

SASPARM

**Support Action for Strengthening Palestinian-administrated Areas
capabilities for seismic Risk Mitigation**

Call ID FP7-INCO.2011-6.2

MODULE 3 : GROUND RESPONSE ANALYSES AND NEAR-SURFACE SITE CHARACTERIZATION

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in collaboration with
Dr. Laura Scandella, PhD

**GROUND RESPONSE
ANALYSES: EXERCISING**

NNU, May 2 – 4, 2013



EERA – Case study

Linear equivalent 1D ground response analysis

WEB SITE TO DOWNLOAD EERA:

<http://gees.usc.edu/GEES/Software/EERA2000/Default.htm>



EERA

Equivalent-linear **E**arthquake site **R**esponse **A**nalysis

Version 2000

This page was last updated on July 02, 2004

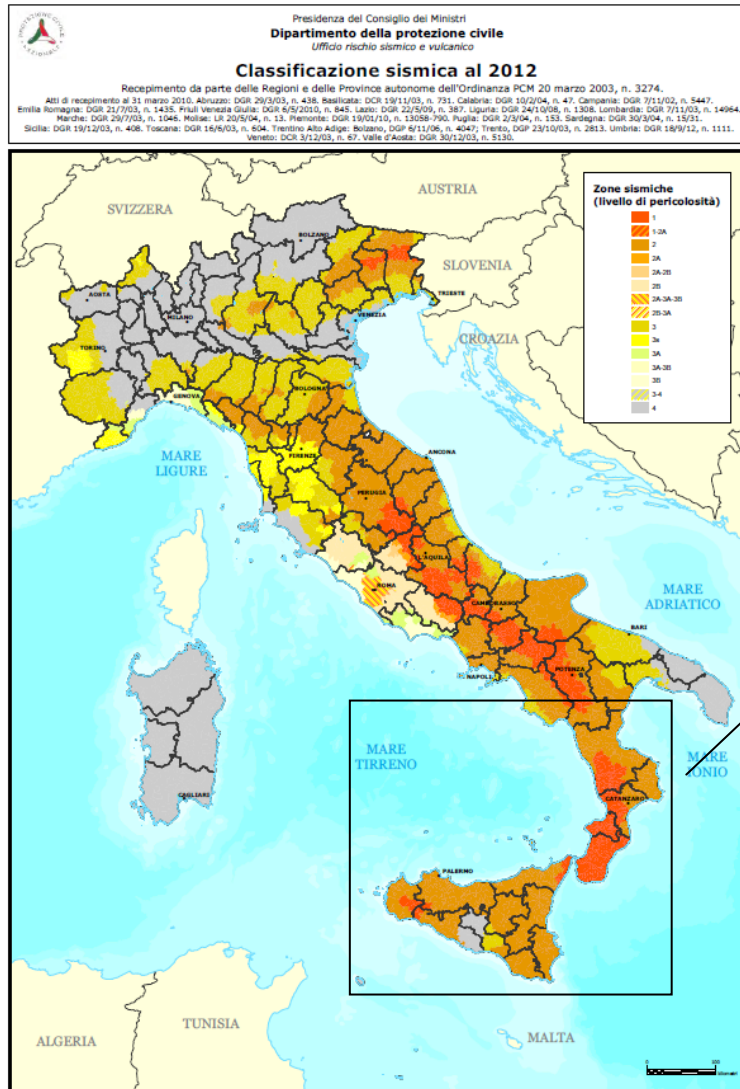
EERA is a modern implementation of the equivalent-linear concept of earthquake site response analysis, previously implemented in the original and later versions of SHAKE.

- [System requirement, downloading files and user's manual](#)
- [Installing EERA](#)
- [Removing EERA](#)
- [Automatizing EERA using Visual Basic macros](#)
- [Frequently asked questions](#)
- [Reporting problems and asking questions](#)



EERA – Case study

Perform 1D site response analysis at the site of Gioia Tauro, Calabria (Italy)



Required inputs :

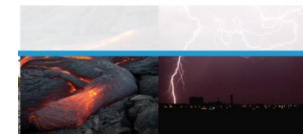
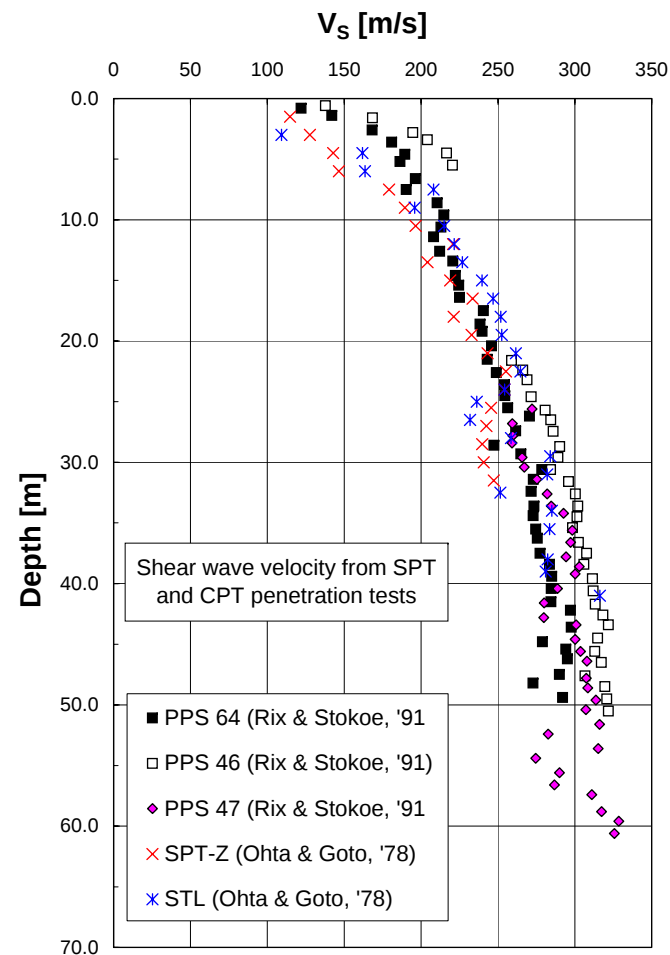
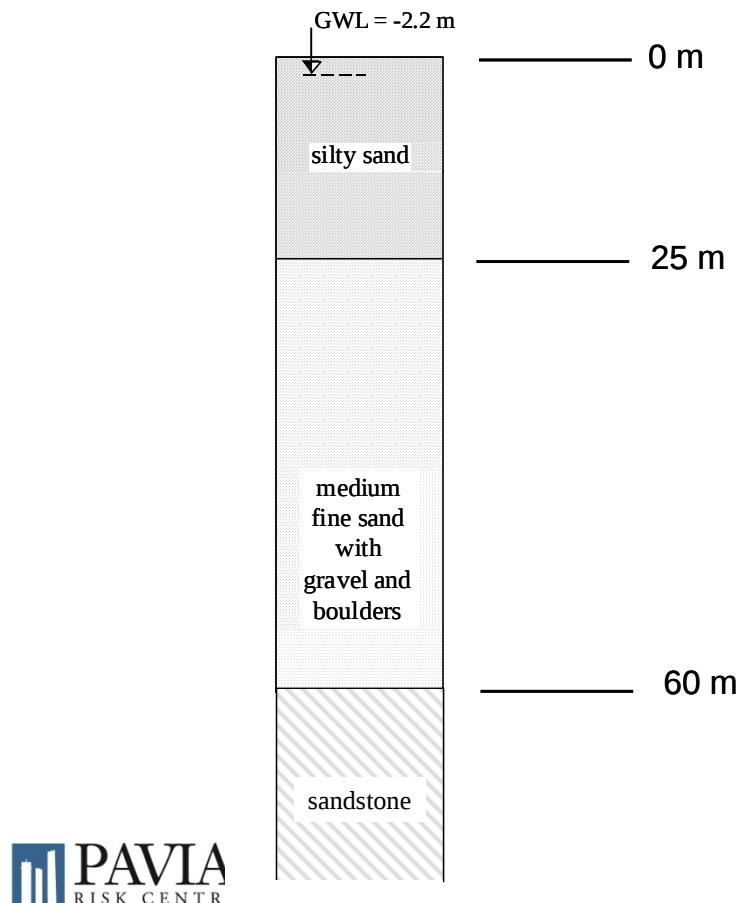
- Soil profile
- Material stress-strain and damping-strain curves
- Seismic input (e.g. outcropping, within)



EERA – Case study

Available input data:

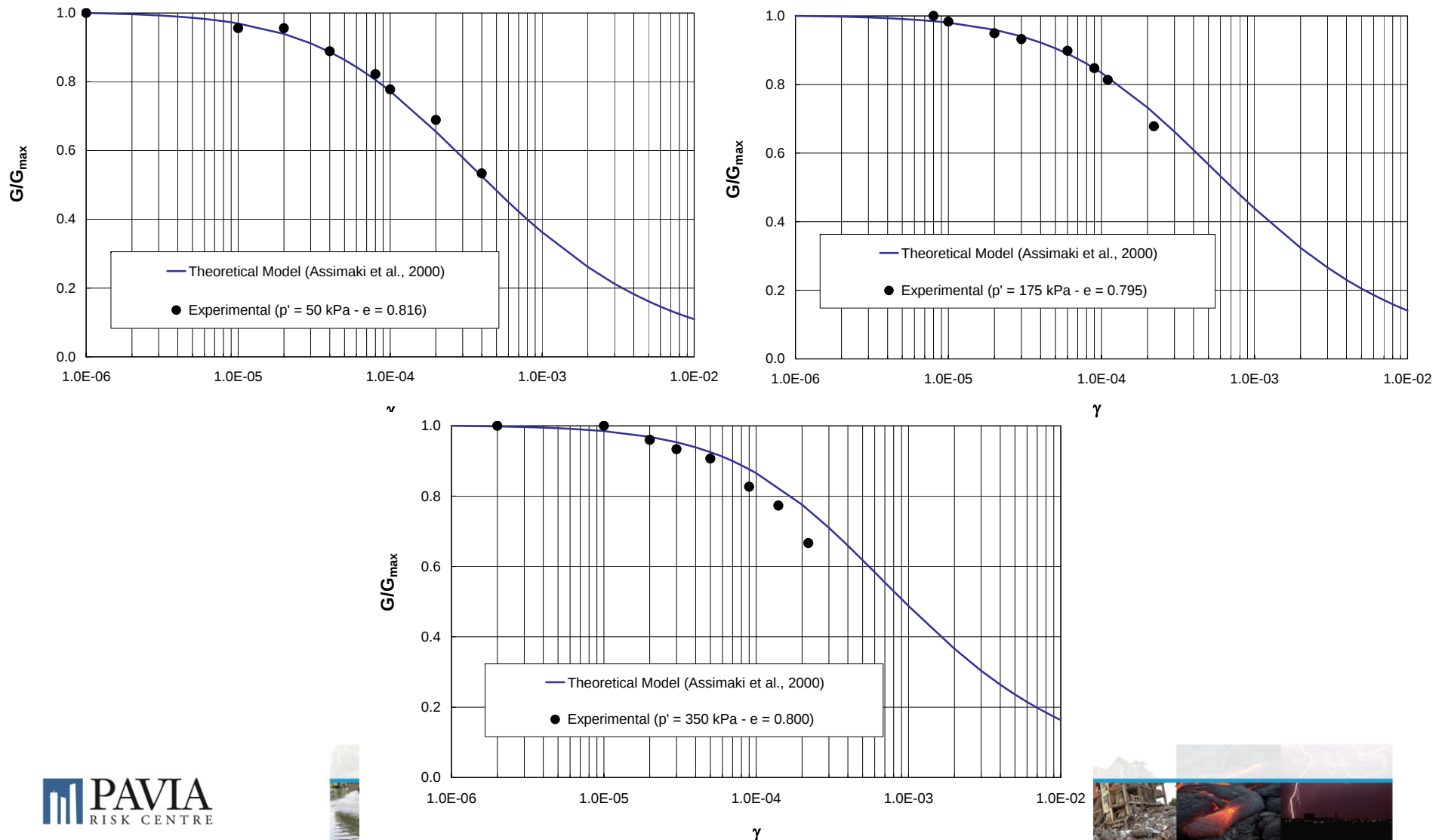
- Lithostratigraphic profile from geological logs
- In-situ and laboratory test results



EERA – Case study

Available input data:

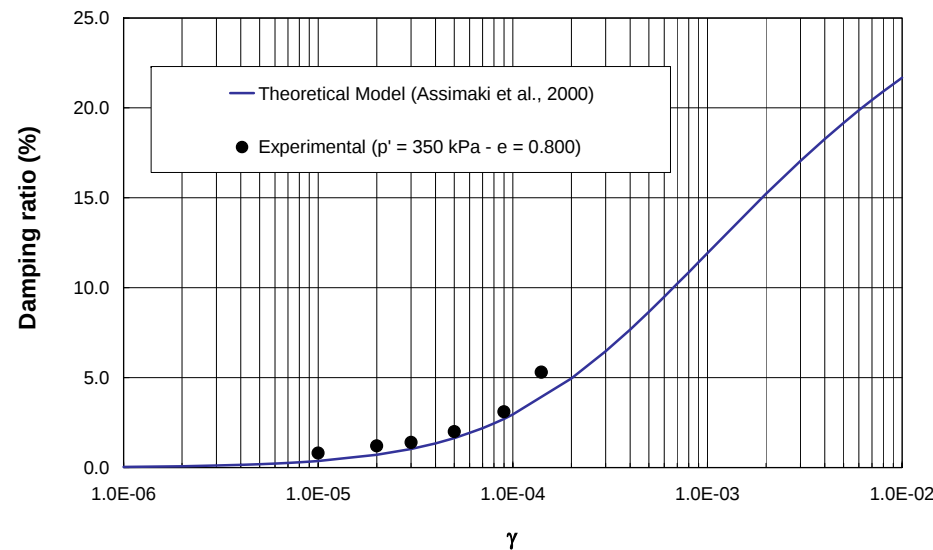
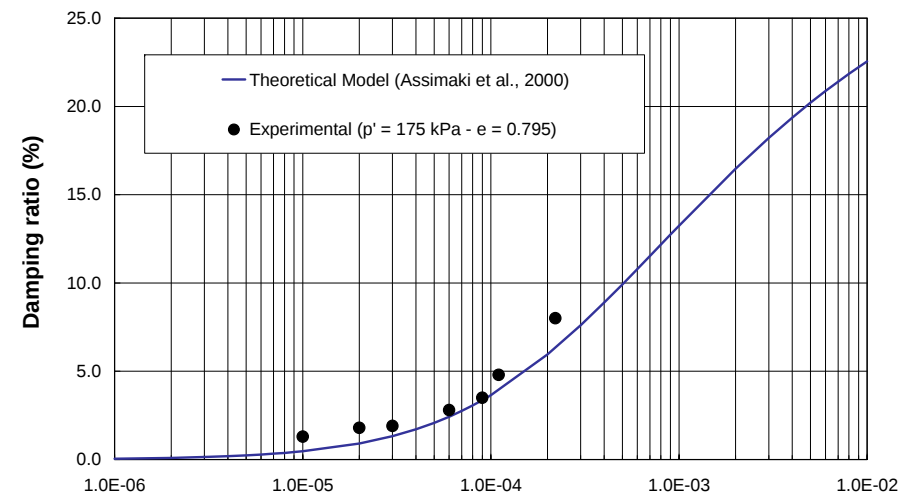
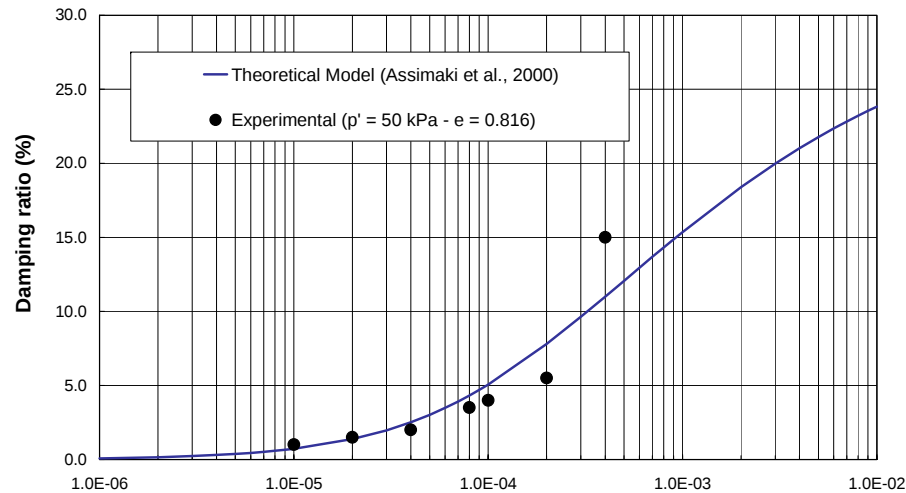
Shear modulus degradation curves for coarse grained soils at the site of Gioia Tauro at different depths associated to different effective pressure $p' = 50, 175, 350$ kPa



EERA – Case study

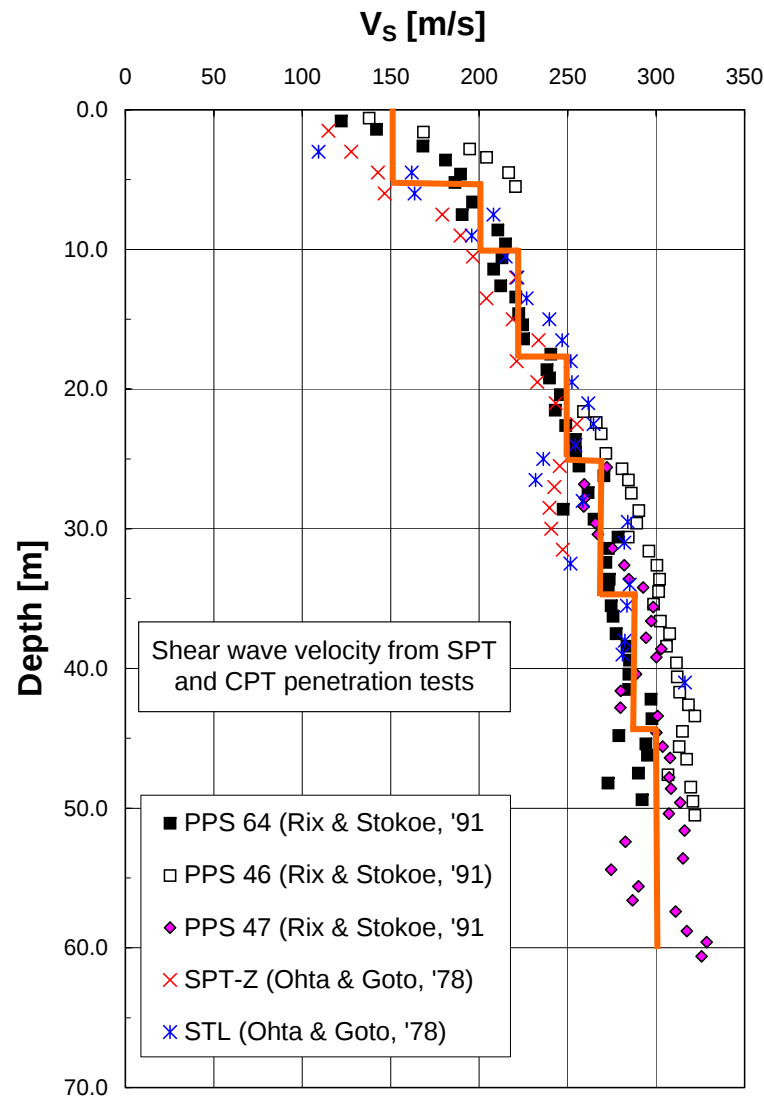
Available input data:

Damping degradation curves for coarse grained soils at the site of Gioia Tauro at different depths associated to different effective pressure $p' = 50, 175, 350$ kPa

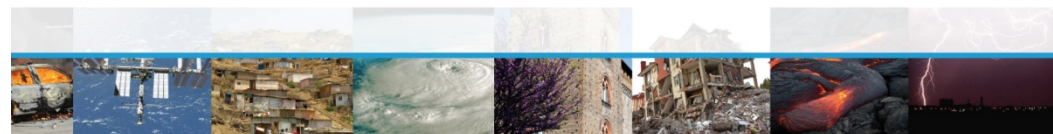


EERA – Case study

- ✓ Selection of an appropriate soil profile



Layer	Depth [m]	V_s [m/s]
1	0-5	150
2	5-10	200
3	10-18	220
4	18-25	250
5	25-35	270
6	35-45	285
7	45-60	300
halfspace	-	1000



EERA – Case study

- ✓ Selection of appropriate modulus vs. shear strain and damping ratio vs. shear strain curves

Hp: $p' = \frac{\sigma'_{v0} + 2\sigma'_{h0}}{3}$ with $\sigma'_{h0} = K_0 \sigma'_{v0} = 0.5\sigma'_{v0} \Rightarrow p' = \frac{2\sigma'_{v0}}{3}$

Given the 3 values of effective pressure $p' = 50, 175, 350 \text{ kPa}$ and assuming a specific weight for the soil, the average depths to which $\Rightarrow z = \frac{\sigma'_{v0}}{\gamma'}$ the available G/G_0 and ξ curves are associated can be calculated

Assuming $\gamma' = 18 \frac{\text{kN}}{\text{m}^3}$:

The 3 provided G/G_0 and ξ curves are respectively adopted for the layers:

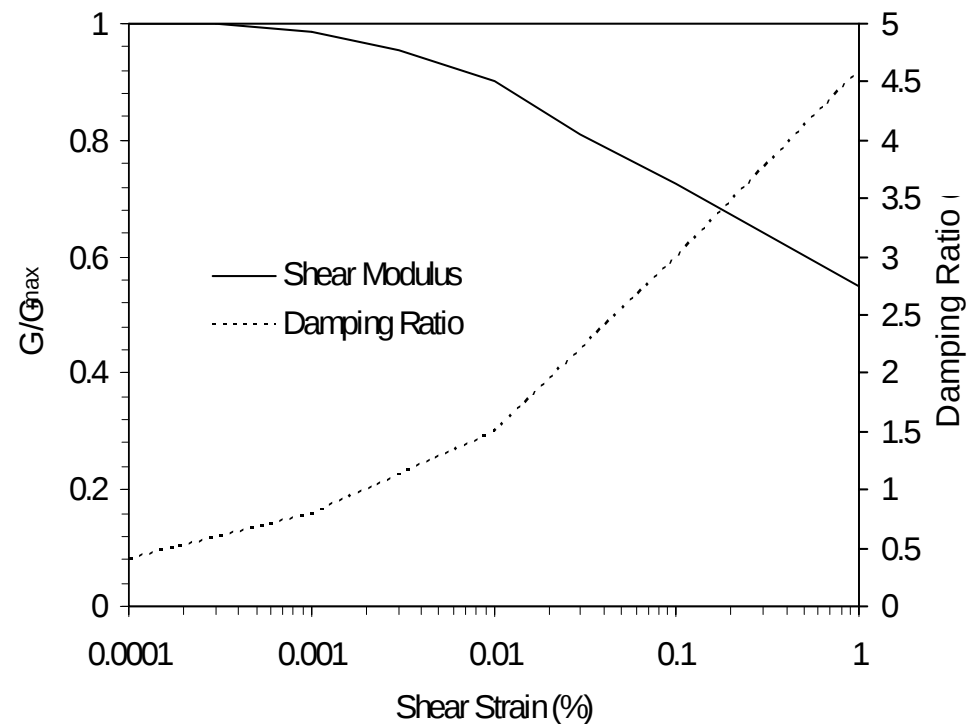
$p' = 50 \text{ kPa}$	$z = 4 \text{ m}$	$G/G_0(50 \text{ kPa}), \xi(50 \text{ kPa}) \rightarrow$	Layer 1-2
$p' = 175 \text{ kPa} \Rightarrow$	$z = 15 \text{ m} \Rightarrow$	$G/G_0(175 \text{ kPa}), \xi(175 \text{ kPa}) \rightarrow$	Layer 3-4
$p' = 350 \text{ kPa}$	$z = 29 \text{ m}$	$G/G_0(350 \text{ kPa}), \xi(350 \text{ kPa}) \rightarrow$	Layer 5-7



EERA – Case study

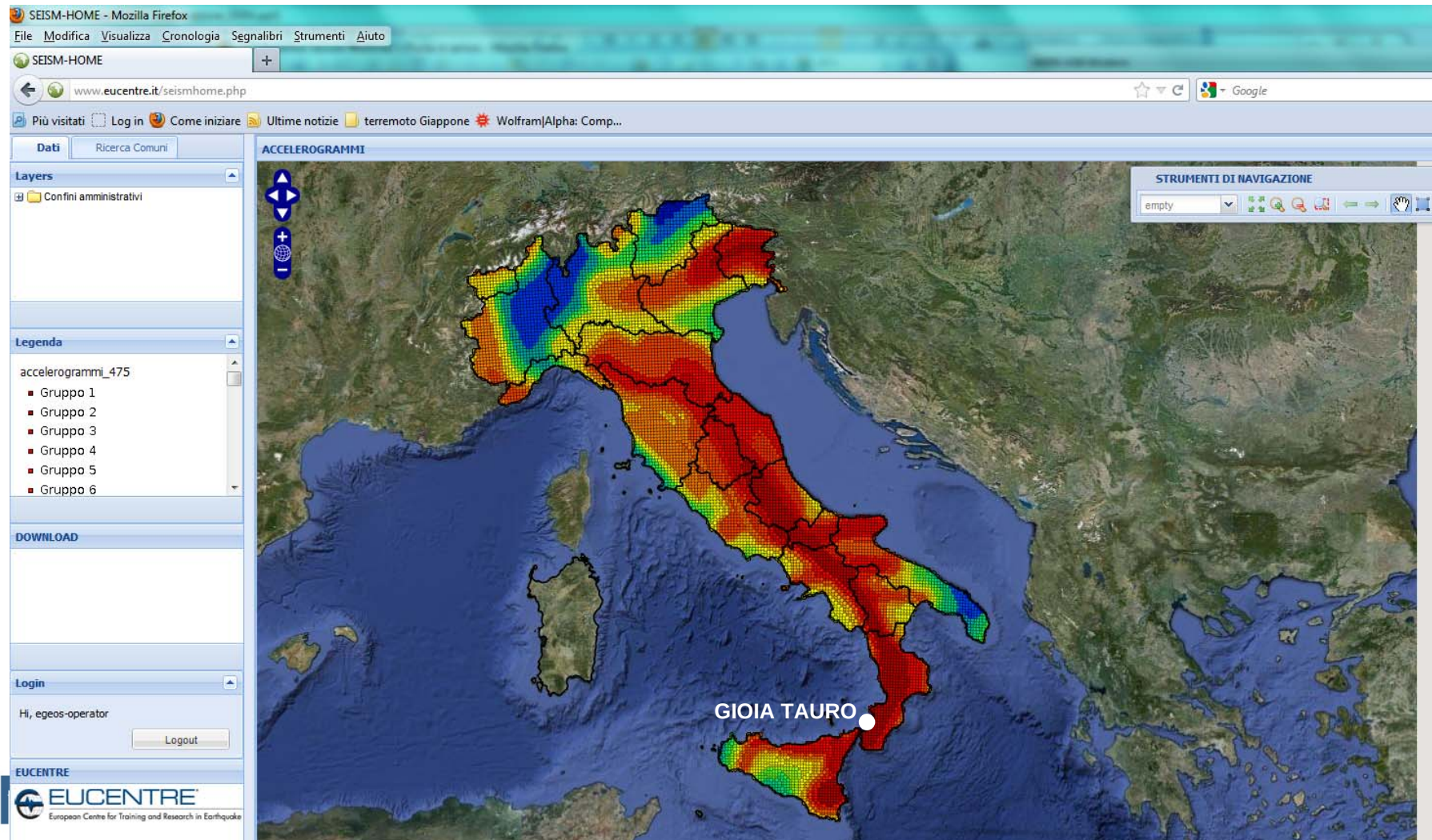
- ✓ Selection of appropriate modulus vs. shear strain and damping ratio vs. shear strain curves

Attenuation of rock average and damping in rock for the halfspace



EERA – Case study

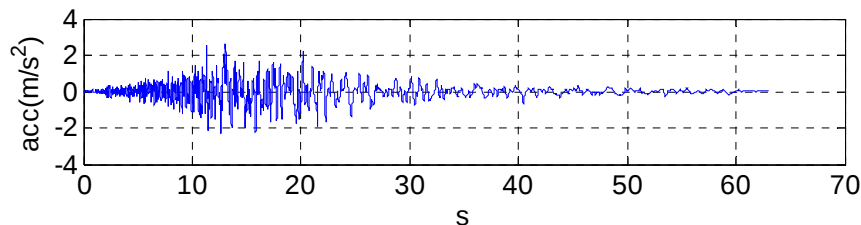
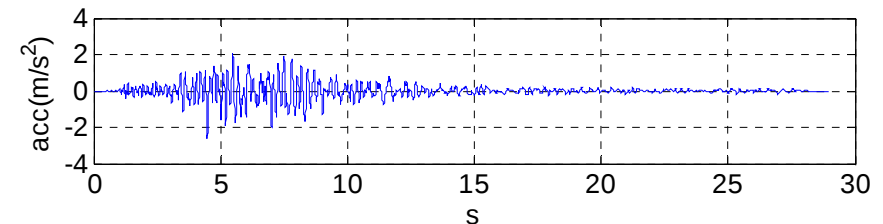
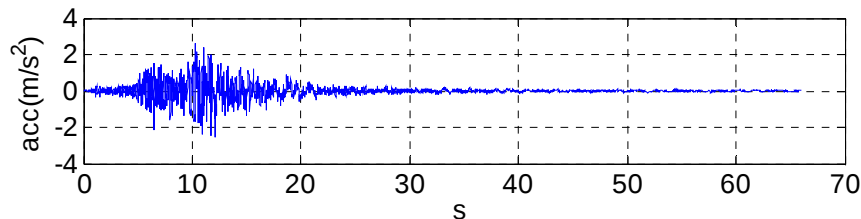
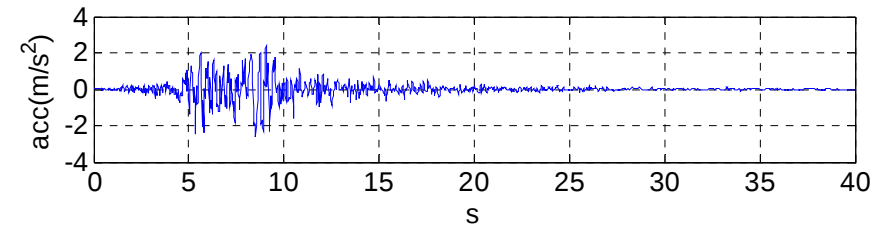
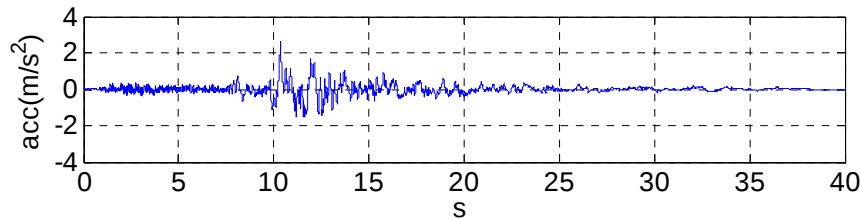
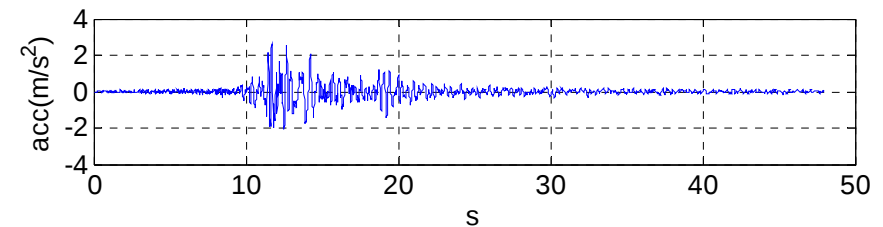
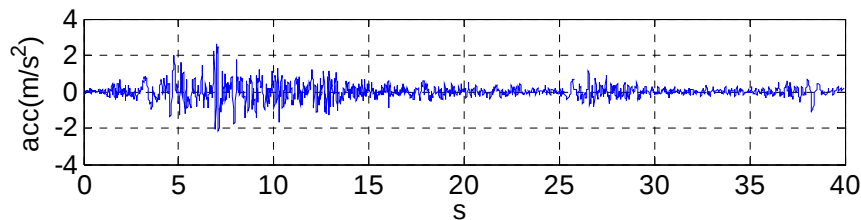
- ✓ Seismic input: 7 real accelerograms recorded on outcropping bedrock, available at <http://www.eucentre.it/seismhome.html> for the site of Gioia Tauro.



EERA – Case study

- ✓ Seismic input: 7 real accelerograms recorded on outcropping bedrock, available at <http://www.eucentre.it/seismhome.html> for the site of Gioia Tauro.

$T_R = 475$ years



EERA – Case study

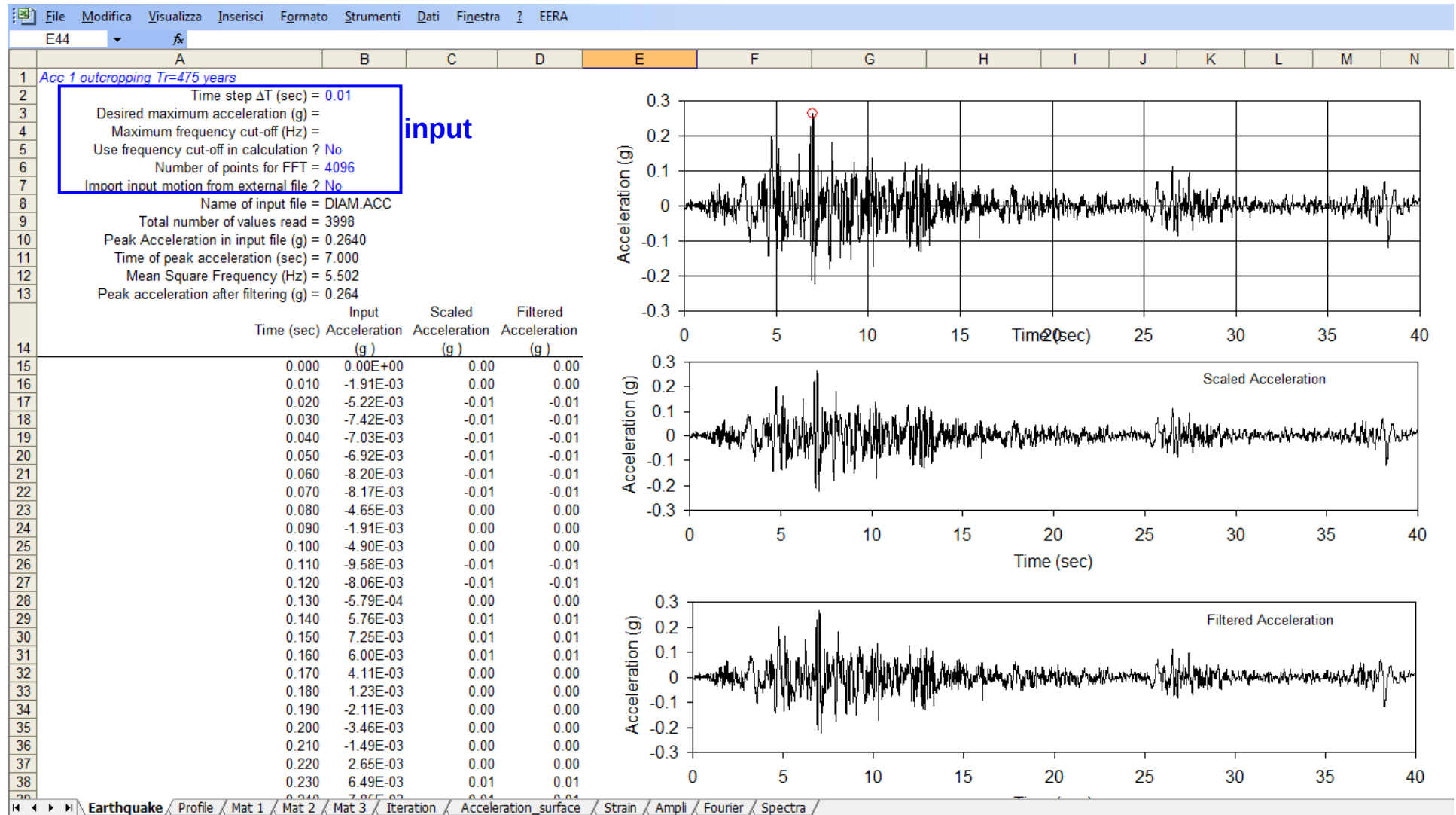
Required outputs :

- Calculate and plot the average acceleration response spectrum (horizontal component and return period of 475 years) at the ground surface
- Calculate and plot the amplification spectra between the outcropping bedrock input motion and the ground surface. In the response spectrum calculations, use a spectral damping ratio of 0.05.



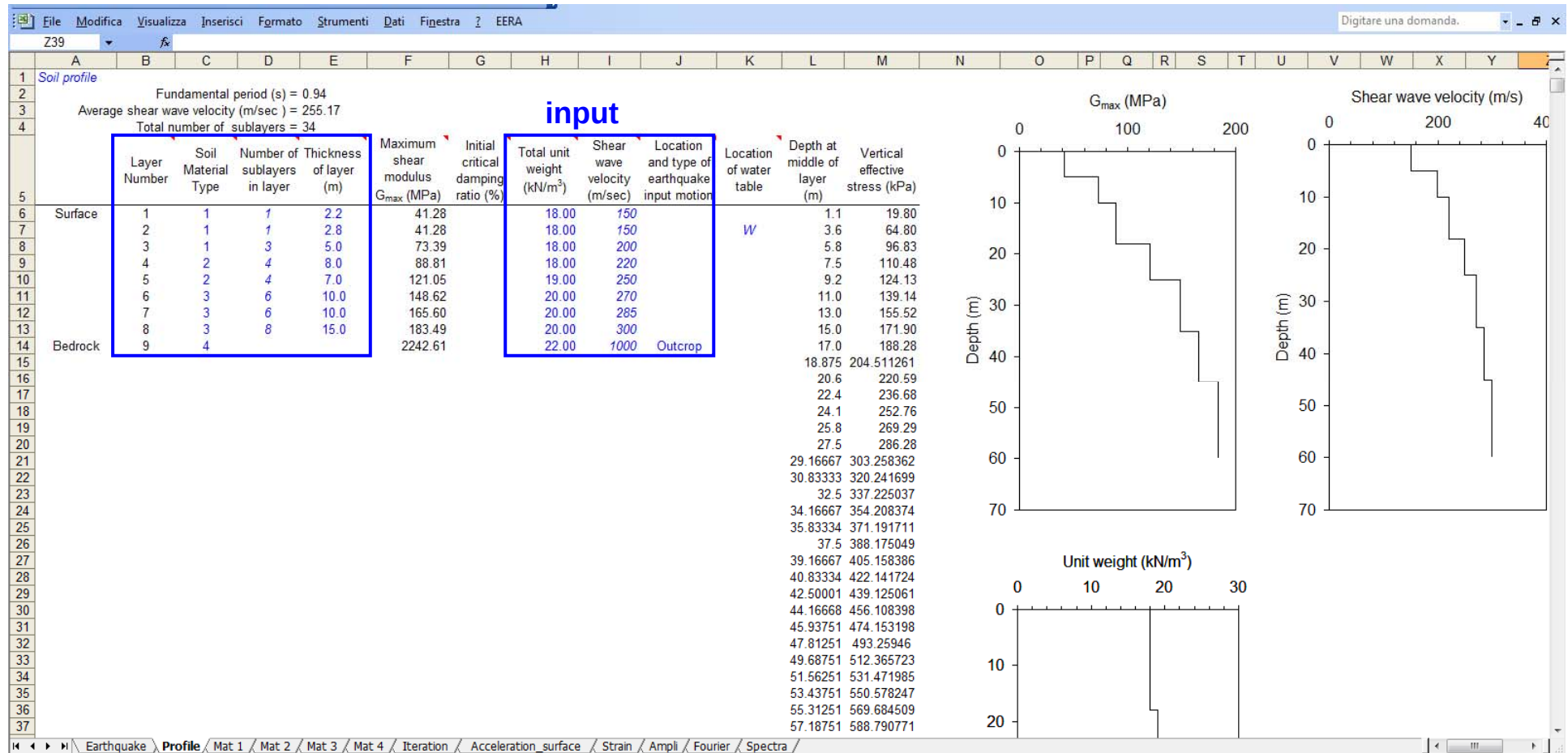
EERA – Case study

- ✓ EERA analysis: earthquake



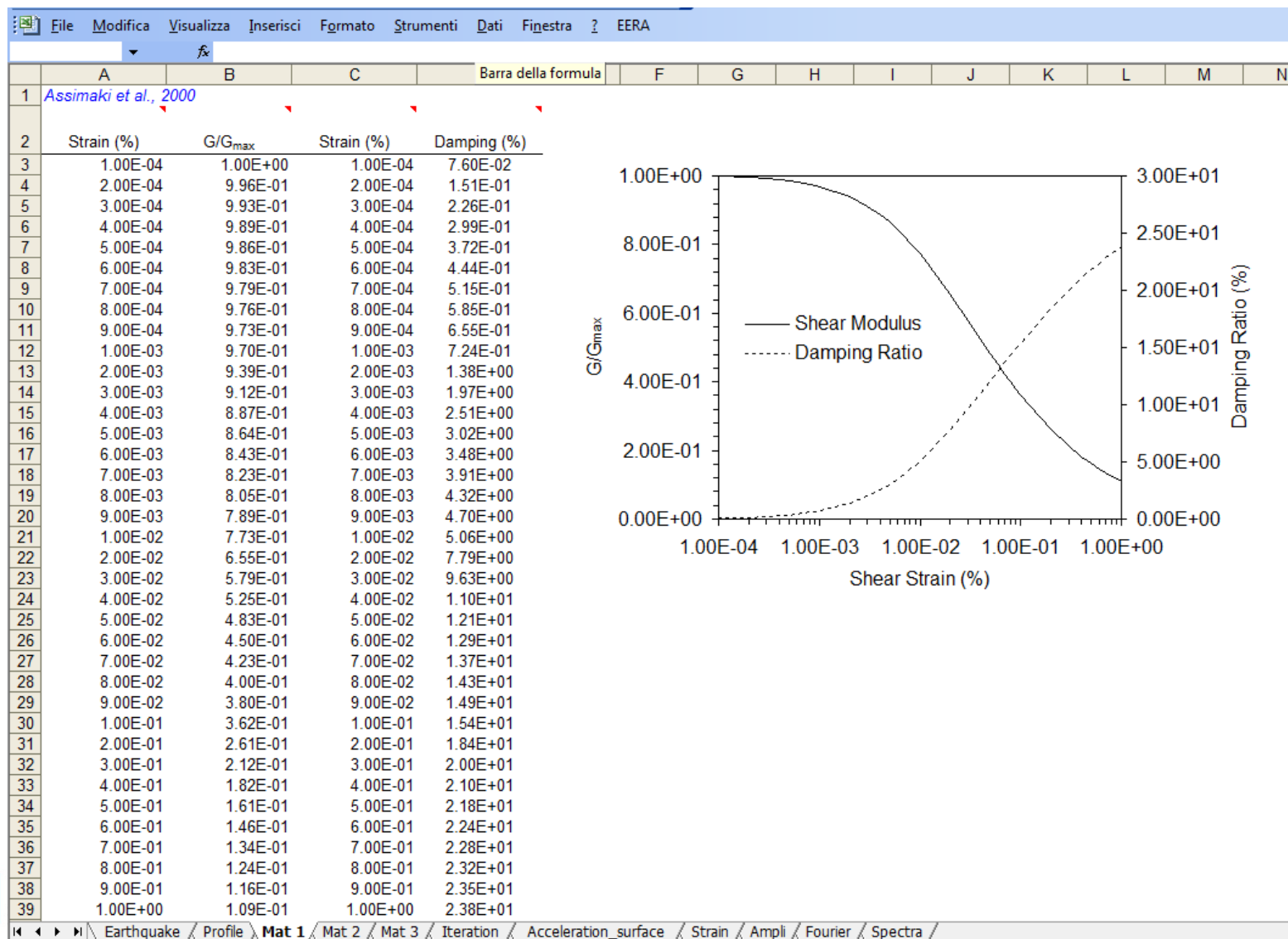
EERA – Case study

✓ EERA analysis: profile



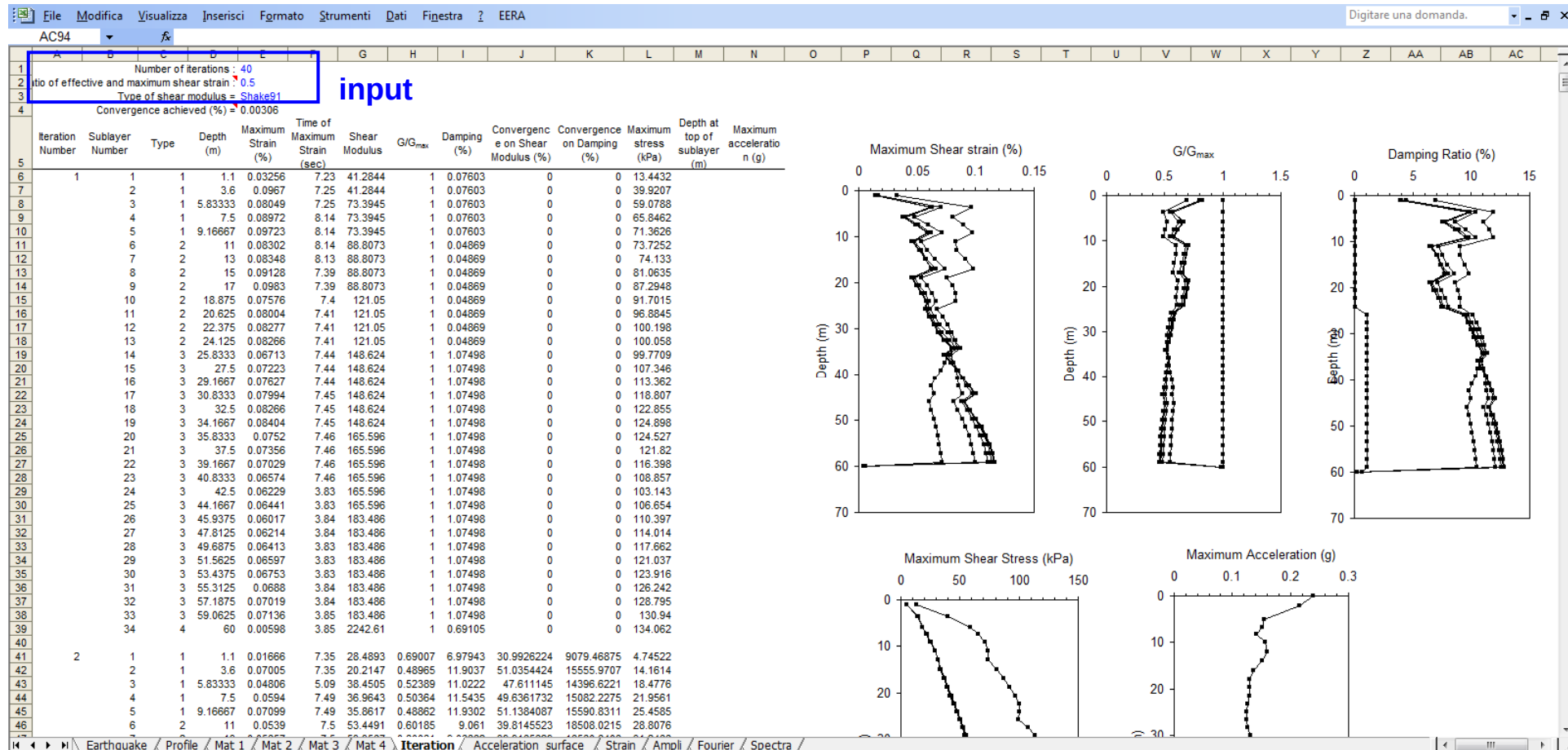
EERA – Case study

✓ EERA analysis: materials (Mat 1)



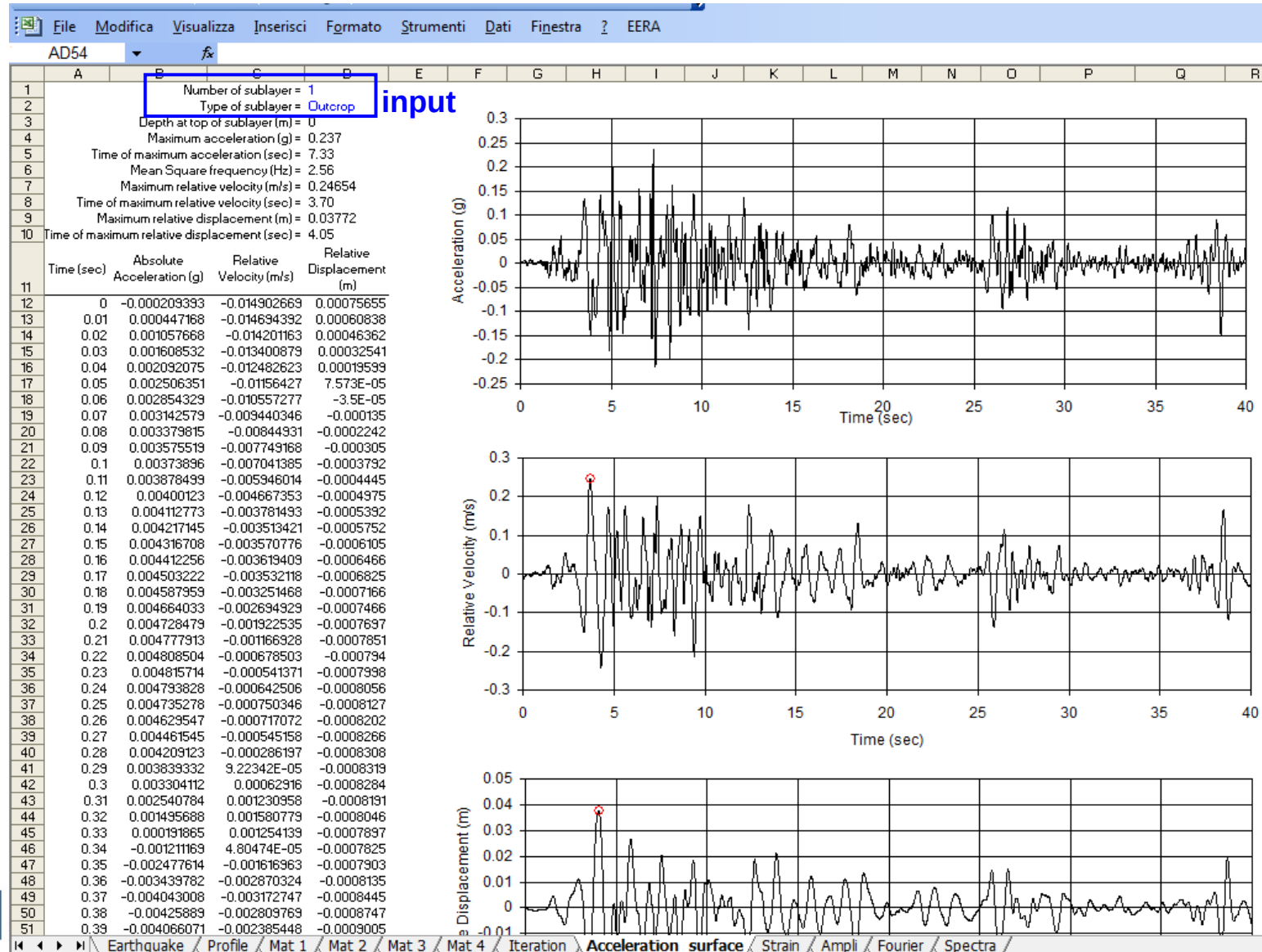
EERA – Case study

✓ EERA analysis: iterations



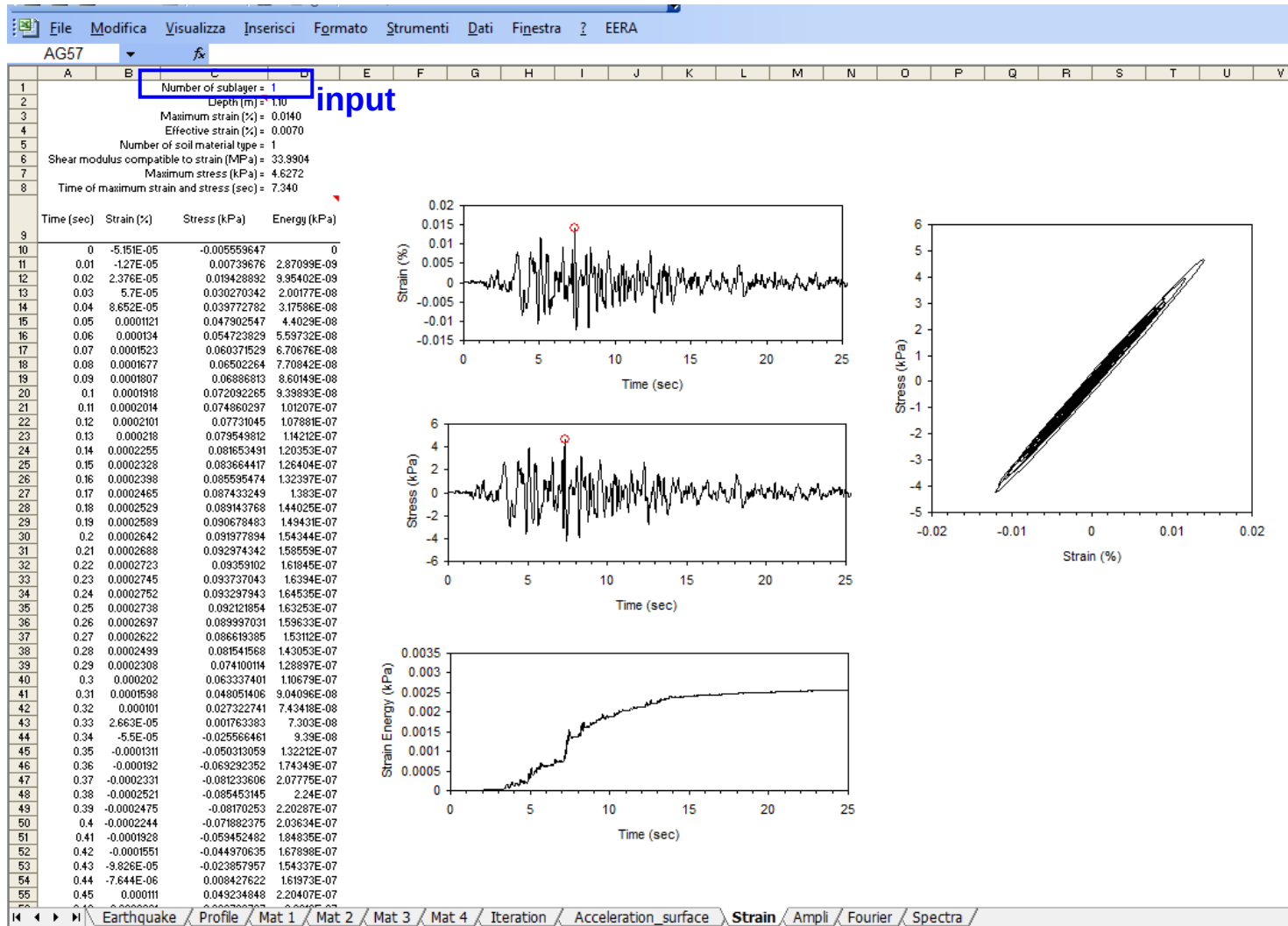
EERA – Case study

✓ EERA results: acceleration, velocity, displacement



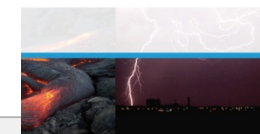
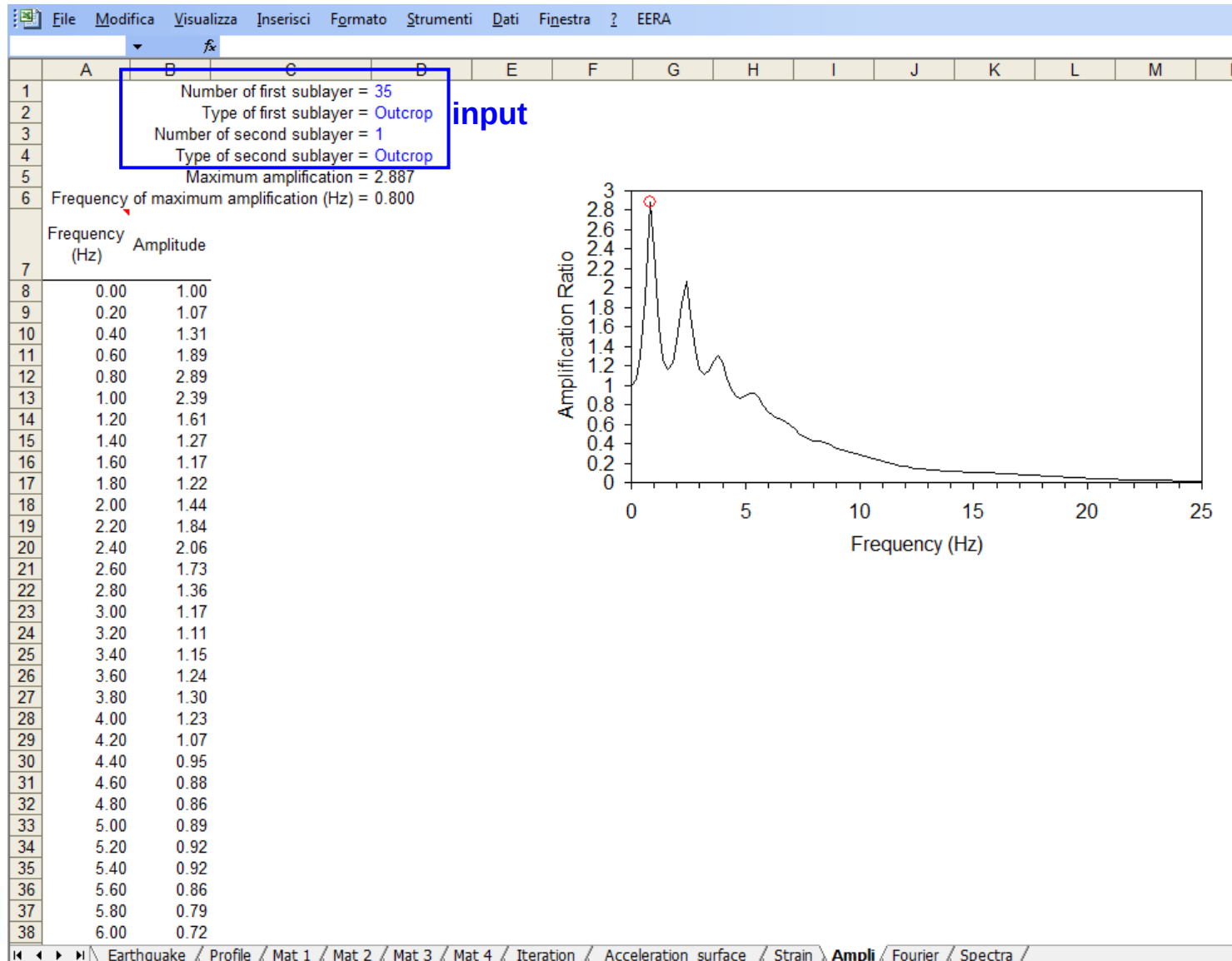
EERA – Case study

✓ EERA results: strain



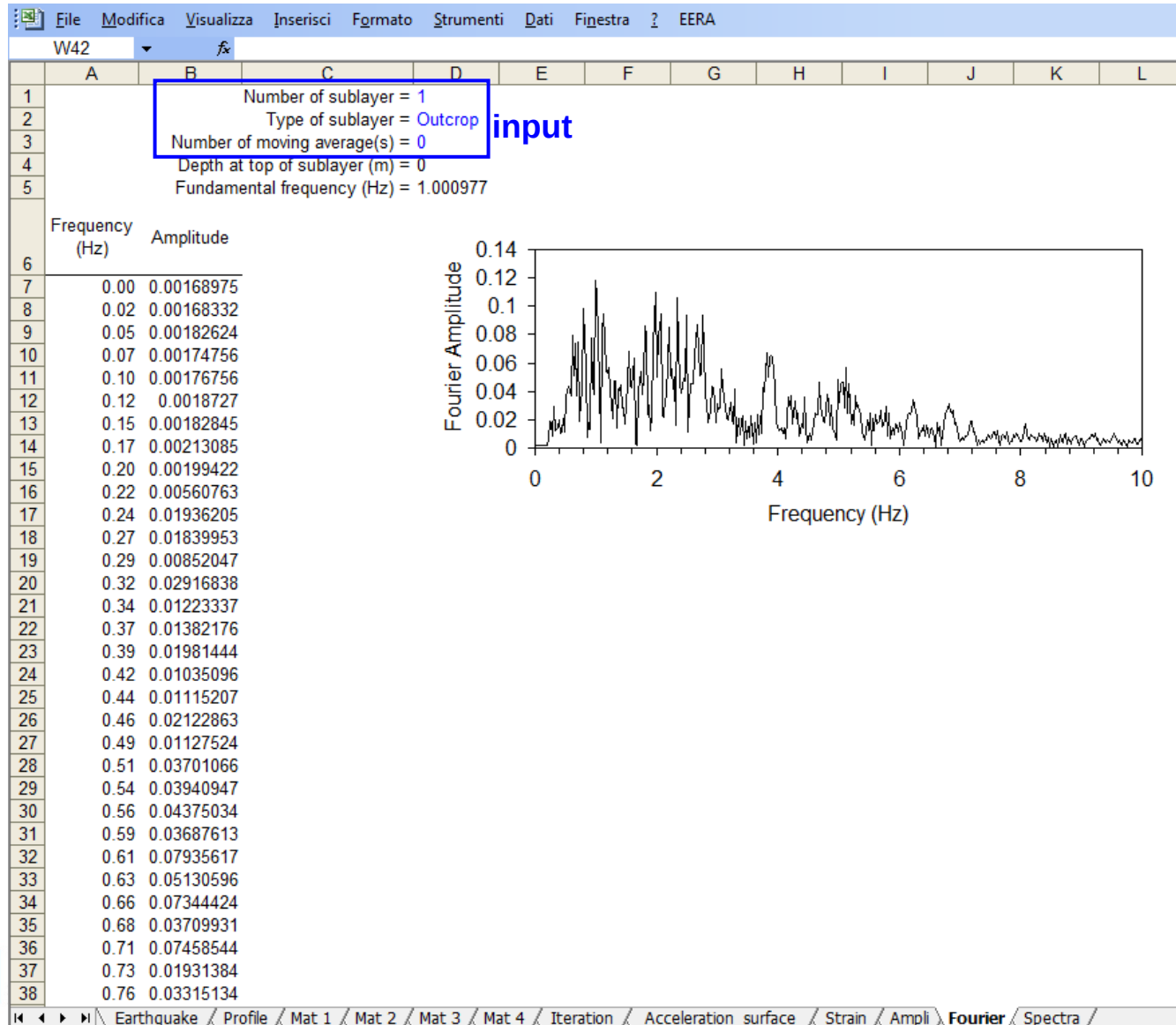
EERA – Case study

✓ EERA results: amplification spectrum



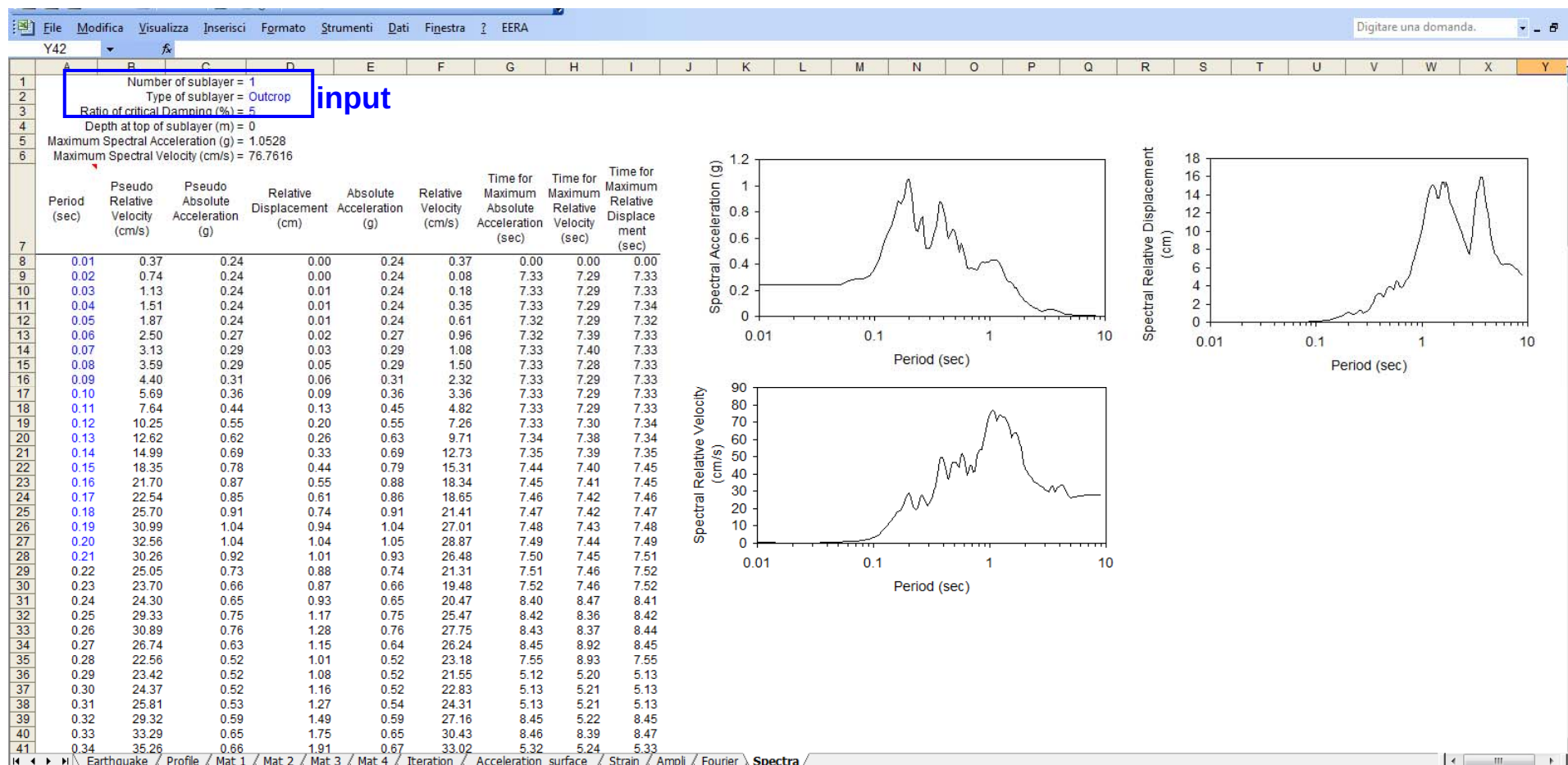
EERA – Case study

✓ EERA results: Fourier spectrum



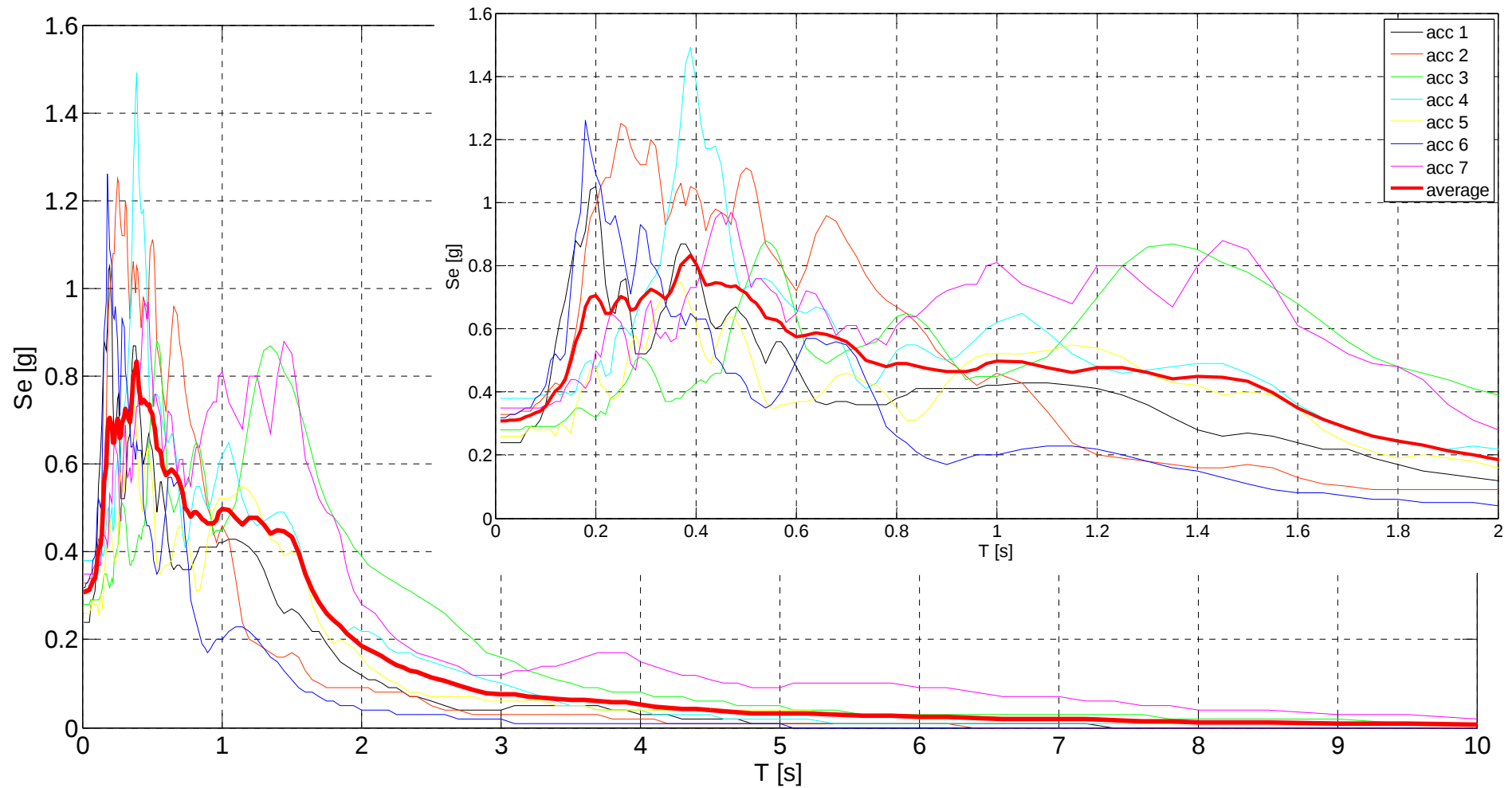
EERA – Case study

✓ EERA results: response spectra



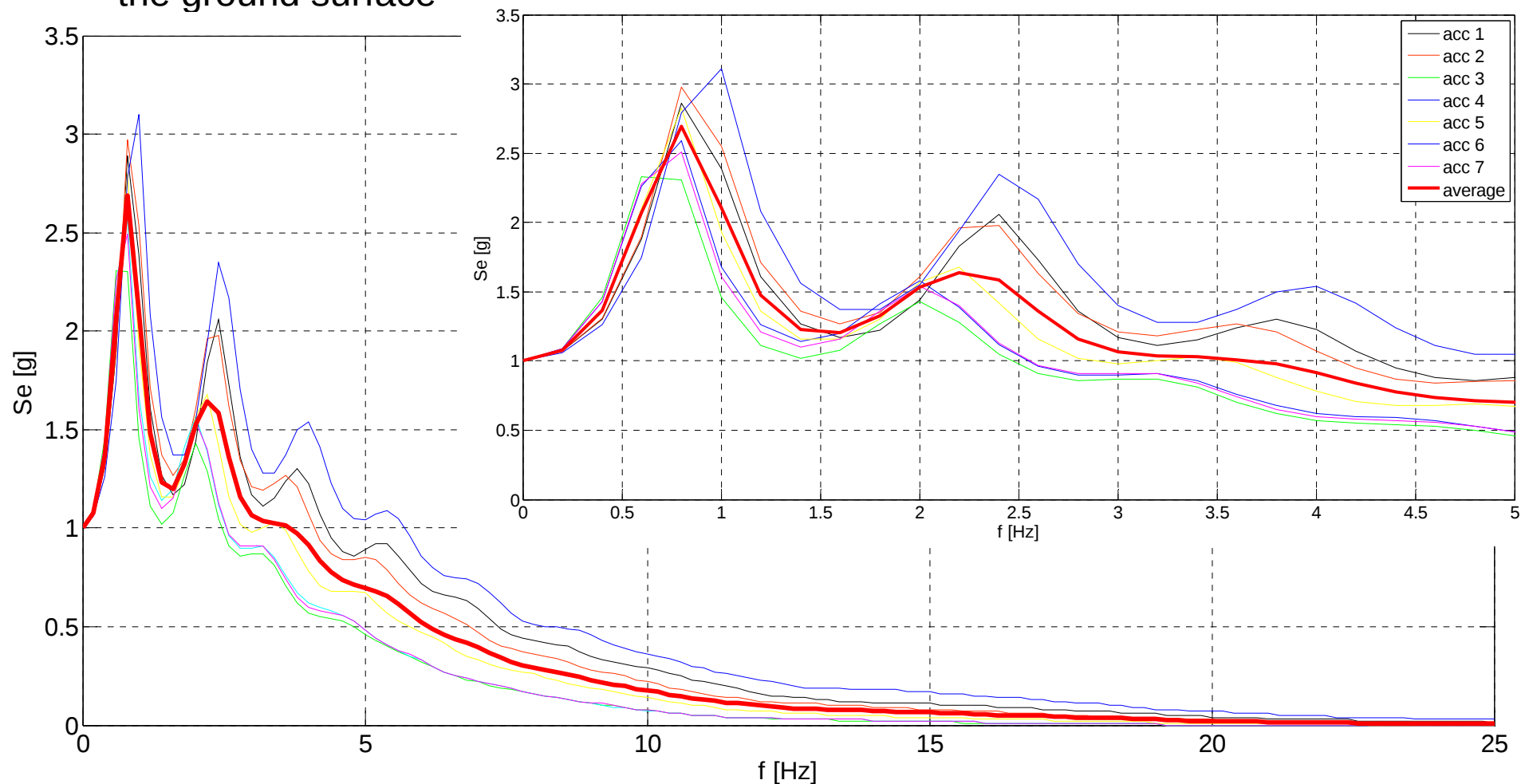
EERA – Case study

- ✓ Results: horizontal acceleration response spectra at the ground surface



EERA – Case study

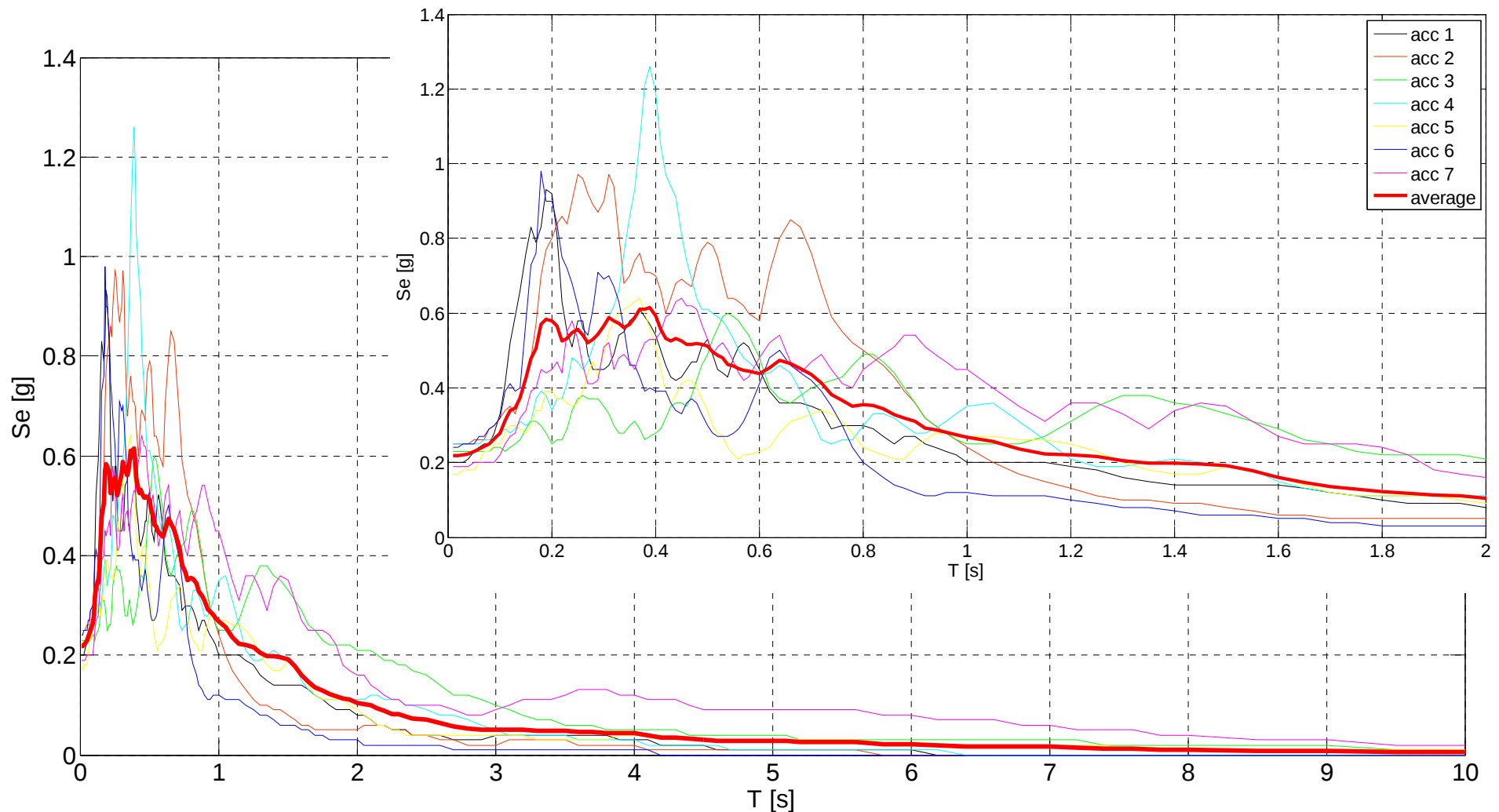
- ✓ Results: amplification spectra between the outcropping bedrock input motion and the ground surface



EERA – Case study

Assuming an halfspace with the same soil properties of the deepest layer ($V_s=300$ m/s)

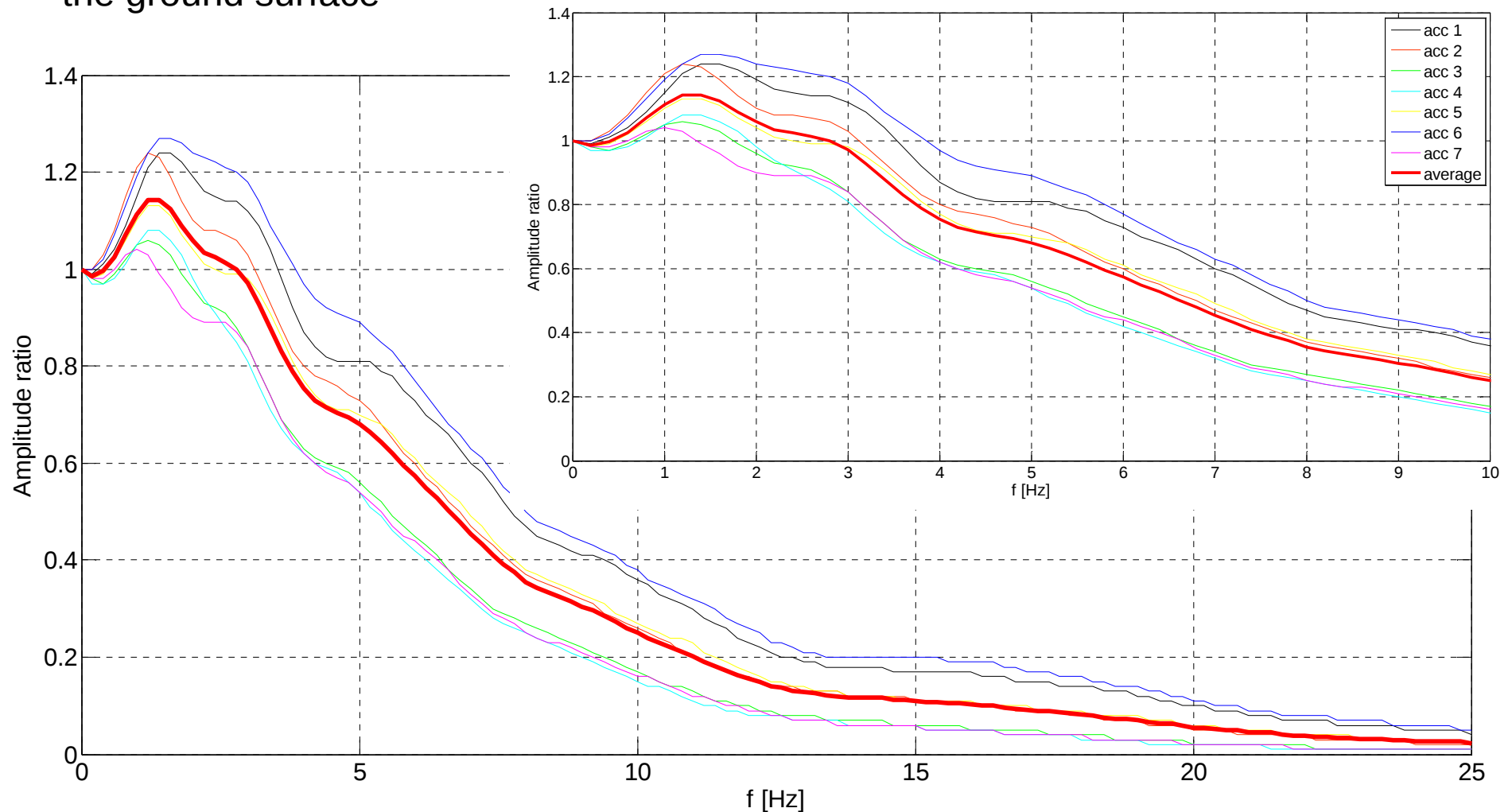
✓ Results: horizontal acceleration response spectra at the ground surface



EERA – Case study

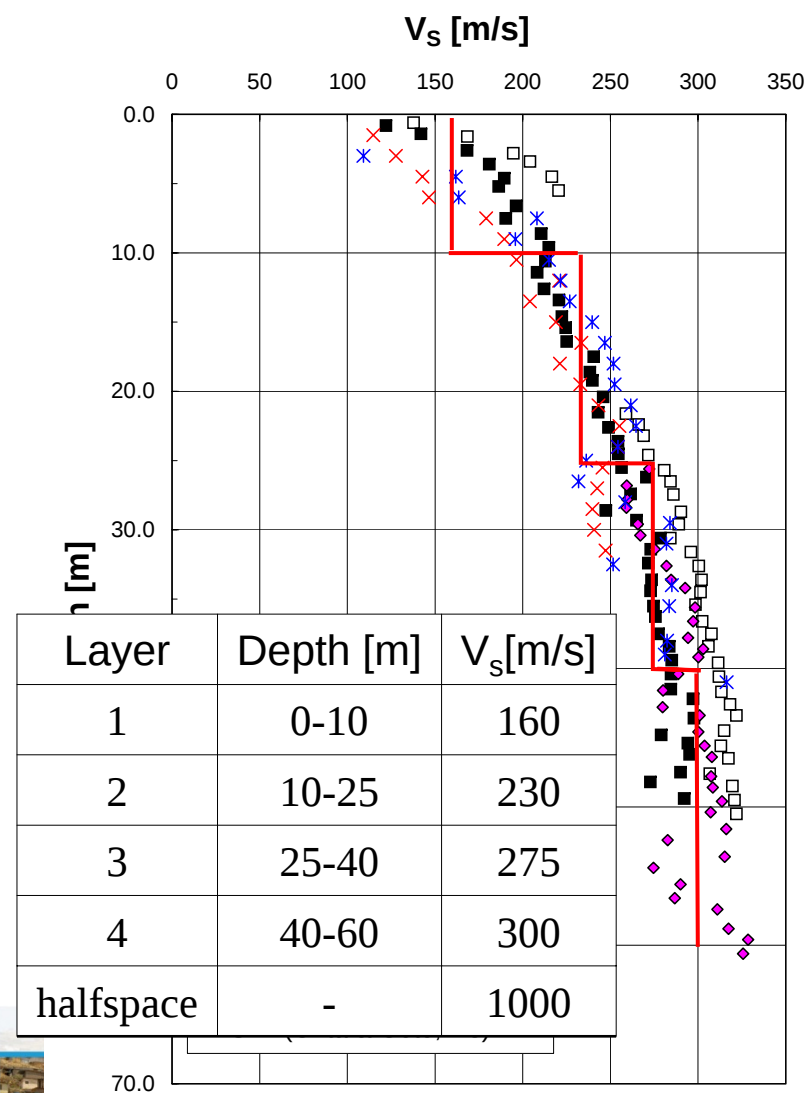
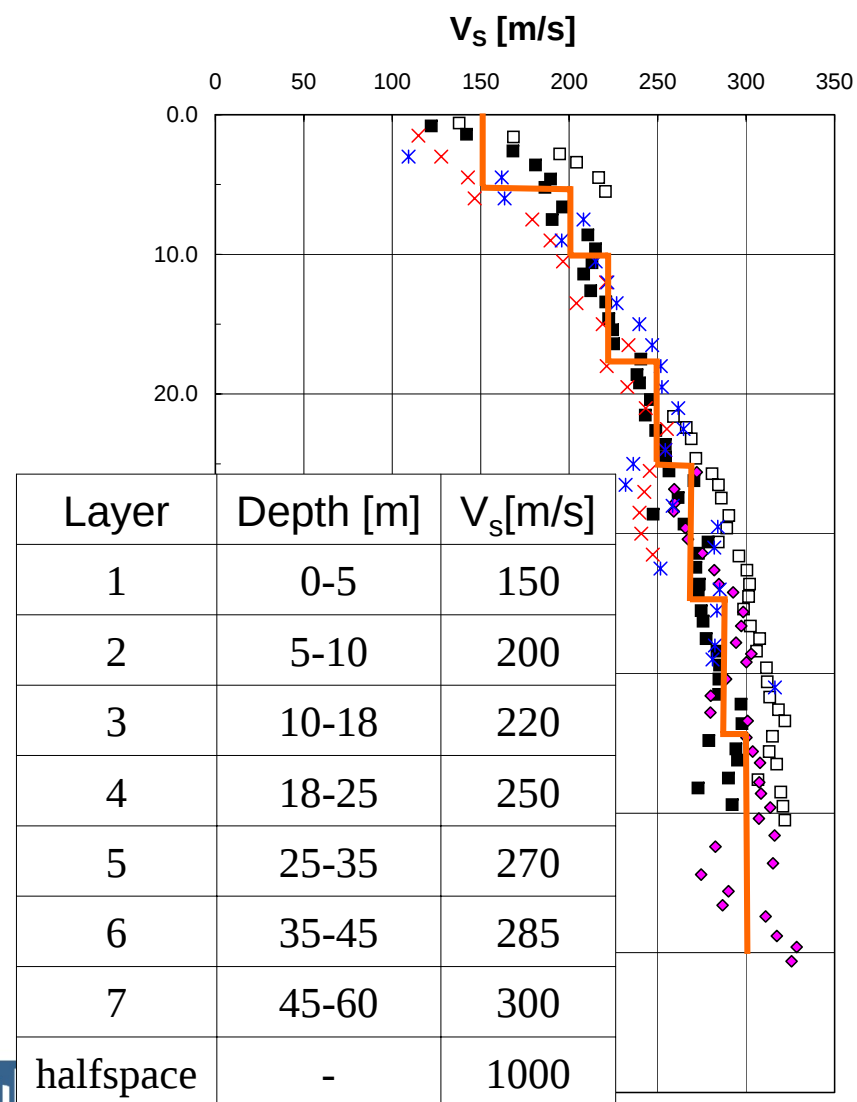
Assuming an halfspace with the same soil properties of the deepest layer ($V_s=300$ m/s)

- ✓ Results: amplification spectra between the outcropping bedrock input motion and the ground surface



EERA – Case study

- ✓ comparison between 2 soil models



EERA – Case study

- ✓ EERA results: 2 models comparison

Acceleration at the ground surface

