PROTEZIONE CIVILE
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Agenzia per la Coesione Territoriale

GOVERNANCE E CAPACITÀ ISTITUZIONALE 2014-2020

EGU General Assembly 2020

Evaluation of the effect of depth to bedrock on seismic amplification phenomena.

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04 May 2020, EGU General Assembly

PON GOVERNANCE 2014-2020
Rischio Sismico e Vulcanico

Topics

- Seismic microzonation: introduction and glossary
- Geometrical, geological and geophysical data from Italian experiences
- Numerical results of parametric seismic site response analyses
- Charts for preliminary design of site investigation in seismic microzonation perspective
- Conclusions

Definition

Seismic microzonation is the process of subdividing the territory into regions with respect to the level of seismic hazard. The result of seismic microzonation is usually presented as a map, which is based on seismic hazard map. Seismic microzonation is useful for hazard reduction such as earthquake-resistant design of structures, risk analysis, land-use planning, etc. (Yu et al., 2011)*

* Yu, Y., Gao, M., Xu, G., 2011. Seismic zonation. Encycl. Earth Sci. Ser. Part 5, 1224–1230. https://doi.org/10.1007/978-90-481-8702-7_184.

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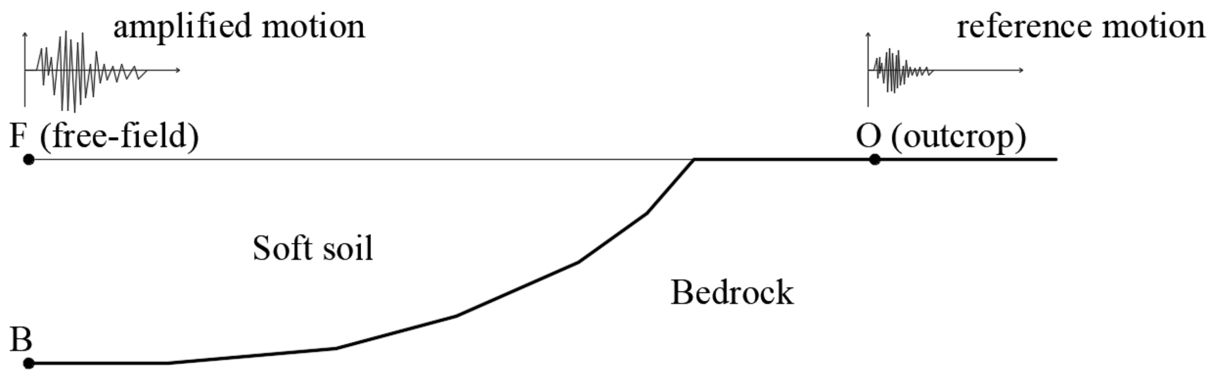

Workflow

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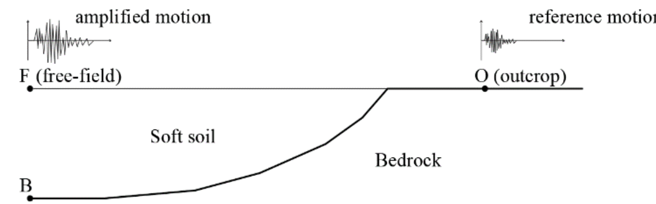
1) Base seismic hazard (reference motion)

2) Site condition (topography and geo-morphological settings)



3) Total seismic hazard (free-field motion: base hazard + site effects)

Data from Italian experiences

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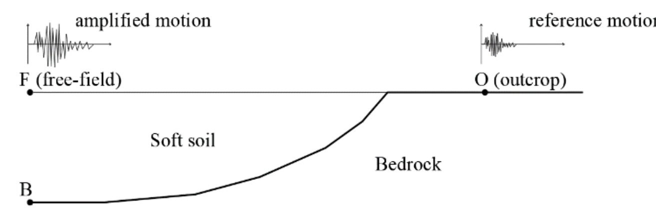


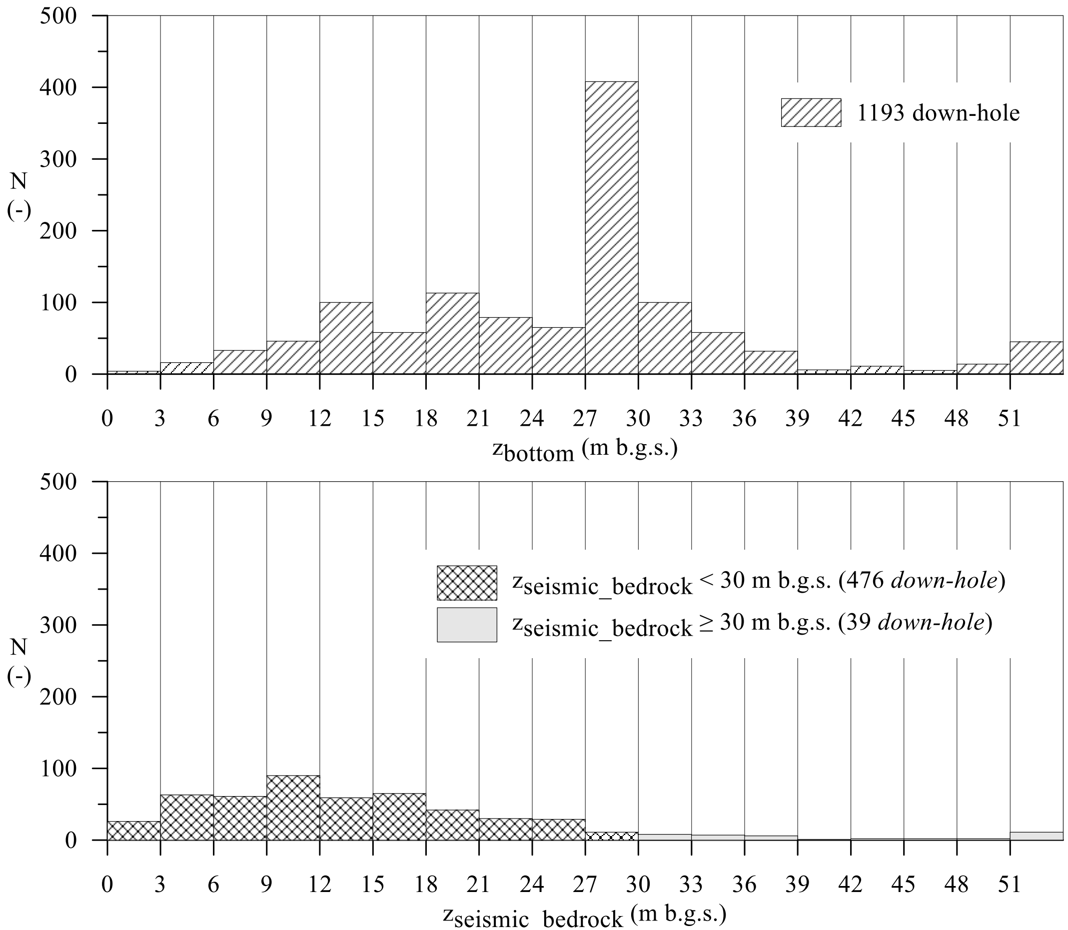
3) Total seismic hazard (free-field motion: base hazard + site effects)

Data from Italian experiences

Geometrical (bottom of site investigation and depth to seismic bedrock) and geophysical (shear wave velocity) data were retrieved from Italian experiences (Database of the Italian seismic microzonation; DPC, 2018)*.

* DPC, Dipartimento della Protezione Civile (2018) Commissione tecnica per il supporto e monitoraggio degli studi di Microzonazione Sismica (ex art.5, OPCM3907/10), (2018) – WebMs; WebCLE. Edit by: Maria Sole Benigni, Fabrizio Bramerini, Gianluca Carbone, Sergio Castenetto, Gian Paolo Cavinato, Monia Coltella, Margherita Giuffrè, Massimiliano Moscatelli, Giuseppe Naso, Andrea Pietrosante, Francesco Stigliano. www.webms.it.

Data from Italian experiences: bottom of site investigation



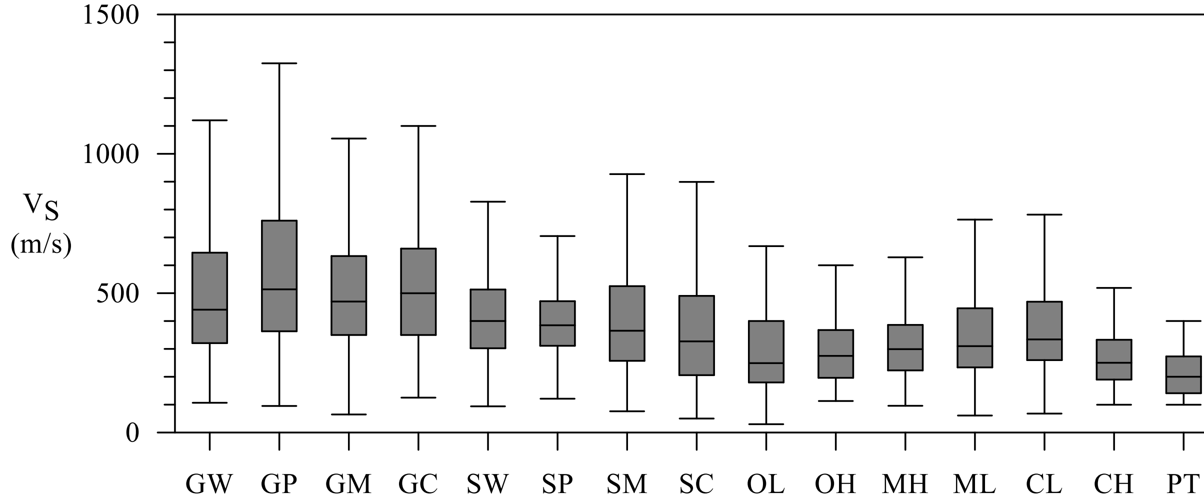
Geophysical surveys are generally extended down to 30 m b.g.s.

Geophysical surveys are generally (57% with respect to 1193 down-hole) not extended down to seismic bedrock.

Data from Italian experiences: shear wave velocity of covers

EGU_C	Description
RI	Terrains containing remains of human activity
GW	Well sorted gravels, mixed gravels and sands
GP	Not sorted gravels, mixed gravels and sands
GM	Silty gravels, mixed gravels, sands and silts
GC	Clayey gravels, mixed gravels, sands and clays
SW	Well sorted sands, mixed sands and gravels
SP	Not well sorted sands
SM	Silty sands, mixed sands and silts
SC	Clayey sands, mixed sands and clays
OL	Organic silts, low plasticity organic silty-clays
OH	Middle plasticity organic clays, organic silts
MH	Inorganic silts, fine sands, diatomic silts
ML	Inorganic silts, fine silty-clayey sands, low plasticity clayey silts
CL	Middle-low plasticity inorganic clays, gravel-sandy clays, silty clays
CH	High plasticity inorganic clays
PT	Peats and others highly organic terrains

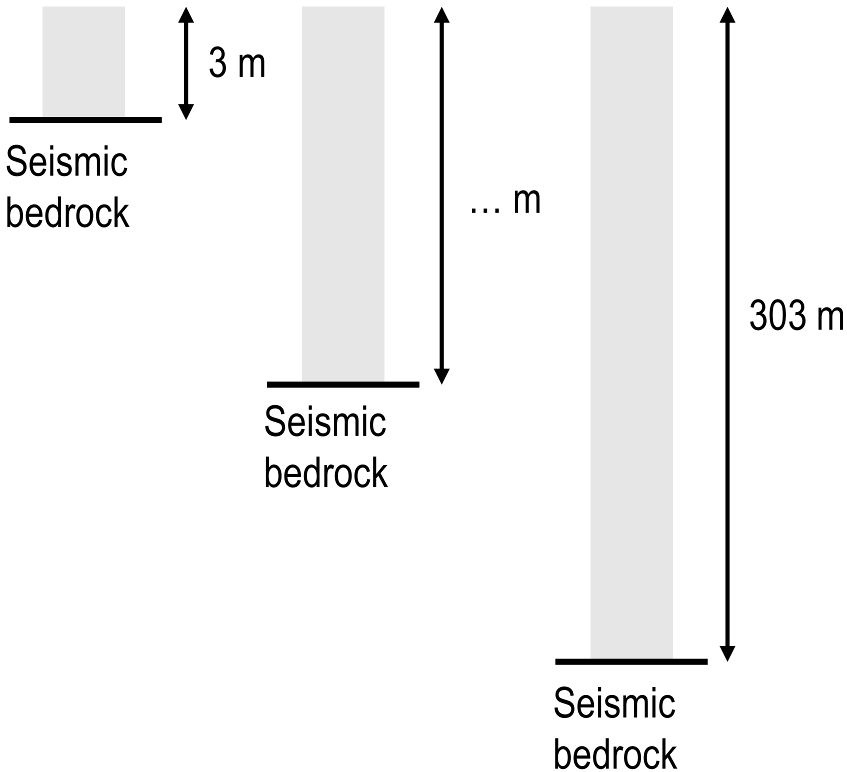
Shear wave velocity of covers is in the range 200-700 m/s.



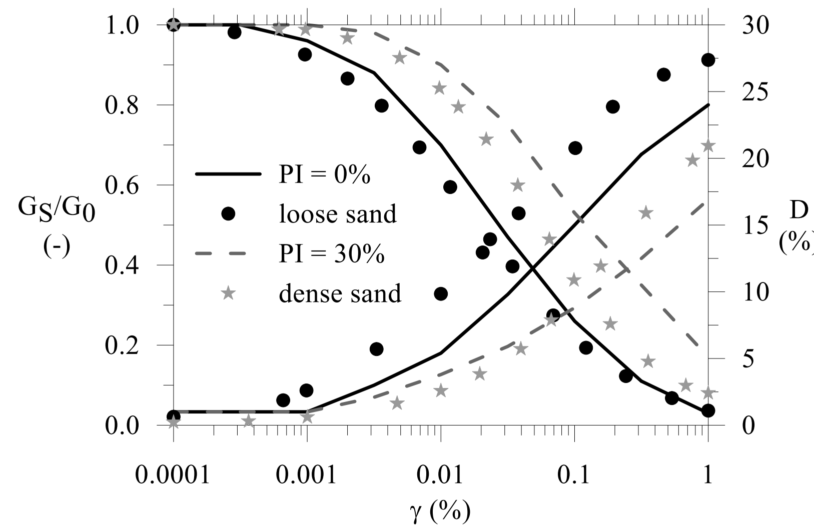
Numerical analyses

- Prototypes based on Italian experiences;
- One dimensional seismic site response analyses were performed by means of code STRATA (Kottke et al., 2013) in the frequency domain adopting the linear equivalent formulation;
- Reference outcropping motions were selected from Italian database;
- Local phenomena were quantified by means of amplification factors.

Data for parametric 1D analysis



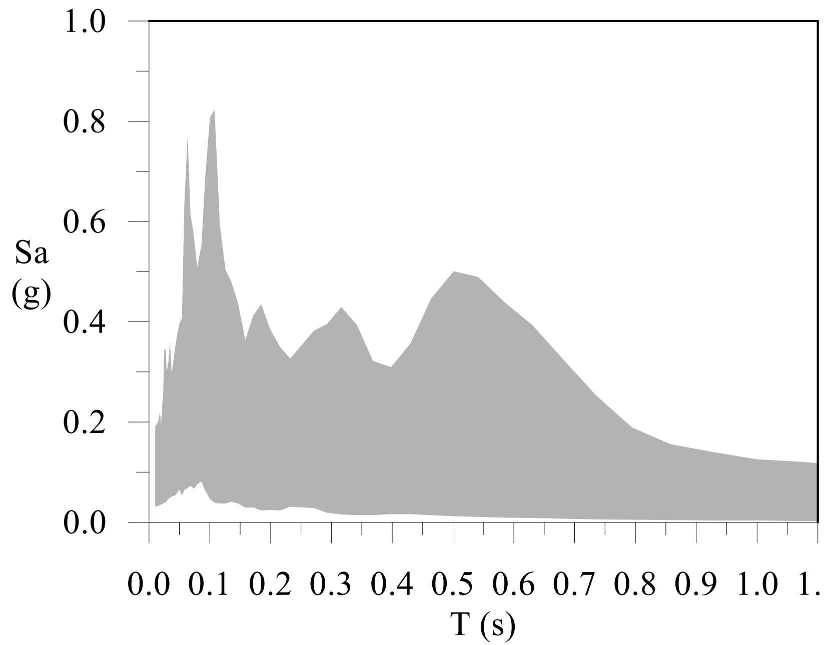
- Homogeneous deposit
  - $V_S(z)$ = cost
  - V_S in the range 100-700 m/s
- Non-linear visco-elastic material*



* Vucetic, M., Dobry, R., 1991. Effect of Soil Plasticity on Cyclic Response. J. Geotech. Eng. 117, 89–107. https://doi.org/10.1061/(ASCE)0733-9410(1991)117:1(89).
Seed, H.B., Idriss, I.M., 1970. Soil Moduli and Damping Factors for Dynamic Response Analyses.

Reference motion

Real acceleration time histories were retrieved from Italian database of strong motion (ITACA, 2019)* and were implemented in the numerical models as outcropping signals.



* ITACA, 2019. Italian Accelerometric Archive. Retrieved October, 2019 from http://itaca.mi.ingv.it/ItacaNet_30/#/home.

Summary output: Amplification Factor

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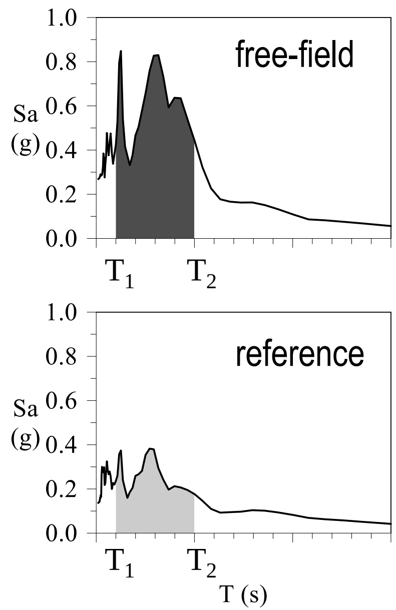
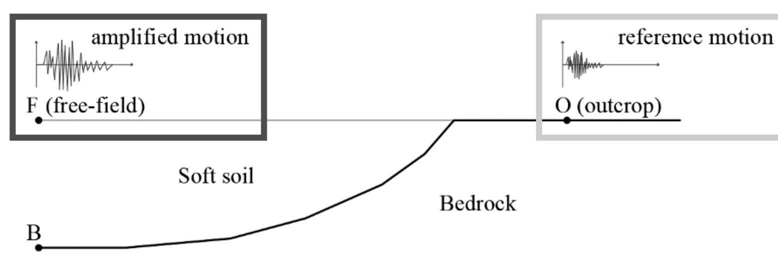


Amplification Factor (AF)

$$AF_{T_1\text{-}T_2} = \frac{\int_{T_1}^{T_2} Sa_o \, dT}{\int_{T_1}^{T_2} Sa_i \, dT}$$



Summary output: intervals of period

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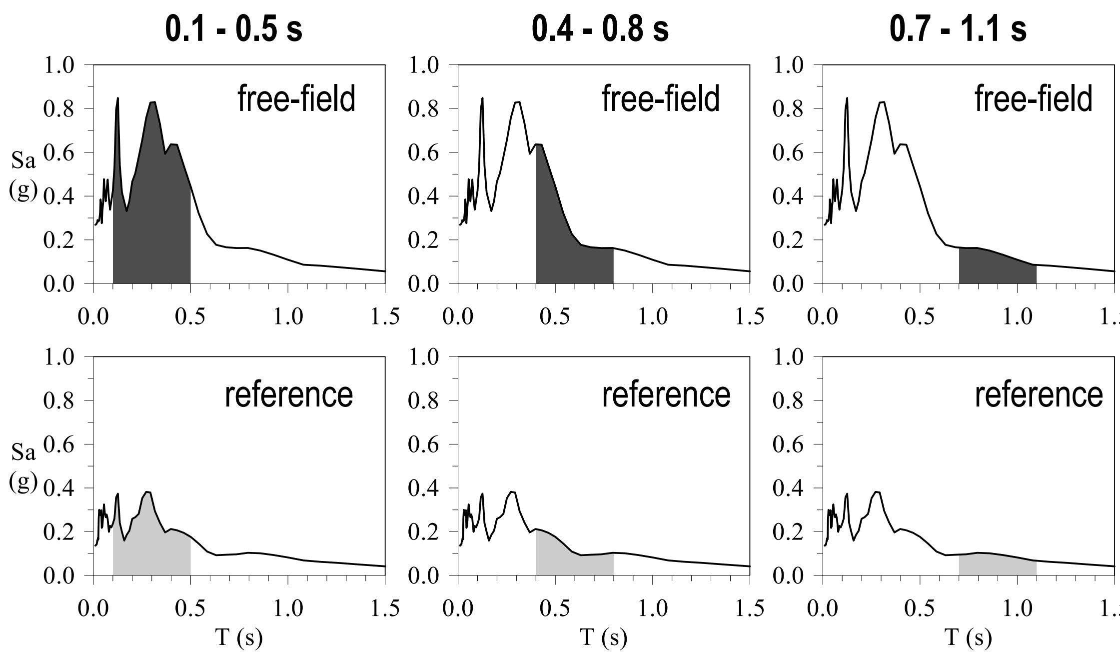

Correlation between summary output and type of structure

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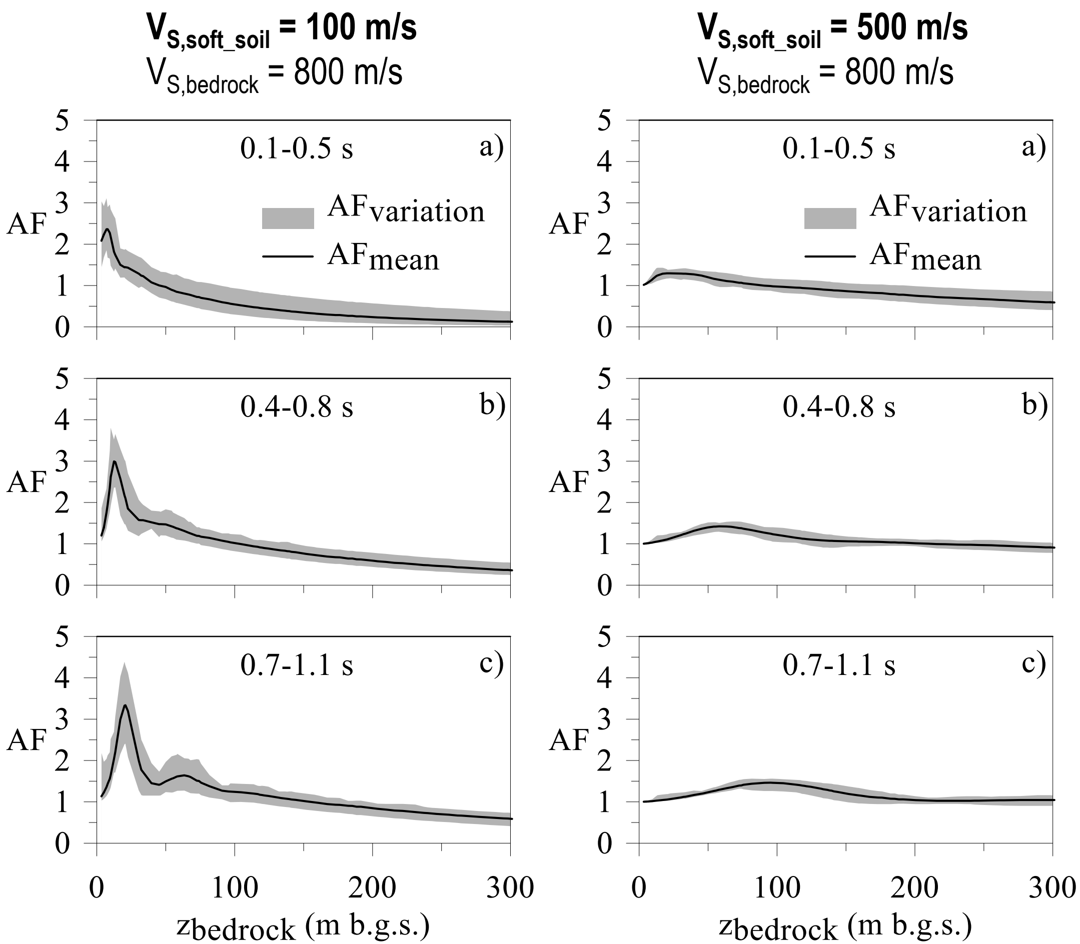
0.1 - 0.5 s
1 - 4 storey

0.4 - 0.8 s
4 - 8 storey

0.7 - 1.1 s
8 - 12 storey

Numerical results: depth to bedrock-amplification factor correlation



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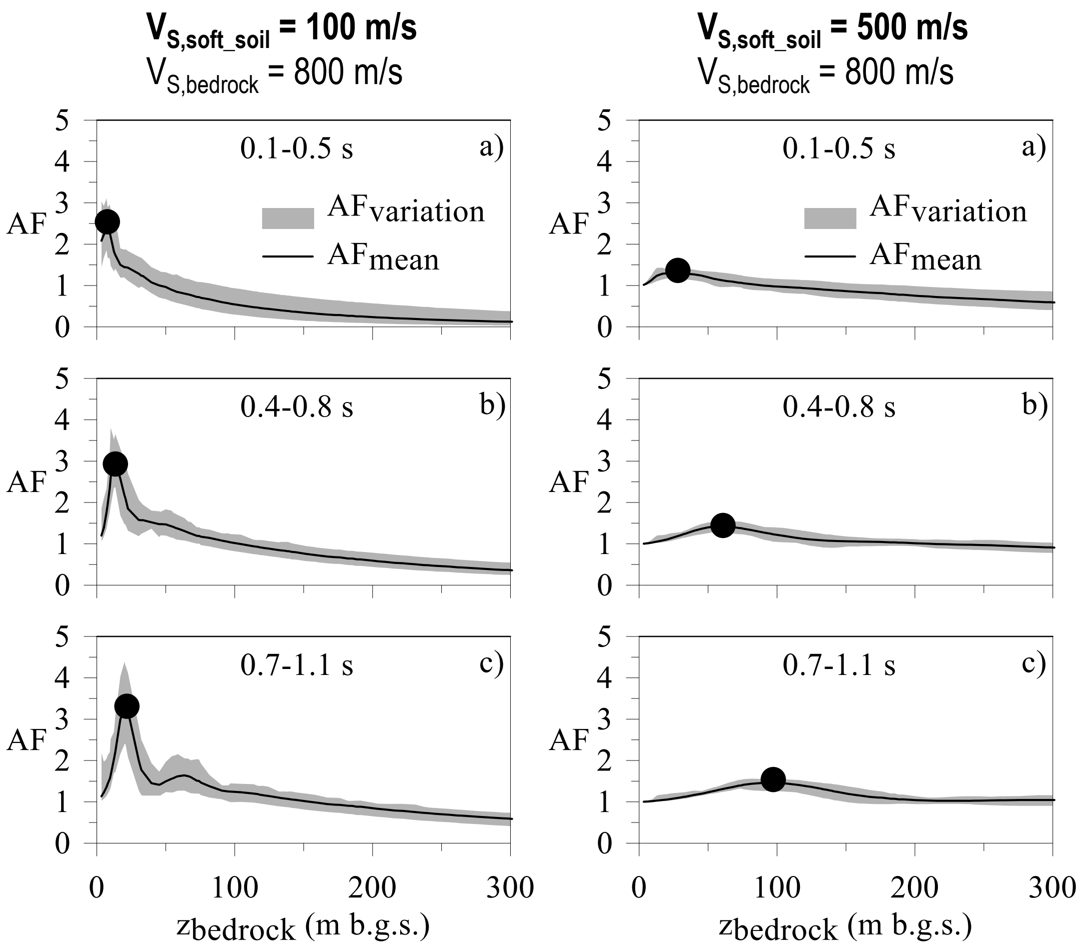

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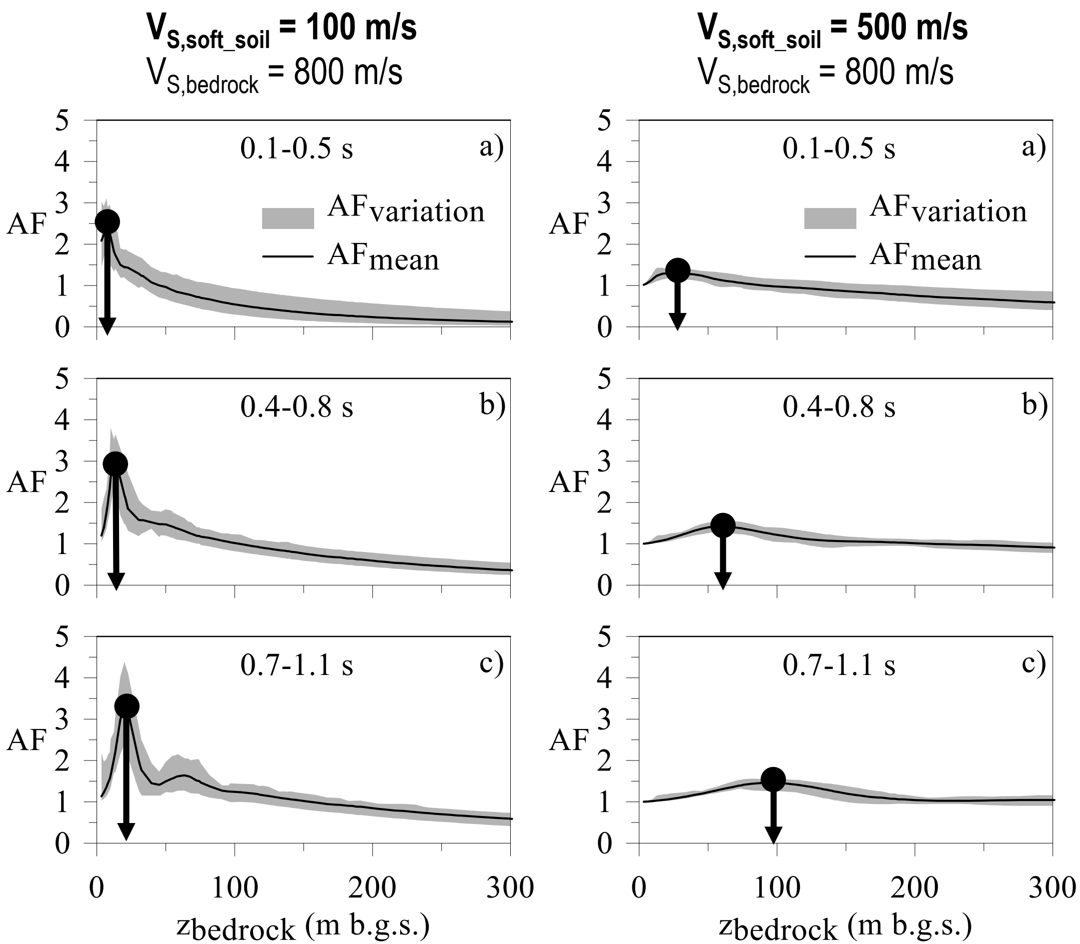

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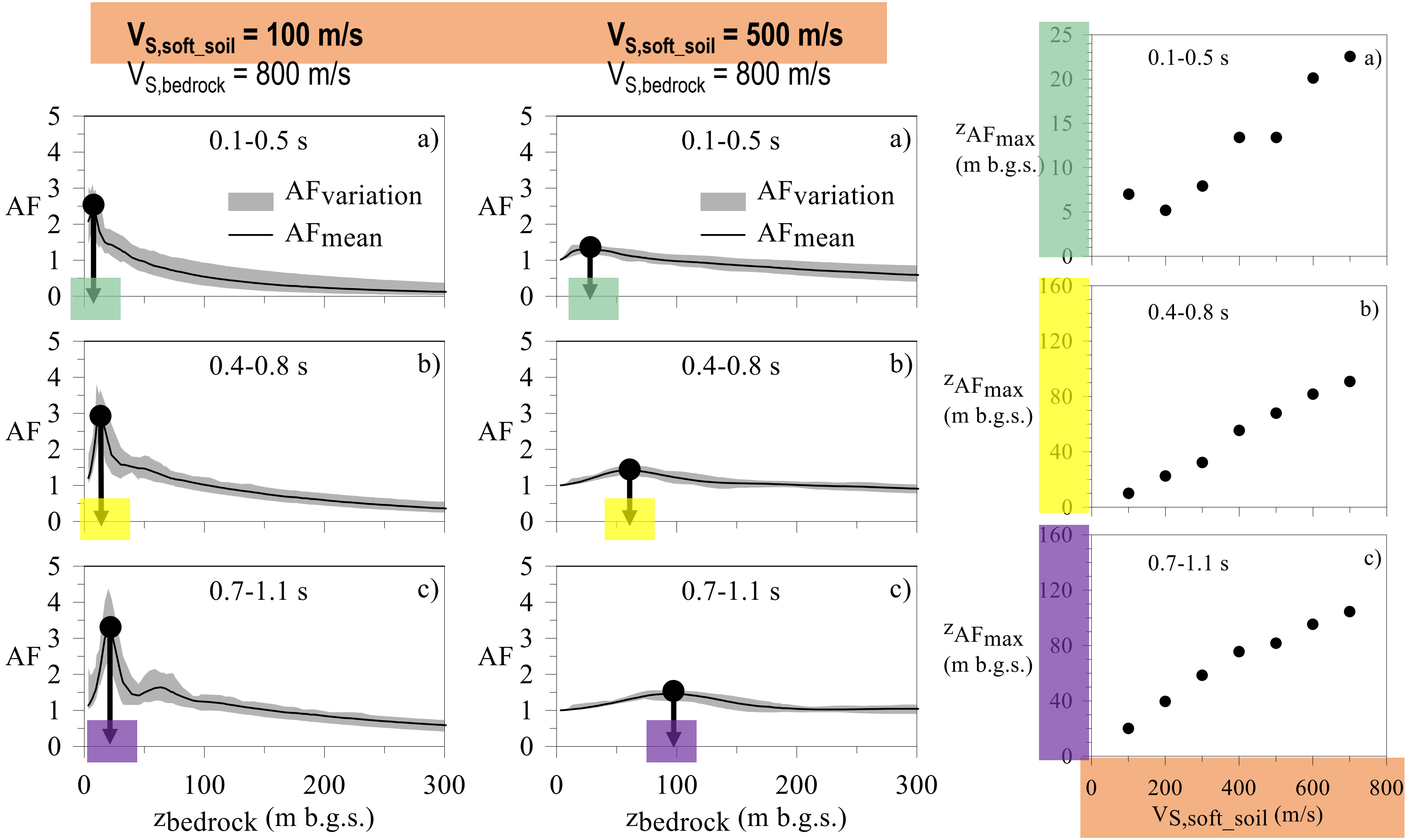
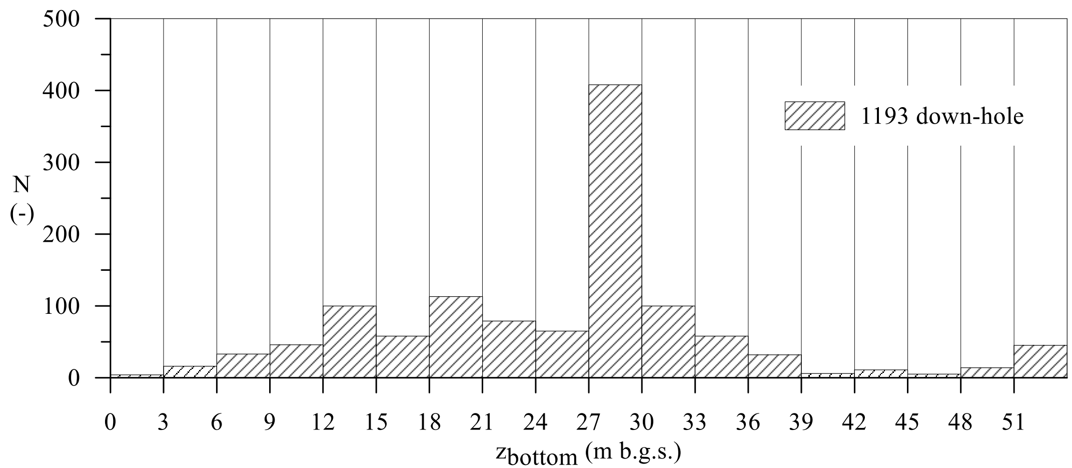


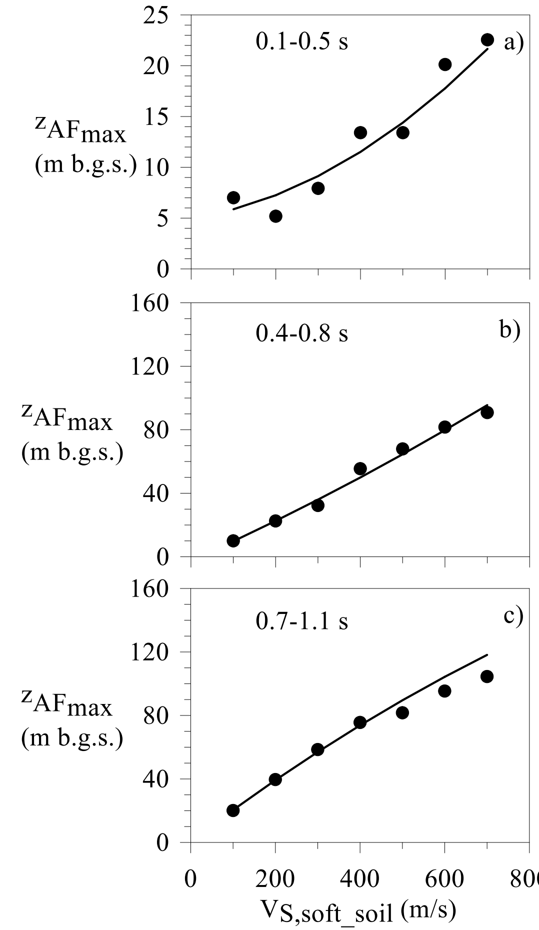
What should be the minimum depth to investigate when the depth to bedrock is higher than the depth of conventional site investigation?



Minimum depth to be investigated charts

$$z_{AFmax} = aV_S^2 + bV_S + c$$

T (s)	a (-)	b (-)	c (-)	R^2 (-)
0.1-0.5	25E-6	0.0063	4.9906	0.9162
0.4-0.8	3E-5	0.1189	-2.4219	0.9830
0.7-1.1	-5E-5	0.2028	0.6582	0.9570



Conclusions

- Geophysical surveys are generally not extended down to the depth of seismic bedrock.
- Italian and European building codes requirement to investigate at most 30 m below ground surface allows to not underestimate the ground motion amplification in the interval of period 0.1-0.5 s.
- Minimum depth to be investigated could be determined based on simplified charts with reference to the interval of period of interest. The minimum depth allows to perform seismic site response analyses according to a precautionary approach at seismic microzonation scale where depth to seismic bedrock is higher than the depth of conventional site investigation.

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THANKS FOR THE ATTENTION

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