Site Effects on Amplification of Earthquke in Southwest of Tehran

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ABSTRACT:

This paper presents the results of site effect analyzing in southwest of Tehran. The main goal of this study was to develop a simple practical tool to estimate soil dynamic amplification factors to be used for earthquake design of structures with different natural periods in the region. Totally, 75 geotechnical profiles in the region were collected from different private and governmental sources. Earthquake response analyses of these profiles were conducted by SHAKE91 using 18 worldwide strong ground motions. For each profile 18 amplification spectra were calculated. The amplification spectra of all profiles were then averaged and mean amplification spectrum of the site was derived. The amplification spectrum of the site was smoothed and a simple practical amplification spectrum was recommended for southwest of Tehran. In order to obtain design spectrum of the site, acceleration response spectra of all records were averaged, multiplied to the recommended amplification response spectrum, and smoothed. The design spectrum of the site was compared with standard design spectrum of Iranian Building Code and modification remarks were suggested.
Keywords: Tehran, Amplification, Design Spectrum, Earthquake, Site Effect.

1. INTRODUCTION

Tehran as capital city of Iran is located in a region with many active faults. High vulnerability of Tehran structures needs more precise seismic hazard study of the area. The role of site effects into seismic hazard study was recently became an attractive topic for engineers. In this paper, the local site effect in southwest of Tehran was evaluated and a useful simple practical equation was recommended for the region.

2. ASSUMPTION AND METHOD OF ANALYSIS

Soil profiles are assumed to be settled on bedrock horizontally and record motion in earthquake effect just cause soil shear deflection and manner of soil layers side extension don't affect the response. Seed and Idriss (1970) recommended graphs were used for variation of soil damping and shear modules versus shear strain.
Totally 75 geotechnical profiles in the region were collected from private and governmental sources. Among them, in 23 cases the shear wave velocity were not directly reported, therefore correlation between SPT and shear wave velocity of Jafari & et all was used to evaluate the shear wave velocity in different soil layers. SHAKE91 was used for earthquake response analysis of soil layers. Soil layers with a shear wave velocity more than 800m/s were assumed as seismic bedrock.
In this study, 2 horizontal components of 9 world wide earthquake records were selected from NISEE data bank related to Berkeley University.
For compatibility with Tehran site condition, earthquake magnitude of 7 to 7.5, focal depth up to 20km and epicentral distance less than 60km, were the major criteria in earthquake record selection. Specifications of selected earthquake records are presented in Table 1.

Table 1 Selected earthquake records

No	Earthquake	Country	Station	Date	Magnitude	Max acc(g)	Focal depth (km)	Epicenter (km)	component
1	Friuli	Italy	Barcis	1976/9/15	6.5	0.028	5.1	55.6	000
2	Friuli	Italy	Barcis	1976/9/15	6.5	0.029	5.1	55.6	270
3	Imprial	Mexico	Delta	1979/10/15	6.5	0.058	10.0	33.7	262
4	Imprial	Mexico	Delta	1979/10/15	6.5	0.111	10.0	33.7	352
5	Izmir	Turkey	Izmir	1977/12/16	5.3	0.410	5.0	2.3	L
6	Izmir	Turkey	Izmir	1977/12/16	5.3	0.146	5.0	2.3	T
7	Kobe	Japan	Kobe University	1995/1/16	6.9	0.290	17.9	25.4	000
8	Kobe	Japan	Kobe University	1995/1/16	6.9	0.310	17.9	25.4	090
9	Northridge	USA	Downey Birchdale	1994/1/17	6.7	0.164	17.5	50.0	090
10	Northridge	USA	Downey Birchdale	1994/1/17	6.7	0.171	17.5	50.0	180
11	Sanfernando	USA	Fort Tejon	1971/2/9	6.6	0.025	13.0	65.6	000
12	Sanfernando	USA	Fort Tejon	1971/2/9	6.6	0.022	13.0	65.6	090
13	Sanfernando	USA	Cachuma Dam Toe	1978/8/13	5.9	0.072	12.7	34.0	250
14	Sanfernando	USA	Cachuma Dam Toe	1978/8/13	5.9	0.033	12.7	34.0	340
15	Tabas	Iran	Dahook	1978/9/16	7.3	0.327	5.8	20.6	LN
16	Tabas	Iran	Dahook	1978/9/16	7.3	0.406	5.8	20.6	TR
17	Victoria	Mexico	Chihuahua	1980/6/9	6.3	0.149	11.0	36.7	102
18	Victoria	Mexico	Chihuahua	1980/6/9	6.3	0.091	11.0	36.7	192

3. GEOTECHNICAL SPECIFICATIONS

Tehran’s valley is made of river granular that end to Tehran field gradiently. Tehran and its suburbs are constructed on young alluvium. These alluviums are obtained from rivers and season floods flow running from Alborz mountain. One of the most reliefest of Tehran soil specifications is gradual reducing of seed size from north and northwest to south and southwest.

Complementary microzonation studies for north of Tehran specified that Tehran’s central areas have a sediment up to 300 meter deep which concealed with sand and gravel. The size of these gravel sometimes grow up to 40cm.

These sand and gravel sediments change to silt and clay layers in southern parts of Tehran. A study on soil condition in southwest of Tehran showed that there is a weak layer with low SPT up to 5m in depth.

4. GEOTECHNICAL PROFILES

For analyzing site effect in zone study, 75 geotechnical profiles in southwest of Tehran are selected. The zone study is limited between Azadi street from North, Kan river from west, Valiasr street and Shaheed Tondguyan highway from East, and Behesht Zahra and Shahr Ray from South. Map of zone study and geotechnical profiles situation can be seen in Figure 1.
Among 75 selected profiles 42 profiles were collected from Seismic geotechnical microzonation of southwest of Tehran, 10 profiles from complementary microzonation studies for south of Tehran, 3 profiles from central fire department of Tehran geotechnical report, 15 profiles from Tehran's cement factory geotechnical report and 5 profiles from south Tehran's refinery geotechnical report.

5. ANALYSIS RESULTS

All geotechnical profiles shown in Figure 1 are subjected to 18 selected earthquake records. For each profile 18 amplification spectra were calculated and graphed.

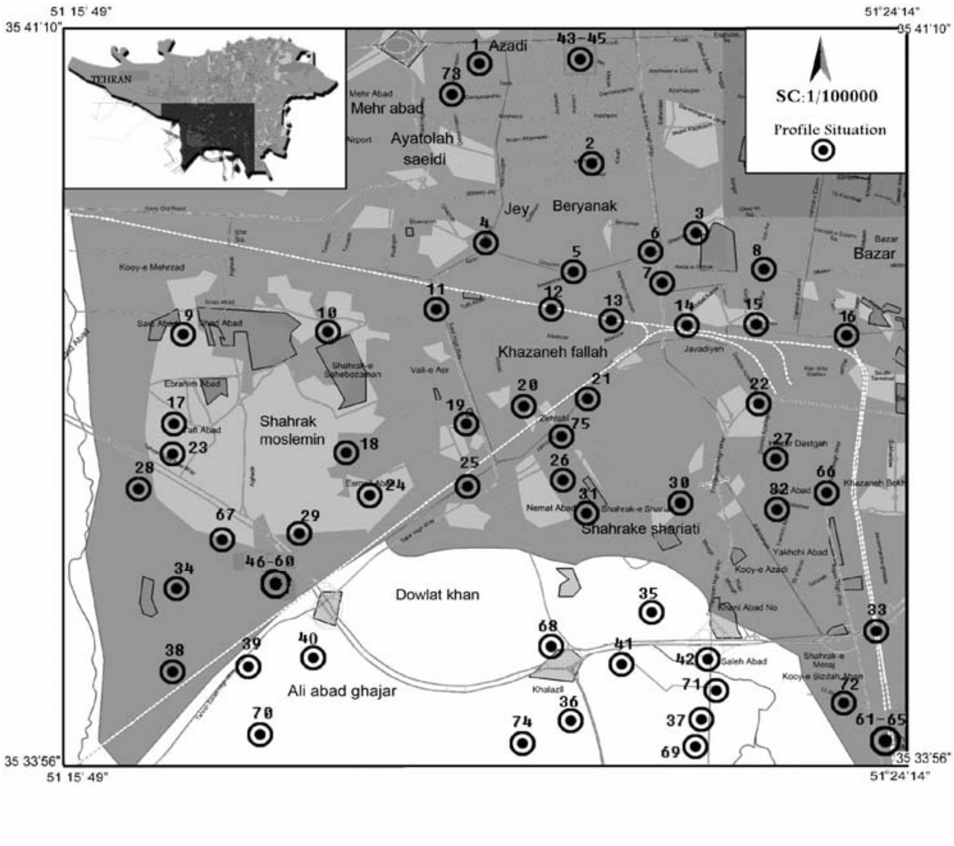


Figure 1 Zone of case study and selected profiles situation

As a sample, these 18 amplification spectra for profile No. 10 are presented in Figure 2. All of these 18 amplification spectra of profile No.10 were then assembled into a unique graph to show the discrepancy of results (Figure 3). Mean value of 18 spectra were calculated and graphed in same Figure.

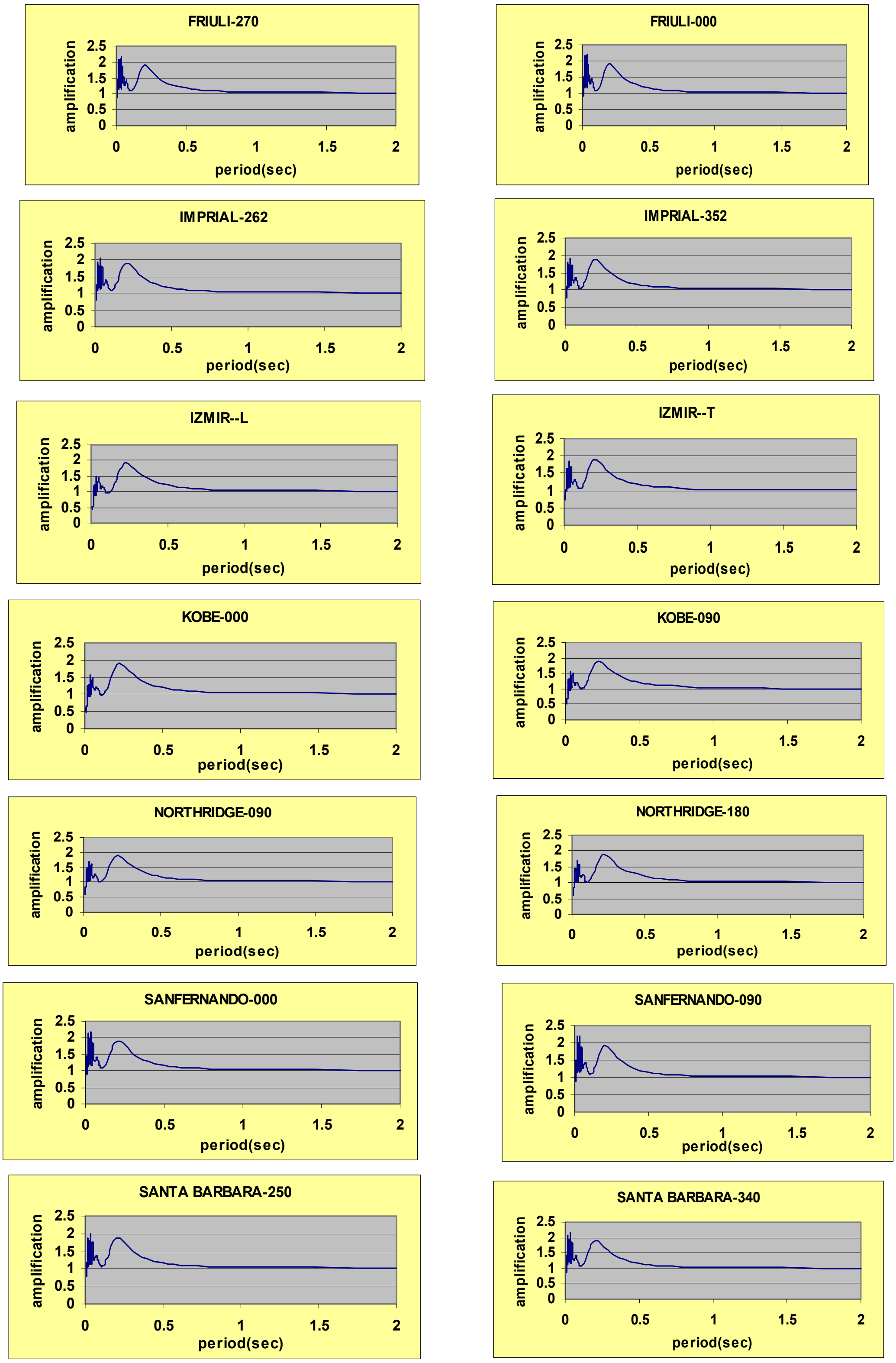
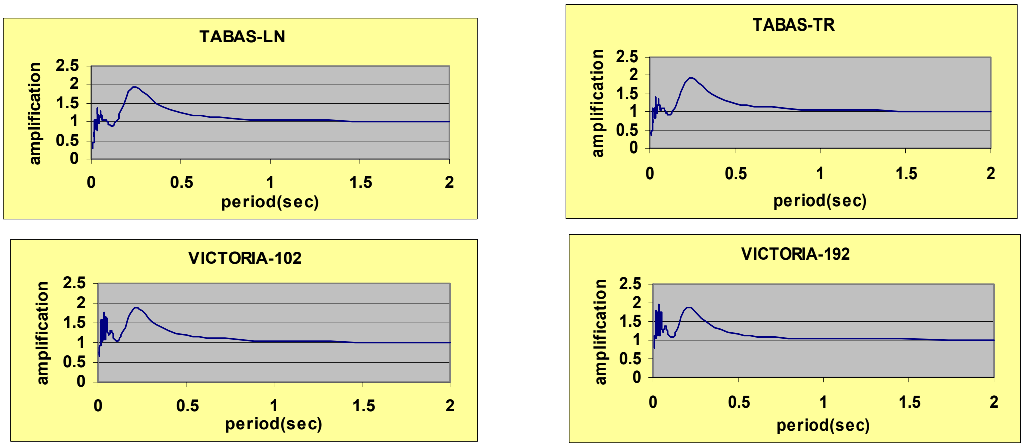


Figure 2 Amplification spectra of Profile No.10



Continue of Figure2

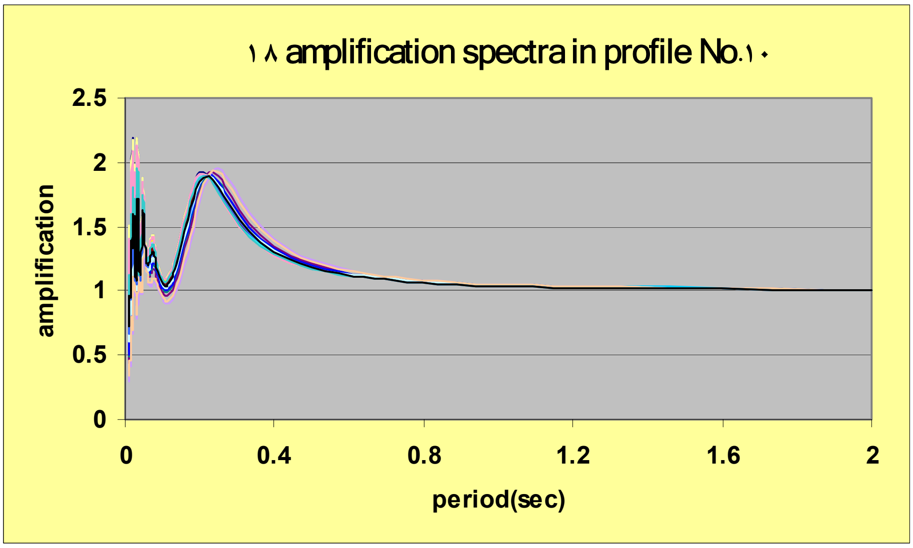


Figure 3 Amplification spectra in Profile No.10

Results of amplification spectra of all 75 geotechnical profiles including mean value for each profile are calculated and graphed..

5-1-MEAN AMPLIFICATION SPECTRUM

To obtain amplification spectrum in southwest of Tehran, all 75 mean amplification spectra were assembled together in Figure 4. The assembled spectra were averaged and mean amplification spectrum were finally derived and graphed in Figure 4.
Figure 5 illustrates the derived mean amplification spectrum for south west of Tehran.

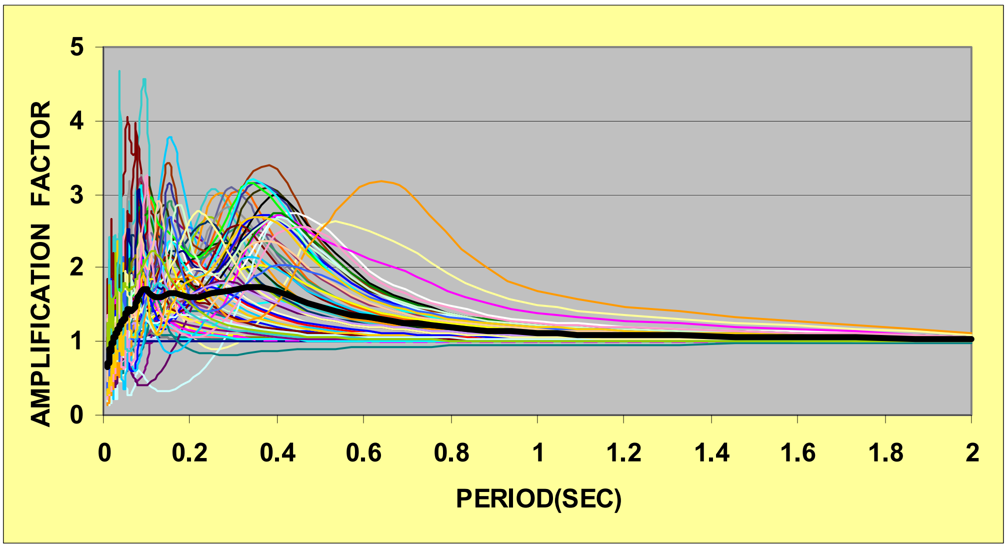


Figure 4 Collection result spectrums in each profile together

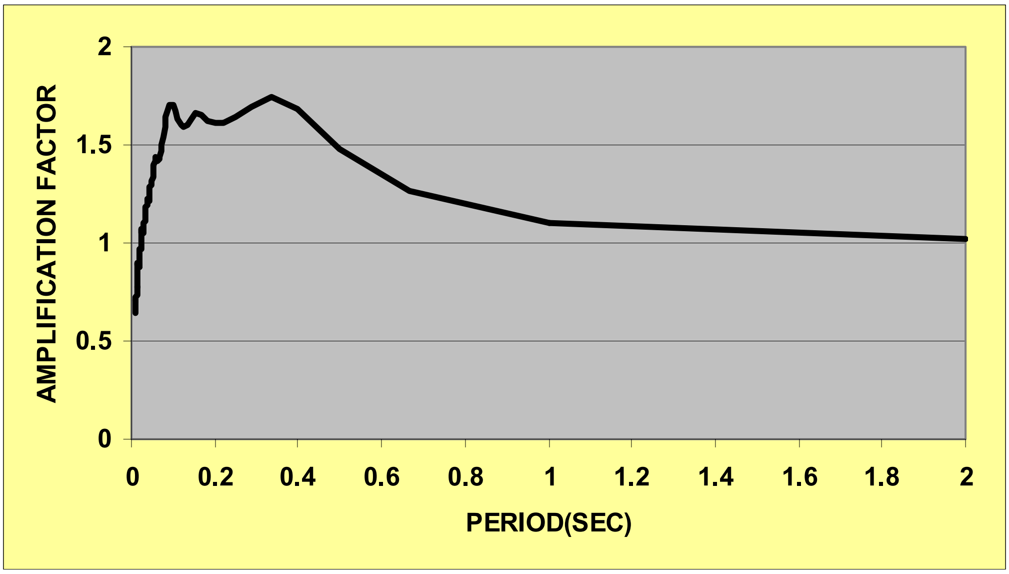


Figure 5 Mean amplification spectrum for southwest of Tehran

In order to obtain a simple practical amplification spectrum of the site, the spectrum was smoothed in Figure 6 and amplification equations were fitted and presented as a practical tools for designers (Eqn.1),

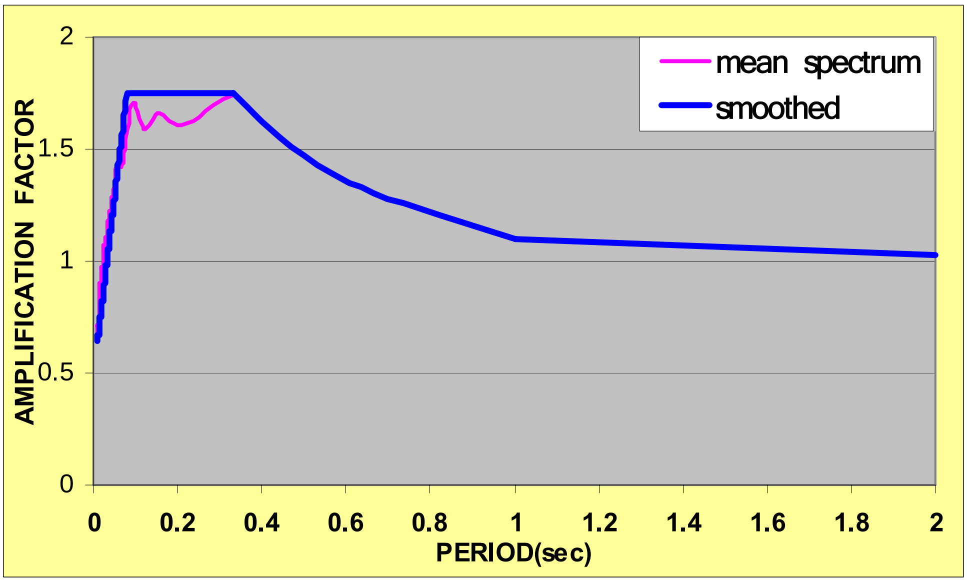


Figure 6 Smoothed mean spectrum

$$
\begin{aligned}
&A = 16T + 0.481 && T < 0.08 \text{ sec} \\
&A = 1.75 && 0.08 < T < 0.33 \text{ sec} \qquad (1)\\
&A = 1.1T^{-0.425} && 0.33 < T < 1 \text{ sec} \\
&A = -0.0787T + 1.18 && 1 < T < 2 \text{ sec}
\end{aligned}
$$

In which A is amplification factor and T is natural period.

5-2-MEAN+σ AMPLIFICATION SPECTRUM

To consider discrepancy of results the amplification spectrum for mean value plus one standard deviation were calculated and presented in Figure 7. The mean+σ amplification spectrum was smoothed in Figure 8 and amplification equations were plotted in same Figure and formulized in Eqn.2.

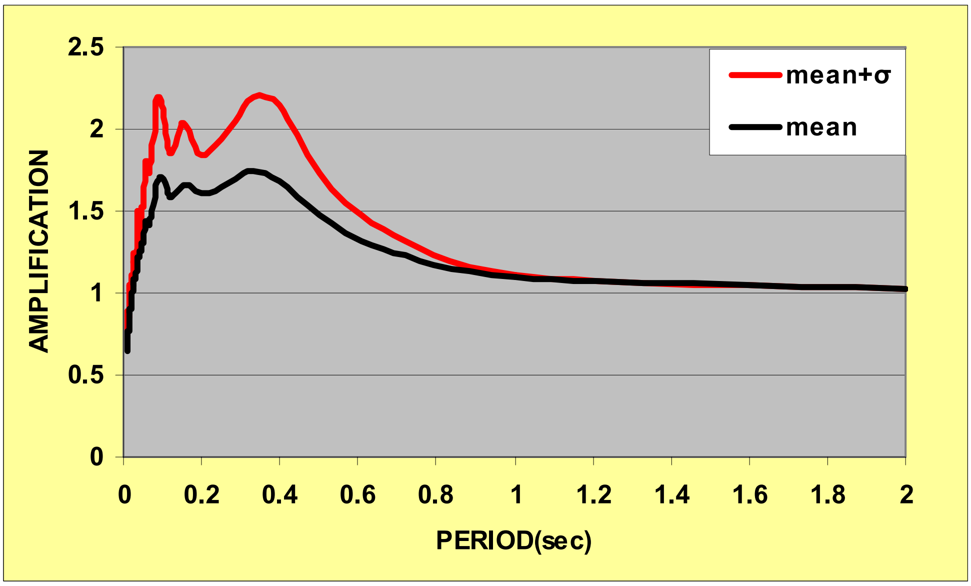


Figure 7 Mean+σ amplification spectrum

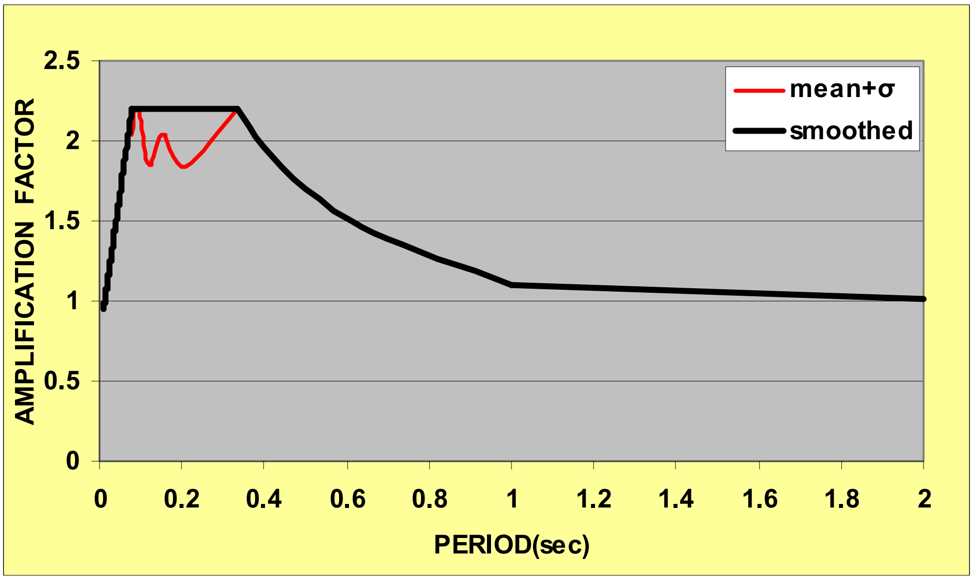


Figure 8 Smoothed mean+σ spectrum

$$
\begin{array}{ll}
A = 17.96T + 0.77 & T < 0.08 \text{ sec} \\
A = 2.20 & 0.08 < T < 0.33 \text{ sec} \\
A = 1.14T^{-0.63} & 0.33 < T < 1 \text{ sec} \\
A = -0.0924T + 1.27 & 1 < T < 2 \text{ sec}
\end{array}
\qquad (2)
$$

In which A is amplification factor and T is natural period.

Recommended mean and mean+σ amplification spectrum for southwest of Tehran is presented in Figure 9.

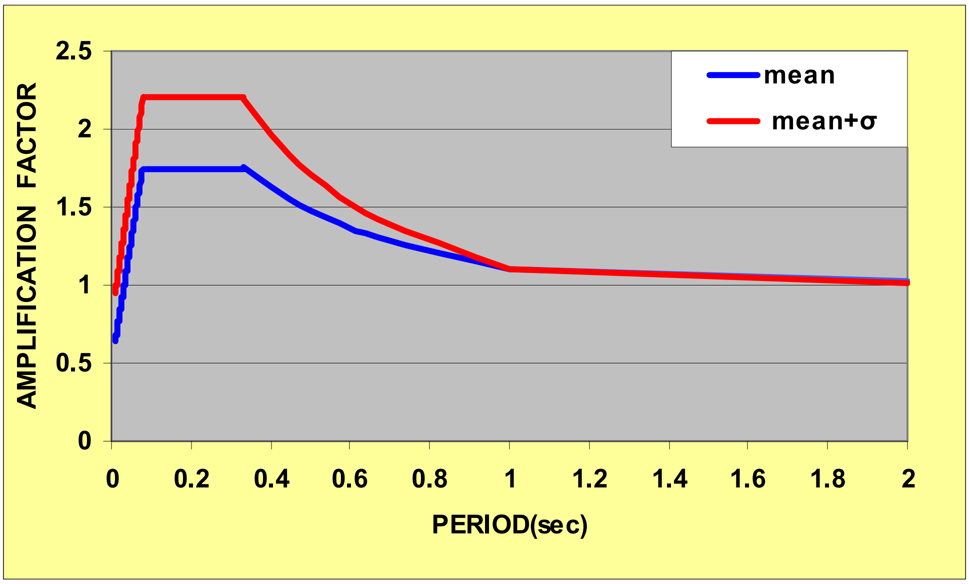


Figure 9 Mean and mean+σ amplification spectra of the site

6-CONCLUSION

Based on earthquake response analyses of 75 geotechnical profiles in southwest of Tehran, the following simple practical equation was suggested to evaluate the soil dynamic amplification design spectrum:

$$
\begin{array}{ll}
A = 16T + 0.481 & T < 0.08 \text{ sec} \\
A = 1.75 & 0.08 < T < 0.33 \text{ sec} \\
A = 1.1T^{-0.425} & 0.33 < T < 1 \text{ sec} \\
A = -0.0787T + 1.18 & 1 < T < 2 \text{ sec}
\end{array}
$$

In which A is amplification factor and T is natural period.
It is recommended to use such simple practical equations to separate the influence of soil and structures in earthquake design spectra of codes. This can help us to apply the site effects more precisely in seismic design of structures.

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