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## COMUNE DI PISA

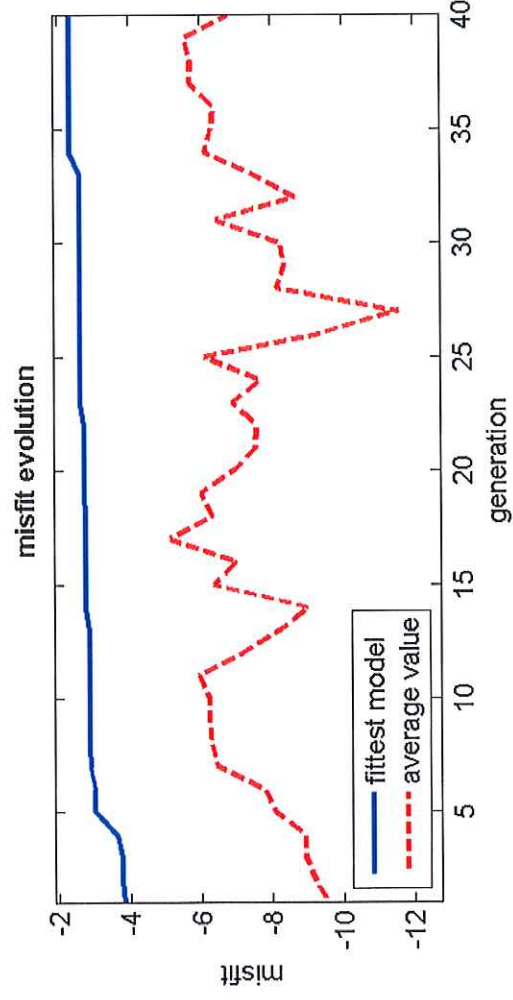
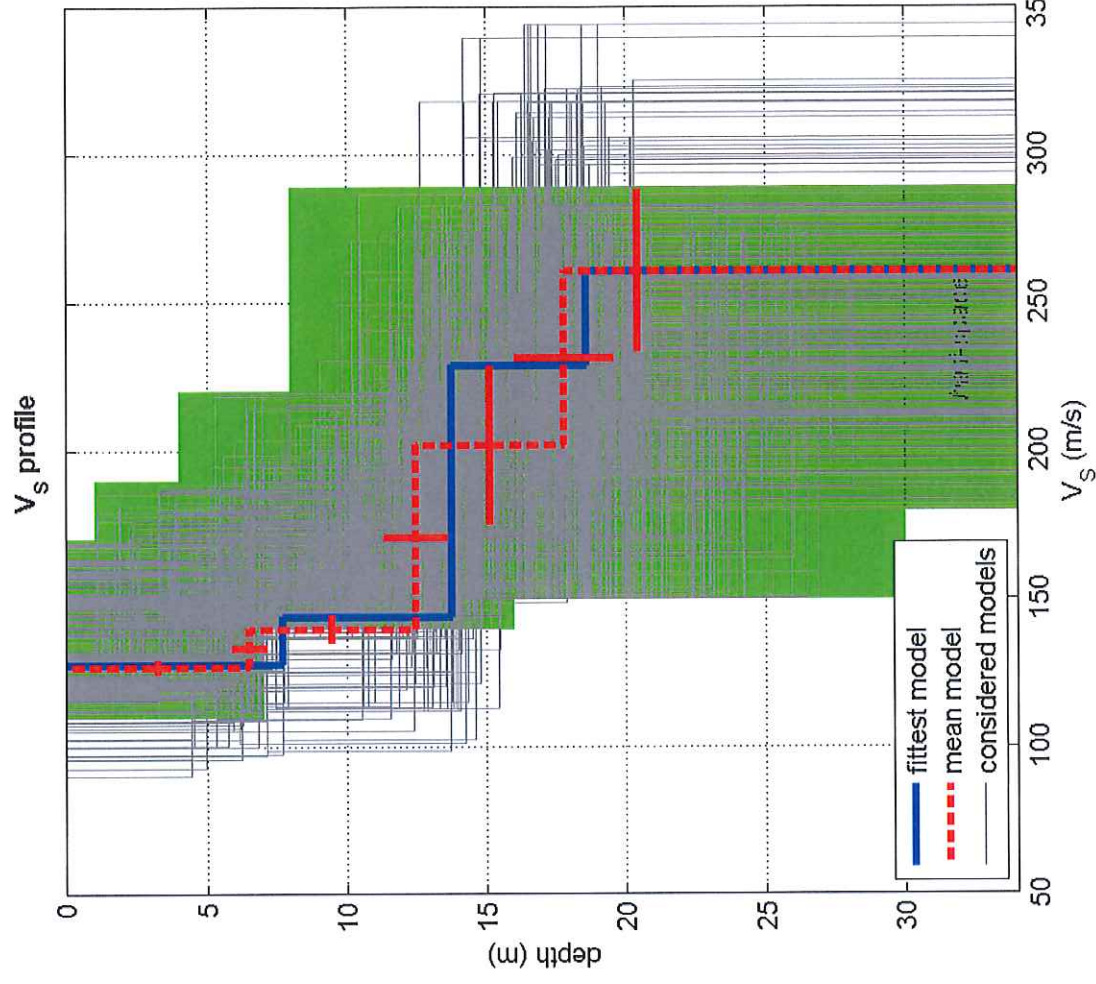
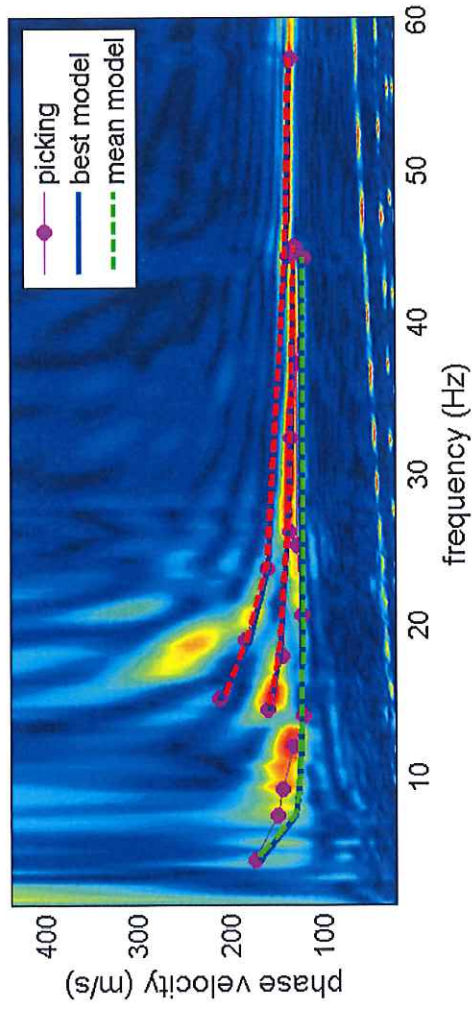
RISULTATI DI UNA PROSPEZIONE GEOFISICA M.A.S.W. ESEGUITA IN VIA CARIOLA  
PRESSO AEROPORTO G. GALILEI DI PISA



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Febbraio 2016

velocity spectrum & dispersion curve



dataset: 8m.SGY  
 dispersion curve: 8m.cdp  
 Vs30 (best model): 180 m/s  
 Vs30 (mean model): 180 m/s



MASW: compute velocity spectrum

phase velocity

☐ f-k

group velocity

save

upload

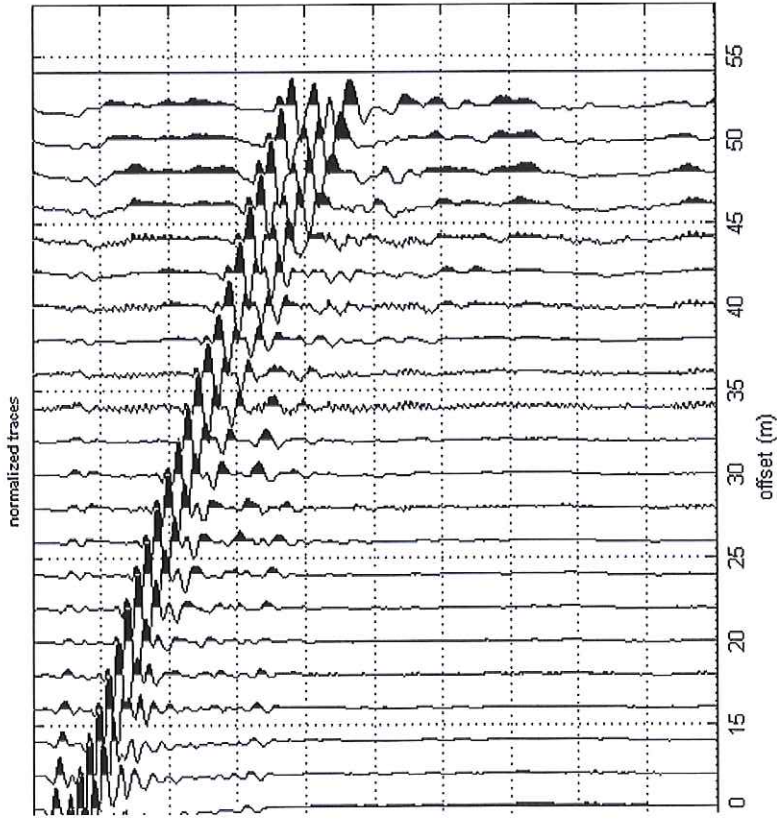
merge

handling the spectra

explore spectrum

mode separation

2 m



data selection

activate

select

cancel

60

save

filtering & spectra

filter

cancel

spectrum

spectrogram

refraction

refraction

upload

clear refraction

100

save

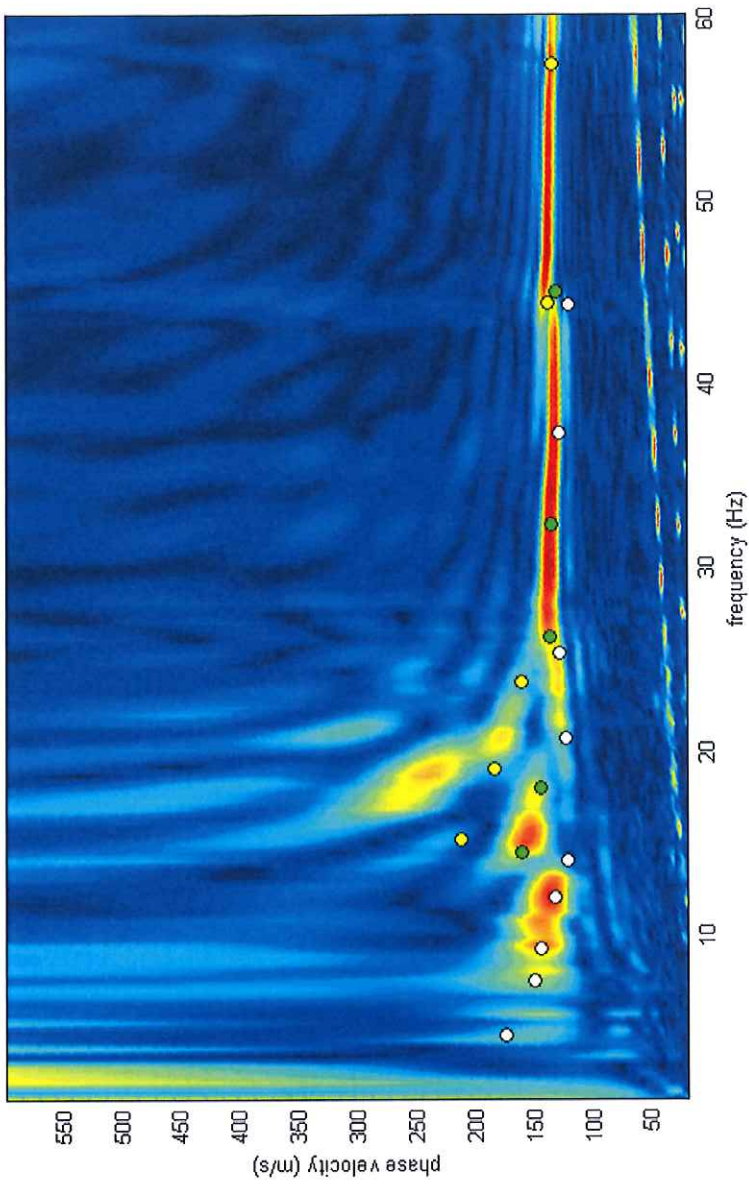
length to visualize (s)

done

flip traces

zero padding

velocity spectrum



general setting

?

about Poisson

Rayleigh

3

phase vel

0

Reference depth

☐ Refraction

☐

H/V body waves

0

H/V modes (SW ellipticity)

Vs (m/s)

100

180

260

400

600

800

1200

0

Poisson

0.4

0.35

0.35

0.35

0.35

0.35

0.3

0.2

thickness (m)

1

2

5

5

7

80

0

calculate

upload mod.

save model

refresh

report

modelling

synthetics

ZVF

☐ elastic

☐ shows DC

synthetics

Analyzing phase velocities

==o== SECTION#1

dataset: 8m.SGY  
minimum offset (m): 8  
geophone spacing (m): 2  
sampling (ms): 0.131  
Dispersion curve: 8m.cdp  
Number of individuals: 30  
Number of generations: 31

Rayleigh-wave dispersion analysis

Analyzing phase Velocities

Adopted search space (minimum Vs & thickness): 110 1 140 3 150 4 180  
Adopted search space (maximum Vs & thickness): 170 7 190 9 220 14 289  
Adopted Poisson values: 0.4 0.35 0.35 0.35

Output folder: C:\studio giuseppe\lavori\sismiche\output\_disp

==o== SECTION#2

Rayleigh wave analysis

Optimizing Vs & Thickness - generation: 1; average & best misfits: -9.5953	-3.8365
Optimizing Vs & Thickness - generation: 2; average & best misfits: -9.2111	-3.7719
Optimizing Vs & Thickness - generation: 3; average & best misfits: -8.9386	-3.7719
Optimizing Vs & Thickness - generation: 4; average & best misfits: -8.9272	-3.6292
Optimizing Vs & Thickness - generation: 5; average & best misfits: -8.0862	-3.0203
Optimizing Vs & Thickness - generation: 6; average & best misfits: -7.7902	-3.0203
Optimizing Vs & Thickness - generation: 7; average & best misfits: -6.4639	-2.8858
Optimizing Vs & Thickness - generation: 8; average & best misfits: -6.3063	-2.8669
Optimizing Vs & Thickness - generation: 9; average & best misfits: -6.2301	-2.8669
Optimizing Vs & Thickness - generation: 10; average & best misfits: -6.2306	-2.8669
Optimizing Vs & Thickness - generation: 11; average & best misfits: -5.9458	-2.8609
Optimizing Vs & Thickness - generation: 12; average & best misfits: -7.1839	-2.8609
Optimizing Vs & Thickness - generation: 13; average & best misfits: -8.2346	-2.8609
Optimizing Vs & Thickness - generation: 14; average & best misfits: -9.0344	-2.748
Optimizing Vs & Thickness - generation: 15; average & best misfits: -6.383	-2.748
Optimizing Vs & Thickness - generation: 16; average & best misfits: -7.027	-2.748
Optimizing Vs & Thickness - generation: 17; average & best misfits: -5.1394	-2.748
Optimizing Vs & Thickness - generation: 18; average & best misfits: -6.3369	-2.748
Optimizing Vs & Thickness - generation: 19; average & best misfits: -6.0183	-2.721
Optimizing Vs & Thickness - generation: 20; average & best misfits: -6.9549	-2.721
Optimizing Vs & Thickness - generation: 21; average & best misfits: -7.5435	-2.721
Optimizing Vs & Thickness - generation: 22; average & best misfits: -7.5743	-2.721
Optimizing Vs & Thickness - generation: 23; average & best misfits: -6.9031	-2.619
Optimizing Vs & Thickness - generation: 24; average & best misfits: -7.7065	-2.619
Optimizing Vs & Thickness - generation: 25; average & best misfits: -6.1368	-2.619
Optimizing Vs & Thickness - generation: 26; average & best misfits: -9.3724	-2.619
Optimizing Vs & Thickness - generation: 27; average & best misfits: -11.5821	-2.61904
Optimizing Vs & Thickness - generation: 28; average & best misfits: -8.1562	-2.619
Optimizing Vs & Thickness - generation: 29; average & best misfits: -8.3622	-2.619
Optimizing Vs & Thickness - generation: 30; average & best misfits: -8.2469	-2.619
Optimizing Vs & Thickness - generation: 31; average & best misfits: -6.4577	-2.619

Forcing search space

Now a finer search around the most promising search space area

Rayleigh wave analysis

Optimizing Vs & Thickness - generation: 1; average & best misfits: -8.6557	-2.619
Optimizing Vs & Thickness - generation: 2; average & best misfits: -7.5273	-2.619
Optimizing Vs & Thickness - generation: 3; average & best misfits: -6.136	-2.345
Optimizing Vs & Thickness - generation: 4; average & best misfits: -6.3326	-2.345
Optimizing Vs & Thickness - generation: 5; average & best misfits: -6.3864	-2.345
Optimizing Vs & Thickness - generation: 6; average & best misfits: -5.7179	-2.345
Optimizing Vs & Thickness - generation: 7; average & best misfits: -5.7264	-2.345
Optimizing Vs & Thickness - generation: 8; average & best misfits: -5.5692	-2.345
Optimizing Vs & Thickness - generation: 9; average & best misfits: -6.7899	-2.345

Model after the Vs & Thickness optimization (fixed Poisson values):

Vs (m/s): 128 144 229 261

Thickness (m): 7.7 6.1 4.8

Poisson: 0.4 0.35 0.35 0.35

Vp & Density Optimization

p14 =

2

p15 =

19

p16 =

Columns 1 through 7

0.1010	0.1682	0.2077	0.2710	0.3164	0.4666	0.5713
0.3212	0.3990	0.5818	0.7180	1.0000	0	0
0.2639	0.3309	0.4132	0.7729	1.0000	0	0
0	0	0	0	0	0	0

Columns 8 through 9

0.8419	1.0000
0	0
0	0
0	0

Rayleigh wave analysis

Optimizing Vp & Density - generation: 1; average & best misfits: -2.6002	-2.0665
Optimizing Vp & Density - generation: 2; average & best misfits: -2.377	-2.0665
Optimizing Vp & Density - generation: 3; average & best misfits: -2.3004	-2.0647
Optimizing Vp & Density - generation: 4; average & best misfits: -2.1752	-2.0647
Optimizing Vp & Density - generation: 5; average & best misfits: -2.1135	-2.0531
Optimizing Vp & Density - generation: 6; average & best misfits: -2.0973	-2.0498
Optimizing Vp & Density - generation: 7; average & best misfits: -2.0919	-2.0482
Optimizing Vp & Density - generation: 8; average & best misfits: -2.0781	-2.0482
Optimizing Vp & Density - generation: 9; average & best misfits: -2.0977	-2.0453

Number of models considered to calculate the average model: 123

#####  
RESULTS  
#####

Dataset: 8m.SGY

Analyzed curve/spectrum: 8m.cdp

===== SECTION#3

Analyzing Phase Velocities

Analyzing Rayleigh-Wave Dispersion

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MEAN MODEL

Vs (m/s): 127 140 202 261  
 Standard deviations (m/s): 2 5 27 27

Thickness (m): 6.5 6.0 5.3  
 Standard deviations (m): 0.6 1.1 1.8

Approximate values for Vp, density, Poisson & Shear modulus

Vp (m/s): 949 542 715 729  
 Density (gr/cm3): 2.04 1.91 1.97 1.98  
 Vp/Vs ratio: 7.47 3.87 3.54 2.79  
 Poisson: 0.49 0.46 0.46 0.43  
 Shear modulus (MPa): 33 37 80 135  
 Estimated static shear modulus (MPa): 0 0 0 0

Fundamental mode

Mean model

f(Hz)	VR(m/s)
4.47742	173.6701
7.45386	130.6165
9.20471	126.1617
12.0061	123.3896
14.0195	122.5103
20.6728	121.4765
25.3125	121.2919
37.3058	121.1909
44.3092	121.1838

First higher mode

Mean model

14.4573	159.2754
17.959	148.0177
26.188	138.294
32.3159	134.8516
45.0096	131.0266

Second higher mode

Mean model

15.1576	207.6493
19.0095	182.9527
23.7368	161.2668
44.3968	140.3011
57.4406	135.8505

===== SECTION#4

BEST MODEL

Vs (m/s): 128 144 229 261  
 thickness (m): 7.7027 6.0684 4.8258

Approximate values for Vp, density, Poisson & Shear modulus

Vp (m/s):	1869	721	1545	447
Density (gr/cm3):	2.21	1.97	2.16	1.86
Vp/Vs ratio:	14.60	5.01	6.75	1.71
Poisson:	0.50	0.48	0.49	0.24
Shear modulus (MPa):	36	41	113	127
Estimated static shear modulus (MPa):	0	0	0	0

dispersion curve (frequency - velocity)

Fundamental mode)

best model

F(Hz)	VR(m/s)
4.47742	168.4415
7.45386	129.6917
9.20471	125.949
12.0061	123.7428
14.0195	123.0904
20.6728	122.397
25.3125	122.293
37.3058	122.2458
44.3092	122.2434

First higher mode)

best model

14.4573	157.4505
17.959	146.9466
26.188	137.3904
32.3159	134.118
45.0096	130.9672

Second higher mode)

best model

15.1576	211.8427
19.0095	178.9853
23.7368	158.6695
44.3968	139.3274
57.4406	134.739

Vs5 (mean model): 127 m/s

Vs5 (best model): 128 m/s

Vs20 (mean model): 155 m/s

Vs20 (best model): 155 m/s

Vs30 (mean model): 180 m/s

Vs30 (best model): 180 m/s

==o== SECTION#6

For Italian Users:

Dalla normativa (modifiche del D.M. 14/09/2005 Norme Tecniche per le Costruzioni, emanate con D.M. Infrastrutture del 14/01/2008, pubblicato su Gazzetta Ufficiale Supplemento ordinario n° 29 del 04/02/2008):

A - Ammassi rocciosi affioranti o terreni molto rigidi, caratterizzati da valori di VS30 superiori a 800 m/s, eventualmente comprendenti in superficie uno strato di alterazione, con spessore massimo di 3 m.

B - Rocce tenere e depositi di terreni a grana grossa molto addensati o terreni a grana fine molto consistenti, con spessori superiori a 30 m, caratterizzati da graduale miglioramento delle proprietà meccaniche con la profondità e valori

del VS30 compresi tra 360 m/s e 800 m/s (ovvero  $NSPT30 > 50$  nei terreni a grana grossa e  $cu30 > 250$  kPa nei terreni a grana fina).

C - Depositi di terreni a grana grossa mediamente addensati o terreni a grana fine mediamente consistenti, con spessori superiori a 30 m caratterizzati da graduale miglioramento delle proprietà meccaniche con la profondità e valori del VS30 compresi tra 180 m/s e 360 m/s (ovvero  $15 < NSPT30 < 50$  nei terreni a grana grossa e  $70 < cu30 < 250$  kPa nei terreni a grana fina).

D - Depositi di terreni a grana grossa scarsamente addensati o terreni a grana fine scarsamente consistenti, con spessori superiori a 30 m caratterizzati da graduale miglioramento delle proprietà meccaniche con la profondità e valori del VS30 inferiori a 180 m/s (ovvero  $NSPT30 < 15$  nei terreni a grana grossa e  $cu30 < 70$  kPa nei terreni a grana fina).

E - Terreni dei sottosuoli dei tipi C o D per spessori non superiori a 20 m, posti sul substrato di riferimento (con  $VS > 800$  m/s).

S1 - Depositi di terreni caratterizzati da valori di VS30 inferiori 100 m/s (ovvero  $10 < cu30 < 20$  kPa) che includono uno strato di almeno 8 m di terreni a grana fina di bassa consistenza, oppure che includano almeno 3 m di torba o argille altamente organiche.

S2 - Depositi di terreni suscettibili di liquefazione, di argille sensitive, o qualsiasi altra categoria di sottosuolo non classificabile nei tipi precedenti.

Results saved in the folder "C:\studio giuseppe\lavori\sismiche\output\_disp".

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winMASW  
Surface Waves & Beyond  
[www.winmasw.com](http://www.winmasw.com)

Number of models used to define the mean model: 123

Vs5 for the best model: 128

Vs30 for the best model: 180

Analyzing phase velocities

Elapsed time is 101.899026 seconds.