4th International Conference on
Earthquake Geotechnical Engineering
June 25-28, 2007
Paper No. 1351

COMPARISON OF ONE AND TWO DIMENSIONAL SITE RESPONSE ANALYSIS RESULTS FOR KUCUKCEKMECE REGION IN ISTANBUL

Cevat ALIM[1], Havvanur KILIC[2], Kutay OZAYDIN[3], Pelin TOHUMCU OZENER[4],

Mustafa YILDIRIM[5]

ABSTRACT

In this study, the dynamic behavior of the approximately 140m thick soil deposits at Kucukcekmece district in Istanbul during a major earthquake expected to affect Marmara region in Turkey are evaluated employing one and two dimensional site response analyses. The findings of a previous study carried out in the region for the assessment of suitability for settlement are utilized in the site response analysis. Six typical geological sections in EW direction starting from the Marmara Sea shoreline and extending towards north are considered in the analysis to study the variation of expected ground surface motions during the probable earthquake. The results of site response analyses performed are used to determine the variation of peak accelerations and spectral accelerations at the ground surface in the study area and effects of topographical and geological conditions are examined comparing the results of one and two dimensional analysis. It is shown that topographical effects can play a significant role in the site response during earthquakes.

Keywords: site response, one and two dimensional analyses, viscous damping

INTRODUCTION

The importance of local geology and site effects on destructive earthquake ground motions is largely recognized in geotechnical earthquake engineering. The local site conditions which include the topography, ground water level and subsurface soil characteristics are important factors modifying the strong ground motions and influencing features of the damage caused by earthquakes. In order to be able to evaluate the effects of local site conditions on the earthquake ground motion, one dimensional equivalent site response analysis is a widely used method in geotechnical earthquake engineering practice. However, experience have shown that one dimensional site response analysis cannot explain the recorded earthquake motions in the existence of complex site conditions, and it is considered acceptable only for horizontally or nearly horizontally stratified soil profiles. By contrast, two-dimensional analyses are reasonably more successful in predicting the surface ground motions, showing the necessity for site response analyses that can take into account the geomorphologic and topographical conditions, especially in valleys where the bedrock depth exceeds 1/5 to 1/10 of valley width.

In this study, the effects of local site conditions on the ground surface motions during earthquakes are investigated through 1D and 2D analysis and the results are compared with each other. The viscous damping parameters which are employed in 2D analysis are determined by two different methods, and

[1] General Directorate of Highways, Email: alimcevat@mynet.com
[2] Faculty of Civil Engineering, Yildiz Technical University, Email:kilic@yildiz.edu.tr
[3] Faculty of Civil Engineering, Yildiz Technical University, Email:ozaydin@yildiz.edu.tr
[4] Faculty of Civil Engineering, Yildiz Technical University, Email:tohumcu@yildiz.edu.tr
[5] Faculty of Civil Engineering, Yildiz Technical University, Email:yildir@yildiz.edu.tr

the effects of parameter variation on the results of analysis are investigated. One dimensional analyses are performed by the computer program EERA which is based on equivalent linear analysis approach and two dimensional dynamic analyses are performed by dynamic version of finite element program PLAXIS.

EERA uses a closed form solution of 1-D wave equation in the frequency domain to calculate the dynamic response of a layered system and models damping as frequency independent; wheras PLAXIS V7.2 uses Rayleigh damping, which formulates the viscous damping matrix as a linear combination of the mass (M) and stiffness (K) matrices in eq. (1).

$$C = \alpha M + \beta K \quad (1)$$

Since Rayleigh damping results in a damping ratio that is different for each of the natural frequencies of the system (Chopra, 1995), in two dimensional analyses two different approaches are adopted for computing the mode of vibration of the soil profile. In the first approach, the equivalent shear wave velocities and average soil layer thicknesses are used to compute the natural frequency at the first mode using the relationship $T= 4H/V_s$, which in turn is converted to angular frequency. The natural frequency corresponding to the second mode of vibration is taken to be 10 Hz, based on the assumption that soil behavior is mostly governed by frequencies up to 10 Hz (Rathje and Bray 2001). Thus the damping coefficients are computed by taking into consideration the soil behavior between the frequencies corresponding to first natural frequency and 10 Hz. However, the topographical features are not taken into account in this manner of calculation. As a second approach, the finite element program LUSAS is used to determine the natural frequencies corresponding to first ten modes of vibration for each section modelling the topographical and geotechnical characteristics of the study area. Then, using the first two natural frequencies, viscous damping coefficients (α and β) are computed.

The 17 August 1999 earthquake, which was caused by the rupture of a 110-km segment in the western extension of the North Anatolian Fault Zone (NAFZ), resulted in damage in some districts of Istanbul, especially in Avcilar, Kucukcekmece, Bagcilar and Bakirkoy. The NAFZ is forked to the west of the bay of Izmit, the northern branch being the major seismic source for Istanbul. A strong movement along this segment would result in a major earthquake to hit the areas along the north coast of the Marmara Sea. Kucukcekmece district is situated at about 12 km north of the active right-lateral fault segment and are in the 1st (most active) seismic zone. In this study, earthquake time histories at bedrock level are determined from the probabilistic seismic hazard analysis based on the seismicity of the region. The detailed information about the tectonical and geological features, seismicity and seismic hazard analysis of the study area are given in Ozaydin et al. (2002), Ozener Tohumcu, et al. (2005) and Kılıc et al. (2005).

GEOTECHNICAL SURVEYS AND THE GEOLOGY OF THE REGION

In order investigate the suitability for settlement of Kucukcekmece region, a total area of 13.43 km^2 was investigated through geological and geotechnical studies undertaken in the study area (Ozaydin et al., 2002). Besides the boreholes drilled within the framework of this study for determination of the soil profile and geologic structure of the site, the soil exploration borings and PS logging tests carried out for the study on a “disaster preventation/mitigation basic plan in Istanbul including seismic microzonation” by Japan International Coorparation Agency (JICA) and Istanbul Metropolitan Municipality (IMM) (2001) are also utilized. In order to determine the geotechnical features of the site, several geophysical explorations, microtremor measurements and Standart Penetration Tests (SPT) were executed, laboratory tests were carried out and geological maps of the area at 1:5000 and 1:1000 scales were prepared. The geological map of the study area (Yildirim ve Savaskan, 2002) is shown in Figure 1 together with the locations of geological sections. The formations outcropping in the area start with the lithologies belonging to Middle Eocene Kirklareli formation. This formation rests unconformably on the “graywacke” sequences of Trakya formation (Carboniferous) and is composed of limestone and argillaceous limestone. Kirklareli formation is overlain by younger deposits of Upper Oligocene–Upper Miocene, which are quite widespread in the area. These start with sand and gravel, gray–cream in color, and continue upward uninterruptedly with green, thinly to medium bedded, horizontal to slightly dipping, overconsolidated clay, and interbedded clay and sand layers (Yildirim and Savaskan, 2002 and 2003). In the upper levels (Upper Miocene) of the sequence, granular lenses, and organic, soft to medium stiff clay lenses respectively named Cukurcesme and Gungoren formations are encountered. The uppermost level of the deposition, called Bakirkoy formation, is characterized by mactra-bearing, argillaceous limestone interbedded with clay and fine sand.

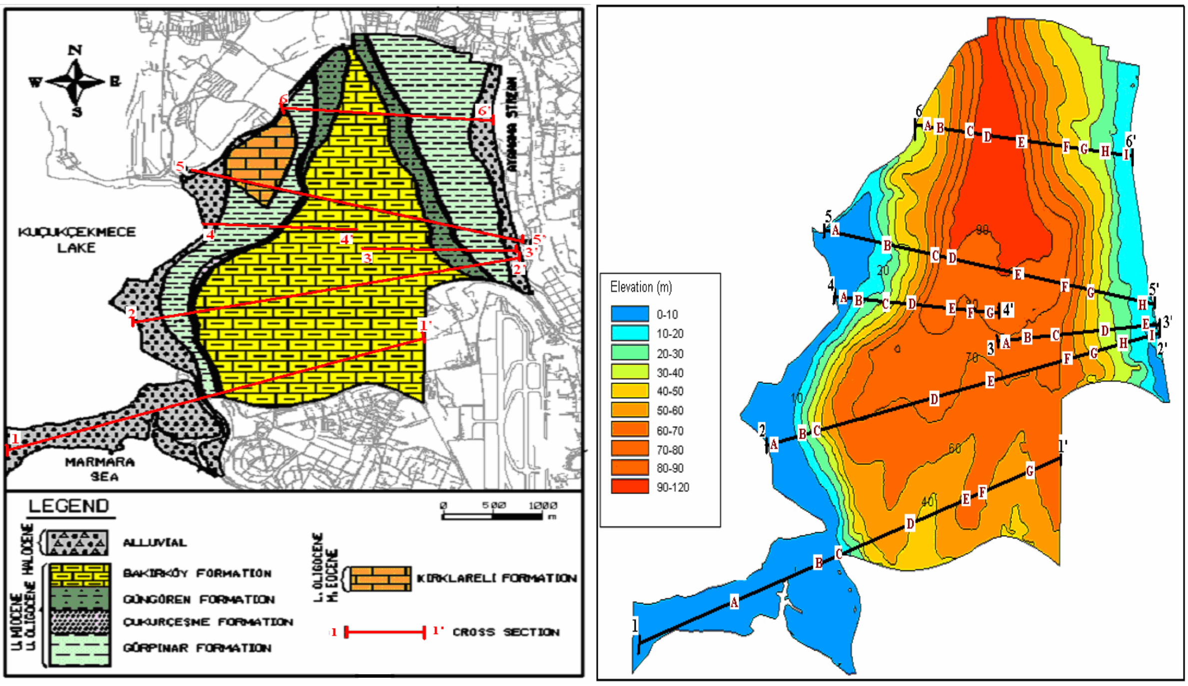

Figure 1. The geology map of the region and the location of the points where 1D and 2D dynamic site response analysis are carried out (Yildirim and Savaskan, 2002)

In Kucukcekmece region, which has a topography modestly sloping towards the south, Kirklareli limestone dips towards the Marmara Sea and the thickness of the younger lithologies consisting of clay, sand and marl overlying it increases to 200 m near the southern boundary of the study area. In other words, while in the northern parts the bedrock is encountered in the depth range of 0 – 20 m this depth is in the range of 180 – 200 m in the southern part, despite the relatively small difference in elevation. Surface water infiltrating to the ground at higher elevations finds its way out on the east and west slopes through the horizontal sand layers in the form of small springs. These layers cannot be considered as true aquifers. The groundwater level lies in the alluvial deposits near the sea level to the west of the area, as well as in the porous limestone layers of Kirklareli formation. On the west slope, towards Lake Kuçukcekmece, the overconsolidated clay (Gurpinar formation) is sometimes encountered in the form of weak claystone, and may therefore form relatively steep slopes. On the contrary, the clay layers encountered on the east slope as well as in the Ayamama streambed forming the eastern boundary of the study area sometimes display high organic content. The alluvial deposits of the Ayamama stream hardly exceed 10m in thickness and are mostly composed of silty clay. The coastal alluvium of Lake Kucukcekmece on the west, however, may reach 30m in thickness and is characterized by high sand and gravel content.

Material properties used in the analysis

The variation of soil parameters which were determined through the soil investigations undertaken in the area and the laboratory tests carried out on the samples recovered from the site are summarized in Ozaydin et al. (2002), and Kilic et al. (2005). The nature of the fill and alluvial deposits appear to change locally. While the fill and alluvial soils near Kucukcekmece Lake on the West are classified as

GM-GC and SM-SC, the fill and alluvial deposits near Ayamama River on the East are classified as CL.

The shear wave velocity (V_s) plays the most important role for the construction of adequate and accurate 1D and 2D profiles for seismic ground response analysis. The shear wave velocities used in the 1D and 2D analyses are determined from PS-Logging tests performed in the study area and empirical relationships related with SPT-N values. The variation of average shear wave velocities with respect to the elevations encountered for Bakirkoy limestone, Gurpinar clay and Gurpinar sand are given in Table 1.

Table 1. The variation of average shear wave velocities determined from PS Logging tests

Bakirkoy Formation*		**Gurpinar Formation***		**Gurpinar Formation+**	
Elevation (m)	Vs (m/s)	Elevation (m)	Vs (m/s)	Elevation (m)	Vs (m/s)
+115.0 - +90.0	350	+100.0 - +25.0	270	+100.0 - +75.0	300
+70.0 - +50.0	450	+25.0 - -25.0	400	+40.0 - -10.0	400
+50.0 - +0.0	350	-25.0 - -55.0	340	-10.0 - -35.0	240
-	-	-55.0 - -80.0	410	-35.0 - -70.0	300
-	-	-80.0 - -100.0	520	-70.0 - -100.0	520

*Clay levels + Sandy levels

For the formations where PS logging measurements are not available, the shear wave velocities are computed from the empirical relationship of İyisan (1996).

$$V_S = 51.5 \times N^{0.516} \quad (2)$$

where, N is the SPT-N blow count number. The SPT-N values for different formations are given in Table 2.

Table 2. SPT-N values for various formations in the research area

Soil Description	SPT N Blow counts
Alluvial Deposit	10-40
Fill	6-27
Bakirkoy Formation*	In the upper 5m 22-28 after>30
Gungoren Formation	At near surface12-20, at deeper >22
Gurpinar Formation^1	13-18
Gurpinar Formation^2	22-28
Gurpinar Formation^3	>Refusal
Gurpinar Formation^4	Refusal
Kirklareli Formation*	>26
Çukurcesme Formation	Refusal

*Clay levels ^{1}(4.0 -7.50 m depth) ^{2}(7.50 -10.50 m depth) ^{3}(>10.50 m) ^{4}(gravel levels)

In the 2D analyses, the location of the faults, the ground water table, the geological interpretation of sections, the physical, mechanical and dynamic properties of soils were taken into account. The material parameters used for various formations in 1D and 2D analysis are outlined in Table 3. Here, γ_d, is the dry unit weight, γ_{sat} is saturated unit weight, c is cohesion, ϕ is the internal friction angle, E is Elasticity modulus and ν is the Poisson's ratio. The parameters which are shown with the suffix (*) are only used in the 2D analysis performed with PLAXIS.

Table 3. Material parameters used in the analysis

Formation	$\gamma_{d,}$ kN/m^3	γ_{sat} kN/m^3	c* kN/m^2	ϕ* (^{o})	Vs m/s	E* kN/m^2	ν*
Fill	14.3	19	1	20	150-270	287200	0.35
Alluvial Deposit [1]	13.3	18	1	25	175-200	112200	0.30
Alluvial Deposit [2]	12.5	17	1	14	150-195	124300	0.35
Gungoren Formation	14.2	19	1	19	180-270	285200	0.35
Cukurcesme Formation	16.0	20	1	30	400-500	679100	0.30
Gurpinar Formation	16.0	20	2	24	190-500	705200	0.35
Gurpinar Base Levels	14.0	21	1	35	450-550	752200	0.30
Kirklareli Formation	20.0	26	-	-	700-1500	2400000	0.20
Bakirkoy Formation	22.5	24	-	-	350-520	674900	0.20
Gurpinar Sand	16.0	21	1	30	250-520	265300	0.30

(*) Parameters used in Plaxis, [1](near Kucukcekmece Lake), [2](near Ayamama river)

During the analysis, the shear wave velocities at the corresponding elevations are chosen with respect to the values given in Table 2 and Table 3. Eosen limestone is considered to be the bedrock with shear wave velocity of V_s=700 m/s.

Determination of Rayleigh damping coefficients using natural period of the soil (first method)

In the first approach, each of the geological cross sections to be analysed is divided into segments in the latitudinal direction. The shear wave velocity (V_{si}) of the formations in each segment and formation thicknesses (H_i) are substituted in the following equation (3) and an equivalent shear wave velocity (V_{se}) is determined for each segment.

$$V_{se} = \frac{\sum (H_i \times Vsi)}{\sum H_i} \qquad (3)$$

The segment shear wave velocities (V_{se}) and the average thicknesses (h_i) of the segments were then put in the equation (4) to determine the equivalent shear wave velocity (V_{seq}) for each geological cross section.

$$V_{seq} = \frac{\sum (V_{se}) \cdot h_i}{\sum h_i} \qquad (4)$$

The equivalent shear wave velocity and average soil thickness of the geologicial sections are used to compute the natural frequency at the first mode using the relationship T= 4H/V_s, and converted to angular frequency. This angular frequency is used as the angular frequency at the first mode (ω_i) and the value of 10 Hz is taken to be the natural frequency (ω_j) corresponding to the second mode of vibration (Rathje and Bray 2001). These natural ferquency values and the damping value (ξ) of %5 are put in the following equation (5) to determine the Rayleigh damping coeffcients of α and β. The values of H_{av}, V_{seq}, ω_i, ω_j, α and β values are given in Table 4.

$$\alpha = 2\xi \frac{\omega_i \times \omega_j}{\omega_i + \omega_j} \qquad \beta = 2\xi \frac{1}{\omega_i + \omega_j} \qquad (5)$$

Table 4. Viscous damping coefficients determined from natural period of soil layers

Section	$V_{s\,eq}$ m/s	H_{av} m	Period s	1st Natural Frequency Hz	ω_i rad/s	2nd Natural Frequency Hz	ω_j rad/s	Rayleigh α	Rayleigh β
1-1'	468	235	2.00	0.50	3.14	10	62.8	0.29	0.0015
2-2'	463	190	1.64	0.61	3.83	10	62.8	0.36	0.0015
3-3'	460	90	0.78	1.28	8.05	10	62.8	0.71	0.0014
4-4'	457	100	0.87	1.15	7.22	10	62.8	0.64	0.0014
5-5'	560	140	1.00	1.00	6.28	10	62.8	0.57	0.0014
6-6'	582	105	0.72	1.38	8.67	10	62.8	0.76	0.0014

Determination of Rayleigh damping coefficients from finite element analysis (second method)

In the second approach, viscous damping coefficients are obtained from the angular frequencies determined from the modal analysis performed with LUSAS. For this purpose, each geological cross section is modelled by LUSAS finite element program by taking into consideration the topographical features and stratigraphic sequence. The first two frequency values determined from LUSAS are converted to angular frequencies and the viscous damping coefficients are computed with the aid of equation (5) by assuming a damping value of %5. The natural frequncies determined from modal analysis corresponding to the first two modes, periods, angular frequencies and viscous damping coefficients are given in Table 5.

Table 5. Viscous damping coefficients determined from modal analysis

Section	Mode	Frequency 1/s	Period s	Angular frequency (ω) rad/s	Rayleigh α	Rayleigh β
1-1′	1	0.46783	2.137529	2.939464	0.154	0.0161
1-1′	2	0.515177	1.941080	3.236958		
2-2′	1	0.760043	1.315715	4.775490	0.2464	0.0101
2-2′	2	0.810327	1.234070	5.091434		
3-3′	1	1.12044	0.892507	7.039957	0.3948	0.00623
3-3′	2	1.43057	0.699022	8.988515		
4-4′	1	0.901064	1.109799	5.661555	0.3023	0.00823
4-4′	2	1.03313	0.967932	6.491325		
5-5′	1	1.28811	0.776331	8.093423	0.430	0.00577
5-5′	2	1.46726	0.681542	9.219083		
6-6′	1	1.2911	0.774533	8.112195	0.454	0.00541
6-6′	2	1.64878	0.606509	10.359585		

The comparison of coefficients Rayleigh α and Rayleigh β given in Table 4 and Table 5 shows that, the Rayleigh α values determined from the first method (Table 4) are higher than the values determined from the second method. On the contrary, the Rayleigh β values determined from the second method (Table 5) appears to be higher than the first method. It is believed that the second approach in which influence of topographical features and stratigraphic sequence is better taken into account is more appropriate for the determination of Rayleigh damping coefficients.

EARTHQUAKE INPUT FILE AND SITE RESPONSE ANALYSES

The probabilistic seismic hazard analysis of the investigated region was performed by Bogazici University Kandilli Observatory and Earthquake Research Institute, KOERI, based on the regional seismicity and regional earthquake hazard parameters at bedrock level were determined. The earthquake hazard parameters were then used to produce simulated earthquake time histories at bedrock level by the computer code TARSCTHS. The peak acceleration and peak spectral acceleration values of the simulated earthquake time histories used for the geological cross sections are given in

Table 6. It is observed from Table 6 that the predominant period of all six excitations used in the analysis are the same and therefore it is not considered to be a factor in the calibration of the Rayleigh damping.

Table 6. The peak acceleration and peak spectral acceleration values of the simulated earthquake time histories at each cross section

Section	Predominant Period (s)	Peak Acceleration (g)	Peak Spectral Acceleration (g)
1 – 1'	0.4819	0.453	0.98
2 – 2'	0.4819	0.418	0.91
3 – 3'	0.4819	0.418	0.91
4 – 4'	0.4819	0.370	0.89
5 – 5'	0.4819	0.365	0.87
6 – 6'	0.4819	0.368	0.82

In order to perform 1D site response analyses for the region, total unit weight, layer thickness, shear wave velocity, variation of G/Gmax and damping with strain level are provided as inputs for each soil layer in the soil profiles. For clay type soils the G/Gmax and damping curves proposed by Vucetic and Dobry (1991) which takes the effect of plasticity into consideration, and for alluvial sites as well as for Cukurcesme and Gurpinar sandy deposits, the curves of Seed and Idriss (1970) and Idriss (1990) are utilized. For Bakirkoy formation, the curves recommended in EERA as Attenuation of Rock average and Damping in Rock are used. The geological cross sections of 2-2′, 6-6′ and the points where the results of 1D and 2D site response analyses were evaluated are shown in Figure 2 and Figure 3, respectively. Because dynamic analysis with PLAXIS encounters problems in the assignment of earthquake boundaries at the bedrock level, the horizontal bottom of the mesh is considered as a reference horizontal bedrock surface in 2D analysis. The same reference bedrock level is also adopted in 1D analysis. The shear wave velocity of the bedrock is taken to be 700 m/s in 1D analysis and the results are referred to as EERA.

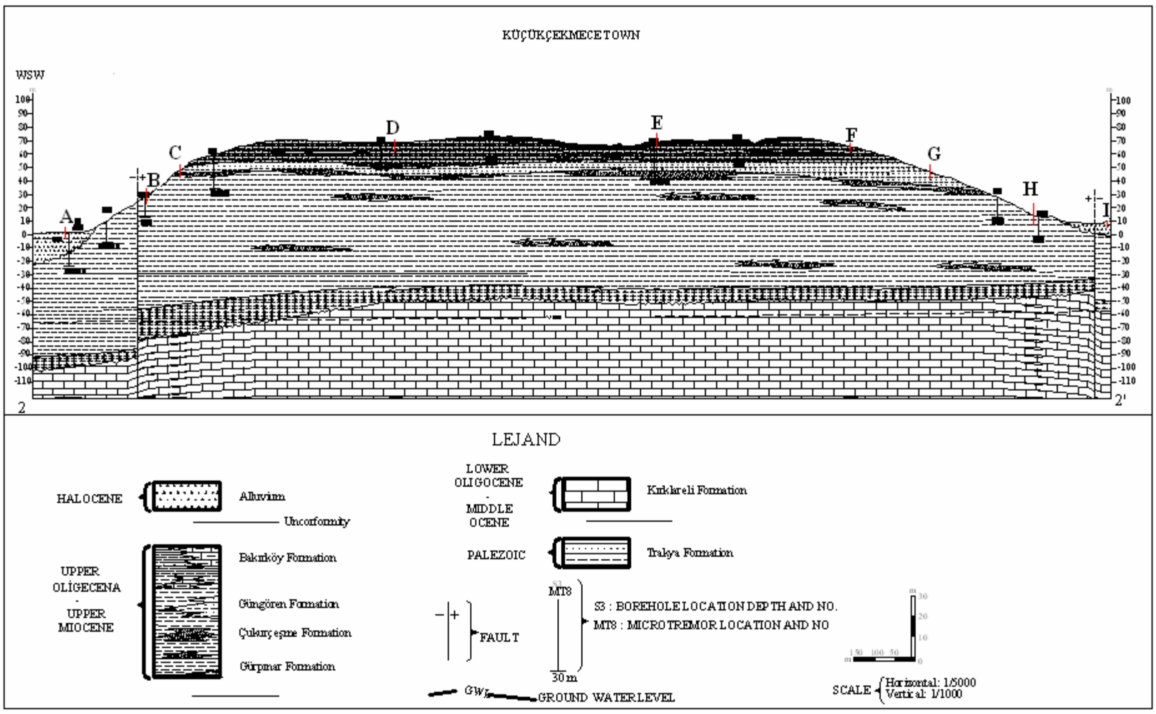

Figure 2. The location of the points on 2-2′ cross section where 1D and 2D analysis is performed

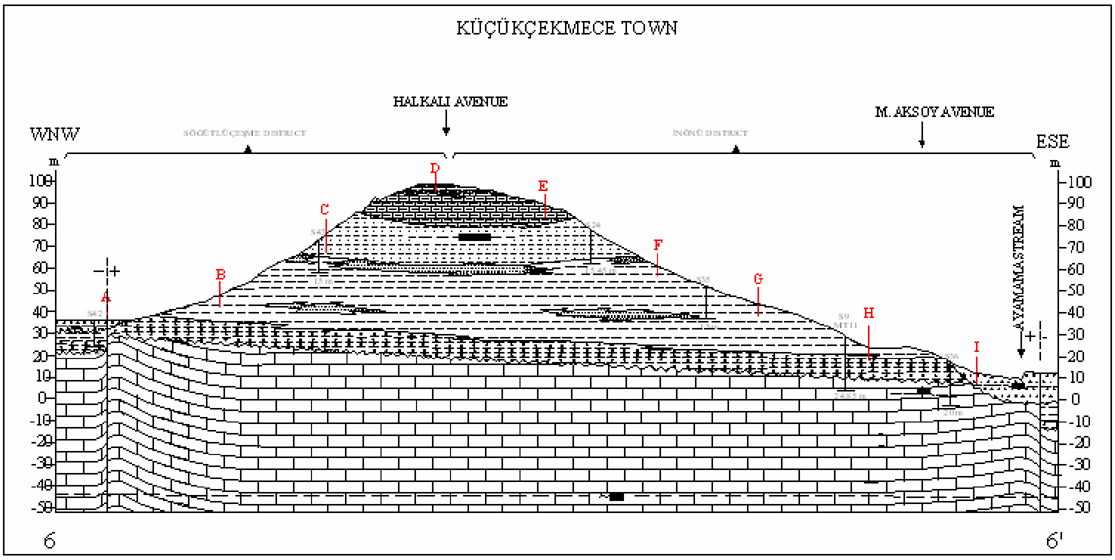

Figure 3. The location of the points on 6-6′ cross section where 1D and 2D analysis is performed

The 1D and 2D dynamic site response analysis are performed at 45 points to determine the variation of peak ground accelerations (PGA) and peak spectral accelerations (PSA) at the ground surface in the region. In order to demonstrate the 2D effects related to site topography, the variations of PGA and PSA along the topographic sections 2-2′ and 6-6′are shown in Figure 4 and Figure 5, respectively.

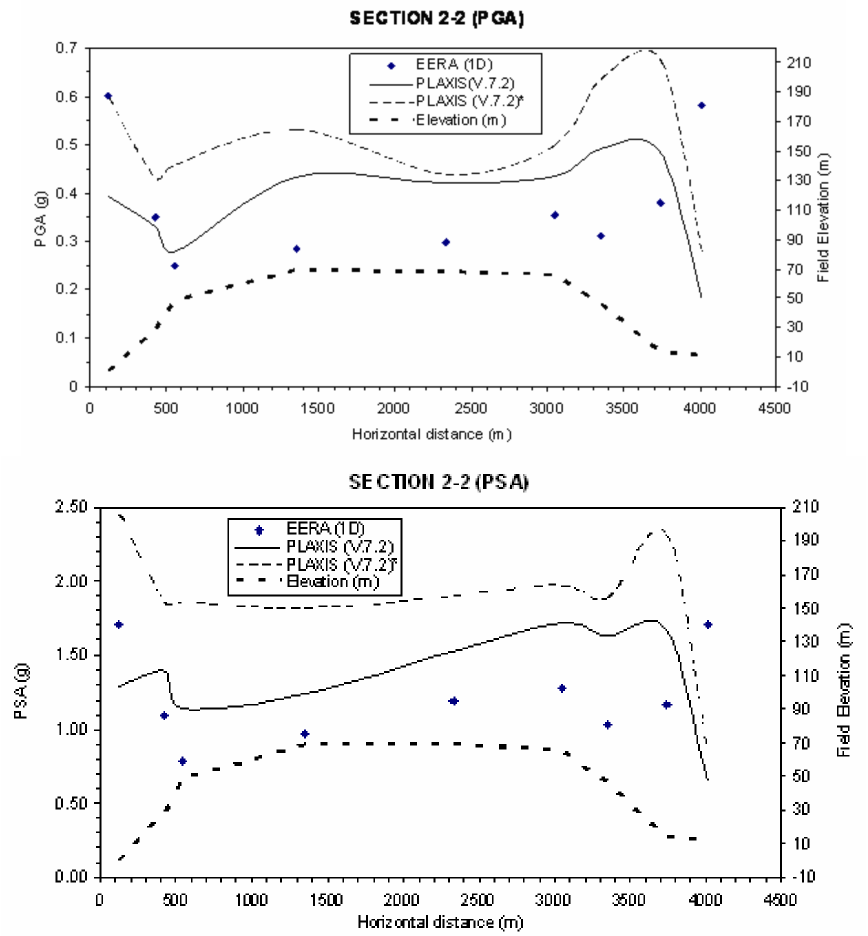

Figure 4. The variations of PGA and PSA along the topographic section 2-2′

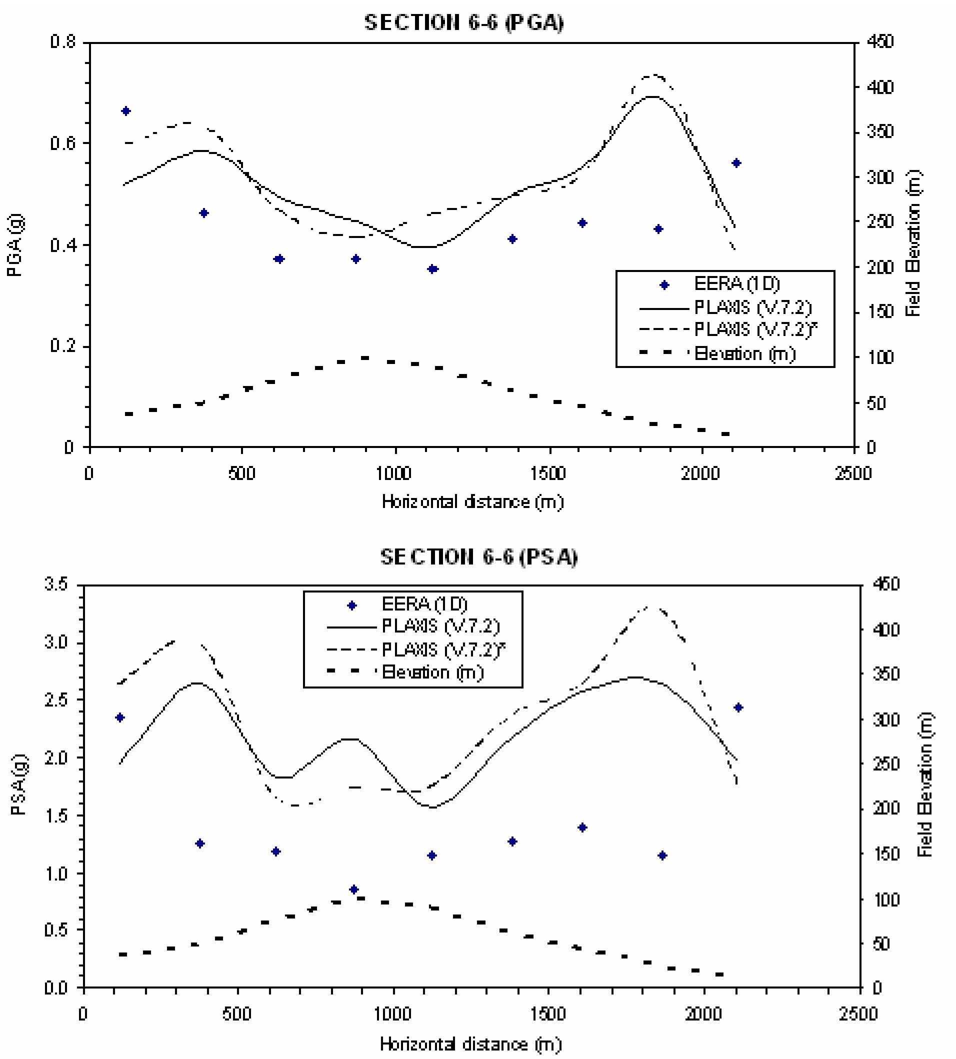

Figure 5. The variations of PGA and PSA along the topographic section 6-6′

As can be seen from these figures, there are some differences between the results of 1D and 2D response analyses in terms of ground surface accelerations and spectral accelerations in the alluvial plains and slopes of the region. For the points on alluvial plains, values determined from 1D analysis seem to be higher whereas at especially the toes of the slopes 2D analysis yielded higher PGA and PSA values. These results show that, topography of the region can have a significant effect in site response, and 2D site response analysis should be performed especially in the slopes of the region.
The peak accelerations and peak spectral accelerations at the ground surface determined from 1D and 2D site response analysis are given in Table 7. Here, the results of 2D analysis for which the viscous damping parameters determined from the first method are used is denoted as Plaxis(V.7.2)* and results from the second method are denoted as Plaxis (V.7.2).

Table 7. The peak accelerations and peak spectral accelerations at the ground surface determined from 1D and 2D site response analysis

Point	Peak Ground Accceleration, PGA (g)			Peak Spectral Acceleration, PSA (g)		
	Plaxis (V.7.2)	Plaxis (V.7.2)*	1D	Plaxis (V.7.2)	Plaxis (V.7.2)*	1D
(1-1)A	0.357	0.506	0.287	1.30	1.60	0.92
(1-1)B	0.513	0.750	0.430	1.90	2.85	2.02
(1-1)C	0.33	0.443	0.290	0.96	1.78	0.92
(1-1)D	0.328	0.440	0.324	1.47	1.70	1.08
(1-1)E	0.383	0.513	0.273	1.49	2.32	0.91
(1-1)F	0.363	0.457	0.224	1.52	2.20	0.83
(1-1)G	0.315	0.398	0.209	1.09	1.64	0.79
(2-2)A	0.393	0.596	0.603	1.29	2.45	1.71
(2-2)B	0.330	0.428	0.350	1.39	1.85	1.10
(2-2)C	0.279	0.457	0.249	1.14	1.85	0.78
(2-2)D	0.434	0.531	0.284	1.24	1.81	0.97
(2-2)E	0.42	0.439	0.298	1.53	1.89	1.20
(2-2)F	0.436	0.497	0.355	1.72	1.97	1.27
(2-2)G	0.493	0.633	0.311	1.63	1.88	1.03
(2-2)H	0.484	0.672	0.380	1.67	2.32	1.16
(2-2)I	0.184	0.274	0.582	0.65	0.85	1.71
(3-3)A	0.354	0.372	0.310	1.38	1.42	1.33
(3-3)B	0.383	0.395	0.249	2.06	1.83	1.92
(3-3)C	0.504	0.497	0.400	2.18	1.97	1.18
(3-3)D	0.595	0.533	0.430	2.32	2.26	1.19
(3-3)E	0.200	0.215	0.588	0.70	0.64	2.00
(4-4)A	0.375	0.429	0.826	1.15	1.44	2.57
(4-4)B	0.440	0.450	0.383	2.02	2.15	1.23
(4-4)C	0.478	0.570	0.342	1.81	1.78	1.07
(4-4)D	0.298	0.473	0.299	1.27	1.50	1.28
(4-4)E	0.343	0.394	0.318	1.92	1.92	0.99
(4-4)F	0.315	0.387	0.295	1.54	1.81	1.28
(4-4)G	0.261	0.424	0.307	1.25	1.00	1.13
(5-5)A	0.721	0.693	0.707	2.50	2.81	2.25
(5-5)B	0.607	0.737	0.396	2.85	3.54	1.21
(5-5)C	0.571	0.605	0.439	2.96	2.88	1.28
(5-5)D	0.443	0.458	0.410	2.07	2.17	1.21
(5-5)E	0.403	0.426	0.358	2.54	2.43	0.90
(5-5)F	0.460	0.523	0.389	1.76	1.74	1.45
(5-5)G	0.548	0.568	0.426	2.64	2.58	1.98
(5-5)H	0.359	0.310	0.625	1.56	1.63	2.13
(6-6)A	0.518	0.597	0.665	1.95	2.63	2.35
(6-6)B	0.583	0.633	0.462	2.65	2.98	1.25
(6-6)C	0.495	0.467	0.374	1.84	1.65	1.18
(6-6)D	0.445	0.413	0.370	2.16	1.73	0.85
(6-6)E	0.394	0.460	0.353	1.57	1.75	1.15
(6-6)F	0.500	0.495	0.410	2.18	2.37	1.28
(6-6)G	0.553	0.536	0.442	2.58	2.63	1.40
(6-6)H	0.691	0.734	0.432	2.65	3.28	1.16
(6-6)I	0.432	0.380	0.562	1.97	1.75	2.43

An examination of the results shows that the peak ground accelaration and spectral acceleration values determined from 1D and 2D analysis different from each other, depending on the topography and the soil profile of the investigated site. The results of 2D analysis in which two different methods of viscous damping computations were used also differ considerably. The viscous damping coefficients determined by two different methods are seen to vary in a wide range, leading to differencies in the computed surface acceleration and spectral acceleration values, emphasizing the importance of viscous damping parameters in 2D analysis.

CONCLUSIONS

In this study, the dynamic behavior of the soil deposits at Kucukcekmece region are evaluated by employing one dimensional and two dimensional site response analyses. One dimensional analyses are carried out by the computer code EERA which is based on equivalent linear analysis approach and two dimensional dynamic analyses are performed by dynamic version of the finite element program PLAXIS. Viscous damping parameters, which are known to be most effective on the results of two dimensional dynamic site response analysis, are determined by two different methods.

The variation of the computed acceleration and the spectral acceleration values at the ground surface, taking into consideration the topography and the sequence of soil profiles discloses that there are some differences between the results of 1D and 2D response analyses in the alluvial plains and slopes of the region. For the points on alluvial plains, values determined from 1D analysis seem to be higher whereas at especially the toes of the slopes 2D analysis yield higher PGA and PSA values. These results show that, topographical effects can play significant role in site response, therefore 2D site response analysis should be performed especially in the slopes of the region.

The values of viscous damping coefficients determined by two different methods are seen to vary in a wide range. The variation of Rayleigh damping coefficient (β) appears to have great effect on the dynamic behavior. Rayleigh β values which are computed from the natural frequencies determined from the modal analysis are seen to be 4-11 times higher than the values determined from the natural frequency of the soil. It is believed that determination of Rayleigh damping coefficients by modal analysis is more appropriate and therefore the peak ground acceleration and spectral acceleration values determined by the second method (denoted as PLAXIS V.7.2) are considered to be more realistic in reflecting the topographical effects.

REFERENCES

Bardet, J.P., Ichii, K., Lin, C.H., “EERA: A Computer Program for Equivalent-Linear Earthquake Response Analyses of Layered soil Deposits”, University of Southern California, Los Angeles., 2000.
Chopra, A.K., “Dynamics of structures: theory and applications to earthquake engineering”, Prentice-Hall Inc., Englewood Cliffs, NJ., 1995.
Idriss, I.M., “Response of Soft Soil Sites during Earthquakes”, Proceedings, Memorial Symposium to Honor Professor Harry Bolton Seed, Berkeley, California, Vol II, May,1990
İyisan, R., “Comparison of seismic and penetration tests for determination of Geotechnical properties”, Ph.D. Thesis, Istanbul Technical University, İstanbul, 1996 (in Turkish).
JICA and IMM, “The study on a disaster prevention/ mitigation basic plan in İstanbul including seismic microzonation in the Republic of Turkey”, Field Report, Vol.3, Appendix 3 and 4, 2001.
Kılıç, H., Adatepe, Ş., Özener Tohumcu, P., Yildirim, M., Özaydın, K., “Evaluation of Kucukcekmece Region with Respect to Soil Amplification” 16 th International Conference on Soil Mechanics and Geotechnical Engineering, pp.2667-2672, 12-16 September, Osaka, Japan, 2005.
LUSAS.LUSAS User and theory manuals, Version 13.5, FEA Ltd., 2004
Özaydın, K., Yildirim, S., Yildirim, M., “İstanbul İli Kucukcekmece İlçesi Sefaköy ve Kucukcekmece Bölgelerinin Jeolojik ve Jeoteknik Etüd Raporu ve Yerleşime Uygunluk Açısından Değerlendirilmesi” Yıldız Teknik Üniversitesi Geoteknik Anabilim Dalı, İstanbul, 2002.
Papageorgiou, A., Halldorsson, B., Dong, G., “TARSCHTS: Target Acceleration Spectra Compatible Time Histories” University of Buffalo, Dept. Of Civil, Structural and Environmental Engrg., NY.,2000.
Plaxis 7.2, “Finite Element Program”, Dynamics Manual, Delft University, Netherlands, 2002.
Rathje, M. E., Bray, D. J., “One and Two Dimensional Seismic Analysis of Solid Waste Landfills”, Canadian Geotechnical Journal, vol38, p.850-862., 2001.

Schnabel, P.B., Lysmer, J., Seed, H.B., "SHAKE: a Computer Program for Earthquake Response Analysis of Horizontally Layered Sites", Report EERC 72-12, Earthquake Enginnering Research Center, University of California, Berkeley, 1972.

Seed, H. B., Idriss, I.M., "Soil Moduli and Damping Factors for Dynamic Response Analysis", Report No. UCB/EERC-70/10, Earthquake Engineering Research Center, University of California, Berkeley, December, 1970.

Özener Tohumcu, P., Kılıç, H., Yildirim, M., Özaydın, K., "Seismic Microzonation of Kucukcekmece and Sefaköy Regions in İstanbul with Respect to Liquefaction Susceptibility" Proceedings of International Conference on Problematic Soils, 985-993, Famagusta, N. Cyprus.,2005.

Vucetic, M., Dobry, R., "Effect of Soil Plasticity on Cyclic Response", Journal of Geotechnical Engineering, ASCE, Vol.117, No.1, 89 -107, 1991.

Yildirim, M., Savaşkan, E., "Engineering Properties and Stratigraphy of Tertiary Sedimentary Formations in İstanbul" Bulletin of Engineering Geology, Publication of International Association of Engineering Geology and the Environment, Turkish National Committee, Issue 18, pp. 48-62, İstanbul, 2002, (in Turkish).

Yildirim, M., Savaşkan, E., " A New Approach to the Stratigraphy of the Tertiary Sedimentary Formations in İstnbul and Their Engineering Properties" Proceedings of National Symposium on İstanbul's Geology, pp 87-102, Kadir Has University, Cibali-İstanbul , 2003