پژوهشگاه بین المللی زلزله شناسی و مهندسی زلزله
International Institute of Earthquake Engineering and Seismology

Role of Site effect and geo hazard in March 28, 2025 Myanmar earthquake, magnitude 7.7

Lessons to be learned

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11/05/2025

Introduction

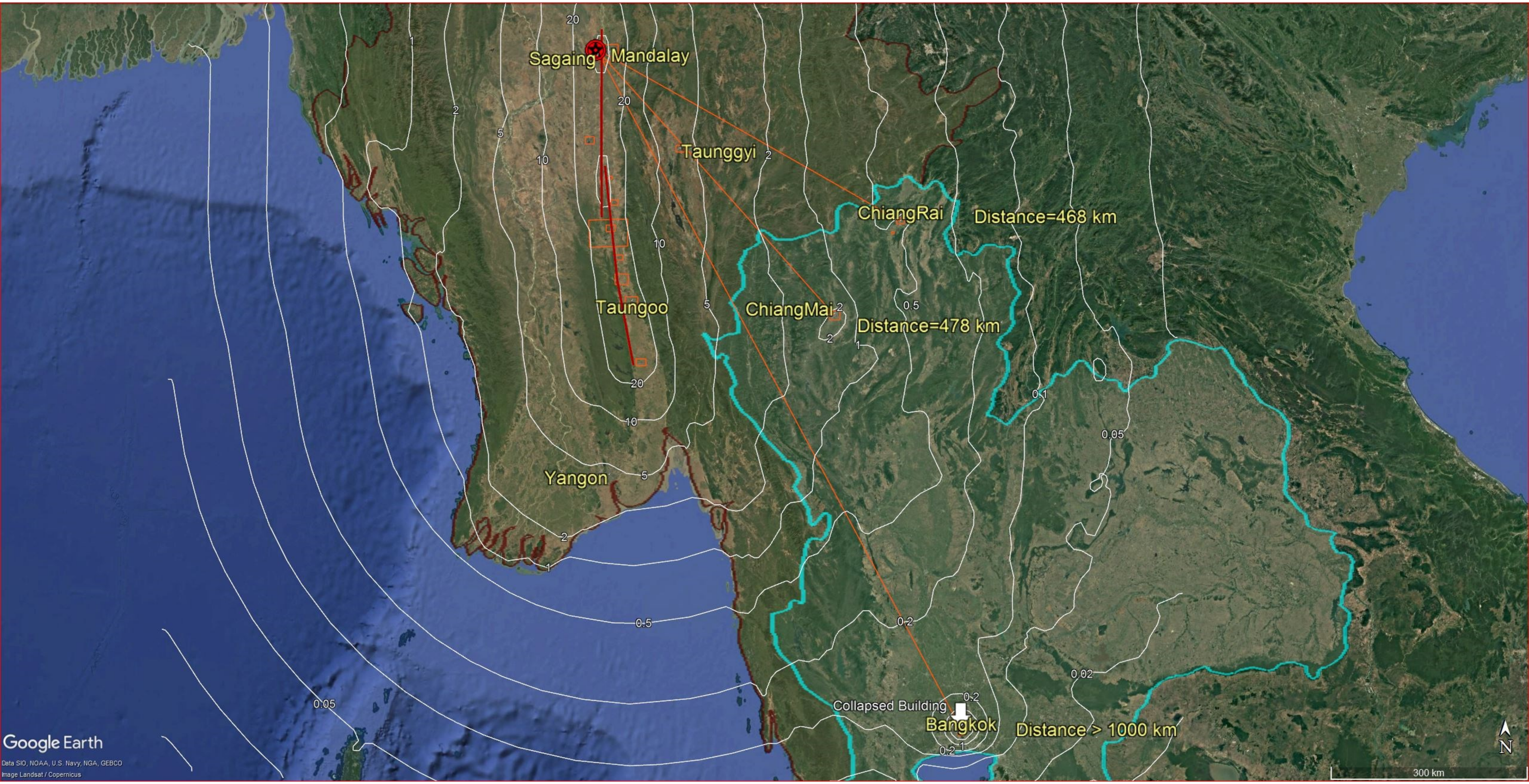
On March 28, 2025, a magnitude 7.7 earthquake struck central Myanmar. The quake occurred along the active right-lateral strike-slip Sagaing Fault and generated violent ground motions across Myanmar. This earthquake was felt in neighboring countries such as China and Thailand.

In Thailand the quake caused a catastrophic structural failures over more that 1000 km away in Bangkok's Chatuchak District, the farthest distance ever reported for damage from an earthquake.

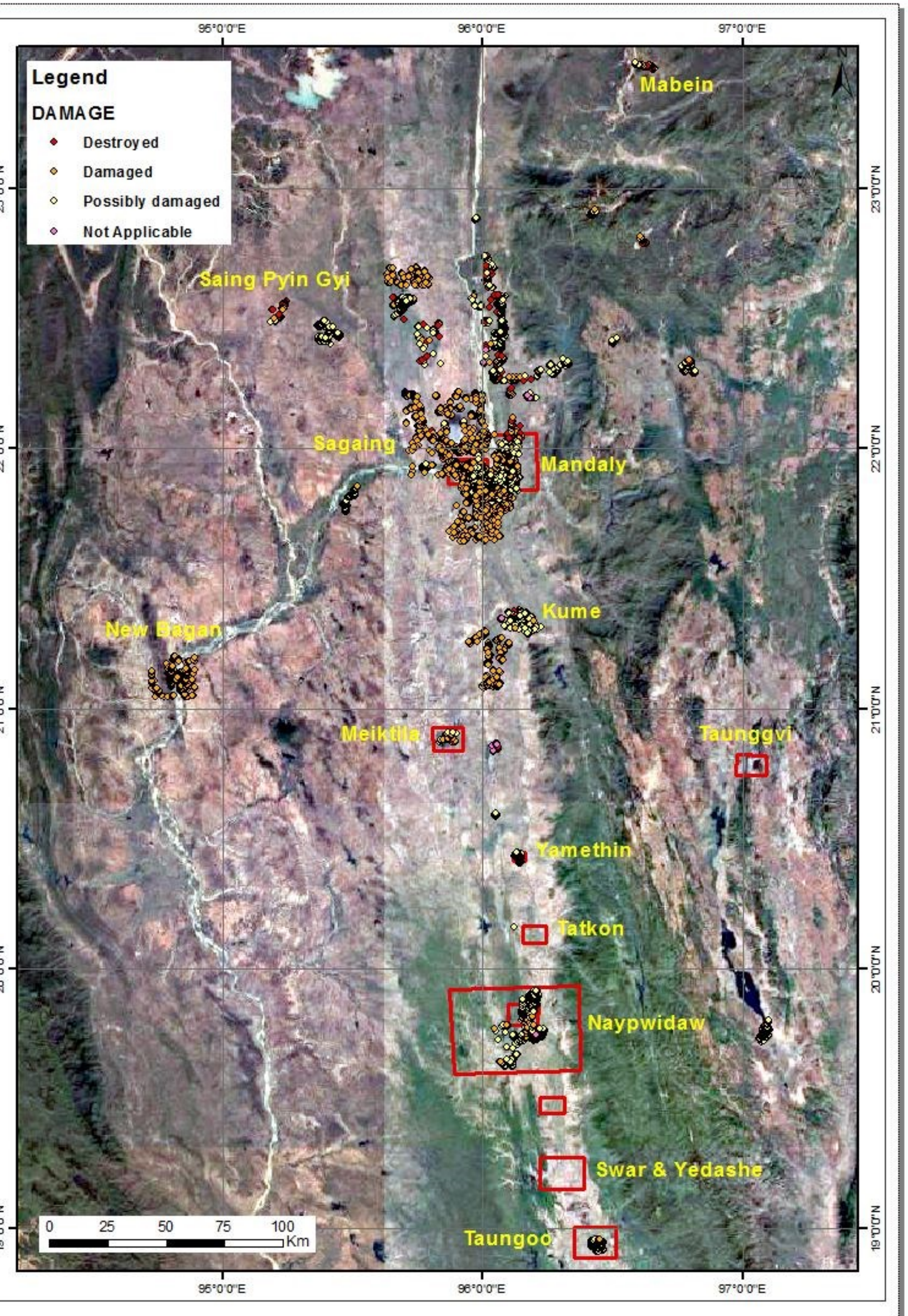
In addition to Bangkok, there are reports of damage in two other district in Thailand (Chiang Mai and Chinag Rai) over 400 kilometers far from the epicenter and considerable distances from the Sagaing Fault.

In all of these cases, the role of local geological conditions appears to be important and will be discussed.

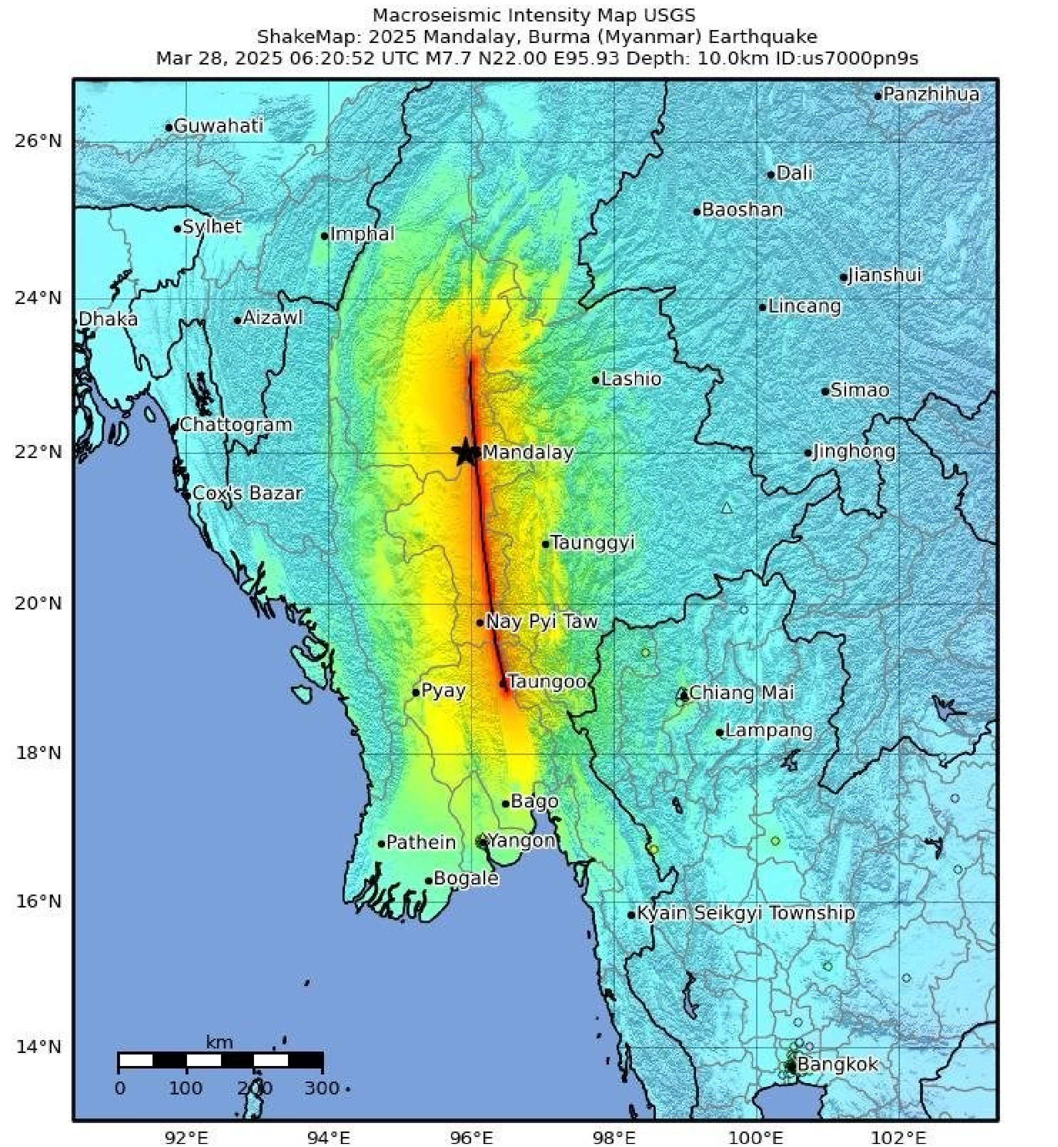
Damages distribution



Damages distribution



Damages distribution



SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	None	None	None	Very light	Light	Moderate	Moderate/heavy	Heavy	Very heavy
PGA(%g)	<0.0464	0.297	2.76	6.2	11.5	21.5	40.1	74.7	>139
PGV(cm/s)	<0.0215	0.135	1.41	4.65	9.64	20	41.4	85.8	>178
INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based on Worden et al. (2012) Version 11: Processed 2025-03-29T19:19:31Z

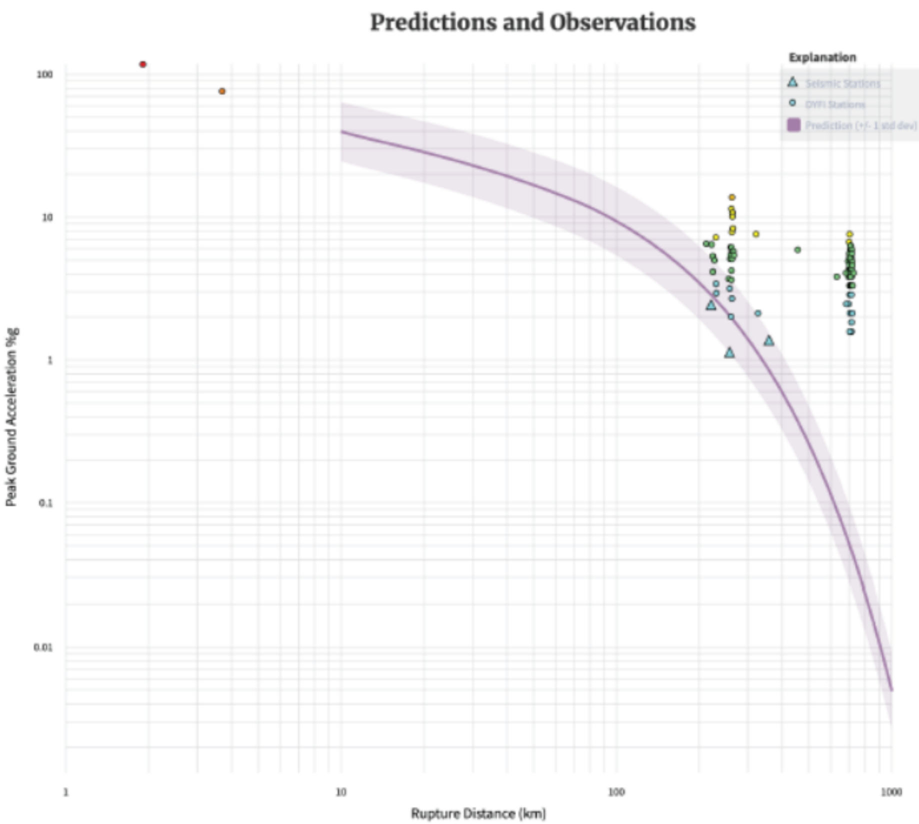
△ Seismic Instrument ○ Reported Intensity ★ Epicenter ▭ Rupture

The Mw 7.7 Myanmar Earthquake caused catastrophic loss of life and structural damage across large portions of Myanmar, radiating south toward Nay Pyi Taw and Taungoo. Effects were felt as far away as Bangkok where at least one office structure under construction collapsed.

GREG LOWITZ

https://www.buildera.com/seismic-analysis-myanmar-quake

Damages distribution



Ground motion observations from the March 28, 2025, Myanmar earthquake reveal significant discrepancies with the predictions made by the Ground Motion Prediction Equation (GMPE) of Boore et al. (2014).

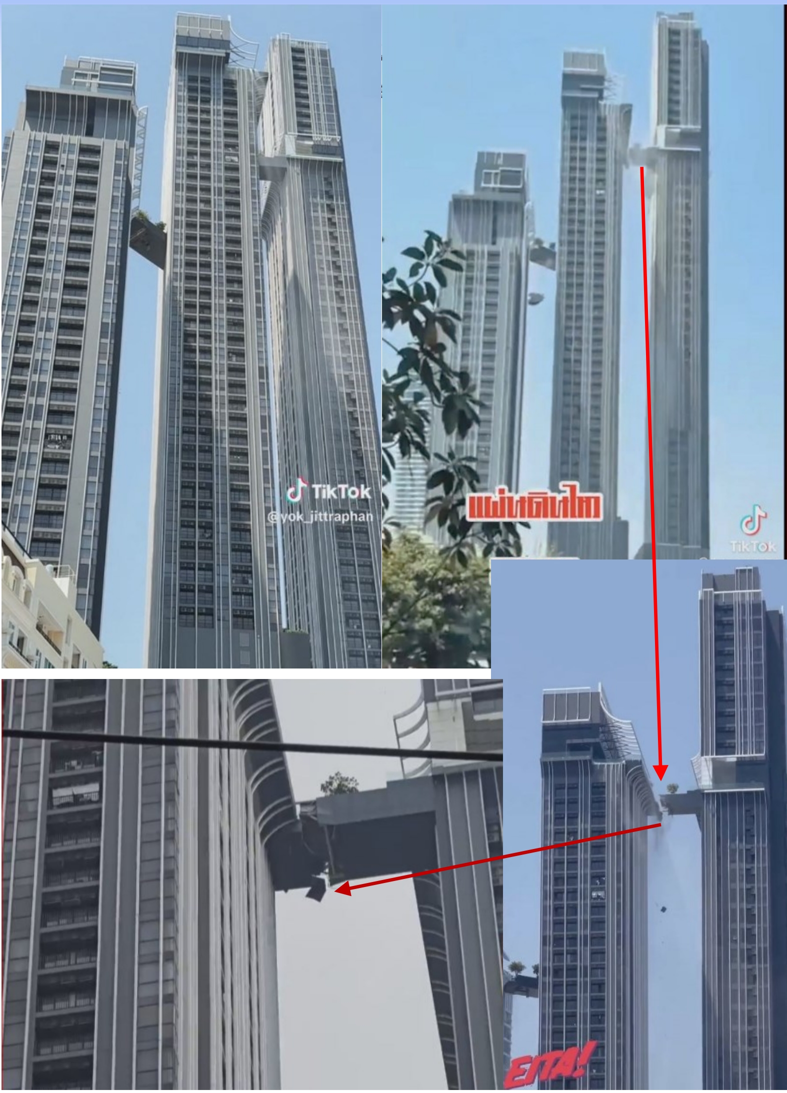
Specially for Intermediate Distances (200–300 km), may be due to directivity or local site effect.

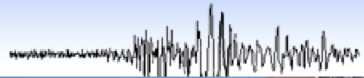
and for Far-Field (300–1000 km) strongly depend to site effect.

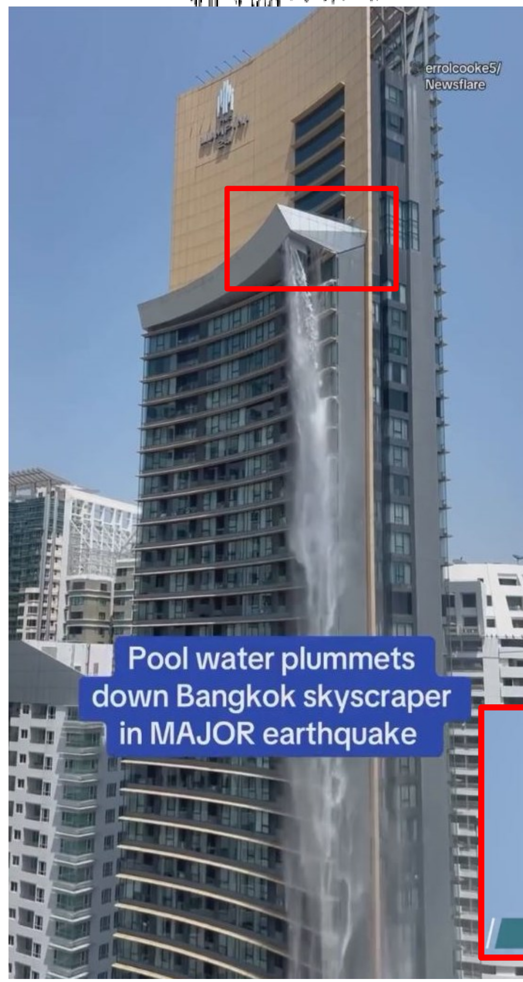
GREG LOWITZ

https://www.buildera.com/seismic-analysis-myanmar-quake

Bangkok case







Park Origin Thonglor

Lumphini 24

Ashton Asoke Roma 9

Long period oscillation of Tall buildings and collapse of an underconstruction 33 story building with more than 10 fatalities.

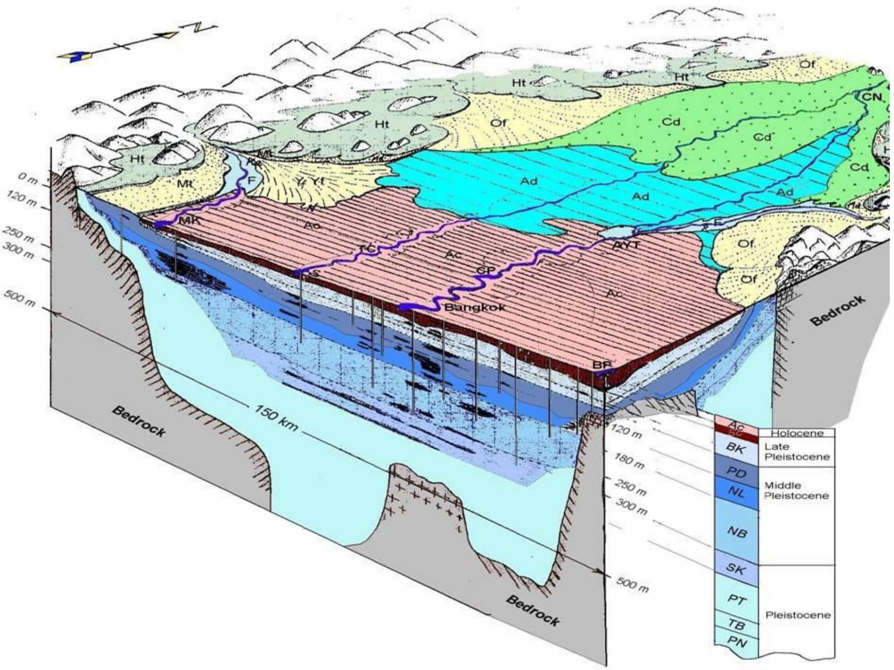
Bangkok case

Long period oscillation of Tall buildings and collapse of an under construction 33 story building with more than 10 fatalities.

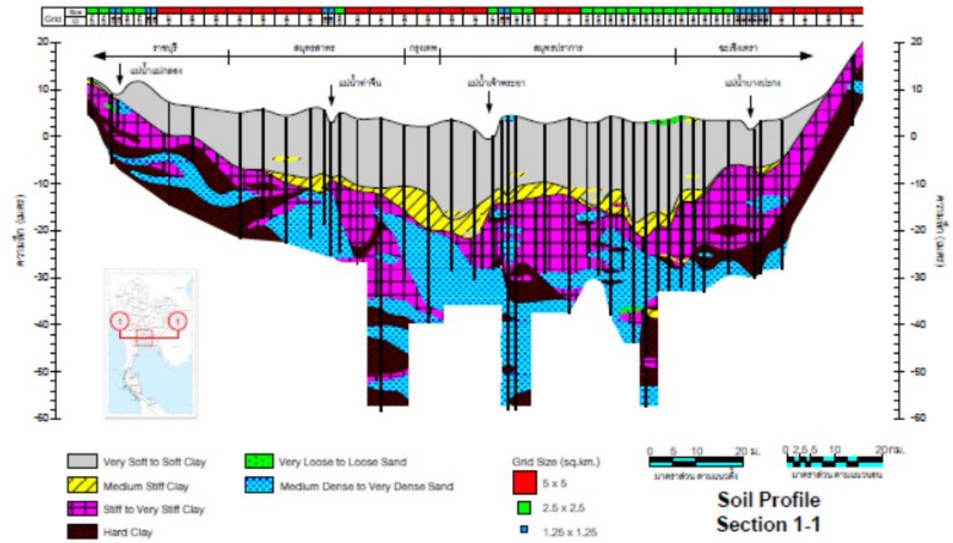
Bangkok case

Location of mentioned buildings on deltaic deposits of Chao-Phraya River

Bangkok case
Soil profile

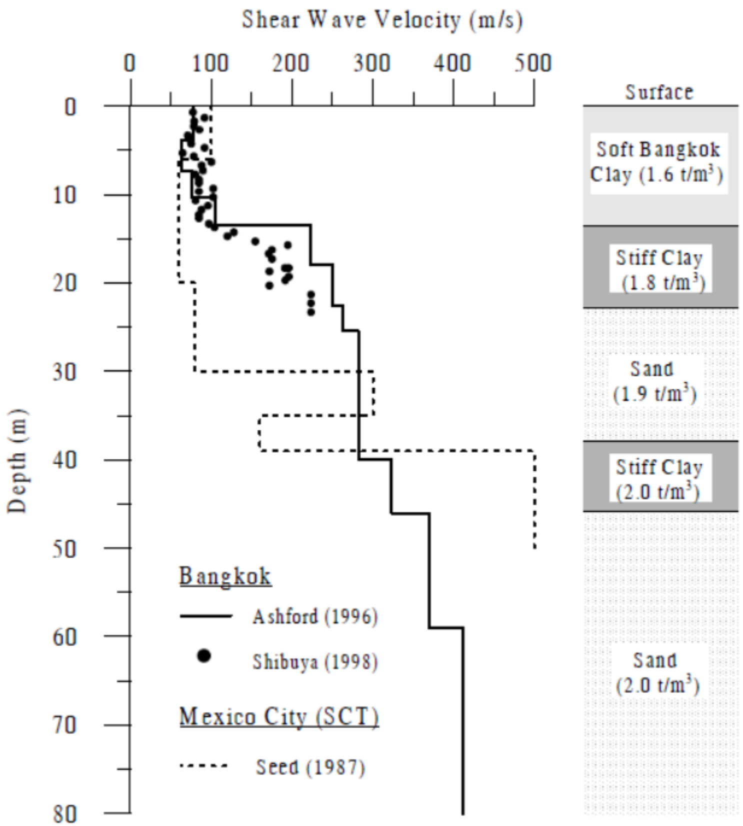


Schematic cross-section of lower Chao Phraya Basin (JICA, 1999), (Mairaing and Cherdpun ,2010)

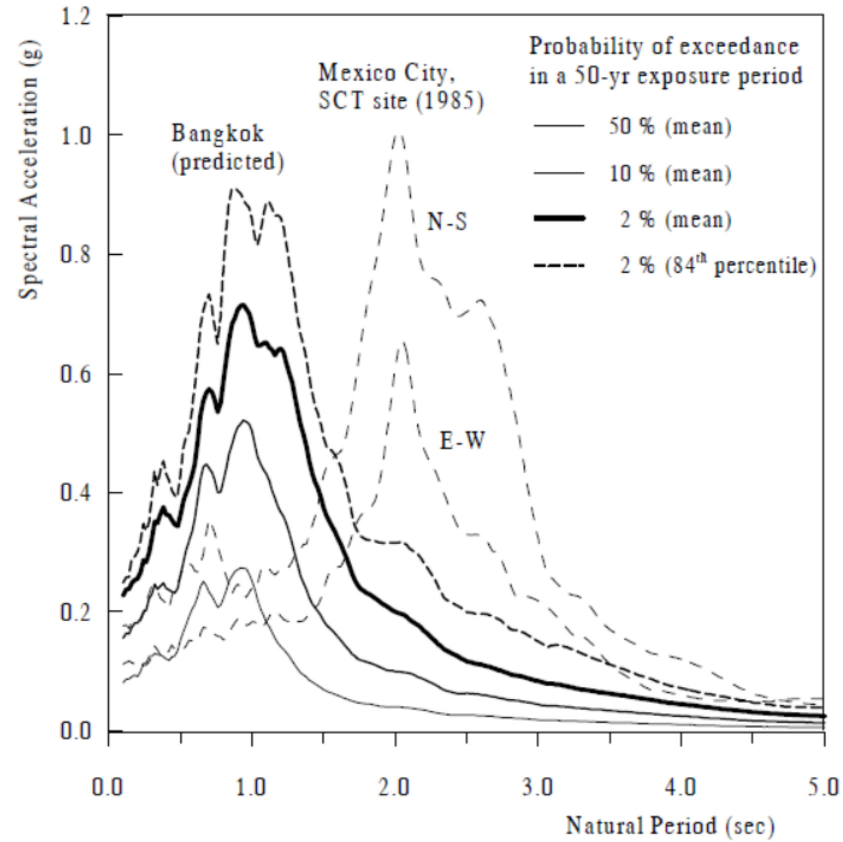


Soil Profiles for East-West Direction ((Mairaing and Cherdpun ,2010)

Bangkok case
1D site effect analysis



Generalized Bangkok soil and shear wave velocity profiles (WARNITCHAI1 et al., 2000, 12WCEE)



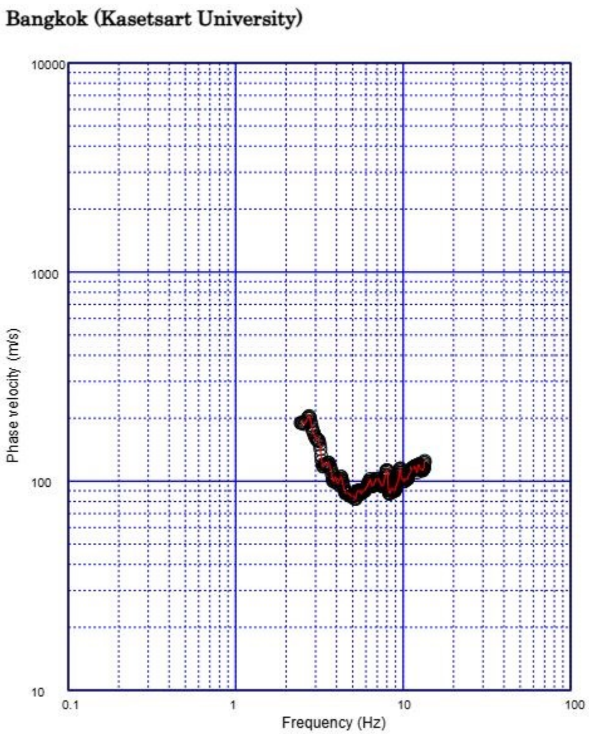
Comparison between the elastic response spectra of predicted ground motions and the spectra of the damaging ground motions in Mexico City (WARNITCHAI1 et al., 2000, 12WCEE)

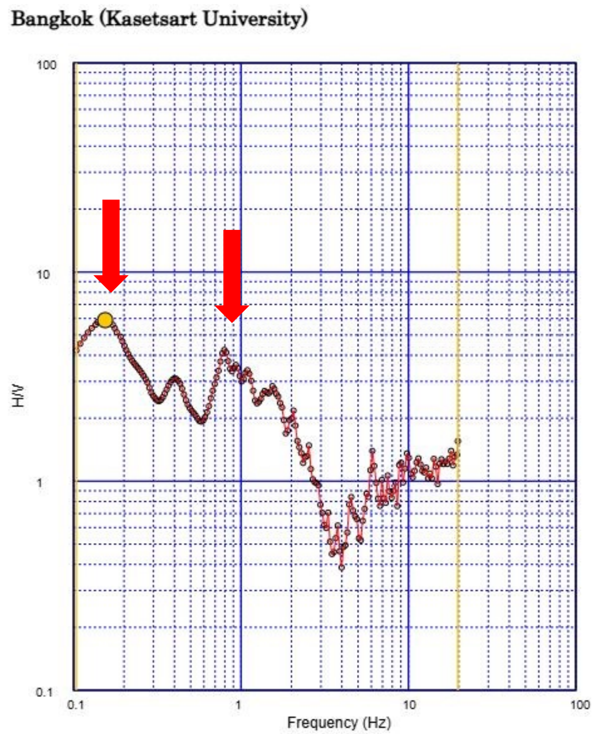
Is it enough to explain the collapse of 33 story building and strong long period oscillation of tall buildings?

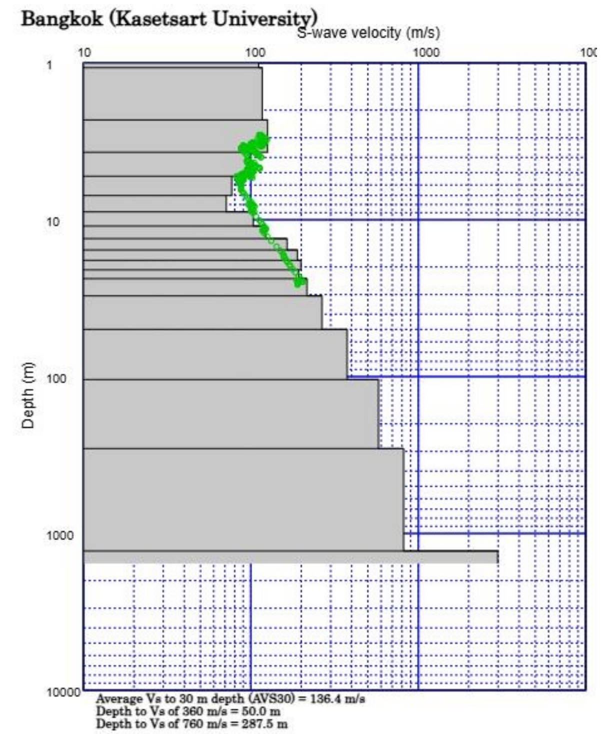
Bangkok case
Microtremor data analysis

Is it enough to explain the collapse of 33 story building and strong long period oscillation of tall buildings?

What can be said using experimental microtremor data?



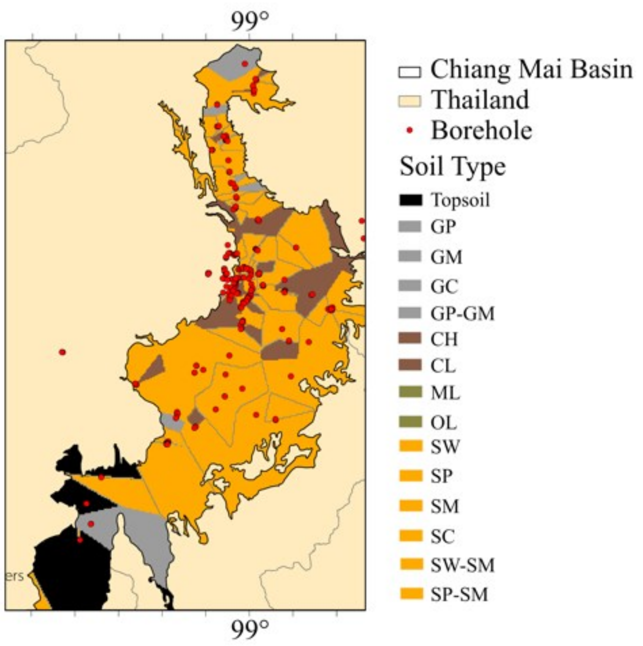




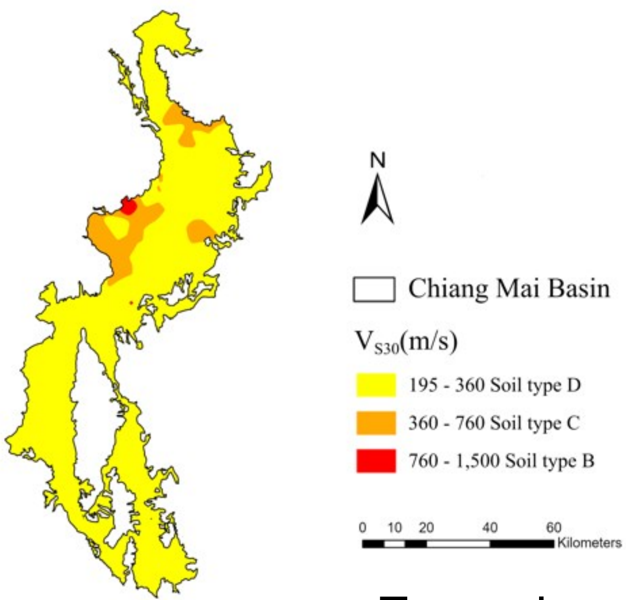
A more important amplification peak at very low frequency.

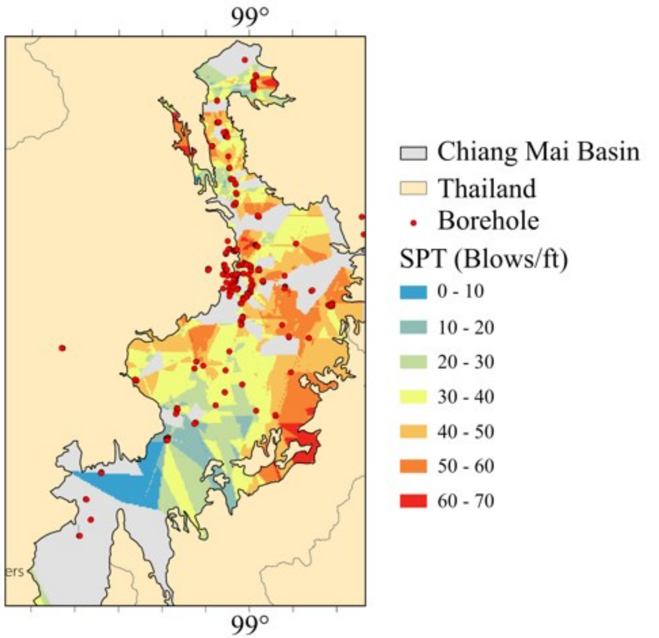
What is the source for this peak ?

Chian Mai & Chian Rai case



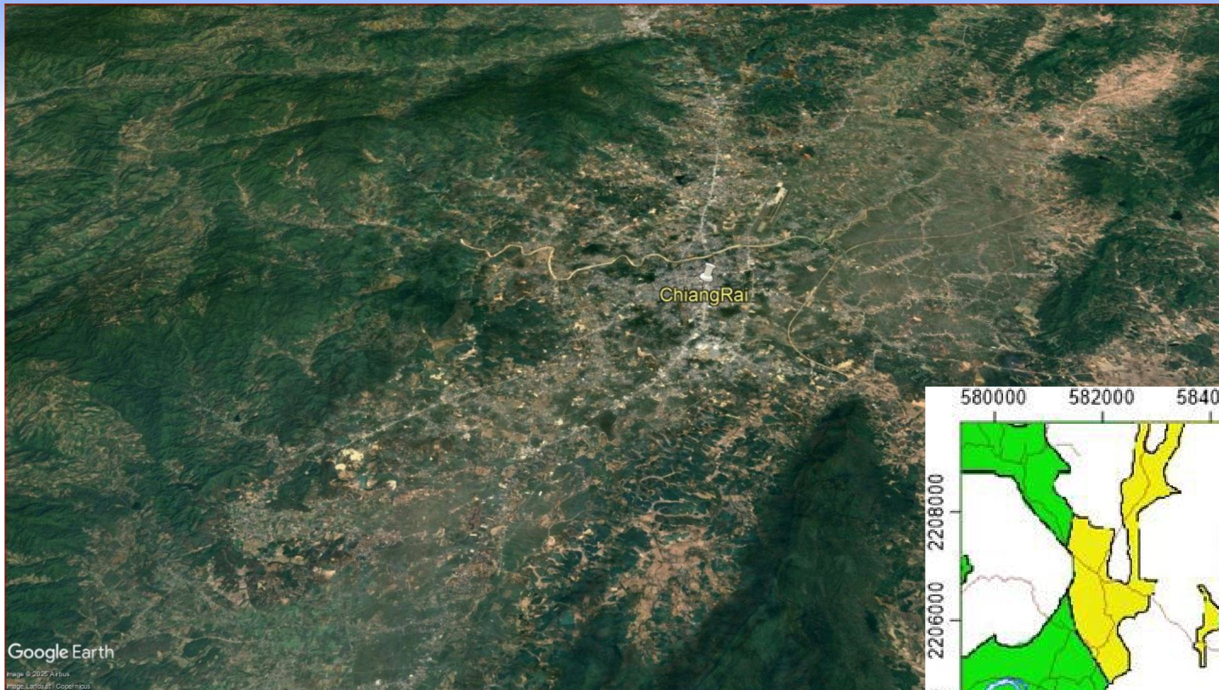
Chian Mai



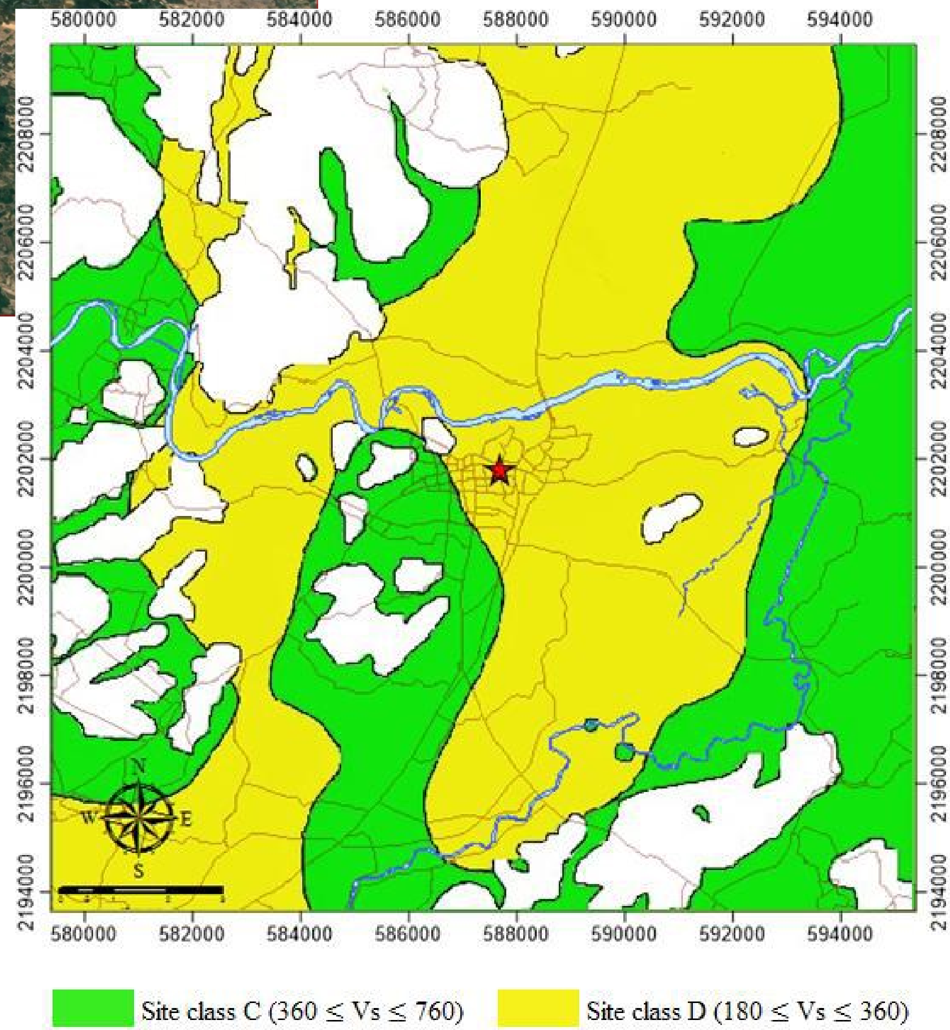


Tanapalungkorn, et al. 2024

Chian Mai & Chian Rai case



Chian Rai



Amplification capability of Chian Rai. The City of Chiangrai that is situated on soil class D may has some risk from soil amplification.

Jintaprasat & Thitimakorn (2017)

Comparison with Iran cases

Is there the any cases similar to Bangkok in iran?

What do you think about Tehran?

Comparison with Iran cases
Tehran

Historical Review on performed Studies & Challenges

Two main and big projects performed on site effect on Tehran up to 2001:

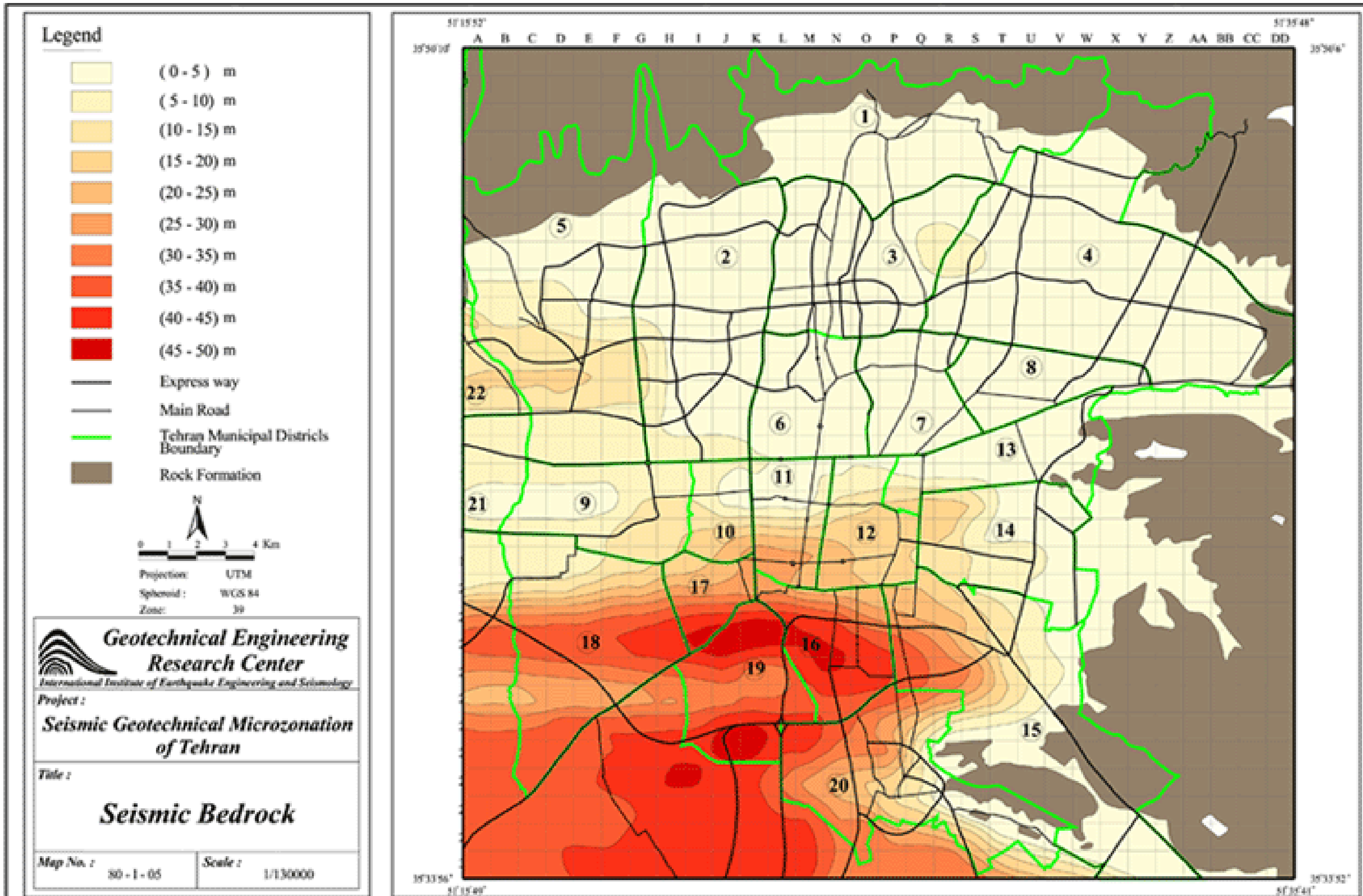
- **Earthquake Geotechnical microzonation : Started since 1994: south-east, southwest and then north (M.K. Jafari et al, IIEES)**
- **Seismic "microzonation" (scenario) : JICA + CEST, 2001**

Results concerning site effects based on 1D modeling

- **Stiff and "shallow" deposits in the North**
- **Softer and thicker (not very thick) deposits in the South**
- **Moderate amplification (<2) only at intermediate and high frequencies (f>1-2 Hz)**

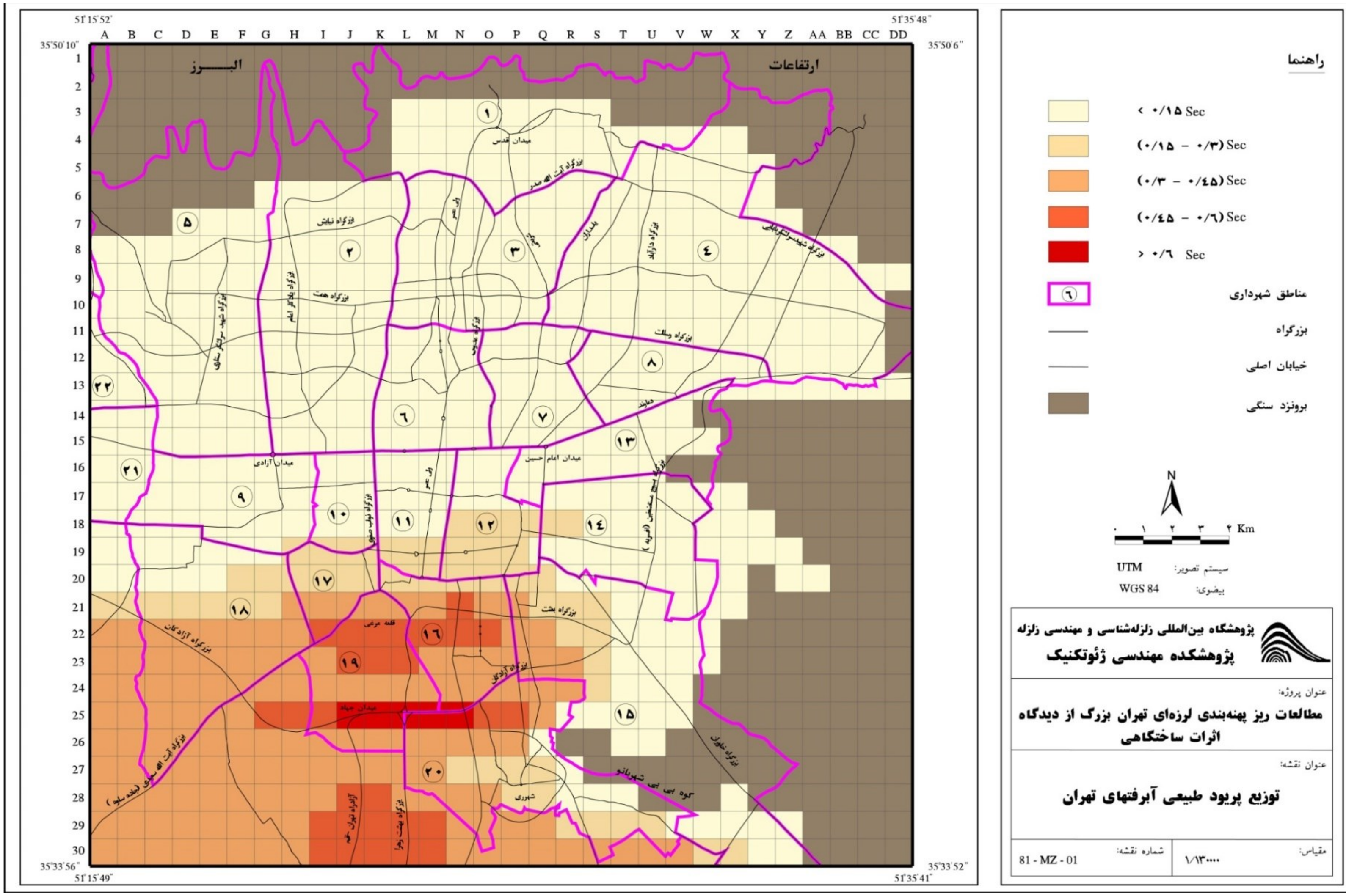
Some results of two referred projects

DEPTH TO "SEISMIC BEDROCK" (IIEES)
[Vs > 600-700 m/s]



Some results of two referred projects

Natural period of soil obtained by 1D modeling



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Some results of two referred projects

Soil columns

JICA & CEST, 2001)

Maximum thickness above "seismic bedrock" : 150 m

Maximum thickness of soft deposits (N = 15) : 30 m

Model No.	Depth (GL-m)																								
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	110	120	130	140	150	
1	C1	C1	C1	C1	C1	C1	CS3	CS3	CS3	CS3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C4
2	C1	C1	C2	C2	C2	C2	CS3	CS3	CS3	CS3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C4
3	C1	C1	CS1	CS1	CS1	CS1	CS3	CS3	CS3	CS3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C4
4	C1	C1	C2	C2	C2	C2	C2	C2	C2	C2	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C4
5	C1	C1	C1	C1	C1	C1	C2	C2	C2	C2	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	C4
6	C2	C2	C2	C2	C2	C2	CS3	CS3	CS3	CS3	CS3	CS3	CS3	CS3	CS3	CS3	C2	C2	C2	C2	C2	C2	C2	C2	C2	C4
7	C1	C1	C2	C2	C2	C2	C2	C2	C2	C2	C3	C3	C3	C3	C4											
8	C1	C1	C2	C2	C2	C2	CS2	CS2	CS2	CS2	CS3	CS3	CS3	CS3	C4											
9	C2	C2	CS2	CS2	CS2	CS2	C3	C3	C3	C3	C2	C2	C2	C2	C4											
10	C1	C1	CS2	CS2	CS2	CS2	C3	C3	C3	C3	C2	C2	C2	C2	C4											
11	C2	C2	C3	C3	C3	C3	CS3	CS3	CS3	CS3	C2	C2	C2	C2	C4											
12	C2	C2	C2	C2	C2	C2	C2	C2	C2	C2	C4															
13	C2	C2	C2	C2	C2	C2	CS3	CS3	CS3	CS3	CS4															
14	C2	C2	C2	C2	C2	C2	CS2	CS2	CS2	CS2	CS4															
15	CS1	CS1	C2	C2	C2	C2	CS3	CS3	CS3	CS3	CS4															
16	C2	C2	C2	C2	C2	C2	CS3	CS3	CS3	CS3	CS4															
17	C2	C2	CS1	CS1	CS1	CS1	CS3	CS3	CS3	CS3	CS4															
18	G2	G2	CS1	CS1	CS1	CS1	G3	G3	G3	G3	G4															
19	C3	C3	C3	C3	C3	C3	G3	G3	G3	G3	G4															
20	C2	C2	C3	C3	C3	C3	CS3	CS3	CS3	CS3	CS4															
21	CS2	CS2	CS3	CS3	CS3	CS3	CS3	CS3	CS3	CS3	CS4															
22	C1	C1	C1	C1	C1	C1	C4																			
23	C2	C2	C2	C2	C2	C2	C4																			
24	CS2	CS2	CS2	CS2	CS2	CS2	CS4																			
25	C1	C1	CS2	CS2	CS2	CS2	CS4																			
26	CS1	CS1	CS3	CS3	CS3	CS3	CS4																			
27	G2	G2	G4	G4	G3	G3	G4																			
28	C2	C2	G3	G3	G3	G4																				
29	S3	S3	S3	S3	S3	G4																				
30	S3	S3	G3	G3	G3	G4																				
31	G3	G3	G3	G3	G3	G4																				
32	G2	G2	G3	G3	G4																					
33	G3	G3	G3	G3	G4																					
34	G3	G3	G3	G4																						
35	S3	S3	S3	G4																						
36	CS3	CS3	CS3	G4																						
37	C1	C1	C1	G4																						
38	C2	C2	C2	G4																						
39	G3	G3	G4																							
40	Pre-Miocene																									
41	Rock																									

Soil Name, Symbol and N Value

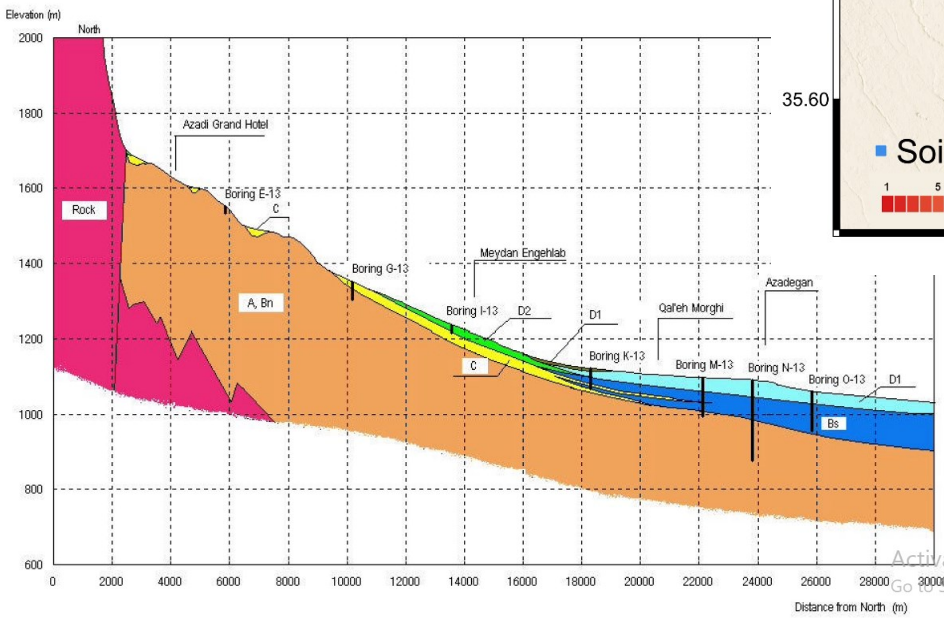
Clay	C1	C2	C3	C4
Average N Value	15	35	75	100
Sand and Clay	CS1	CS2	CS3	CS4
Average N Value	15	35	75	100
Sand	S1	S2	S3	S4
Average N Value	15	35	75	100
Gravel	G1	G2	G3	G4
Average N Value	15	35	75	100

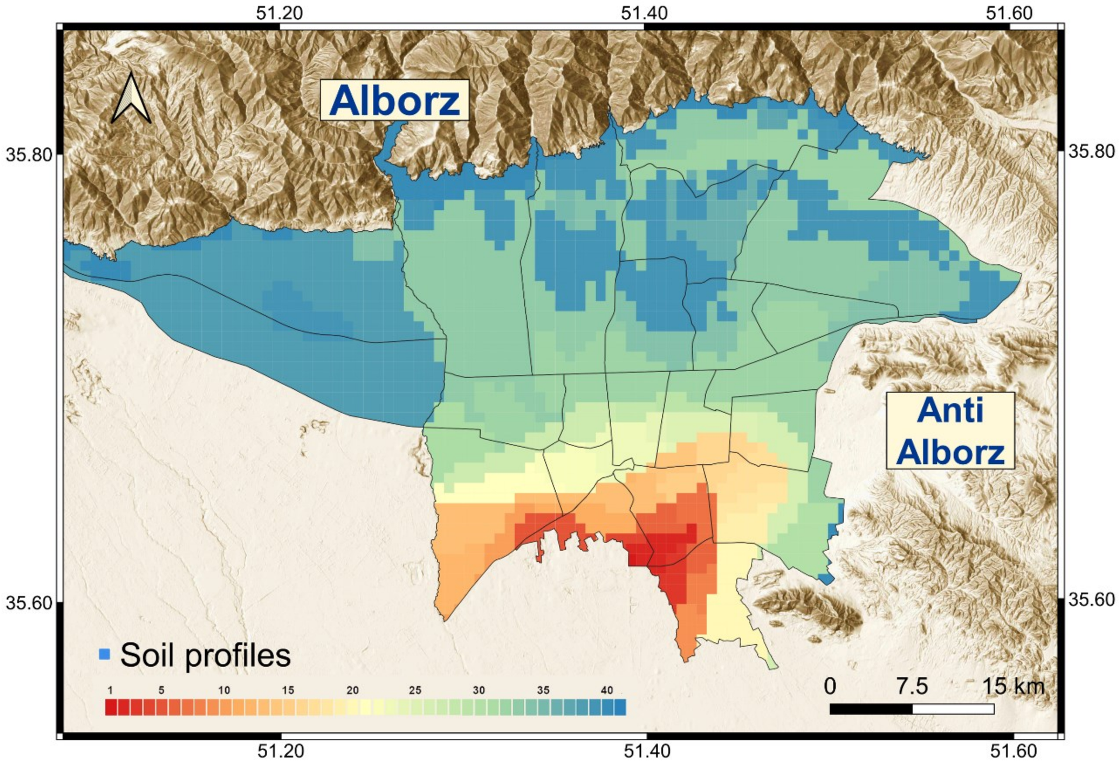
G4 Engineering seismic bedrock and its soil type

Some results of two referred projects

Soil columns & section

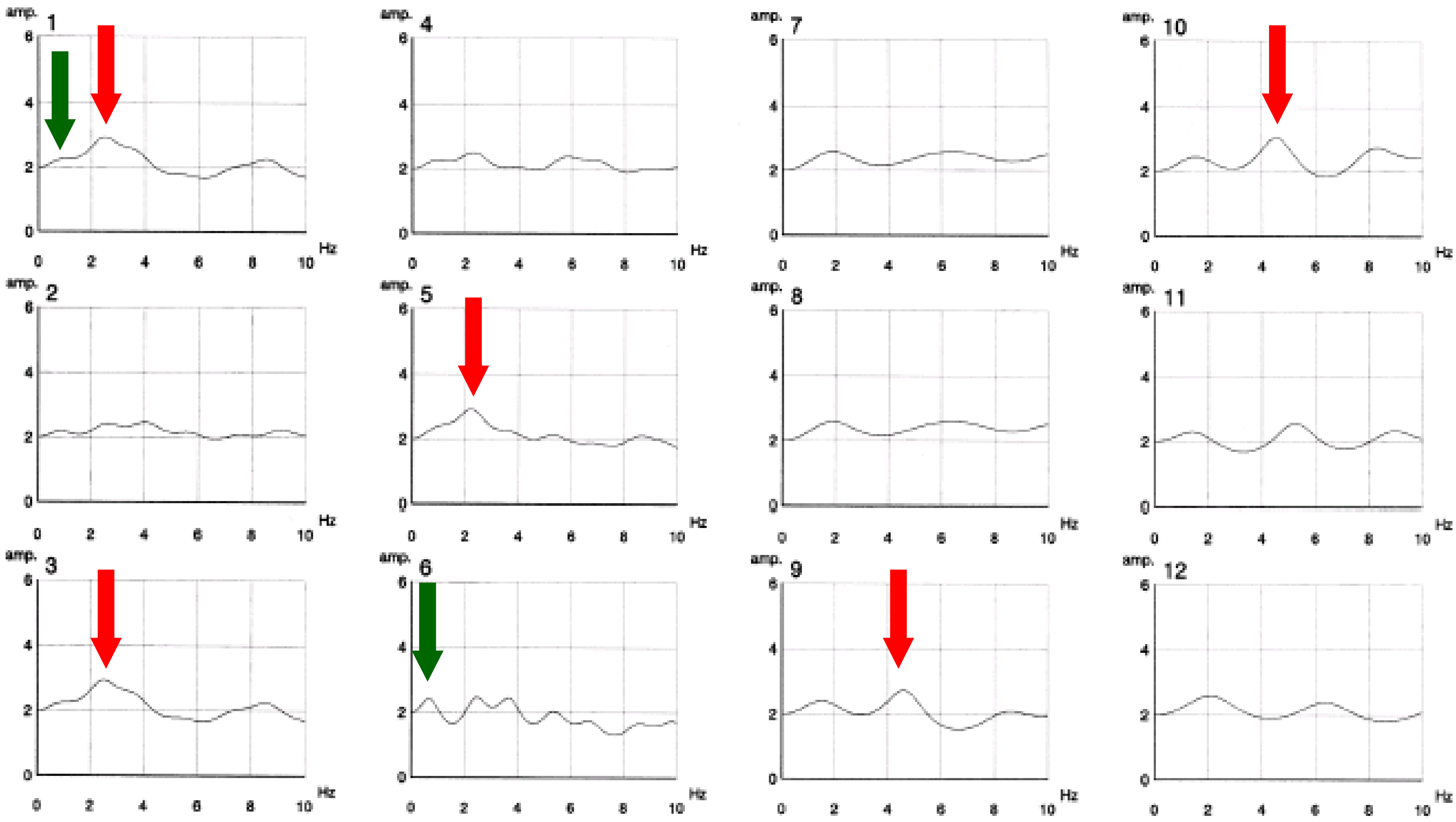
JICA & CEST, 2001)





Some results of two referred projects

Estimated 1D Fourier transfer functions
JICA & CEST, 2001)



Historical Review on performed Studies & Challenges

Some results of two referred projects

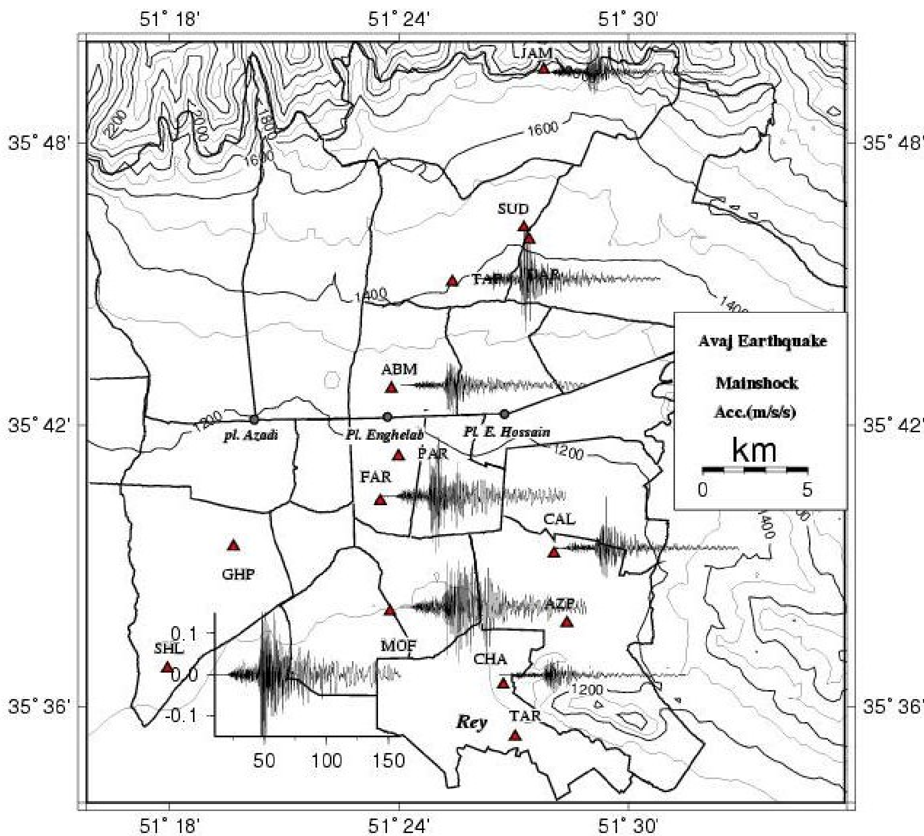
Results concerning site effects based on microtremor H/V processing

They ignored H/V results

Why?

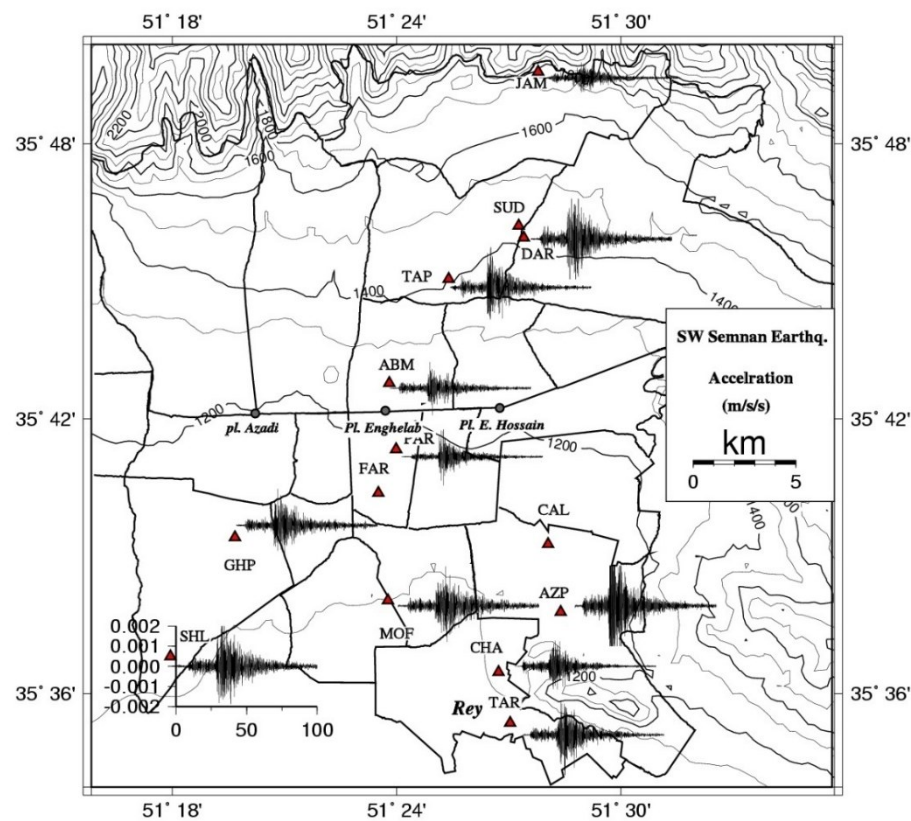
Time history observation for Two events recorded

Experimental study ; Some results (Haghshenas 2005)



Main- shock of Changureh-Avaj Earth, 22/06/2002, Comp. NS (m/s²)

Variation of PGA form 4 to 23 cm/s²)



Event of SW Semnan (E. of Tehran) m=4.4; Comp. NS, (m/s²)

Experimental study ; Some results (Haghshenas 2005)

Site to reference Spectral Ratio (EQ)

Borcherdt (1970)

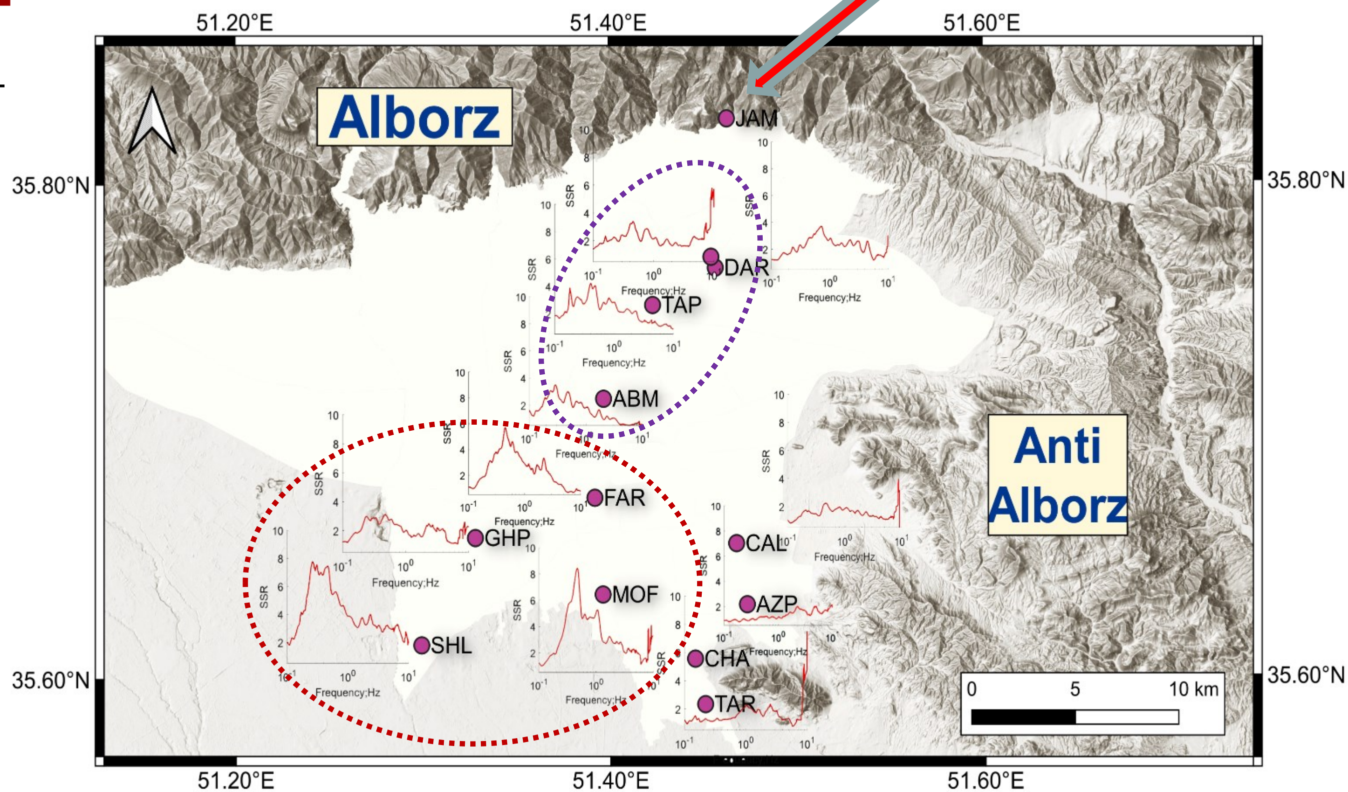
$$SSR(\omega) = \frac{A_H(\omega)\ \text{Sediment}}{A_H(\omega)\ Bedrock}$$

Increasing trend from NE to Sw

Large-band in all Part, exception of SE (TAR, AZP, CAL)

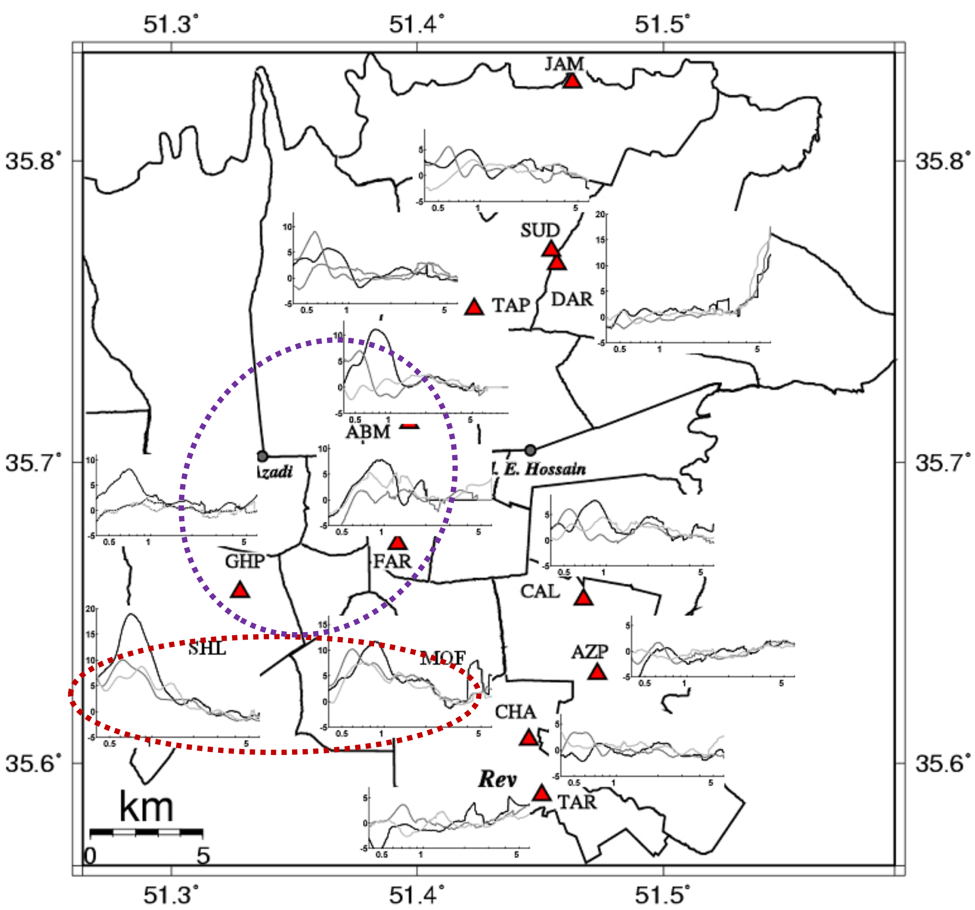
Stability of spectral ratio whatever the reference, and Component

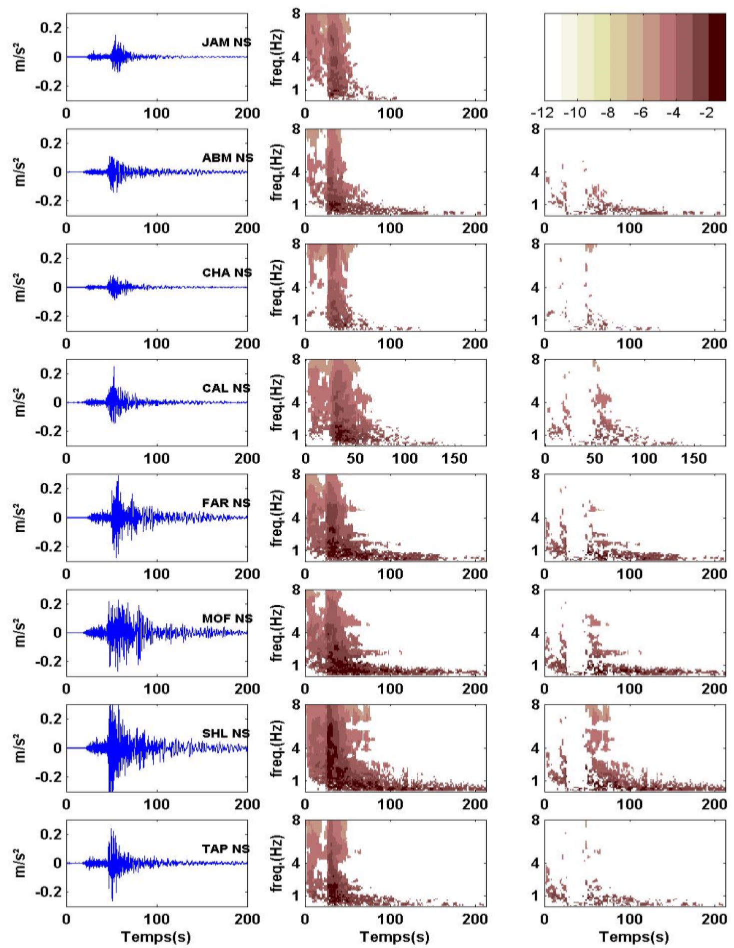
JAM = Reference station at rock



Experimental study ; Some results (Haghshenas 2005)

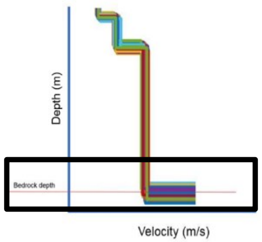
Frequency lengthening using Group-Delay & Sonogram Techicques





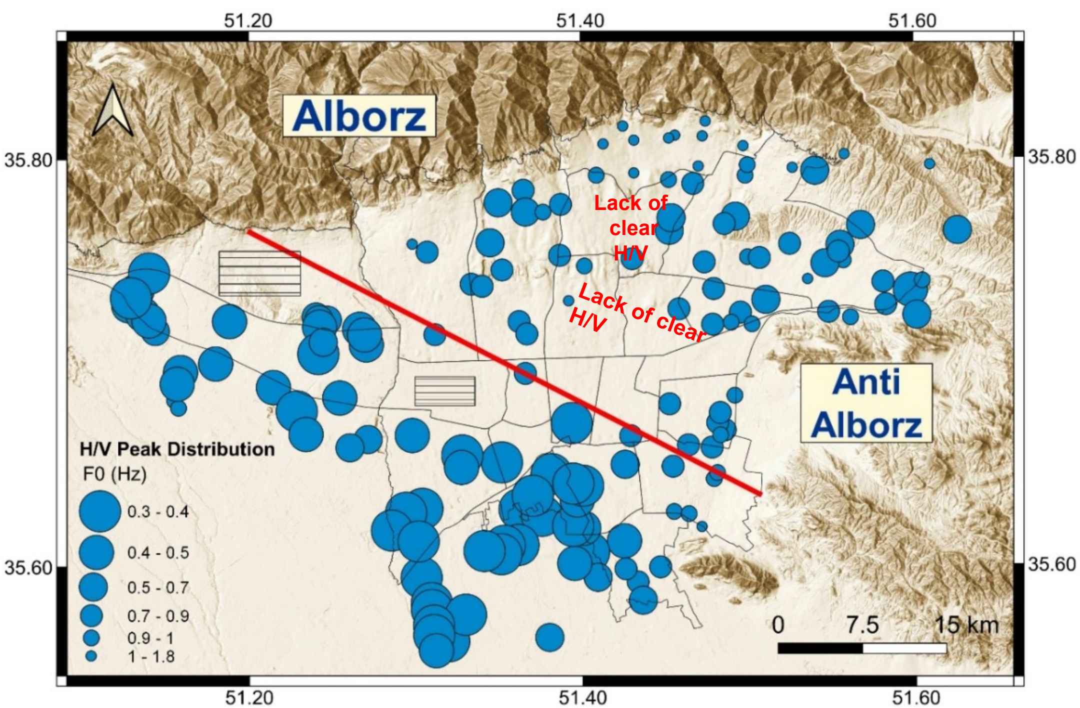
تعیین مدل سه بعدی

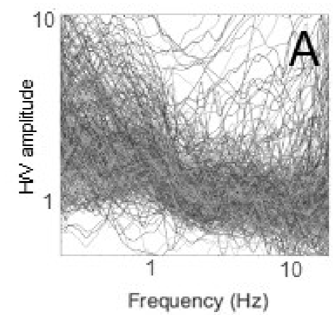
پردازش داده ها (داده های تک ایستگاهی)

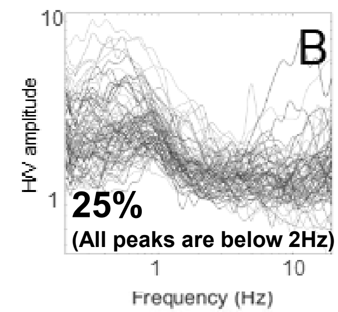


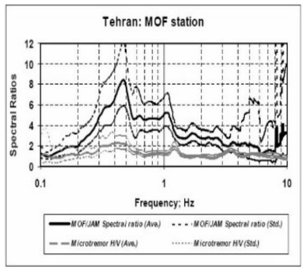
فرکانس تشدید به دست آمده از
روش نسبت طیفی افقی به قائم

≈ ۶۰۰ اندازه گیری تک ایستگاهی

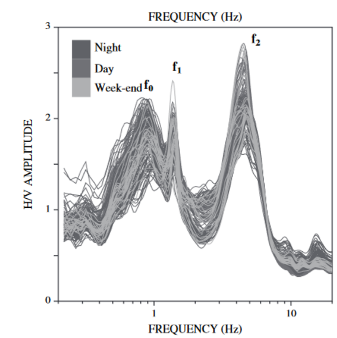








Haghshenas, 2005

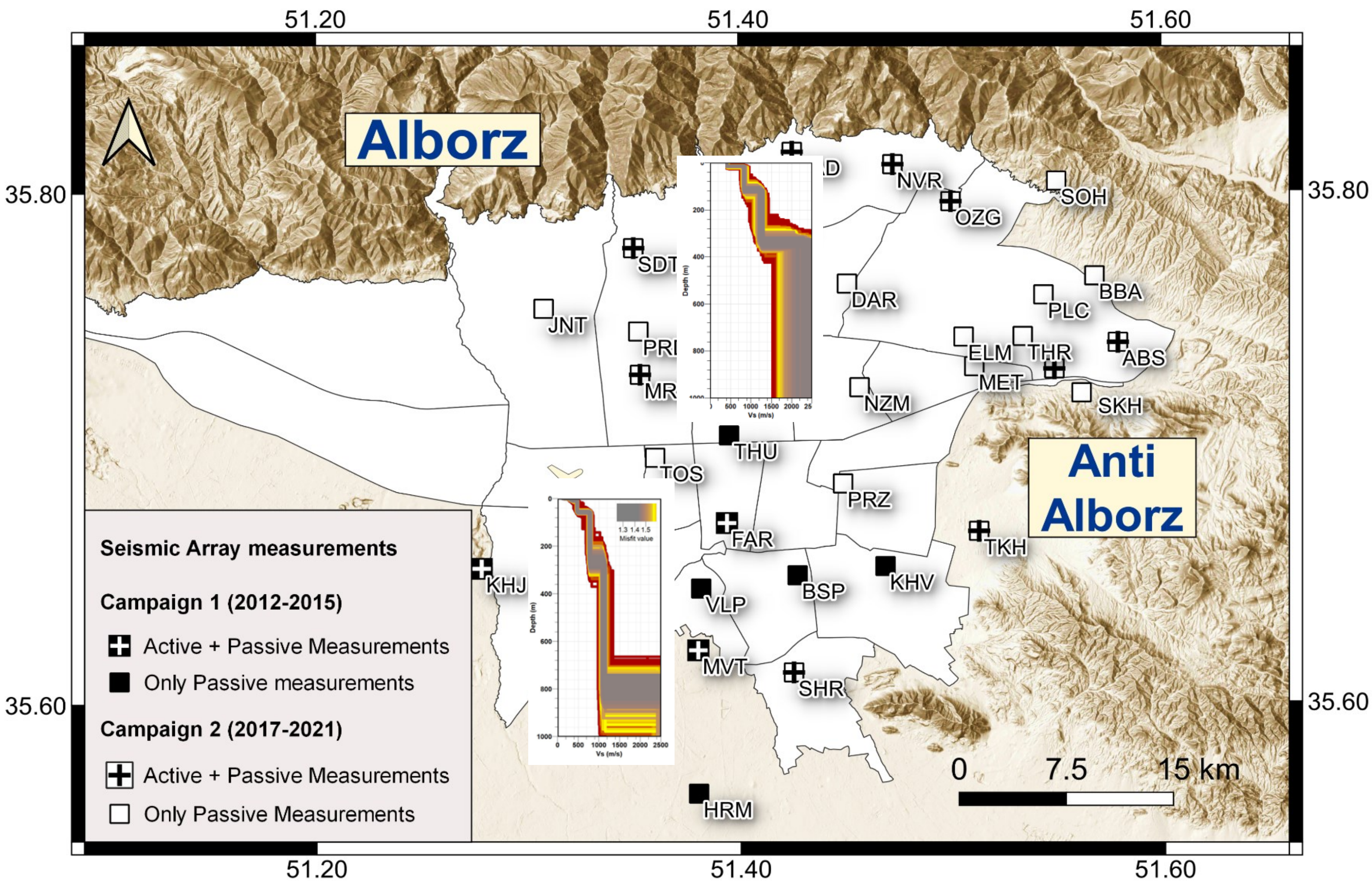


Guillier et al., 2007

تغییرپذیری محتوای میدان موج در
زمان و مکان (پیچیده تر در شمال شهر)

تعیین مدل سه بعدی

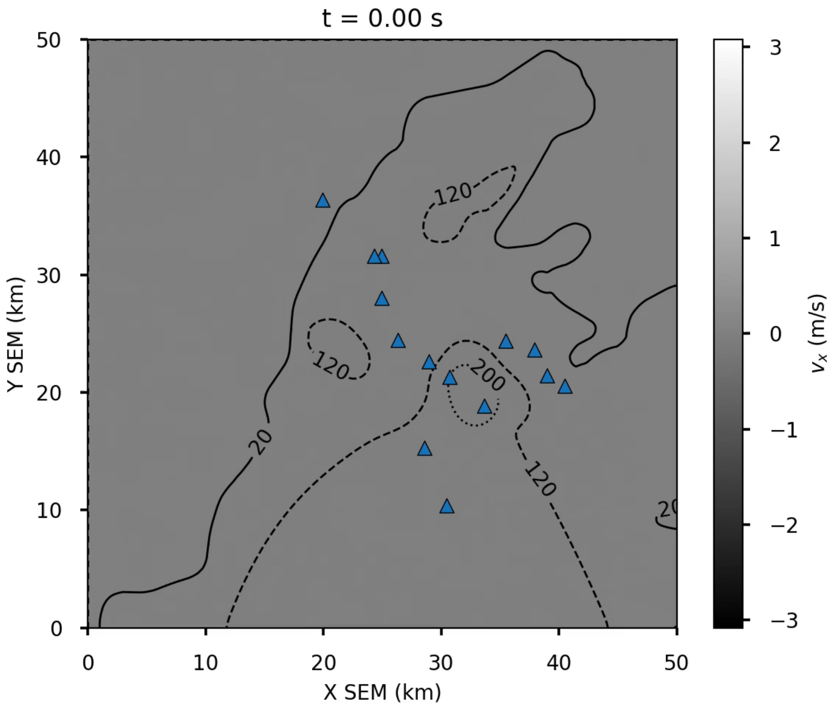
وارون سازی و استخراج مدل سرعتی موج برشی



انیمیشن انتشار میدان موج

Spectral element method scheme (in practice)

Snapshot



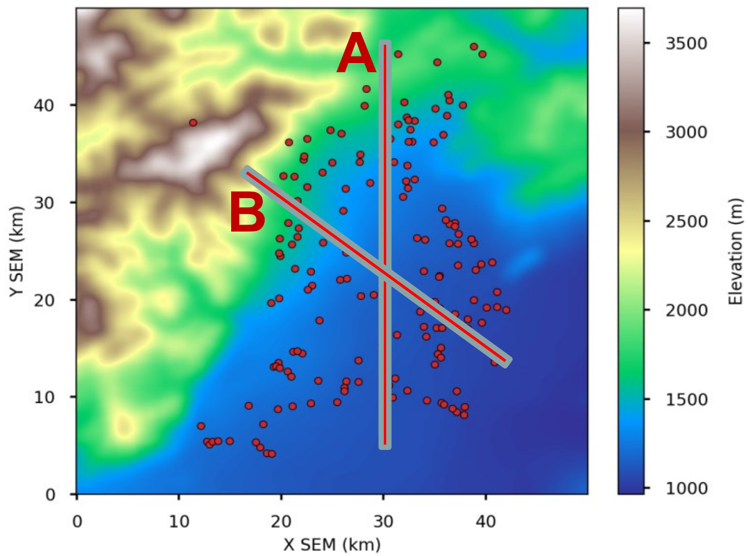
The extracted time series data

(i) The seismological stations (13)

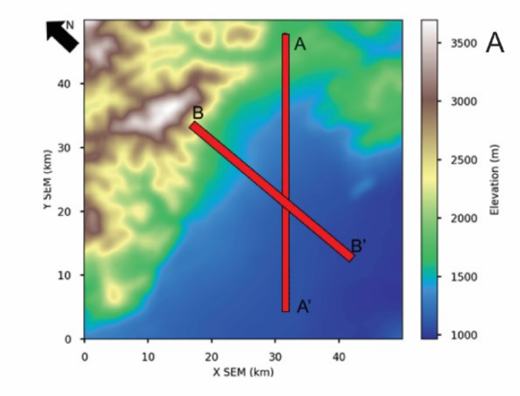
(ii) H/V ambient noise location (159)

(iii) Along two (A & B) cross sections (81)

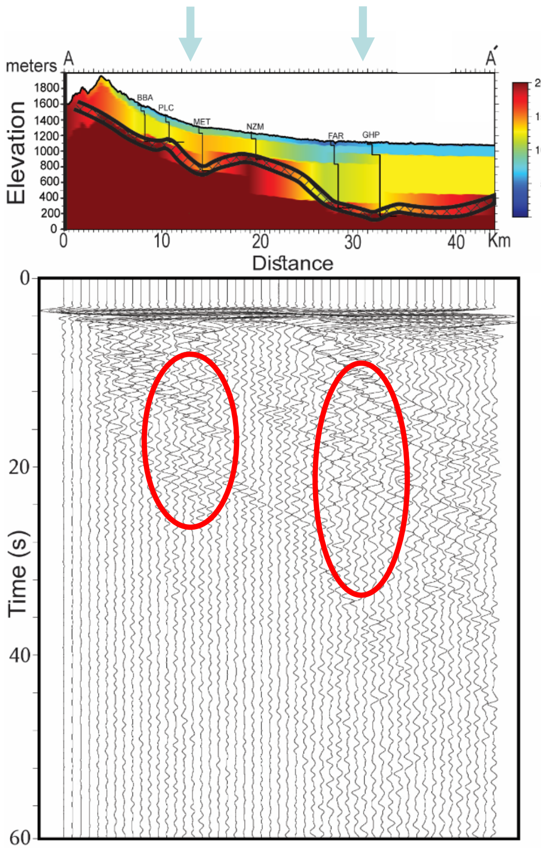
(iv) Different reference station at rock (18)

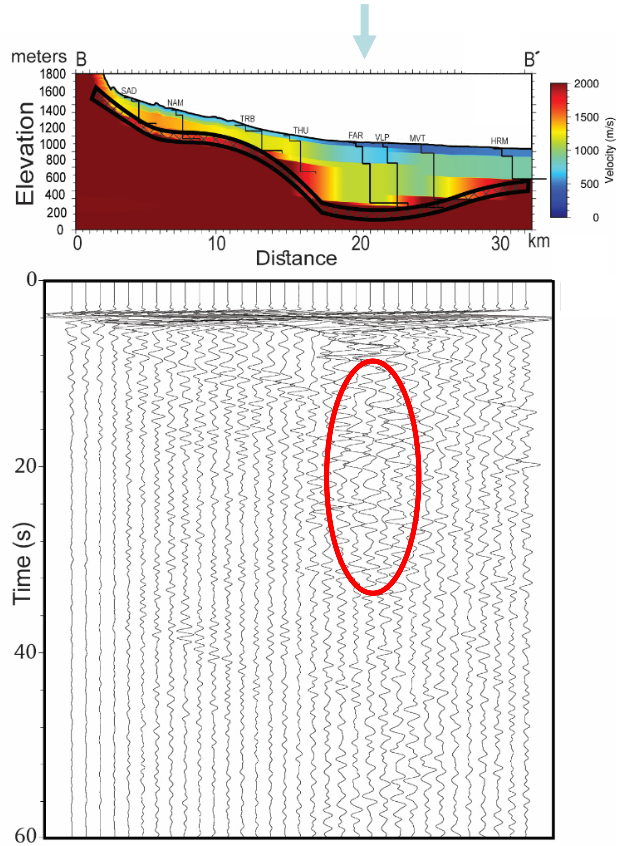


نگاشت های زمانی حاصله در طول دو مقطع



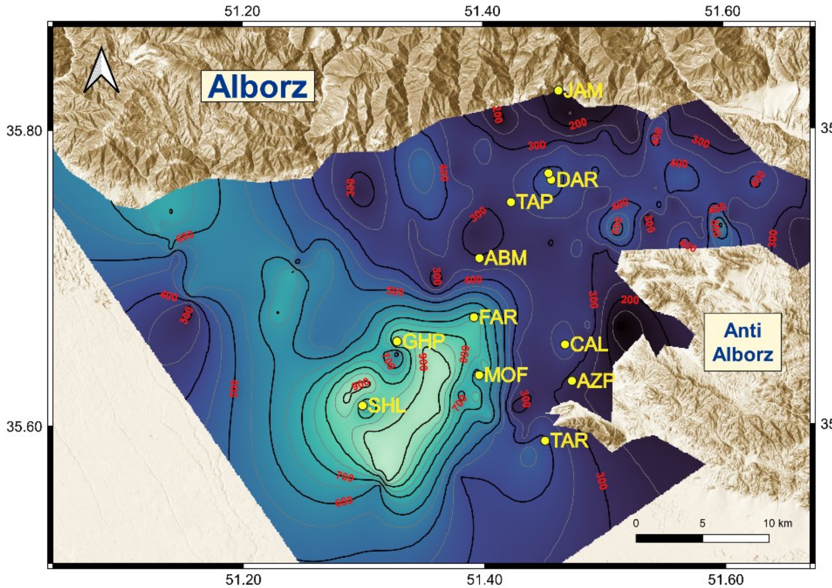
اثرات ۳ بعدی
ایجاد امواج سطحی
تفرق یافته در حاشیه
حوضه در طول مقاطع





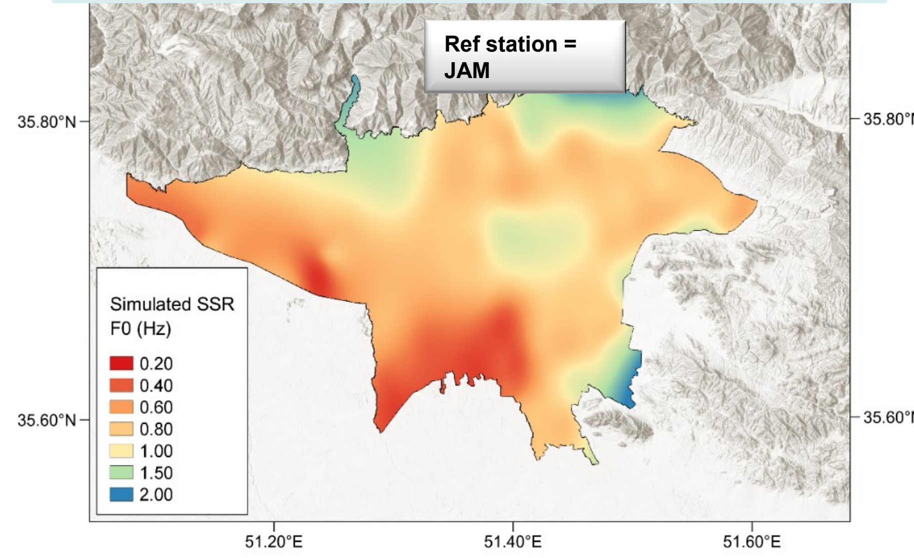
Numerical simulation

3D velocity model of Tehran basin



Soltani et al., (2025, under review)

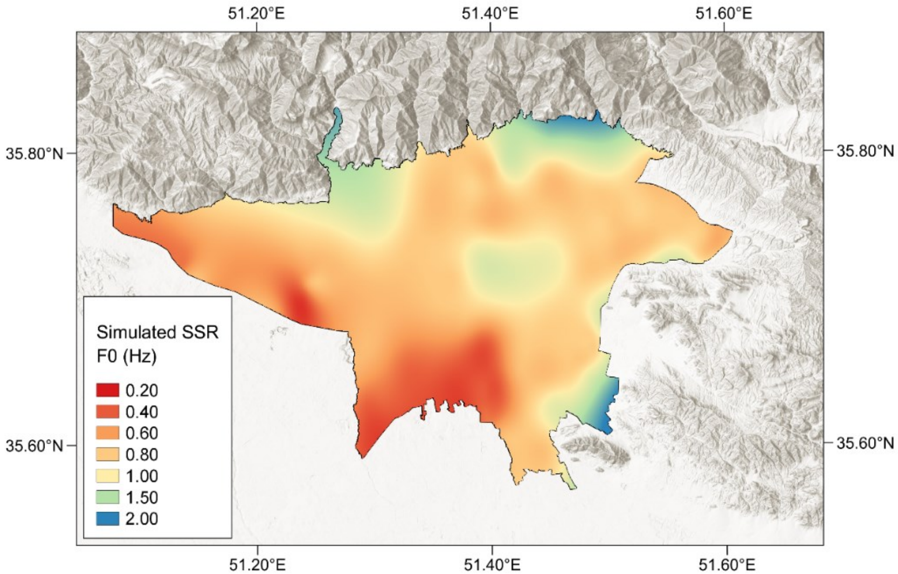
Simulated site to refrence spectral ratio (F0)



Soltani et al., (2025, in prep.)

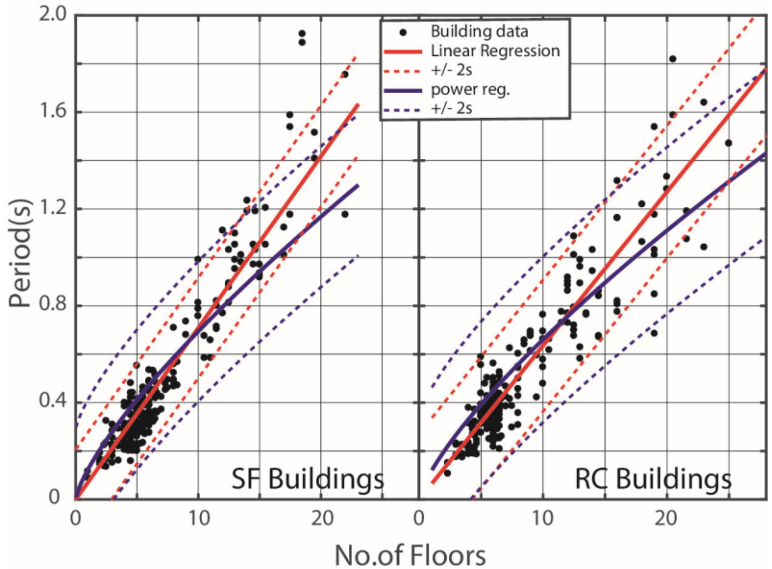
$$T = \frac{N}{15.7} = 0.0212H$$

Simulated site to refrence spectral ratio (F0 = 1/T0)



Soltani et al., (2025, in prep.)

Empirical T0-No of floor relationship for Tehran

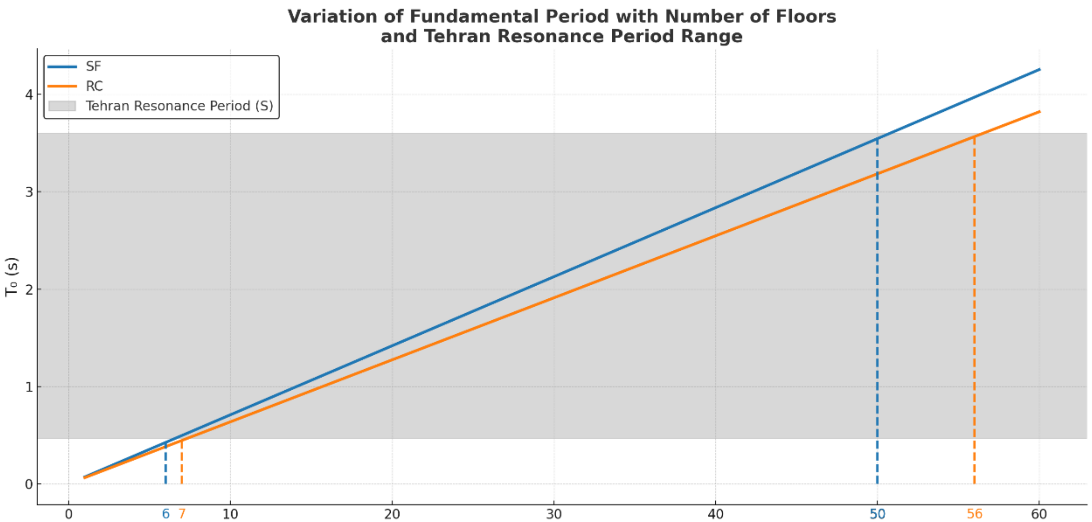


Oghalaei (2021)

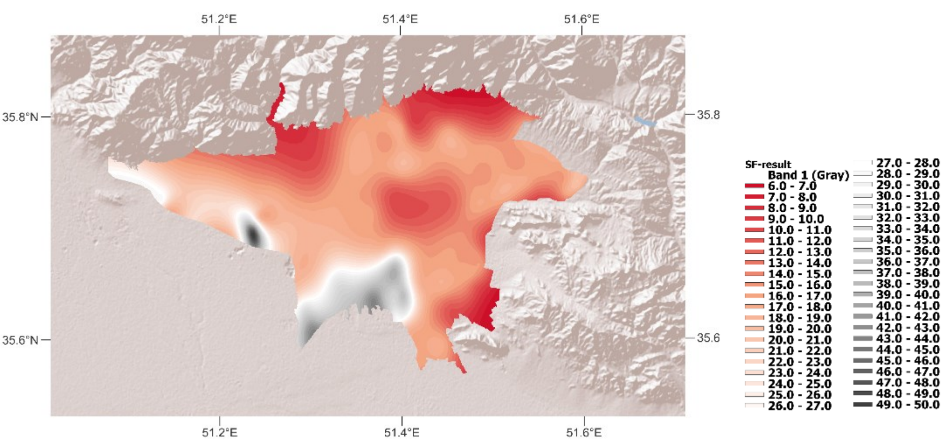
Compare

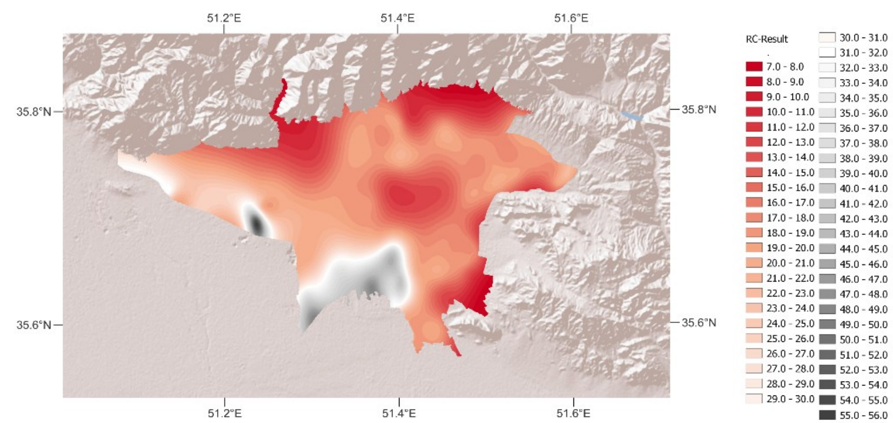
Linear relationship = best fit

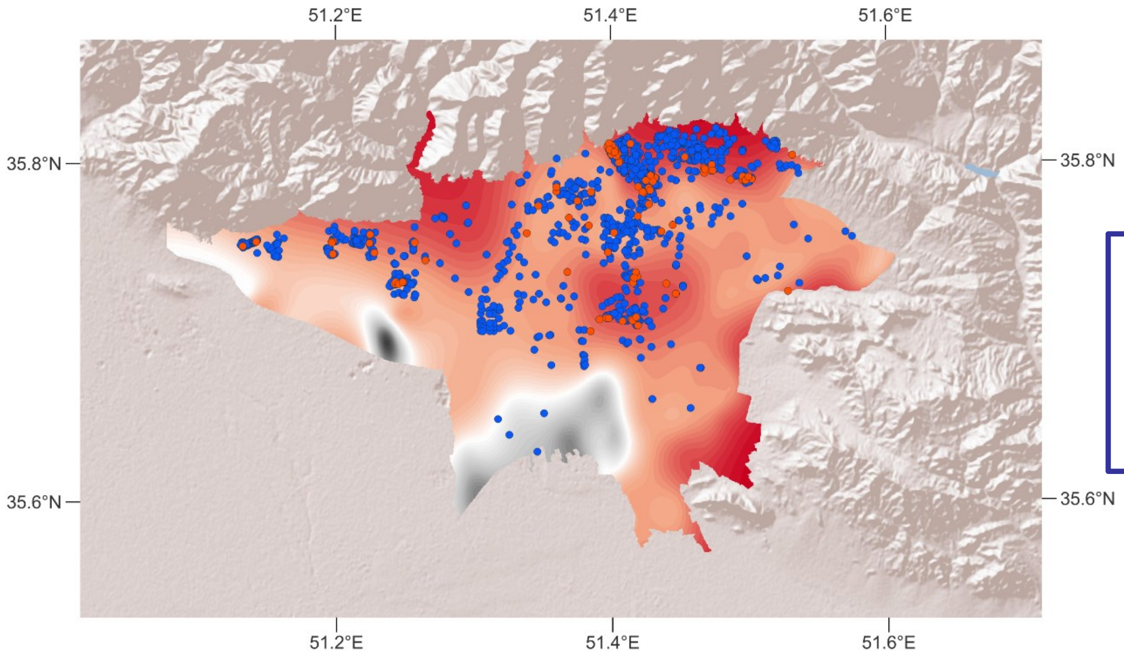
Building type	Formula	R^2
Steel Frame Building	$T = \frac{N}{14.1} = 0.0236H$	0.897
RC Building	$T = \frac{N}{15.7} = 0.0212H$	0.857



Based on Tehran resonance period range, steel-frame (SF) buildings with 6 to 50 floors and reinforced concrete (RC) buildings with 7 to 56 floors are potentially vulnerable to resonance effects.





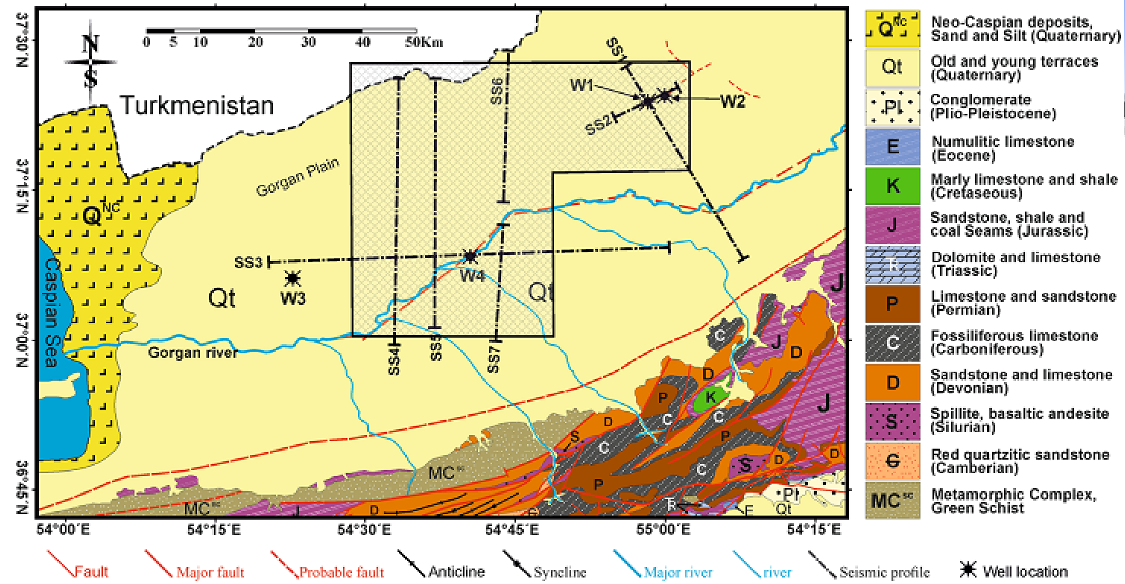


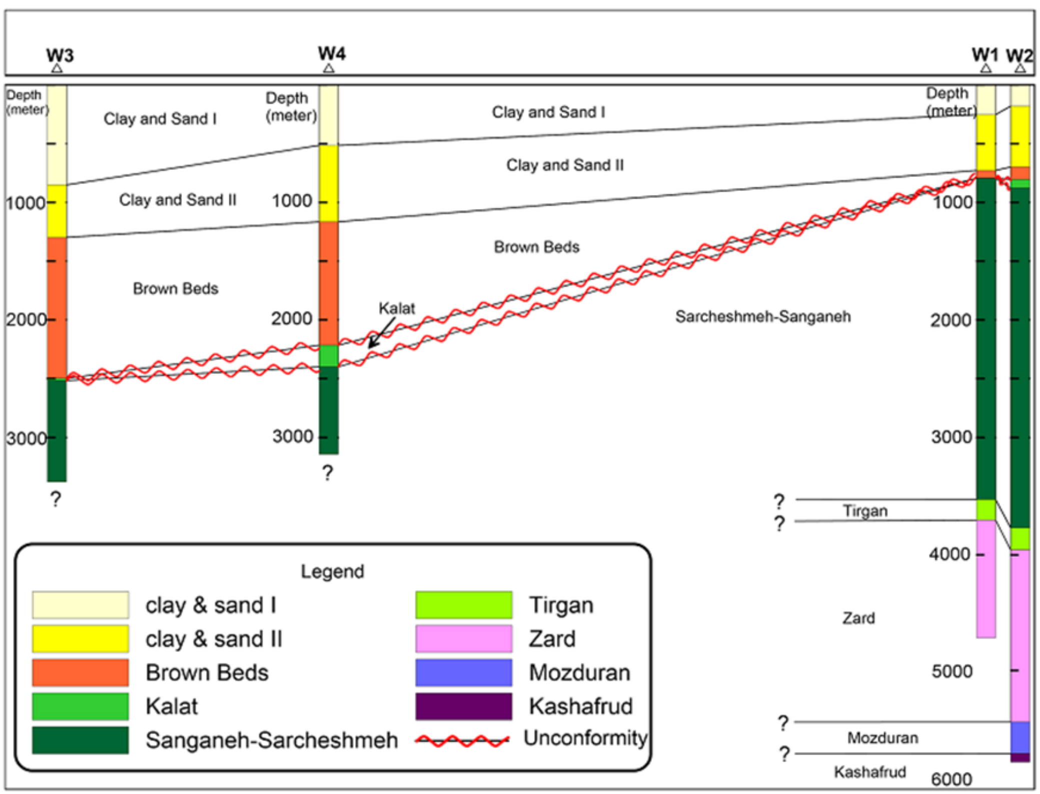
Comparison of building heights (number of floors) from nearly 1,000 high-rise buildings in Tehran (Beitollahi et al.). Approximately 10% potentially fall within critical resonance period band (red dots).

Soltani et al., (2025, in prep.)

Comparison with Iran cases

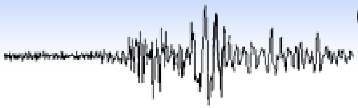
Gorgan Plain

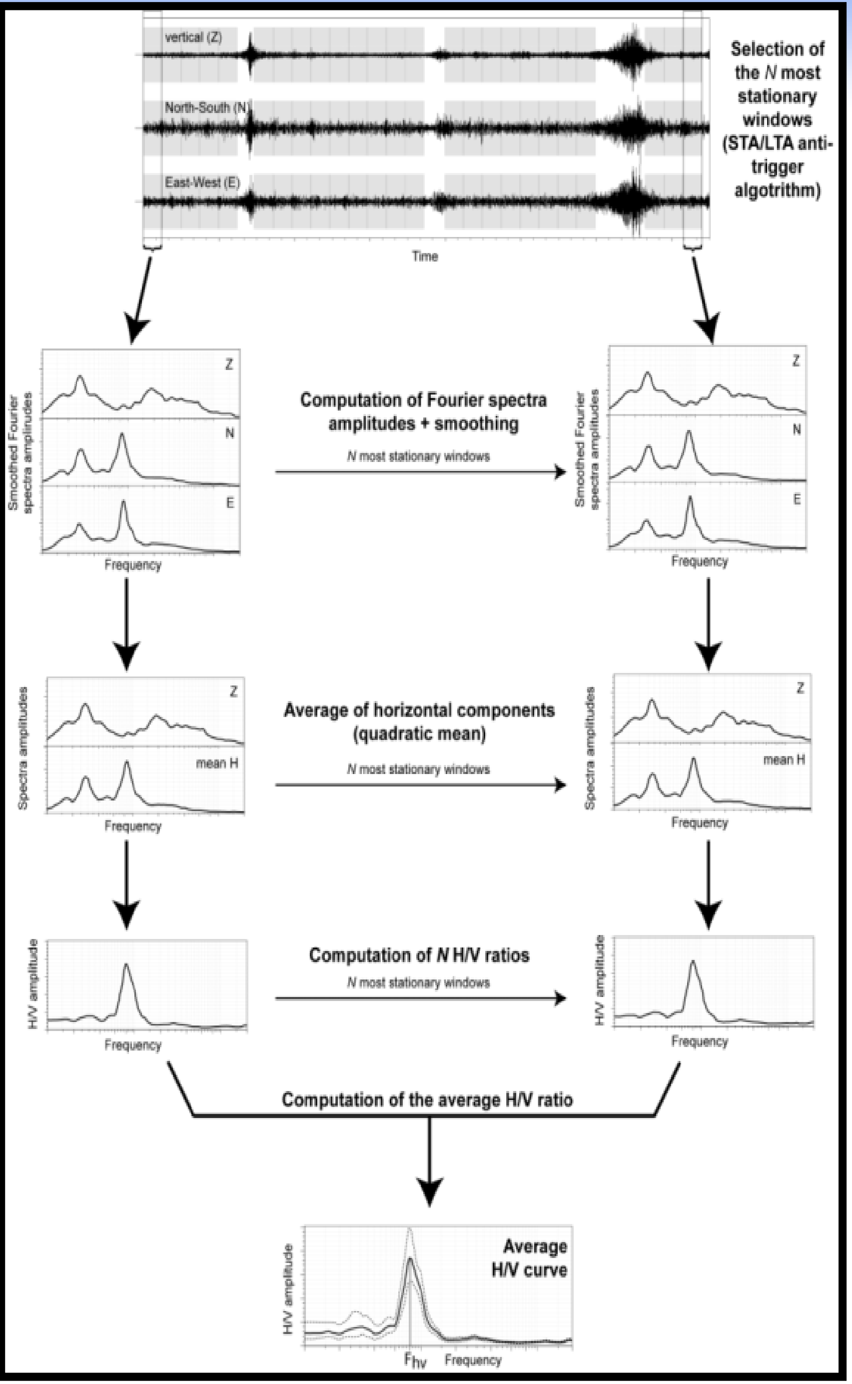


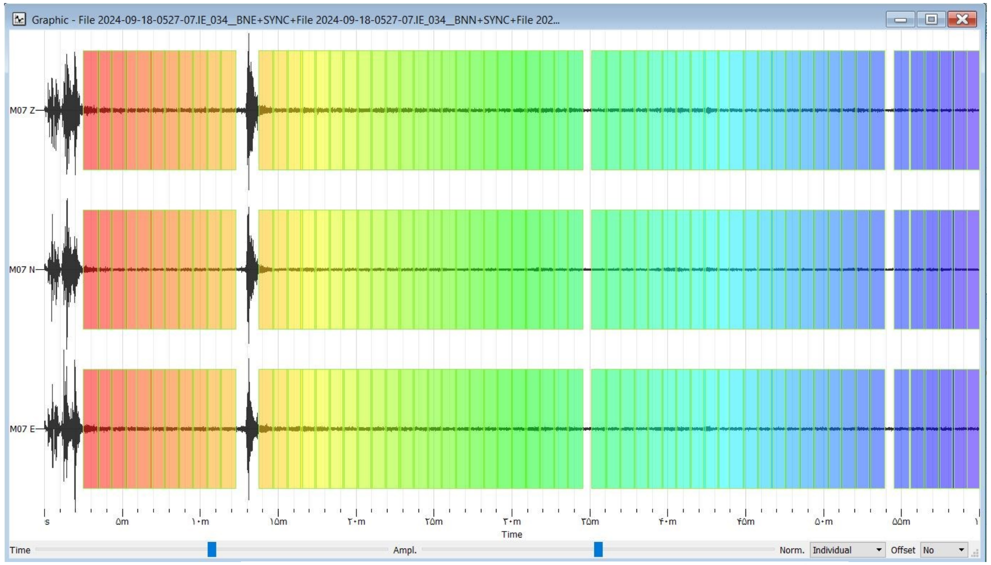


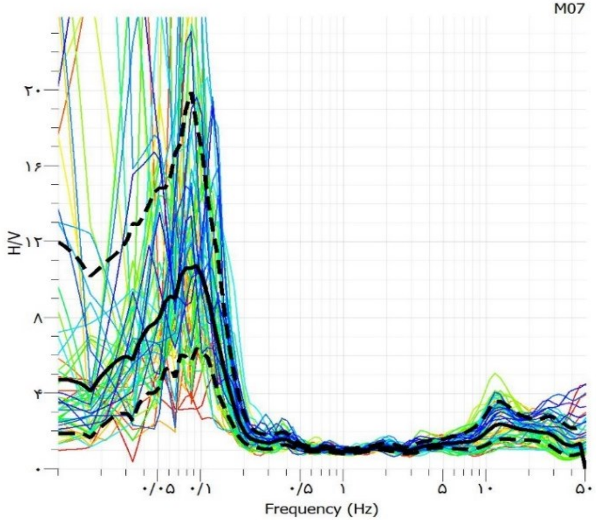
Radfar et al., 2018

مطالعات تک ایستگاهی









مطالعات آرایه ای

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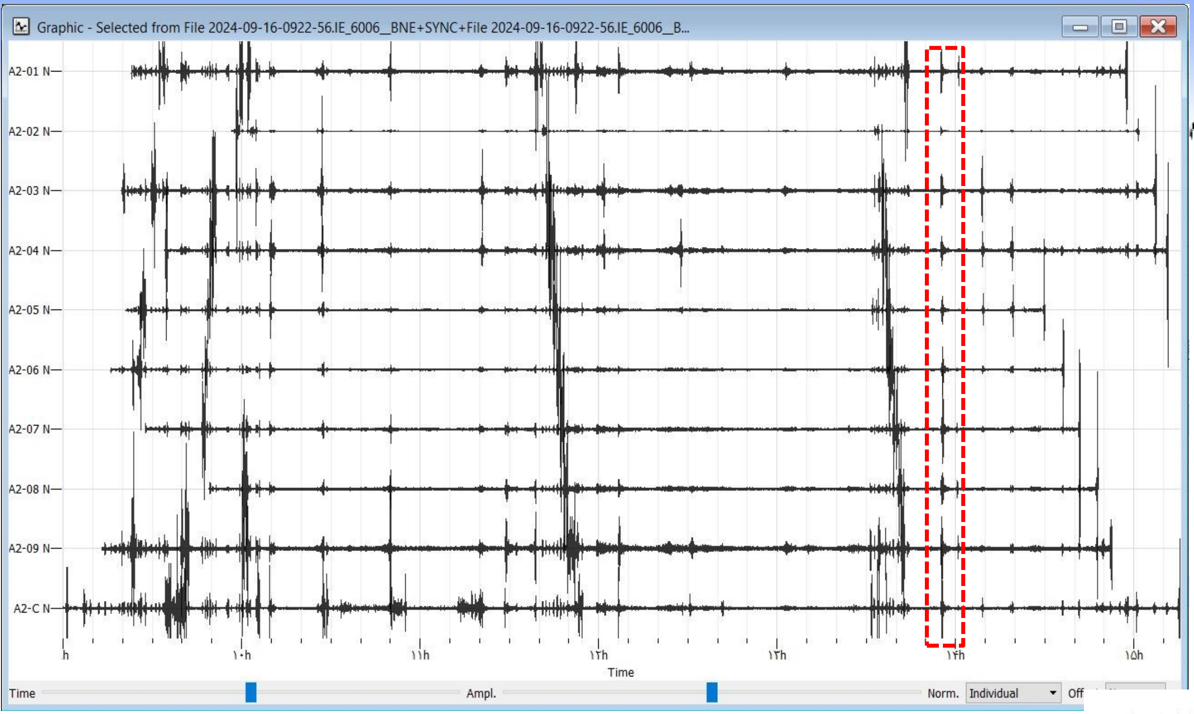
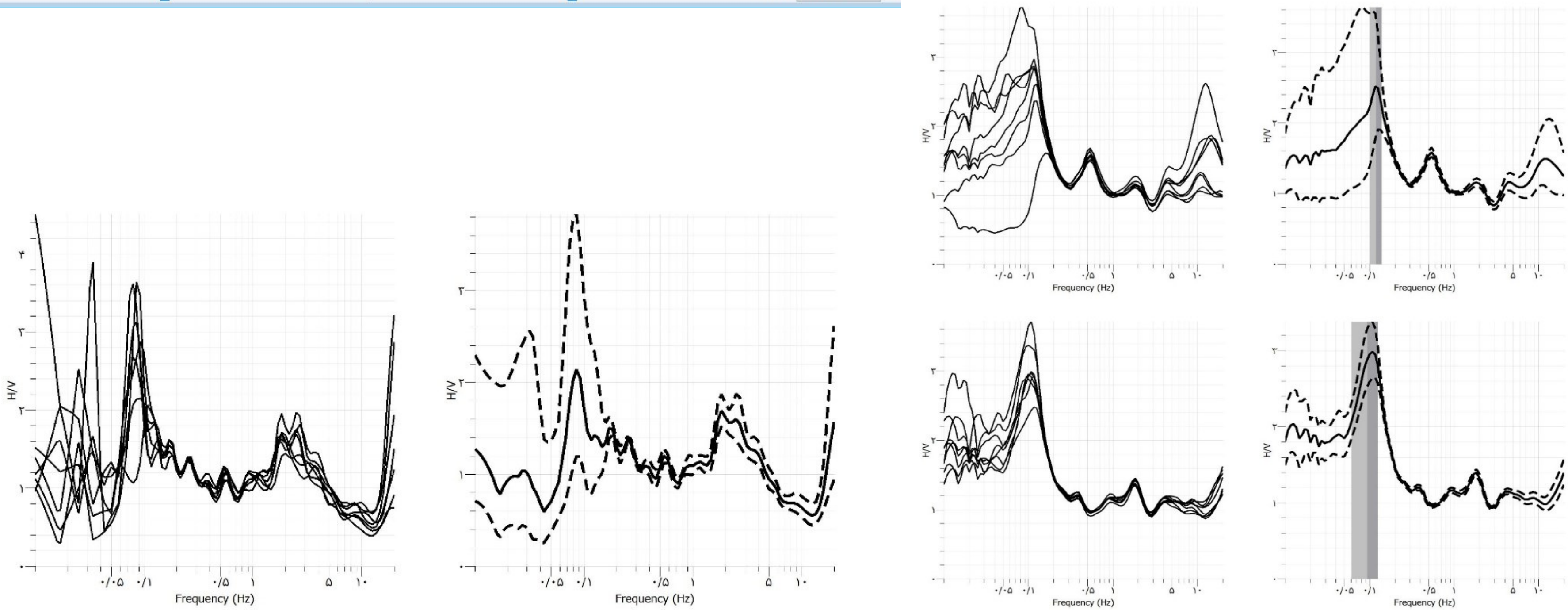
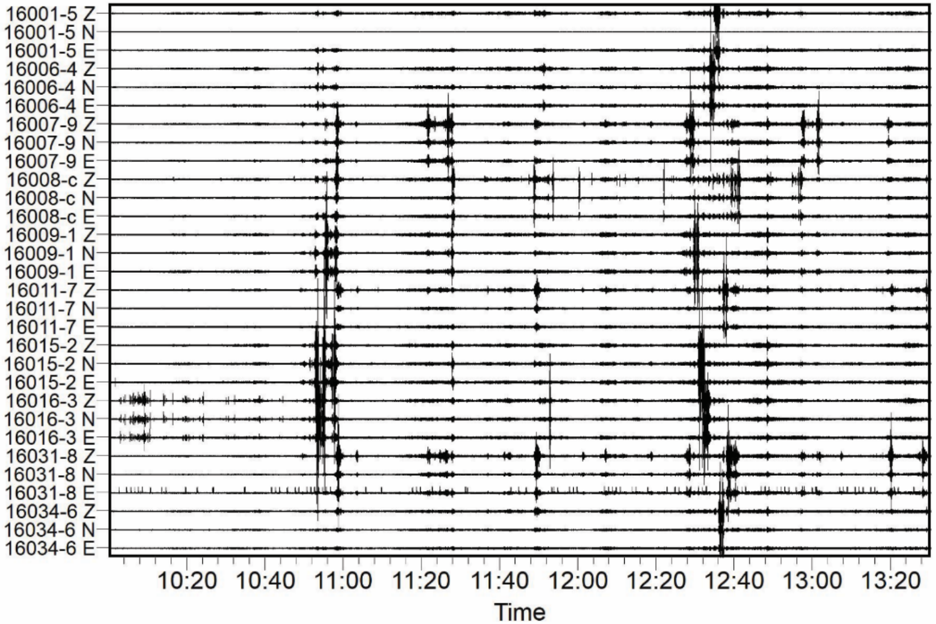
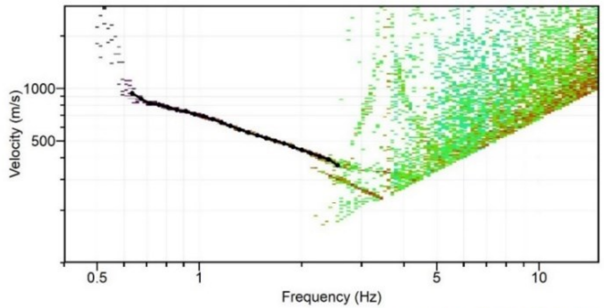
پردازش تک ایستگاهی داده های آرایه

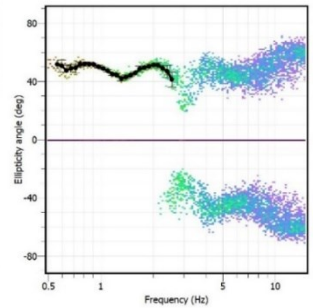


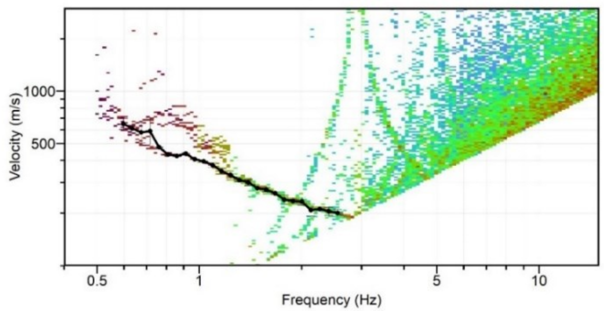


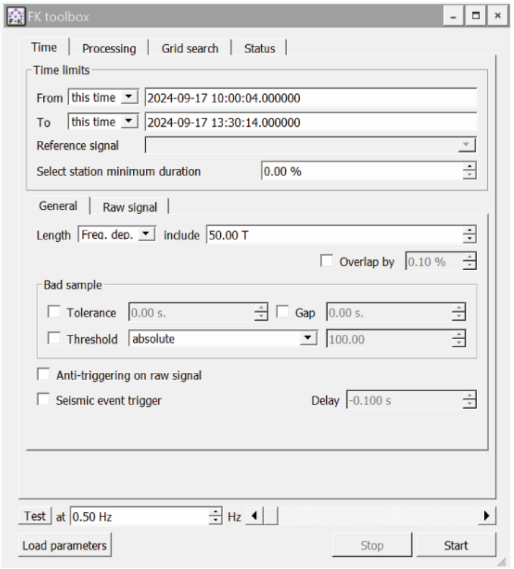
مطالعات آرایه ای

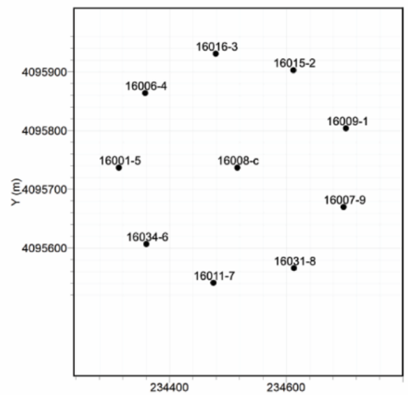




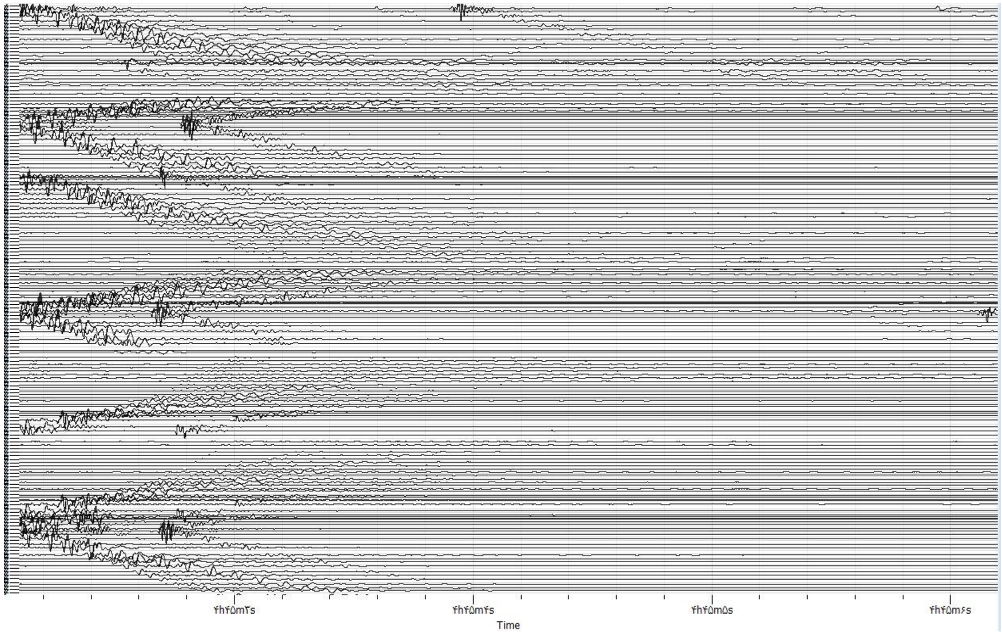


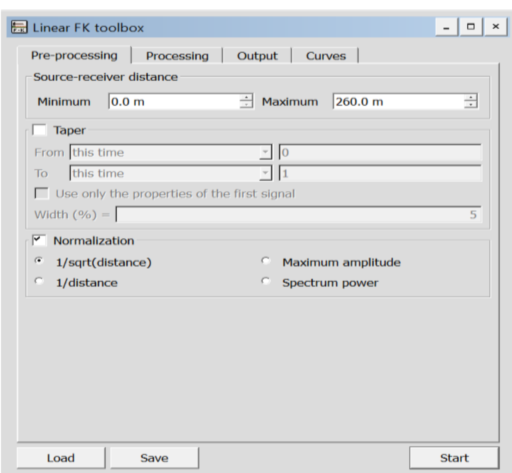


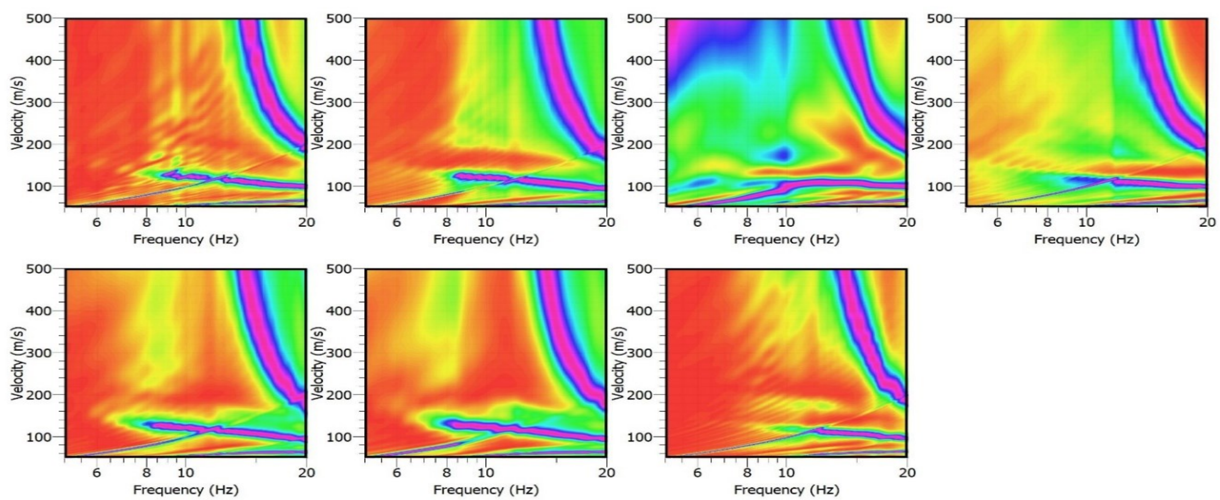




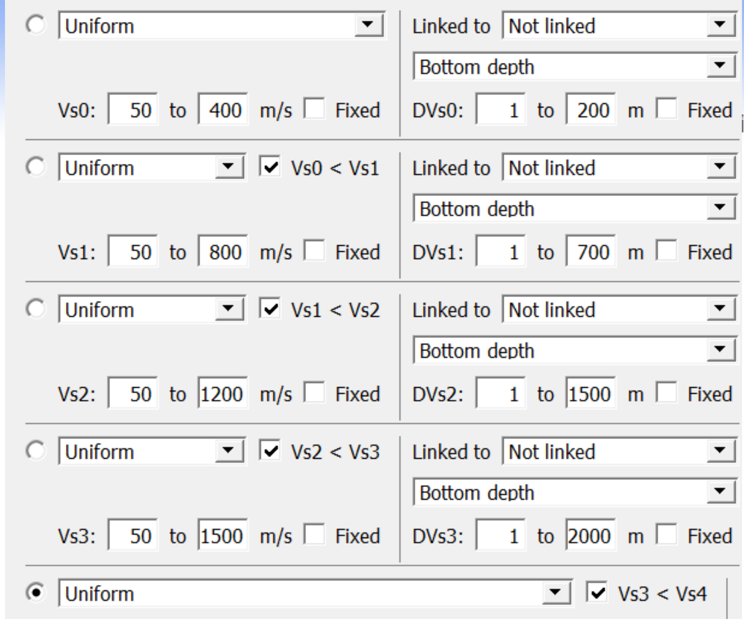
پردازش چند کاناله امواج سطحی با استفاده از برداشت های لرزه ای موسسه ژئوفیزیک

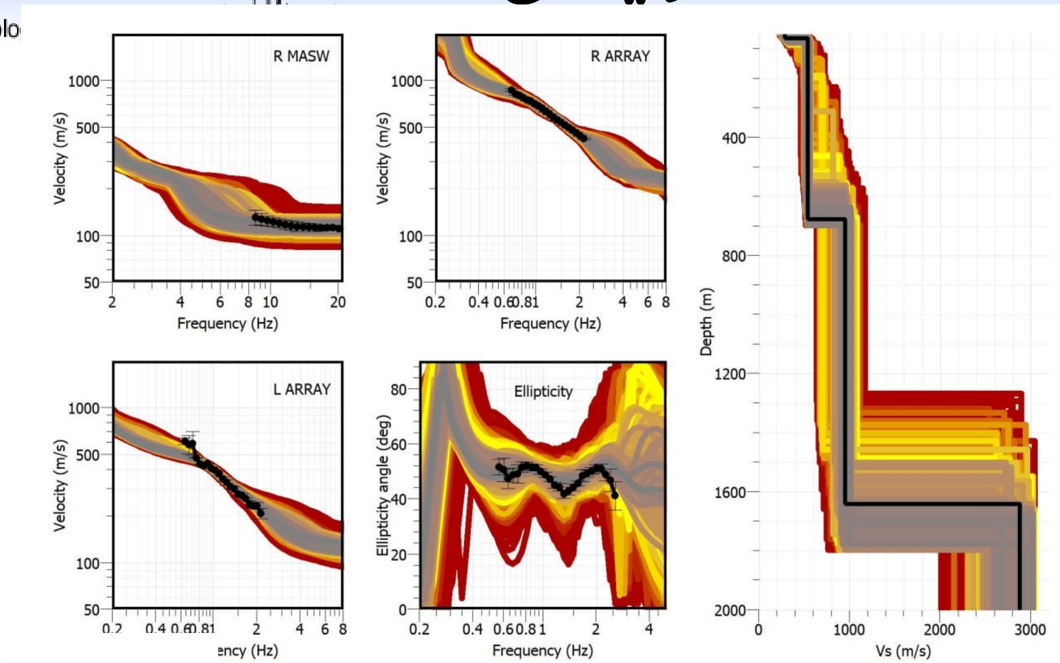


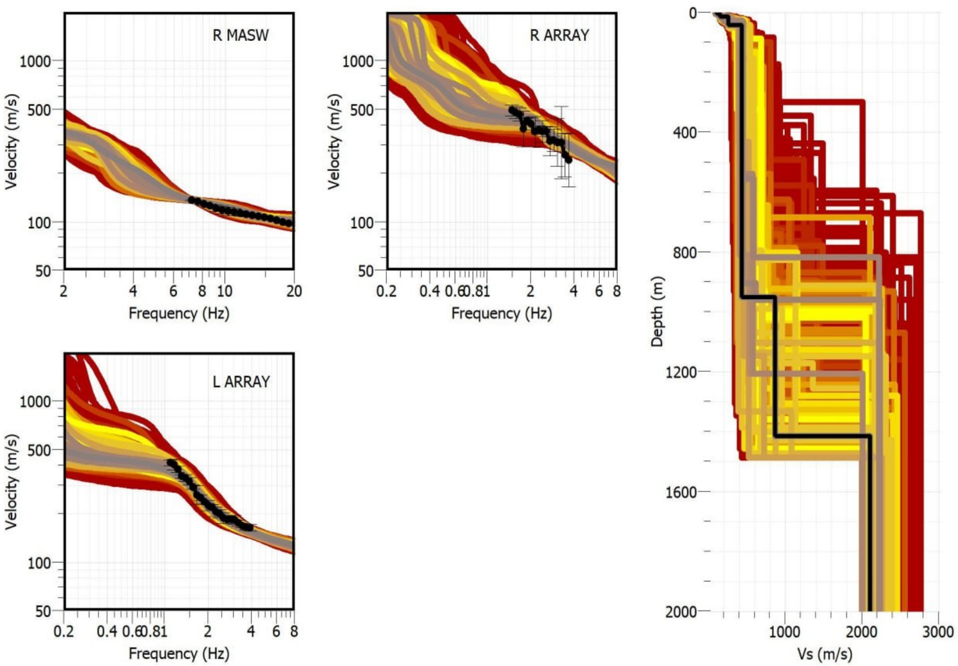




مطالعات آرایه ای

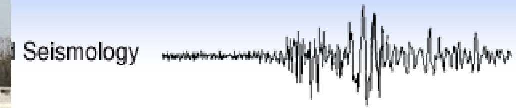






وارون سازی

Geohazards



In future webinar

Thanks for your attention