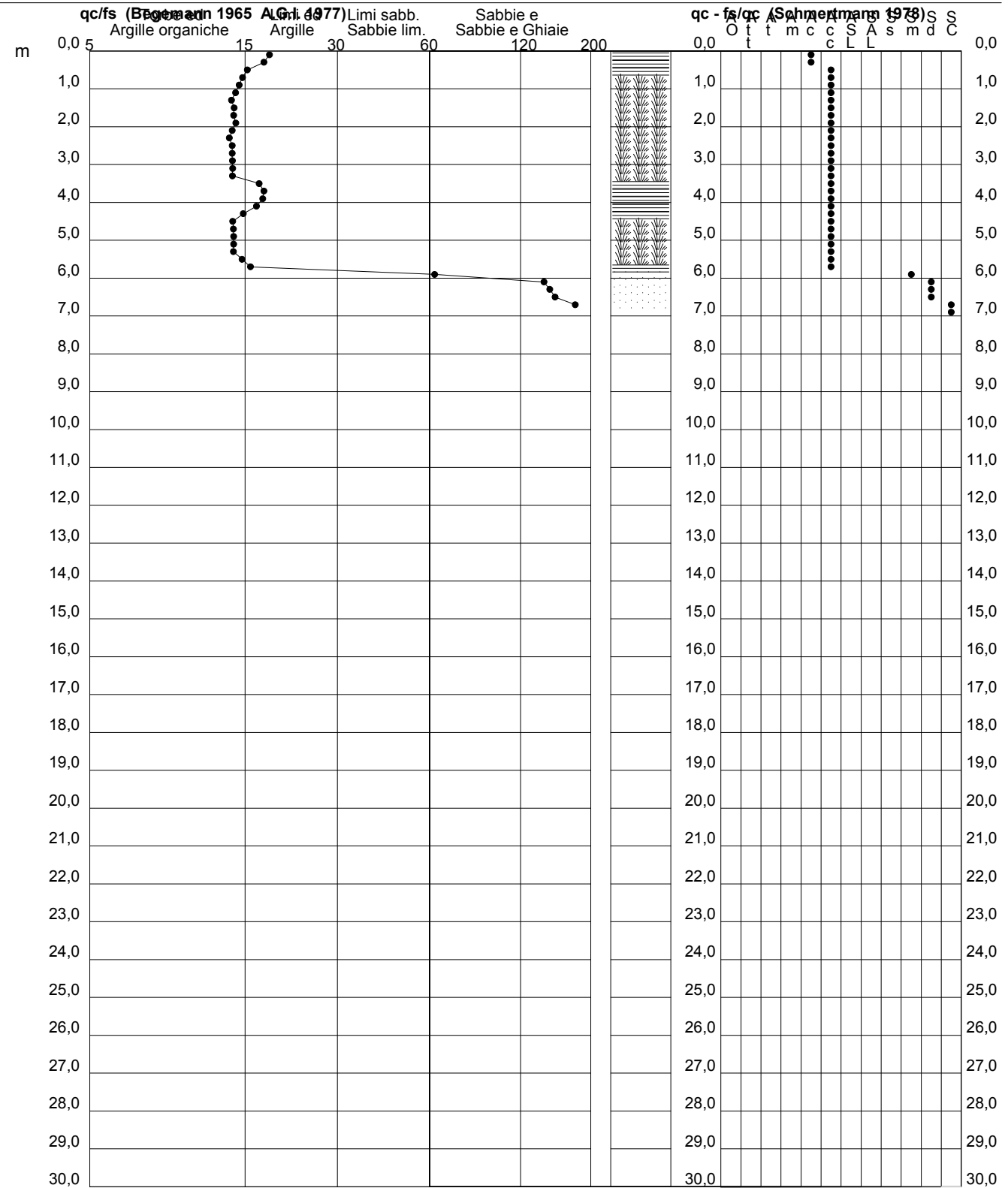
CPT 4

2.0105-PG037

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via Vedriani
- resp. cantiere :
- assist. cantiere :

- data : 29/10/2010
- quota inizio : Piano Campagna
- falda : Falda non rilevata

- data di emissione : 03/11/2010



PROVA PENETROMETRICA STATICA **TABELLA PARAMETRI GEOTECNICI**

CPT 4

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Vedriani
 - resp. cantiere :
 - assist. cantiere :

- data : 29/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

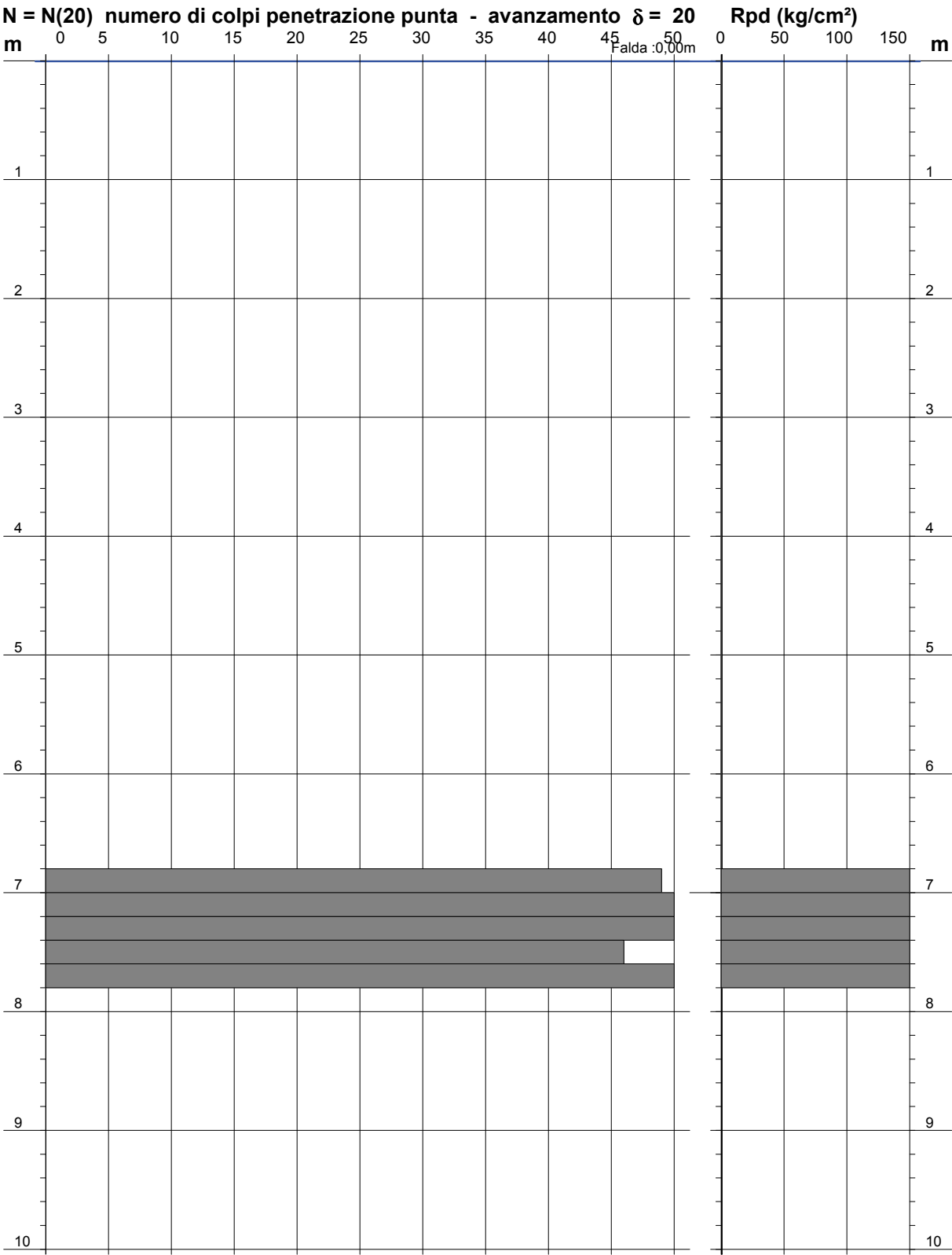
NATURA COESIVA											NATURA GRANULARE										
Prof. m	qc kg/cm²	qc/fs (-)	Natura Litol.	Y' t/m³	p'vo kg/cm²	Cu kg/cm²	OCR (-)	Eu50 kg/cm²	Eu25 kg/cm²	Mo kg/cm²	Dr %	ø1s (°)	ø2s (°)	ø3s (°)	ø4s (°)	ødm (°)	ømy (°)	Amax/g (-)	E'50 kg/cm²	E'25 kg/cm²	Mo
0,20	10	19	2////	1,85	0,04	0,50	99,9	85	128	40	--	--	--	--	--	--	--	--	--	--	--
0,40	12	18	2////	1,85	0,07	0,57	80,8	97	146	45	--	--	--	--	--	--	--	--	--	--	--
0,60	17	16	2////	1,85	0,11	0,72	65,4	123	184	54	--	--	--	--	--	--	--	--	--	--	--
0,80	40	15	4//:	1,85	0,15	1,33	98,0	227	340	120	87	40	42	43	45	41	30	0,213	67	100	120
1,00	39	15	4//:	1,85	0,19	1,30	71,8	221	332	117	81	39	41	43	44	40	30	0,193	65	98	117
1,20	38	15	4//:	1,85	0,22	1,27	55,4	215	323	114	75	39	40	42	44	39	30	0,176	63	95	114
1,40	35	14	4//:	1,85	0,26	1,17	41,2	198	298	105	69	38	40	41	44	38	29	0,156	58	88	105
1,60	54	14	4//:	1,85	0,30	1,80	60,0	306	459	162	81	39	41	43	44	40	31	0,192	90	135	162
1,80	49	14	4//:	1,85	0,33	1,63	45,8	278	417	147	74	38	40	42	44	39	31	0,172	82	123	147
2,00	41	15	4//:	1,85	0,37	1,37	32,1	232	349	123	66	37	39	41	43	38	30	0,146	68	103	123
2,20	39	14	4//:	1,85	0,41	1,30	26,8	221	332	117	62	37	39	41	43	37	30	0,135	65	98	117
2,40	40	14	4//:	1,85	0,44	1,33	24,8	227	340	120	60	36	38	41	43	36	30	0,131	67	100	120
2,60	39	14	4//:	1,85	0,48	1,30	21,8	221	332	117	57	36	38	40	43	36	30	0,124	65	98	117
2,80	38	14	4//:	1,85	0,52	1,27	19,2	215	323	114	55	36	38	40	42	35	30	0,116	63	95	114
3,00	40	14	4//:	1,85	0,55	1,33	18,8	227	340	120	55	36	38	40	42	35	30	0,117	67	100	120
3,20	41	14	4//:	1,85	0,59	1,37	17,9	232	349	123	54	36	38	40	42	35	30	0,115	68	103	123
3,40	40	14	4//:	1,85	0,63	1,33	16,1	227	340	120	52	35	37	40	42	34	30	0,109	67	100	120
3,60	29	17	4//:	1,85	0,67	0,98	10,2	167	251	87	39	34	36	38	41	32	29	0,078	48	73	87
3,80	24	18	4//:	1,85	0,70	0,89	8,4	167	251	72	32	32	35	38	41	31	28	0,061	40	60	72
4,00	25	18	4//:	1,85	0,74	0,91	8,1	177	266	75	32	32	35	38	41	31	28	0,061	42	63	75
4,20	25	17	4//:	1,85	0,78	0,91	7,6	189	284	75	31	32	35	38	40	31	28	0,059	42	63	75
4,40	33	15	4//:	1,85	0,81	1,10	9,1	193	290	99	39	33	36	38	41	32	29	0,077	55	83	99
4,60	42	14	4//:	1,85	0,85	1,40	11,7	238	357	126	46	34	37	39	42	33	30	0,094	70	105	126
4,80	48	14	4//:	1,85	0,89	1,60	13,1	272	408	144	50	35	37	40	42	34	31	0,103	80	120	144
5,00	49	14	4//:	1,85	0,93	1,63	12,8	278	417	147	49	35	37	39	42	33	31	0,102	82	123	147
5,20	50	14	4//:	1,85	0,96	1,67	12,5	283	425	150	49	35	37	39	42	33	31	0,102	83	125	150
5,40	47	14	4//:	1,85	1,00	1,57	11,0	266	400	141	46	34	37	39	42	33	31	0,094	78	118	141
5,60	45	15	4//:	1,85	1,04	1,50	10,0	255	383	135	44	34	36	39	41	32	31	0,088	75	113	135
5,80	25	16	4//:	1,85	1,07	0,91	5,1	295	443	75	23	31	34	37	40	29	28	0,043	42	63	75
6,00	97	63	3:::	1,85	1,11	--	--	--	--	--	68	38	39	41	43	36	34	0,154	162	243	291
6,20	283	142	3:::	1,85	1,15	--	--	--	--	--	100	42	43	45	46	41	40	0,258	472	708	849
6,40	345	148	3:::	1,85	1,18	--	--	--	--	--	100	42	43	45	46	42	40	0,258	575	863	1035
6,60	410	154	3:::	1,85	1,22	--	--	--	--	--	100	42	43	45	46	42	40	0,258	683	1025	1230
6,80	475	178	3:::	1,85	1,26	--	--	--	--	--	100	42	43	45	46	43	40	0,258	792	1188	1425
7,00	520	--	3:::	1,85	1,30	--	--	--	--	--	100	42	43	45	46	43	40	0,258	867	1300	1560

PROVA PENETROMETRICA DINAMICA
DIAGRAMMA NUMERO COLPI PUNTA - Rpd

DIN 4

Scala 1: 50

- committente :	S.G.G. Siena	- data :	29/10/2010
- lavoro :		- quota inizio :	-6.8 m da p.c.a.
- località :	MO - Formigine, via A. Fiori	- prof. falda :	0,00 m da quota inizio
- note :	Prova eseguita in continuità con CPT4	- pagina :	1



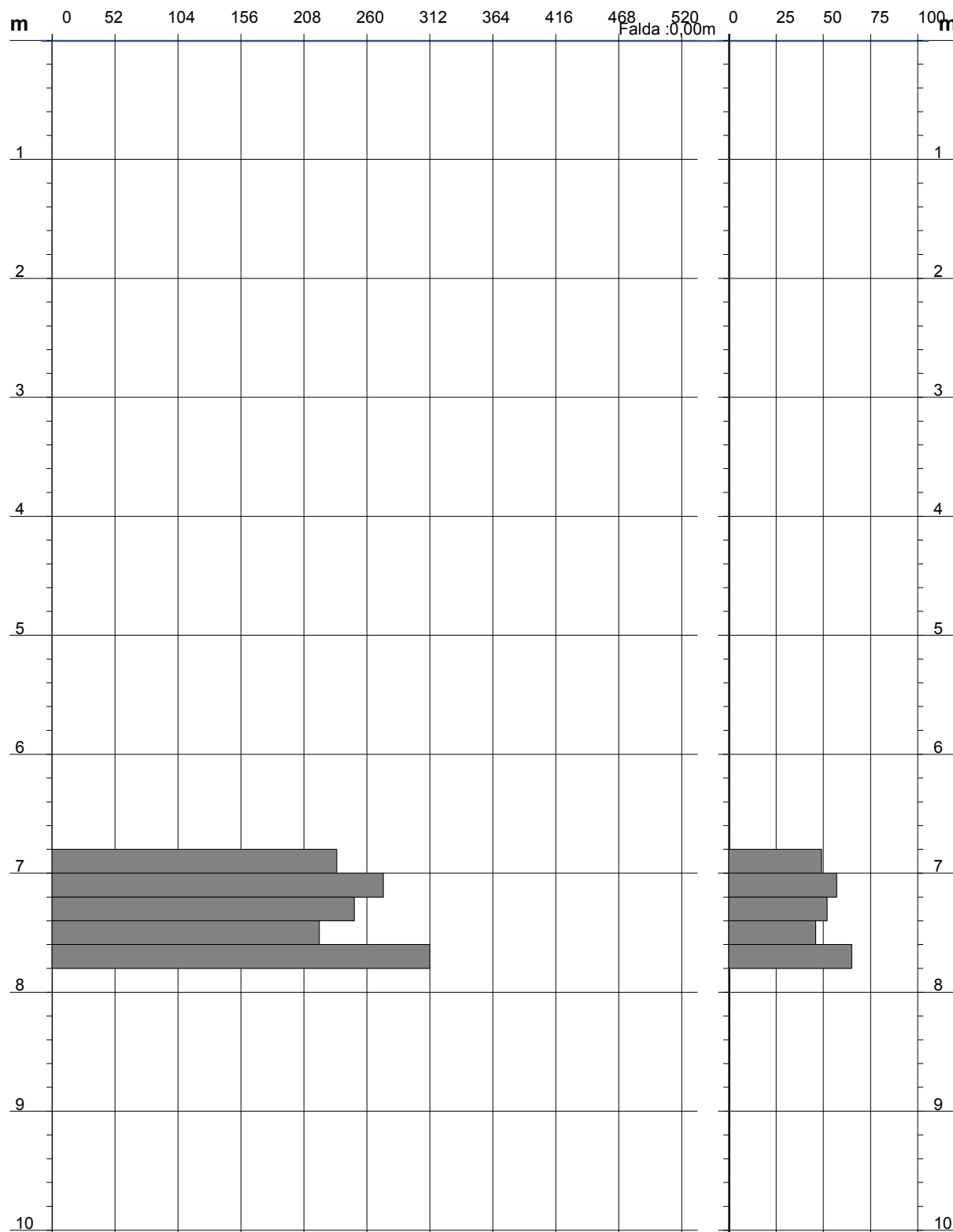
PROVA PENETROMETRICA DINAMICA DIAGRAMMA RESISTENZA DINAMICA PUNTA

DIN 4

Scala 1: 50

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via A. Fiori

- data : 29/10/2010
- quota inizio : -6.8 m da p.c.a.
- prof. falda : 0,00 m da quota inizio

Rpd (kg/cm²) Resistenza dinamica alla punta, formula "Olandese"N = N(20) n° colpi $\delta = 20$ 

PROVA PENETROMETRICA STATICA **LETTURE DI CAMPAGNA / VALORI DI RESISTENZA**

CPT 5

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Cipollino
 - resp. cantiere :
 - assist. cantiere :

- data : 28/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

prf	L1	L2	qc	fs	qc/fs	prf	L1	L2	qc	fs	qc/fs
m	-	-	Kg/cm ²	Kg/cm ²	-	m	-	-	Kg/cm ²	Kg/cm ²	-
0,20	4,0	----	4,0	0,20	20,0	2,60	25,0	44,0	25,0	1,33	19,0
0,40	15,0	18,0	15,0	0,93	16,0	2,80	28,0	48,0	28,0	1,80	16,0
0,60	16,0	30,0	16,0	1,00	16,0	3,00	27,0	54,0	27,0	1,80	15,0
0,80	15,0	30,0	15,0	1,00	15,0	3,20	32,0	59,0	32,0	2,13	15,0
1,00	13,0	28,0	13,0	0,87	15,0	3,40	36,0	68,0	36,0	2,47	15,0
1,20	21,0	34,0	21,0	1,27	17,0	3,60	39,0	76,0	39,0	2,60	15,0
1,40	27,0	46,0	27,0	1,60	17,0	3,80	51,0	90,0	51,0	1,47	35,0
1,60	32,0	56,0	32,0	1,73	18,0	4,00	142,0	164,0	142,0	1,67	85,0
1,80	28,0	54,0	28,0	1,60	17,0	4,20	266,0	291,0	266,0	2,00	133,0
2,00	28,0	52,0	28,0	1,60	17,0	4,40	350,0	380,0	350,0	2,33	150,0
2,20	25,0	49,0	25,0	1,33	19,0	4,60	430,0	465,0	430,0	2,67	161,0
2,40	23,0	43,0	23,0	1,27	18,0	4,80	500,0	540,0	500,0	-----	----

- PENETROMETRO STATICO tipo da 20 t - (con anello allargatore) -
 - COSTANTE DI TRASFORMAZIONE Ct = 10 - Velocità avanzamento punta 2 cm/s
 - punta meccanica tipo Begemann $\phi = 35.7$ mm (area punta 10 cm² - apertura 60°)
 - manicotto laterale (superficie 150 cm²)

PROVA PENETROMETRICA DINAMICA TABELLE VALORI DI RESISTENZA

DIN 5

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via A. Fiori
- note : Prova eseguita in continuità con CPT5

- data : 28/10/2010
- quota inizio : -4.6 m da p.c.a.
- prof. falda : 0,00 m da quota inizio
- pagina : 1

Prof.(m)	N(colpi p)	Rpd(kg/cm ²)	N(colpi r)	asta	Prof.(m)	N(colpi p)	Rpd(kg/cm ²)	N(colpi r)	asta
0,00 - 0,20	----	----	----	1	2,60 - 2,80	----	----	----	3
0,20 - 0,40	----	----	----	1	2,80 - 3,00	----	----	----	4
0,40 - 0,60	----	----	----	1	3,00 - 3,20	----	----	----	4
0,60 - 0,80	----	----	----	1	3,20 - 3,40	----	----	----	4
0,80 - 1,00	----	----	----	2	3,40 - 3,60	----	----	----	4
1,00 - 1,20	----	----	----	2	3,60 - 3,80	----	----	----	4
1,20 - 1,40	----	----	----	2	3,80 - 4,00	----	----	----	5
1,40 - 1,60	----	----	----	2	4,00 - 4,20	----	----	----	5
1,60 - 1,80	----	----	----	2	4,20 - 4,40	----	----	----	5
1,80 - 2,00	----	----	----	3	4,40 - 4,60	----	----	----	5
2,00 - 2,20	----	----	----	3	4,60 - 4,80	58	328,5	----	5
2,20 - 2,40	----	----	----	3	4,80 - 5,00	54	288,5	----	6
2,40 - 2,60	----	----	----	3	5,00 - 5,20	68	363,3	----	6

- PENETROMETRO DINAMICO tipo : **EMILIA (20)**

- M (massa battente)= **63,50** kg - H (altezza caduta)= **0,75** m - A (area punta)= **20,00** cm² - D(diam. punta)= **50,50** mm

- Numero Colpi Punta N = N(**20**) [δ = 20 cm]

- Uso rivestimento / fanghi iniezione : **SI**

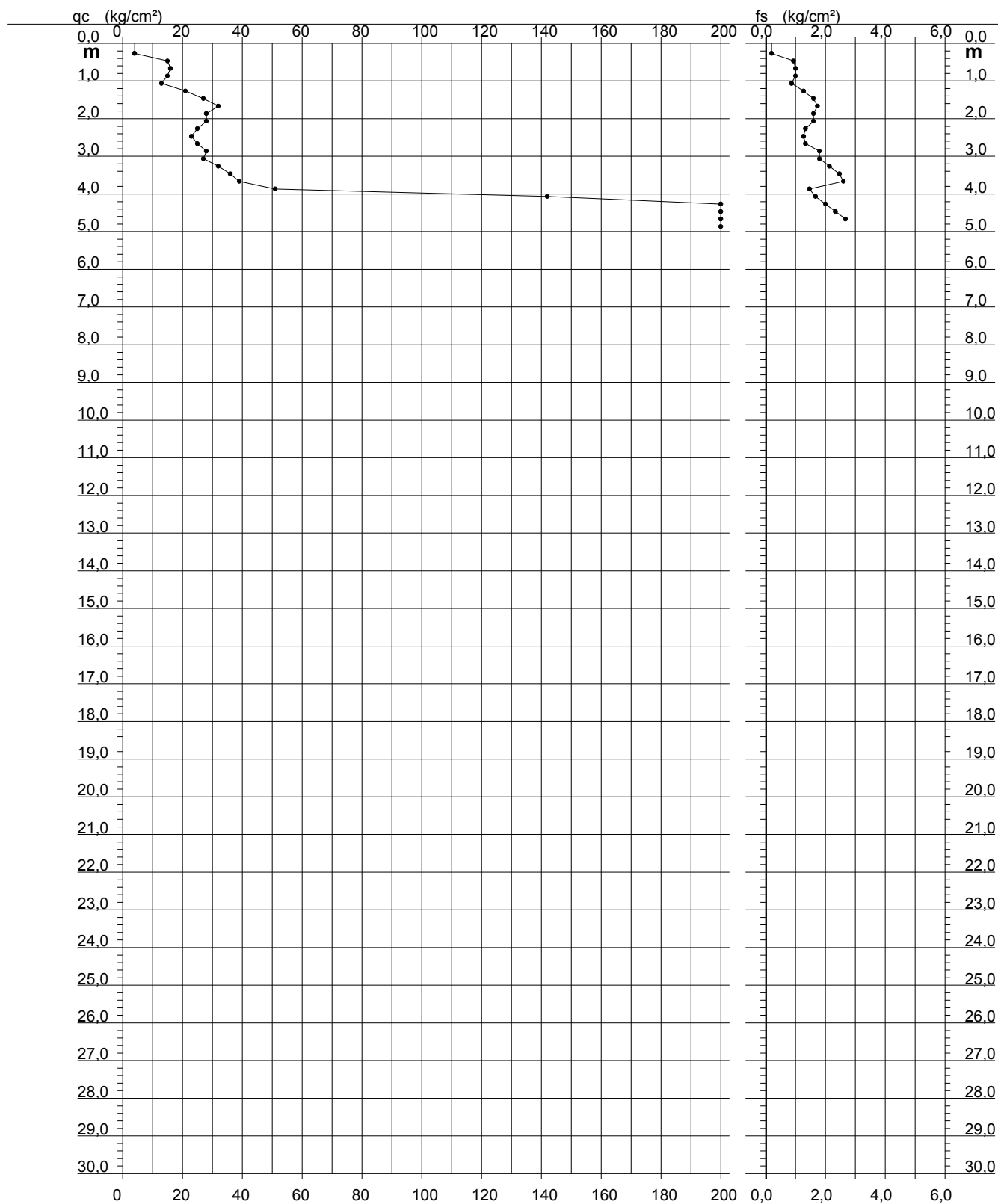
**PROVA PENETROMETRICA STATICA
DIAGRAMMA DI RESISTENZA****CPT 5**

2.0105-PG037

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via Cipollino
- resp. cantiere :
- assist. cantiere :

- data : 28/10/2010
- quota inizio : Piano Campagna
- falda : Falda non rilevata

- data di emissione :
03/11/2010

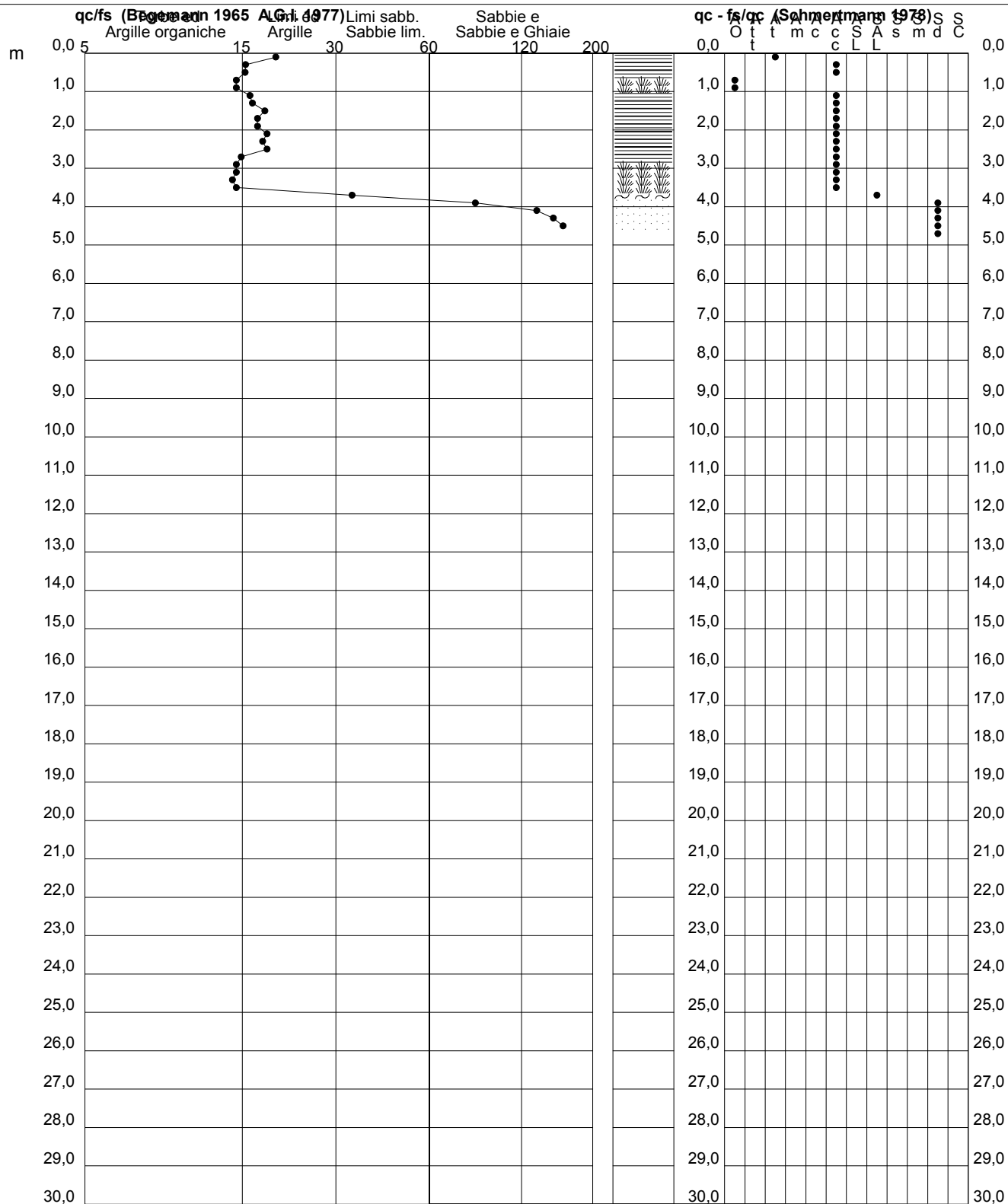


CPT 5

2.0105-PG037

- data : 28/10/2010
- quota inizio : Piano Campagna
- falda : Falda non rilevata

- data di emissione : 03/11/2010



PROVA PENETROMETRICA STATICA **TABELLA PARAMETRI GEOTECNICI**

CPT 5

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Cipollino
 - resp. cantiere :
 - assist. cantiere :

- data : 28/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

NATURA COESIVA											NATURA GRANULARE										
Prof. m	qc kg/cm²	qc/fs (-)	Natura Litol.	Y' t/m³	p'vo kg/cm²	Cu kg/cm²	OCR (-)	Eu50 kg/cm²	Eu25 kg/cm²	Mo kg/cm²	Dr %	ø1s (°)	ø2s (°)	ø3s (°)	ø4s (°)	ødm (°)	ømy (°)	Amax/g (-)	E'50 kg/cm²	E'25 kg/cm²	Mo
0,20	4	20	2////	1,85	0,04	0,20	51,7	34	51	20	--	--	--	--	--	--	--	--	--	--	--
0,40	15	16	2////	1,85	0,07	0,67	98,0	113	170	50	--	--	--	--	--	--	--	--	--	--	--
0,60	16	16	2////	1,85	0,11	0,70	62,3	118	177	52	--	--	--	--	--	--	--	--	--	--	--
0,80	15	15	2////	1,85	0,15	0,67	41,2	113	170	50	--	--	--	--	--	--	--	--	--	--	--
1,00	13	15	2////	1,85	0,19	0,60	27,6	103	154	47	--	--	--	--	--	--	--	--	--	--	--
1,20	21	17	4/./	1,85	0,22	0,82	32,3	140	210	63	55	36	38	40	42	37	27	0,117	35	53	63
1,40	27	17	4/./	1,85	0,26	0,95	31,8	161	242	81	60	36	38	41	43	37	28	0,130	45	68	81
1,60	32	18	4/./	1,85	0,30	1,07	31,2	181	272	96	63	37	39	41	43	37	29	0,137	53	80	96
1,80	28	17	4/./	1,85	0,33	0,97	23,8	164	246	84	55	36	38	40	42	36	28	0,117	47	70	84
2,00	28	17	4/./	1,85	0,37	0,97	20,8	164	246	84	52	35	38	40	42	35	28	0,110	47	70	84
2,20	25	19	4/./	1,85	0,41	0,91	17,1	155	232	75	46	34	37	39	42	34	28	0,095	42	63	75
2,40	23	18	4/./	1,85	0,44	0,87	14,5	148	221	69	41	34	36	39	41	33	28	0,083	38	58	69
2,60	25	19	4/./	1,85	0,48	0,91	13,9	155	232	75	42	34	36	39	41	33	28	0,085	42	63	75
2,80	28	16	4/./	1,85	0,52	0,97	13,7	164	246	84	44	34	37	39	42	34	28	0,090	47	70	84
3,00	27	15	4/./	1,85	0,55	0,95	12,2	161	242	81	41	34	36	39	41	33	28	0,083	45	68	81
3,20	32	15	4/./	1,85	0,59	1,07	13,1	181	272	96	46	34	37	39	42	34	29	0,093	53	80	96
3,40	36	15	4/./	1,85	0,63	1,20	14,1	204	306	108	48	35	37	39	42	34	30	0,099	60	90	108
3,60	39	15	4/./	1,85	0,67	1,30	14,5	221	332	117	50	35	37	40	42	34	30	0,103	65	98	117
3,80	51	35	3:---	1,85	0,70	--	--	--	--	--	57	36	38	40	43	35	31	0,123	85	128	153
4,00	142	85	3:---	1,85	0,74	--	--	--	--	--	91	41	42	44	45	40	36	0,228	237	355	426
4,20	266	133	3:---	1,85	0,78	--	--	--	--	--	100	42	43	45	46	42	40	0,258	443	665	798
4,40	350	150	3:---	1,85	0,81	--	--	--	--	--	100	42	43	45	46	43	40	0,258	583	875	1050
4,60	430	161	3:---	1,85	0,85	--	--	--	--	--	100	42	43	45	46	44	40	0,258	717	1075	1290
4,80	500	--	3:---	1,85	0,89	--	--	--	--	--	100	42	43	45	46	44	40	0,258	833	1250	1500

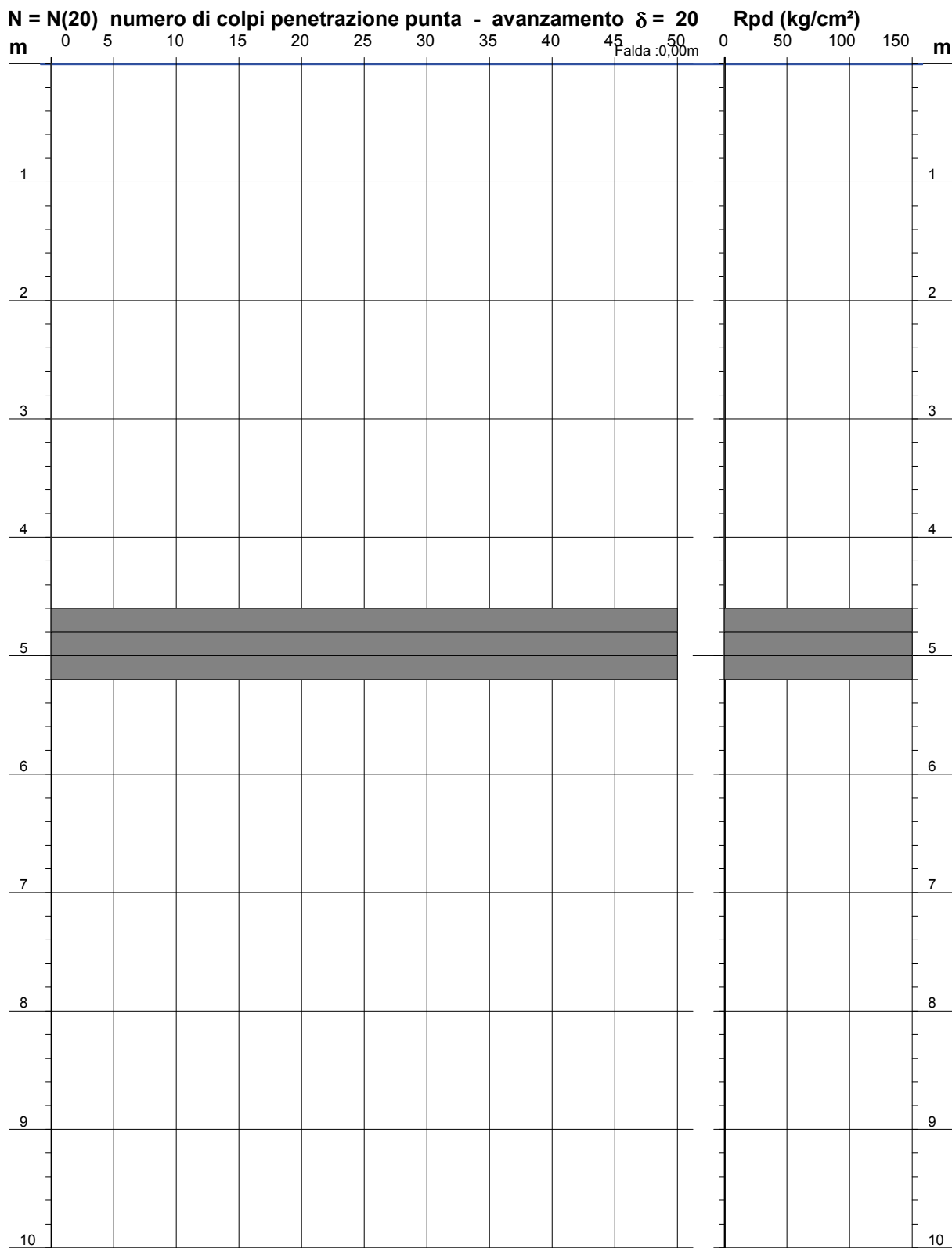
PROVA PENETROMETRICA DINAMICA DIAGRAMMA NUMERO COLPI PUNTA - Rpd

DIN 5

Scala 1: 50

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via A. Fiori
 - note : Prova eseguita in continuità con CPT5

- data : 28/10/2010
 - quota inizio : -4.6 m da p.c.a.
 - prof. falda : 0,00 m da quota inizio
 - pagina : 1



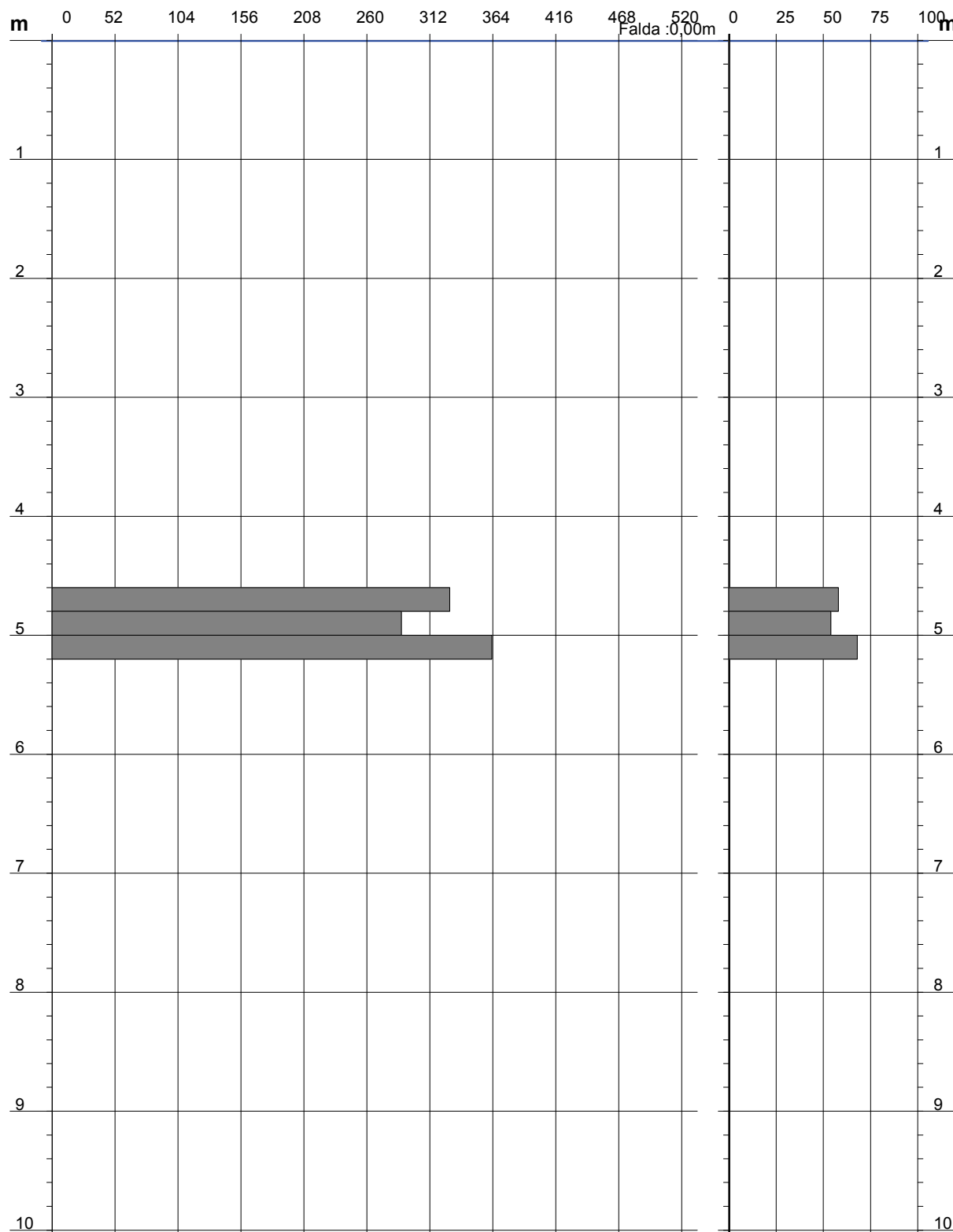
PROVA PENETROMETRICA DINAMICA DIAGRAMMA RESISTENZA DINAMICA PUNTA

DIN 5

Scala 1: 50

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via A. Fiori

- data : 28/10/2010
- quota inizio : -4.6 m da p.c.a.
- prof. falda : 0,00 m da quota inizio

Rpd (kg/cm²) Resistenza dinamica alla punta, formula "Olandese"N = N(20) n° colpi $\delta = 20$ 

PROVA PENETROMETRICA STATICA **LETTURE DI CAMPAGNA / VALORI DI RESISTENZA**

CPT 6

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Mosca
 - resp. cantiere :
 - assist. cantiere :

- data : 28/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

prf	L1	L2	qc	fs	qc/fs	prf	L1	L2	qc	fs	qc/fs
m	-	-	Kg/cm ²	Kg/cm ²	-	m	-	-	Kg/cm ²	Kg/cm ²	-
0,20	18,0	----	18,0	0,93	19,0	2,40	43,0	82,0	43,0	2,73	16,0
0,40	17,0	31,0	17,0	0,93	18,0	2,60	43,0	84,0	43,0	2,67	16,0
0,60	21,0	35,0	21,0	1,20	17,0	2,80	30,0	70,0	30,0	1,20	25,0
0,80	96,0	114,0	96,0	2,93	33,0	3,00	32,0	50,0	32,0	1,27	25,0
1,00	101,0	145,0	101,0	3,27	31,0	3,20	44,0	63,0	44,0	1,27	35,0
1,20	81,0	130,0	81,0	2,67	30,0	3,40	55,0	74,0	55,0	1,33	41,0
1,40	58,0	98,0	58,0	2,27	26,0	3,60	248,0	268,0	248,0	2,00	124,0
1,60	37,0	71,0	37,0	2,33	16,0	3,80	350,0	380,0	350,0	2,33	150,0
1,80	35,0	70,0	35,0	2,27	15,0	4,00	420,0	455,0	420,0	2,67	157,0
2,00	37,0	71,0	37,0	2,47	15,0	4,20	500,0	540,0	500,0	-----	----
2,20	40,0	77,0	40,0	2,60	15,0						

- PENETROMETRO STATICO tipo da 20 t - (con anello allargatore) -
 - COSTANTE DI TRASFORMAZIONE Ct = 10 - Velocità avanzamento punta 2 cm/s
 - punta meccanica tipo Begemann $\phi = 35.7$ mm (area punta 10 cm² - apertura 60°)
 - manicotto laterale (superficie 150 cm²)

PROVA PENETROMETRICA DINAMICA TABELLE VALORI DI RESISTENZA

DIN 6

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via A. Fiori
 - note : Prova eseguita in continuità con CPT6

- data : 28/10/2010
 - quota inizio : -4.0 m da p.c.a.
 - prof. falda : 0,00 m da quota inizio
 - pagina : 1

Prof.(m)	N(colpi p)	Rpd(kg/cm ²)	N(colpi r)	asta	Prof.(m)	N(colpi p)	Rpd(kg/cm ²)	N(colpi r)	asta
0,00 - 0,20	----	----	----	1	2,40 - 2,60	----	----	----	3
0,20 - 0,40	----	----	----	1	2,60 - 2,80	----	----	----	3
0,40 - 0,60	----	----	----	1	2,80 - 3,00	----	----	----	4
0,60 - 0,80	----	----	----	1	3,00 - 3,20	----	----	----	4
0,80 - 1,00	----	----	----	2	3,20 - 3,40	----	----	----	4
1,00 - 1,20	----	----	----	2	3,40 - 3,60	----	----	----	4
1,20 - 1,40	----	----	----	2	3,60 - 3,80	----	----	----	4
1,40 - 1,60	----	----	----	2	3,80 - 4,00	----	----	----	5
1,60 - 1,80	----	----	----	2	4,00 - 4,20	44	249,2	----	5
1,80 - 2,00	----	----	----	3	4,20 - 4,40	58	328,5	----	5
2,00 - 2,20	----	----	----	3	4,40 - 4,60	53	300,2	----	5
2,20 - 2,40	----	----	----	3	4,60 - 4,80	67	379,4	----	5

- PENETROMETRO DINAMICO tipo : **EMILIA (20)**

- M (massa battente)= **63,50** kg - H (altezza caduta)= **0,75** m - A (area punta)= **20,00** cm² - D(diam. punta)= **50,50** mm

- Numero Colpi Punta N = N(**20**) [δ = 20 cm]

- Uso rivestimento / fanghi iniezione : **SI**

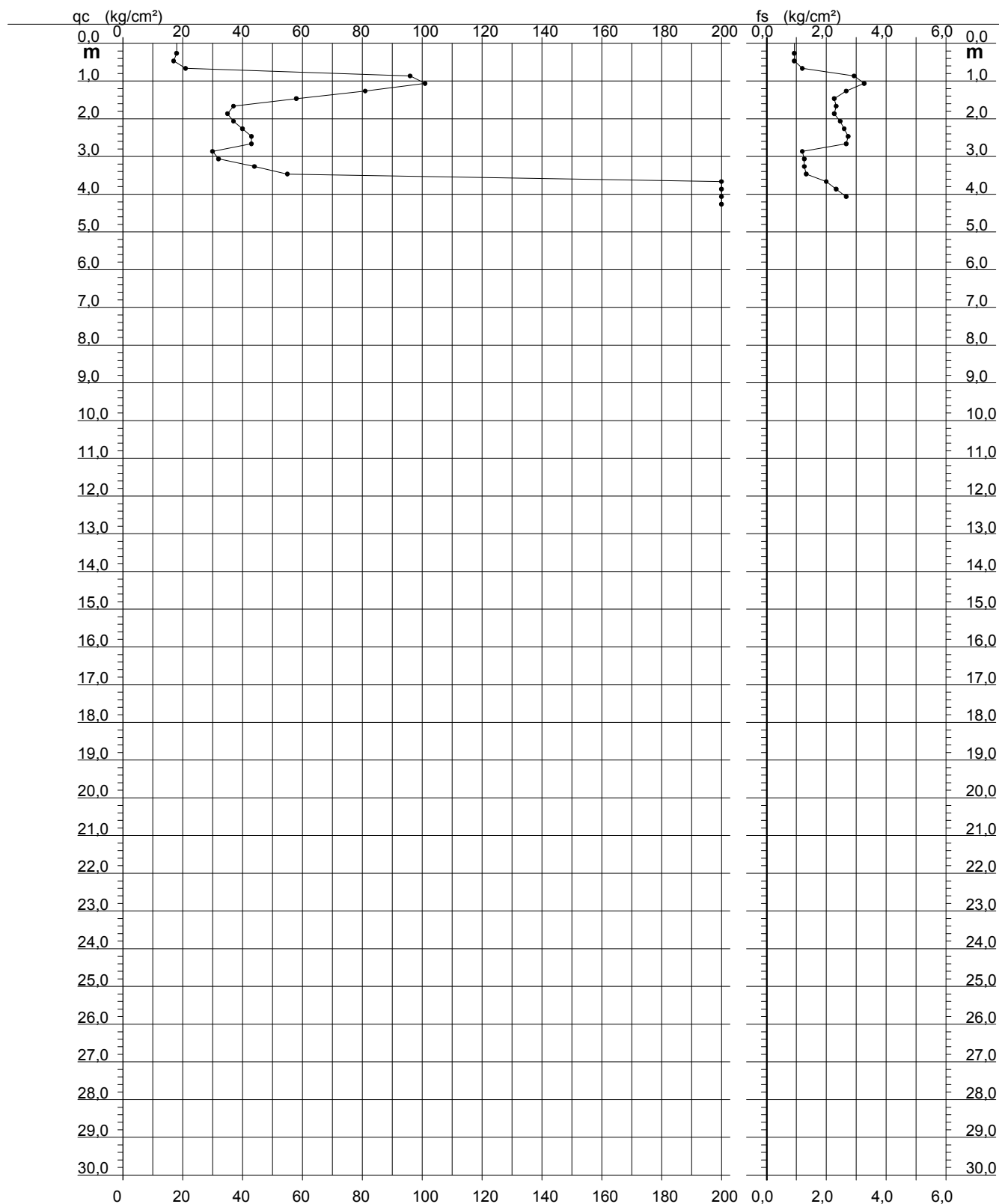
**PROVA PENETROMETRICA STATICA
DIAGRAMMA DI RESISTENZA****CPT 6**

2.0105-PG037

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via Mosca
- resp. cantiere :
- assist. cantiere :

- data : 28/10/2010
- quota inizio : Piano Campagna
- falda : Falda non rilevata

- data di emissione :
03/11/2010

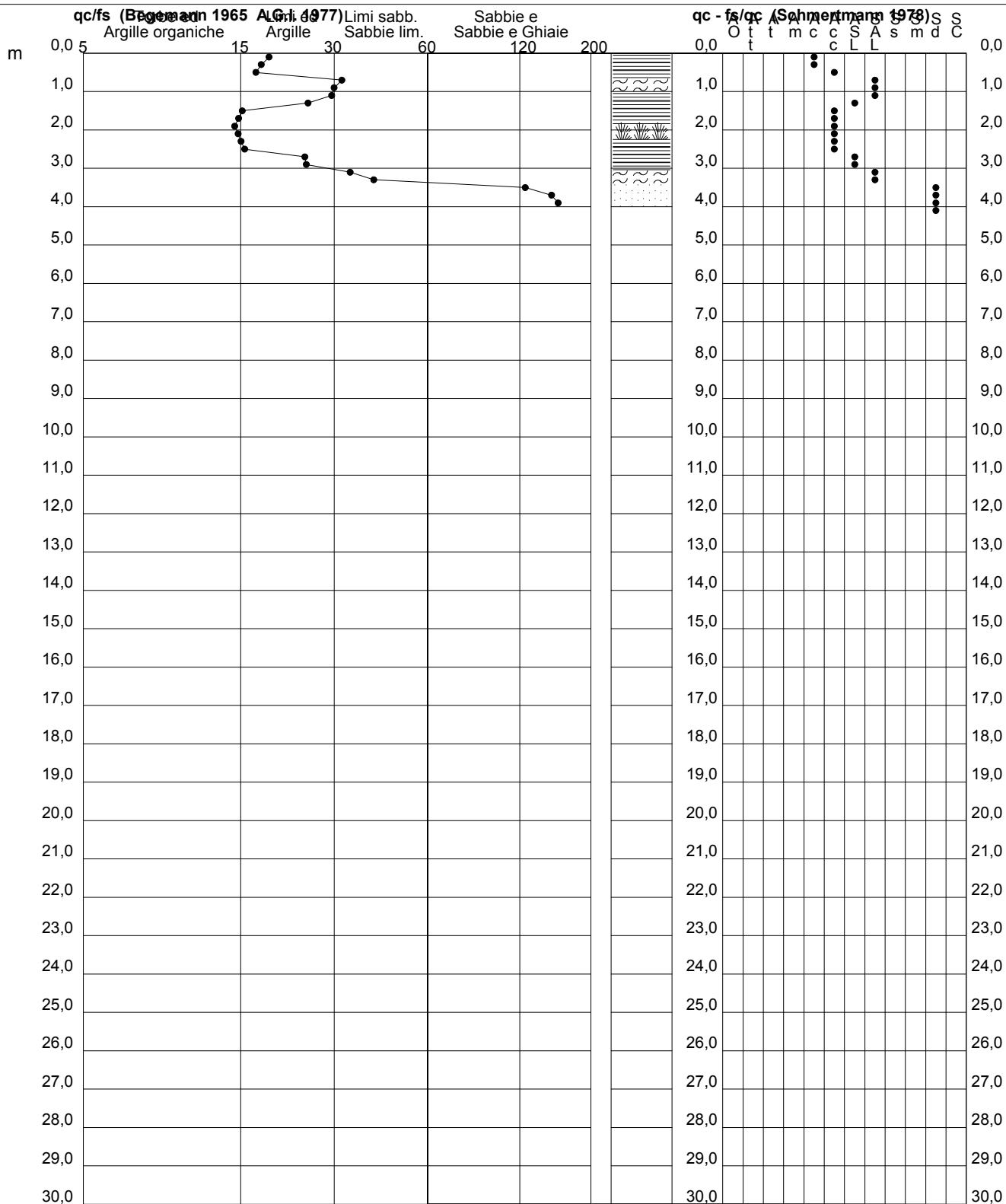


CPT 6

2.0105-PG037

- data : 28/10/2010
- quota inizio : Piano Campagna
- falda : Falda non rilevata

- data di emissione : 03/11/2010



PROVA PENETROMETRICA STATICA **TABELLA PARAMETRI GEOTECNICI**

CPT 6

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Mosca
 - resp. cantiere :
 - assist. cantiere :

- data : 28/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

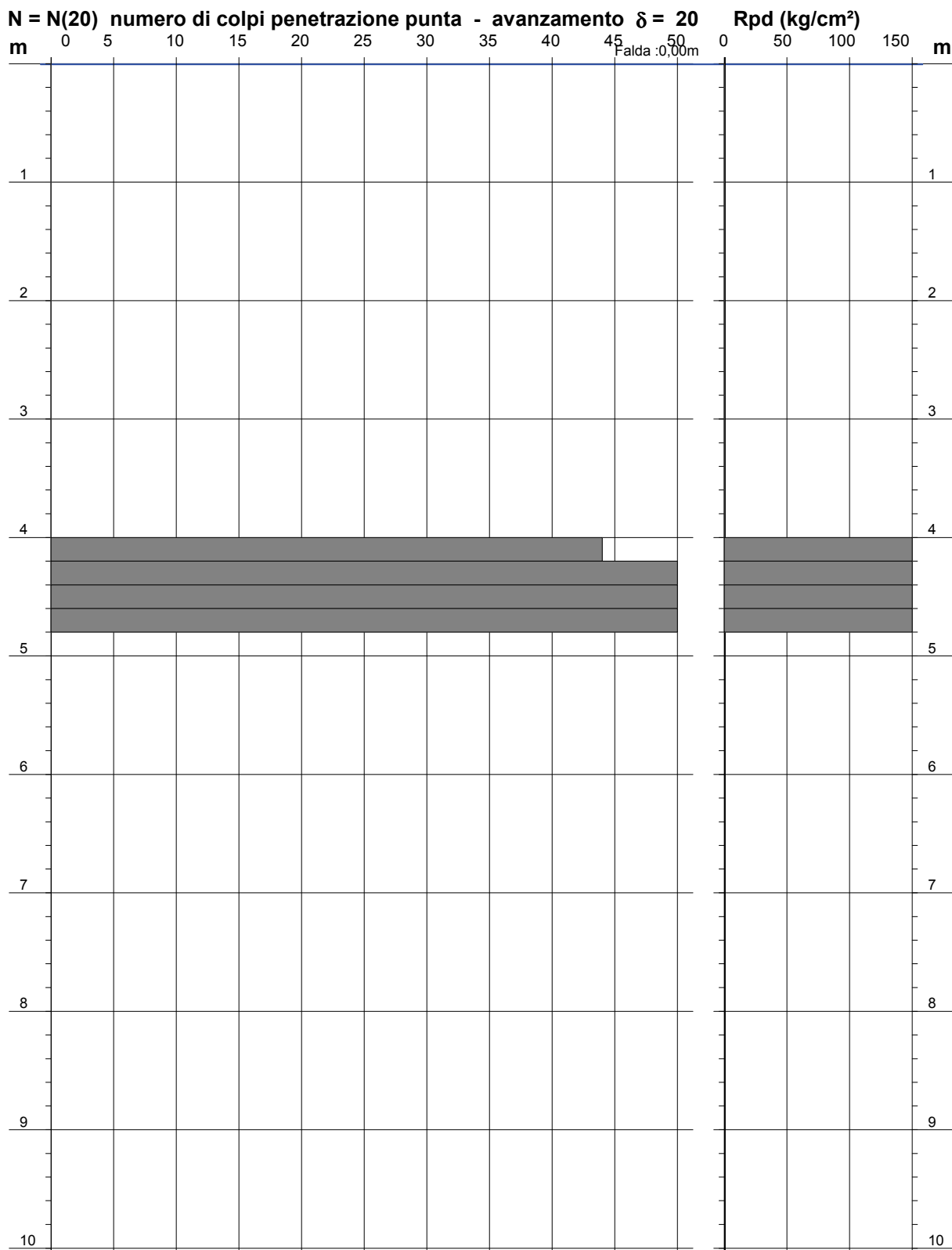
NATURA COESIVA											NATURA GRANULARE										
Prof. m	qc kg/cm ²	qc/fs (-)	Natura Litol.	Y' t/m ³	p'vo kg/cm ²	Cu kg/cm ²	OCR (-)	Eu50 kg/cm ²	Eu25 kg/cm ²	Mo kg/cm ²	Dr %	ø1s (°)	ø2s (°)	ø3s (°)	ø4s (°)	ødm (°)	ømy (°)	Amax/g (-)	E'50 kg/cm ²	E'25 kg/cm ²	Mo kg/cm ²
0,20	18	19	2////	1,85	0,04	0,75	99,9	128	191	56	--	--	--	--	--	--	--	--	--	--	--
0,40	17	18	2////	1,85	0,07	0,72	99,9	123	184	54	--	--	--	--	--	--	--	--	--	--	--
0,60	21	17	4:/:/	1,85	0,11	0,82	76,9	140	210	63	72	38	40	42	44	40	27	0,165	35	53	63
0,80	96	33	3:/:/	1,85	0,15	--	--	--	--	--	100	42	43	45	46	45	34	0,258	160	240	288
1,00	101	31	3:/:/	1,85	0,19	--	--	--	--	--	100	42	43	45	46	44	34	0,258	168	253	303
1,20	81	30	4:/:/	1,85	0,22	2,70	99,9	459	689	243	100	42	43	45	46	43	33	0,258	135	203	243
1,40	58	26	4:/:/	1,85	0,26	1,93	77,5	329	493	174	86	40	42	43	45	41	31	0,210	97	145	174
1,60	37	16	4:/:/	1,85	0,30	1,23	37,4	210	315	111	68	37	39	41	43	38	30	0,152	62	93	111
1,80	35	15	4:/:/	1,85	0,33	1,17	30,1	198	298	105	63	37	39	41	43	37	29	0,138	58	88	105
2,00	37	15	4:/:/	1,85	0,37	1,23	28,3	210	315	111	62	37	39	41	43	37	30	0,136	62	93	111
2,20	40	15	4:/:/	1,85	0,41	1,33	27,7	227	340	120	62	37	39	41	43	37	30	0,137	67	100	120
2,40	43	16	4:/:/	1,85	0,44	1,43	27,2	244	366	129	63	37	39	41	43	37	30	0,138	72	108	129
2,60	43	16	4:/:/	1,85	0,48	1,43	24,6	244	366	129	61	37	39	41	43	36	30	0,133	72	108	129
2,80	30	25	4:/:/	1,85	0,52	1,00	14,3	170	255	90	47	35	37	39	42	34	29	0,096	50	75	90
3,00	32	25	4:/:/	1,85	0,55	1,07	14,2	181	272	96	47	35	37	39	42	34	29	0,097	53	80	96
3,20	44	35	3:/:/	1,85	0,59	--	--	--	--	--	57	36	38	40	43	35	31	0,121	73	110	132
3,40	55	41	3:/:/	1,85	0,63	--	--	--	--	--	63	37	39	41	43	36	31	0,138	92	138	165
3,60	248	124	3:/:/	1,85	0,67	--	--	--	--	--	100	42	43	45	46	43	39	0,258	413	620	744
3,80	350	150	3:/:/	1,85	0,70	--	--	--	--	--	100	42	43	45	46	44	40	0,258	583	875	1050
4,00	420	157	3:/:/	1,85	0,74	--	--	--	--	--	100	42	43	45	46	44	40	0,258	700	1050	1260
4,20	500	--	3:/:/	1,85	0,78	--	--	--	--	--	100	42	43	45	46	45	40	0,258	833	1250	1500

**PROVA PENETROMETRICA DINAMICA
DIAGRAMMA NUMERO COLPI PUNTA - Rpd****DIN 6**

Scala 1: 50

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via A. Fiori
- note : Prova eseguita in continuità con CPT6

- data : 28/10/2010
- quota inizio : -4.0 m da p.c.a.
- prof. falda : 0,00 m da quota inizio
- pagina : 1

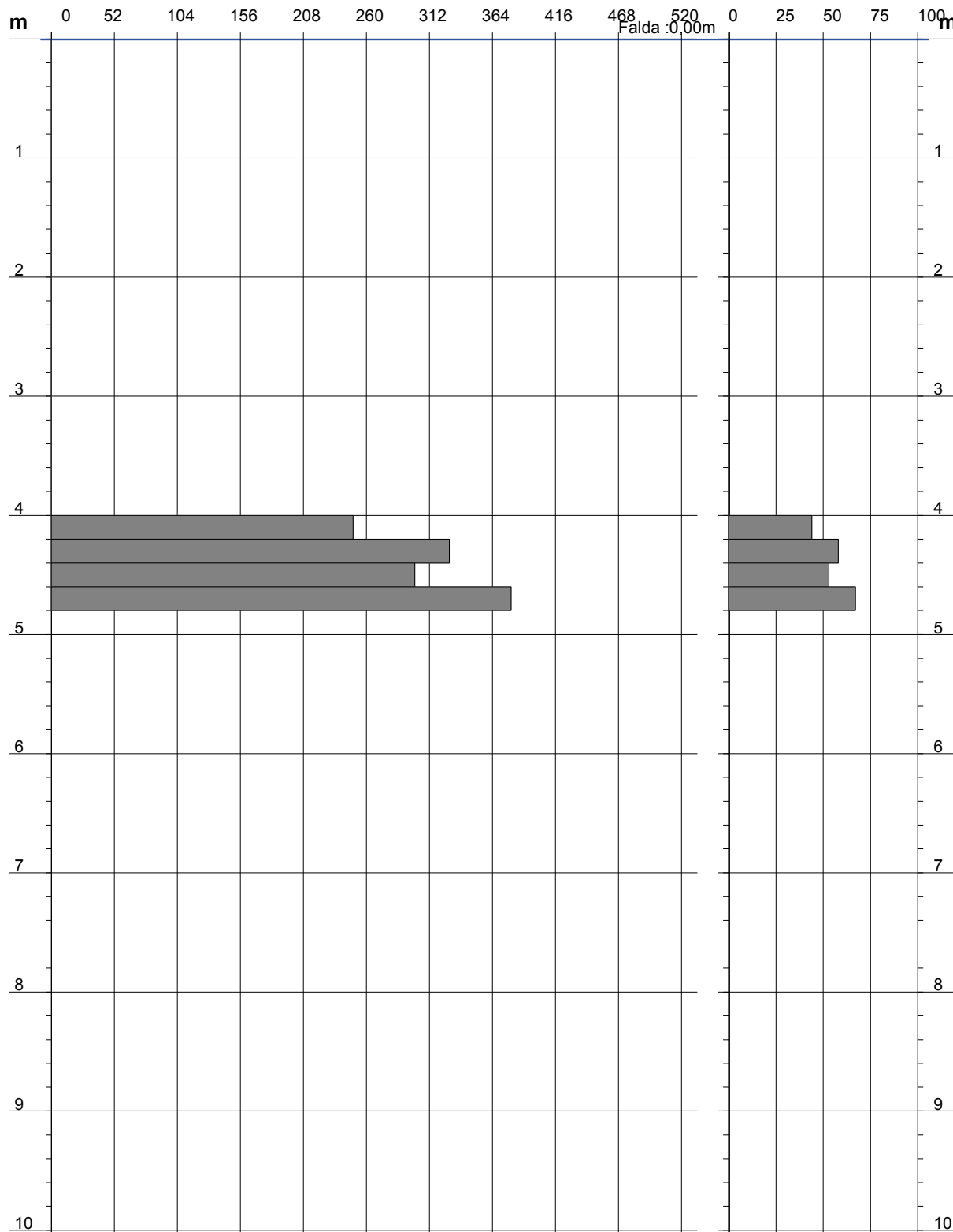


**PROVA PENETROMETRICA DINAMICA
DIAGRAMMA RESISTENZA DINAMICA PUNTA****DIN 6**

Scala 1: 50

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via A. Fiori

- data : 28/10/2010
- quota inizio : -4.0 m da p.c.a.
- prof. falda : 0,00 m da quota inizio

Rpd (kg/cm²) Resistenza dinamica alla punta, formula "Olandese"**N = N(20) n°colpi $\delta = 20$** 

PROVA PENETROMETRICA STATICA **LETTURE DI CAMPAGNA / VALORI DI RESISTENZA**

CPT 7

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Pascoli
 - resp. cantiere :
 - assist. cantiere :

- data : 28/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

prf	L1	L2	qc	fs	qc/fs	prf	L1	L2	qc	fs	qc/fs
m	-	-	Kg/cm ²	Kg/cm ²	-	m	-	-	Kg/cm ²	Kg/cm ²	-
0,20	21,0	----	21,0	1,20	17,0	2,80	22,0	44,0	22,0	1,13	19,0
0,40	58,0	76,0	58,0	2,33	25,0	3,00	18,0	35,0	18,0	0,87	21,0
0,60	40,0	75,0	40,0	1,53	26,0	3,20	24,0	37,0	24,0	1,13	21,0
0,80	65,0	88,0	65,0	2,67	24,0	3,40	23,0	40,0	23,0	1,13	20,0
1,00	40,0	80,0	40,0	2,27	18,0	3,60	17,0	34,0	17,0	1,00	17,0
1,20	31,0	65,0	31,0	2,00	16,0	3,80	18,0	33,0	18,0	1,00	18,0
1,40	27,0	57,0	27,0	1,73	16,0	4,00	14,0	29,0	14,0	0,73	19,0
1,60	26,0	52,0	26,0	1,73	15,0	4,20	19,0	30,0	19,0	1,00	19,0
1,80	29,0	55,0	29,0	1,47	20,0	4,40	235,0	250,0	235,0	1,67	141,0
2,00	24,0	46,0	24,0	1,67	14,0	4,60	305,0	330,0	305,0	2,00	152,0
2,20	25,0	50,0	25,0	1,73	14,0	4,80	380,0	410,0	380,0	2,33	163,0
2,40	24,0	50,0	24,0	1,73	14,0	5,00	450,0	485,0	450,0	2,67	169,0
2,60	43,0	69,0	43,0	1,47	29,0	5,20	520,0	560,0	520,0	-----	----

- PENETROMETRO STATICO tipo da 20 t - (con anello allargatore) -
 - COSTANTE DI TRASFORMAZIONE Ct = 10 - Velocità avanzamento punta 2 cm/s
 - punta meccanica tipo Begemann $\phi = 35.7$ mm (area punta 10 cm² - apertura 60°)
 - manicotto laterale (superficie 150 cm²)

PROVA PENETROMETRICA DINAMICA TABELLE VALORI DI RESISTENZA

DIN 7

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via A. Fiori
 - note : Prova eseguita in continuità con CPT7

- data : 28/10/2010
 - quota inizio : -5.0 m da p.c.a.
 - prof. falda : 0,00 m da quota inizio
 - pagina : 1

Prof.(m)	N(colpi p)	Rpd(kg/cm ²)	N(colpi r)	asta	Prof.(m)	N(colpi p)	Rpd(kg/cm ²)	N(colpi r)	asta
0,00 - 0,20	----	----	----	1	2,80 - 3,00	----	----	----	4
0,20 - 0,40	----	----	----	1	3,00 - 3,20	----	----	----	4
0,40 - 0,60	----	----	----	1	3,20 - 3,40	----	----	----	4
0,60 - 0,80	----	----	----	1	3,40 - 3,60	----	----	----	4
0,80 - 1,00	----	----	----	2	3,60 - 3,80	----	----	----	4
1,00 - 1,20	----	----	----	2	3,80 - 4,00	----	----	----	5
1,20 - 1,40	----	----	----	2	4,00 - 4,20	----	----	----	5
1,40 - 1,60	----	----	----	2	4,20 - 4,40	----	----	----	5
1,60 - 1,80	----	----	----	2	4,40 - 4,60	----	----	----	5
1,80 - 2,00	----	----	----	3	4,60 - 4,80	----	----	----	5
2,00 - 2,20	----	----	----	3	4,80 - 5,00	----	----	----	6
2,20 - 2,40	----	----	----	3	5,00 - 5,20	61	325,9	----	6
2,40 - 2,60	----	----	----	3	5,20 - 5,40	68	363,3	----	6
2,60 - 2,80	----	----	----	3					

- PENETROMETRO DINAMICO tipo : **EMILIA (20)**

- M (massa battente)= **63,50** kg - H (altezza caduta)= **0,75** m - A (area punta)= **20,00** cm² - D(diam. punta)= **50,50** mm

- Numero Colpi Punta N = N(**20**) [δ = 20 cm]

- Uso rivestimento / fanghi iniezione : **SI**

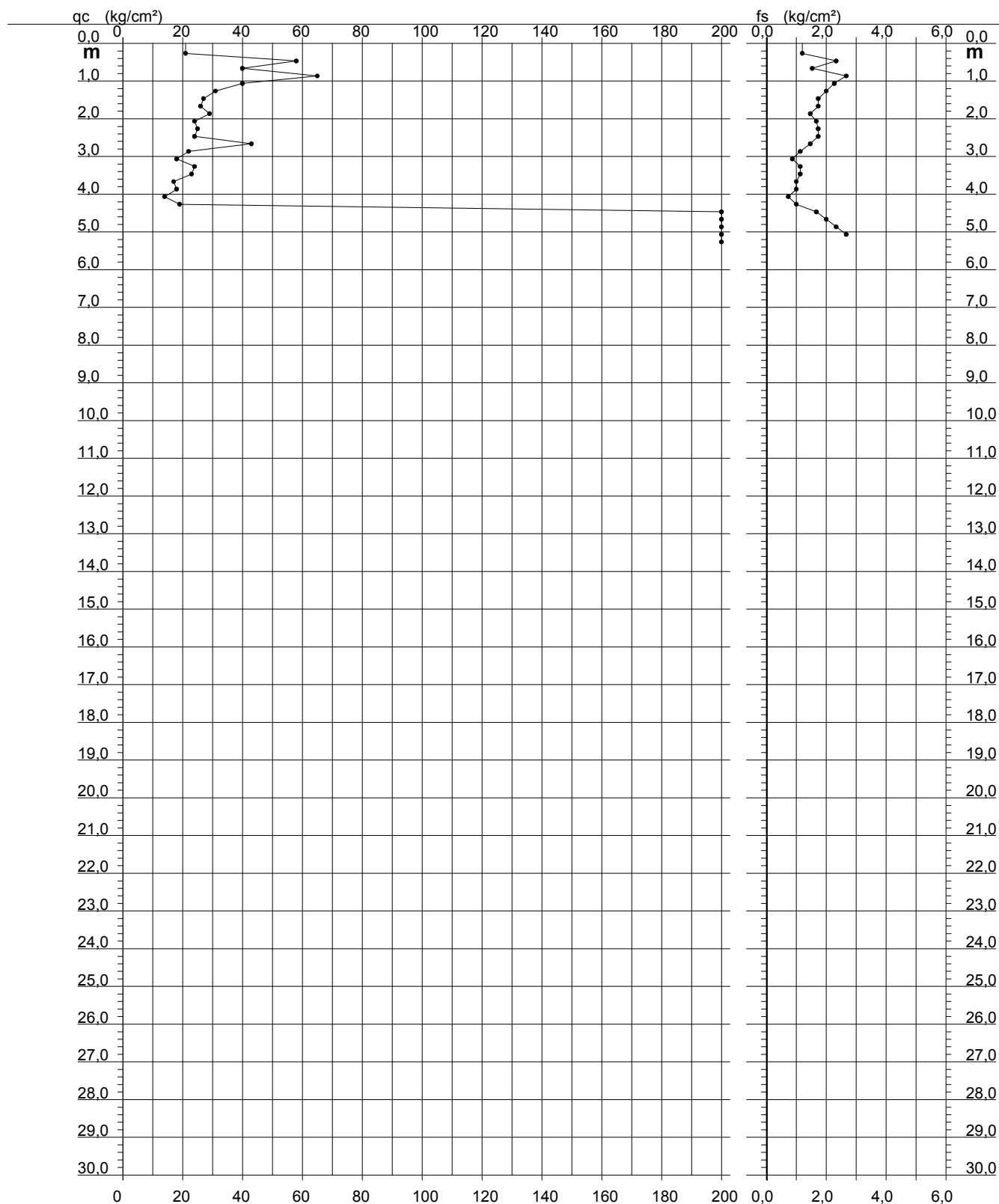
**PROVA PENETROMETRICA STATICA
DIAGRAMMA DI RESISTENZA****CPT 7**

2.0105-PG037

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via Pascoli
- resp. cantiere :
- assist. cantiere :

- data : 28/10/2010
- quota inizio : Piano Campagna
- falda : Falda non rilevata

- data di emissione :
03/11/2010



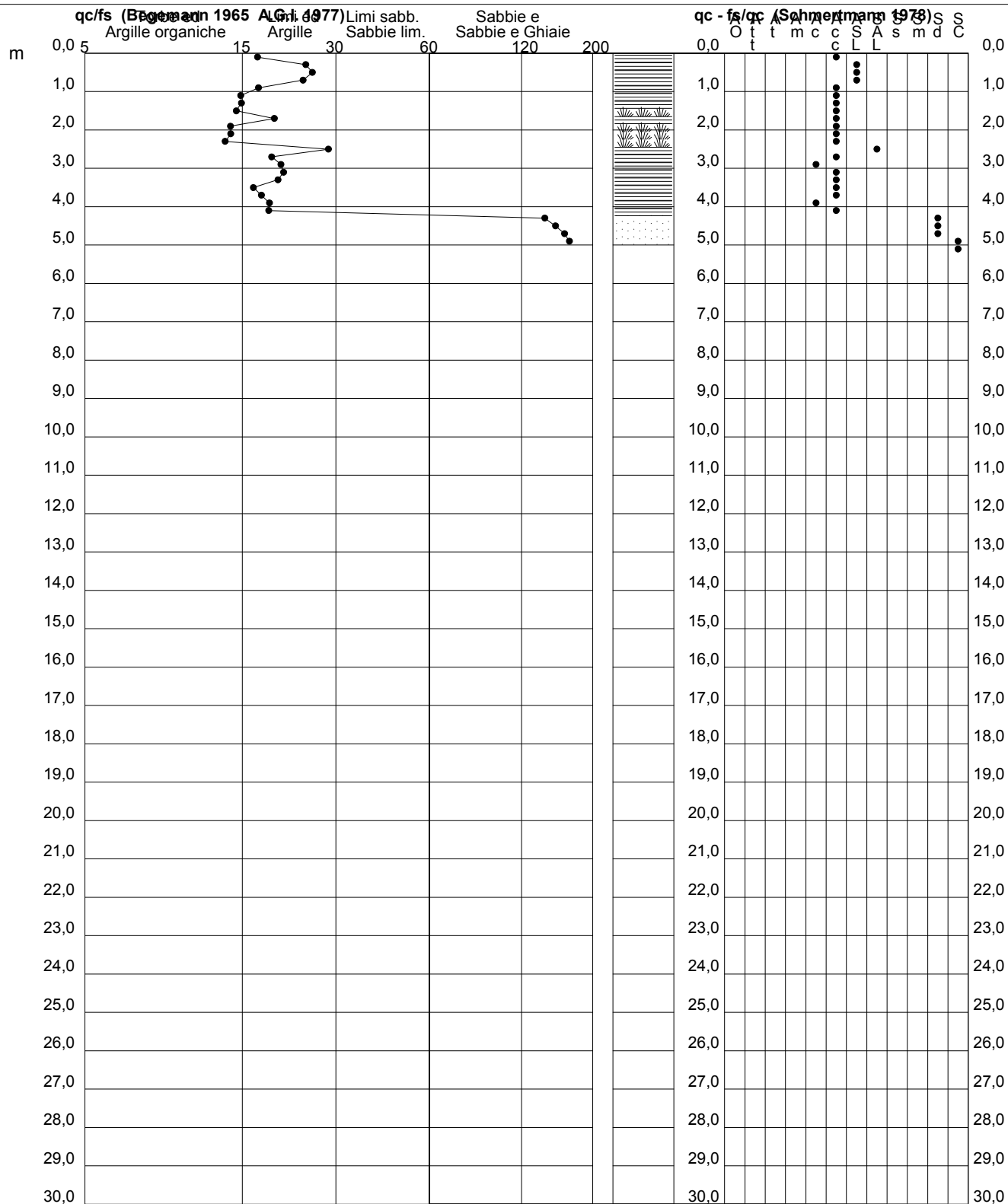
PROVA PENETROMETRICA STATICA **VALUTAZIONI LITOLOGICHE**

CPT 7

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Pascoli
 - resp. cantiere :
 - assist. cantiere :

- data : 28/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010



PROVA PENETROMETRICA STATICA **TABELLA PARAMETRI GEOTECNICI**

CPT 7

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Pascoli
 - resp. cantiere :
 - assist. cantiere :

- data : 28/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

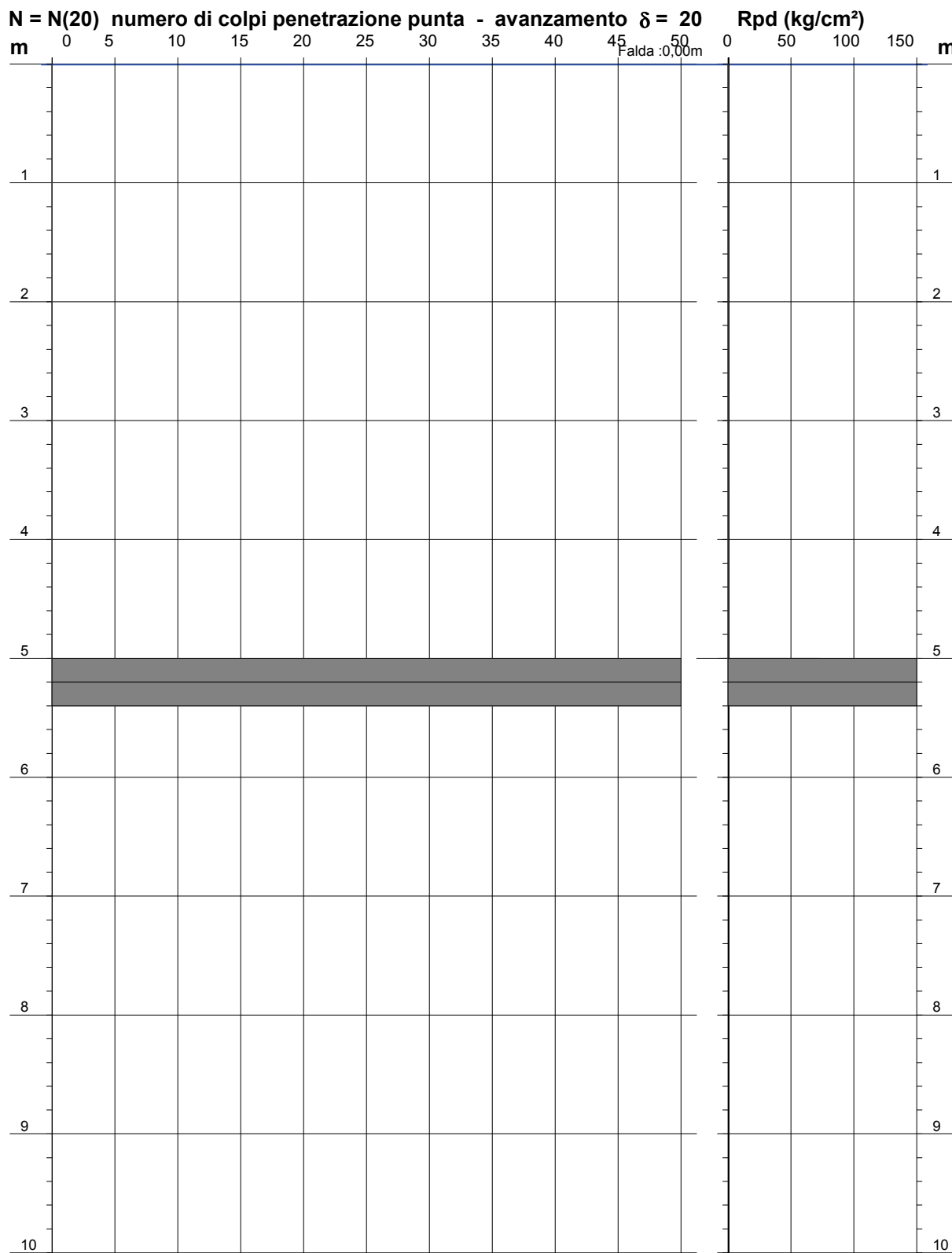
NATURA COESIVA											NATURA GRANULARE										
Prof. m	qc kg/cm²	qc/fs (-)	Natura Litol.	Y' t/m³	p'vo kg/cm²	Cu kg/cm²	OCR (-)	Eu50 kg/cm²	Eu25 kg/cm²	Mo kg/cm²	Dr %	ø1s (°)	ø2s (°)	ø3s (°)	ø4s (°)	ødm (°)	ømy (°)	Amax/g (-)	E'50 kg/cm²	E'25 kg/cm²	Mo
0,20	21	17	4/1:	1,85	0,04	0,82	99,9	140	210	63	99	42	43	44	46	44	27	0,254	35	53	63
0,40	58	25	4/1:	1,85	0,07	1,93	99,9	329	493	174	100	42	43	45	46	45	31	0,258	97	145	174
0,60	40	26	4/1:	1,85	0,11	1,33	99,9	227	340	120	94	41	43	44	46	43	30	0,237	67	100	120
0,80	65	24	4/1:	1,85	0,15	2,17	99,9	368	553	195	100	42	43	45	46	43	32	0,258	108	163	195
1,00	40	18	4/1:	1,85	0,19	1,33	74,1	227	340	120	82	39	41	43	45	40	30	0,195	67	100	120
1,20	31	16	4/1:	1,85	0,22	1,03	42,9	176	264	93	68	38	39	41	43	39	29	0,155	52	78	93
1,40	27	16	4/1:	1,85	0,26	0,95	31,8	161	242	81	60	36	38	41	43	37	28	0,130	45	68	81
1,60	26	15	4/1:	1,85	0,30	0,93	26,2	158	237	78	55	36	38	40	42	36	28	0,118	43	65	78
1,80	29	20	4/1:	1,85	0,33	0,98	24,3	167	251	87	56	36	38	40	43	36	29	0,120	48	73	87
2,00	24	14	4/1:	1,85	0,37	0,89	18,8	151	227	72	47	35	37	39	42	35	28	0,097	40	60	72
2,20	25	14	4/1:	1,85	0,41	0,91	17,1	155	232	75	46	34	37	39	42	34	28	0,095	42	63	75
2,40	24	14	4/1:	1,85	0,44	0,89	15,0	151	227	72	43	34	36	39	41	34	28	0,086	40	60	72
2,60	43	29	4/1:	1,85	0,48	1,43	24,6	244	366	129	61	37	39	41	43	36	30	0,133	72	108	129
2,80	22	19	4/1:	1,85	0,52	0,85	11,6	144	216	66	36	33	36	38	41	32	28	0,071	37	55	66
3,00	18	21	2/III	1,85	0,55	0,75	9,1	132	198	56	--	--	--	--	--	--	--	--	--	--	--
3,20	24	21	4/1:	1,85	0,59	0,89	10,4	151	227	72	36	33	36	38	41	32	28	0,070	40	60	72
3,40	23	20	4/1:	1,85	0,63	0,87	9,4	150	226	69	33	33	35	38	41	31	28	0,064	38	58	69
3,60	17	17	2/III	1,85	0,67	0,72	7,0	167	251	54	--	--	--	--	--	--	--	--	--	--	--
3,80	18	18	2/III	1,85	0,70	0,75	6,8	178	267	56	--	--	--	--	--	--	--	--	--	--	--
4,00	14	19	2/III	1,85	0,74	0,64	5,2	203	304	48	--	--	--	--	--	--	--	--	--	--	--
4,20	19	19	2/III	1,85	0,78	0,78	6,3	203	304	58	--	--	--	--	--	--	--	--	--	--	--
4,40	235	141	3:::	1,85	0,81	--	--	--	--	--	100	42	43	45	46	42	39	0,258	392	588	705
4,60	305	152	3:::	1,85	0,85	--	--	--	--	--	100	42	43	45	46	43	40	0,258	508	763	915
4,80	380	163	3:::	1,85	0,89	--	--	--	--	--	100	42	43	45	46	43	40	0,258	633	950	1140
5,00	450	169	3:::	1,85	0,93	--	--	--	--	--	100	42	43	45	46	44	40	0,258	750	1125	1350
5,20	520	--	3:::	1,85	0,96	--	--	--	--	--	100	42	43	45	46	44	40	0,258	867	1300	1560

**PROVA PENETROMETRICA DINAMICA
DIAGRAMMA NUMERO COLPI PUNTA - Rpd****DIN 7**

Scala 1: 50

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via A. Fiori
- note : Prova eseguita in continuità con CPT7

- data : 28/10/2010
- quota inizio : -5.0 m da p.c.a.
- prof. falda : 0,00 m da quota inizio
- pagina : 1



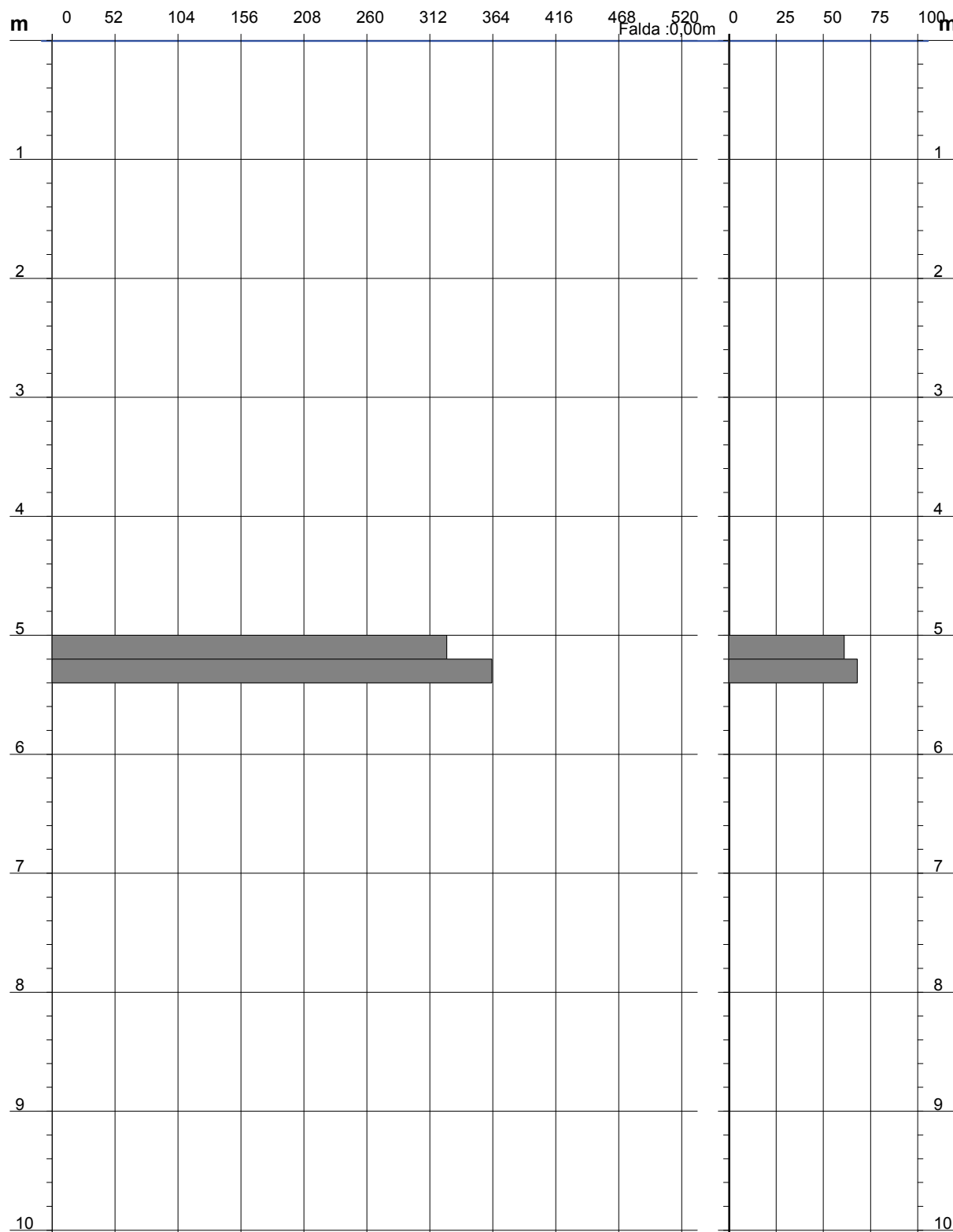
PROVA PENETROMETRICA DINAMICA DIAGRAMMA RESISTENZA DINAMICA PUNTA

DIN 7

Scala 1: 50

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via A. Fiori

- data : 28/10/2010
- quota inizio : -5.0 m da p.c.a.
- prof. falda : 0,00 m da quota inizio

Rpd (kg/cm²) Resistenza dinamica alla punta, formula "Olandese"N = N(20) n° colpi $\delta = 20$ 

PROVA PENETROMETRICA STATICA **LETTURE DI CAMPAGNA / VALORI DI RESISTENZA**

CPT 8

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Pascoli
 - resp. cantiere :
 - assist. cantiere :

- data : 28/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

prf	L1	L2	qc	fs	qc/fs	prf	L1	L2	qc	fs	qc/fs
m	-	-	Kg/cm ²	Kg/cm ²	-	m	-	-	Kg/cm ²	Kg/cm ²	-
0,20	15,0	----	15,0	0,80	19,0	2,20	35,0	69,0	35,0	2,20	16,0
0,40	12,0	24,0	12,0	0,73	16,0	2,40	31,0	64,0	31,0	2,00	16,0
0,60	11,0	22,0	11,0	0,73	15,0	2,60	30,0	60,0	30,0	1,93	16,0
0,80	13,0	24,0	13,0	0,93	14,0	2,80	34,0	63,0	34,0	2,13	16,0
1,00	35,0	49,0	35,0	1,33	26,0	3,00	51,0	83,0	51,0	1,47	35,0
1,20	112,0	132,0	112,0	2,93	38,0	3,20	222,0	244,0	222,0	2,00	111,0
1,40	74,0	118,0	74,0	2,20	34,0	3,40	300,0	330,0	300,0	2,33	129,0
1,60	39,0	72,0	39,0	2,47	16,0	3,60	380,0	415,0	380,0	2,33	163,0
1,80	38,0	75,0	38,0	2,33	16,0	3,80	450,0	485,0	450,0	2,67	169,0
2,00	37,0	72,0	37,0	2,27	16,0	4,00	530,0	570,0	530,0	-----	----

- PENETROMETRO STATICO tipo da 20 t - (con anello allargatore) -
 - COSTANTE DI TRASFORMAZIONE Ct = 10 - Velocità avanzamento punta 2 cm/s
 - punta meccanica tipo Begemann $\phi = 35.7$ mm (area punta 10 cm² - apertura 60°)
 - manicotto laterale (superficie 150 cm²)

PROVA PENETROMETRICA DINAMICA TABELLE VALORI DI RESISTENZA

DIN 8

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via A. Fiori
 - note : Prova eseguita in continuità con CPT8

- data : 28/10/2010
 - quota inizio : -3.8 m da p.c.a.
 - prof. falda : 0,00 m da quota inizio
 - pagina : 1

Prof.(m)	N(colpi p)	Rpd(kg/cm ²)	N(colpi r)	asta	Prof.(m)	N(colpi p)	Rpd(kg/cm ²)	N(colpi r)	asta
0,00 - 0,20	----	----	----	1	2,40 - 2,60	----	----	----	3
0,20 - 0,40	----	----	----	1	2,60 - 2,80	----	----	----	3
0,40 - 0,60	----	----	----	1	2,80 - 3,00	----	----	----	4
0,60 - 0,80	----	----	----	1	3,00 - 3,20	----	----	----	4
0,80 - 1,00	----	----	----	2	3,20 - 3,40	----	----	----	4
1,00 - 1,20	----	----	----	2	3,40 - 3,60	----	----	----	4
1,20 - 1,40	----	----	----	2	3,60 - 3,80	----	----	----	4
1,40 - 1,60	----	----	----	2	3,80 - 4,00	48	271,8	----	5
1,60 - 1,80	----	----	----	2	4,00 - 4,20	54	305,8	----	5
1,80 - 2,00	----	----	----	3	4,20 - 4,40	60	339,8	----	5
2,00 - 2,20	----	----	----	3	4,40 - 4,60	53	300,2	----	5
2,20 - 2,40	----	----	----	3	4,60 - 4,80	64	362,4	----	5

- PENETROMETRO DINAMICO tipo : **EMILIA (20)**

- M (massa battente)= **63,50** kg - H (altezza caduta)= **0,75** m - A (area punta)= **20,00** cm² - D(diam. punta)= **50,50** mm

- Numero Colpi Punta N = N(**20**) [δ = 20 cm]

- Uso rivestimento / fanghi iniezione : **SI**

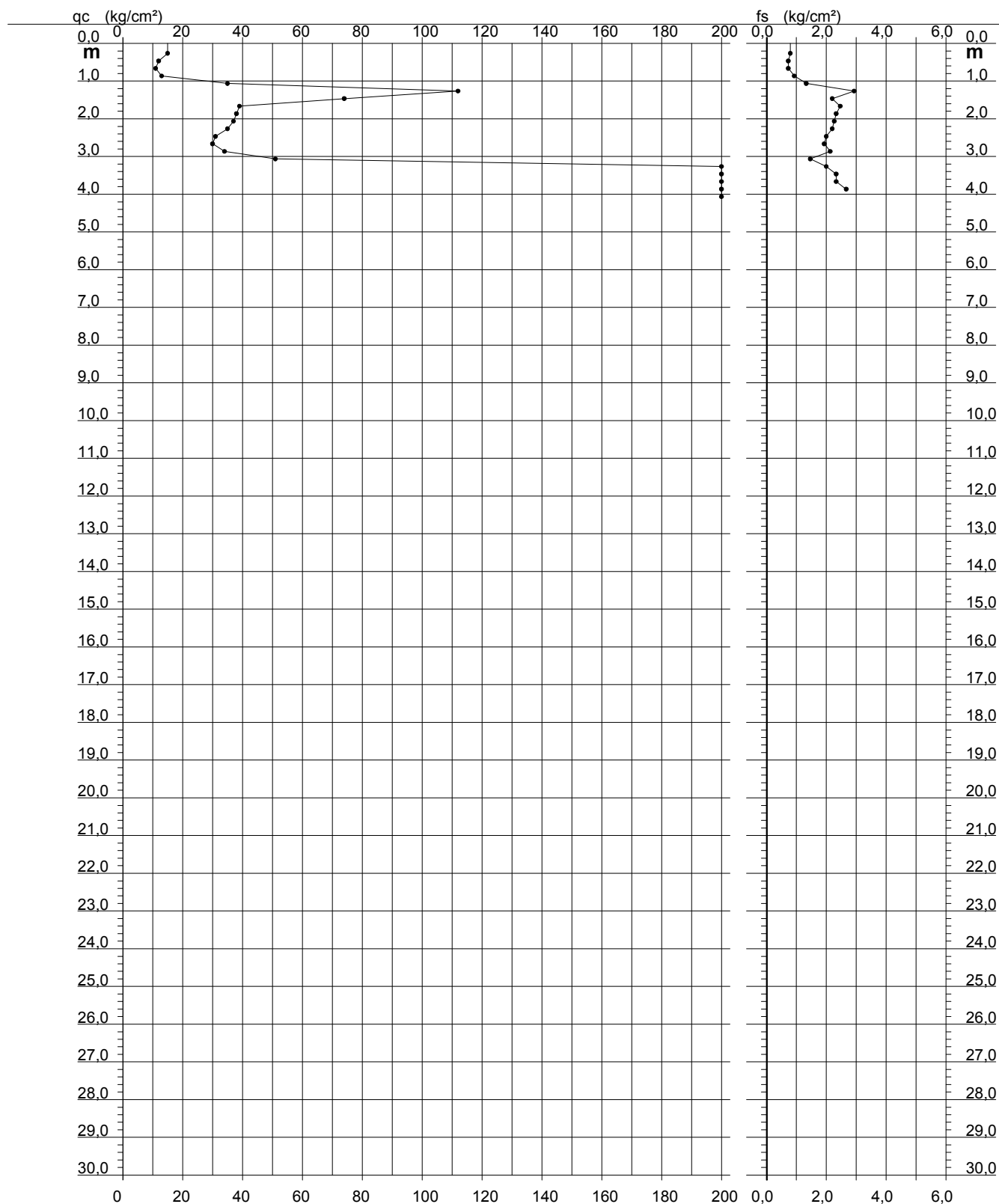
**PROVA PENETROMETRICA STATICA
DIAGRAMMA DI RESISTENZA****CPT 8**

2.0105-PG037

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via Pascoli
- resp. cantiere :
- assist. cantiere :

- data : 28/10/2010
- quota inizio : Piano Campagna
- falda : Falda non rilevata

- data di emissione :
03/11/2010



PROVA PENETROMETRICA STATICA VALUTAZIONI LITOLOGICHE

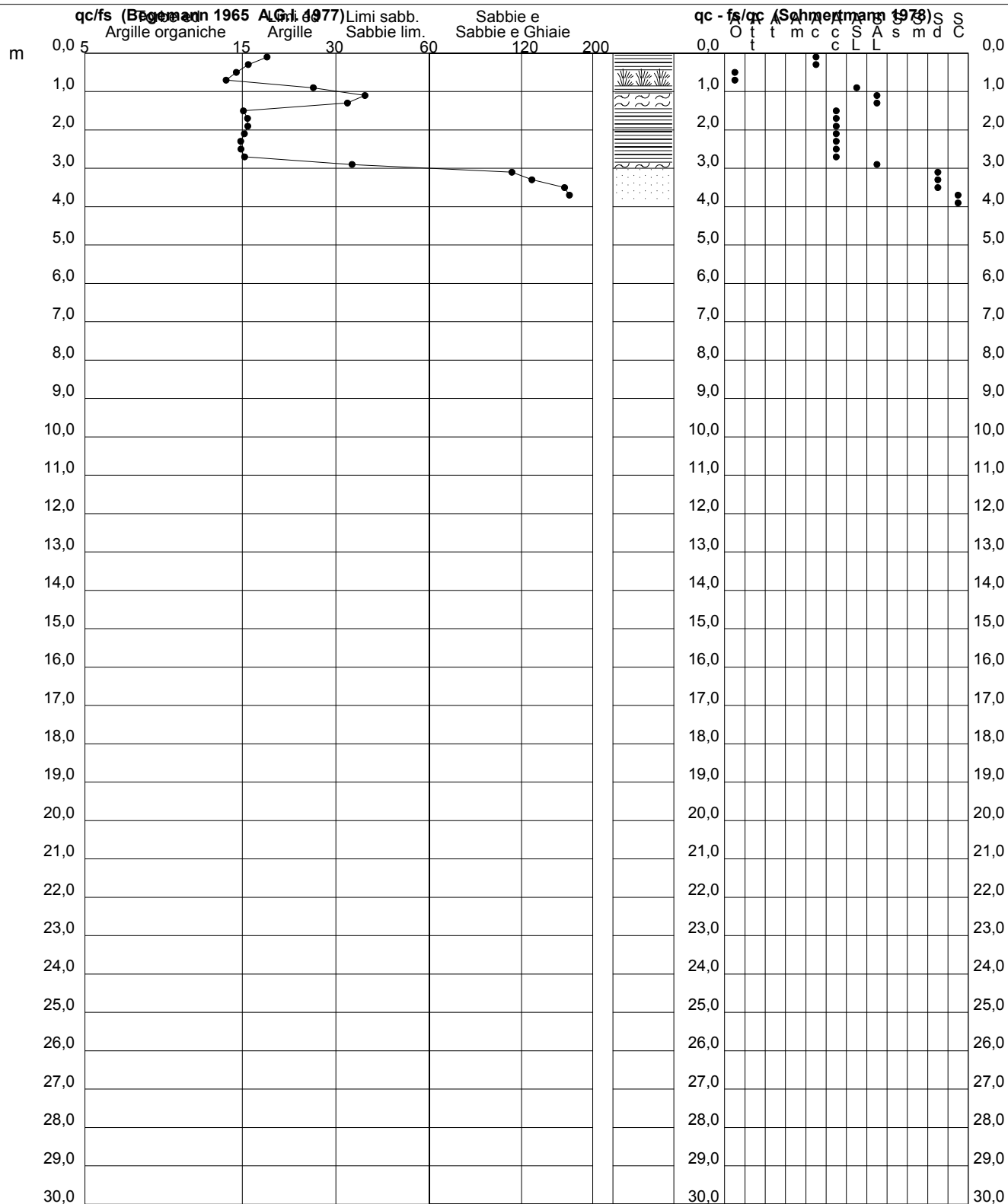
CPT 8

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Pascoli
 - resp. cantiere :
 - assist. cantiere :

- data : 28/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata

- data di emissione :
 03/11/2010



PROVA PENETROMETRICA STATICA **TABELLA PARAMETRI GEOTECNICI**

CPT 8

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Pascoli
 - resp. cantiere :
 - assist. cantiere :

- data : 28/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

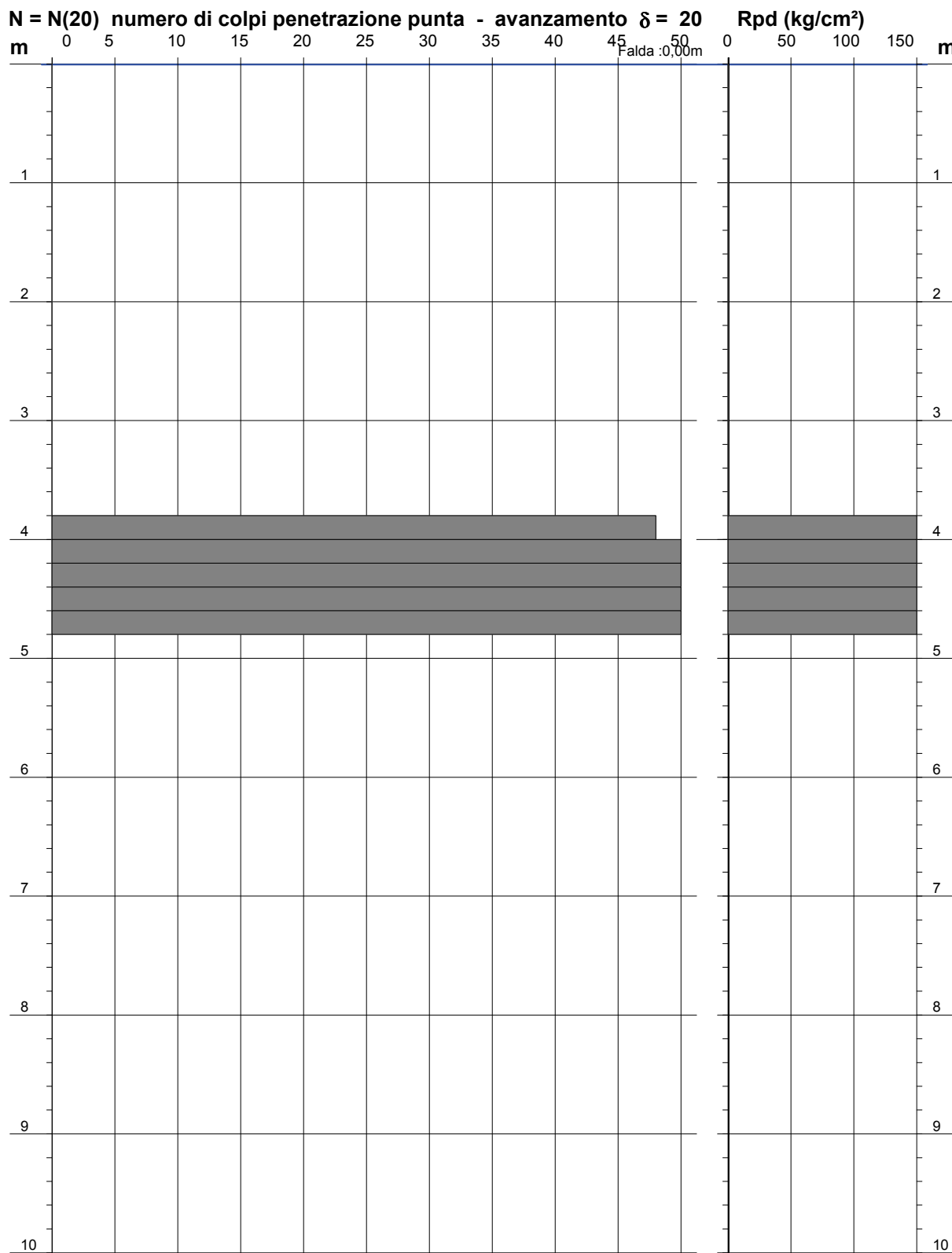
NATURA COESIVA											NATURA GRANULARE										
Prof. m	qc kg/cm²	qc/fs (-)	Natura Litol.	Y' t/m³	p'vo kg/cm²	Cu kg/cm²	OCR (-)	Eu50 kg/cm²	Eu25 kg/cm²	Mo kg/cm²	Dr %	ø1s (°)	ø2s (°)	ø3s (°)	ø4s (°)	ødm (°)	ømy (°)	Amax/g (-)	E'50 kg/cm²	E'25 kg/cm²	Mo kg/cm²
0,20	15	19	2////	1,85	0,04	0,67	99,9	113	170	50	--	--	--	--	--	--	--	--	--	--	--
0,40	12	16	2////	1,85	0,07	0,57	80,8	97	146	45	--	--	--	--	--	--	--	--	--	--	--
0,60	11	15	2////	1,85	0,11	0,54	45,0	91	137	42	--	--	--	--	--	--	--	--	--	--	--
0,80	13	14	2////	1,85	0,15	0,60	36,5	103	154	47	--	--	--	--	--	--	--	--	--	--	--
1,00	35	26	4/./.	1,85	0,19	1,17	62,7	198	298	105	77	39	40	42	44	40	29	0,181	58	88	105
1,20	112	38	3....	1,85	0,22	--	--	--	--	--	100	42	43	45	46	44	34	0,258	187	280	336
1,40	74	34	3....	1,85	0,26	--	--	--	--	--	95	41	43	44	46	42	32	0,239	123	185	222
1,60	39	16	4/./.	1,85	0,30	1,30	39,9	221	332	117	69	38	40	42	44	38	30	0,157	65	98	117
1,80	38	16	4/./.	1,85	0,33	1,27	33,4	215	323	114	66	37	39	41	43	38	30	0,146	63	95	114
2,00	37	16	4/./.	1,85	0,37	1,23	28,3	210	315	111	62	37	39	41	43	37	30	0,136	62	93	111
2,20	35	16	4/./.	1,85	0,41	1,17	23,4	198	298	105	58	36	38	40	43	36	29	0,125	58	88	105
2,40	31	16	4/./.	1,85	0,44	1,03	18,0	176	264	93	52	35	37	40	42	35	29	0,108	52	78	93
2,60	30	16	4/./.	1,85	0,48	1,00	15,7	170	255	90	48	35	37	39	42	34	29	0,100	50	75	90
2,80	34	16	4/./.	1,85	0,52	1,13	16,7	193	289	102	51	35	37	40	42	35	29	0,106	57	85	102
3,00	51	35	3....	1,85	0,55	--	--	--	--	--	63	37	39	41	43	37	31	0,139	85	128	153
3,20	222	111	3....	1,85	0,59	--	--	--	--	--	100	42	43	45	46	43	38	0,258	370	555	666
3,40	300	129	3....	1,85	0,63	--	--	--	--	--	100	42	43	45	46	44	40	0,258	500	750	900
3,60	380	163	3....	1,85	0,67	--	--	--	--	--	100	42	43	45	46	44	40	0,258	633	950	1140
3,80	450	169	3....	1,85	0,70	--	--	--	--	--	100	42	43	45	46	45	40	0,258	750	1125	1350
4,00	530	--	3....	1,85	0,74	--	--	--	--	--	100	42	43	45	46	45	40	0,258	883	1325	1590

**PROVA PENETROMETRICA DINAMICA
DIAGRAMMA NUMERO COLPI PUNTA - Rpd****DIN 8**

Scala 1: 50

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via A. Fiori
- note : Prova eseguita in continuità con CPT8

- data : 28/10/2010
- quota inizio : -3.8 m da p.c.a.
- prof. falda : 0,00 m da quota inizio
- pagina : 1



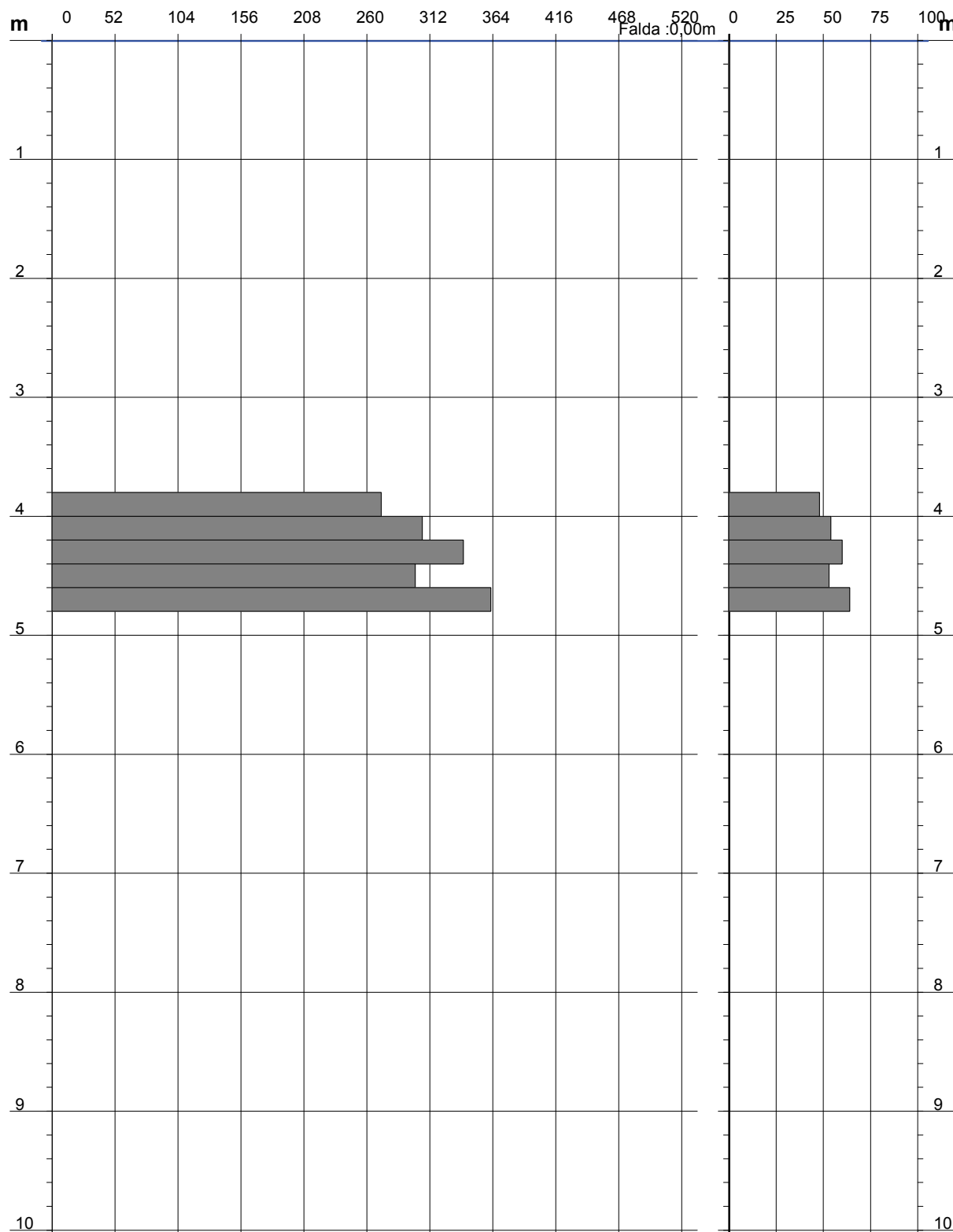
PROVA PENETROMETRICA DINAMICA DIAGRAMMA RESISTENZA DINAMICA PUNTA

DIN 8

Scala 1: 50

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via A. Fiori

- data : 28/10/2010
- quota inizio : -3.8 m da p.c.a.
- prof. falda : 0,00 m da quota inizio

Rpd (kg/cm²) Resistenza dinamica alla punta, formula "Olandese"N = N(20) n° colpi $\delta = 20$ 

PROVA PENETROMETRICA STATICA **LETTURE DI CAMPAGNA / VALORI DI RESISTENZA**

CPT 9

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Alessandri
 - resp. cantiere :
 - assist. cantiere :

- data : 28/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

prf	L1	L2	qc	fs	qc/fs	prf	L1	L2	qc	fs	qc/fs
m	-	-	Kg/cm ²	Kg/cm ²	-	m	-	-	Kg/cm ²	Kg/cm ²	-
0,20	13,0	----	13,0	0,73	18,0	1,80	40,0	99,0	40,0	2,33	17,0
0,40	16,0	27,0	16,0	1,00	16,0	2,00	135,0	170,0	135,0	1,53	88,0
0,60	13,0	28,0	13,0	0,87	15,0	2,20	202,0	225,0	202,0	1,87	108,0
0,80	14,0	27,0	14,0	0,87	16,0	2,40	253,0	281,0	253,0	2,00	126,0
1,00	35,0	48,0	35,0	2,13	16,0	2,60	350,0	380,0	350,0	2,33	150,0
1,20	36,0	68,0	36,0	2,40	15,0	2,80	430,0	465,0	430,0	2,67	161,0
1,40	41,0	77,0	41,0	2,67	15,0	3,00	530,0	570,0	530,0	-----	----
1,60	62,0	102,0	62,0	3,93	16,0						

- PENETROMETRO STATICO tipo da 20 t - (con anello allargatore) -
 - COSTANTE DI TRASFORMAZIONE Ct = 10 - Velocità avanzamento punta 2 cm/s
 - punta meccanica tipo Begemann $\phi = 35.7$ mm (area punta 10 cm² - apertura 60°)
 - manicotto laterale (superficie 150 cm²)

PROVA PENETROMETRICA DINAMICA TABELLE VALORI DI RESISTENZA

DIN 9

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via A. Fiori
 - note : Prova eseguita in continuità con CPT9

- data : 28/10/2010
 - quota inizio : -2.8 m da p.c.a.
 - prof. falda : 0,00 m da quota inizio
 - pagina : 1

Prof.(m)	N(colpi p)	Rpd(kg/cm ²)	N(colpi r)	asta	Prof.(m)	N(colpi p)	Rpd(kg/cm ²)	N(colpi r)	asta
0,00 - 0,20	----	----	----	1	1,80 - 2,00	----	----	----	3
0,20 - 0,40	----	----	----	1	2,00 - 2,20	----	----	----	3
0,40 - 0,60	----	----	----	1	2,20 - 2,40	----	----	----	3
0,60 - 0,80	----	----	----	1	2,40 - 2,60	----	----	----	3
0,80 - 1,00	----	----	----	2	2,60 - 2,80	----	----	----	3
1,00 - 1,20	----	----	----	2	2,80 - 3,00	55	331,3	----	4
1,20 - 1,40	----	----	----	2	3,00 - 3,20	51	307,2	----	4
1,40 - 1,60	----	----	----	2	3,20 - 3,40	63	379,5	----	4
1,60 - 1,80	----	----	----	2	3,40 - 3,60	70	421,7	----	4

- PENETROMETRO DINAMICO tipo : **EMILIA (20)**

- M (massa battente)= **63,50** kg - H (altezza caduta)= **0,75** m - A (area punta)= **20,00** cm² - D(diam. punta)= **50,50** mm

- Numero Colpi Punta N = N(**20**) [δ = 20 cm]

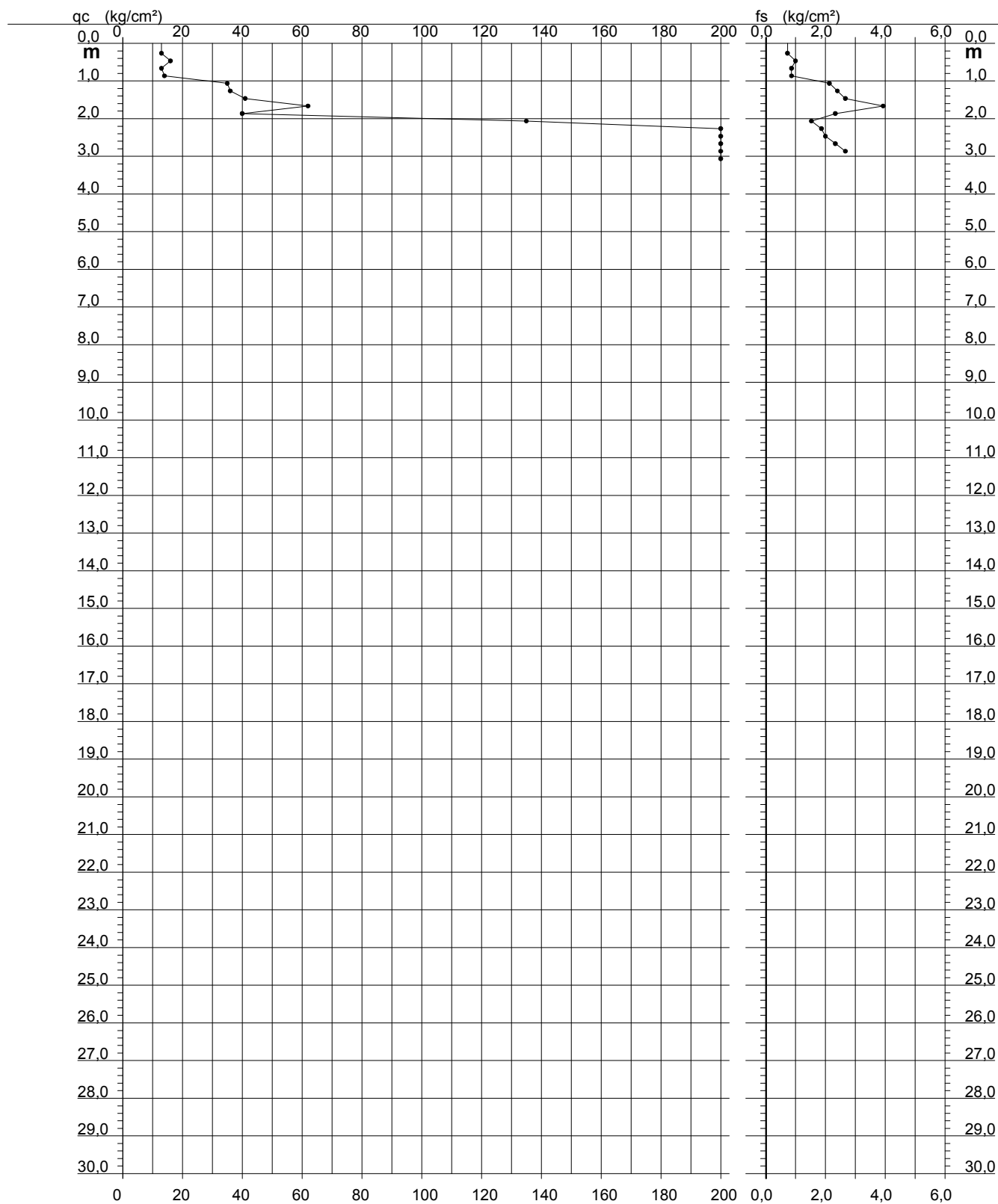
- Uso rivestimento / fanghi iniezione : **SI**

**PROVA PENETROMETRICA STATICA
DIAGRAMMA DI RESISTENZA****CPT 9**

2.0105-PG037

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via Alessandri
- resp. cantiere :
- assist. cantiere :

- data : 28/10/2010
- quota inizio : Piano Campagna
- falda : Falda non rilevata
- data di emissione : 03/11/2010

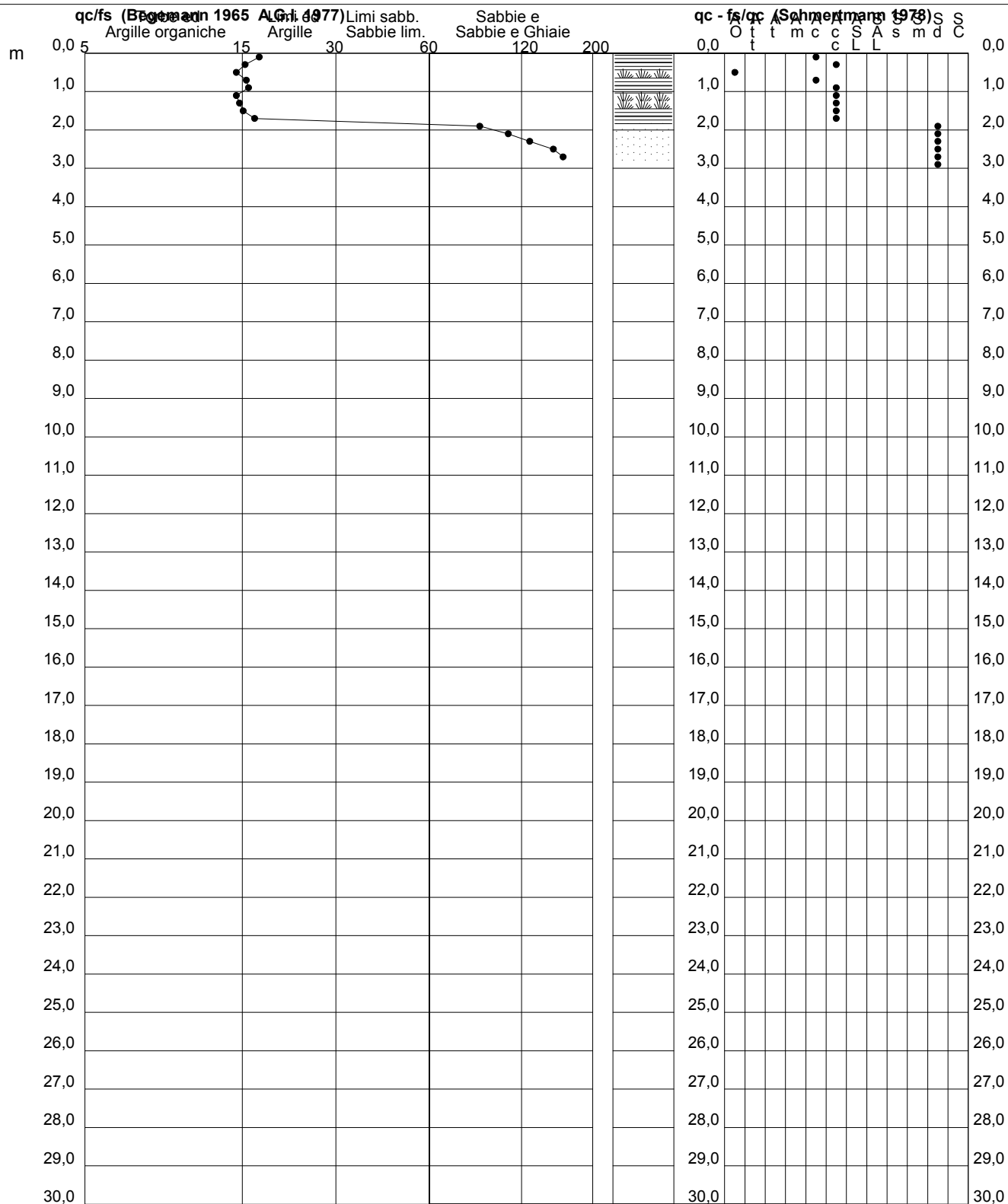


CPT 9

2.0105-PG037

- data : 28/10/2010
- quota inizio : Piano Campagna
- falda : Falda non rilevata

- data di emissione : 03/11/2010



PROVA PENETROMETRICA STATICA **TABELLA PARAMETRI GEOTECNICI**

CPT 9

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Alessandri
 - resp. cantiere :
 - assist. cantiere :

- data : 28/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

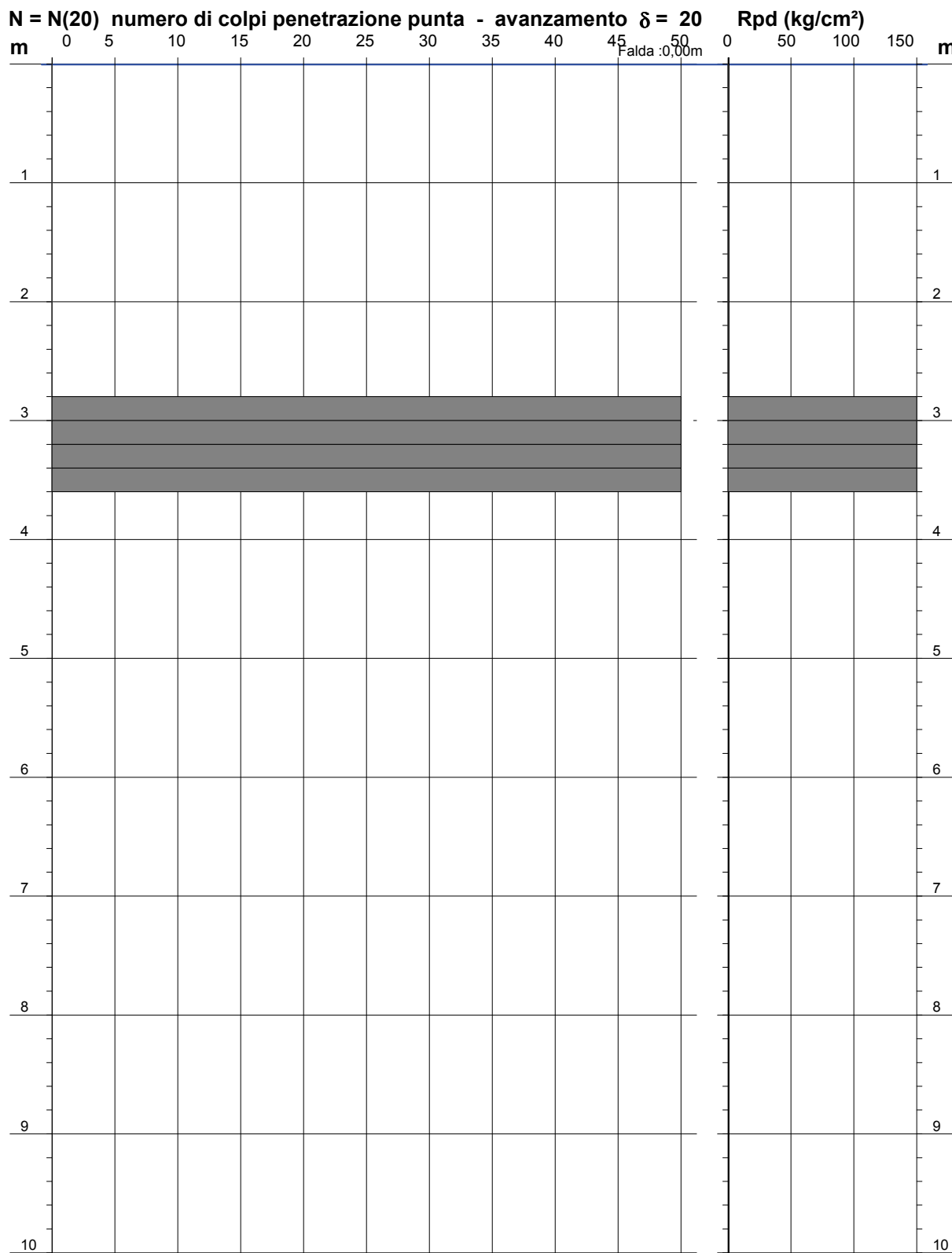
NATURA COESIVA											NATURA GRANULARE										
Prof. m	qc kg/cm ²	qc/fs (-)	Natura Litol.	Y' t/m ³	p'vo kg/cm ²	Cu kg/cm ²	OCR (-)	Eu50 kg/cm ²	Eu25 kg/cm ²	Mo kg/cm ²	Dr %	ø1s (°)	ø2s (°)	ø3s (°)	ø4s (°)	ødm (°)	ømy (°)	Amax/g (-)	E'50 kg/cm ²	E'25 kg/cm ²	Mo kg/cm ²
0,20	13	18	2////	1,85	0,04	0,60	99,9	103	154	47	--	--	--	--	--	--	--	--	--	--	--
0,40	16	16	2////	1,85	0,07	0,70	99,9	118	177	52	--	--	--	--	--	--	--	--	--	--	--
0,60	13	15	2////	1,85	0,11	0,60	52,2	103	154	47	--	--	--	--	--	--	--	--	--	--	--
0,80	14	16	2////	1,85	0,15	0,64	38,9	108	162	48	--	--	--	--	--	--	--	--	--	--	--
1,00	35	16	4/./	1,85	0,19	1,17	62,7	198	298	105	77	39	40	42	44	40	29	0,181	58	88	105
1,20	36	15	4/./	1,85	0,22	1,20	51,7	204	306	108	74	38	40	42	44	39	30	0,170	60	90	108
1,40	41	15	4/./	1,85	0,26	1,37	50,2	232	349	123	74	38	40	42	44	39	30	0,172	68	103	123
1,60	62	16	4/./	1,85	0,30	2,07	71,3	351	527	186	85	40	41	43	45	40	32	0,207	103	155	186
1,80	40	17	4/./	1,85	0,33	1,33	35,6	227	340	120	67	37	39	41	43	38	30	0,151	67	100	120
2,00	135	88	3....	1,85	0,37	--	--	--	--	--	100	42	43	45	46	43	35	0,258	225	338	405
2,20	202	108	3....	1,85	0,41	--	--	--	--	--	100	42	43	45	46	44	38	0,258	337	505	606
2,40	253	126	3....	1,85	0,44	--	--	--	--	--	100	42	43	45	46	44	39	0,258	422	633	759
2,60	350	150	3....	1,85	0,48	--	--	--	--	--	100	42	43	45	46	45	40	0,258	583	875	1050
2,80	430	161	3....	1,85	0,52	--	--	--	--	--	100	42	43	45	46	45	40	0,258	717	1075	1290
3,00	530	--	3....	1,85	0,55	--	--	--	--	--	100	42	43	45	46	45	40	0,258	883	1325	1590

**PROVA PENETROMETRICA DINAMICA
DIAGRAMMA NUMERO COLPI PUNTA - Rpd****DIN 9**

Scala 1: 50

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via A. Fiori
- note : Prova eseguita in continuità con CPT9

- data : 28/10/2010
- quota inizio : -2.8 m da p.c.a.
- prof. falda : 0,00 m da quota inizio
- pagina : 1

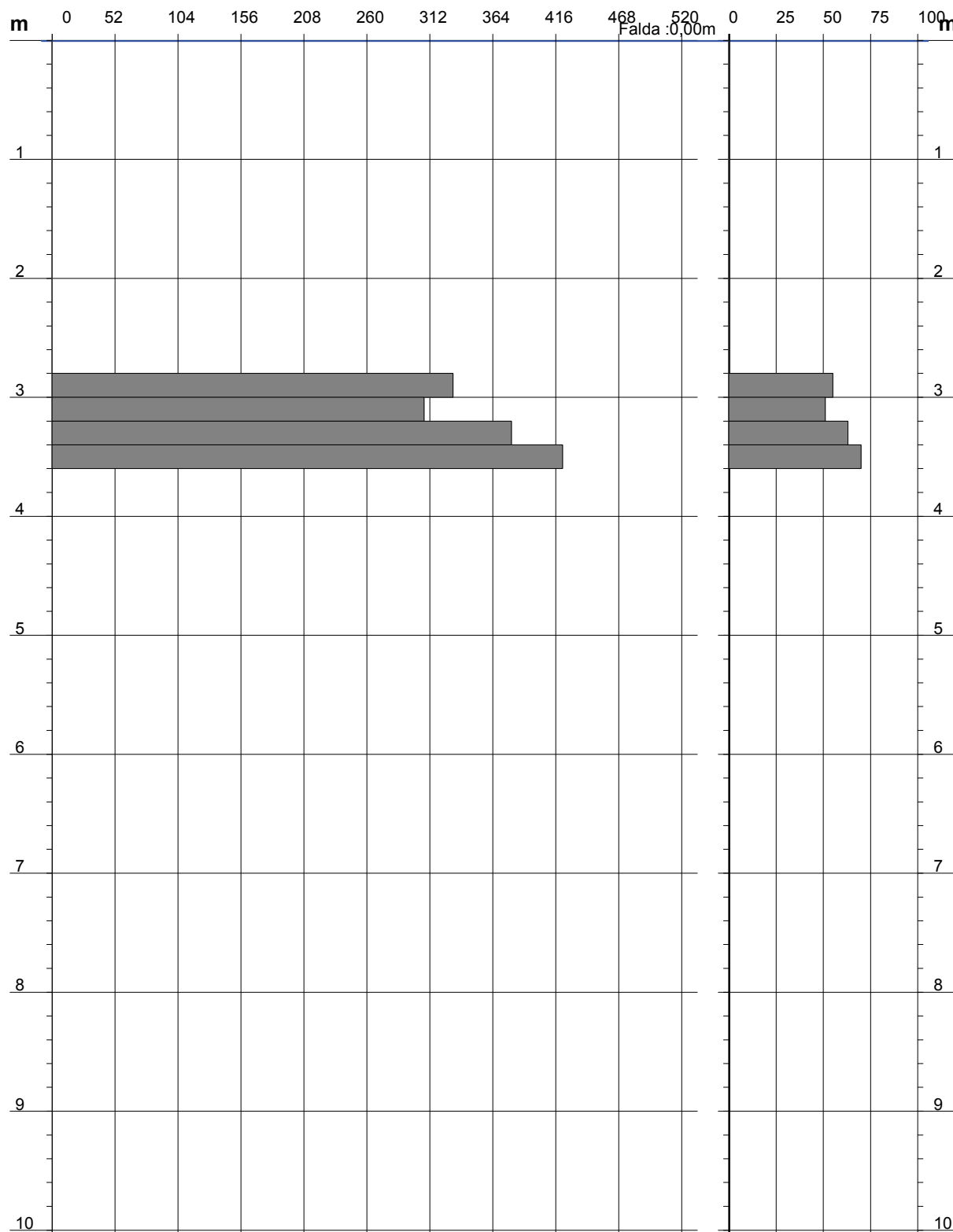


**PROVA PENETROMETRICA DINAMICA
DIAGRAMMA RESISTENZA DINAMICA PUNTA****DIN 9**

Scala 1: 50

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via A. Fiori

- data : 28/10/2010
- quota inizio : -2.8 m da p.c.a.
- prof. falda : 0,00 m da quota inizio

Rpd (kg/cm²) Resistenza dinamica alla punta, formula "Olandese"**N = N(20) n°colpi $\delta = 20$** 

PROVA PENETROMETRICA STATICA **LETTURE DI CAMPAGNA / VALORI DI RESISTENZA**

CPT 10

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Radici in Piano, loc. la Fossa
 - resp. cantiere :
 - assist. cantiere :

- data : 28/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

prf	L1	L2	qc	fs	qc/fs	prf	L1	L2	qc	fs	qc/fs
m	-	-	Kg/cm ²	Kg/cm ²	-	m	-	-	Kg/cm ²	Kg/cm ²	-
0,20	8,0	----	8,0	0,40	20,0	1,40	112,0	161,0	112,0	2,60	43,0
0,40	15,0	21,0	15,0	0,67	22,0	1,60	235,0	274,0	235,0	2,00	118,0
0,60	58,0	68,0	58,0	1,93	30,0	1,80	370,0	400,0	370,0	2,33	159,0
0,80	76,0	105,0	76,0	2,73	28,0	2,00	450,0	485,0	450,0	2,67	169,0
1,00	77,0	118,0	77,0	2,60	30,0	2,20	520,0	560,0	520,0	-----	----
1,20	145,0	184,0	145,0	3,27	44,0						

- PENETROMETRO STATICO tipo da 20 t - (con anello allargatore) -
 - COSTANTE DI TRASFORMAZIONE Ct = 10 - Velocità avanzamento punta 2 cm/s
 - punta meccanica tipo Begemann $\phi = 35.7$ mm (area punta 10 cm² - apertura 60°)
 - manicotto laterale (superficie 150 cm²)

PROVA PENETROMETRICA DINAMICA TABELLE VALORI DI RESISTENZA

DIN 10

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via A. Fiori
 - note : Prova eseguita in continuità con CPT10

- data : 28/10/2010
 - quota inizio : -2.0 m da p.c.a.
 - prof. falda : 0,00 m da quota inizio
 - pagina : 1

Prof.(m)	N(colpi p)	Rpd(kg/cm ²)	N(colpi r)	asta	Prof.(m)	N(colpi p)	Rpd(kg/cm ²)	N(colpi r)	asta
0,00 - 0,20	----	----	----	1	1,60 - 1,80	----	----	----	2
0,20 - 0,40	----	----	----	1	1,80 - 2,00	----	----	----	3
0,40 - 0,60	----	----	----	1	2,00 - 2,20	49	315,3	----	3
0,60 - 0,80	----	----	----	1	2,20 - 2,40	56	360,3	----	3
0,80 - 1,00	----	----	----	2	2,40 - 2,60	62	398,9	----	3
1,00 - 1,20	----	----	----	2	2,60 - 2,80	45	289,5	----	3
1,20 - 1,40	----	----	----	2	2,80 - 3,00	51	307,2	----	4
1,40 - 1,60	----	----	----	2	3,00 - 3,20	68	409,7	----	4

- PENETROMETRO DINAMICO tipo : **EMILIA (20)**

- M (massa battente)= **63,50** kg - H (altezza caduta)= **0,75** m - A (area punta)= **20,00** cm² - D(diam. punta)= **50,50** mm

- Numero Colpi Punta N = N(**20**) [δ = 20 cm]

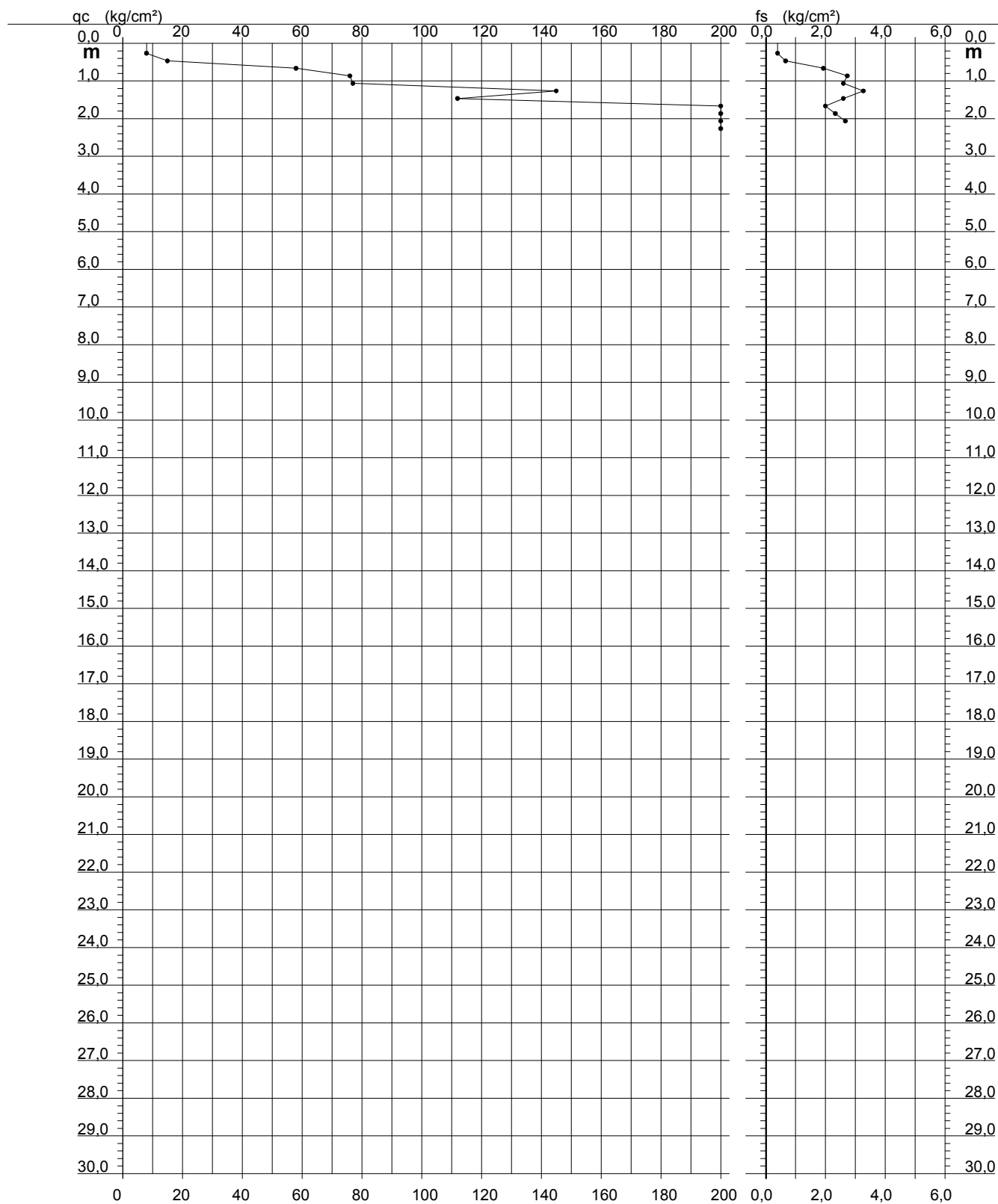
- Uso rivestimento / fanghi iniezione : **SI**

**PROVA PENETROMETRICA STATICA
DIAGRAMMA DI RESISTENZA****CPT 10**

2.0105-PG037

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via Radici in Piano, loc. la Fossa
- resp. cantiere :
- assist. cantiere :

- data : 28/10/2010
- quota inizio : Piano Campagna
- falda : Falda non rilevata
- data di emissione : 03/11/2010

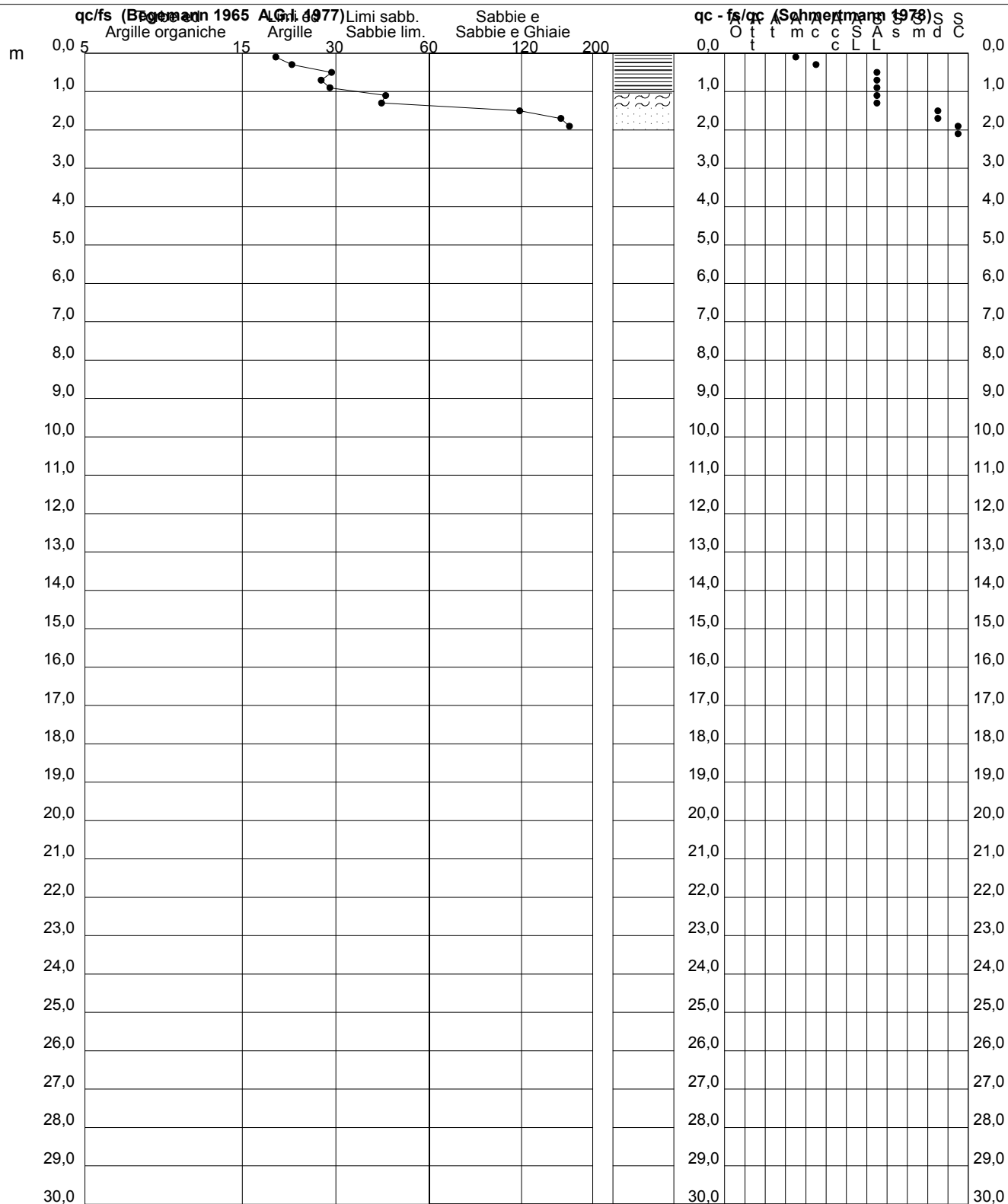


CPT 10

2.0105-PG037

- data : 28/10/2010
- quota inizio : Piano Campagna
- falda : Falda non rilevata

- data di emissione : 03/11/2010



PROVA PENETROMETRICA STATICA **TABELLA PARAMETRI GEOTECNICI**

CPT 10

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Radici in Piano, loc. la Fossa
 - resp. cantiere :
 - assist. cantiere :

- data : 28/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

NATURA COESIVA												NATURA GRANULARE											
Prof. m	qc kg/cm²	qc/fs (-)	Natura Litol.	Y' t/m³	p'vo kg/cm²	Cu kg/cm²	OCR (-)	Eu50 kg/cm²	Eu25 kg/cm²	Mo kg/cm²	Dr %	ø1s (°)	ø2s (°)	ø3s (°)	ø4s (°)	ødm (°)	ømy (°)	Amax/g (-)	E'50 kg/cm²	E'25 kg/cm²	Mo kg/cm²		
0,20	8	20	2////	1,85	0,04	0,40	99,9	68	102	35	--	--	--	--	--	--	--	--	--	--	--		
0,40	15	22	2////	1,85	0,07	0,67	98,0	113	170	50	--	--	--	--	--	--	--	--	--	--	--		
0,60	58	30	4/./.	1,85	0,11	1,93	99,9	329	493	174	100	42	43	45	46	44	31	0,258	97	145	174		
0,80	76	28	4/./.	1,85	0,15	2,53	99,9	431	646	228	100	42	43	45	46	44	33	0,258	127	190	228		
1,00	77	30	4/./.	1,85	0,19	2,57	99,9	436	655	231	100	42	43	45	46	43	33	0,258	128	193	231		
1,20	145	44	3:::	1,85	0,22	--	--	--	--	--	100	42	43	45	46	45	36	0,258	242	363	435		
1,40	112	43	3:::	1,85	0,26	--	--	--	--	--	100	42	43	45	46	43	34	0,258	187	280	336		
1,60	235	118	3:::	1,85	0,30	--	--	--	--	--	100	42	43	45	46	45	39	0,258	392	588	705		
1,80	370	159	3:::	1,85	0,33	--	--	--	--	--	100	42	43	45	46	45	40	0,258	617	925	1110		
2,00	450	169	3:::	1,85	0,37	--	--	--	--	--	100	42	43	45	46	45	40	0,258	750	1125	1350		
2,20	520	--	3:::	1,85	0,41	--	--	--	--	--	100	42	43	45	46	45	40	0,258	867	1300	1560		

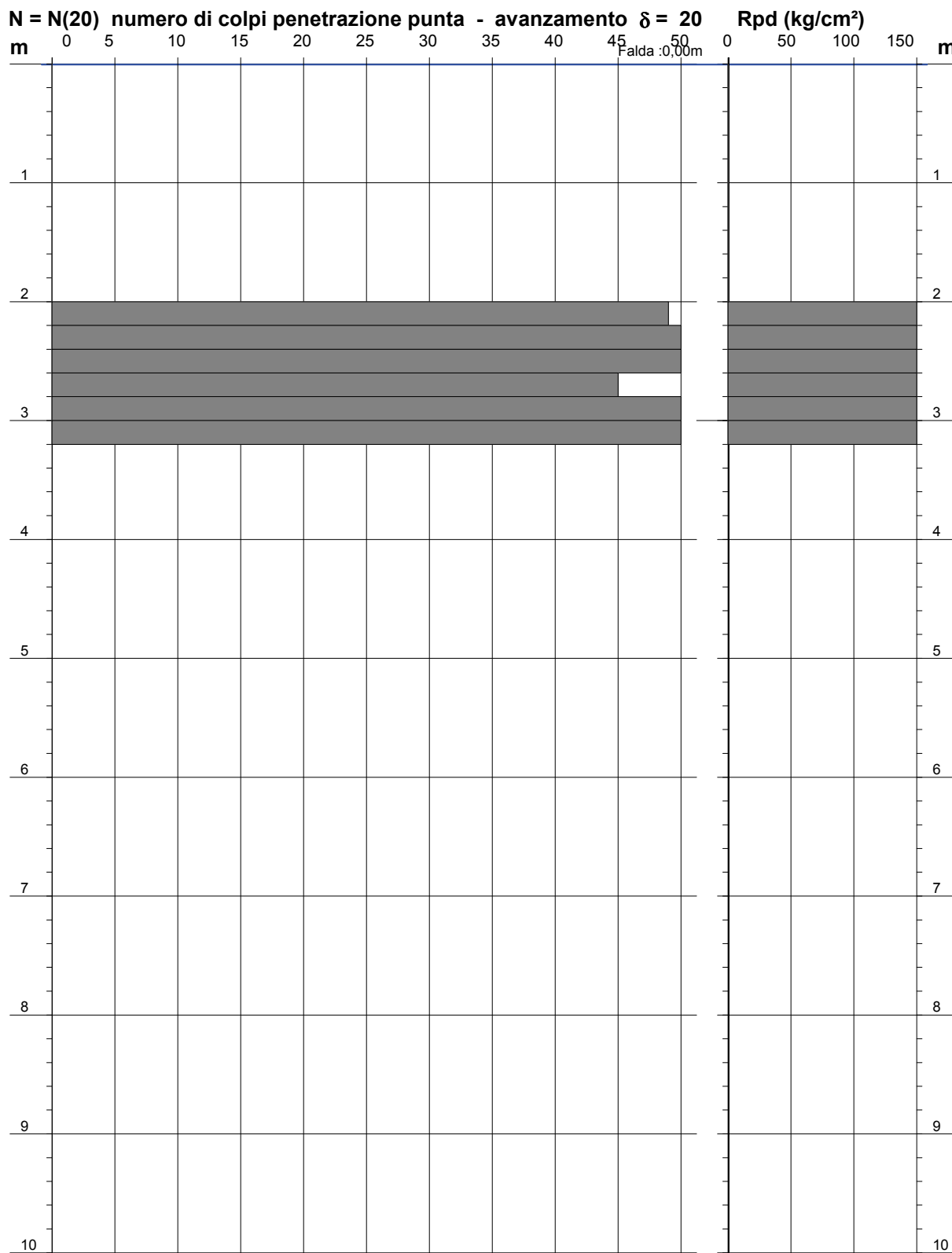
PROVA PENETROMETRICA DINAMICA DIAGRAMMA NUMERO COLPI PUNTA - Rpd

DIN 10

Scala 1: 50

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via A. Fiori
 - note : Prova eseguita in continuità con CPT10

- data : 28/10/2010
 - quota inizio : -2.0 m da p.c.a.
 - prof. falda : 0,00 m da quota inizio
 - pagina : 1



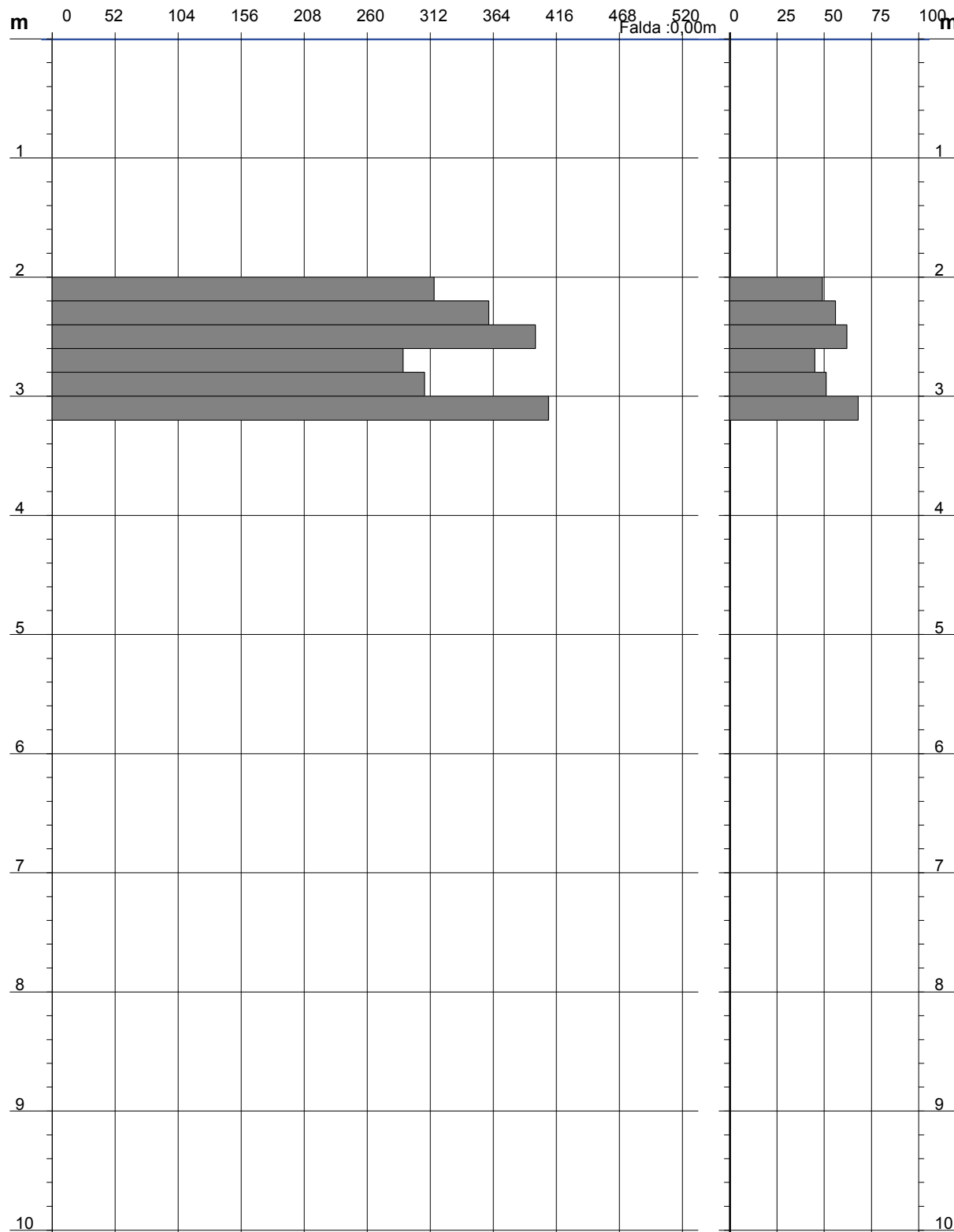
PROVA PENETROMETRICA DINAMICA DIAGRAMMA RESISTENZA DINAMICA PUNTA

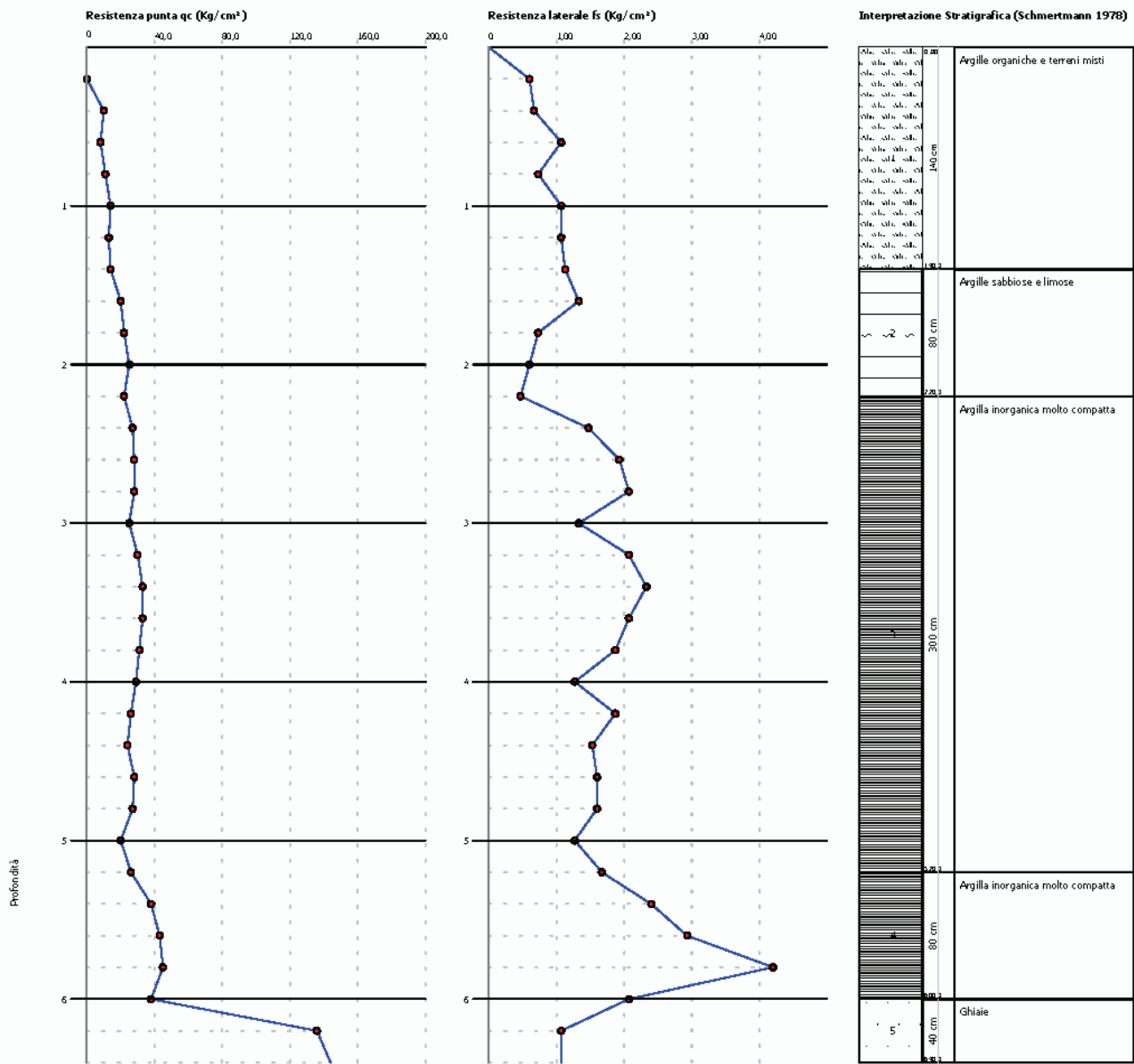
DIN 10

Scala 1: 50

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via A. Fiori

- data : 28/10/2010
- quota inizio : -2.0 m da p.c.a.
- prof. falda : 0,00 m da quota inizio

Rpd (kg/cm²) Resistenza dinamica alla punta, formula "Olandese"N = N(20) n° colpi $\delta = 20$ 



PROVA PENETROMETRICA STATICA **LETTURE DI CAMPAGNA / VALORI DI RESISTENZA**

CPT 12

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Viazza di Sotto
 - resp. cantiere :
 - assist. cantiere :

- data : 29/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

prf	L1	L2	qc	fs	qc/fs	prf	L1	L2	qc	fs	qc/fs
m	-	-	Kg/cm ²	Kg/cm ²	-	m	-	-	Kg/cm ²	Kg/cm ²	-
0,20	15,0	----	15,0	0,60	25,0	10,20	124,0	130,0	124,0	1,07	116,0
0,40	30,0	39,0	30,0	1,33	22,0	10,40	165,0	181,0	165,0	1,27	130,0
0,60	24,0	44,0	24,0	1,13	21,0	10,60	175,0	194,0	175,0	1,53	114,0
0,80	21,0	38,0	21,0	1,20	17,0	10,80	178,0	201,0	178,0	1,33	133,0
1,00	16,0	34,0	16,0	1,07	15,0	11,00	310,0	330,0	310,0	2,00	155,0
1,20	18,0	34,0	18,0	1,20	15,0	11,20	218,0	248,0	218,0	1,67	131,0
1,40	17,0	35,0	17,0	1,20	14,0	11,40	340,0	365,0	340,0	1,93	176,0
1,60	15,0	33,0	15,0	1,07	14,0	11,60	117,0	146,0	117,0	1,33	88,0
1,80	15,0	31,0	15,0	1,00	15,0	11,80	300,0	320,0	300,0	1,73	173,0
2,00	12,0	27,0	12,0	0,80	15,0	12,00	62,0	88,0	62,0	3,00	21,0
2,20	8,0	20,0	8,0	0,27	30,0	12,20	50,0	95,0	50,0	2,53	20,0
2,40	33,0	37,0	33,0	0,53	62,0	12,40	52,0	90,0	52,0	2,53	21,0
2,60	15,0	23,0	15,0	0,47	32,0	12,60	40,0	78,0	40,0	2,20	18,0
2,80	32,0	39,0	32,0	0,47	69,0	12,80	45,0	78,0	45,0	2,47	18,0
3,00	29,0	36,0	29,0	0,67	43,0	13,00	55,0	92,0	55,0	3,27	17,0
3,20	20,0	30,0	20,0	0,93	21,0	13,20	55,0	104,0	55,0	3,33	17,0
3,40	18,0	32,0	18,0	0,87	21,0	13,40	70,0	120,0	70,0	3,80	18,0
3,60	20,0	33,0	20,0	0,93	21,0	13,60	74,0	131,0	74,0	4,07	18,0
3,80	28,0	42,0	28,0	1,53	18,0	13,80	60,0	121,0	60,0	3,53	17,0
4,00	25,0	48,0	25,0	1,53	16,0	14,00	84,0	137,0	84,0	4,47	19,0
4,20	23,0	46,0	23,0	1,40	16,0	14,20	63,0	130,0	63,0	3,93	16,0
4,40	26,0	47,0	26,0	1,33	19,0	14,40	75,0	134,0	75,0	4,40	17,0
4,60	25,0	45,0	25,0	1,27	20,0	14,60	80,0	146,0	80,0	4,93	16,0
4,80	28,0	47,0	28,0	1,47	19,0	14,80	103,0	177,0	103,0	6,20	17,0
5,00	28,0	50,0	28,0	1,40	20,0	15,00	95,0	188,0	95,0	5,93	16,0
5,20	23,0	44,0	23,0	0,80	29,0	15,20	77,0	166,0	77,0	3,80	20,0
5,40	19,0	31,0	19,0	0,67	28,0	15,40	41,0	98,0	41,0	1,87	22,0
5,60	16,0	26,0	16,0	0,60	27,0	15,60	40,0	68,0	40,0	1,87	21,0
5,80	14,0	23,0	14,0	0,53	26,0	15,80	32,0	60,0	32,0	1,93	17,0
6,00	15,0	23,0	15,0	0,53	28,0	16,00	36,0	65,0	36,0	1,93	19,0
6,20	105,0	113,0	105,0	1,07	98,0	16,20	35,0	64,0	35,0	1,80	19,0
6,40	22,0	38,0	22,0	0,47	47,0	16,40	31,0	58,0	31,0	1,87	17,0
6,60	20,0	27,0	20,0	0,47	43,0	16,60	132,0	160,0	132,0	3,27	40,0
6,80	48,0	55,0	48,0	0,67	72,0	16,80	63,0	112,0	63,0	3,07	21,0
7,00	300,0	310,0	300,0	2,00	150,0	17,00	65,0	111,0	65,0	3,00	22,0
7,20	270,0	300,0	270,0	2,00	135,0	17,20	73,0	118,0	73,0	2,27	32,0
7,40	130,0	160,0	130,0	1,13	115,0	17,40	107,0	141,0	107,0	2,47	43,0
7,60	19,0	36,0	19,0	1,13	17,0	17,60	75,0	112,0	75,0	2,53	30,0
7,80	20,0	37,0	20,0	1,13	18,0	17,80	77,0	115,0	77,0	2,67	29,0
8,00	25,0	42,0	25,0	1,40	18,0	18,00	68,0	108,0	68,0	2,47	28,0
8,20	28,0	49,0	28,0	1,60	17,0	18,20	77,0	114,0	77,0	2,60	30,0
8,40	20,0	44,0	20,0	1,07	19,0	18,40	106,0	145,0	106,0	2,87	37,0
8,60	60,0	76,0	60,0	0,73	82,0	18,60	118,0	161,0	118,0	3,40	35,0
8,80	156,0	167,0	156,0	1,40	111,0	18,80	86,0	137,0	86,0	4,53	19,0
9,00	222,0	243,0	222,0	1,60	139,0	19,00	82,0	150,0	82,0	4,40	19,0
9,20	204,0	228,0	204,0	1,33	153,0	19,20	93,0	159,0	93,0	5,13	18,0
9,40	350,0	370,0	350,0	2,07	169,0	19,40	90,0	167,0	90,0	5,07	18,0
9,60	215,0	246,0	215,0	1,33	161,0	19,60	93,0	169,0	93,0	5,13	18,0
9,80	335,0	355,0	335,0	1,87	179,0	19,80	97,0	174,0	97,0	5,07	19,0
10,00	18,0	46,0	18,0	0,40	45,0	20,00	98,0	174,0	98,0	5,27	19,0

- PENETROMETRO STATICO tipo da 20 t - (con anello allargatore) -
 - COSTANTE DI TRASFORMAZIONE Ct = 10 - Velocità avanzamento punta 2 cm/s
 - punta meccanica tipo Begemann $\phi = 35.7$ mm (area punta 10 cm² - apertura 60°)
 - manicotto laterale (superficie 150 cm²)

PROVA PENETROMETRICA STATICA **LETTURE DI CAMPAGNA / VALORI DI RESISTENZA**

CPT 12

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Viazza di Sotto
 - resp. cantiere :
 - assist. cantiere :

- data : 29/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

prf	L1	L2	qc	fs	qc/fs	prf	L1	L2	qc	fs	qc/fs
m	-	-	Kg/cm ²	Kg/cm ²	-	m	-	-	Kg/cm ²	Kg/cm ²	-
20,20	83,0	162,0	83,0	4,60	18,0	21,20	70,0	122,0	70,0	3,53	20,0
20,40	64,0	133,0	64,0	3,53	18,0	21,40	135,0	188,0	135,0	3,33	41,0
20,60	65,0	118,0	65,0	3,60	18,0	21,60	210,0	260,0	210,0	4,33	48,0
20,80	63,0	117,0	63,0	3,47	18,0	21,80	265,0	330,0	265,0	-----	----
21,00	62,0	114,0	62,0	3,47	18,0						

- PENETROMETRO STATICO tipo da 20 t - (con anello allargatore) -
 - COSTANTE DI TRASFORMAZIONE Ct = 10 - Velocità avanzamento punta 2 cm/s
 - punta meccanica tipo Begemann $\phi = 35.7$ mm (area punta 10 cm² - apertura 60°)
 - manicotto laterale (superficie 150 cm²)

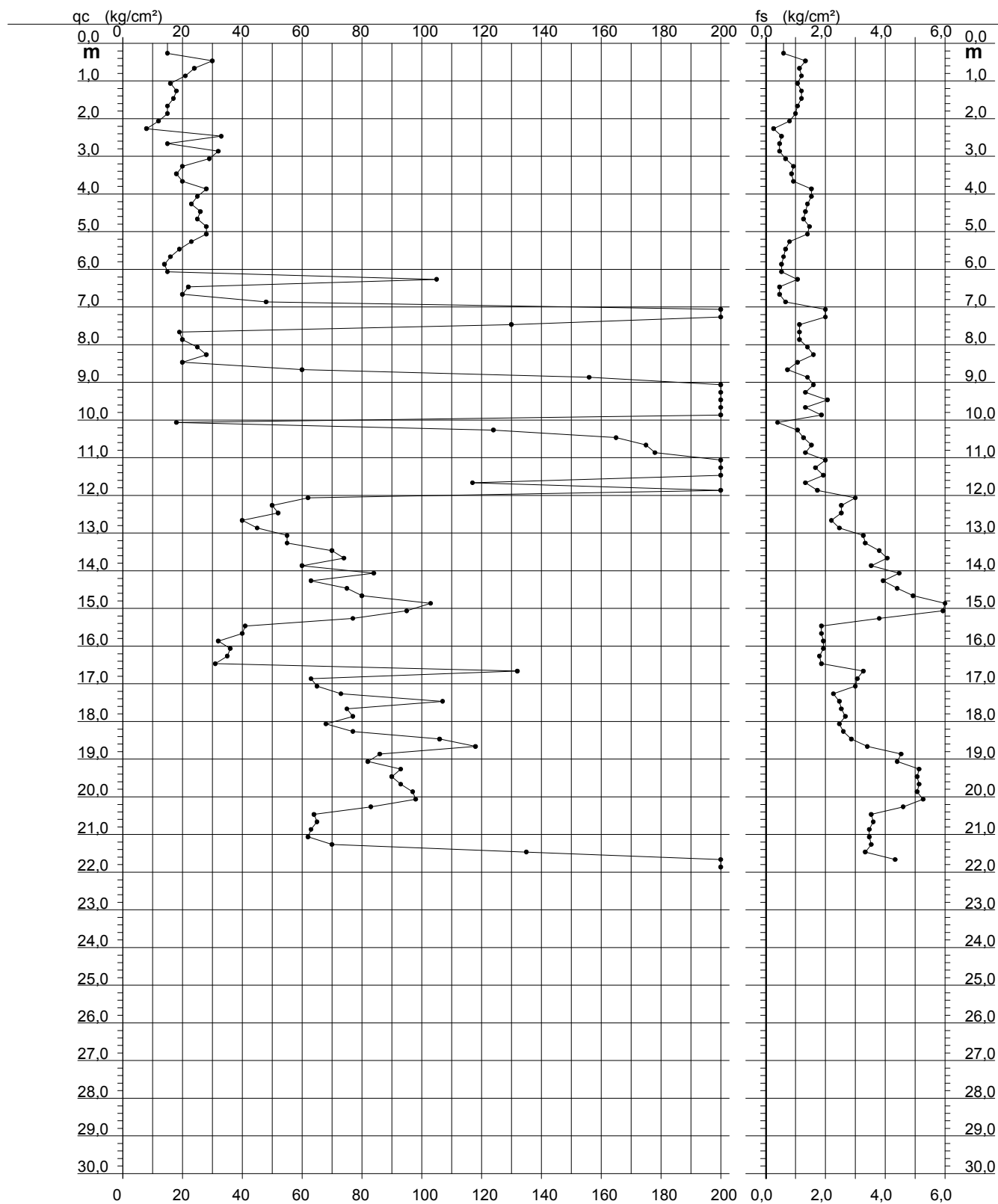
**PROVA PENETROMETRICA STATICA
DIAGRAMMA DI RESISTENZA****CPT 12**

2.0105-PG037

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via Viazza di Sotto
- resp. cantiere :
- assist. cantiere :

- data : 29/10/2010
- quota inizio : Piano Campagna
- falda : Falda non rilevata

- data di emissione :
03/11/2010



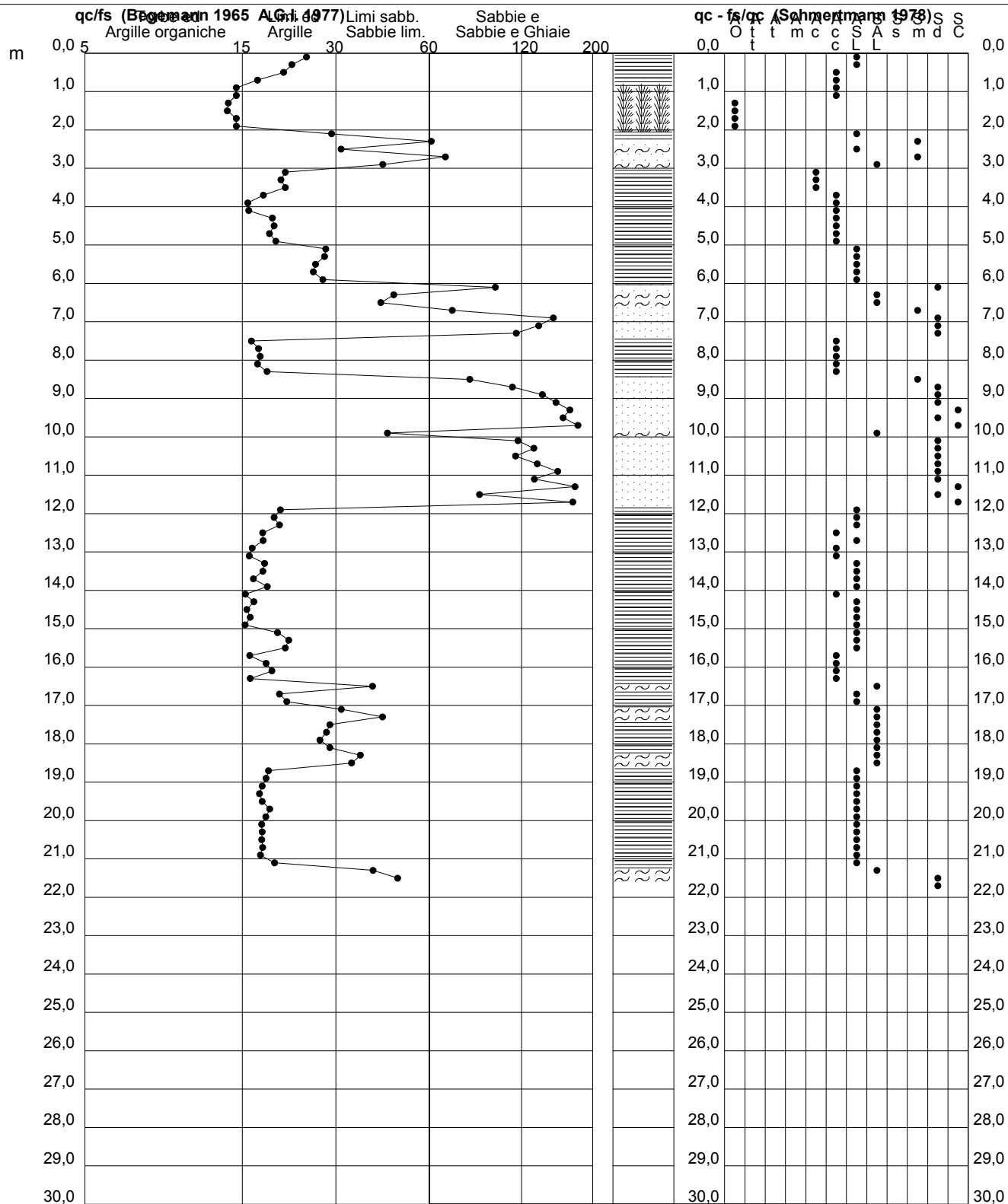
**PROVA PENETROMETRICA STATICA
VALUTAZIONI LITOLOGICHE****CPT 12**

2.0105-PG037

- committente : S.G.G. Siena
- lavoro :
- località : MO - Formigine, via Viazza di Sotto
- resp. cantiere :
- assist. cantiere :

- data : 29/10/2010
- quota inizio : Piano Campagna
- falda : Falda non rilevata

- data di emissione : 03/11/2010



PROVA PENETROMETRICA STATICA **TABELLA PARAMETRI GEOTECNICI**

CPT 12

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Viazza di Sotto
 - resp. cantiere :
 - assist. cantiere :

- data : 29/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

NATURA COESIVA											NATURA GRANULARE										
Prof. m	qc kg/cm²	qc/fs (-)	Natura Litol.	Y' t/m²	p'vo kg/cm²	Cu kg/cm²	OCR (-)	Eu50 kg/cm²	Eu25 kg/cm²	Mo kg/cm²	Dr %	ø1s (°)	ø2s (°)	ø3s (°)	ø4s (°)	ødm (°)	ømy (°)	Amax/g (-)	E'50 kg/cm²	E'25 kg/cm²	Mo
0,20	15	25	2///	1,85	0,04	0,67	99,9	113	170	50	--	--	--	--	--	--	--	--	--	--	--
0,40	30	22	4///	1,85	0,07	1,00	99,9	170	255	90	94	41	43	44	46	43	29	0,237	50	75	90
0,60	24	21	4///	1,85	0,11	0,89	84,6	151	227	72	77	39	40	42	44	40	28	0,179	40	60	72
0,80	21	17	4///	1,85	0,15	0,82	53,7	140	210	63	65	37	39	41	43	39	27	0,144	35	53	63
1,00	16	15	2///	1,85	0,19	0,70	32,9	118	177	52	--	--	--	--	--	--	--	--	--	--	--
1,20	18	15	2///	1,85	0,22	0,75	28,8	128	191	56	--	--	--	--	--	--	--	--	--	--	--
1,40	17	14	2///	1,85	0,26	0,72	22,7	123	184	54	--	--	--	--	--	--	--	--	--	--	--
1,60	15	14	2///	1,85	0,30	0,67	17,3	113	170	50	--	--	--	--	--	--	--	--	--	--	--
1,80	15	15	2///	1,85	0,33	0,67	15,0	113	170	50	--	--	--	--	--	--	--	--	--	--	--
2,00	12	15	2///	1,85	0,37	0,57	10,8	97	146	45	--	--	--	--	--	--	--	--	--	--	--
2,20	8	30	4///	1,85	0,41	0,40	6,1	107	160	35	7	29	32	35	39	28	26	0,016	13	20	24
2,40	33	62	3///	1,85	0,44	--	--	--	--	--	54	36	38	40	42	35	29	0,114	55	83	99
2,60	15	32	4///	1,85	0,48	0,67	9,4	115	173	50	25	31	34	37	40	30	27	0,047	25	38	45
2,80	32	69	3///	1,85	0,52	--	--	--	--	--	49	35	37	39	42	34	29	0,101	53	80	96
3,00	29	43	3///	1,85	0,55	--	--	--	--	--	44	34	37	39	42	33	29	0,089	48	73	87
3,20	20	21	4///	1,85	0,59	0,80	9,1	141	211	60	29	32	35	37	40	31	27	0,057	33	50	60
3,40	18	21	2///	1,85	0,63	0,75	7,8	152	228	56	--	--	--	--	--	--	--	--	--	--	--
3,60	20	21	4///	1,85	0,67	0,80	7,9	160	241	60	27	32	34	37	40	30	27	0,051	33	50	60
3,80	28	18	4///	1,85	0,70	0,97	9,3	168	252	84	37	33	36	38	41	32	28	0,073	47	70	84
4,00	25	16	4///	1,85	0,74	0,91	8,1	177	266	75	32	32	35	38	41	31	28	0,061	42	63	75
4,20	23	16	4///	1,85	0,78	0,87	7,2	193	289	69	28	32	35	37	40	30	28	0,053	38	58	69
4,40	26	19	4///	1,85	0,81	0,93	7,4	200	300	78	31	32	35	38	40	31	28	0,059	43	65	78
4,60	25	20	4///	1,85	0,85	0,91	6,8	216	323	75	28	32	35	37	40	30	28	0,054	42	63	75
4,80	28	19	4///	1,85	0,89	0,97	7,0	223	335	84	31	32	35	38	40	31	28	0,060	47	70	84
5,00	28	20	4///	1,85	0,93	0,97	6,6	237	355	84	30	32	35	38	40	30	28	0,058	47	70	84
5,20	23	29	4///	1,85	0,96	0,87	5,5	260	391	69	22	31	34	37	40	29	28	0,043	38	58	69
5,40	19	28	2///	1,85	1,00	0,78	4,6	278	418	58	--	--	--	--	--	--	--	--	--	--	--
5,60	16	27	2///	1,85	1,04	0,70	3,8	292	437	52	--	--	--	--	--	--	--	--	--	--	--
5,80	14	26	2///	1,85	1,07	0,64	3,3	300	450	48	--	--	--	--	--	--	--	--	--	--	--
6,00	15	28	2///	1,85	1,11	0,67	3,3	311	466	50	--	--	--	--	--	--	--	--	--	--	--
6,20	105	98	3///	1,85	1,15	--	--	--	--	--	70	38	40	42	44	36	34	0,160	175	263	315
6,40	22	47	3///	1,85	1,18	--	--	--	--	--	16	30	33	36	39	28	28	0,030	37	55	66
6,60	20	43	4///	1,85	1,22	0,80	3,7	345	517	60	12	30	33	36	39	27	27	0,023	33	50	60
6,80	48	72	3///	1,85	1,26	--	--	--	--	--	41	34	36	39	41	32	31	0,082	80	120	144
7,00	300	150	3///	1,85	1,30	--	--	--	--	--	100	42	43	45	46	41	40	0,258	500	750	900
7,20	270	135	3///	1,85	1,33	--	--	--	--	--	99	42	43	45	46	40	40	0,255	450	675	810
7,40	130	115	3///	1,85	1,37	--	--	--	--	--	73	38	40	42	44	37	35	0,169	217	325	390
7,60	19	17	2///	1,85	1,41	0,78	3,0	384	575	58	--	--	--	--	--	--	--	--	--	--	--
7,80	20	18	4///	1,85	1,44	0,80	3,0	394	592	60	8	29	32	35	39	26	27	0,017	33	50	60
8,00	25	18	4///	1,85	1,48	0,91	3,4	416	624	75	15	30	33	36	39	27	28	0,029	42	63	75
8,20	28	17	4///	1,85	1,52	0,97	3,6	428	642	84	18	31	33	36	39	28	28	0,034	47	70	84
8,40	20	19	4///	1,85	1,55	0,80	2,7	411	616	60	6	29	32	35	38	26	27	0,014	33	50	60
8,60	60	82	3///	1,85	1,59	--	--	--	--	--	43	34	36	39	41	32	32	0,087	100	150	180
8,80	156	111	3///	1,85	1,63	--	--	--	--	--	75	39	40	42	44	37	36	0,175	260	390	468
9,00	222	139	3///	1,85	1,66	--	--	--	--	--	87	40	42	43	45	38	38	0,213	370	555	666
9,20	204	153	3///	1,85	1,70	--	--	--	--	--	84	40	41	43	45	38	38	0,201	340	510	612
9,40	350	169	3///	1,85	1,74	--	--	--	--	--	100	42	43	45	46	40	40	0,258	583	875	1050
9,60	215	161	3///	1,85	1,78	--	--	--	--	--	84	40	41	43	45	38	38	0,204	358	538	645
9,80	335	179	3///	1,85	1,81	--	--	--	--	--	99	42	43	45	46	40	40	0,255	558	838	1005
10,00	18	45	4///	1,85	1,85	0,75	2,0	419	628	56	--	28	31	35	38	25	27	--	30	45	54
10,20	124	116	3///	1,85	1,89	--	--	--	--	--	64	37	39	41	43	35	35	0,141	207	310	372
10,40	165	130	3///	1,85	1,92	--	--	--	--	--	73	38	40	42	44	36	37	0,169	275	413	495
10,60	175	114	3///	1,85	1,96	--	--	--	--	--	75	38	40	42	44	36	37	0,174	292	438	525
10,80	178	133	3///	1,85	2,00	--	--	--	--	--	75	38	40	42	44	36	37	0,174	297	445	534
11,00	310	155	3///	1,85	2,03	--	--	--	--	--	94	41	42	44	45	39	40	0,235	517	775	930
11,20	218	131	3///	1,85	2,07	--	--	--	--	--	81	39	41	43	44	37	38	0,193	363	545	654
11,40	340	176	3///	1,85	2,11	--	--	--	--	--	96	41	43	44	46	39	40	0,243	567	850	1020
11,60	117	88	3///	1,85	2,15	--	--	--	--	--	59	36	38	40	43	34	35	0,127	195	293	351
11,80	300	173	3///	1,85	2,18	--	--	--	--	--	91	41	42	44	45	39	40	0,225	500	750	900
12,00	62	21	4///	1,85	2,22	2,07	5,7	595	893	186	36	33	36	38	41	30	32	0,071	103	155	186
12,20	50	20	4///	1,85	2,26	1,67	4,3	630	946	150	28	32	35	37	40	29	31	0,054	83	125	150
12,40	52	21	4///	1,85	2,29	1,73	4,4	640	960	156	29	32	35	37	40	29	31	0,056	87	130	156
12,60	40	18	4///	1,85	2,33	1,33	3,1	644	967	120	20	31	34	37	40	27	30	0,038	67	100	120
12,80	45	18	4///	1,85	2,37	1,50	3,														

PROVA PENETROMETRICA STATICA **TABELLA PARAMETRI GEOTECNICI**

CPT 12

2.0105-PG037

- committente : S.G.G. Siena
 - lavoro :
 - località : MO - Formigine, via Viazza di Sotto
 - resp. cantiere :
 - assist. cantiere :

- data : 29/10/2010
 - quota inizio : Piano Campagna
 - falda : Falda non rilevata
 - data di emissione : 03/11/2010

NATURA COESIVA											NATURA GRANULARE										
Prof. m	qc kg/cm²	qc/fs (-)	Natura Litol.	Y' t/m³	p'vo kg/cm²	Cu kg/cm²	OCR (-)	Eu50 kg/cm²	Eu25 kg/cm²	Mo kg/cm²	Dr %	ø1s (°)	ø2s (°)	ø3s (°)	ø4s (°)	ødm (°)	ømy (°)	Amax/g (-)	E'50 kg/cm²	E'25 kg/cm²	Mo
20,20	83	18	4/./.	1,85	3,74	2,77	4,3	1044	1565	249	33	33	35	38	41	29	33	0,065	138	208	249
20,40	64	18	4/./.	1,85	3,77	2,13	3,1	1039	1559	192	24	31	34	37	40	27	32	0,066	107	160	192
20,60	65	18	4/./.	1,85	3,81	2,17	3,1	1051	1577	195	25	31	34	37	40	27	32	0,047	108	163	195
20,80	63	18	4/./.	1,85	3,85	2,10	2,9	1045	1568	189	23	31	34	37	40	27	32	0,044	105	158	189
21,00	62	18	4/./.	1,85	3,88	2,07	2,9	1043	1565	186	22	31	34	37	40	27	32	0,043	103	155	186
21,20	70	20	4/./.	1,85	3,92	2,33	3,3	1096	1644	210	26	32	34	37	40	27	32	0,050	117	175	210
21,40	135	41	3:...	1,85	3,96	--	--	--	--	--	49	35	37	39	42	31	35	0,101	225	338	405
21,60	210	48	3:...	1,85	4,00	--	--	--	--	--	64	37	39	41	43	33	38	0,141	350	525	630
21,80	265	--	3:...	1,85	4,03	--	--	--	--	--	71	38	40	42	44	35	40	0,163	442	663	795

PENETROMETRO DINAMICO IN USO : **EMILIA (20)**

Classificazione ISSMFE (1988) dei penetrometri dinamici		
TIPO	Sigla riferimento	Peso Massa Battente M (kg)
Leggero	DPL (Light)	$M \leq 10$
Medio	DPM (Medium)	$10 < M < 40$
Pesante	DPH (Heavy)	$40 \leq M < 60$
Super pesante	DPSH (Super Heavy)	$M \geq 60$

CARATTERISTICHE TECNICHE : EMILIA (20)

PESO MASSA BATTENTE	M = 63,50 kg
ALTEZZA CADUTA LIBERA	H = 0,75 m
PESO SISTEMA BATTUTA	Ms = 30,00 kg
DIAMETRO PUNTA CONICA	D = 50,50 mm
AREA BASE PUNTA CONICA	A = 20,00 cm ²
ANGOLO APERTURA PUNTA	$\alpha = 60^\circ$
LUNGHEZZA DELLE ASTE	La = 1,00 m
PESO ASTE PER METRO	Ma = 8,00 kg
PROF. GIUNZIONE 1 ^a ASTA	P1 = 0,80 m
AVANZAMENTO PUNTA	$\delta = 0,20$ m
NUMERO DI COLPI PUNTA	N = N(20) $\Rightarrow$ Relativo ad un avanzamento di 20 cm
RIVESTIMENTO / FANGHI	SI
ENERGIA SPECIFICA x COLPO	Q = (MH)/(A δ) = 11,91 kg/cm ² (prova SPT : Qspt = 7.83 kg/cm ²)
COEFF.TEORICO DI ENERGIA	$\beta_t = Q/Q_{spt} = 1,521$ (teoricamente : Nspt = β_t N)

Valutazione resistenza dinamica alla punta Rpd [funzione del numero di colpi N] (FORMULA OLANDESE) :

$$R_{pd} = M^2 H / [A e (M+P)] = M^2 H N / [A \delta (M+P)]$$

Rpd = resistenza dinamica punta [area A]
e = infissione per colpo = δ / N

M = peso massa battente (altezza caduta H)
P = peso totale aste e sistema battuta

UNITA' di MISURA (conversioni)

1 kg/cm² = 0.098067 MPa
1 MPa = 1 MN/m² = 10.197 kg/cm²
1 bar = 1.0197 kg/cm² = 0.1 MPa
1 kN = 0.001 MN = 101.97 kg

APPENDICE 2:

NOTA ESPLICATIVE PER L'USO DEGLI ELABORATI

In riferimento alla TAV. GEO 4 relativa al periodo fondamentale di vibrazione vengono fornite le seguenti indicazioni tipologiche:

AREA	PERIODO (s)	FREQUENZA (Hz)	NOTE
SECCHIA	0,0 – 0,05	>20	Esclusione della doppia risonanza
	0,05 – 0,09	11,0 – 20,0	Esclusione della doppia risonanza
	0,09 – 0,15	6,5 – 11,0	Possibili fenomeni della doppia risonanza
	0,15 – 0,22	4,5 – 6,5	Possibili fenomeni della doppia risonanza
TORRENTI APPENNINICI MINORI	0,04 – 0,10	10,0 – 25,0	Possibili fenomeni della doppia risonanza
	0,10 – 0,25	4,0 – 10,0	Possibili fenomeni della doppia risonanza

Pertanto in riferimento alla zonazione citata si possono formulare le seguenti indicazioni generiche che dovranno comunque essere verificate in funzione della tipologia costruttiva dell'edificio da parte del progettista in riferimento alla normativa nazionale vigente:

AREA	FREQUENZA (Hz)	
SECCHIA	6,5 – 11,0	Per gli edifici standard ad un piano è da verificare che la frequenza propria dell'edificio non ricada in questo intervallo di frequenza
	4,5 – 6,5	Per gli edifici standard a due piani è da verificare che la frequenza propria dell'edificio non ricada in questo intervallo di frequenza

AREA	FREQUENZA (Hz)	
TORRENTI APPENNINICI MINORI	4,0 – 10,0	Per gli edifici standard ad uno e due piani è da verificare che la frequenza propria dell'edificio non sia prossimo ai valori di frequenza specifici indicati per questa area (GEO 4)
	10,0 – 25,0	Per gli edifici standard ad un piano è da verificare che la frequenza propria dell'edificio non sia prossimo ai valori di frequenza specifici indicati per questa area (GEO 4)

Per la determinazione della PGA di sito si dovrà utilizzare la PGA di base (accelerazione massima al suolo riferita al suolo rigido $V_s > 800$ m/sec - categoria A) moltiplicandola per il fattore di amplificazione FA_{PGA} specifico della porzione del territorio comunale in riferimento alla zonazione di TAV. GEO 5.

Per la determinazione dello “spettro di risposta di sito” il progettista potrà utilizzare gli elaborati TAV. GEO 6 e TAV. GEO 7.

A titolo orientativo si ricordano i seguenti criteri generali:

- per gli edifici standard con un numero di piani inferiore a 5, lo spettro di risposta di normativa e riferito a suoli rigidi di categoria A, dovrà essere moltiplicato per il valore del fattore di amplificazione (FA) specifico della porzione del territorio comunale in riferimento alla zonazione di TAV. GEO 6 e relativa ad una intensità spettrale nell'intervallo 0,1s - 0,5s.
- per gli edifici standard con un numero di piani uguale o superiori a 5, lo spettro di risposta di normativa e riferito a suoli rigidi di categoria A, dovrà essere moltiplicato per il valore del fattore di amplificazione (FA) specifico della porzione del territorio comunale in riferimento alla zonazione di TAV. GEO 7 e relativa ad una intensità spettrale nell'intervallo 0,5s - 1,0s.

Le indagini geologiche da effettuare per la realizzazione di opere di ingegneria devono essere adeguate per numero e profondità di esecuzione all'ampiezza dell'area di progetto (fase di progettazione preliminare) ed all'impegno dell'opera da realizzare (fase di progettazione di massima ed esecutiva), come prescritto dal DM 14.01.2008.

A titolo esemplificativo, in riferimento al valore della PGA di sito definita secondo le procedure sopra indicate, si suggerisce la consistenza e la tipologia delle indagini minime, a supporto della progettazione, da eseguire in funzione delle caratteristiche dell'opera da realizzare. I presenti suggerimenti vengono forniti per l'edilizia ordinaria di nuova edificazione.

CARATTERISTICHE DELL'OPERA	PGA di sito	
	tra 0,125 e 0,200	> 0,200
VOLUME LORDO <150 mc ED ALTEZZA IN GRONDA <6 m	<i>Utilizzo di indagini già eseguite in prossimità dell'intervento e/o precedenti studi già compiuti nelle aree interessate</i>	<i>Nuove indagini nel sito:</i> sondaggi geognostici con prove per la caratterizzazione geotecnica dei terreni
VOLUME LORDO <1.500 mc ED ALTEZZA IN GRONDA <10 m	<i>Nuove indagini nel sito:</i> 2 penetrometrie o sondaggi geognostici (se penetr. raggiunge subito il rifiuto) determinazione Vs con metodologia attiva o passiva	<i>Nuove indagini nel sito:</i> sondaggi geognostici con prove per la caratterizzazione geotecnica dei terreni determinazione Vs con metodologia attiva o passiva
VOLUME LORDO <6.000 mc ED ALTEZZA IN GRONDA <20 m	<i>Nuove indagini nel sito:</i> sondaggi geognostici con prove per la caratterizzazione geotecnica dei terreni carotaggio sismico DH onde S	<i>Nuove indagini nel sito:</i> sondaggi geognostici con prove per la caratterizzazione geotecnica dei terreni carotaggio sismico DH onde S
VOLUME LORDO >6.000 mc ED ALTEZZA IN GRONDA >20 m	<i>Nuove indagini nel sito:</i> sondaggi geognostici con prove per la caratterizzazione geotecnica dei terreni carotaggio sismico DH onde S	<i>Nuove indagini nel sito:</i> sondaggi geognostici con prove per la caratterizzazione geotecnica dei terreni carotaggio sismico DH onde S prova dinamica laboratorio

La tabella sopra riportata non costituisce comunque elemento prescrittivo, ma le quantità e la tipologia delle prove stesse saranno definite dal professionista incaricato. I procedimenti proposti costituiscono riferimento tecnico-operativo non prescrittivo e possono essere motivatamente sostituiti da altri procedimenti di analoghe o migliori prestazioni.