DOKUZ EYLUL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

A GEOTECHNICAL EARTHQUAKE ENGINEERING INVESTIGATION FOR SOILS OF SOUTH EASTERN COAST OF IZMIR BAY

by
İbrahim Alper YALÇIN

March, 2008
IZMIR

A GEOTECHNICAL EARTHQUAKE ENGINEERING INVESTIGATION FOR SOILS OF SOUTH EASTERN COAST OF IZMIR BAY

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İbrahim Alper YALÇIN

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M.Sc THESIS EXAMINATION RESULT FORM

We have read the thesis entitled **"A GEOTECHNICAL EARTHQUAKE ENGINEERING INVESTIGATION FOR SOILS OF SOUTH EASTERN COAST OF IZMIR BAY"** completed by **IBRAHIM ALPER YALÇIN** under supervision of **PROF. DR. ARIF ŞENGUN KAYALAR** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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İbrahim Alper YALÇIN

A GEOTECHNICAL EARTHQUAKE ENGINEERING INVESTIGATION ON THE SOILS OF SOUTHEAST COAST OF IZMIR BAY

ABSTRACT

In this study it is aimed to investigate the soils of southeastern coast of Izmir Bay in terms of geotechnical earthquake engineering. Through this aim the seismicity of the region and critical earthquake source were determined. Izmir Fault has been accepted as "critical earthquake source" in the frame of RADIUS (1999) Project. The 1977 Izmir Earthquake (M=5.3) has been treated as "critical earthquake". Epicenter of this earthquake was quite near to Izmir Fault. Moreover, the 2005 Urla Earthquake (M=5.9) which was close to the Güzelbahçe Fault, has been added to the analysis as the "critical long distance earthquake".

The idealized soil profiles have been prepared by using the data gained from the site tests and laboratory tests which were made by various firms in the frame of applied researches in the region.

One dimensional dynamic soil behaviour analyses for the critical earthquake (Izmir Earthquake, M=5.3) and scenario earthquake (produced from Izmir Earthquake with M=6.5) have been performed by the equivalent linear method via using EERA software.

Peak ground acceleration and average shear strength values obtained from the site response analyses for the controlling earthquakes have been used in the evaluation of liquefaction potential of the region. These data were evaluated in the frame of national earthquake regulation.

Keywords: The soils of southeast coast of Izmir Bay, critical earthquake source, site response analysis, equivalent linear method, EERA, liquefaction potential.

İZMİR KÖRFEZİ GÜNEYDOĞU KIYISI ZEMİNLERİ İÇİN BİR GEOTEKNİK DEPREM MÜHENDİSLİĞİ ARAŞTIRMASI

ÖZ

Bu çalışmada İzmir Körfezi güneydoğu kıyısı zeminlerinin geoteknik deprem mühendisliği açısından değerlendirilmesi amaçlanmıştır. Bu amaçla yörenin depremselliği ve kritik deprem kaynağı araştırılmıştır. Kritik deprem kaynağı olarak RADIUS (1999) projesi kapsamında kabul gören İzmir Fayı seçilmiş; bu fay yakınlarında meydana gelen 1977 İzmir Depremi (M=5.3) de "kritik yakın mesafe depremi" olarak kabul edilmiştir. Ayrıca "kritik uzak mesafe depremi" olarak da Gülbahçe Fayı yakınlarında meydana gelen 2005 Urla Depremi (M=5.9) analizlere dahil edilmiştir.

Yörede uygulamalı araştırmalar kapsamında çeşitli firmalar tarafından yapılmış olan arazi ve laboratuar deneylerinden elde edilen geoteknik veriler kullanılarak idealize zemin profilleri oluşturulmuştur. Oluşturulan bu profiller için İzmir Fayı üzerinde olası muhtemel maksimum deprem olan 6.5 büyüklüğünde senaryo depremi ve 1977 İzmir Depremi (M=5.3) kayıtları ile tek boyutlu dinamik zemin davranışı analizleri, eşdeğer lineer yöntemle EERA yazılımı kullanılarak gerçekleştirilmiştir.

Bölgedeki sıvılaşma potansiyelinin tespiti için olası muhtemel maksimum deprem için yapılan dinamik zemin davranışı analizlerinden elde edilen maksimum yüzey ivmesi değerleri ve ortalama kayma gerilmeleri kullanılmıştır. Bu değerler ulusal deprem yönetmeliği çerçevesinde değerlendirilmiştir.

Anahtar sözcükler: İzmir Körfezi güneydoğu kıyı zeminleri, kritik deprem kaynağı, dinamik zemin davranışı analizi,eşdeğer lineer yöntem, EERA, sıvılaşma potansiyeli

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CHAPTER ONE
INTRODUCTION

The rapid population increase resulted the necessity of more residential and industrial structures at big cities. With the combination of these necessities and the improvements in construction technologies in recent years, the directions of the constructions shifted to alluvium areas that are at active earthquake sites.

After Marmara Earthquake (1999), there have been some apprehensions against the constructions that are built in alluvium areas at active earthquake sites. At that point the necessity of determining the dynamic behaviors of soil layers down to the bedrock has aroused.

Soils of south eastern coast of Izmir Bay which was fed by Meles River sediments are alluvium soils and this site is an active earthquake site. This region possesses important historical, industrial and transportation structures in addition to residential buildings.

In this thesis study it is aimed to investigate the dynamic behavior of soils of southeast coast of Izmir Bay in terms of Geotechnical Earthquake Engineering. At this point, primarily it is needed to define the reference ground motion and seismicity of the site. Izmir Fault has been evaluated as the critical earthquake source in dependence to the view of RADIUS (1999) project team on Izmir Fault and closeness of the epicenters of earlier destructive earthquakes to the Izmir Fault.

The unique acceleration records which belongs to the 1977 Izmir Earthquake (M=5.3) and the records that are modified for Izmir Scenario Earthquake (M=6.5) were chosen as the reference ground motion

After the identification of reference ground motion, one dimensional site response analyses based on the equivalent linear model were performed by using the EERA computer program (Bardet et al., 2000) on 1977 Izmir Earthquake (M=5.3) as the reference earthquake, Izmir Scenario Earthquake (M=6.5) as the controlling earthquake and the 2005 Urla Earthquake as the long distance earthquake. By these analyses the peak ground accelerations and amplifications have been estimated.

Liquefaction analyses were achieved via estimated peak ground accelerations and average shear strengths. Results of these analyses have been compared with the results obtained using the peak ground acceleration value mentioned in national earthquake regulation.

In chapter two of this dissertation the study area was introduced; structuring, geology and tectonic of the study area were briefly mentioned and the sources of geotechnical data and their distribution over the study area were presented

In chapter three, maximum bedrock acceleration that is needed for site response analyses, soil layering between bedrock and ground surface, parameters that are needed for site response analyses, brief explanation of EERA computer program and the findings and results of site response analyses have been given.

Liquefaction phenomenon, factors that affect liquefaction potential, evaluation of liquefaction potential, results of liquefaction analyses, and the liquefaction potential of the study area have been presented in chapter four.

In the last chapter the results and a general evaluation of the site in terms of geotechnical earthquake engineering have been given.

The geotechnical data, idealized soil profiles and the results of analyses have been given in appendices.

CHAPTER TWO
STUDY AREA & SOIL INVESTIGATION DATA

2.1 Location and Status of the Study Area

Konak County, especially Alsancak district is an important commercial and entertainment centre of Izmir City. There are important facilities at this region such as Izmir Harbour, Alsancak Terminal, City Hall and Statehouse. The importance of the region is obvious not only for Izmir but also for all the Aegean Region because of its great population and being an important historical, commercial and entertainment place.

Several investigators had performed various geotechnical earthquake engineering investigations in Izmir, but these investigations only concern about the overall city or some specific regions and there have been no comprehensive investigation about the region mentioned above.

This region is chosen as the study area because of its dense population, important facilities, and absence of geotechnical earthquake investigations.

The study area is at southeast coast of Izmir Bay in Izmir-Turkey (Figure 2.1); and the whole study area is within the borders of Konak County. Moreover the populated districts such as Alsancak, Çankaya, Kültür, and Ismet Kaptan are in the study area, as well.

The study area starts with Meles Brook at the east of Izmir Harbour, follows all the southeast shore line and finishes near Konak deck. In the study area there are shore structures, commercial centers, highway structures, government buildings, railway structures, hospitals and an intense housing. There are also a lot of historical places in this region.

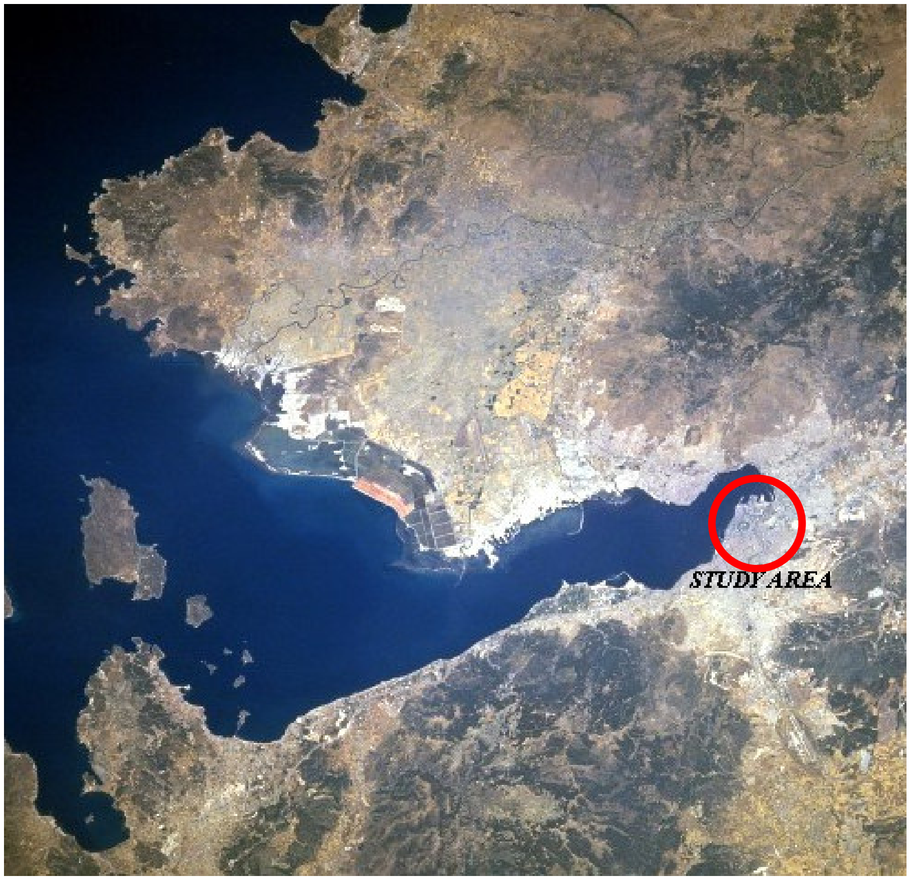


Figure 2.1 Satellite view of Izmir Bay

2.2 General Geology and Tectonic of the Study Area

2.2.1 General Geology

The earth movements in Izmir territory started at Neotectonic age composed the basement of today's geomorphology. In this age Izmir-Ankara zone was fragmented and broken in the directions of NE-SW and NW-SE. Afterwards the Menderes massive has risen and Miocene lakes were arisen. The valleys at the interjacent of the ascendant blocks, which had been ascent by the end of Miocene Era, are deepened and east-west directioned new fault zones have been formed. Today's morphology has reached its formation through this faulting and breaking process. With the help of tectonic movements at Izmir Bay shore the alluvial sediments which consists of the materials carried by rivers from the higher parts of the mountains to the lowland, covered the terrestrial deposits (Kayan, 2000). The coverage of the whole study area by alluvium deposits can be seen at Figure 2.3.

The alluvial deposits are formed by Meles Brook. The Delta of Meles Brook covers the area between Southeastern shore line and the skirts of Kadifekale from Konak Wharf to Halkapınar. In addition, because the sea filling works have started at the end of 19th century, the area containing the shore line between Konak Wharf and Alsancak Harbour is artificial filled as well (Sonuvar, 2004).

2.2.2 General Tectonic

In Izmir territory there have been intensive earthquake activities from the historical period until now. The main graben system which can be a source to this intensive earthquake activity is the Gediz Graben System. Lots of normal faults improved as parallel to this major graben system (Figure 2.2) (RADIUS, 1999).

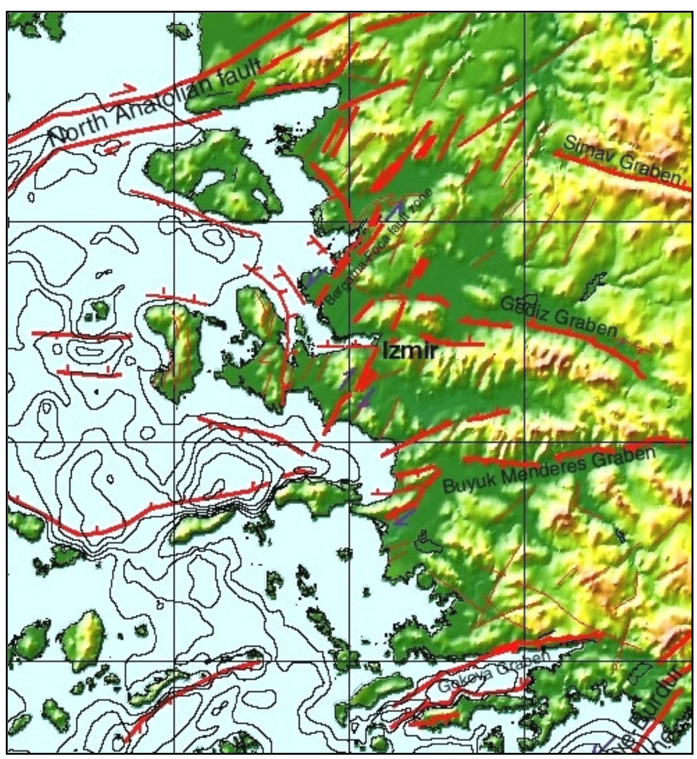


Figure 2.2 Major grabens and fault systems in the vicinity of Izmir (RADIUS, 1999)

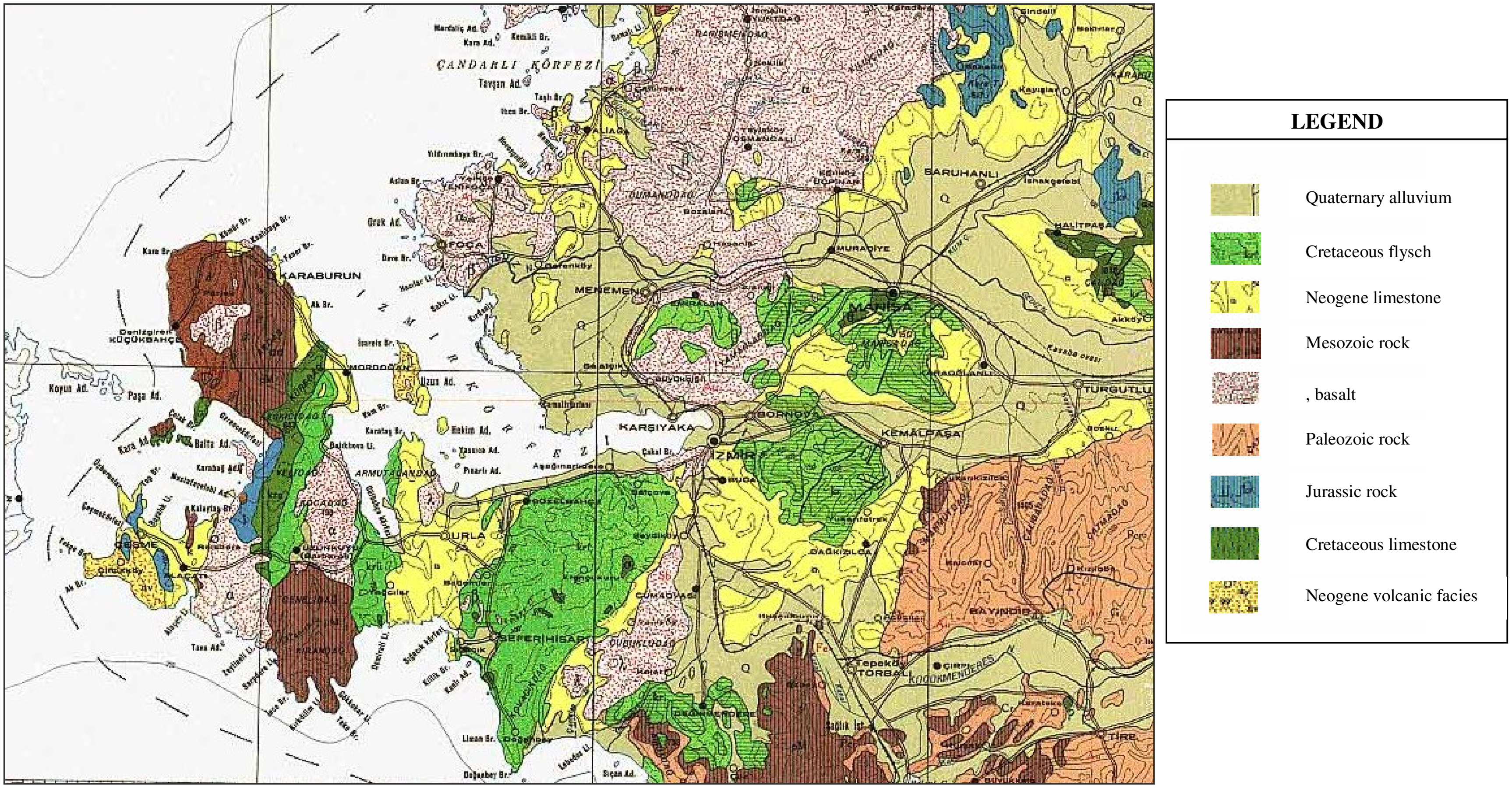


Figure 2.3 Geological map of the Western Anatolia (1/500,000 "Geological Map of Türkiye", MTA, 1964)

Gediz Graben System is at the east of Izmir Bay and the common structures of this graben system are normal faults. Besides this system there are neotectonic period faults which have the characteristic of strike slip faults which are at the south and east of Izmir Bay (RADIUS, 1999).

Since the source of the reference motion is this fault and the position of the fault is important for the study, the Izmir Fault is far more important than the other faults in the region for this research.

This fault is located at the South of Izmir Bay with east to west direction and the location of fault has a maximal urban population. Because of this, the earthquakes produced by this fault have caused serious damages to the city. The fault lies from Güzelbahçe to the east of Kemalpaşa Fault for 35 kilometers (RADIUS, 1999).

Since the 1688, 1739 and 1778 earthquakes were on or very near to this fault, the Izmir Fault accepted as an active fault. Since, this fault located in a very populated area and a limited geological investigation could be held, there are not enough seismic data (RADIUS, 1999). The epicentral coordinates of 1977 Izmir earthquakes are quite near to the Izmir Fault Zone and there are no other main faults at this region to make such an impact. Because of these reasons it is a high possibility that the cause of the 1977 earthquakes is Izmir Fault (Kuruoğlu, 2004).

2.3 Structuring at Study Area

Since the Alsancak Terminal which is the starting point of Izmir-Aydın Railway as the first railway in Turkey and Izmir Harbour which is the largest harbour in Aegean Region are in this area, the area's commercial volume enhanced greatly. Regarding to this volume there have been a rapid structuring and settlement at the area starting from the last decades of the 18th century. Among these intensive housing there are buildings such as the Izmir Harbour, Alsancak Terminal, Konak Wharf, Izmir International Fair, commercial centers, government buildings and historical structures in the area.

Generally the structuring consists of 7-8 stories abutting buildings but one can also see single or double layered historical buildings either. Nonetheless in the last decade with the help of technologic improvements there are plenty of 15-20 floored buildings rising at the Alsancak area. Moreover, the highest building of the study area is a 35 floored building, namely Hilton Hotel Izmir. The intensive structuring at the area can be seen in Figure 2.4.

Figure 2.4 Satellite view of Study Area showing intense structuring

2.4 Establishing Geotechnical Database

In the scope of this research project, primarily it is needed to establish a geotechnical data base for performing the dynamic analyses of southeast coast of Izmir Bay. The geotechnical data which required for establishing the geotechnical database has been collected from the present geotechnical investigation reports, from Dokuz Eylül University Department of Civil Engineering Geotechnics Division and firms who are working on geological and geotechnical engineering.

The information about the data sources are given in Table 2.1. Table2.1 includes project names, number and depth of borings, sources of in-situ and laboratory tests. Location numbers in this table were assigned by the author.

Table 2.1 Sources of the Geotechnical Data

Location	Project name	Number of Borings	Variation of Depths of Borings	Source of the In-situ tests	Source of the Laboratory tests
1	193 Pafta 3646 Ada 26 Parsel	8	30.5 – 35.0	Çakıcı (2005)	Çakıcı (2005)
2	Behçet Uz Çocuk Hast. G Blok İnş.	2	23.5 – 27.0	Bayındırlık İskan Müdürlüğü (2004)	Bayındırlık İskan Müdürlüğü (2004)
3	Izmir Liman CFS Binası	7	30.0 – 52.0	Çakıcı (1992)	Çakıcı (1992)
4	Ağartıoğlu Otel	5	35.0 – 35.0	Çakıcı (1998)	Çakıcı (1998)
5	Ege İhracatcı Birlikleri	3	30.0 – 30.5	Çakıcı (2000)	Çakıcı (2000)
6	Tınaz Apartmanı	2	25.0 – 25.5	Çakıcı (2001)	Çakıcı (2001)
7	192 Pafta 1164 Ada 13 Parsel	1	28.0	Çakıcı (2003)	Çakıcı (2003)
8	Alak Otel	5	35.0 – 35.5	Çakıcı(1997)	Çakıcı(1997)
9	Mert Plaza	2	30.5 – 36.0	Çakıcı (2002)	Kayalar &Özden (2002)
10	Konak Galeria	12	20.0 – 25.0	Çakıcı (1992)	Kayalar & Ülküdaş (1992)
11	Yaşar Eğitim Vakfı Izmir Müzesi	3	25.5 – 35.0	Çakıcı (1999)	Kayalar & Ülküdaş (1999)
12	İ.B.B. Konak Binası	7	20.0 – 51.5	RADON LTD.ŞTİ (2006)	RADON LTD.ŞTİ (2006)
13-20	Izmir-Urla-Çeşme Otoyolu Konak-Alsancak Arası Deniz Dolgusu	24	35.0 – 56.0	TEMELSON (1991-1992)	TEMELSON (1991-1992)

The SPT depth, the SPT-N blow count, water content, sieve analyses, consistency limits, unit weight, specific gravity, group symbol in USCS and strength parameters are recorded individually for every bore position. All these geotechnical data are given in Appendix A.

After finishing the process of uploading all the geotechnical data to the database, it has been controlled again. By browsing logs of borings in detail and controlling the test results, errors have been corrected in this section.

There are totally 81 borings in the content of 13 geotechnical reports related with the study area. It is needed for the site response analysis to decide whether every boring should be analyzed individually or not. Since the locations of bores that are made in the same parcel are usually very close to each other (although some of the bores in one parcel exhibit different profiles), earthquake behavior of the soils in one parcel is expected to be the same. Because of that, it is regarded as favorable to represent the bores in one parcel with one idealized profile.

In each location an idealized soil profile has been developed. Location 13~20 belong to road fill representing 24 borings with triple groups.

In idealization process some problems were confronted in most of the locations since the in-situ and laboratory tests had not been done for the surficial fill layer. For these locations, the idealization was done by making use of the test data of other locations in the study area (Table 2.2).

In the idealization process the modeling was done in reference to the boring logs and laboratory tests results. Values of the geotechnical parameters of idealized profiles have been determined in relation to the laboratory tests results. Totally 20 idealized profiles have been composed. Distribution of locations of these idealized profiles at the study area is shown in Figure 2.5. The profiles and models are given at Appendix B.

Table 2.2 Geotechnical parameters of surficial fill layer and the geotechnical parameters derived from this data

Location	Fill Layer				
	Thickness (m)	SPT-N	-No 200 (%)	Ip	γ (kN/m3)
1	3.50	12	11	NP	18.00
2	7.50	-	9	NP	-
3	2.00	11	20	NP	-
4	5.50	11	-	-	-
5	3.00	12	11	10	-
6	3.00	-	-	-	-
7	3.00	-	-	-	-
8	3.00	9	13	NP	-
9	1.50	-	-	-	-
10	3.00	35	15	NP	-
11	3.00	-	-	-	-
12	7.00	34	25	NP	-
Mean	3.50	17	15	-	-
Accepted	-	12	10	NP	18.00

In Appendix B, the soil types by USCS are presented and in the case of absence of USCS classification the boring profile classifications are used. The idealized profiles which were prepared to be used in the site response analysis and their engineering properties are given in Appendix C.

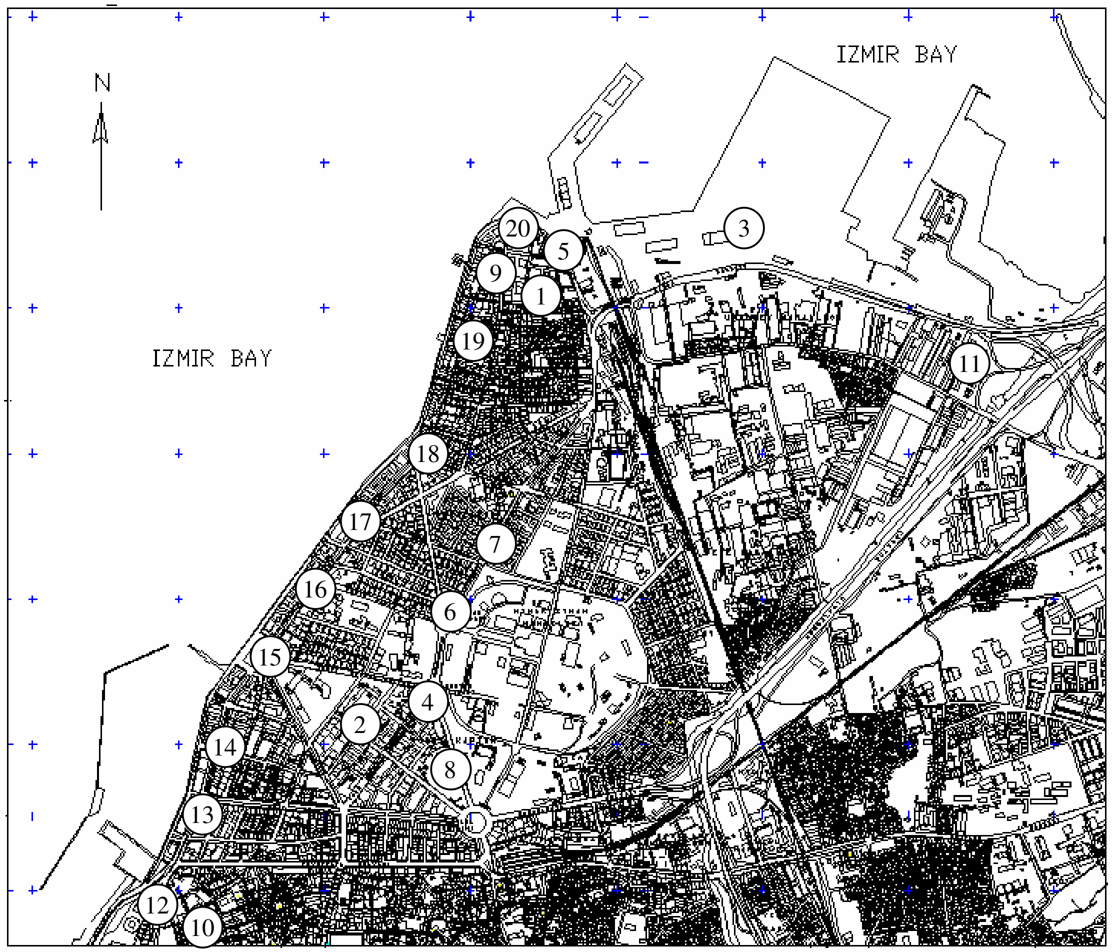


Figure 2.5 Locations of the idealized soil profiles on site

CHAPTER THREE
SITE RESPONSE ANALYSES

3.1 Determination of the Maximum Bedrock Acceleration for the Study Area

One of the main problems of Geotechnical Earthquake Engineering is establishing the dynamic response of the site. The dynamic site response analyses are used in many of applications of Geotechnical earthquake engineering (such as the improvement of design response for the estimation of ground motions, the designation of dynamic stresses and strains for the determination of liquefaction). In site response analyses the fault mechanism as the source of the earthquake, and the movement of shear waves from the bedrock to the surface are modeled. With the help of this model, the effect of the soil condition above the bedrock on ground motion is determined. However, in reality the faulting mechanism is much more complicated and the energy variation between the site and the source of the earthquake is undetermined (Kramer, 1996).

To determine the ground motion; primarily the maximum bedrock acceleration, soil properties between the bedrock and the surface, and the effects of this soil conditions to the ground motion should be determined. For the determination of the effects of soil conditions on the ground motion, firstly the method must be chosen and the parameters which will be used in this method should be calculated.

The steps applied for the site response analysis are given later in the thesis.

The maximum bedrock acceleration is predicted by using the attenuation relationships related to fault conditions in a defined region. In the prediction of bedrock acceleration, recorded acceleration values are used and on the other hand magnitude of the earthquake, fault mechanism and soil conditions are also important (Kramer, 1996).

In the dynamic site response analysis of the Southeastern Coast of Izmir Bay, Izmir Fault was selected as the critical earthquake source. Moreover, based on the RADIUS Project, the scenario earthquake was predicted as on this fault, with a magnitude of 6.5 and an epicenter depth of 10 km. The approximate position of the Izmir Fault has been illustrated in Figure 3.1. The minimum and the maximum distances between the critical earthquake source and the study area have been evaluated as 1 km and 13 km (Figure 3.1).

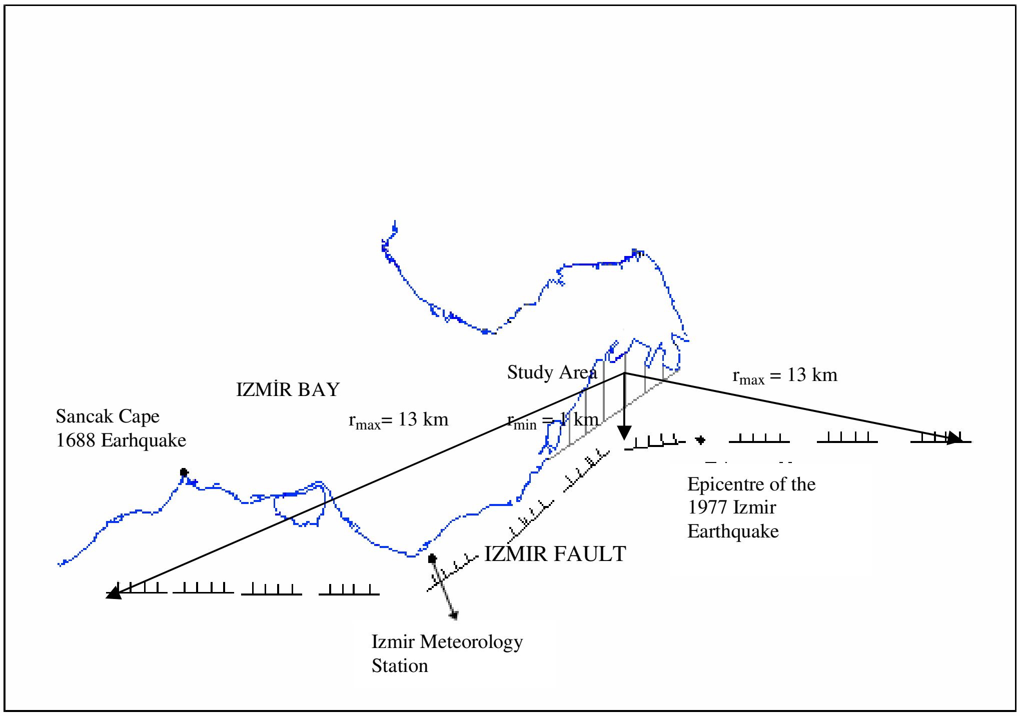


Figure 3.1 Source-to-site distances between study area and segments of the Izmir Fault (Kuruoğlu, 2004)

The maximum bedrock accelerations have been determined for the 1977 Izmir Earthquake (M = 5.3) and Izmir Scenario Earthquake (M = 6.5) by using the Campell (1997) attenuation relationship given in Equation 3.1. These earthquakes were presupposed as they happened or will happen on Izmir Fault. In using the attenuation relationships the maximum and minimum distance of the earthquake epicenters to the study area were used.

Campbell attenuation relationship was considered to be appropriate for prediction of free field amplitudes from earthquakes of which moment magnitude (M_w) greater than 5.0 and seismogenic distance (r_{seis}) closer than 60 km. The seismogenical distance cannot be lower than seismogenical depth which is defined as a depth of upper level of seismogenical part of earth's crust. Seismogenical depth must not be lower than 2-4 km (Campbell, 1997).

The general form of the equation is given as follows:

$$\ln(A_H) = -3.512 + 0.904\ M - 1.328\ \ln [\mathrm{sqrt}\{\ r_{seis}^2 + [0.149\ \exp(0647\ M)]^2\}]$$
$$+[1.125 - 0.112\ \ln (r_{seis}) - 0.0957\ M]\ F + [0.44 - 0.171\ \ln (r_{seis})]\ S_{SR}$$
$$+[0.405 - 0.222\ \ln (r_{seis})]\ S_{HR} + \varepsilon \qquad (3.1)$$

where,

A_H: PGA (in g), ε: Random error term

F=0 for strike slip faults, and F=1 for reverse, thrust, and reverse oblique faults

S_{SR}=1 for soft rock, and S_{SR}=0 otherwise

S_{HR}=1 for hard rock, and S_{HR}=0 otherwise

The standard error (ε)estimation is given by:

$\varepsilon = \sigma / 2$

where,

$\sigma = 0.889\text{-}0.0691\ M$ for $M < 7.4$

$\sigma = 0.38$ for $M \geq 7.4$

Various source-study area distance definitions have been made for use in attenuation relationships . The mainly used distance symbols are r_{rup}, r_{seis}, r_{jb}, and r_{hypo}. These distance measures and the symbols for the study area are given in Figure 3.2. The nearest horizontal distance between the vertical projection of fault and site is called as Joyner-Boore distance (r_{jb}). The shortest distance between the rupture surface and site is called as rupture distance (r_{rup}). The closest distance between the seismogenical rupture surface and site is seismogenical distance (r_{seis}). Seismogenical depth is the distance between the surface and the upper base of the seismogenical crust of the earth (Campbell,1997).

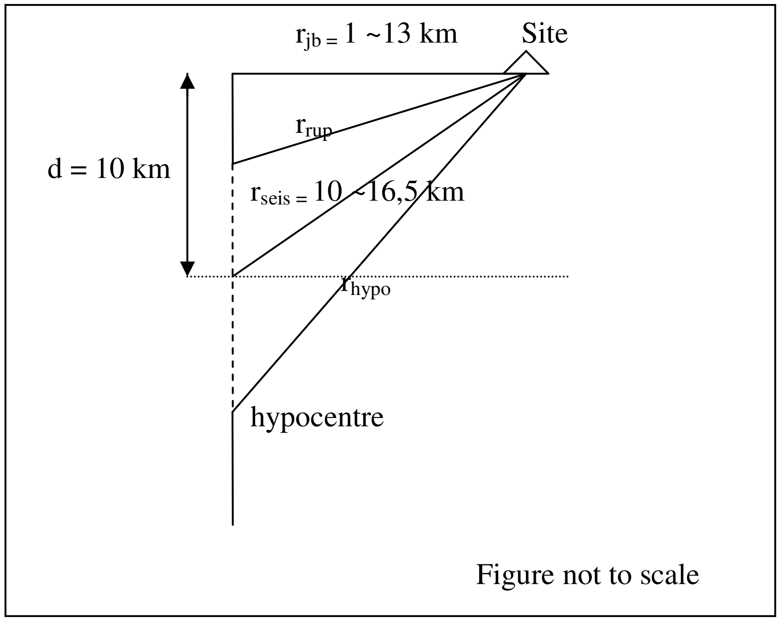


Figure 3.2 Source geometry and distance measures for the Izmir Fault

The acceleration records of the earthquake, is needed in order to use in the dynamic site response analysis. The unique earthquake acceleration recording near Izmir Fault has been taken for the 1977 Izmir Earthquake (M = 5.3) which is used as the reference earthquake in this thesis. These acceleration records are used for 1977 Izmir Earthquake (M = 5.3) and modified for Izmir Scenario earthquake (M = 6.5). Modified acceleration records have been taken from Kuruoğlu (2004).

2005 Urla Earthquake (M = 5.9), which happened in 21.10.2005 at 47 km. southeast of Izmir with a 10 km seismogenical depth, were chosen as the critical distant earthquake. The reason for choosing this earthquake is the prediction in RADIUS Project that the critical distant earthquake which will affect Izmir, could happen close to Karaburun Peninsula.

The maximum bedrock acceleration values which can occur in the study area were calculated for the critical distant earthquake, critical close distance earthquake and scenario earthquake, by using the Campbell (1997) attenuation relationship. These values are given in Table 3.1.

Table 3.1 Estimated maximum bedrock accelerations in the Study Area

Earthquake	Attenuation Relationship	Maximum Bedrock Acceleration (g)		
		r_{jb} =1km	r_{jb} = 13km	r_{jb} = 48km
Izmir 1977 - M=5.3	Campbell 1997	0.21	0.10	-
Izmir Scenario - M=6.5		0.40	0.23	-
Urla 2005 - M=5.9		-	-	0.03

3.2 Subsurface Profile Development

As it happens in all geotechnical engineering analyses, in dynamic site response analysis also it is needed to define the subsurface profile exactly in the study area. In order to achieve this definition the information of ground water level, soil stratigraphy, depth and characteristics of bedrock is needed (Kavazanjian,E. et al. 1997).

3.2.1. Soil Stratigraphy

The preparation processes of the database needed for to define the soil stratigraphy of the study area are given in the section 2.4. By using the geotechnical database, the soil stratigraphies in 20 locations have been defined.

The detailed data about the soil conditions of the study area were presented in Appendix A and the soil profiles were given in Appendix B. The modeling is done for all the profiles with the help of the geotechnical data and boring logs for the 20 locations. The soil profiles which are the main references to the analysis in this thesis study are presented in Appendix C, under the title of idealized soil profiles.

3.2.2. Water Level

The study area is near the sea and because of this the ground water level is under the control of sea level. An average value for the ground water levels given in the log of borings is taken.

3.2.3 Depth To Bedrock

It is very important to determine the exact depth of bedrock in the site response analysis. It is possible to determine the depth of the bedrock with the help of deep borings and seismic methods. But no information about the depth of bedrock is present in the geotechnical investigation reports used in this study. In addition to this, the seismic studies made in the region are also not sufficient to determine the depth of the bedrock.

Since depth to bedrock in the study area has not been determined by physical methods, an estimation for the depth of the bedrock has been made. As it can be seen in Figure 2.3, there is an andesite formation starting from the ridge of Kadifekale through the southeast of the study area. Taking this into account and by considering the general geology of the region, the depth of the bedrock has been estimated in the interval of 100~150 m. (Çakıcı, S., 2007). But no concrete data to support this estimation is present.

In the case of absence of bedrock depth, it is recommended to work with an at least 30 m. deep profile (Kavazanjian,E. et al. 1997). The deepest boring made on the study area is 52 m.; in other words the bedrock depth is more than 52 meters. Among the idealized profiles, the ones with at least 30 m. depth are seen as suitable to be used. But in the cases where the idealized profile depths are lesser than 30 meters, it is needed to lengthen these profiles to at least 30 m. In this study, the idealized profiles of the 2^{nd}, 6^{th}, 7^{th} and 10^{th} locations do not provide the depth provision of 30 meters and so these profiles have been extended to 30 m.

3.3 Calculation of the Parameters Required for Site-Response Analysis

The effects of local soil conditions to seismic ground motion can be assigned by empirical methods or site response analysis. In geotechnical earthquake engineering applications there are three approaches to make site response analysis; these are,

- Simplified (empirical) analysis
- Equivalent-linear one-dimensional site response analyses
- Advanced one and two-dimensional site response analyses

In this study Equivalent-linear one-dimensional site response analysis approach has been used. In this method, the soils are considered to be horizontally layered and, these layers consist of linear visco-elastic materials represented by initial shear modulus and equivalent viscous damping ratio (Kavazanjian,E. et al. 1997).

The maximum shear modulus (G_{max}) and damping ratio (ζ), are known as the linear parameters of soils which are used to detect the dynamic behaviors of the soils. The change of shear modulus ratio (G/G_{max}), can be estimated depending on unit shear deformation (γ) (Kramer, 1996). The methods used to calculate the equivalent-linear parameters are given below.

The maximum shear modulus (G_{max}) values can be evaluated by the use of various empirical methods. In the case of cohesionless soils, the maximum shear modulus can be calculated by two different methods. These are Seed&Idriss (1970) and Otha&Gota (1976) methods.

In Seed&Idriss (1970) method G_{max} is given as follows:

$$G_{max} = 1000 * K_{2max} * (\sigma'_m)^{0,5} \tag{3.2}$$

Here, K_{2max} is a modulus which depends on the void ratio and relative density (Table 3.2), and σ'_m is the mean effective stress. Units of G_{max} and σ'_m are as (lb/ft^2). After the calculation of G_{max} , it is converted to (kPa).

Table 3.2 K_{2max} values (Seed &Idriss ,1970)

e	K_{2max}	Dr(%)	K_{2max}
0.4	70	30	34
0.5	60	40	40
0.6	51	45	43
0.7	44	60	52
0.8	39	75	59
0.9	34	90	70

If the void ratio could not be determined, the maximum shear modulus is predicted with the help of in situ test parameters such as SPT-N.

When the maximum shear modulus can not be determined by the above method, Otha&Gota (1976) method based on SPT-N can be used. Otha&Gota (1976) relation is as follows:

$$Gmax = 20000 * (N_1)_{60}^{0,333} * (\sigma'_m)^{0,5} \qquad (3.3)$$

where, σ'_m is the mean effective vertical stress. In this equation the G_{max} and σ'_m are in lb/ft^2. After calculating the G_{max} , its unit is converted to kPa.

In the above equation the standard penetration test corrections modified by Skempton are used (Table 3.3) as in Equation 3.4.

$$(N_1)_{60} = N_m * C_N * C_E * C_B * C_R * C_S \qquad (3.4)$$

where N_m is standard penetration resistance; C_E is correction for hammer energy ratio; C_B is correction factor for borehole diameter; C_R is correction factor for rod length; and C_S is correction for sampler with or without liners; C_N is a factor to normalize N_m to a common reference effective overburden stress. C_N is commonly estimated from the following equation and the value of C_N should not exceed 1.7.

$$C_N = (P_a / \sigma'_{vo})^{0.5} \qquad (3.5)$$

If the standard penetration test is performed in fine sand or non-plastic silt layers below the ground water level and the measured SPT-N value is greater than 15, the resistance value is corrected for the increased resistance due to negative excess pore water pressure formation (Craig, 1992). This correction is made by using the following equation:

$$N' = 15 + \tfrac{1}{2}(N-15) \quad (3.6)$$

Table 3.3 Corrections to SPT (Modified from Skempton 1986)

Factor	Equipment Variable	Term	Correction
Overburden pressure	-	C_N	$(P_a / \sigma'_{vo})^{0.5}$
Overburden pressure	-	C_N	$C_N \leq 1.7$
Energy Ratio	Donut Hammer	C_E	0.5-1.0
Energy Ratio	Safety Hammer	C_E	0.7-1.2
Energy Ratio	Automatic-trip Donut-type hammer	C_E	0.8-1.3
Borehole Diameter	65-115 mm	C_B	1.0
Borehole Diameter	150 mm	C_B	1.05
Borehole Diameter	200 mm	C_B	1.15
Rod Length	< 3m	C_R	0.75
Rod Length	3 – 4 m	C_R	0.80
Rod Length	4 – 6 m	C_R	0.85
Rod Length	6 – 10 m	C_R	0.95
Rod Length	10 – 30 m	C_R	1.0
Sampling Method	Standard sampler	C_S	1.0
Sampling Method	Sampler without liners	C_S	1.1-1.3

The maximum shear modulus (G_{max}) can be calculated by two different methods for cohesive soils. One of these is a correlative equation (Equation 3.7) that depends on plasticity index (Ip), over-consolidation ratio (OCR) and undrained shear strength (c_u).

$$G_{max} = A * c_u \quad (3.7)$$

In this equation A is a ratio depending on the plasticity index (Ip) and over-consolidation ratio (OCR), c_u is undrained shear strength. Values of A depending on Ip and OCR are given in Table 3.4. In this equation units of G_{max} and c_u are in kPa.

In the frame of this study, soils are assumed to be normally consolidated (OCR=1). In the case of absence of c_u values, use of Skempton's empirical formula (Equation 3.8) has been made.

$$c_u = (0.11 + 0.0037\ Ip) * \sigma_v' \quad (3.8)$$

In this equation Ip is plasticity index and σ_v' is effective vertical stress.

Table 3.4 Values of A (S.L. Kramer, 1996)

Ip	Overconsolidation Ratio ,OCR		
	1	2	5
15-20	1100	900	600
20-25	700	600	500
35-45	450	380	300

The other calculation method for maximum shear modulus value of cohesive soils is Hardin (1978) Equation 3.9. This equation is as follows;

$$G_{max} = 625 * F(e) * OCR^k * p_a^{0,5} *(\sigma'_m)^{0,5} \quad (3.9)$$

In this equation F(e) is a function depending on the void ratio, the exponent of OCR (k) is a coefficient that is connected to the plasticity index (Table 3.5), σ'_m is mean effective stress and p_a is atmospheric pressure. G_{max}, p_a and σ'_m should be used in the same unit (kPa). The F(e) function is given below.

$$F(e) = 1 / (0.3 + 0.7e^2) \quad (3.10)$$

Table 3.5 Overconsolidation ratio exponent, k (S.L. Kramer, 1996)

Plasticity Index	k
0	0.00
20	0.18
40	0.30
60	0.41
80	0.48
≥100	0.50

If shear wave velocity, is not determined by in-situ tests, it can be calculated by Equation 3.11 in terms of the maximum shear modulus and soil mass density.

$$G_{max} = \rho * V_s^2 \tag{3.11}$$

In this equation ρ is mass density and it is the ratio of the unit weight to the acceleration of gravity.

The shear modulus ratio (G/G_{max}) for cohesive and cohesionless soils can be calculated via following Ishibashi and Zhang (1993) equation.

$$G/G_{max} = K(\gamma,Ip)\,(\sigma'_m)^{\,m(\gamma,Ip)-mo} \tag{3.12}$$

In this equation the K(γ,Ip) component can be calculated by Equation 3.13 and superscript of σ'_m can be calculated by Equation 3.14.

$$K(\gamma,Ip) = 0.5\left\{1+\tanh\left[\ln\left(\frac{0{,}000102+n(Ip)}{\gamma}\right)^{0.492}\right]\right\} \tag{3.13}$$

$$m(\gamma,Ip)-m_0 = 0.272\left\{1-\tanh\left[\ln\left(\frac{0.000556}{\gamma}\right)^{0.4}\right]\right\}\exp(-0.0145Ip^{1.3}) \tag{3.14}$$

The n(Ip) component can be calculated according to the plasticity index by using Table 3.6.

Table 3.6 Variation of $n(I_p)$ component with plasticity index

I_p (%)	$n(I_p)$
0	0
$0 < I_p \leq 15$	$3.37\times10^{-6}\ I_p^{1.404}$
$15 < I_p \leq 70$	$7.0\times10^{-7}\ I_p^{1.976}$
$I_p > 70$	$2.7\times10^{-5}\ I_p^{1.115}$

The damping ratio for the cohesive and cohesionless soils can also be estimated by using following Equation 3.15 of Ishibashi and Zhang (1993).

$$\xi = 0.333 \frac{1+\exp(-0.0145 Ip^{1.3})}{2} \left[0.586 \left(\frac{G}{G_{\max}} \right)^2 - 1.547 \frac{G}{G_{\max}} + 1 \right] \tag{3.15}$$

Shear modulus ratio values and the damping ratio values (ζ) have been calculated for different values of unit shear deformation (γ) (between 0.0001 and 10) by using Ishibashi and Zhang method.

3.4 E.E.R.A Computer Program

Previous earthquakes showed that the ground motions resulting from the earthquakes in the soft soil sites are much bigger than the places where the rock outcrops are in surface. Some computer programs have been developed in order to stimulate this amplification (Bardett,Ichii&Lin,2000). The first of these programs is the SHAKE which was developed by Schabel and Lysmer (1972). In the following years the program SHAKE was expanded and improved many times (Destegul, U. 2004).

The EERA computer program, which was developed in accordance to the algorithm of the SHAKE; and coded by the use of FORTRAN 90 in 1998 supplies the general concepts of equivalent linear site response analysis (Bardett, Ichii&Lin, 2000). In this study the E.E.R.A program has been used.

The data input pages of the EERA computer program which was developed on equivalent linear model, were adapted to the Ms Excel. With the help of this all the studies can be administrated by an Excel worksheet easily. There are 9 worksheets in the EERA program and both the data input and the results can be seen on these pages. These worksheets and their contents are given in Table 3.7.

Table 3.7 Types of worksheets in EERA and their contents (EERA manual book)

Worksheet	Contents	Duplication	Number of input
Earthquake	Earthquake input time history	No	7
Material	Material curves (G/Gmax and Damping versus strain for material type	Yes	Dependent on number of soil layers
Profile	Vertical profile of layers	No	Dependent on number of data points per material curve
Iteration	Results on main calculation	No	3
Acceleration	Time history of acceleration/velocity/displacement	Yes	2
Strain	Time history of stress and strain	Yes	1
Amplification	Amplification between two sub-layers	Yes	4
Fourier	Fourier amplitude spectrum of acceleration	Yes	3
Spectra	Response spectra	Yes	3

While performing the site response analysis through the EERA program which can easily be worked on Ms Excel environment, the following processes are followed.

Earthquake data are entered on the earthquake data input page. After this step the data of idealized profiles' status and geotechnical data entered to the profile page. A new material page; where the maximum shear modulus (G_{max}) and the damping ratio's (ζ) parametric values between 0.0001 and 10, are registered for each layer in the idealized profiles. Following these steps, the data input needed for the worksheets of iteration, acceleration, strain, amplification, fourier and spectra entered and than the program is ready to run. After the data inputting process, the program is run and the results also can be observed on the data input pages.

3.5 Site Response Analyses Studies

The depth of bedrock has a great importance in site response analysis. The depth of the bedrock in the study area couldn't be determined as it has been previously declared. Bedrock depth in the study area is estimated to be in the interval of 100 – 150 m.(Çakıcı, S., 2007).

In order to see the effect of the bedrock depth and the other factors (if there any) on the findings of the site response analysis, it is aimed to go through the analysis in a selected location. The results of these analyses are thought to be a reference for the site response analyses of the whole study area.

The idealized profile of location 3 has been chosen as reference profile. This profile is the deepest of all and it provides least thickness of soil with unknown properties between the bedrock and the borehole bottom.

After fixing the location of the reference analyses, the site response analyses have been done. The site response analyses carried out under two sub-headings. These are "the factors affecting the peak ground acceleration" and "site response analyses and findings".

3.5.1 Factors Affecting the Peak Ground Acceleration

The site response analyses have been done for the bedrock depths of 30 m. (required minimum depth), 52 m. (actual borehole depth), 100 m. and 150 m. (extended depths). In the case of extended depths, stratification conditions and the soil properties between the borehole bottom and bedrock were needed to be estimated.

Careful examination of the idealized profile for location 3 revealed that there is ~5 m sand and ~10 m clay stratification below 6 m depth. It has been accepted that this stratification is also valid from the bottom of the borehole to the bedrock. The extended idealized soil profile which was formed via this idea can be seen in Figure 3.3.

Moreover, in order to observe the effects of the other soil stratifications on the results of the site response analysis, the soil below the bottom of the borehole has been assumed to be of one type. That is either totally sand or clay. The values of the geotechnical soil parameters in the idealized profile have been taken into account. The soils have been divided into 10 m sublayers. The extended idealized soil profiles formed under these conditions are shown in Figure 3.4 (sand extension) and Figure 3.5 (clay extension).

Depths and layerings in the reference analyses aiming the effects of the bedrock depth to the site response analysis can be summarized as follows:

<u>Bedrock Depth</u>

1- 30 m (required min. depth)

2- 52 m (borehole depth)

3- 100m (extended depth)

4- 150m (extended depth)

<u>Assumed layering below the borehole bottom</u>

i- Consecutive sand and clay layers (5m sand and 10m clay)

ii- Sand with 10m sublayers

iii- Clay with 10m sublayers

0.0

GWT=1.75m

2.00	BACKFILL		γ_n=18.0 kN/m^3 ,	Ip= NP	w_n = 21%	N=11
6.00	GRAVEL	(GP-GC)	γ_n=18.0 kN/m^3 ,	Ip = NP	w_n = 19%	N=20
10.00	SAND	(SC)	γ_n=18.0 kN/m^3,	Ip = 15,	w_n = 18% ,	N=16
17.00	CLAY	(CL)	γ_n=19.0 kN/m^3,	Ip = 7 ,	w_n = 40%	N=25
22.50	SAND	(SC)	γ_n=19.0 kN/m^3,	Ip = 18	w_n = 18%	N=24
33.50	CLAY	(CL)	γ_n=19.0 kN/m^3,	Ip = 20	w_n = 24%	N=21
39.00	SAND	(SC)	γ_n=20.0 kN/m^3,	Ip = NP		N=28
50.00	CLAY	(CL)	γ_n=20.0 kN/m^3,	Ip = 18 ,	w_n = 29%	N=25
52.00	SAND	(SC)	γ_n=20.0 kN/m^3,	Ip = NP ,	w_n = 20%	N=45 End of Borehole
60.00	CLAY	(CL)	γ_n=20.0 kN/m^3,	Ip = 20 ,		N=50
65.00	SAND	(SC)	γ_n=20.0 kN/m^3,	Ip = NP ,		N=50
75.00	CLAY	(CL)	γ_n=21.0 kN/m^3,	Ip = 20 ,		N=50
80.00	SAND	(SC)	γ_n=21.0 kN/m^3,	Ip = NP ,		N=50
90.00	CLAY	(CL)	γ_n=21.0 kN/m^3,	Ip = 20 ,		N=50
95.00	SAND	(SC)	γ_n=21.0 kN/m^3,	Ip = NP ,		N=50
100.00	CLAY	(CL)	γ_n=21.0 kN/m^3,	Ip = 20 ,		N=50
105.00	CLAY	(CL)	γ_n=21.0 kN/m^3,	Ip = 20 ,		N=50
110.00	SAND	(SC)	γ_n=21.0 kN/m^3,	Ip = NP ,		N=50
120.00	CLAY	(CL)	γ_n=21.0 kN/m^3,	Ip = 20 ,		N=50
125.00	SAND	(SC)	γ_n=21.0 kN/m^3,	Ip = NP ,		N=50
135.00	CLAY	(CL)	γ_n=21.0 kN/m^3,	Ip = 20 ,		N=50
140.00	SAND	(SC)	γ_n=21.0 kN/m^3,	Ip = NP ,		N=50
150.00	CLAY	(CL)	γ_n=21.0 kN/m^3,	Ip = 20 ,		N=50

Figure 3.3 Extended idealized soil profile of location 3 with consecutive (5m sand and 10m clay) layers

Depth (m)	Soil	Unit weight	Ip	w_n	N
0.0					GWT=1.75m
2.00	BACKFILL	γ_n=18.0 kN/m^3 ,	Ip= NP	w_n = 21%	N=11
6.00	GRAVEL (GP-GC)	γ_n=18.0 kN/m^3 ,	Ip = NP	w_n = 19%	N=20
10.00	SAND (SC)	γ_n=18.0 kN/m^3,	Ip = 15,	w_n = 18% ,	N=16
17.00	CLAY (CL)	γ_n=19.0 kN/m^3,	Ip = 7 ,	w_n = 40%	N=25
22.50	SAND (SC)	γ_n=19.0 kN/m^3,	Ip = 18	w_n = 18%	N=24
33.50	CLAY (CL)	γ_n=19.0 kN/m^3,	Ip = 20	w_n = 24%	N=21
39.00	SAND (SC)	γ_n=20.0 kN/m^3,	Ip = NP		N=28
50.00	CLAY (CL)	γ_n=20.0 kN/m^3,	Ip = 18 ,	w_n = 29%	N=25
52.00	SAND (SC)	γ_n=20.0 kN/m^3,	Ip = NP ,	w_n = 20%	N=45 End of Borehole
60.00	SAND (SC)	γ_n=20.0 kN/m^3,	Ip = NP,		N=50
70.00	SAND (SC)	γ_n=20.0 kN/m^3,	Ip = NP,		N=50
80.00	SAND (SC)	γ_n=20.0 kN/m^3,	Ip = NP,		N=50
90.00	SAND (SC)	γ_n=21.0 kN/m^3,	Ip = NP,		N=50
100.00	SAND (SC)	γ_n=21.0 kN/m^3,	Ip = NP,		N=50
110.00	SAND (SC)	γ_n=21.0 kN/m^3,	Ip = NP,		N=50
120.00	SAND (SC)	γ_n=21.0 kN/m^3,	Ip = NP,		N=50
130.00	SAND (SC)	γ_n=21.0 kN/m^3,	Ip = NP,		N=50
140.00	SAND (SC)	γ_n=21.0 kN/m^3,	Ip = NP,		N=50
150.00	SAND (SC)	γ_n=21.0 kN/m^3,	Ip = NP,		N=50

Figure 3.4 Extended idealized soil profile of location 3 with sand having 10 m. sublayers

Depth (m)	Soil	γ_n	Ip	w_n	N
0.0					GWT=1.75m
2.00	BACKFILL	γ_n=18.0 kN/m^3 ,	Ip= NP	w_n = 21%	N=11
6.00	GRAVEL (GP-GC)	γ_n=18.0 kN/m^3 ,	Ip = NP	w_n = 19%	N=20
10.00	SAND (SC)	γ_n=18.0 kN/m^3,	Ip = 15,	w_n = 18% ,	N=16
17.00	CLAY (CL)	γ_n=19.0 kN/m^3,	Ip = 7 ,	w_n = 40%	N=25
22.50	SAND (SC)	γ_n=19.0 kN/m^3,	Ip = 18	w_n = 18%	N=24
33.50	CLAY (CL)	γ_n=19.0 kN/m^3,	Ip = 20	w_n = 24%	N=21
39.00	SAND (SC)	γ_n=20.0 kN/m^3,	Ip = NP		N=28
50.00	CLAY (CL)	γ_n=20.0 kN/m^3,	Ip = 18 ,	w_n = 29%	N=25
52.00	SAND (SC)	γ_n=20.0 kN/m^3,	Ip = NP ,	w_n = 20%	N=45 End of Borehole
60.00	CLAY(CL)	γ_n=20.0 kN/m^3,	Ip = 20		N=45
70.00	CLAY(CL)	γ_n=21.0 kN/m^3,	Ip = 20		N=50
80.00	CLAY(CL)	γ_n=21.0 kN/m^3,	Ip = 20		N=50
90.00	CLAY(CL)	γ_n=21.0 kN/m^3,	Ip = 20		N=50
100.00	CLAY(CL)	γ_n=21.0 kN/m^3,	Ip = 20		N=50
110.00	CLAY(CL)	γ_n=21.0 kN/m^3,	Ip = 20		N=50
120.00	CLAY(CL)	γ_n=21.0 kN/m^3,	Ip = 20		N=50
130.00	CLAY(CL)	γ_n=21.0 kN/m^3,	Ip = 20		N=50
140.00	CLAY(CL)	γ_n=21.0 kN/m^3,	Ip = 20		N=50
150.00	CLAY(CL)	γ_n=21.0 kN/m^3,	Ip = 20		N=50

Figure 3.5 Extended idealized soil profile of location 3 with clay having 10 m. sublayers

In the site response analyses the maximum shear modulus (G_{max}) were calculated with the help of Equation 3.7 and Equation 3.9 for the cohesive soils and Equation 3.2 and Equation 3.3 for the cohesionless soil. Damping ratio (ζ) values were calculated with the help of Equation 3.15. Values of unit weight, Spt-N and plasticity index are needed in order to calculate the above parameters. In the estimation of these parameters for the case of extended idealized profiles, end of borehole values have been taken into account.

For each layer in the idealized soil profile the shear modulus ratio (G/G_{max}) and damping ratio (ζ) values have been determined for unit shear deformation values of 0.0001 - 10 percent by making use of MS Excel spread sheet. The EERA computer program were run both with the values obtained as mentioned above and the maximum bedrock acceleration values (g) given in Table 3.1. Results for extended idealized profile with consecutive sand and clay layers have been presented in Table 3.8.

Table 3.8 Estimated peak ground accelerations for bedrock depth variations at Location 3

Bedrock Depth	Maximum Bedrock Acceleration (g)			
	0.10	*0.21*	*0.23*	*0.40*
30 m (Required min. depth)	0.21	0.39	0.41	0.60
52 m (End of borehole)	0.20	0.37	0.40	0.57
100 m (Extended profile)	0.19	0.34	0.36	0.53
150 m (Extended profile)	0.16	0.28	0.29	0.41

It can be seen in Table 3.8 that surface acceleration values decrease as bedrock depth increase. Each acceleration value calculated for the layers in the profile has been carefully studied. The graphs of maximum acceleration from EERA are presented in Figure 3.6.

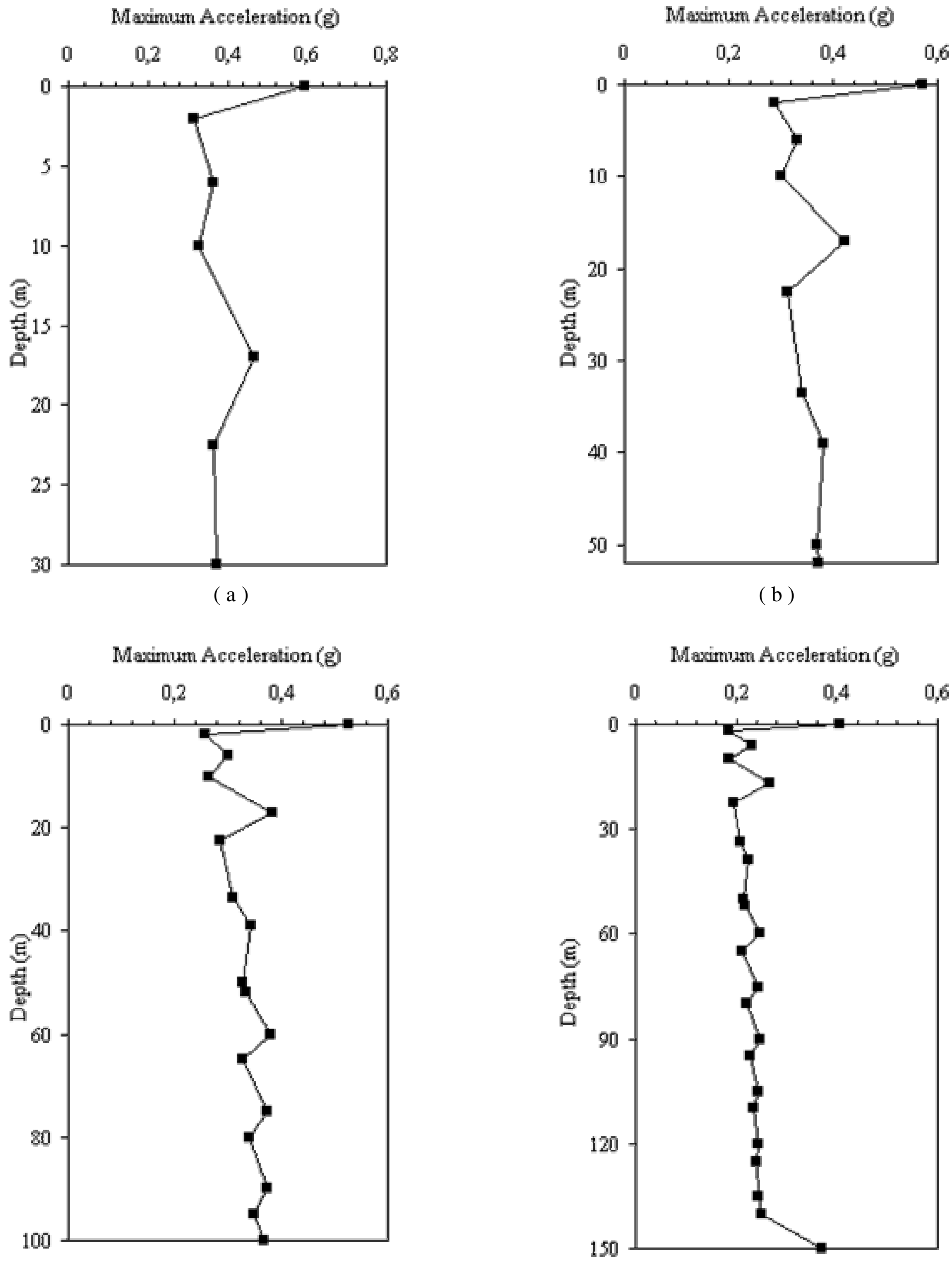


Figure 3.6 Estimated accelerations at location 3 for various bedrock depths : (a) 30 meters - required min. depth (b) 52 meters - boring depth (c) 100 meters - 48 m extended) (d) 150 meters - 98 m extended

In order to make a comparison, they have been drawn on the same graph for 25 m depth as given in Figure 3.7. By examining Figure 3.7, the decreasing effect of bedrock depth increase on peak ground acceleration can be clearly seen. Moreover, fill layer causes a relatively large increase of surface acceleration.

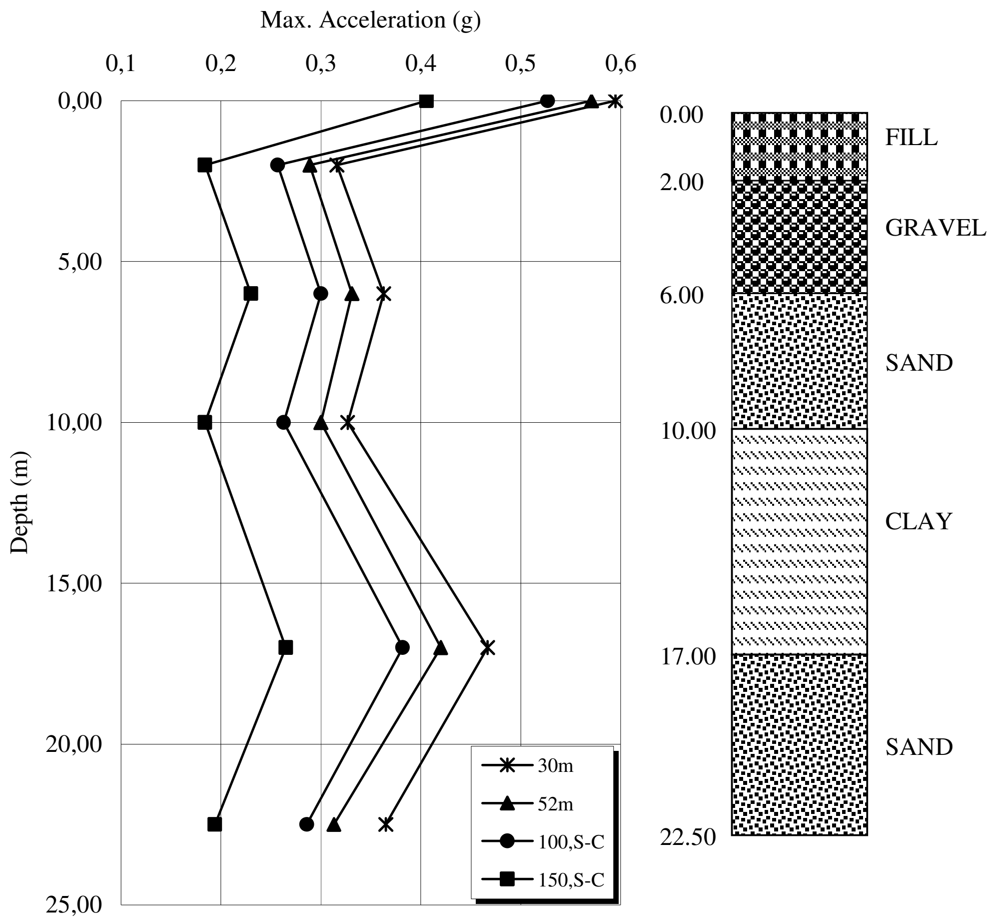


Figure 3.7 Max. Acceleration vs. Depth Graphs (for Various Bedrock Depth and 0.40g Max. Bedrock Acceleration)

Running an analysis by loom larging the stratification and stratum thickness has been considered to be beneficial to determine the effects of the stratification conditions on the peak ground acceleration. For this purpose the idealized profiles given in Figure 3.3, Figure 3.4 and Figure 3.5 have been analyzed.

The 0.3g , 0.5g and 0.6 bedrock accelerations were also included since they are believed to enrich the results of the study. The analyses were held for a total of 8 different bedrock depths and stratification, and for 7 different bedrock acceleration values.

The results of the analyses for the above mentioned conditions are given below in Table 3.9 and Figure 3.8. In addition the median relation curve has also been drawn in Figure 3.8. This curve shows an updated site amplification relationship for free-field soft soil sites developed by Idriss(1990) (Kavazanjian,E. et al. 1997).

Table 3.9 Estimated peak ground accelerations for bedrock depth and layering variations at Location 3

Depth of Bedrock	Assumed Layering	Max. Bedrock Acceleration						
		0.10	*0.21*	*0.23*	*0.30*	*0.40*	*0.50*	*0.60*
150m	Below 52m depth : Consecutive sand and clay layers (5m sand and 10m clay)	0.162	0.278	0.293	0.349	0.406	0.450	0.488
150m	Below 52m depth : Clay with 10m sublayers	0.170	0.275	0.294	0.344	0.392	0.433	0.471
150m	Below 52m depth : Sand with 10m sublayers	0.158	0.277	0.291	0.349	0.411	0.451	0.467
100m	Below 52m depth : Consecutive sand and clay layers (5m sand and 10m clay)	0.185	0.337	0.363	0.441	0.527	0.599	0.655
100m	Below 52m depth :Clay with 10m sublayers	0.185	0.347	0.370	0.452	0.545	0.617	0.670
100m	Below 52m depth : Sand with 10m sublayers	0.190	0.344	0.369	0.448	0.527	0.587	0.642
52m	As at idealized profile	0.203	0.372	0.397	0.481	0.571	0.635	0.687
30m	As at idealized profile up to 30 m depth	0.210	0.385	0.412	0.496	0.595	0.664	0.718

The above results have shown that there are many factors effecting peak ground acceleration. However, the most important of all is bedrock depth. And this can be clearly seen in Figure 3.8.

The effect of bedrock acceleration on PGA can also be seen in Figure 3.8. Although it is not as affective as the bedrock depth and acceleration, the effect of stratification can also be figured out in Figure 3.8. Moreover, the similarity of the curves between the median relation curve proposed by Idriss (1990) and the curve for the 150 meters bedrock depth is conspicuous.

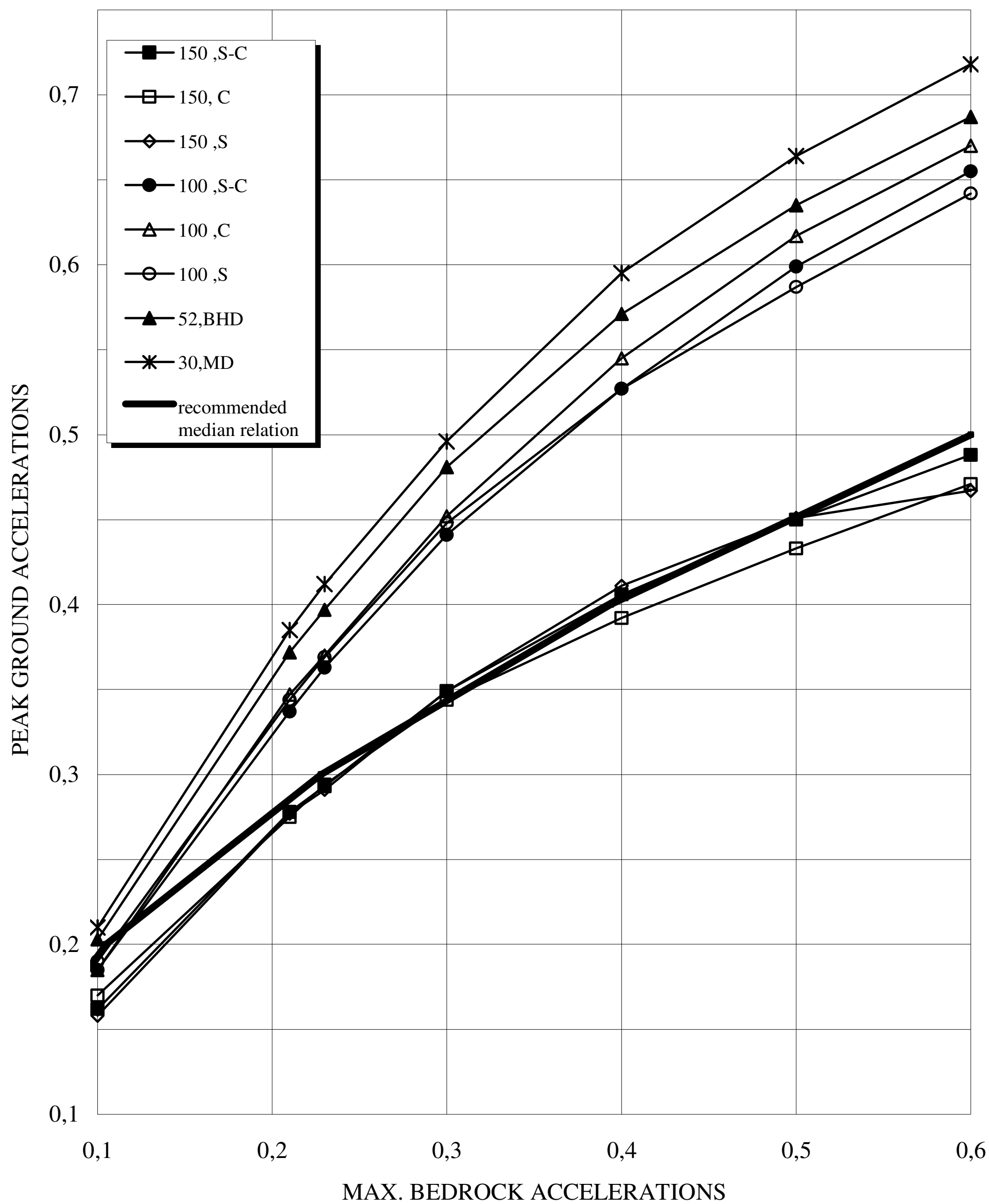


Figure 3.8 Peak ground accelerations vs. max. bedrock accelerations for different bedrock depth and layering conditions at Location 3

The common point in the result of all analyses is that, the surficial layer has a relatively big enlarging affect on surface acceleration. Although, amplification largely depends on the bedrock depth and stratification; the enlarging affect of the surficial layer can be seen in all kinds of soil conditions and bedrock depths.

In order to see its affect, the SPT-N value of the surficial fill layer has been increased from 11 to 30, and its unit weight has been increased from 17.7 kN/m^3 to 20.5 kN/m^3. The EERA program has been run for each increase separately and the data input and result pages are presented in Figure 3.9 and Figure 3.10.

Results presented in Figure 3.9 and Figure 3.10 depicts that surface acceleration decreases from 0.57g to 0.48 g when the strength of the surficial fill layer is increased. Hence, amplification affect of surficial layer can be decreased by increasing its strength.

It is seen that the amplification deriving from the surficial layer partly results from the geotechnical parameters of that layer. Moreover, ascertaining the effect of the calculation layers' (sublayer) thickness could be efficacious. In order to effectuate this, the first 10 m. thickness of the idealized profile has been divided into 1 m. sublayers and the results were compared with the previous results. This comparison has been given in Figure 3.11.

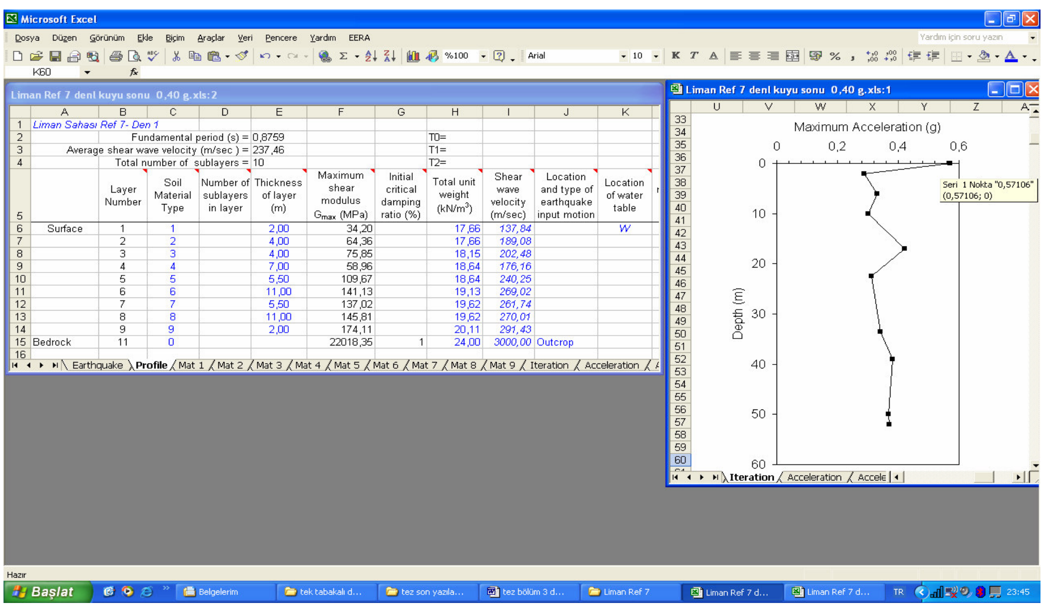


Figure 3.9 EERA Profile Worksheet and Max. Acceleration Graph for the Idealized Soil Profile at Location 3

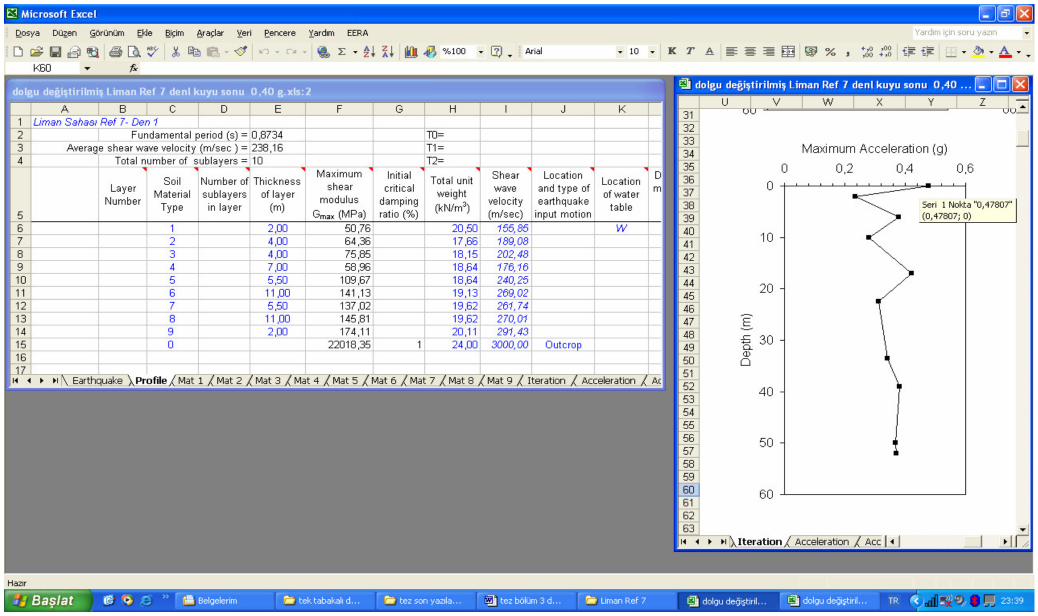
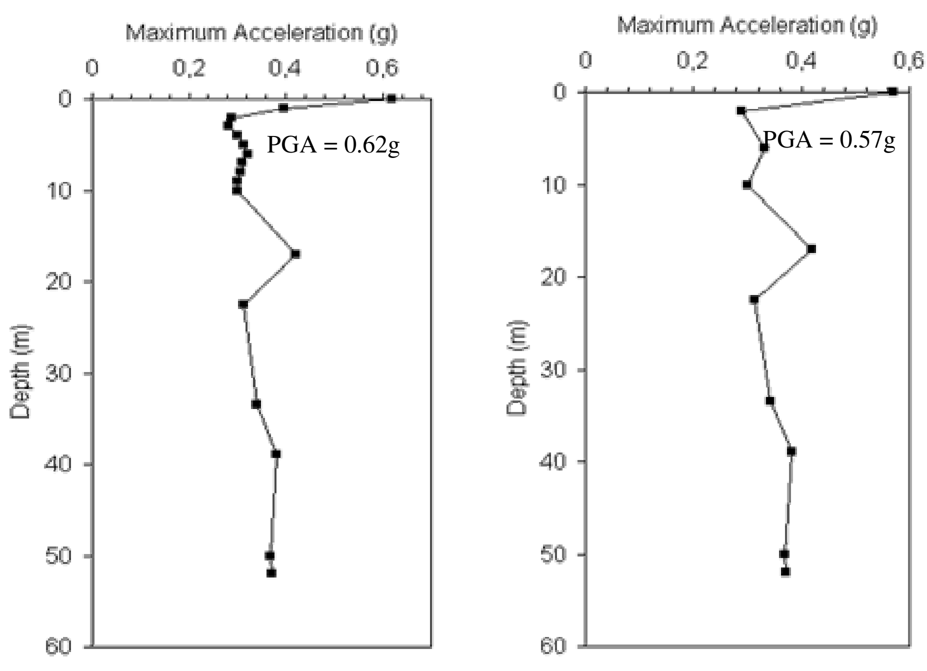


Figure 3.10 EERA Profile Worksheet and Max. Acceleration Graph for the Idealized Soil Profile with Stabilized Fill Layer at Location 3



(a) (b)

Figure 3.11 Effect of sublayer thickness on PGA at Location 3 : (a) fine sublayering with 1 m (b) no sublayer

As it can be seen in Figure 3.11 there is an increasing effect of fine layering on the peak ground acceleration. However, this effect is not as big as the effects of bedrock depth and stratification.

The effect of soil type has also been investigated. One type of soil (clay or sand) has been assumed for 100 m. and 150 m. bedrock depths. In order to observe the effect of sublayer thickness, two different sublayer thicknesses (5 m. and 10 m.) have been taken into account. The geotechnical parameters of these soils have been derived by considering the properties of the idealized profiles in the location 3. The results of these analyses have been given in Table 3.10 and Figure 3.12

Table 3.10 Estimated peak ground accelerations for bedrock depth ,layering and soil type variations

Depth of Bedrock	Assumed Layering	Max. Bedrock Acceleration						
		0.10	*0.21*	*0.23*	*0.30*	*0.40*	*0.50*	*0.60*
150m	Sand with 10m sublayers	0.151	0.283	0.300	0.370	0.452	0.509	0.558
	Sand with 5m sublayers	0.169	0.320	0.342	0.422	0.511	0.573	0.629
100m	Sand with 10m sublayers	0.167	0.308	0.328	0.407	0.480	0.538	0.591
	Sand with 5m sublayers	0.187	0.349	0.374	0.462	0.543	0.612	0.670
150m	Clay with 10m sublayers	0.200	0.300	0.309	0.337	0.361	0.375	0.377
	Clay with 5m sublayers	0.207	0.331	0.347	0.392	0.438	0.460	0.462
100m	Clay with 10m sublayers	0.202	0.316	0.335	0.379	0.417	0.419	0.407
	Clay with 5m sublayers	0.211	0.335	0.350	0.413	0.473	0.492	0.481

By looking at the results given in Table 3.10 and Figure 3.12, following conclusions can be made. After analyzing the profiles with the same bedrock depth and the same soil types; smaller sublayer thickness resulted in larger peak ground acceleration value supporting the previous finding that the calculation layer thickness effects the surface acceleration. This increase in clay soils accrues from 5% to 20% depending on the bedrock acceleration. However, for sand soils in an average of % 12 increase has been observed which is independent from bedrock acceleration.

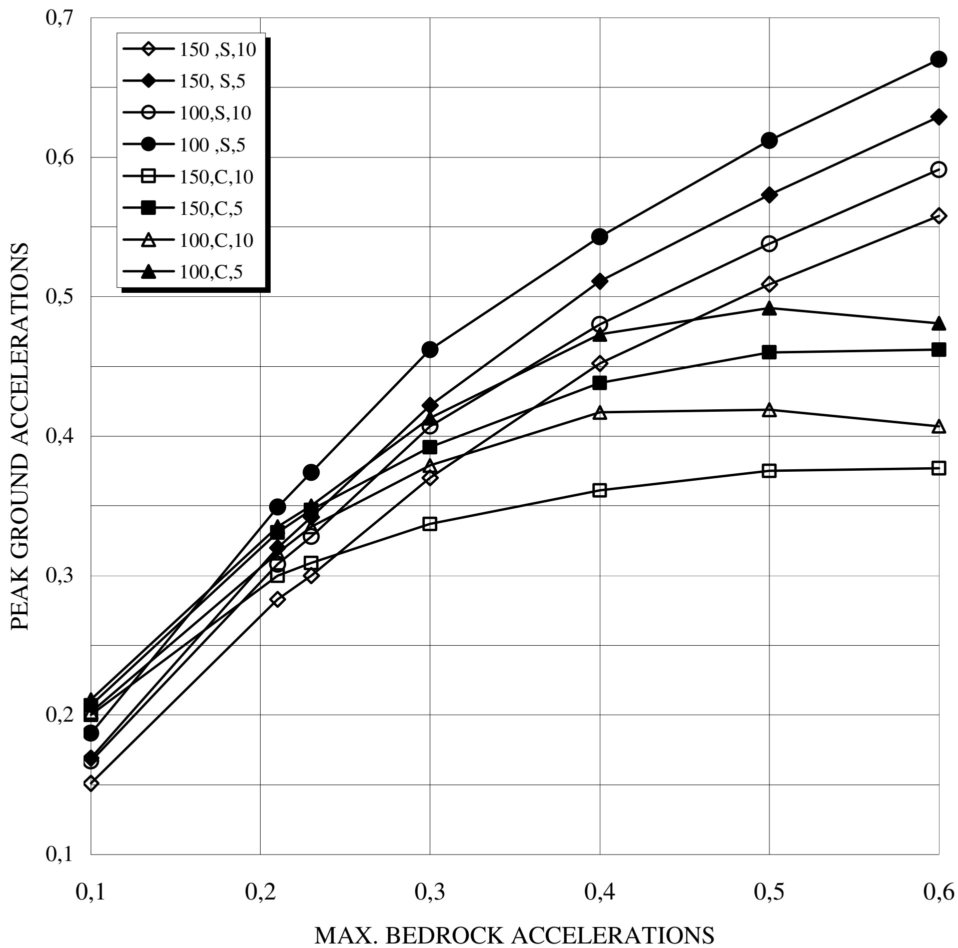


Figure 3.12 Graph of peak ground accelerations vs. peak bedrock accelerations for bedrock depth, layering and soil type variations

In the case of sand, the peak ground acceleration increases with an increase in the maximum bedrock acceleration. On the other hand, peak ground acceleration increases up to 0.4 g and then remains more or less constant for clay type soil.

As a result, all these analyses have shown that peak ground acceleration has been affected by many parameters. These parameters are the bedrock depth, maximum bedrock acceleration and soil stratigraphy. It has been seen that, without determining all these factors, it is not possible to run a clear site response analysis

3.5.2 Site Response Analysis and Findings

In addition to the effect of bedrock depth; soil type, layer thickness and bedrock acceleration have important affects on the surface acceleration. When conducting a site response analysis, it is essential to know the bedrock depth and the stratification up to the bedrock.

A minimum 30 meters of bedrock depth has been accepted for the analysis related with the study area. In the locations where the depths of idealized profiles are greater than 30 meters the bedrock is assumed to be at the end of the borehole.

In the locations 2,6,7 and 10 where the idealized profiles are somewhat shallower than 30 m the profiles has been extended to 30 m.

Site response analyses have been made for all locations by using EERA computer program for 1977 Izmir Earthquake (M=5.3), Izmir Scenario Earthquake (M=6.5) and 2005 Urla Earthquake (M=5.9). The results obtained from the site response analyses (peak ground accelerations, max bedrock accelerations, amplifications of ground acceleration, max spectral ground accelerations, max spectral bedrock accelerations, amplifications of spectral ground acceleration, fundamental periods of soil deposit and fundamental periods of earthquake) and the information about the locations has been presented in Appendix D.

The peak ground accelerations and amplifications at the related locations have been presented in Figure 3.13 and Figure 3.14, respectively, as scatter diagrams.

The distance of the epicenter of the earthquake to the study area has a dramatic effect on peak ground acceleration. The earthquake with the highest magnitude in the closest position in terms of epicenter gives the highest value of peak ground acceleration (Figure 3.13). It is interesting to note that, the calculated peak ground acceleration values of 1977 Izmir Earthquake (M=5.3 and r_{jb}=1 km) and Izmir Scenario Earthquake (M=6.5 and r_{jb}=13 km) are almost identical.

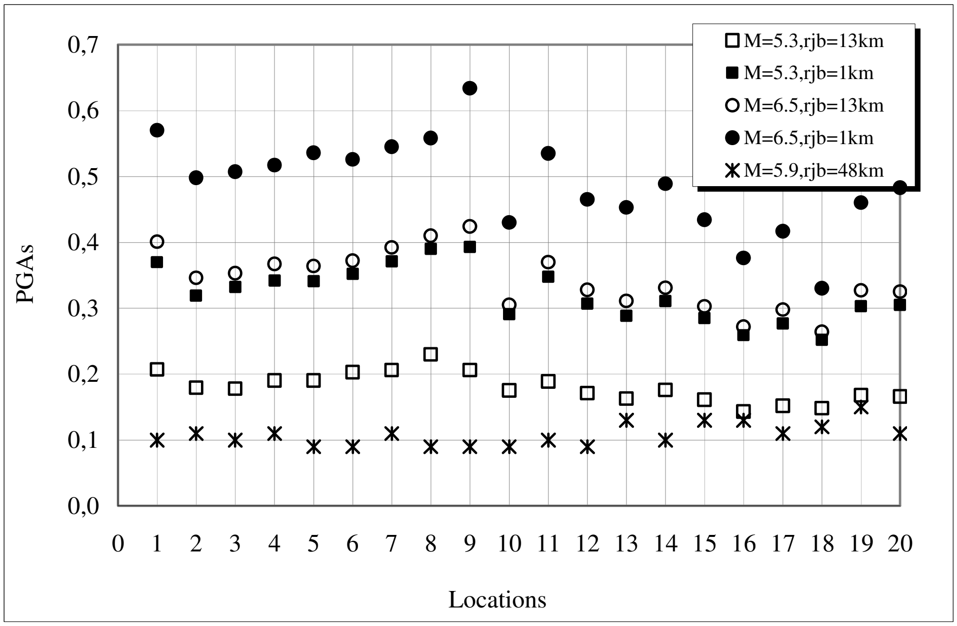


Figure 3.13 Peak ground accelerations vs. locations at the study area

The peak ground acceleration values calculated via the use of Izmir Scenario Earthquake (M=6.5, r_{jb}=1) for the study area has a maximum value of 0.63g, a minimum value of 0.33g, and an average of 0.49g. This average value of the peak ground acceleration (0.49 g) is bigger than the value stated by the national earthquake regulation (0.40g).

Location based distribution of peak ground acceleration amplifications from the site response has been presented in Figure 3.14. An increase of maximum bedrock acceleration results in a decrease of peak ground acceleration amplification for the study area. The average of the peak ground acceleration amplifications calculated for the 2005 Urla Earthquake (M=5.9, r_{jb}=48 km) is 3.6. However, this value decreases to 1.2 for Izmir Scenario Earthquake (M=6.5, r_{jb}=1 km).

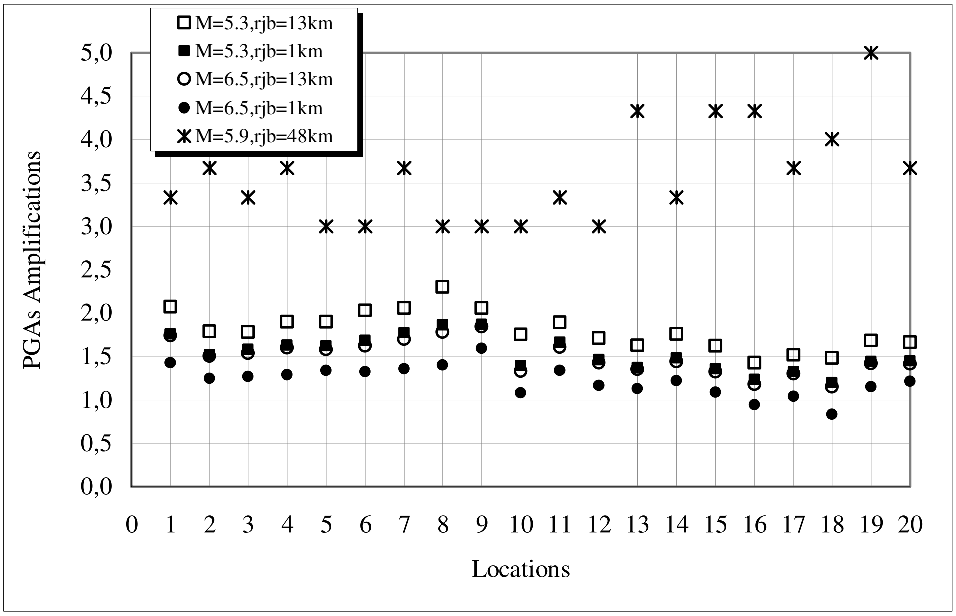


Figure 3.14 Peak ground accelerations amplifications vs. locations at the study area

The distribution of calculated maximum spectral accelerations has been given in Figure 3.15. The highest spectral acceleration value belongs to the earthquake with highest magnitude and closest epicentral distance as in the case of peak ground acceleration. Moreover, when the maximum bedrock acceleration values decrease, the spectral acceleration values also decrease.

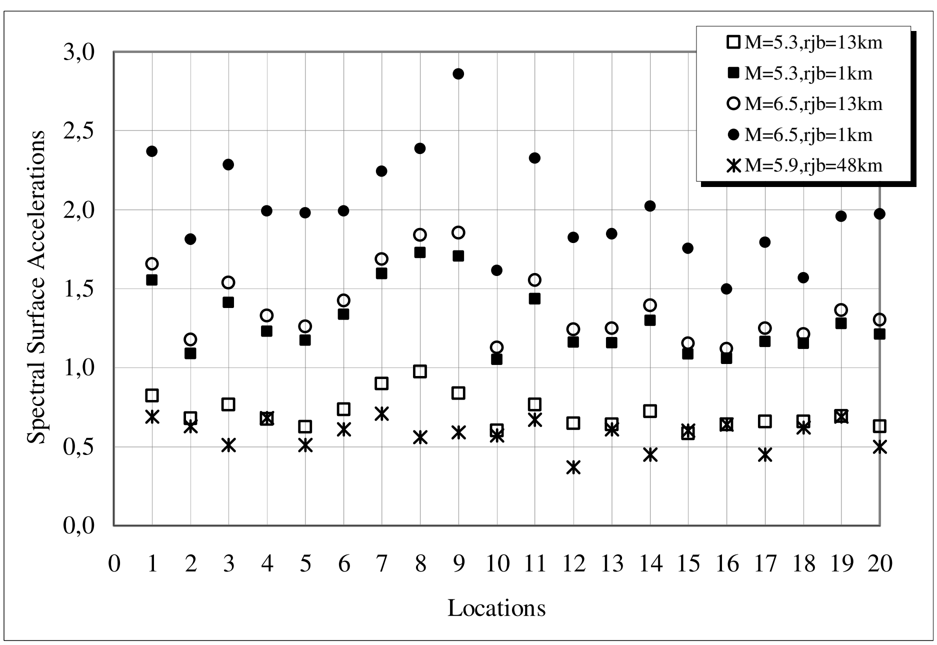


Figure 3.15 Peak ground spectral accelerations vs. locations at the study area

The distribution of maximum spectral acceleration amplifications calculated for the subject matter earthquakes has been given in the Figure 3.16. It can be seen that there are similar results to the ones given in Figure 3.14.

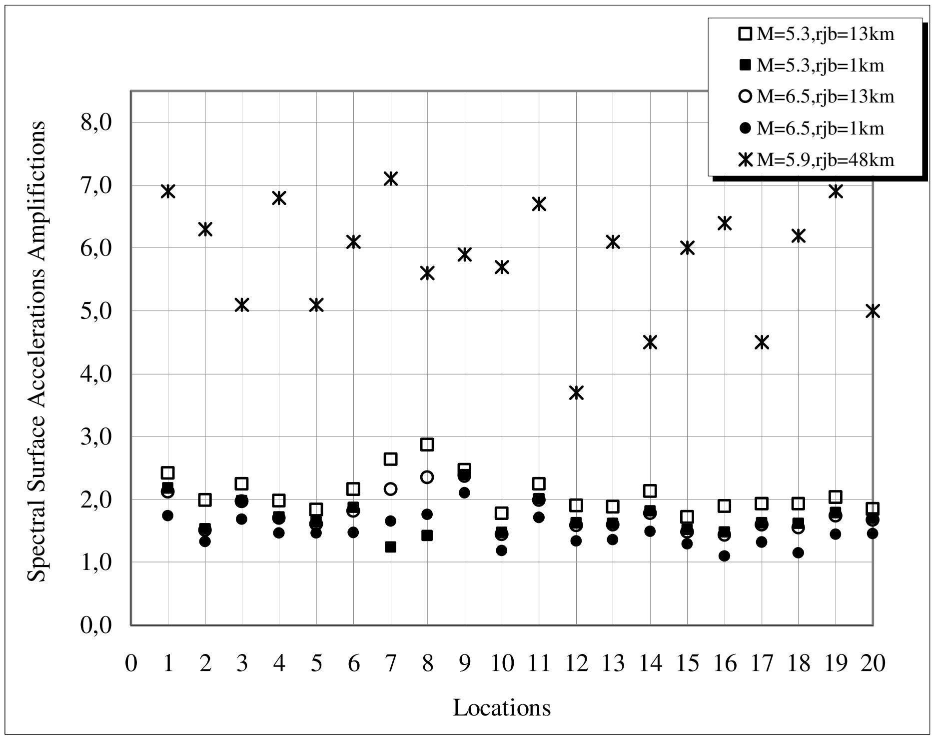


Figure 3.16 Peak ground spectral accelerations amplifications vs. locations at the study area

It can be seen that increase in maximum bedrock acceleration decreases the maximum spectral acceleration amplifications for the study area. However, in this graph (Figure 3.16) the amplification values have been seriously affected from the epicentral distance of the earthquake. For example the average of calculated maximum spectral acceleration amplification for the 2005 Urla Earthquake (M=5.9) was 5.8; however, this value is 1.5 in the Izmir Scenario (M=6.5) earthquake whose epicentral distance is 1 km far from the study area.

It is also aimed to show the distribution of all the values according to the locations and draw the isoline in order to get them ready to be used in future studies. However, the values obtained from the site response analyses have a random distribution over the study area and it has not been possible to create an isoline plan.

The amplification factors and the peak ground acceleration for the 1977 Izmir (M=5.3), Izmir Scenario (M=6.5) and 2005 Urla (M=5.9) earthquakes have been put on the maps and the distributions of these values over the study area have been given in Appendix E.

CHAPTER FOUR
LIQUEFACTION ANALYSES

4.1 Liquefaction

Liquefaction is, one of the most important, complex and controversial topic of the geotechnical earthquake engineering. Various researchers have proposed different terminologies, procedures and analysis methods on liquefaction (Kramer, S. L. 1996).

Liquefaction is the state of "granular materials showing liquid features" because of the increase of excess pore water pressure and decrease in effective stress. In saturated granular soils and in poor drainage conditions with the effect of cyclic shear deformation the pore water pressure increases. This increase in pore water pressure results in a decrease in effective stress and under these conditions it causes a decrease in shear strength. The reduction of the shear strength may cause the solid material behave like liquids that is named as liquefaction (Youd, T. L et al. 2001).

Liquefaction can influence the nature of ground surface motions. Flow liquefaction can produce massive flow slides and contribute to the sinking or tilting of heavy structures, the floating of light buried structures, and to the failure of retaining structures. Cyclic mobility can cause slumping of slopes, settlement of buildings, lateral spreading, and retaining wall failure (Kramer, S. L.1996).

In the study area the ground water level is high and the soil profile consists of generally consecution of cohesive and granular soil layers. This consecutive formation will affect the drainage conditions negatively in the case of an earthquake. These conditions make it essential to determine the liquefaction potential at the study area which is really important in the scope of geotechnical earthquake engineering.

4.2 Factors Affecting Liquefaction Potential

In the previous studies many researchers presented that there are several definite factors which affect the liquefaction potential. The primal of these factors are geological age and origin, fines content, plasticity index, saturation, depth below ground surface, and soil penetration resistance (Kavazanjian, E. et al.1997). In addition to these there are some opinions on the soil conditions where the liquefaction can occur and the factors which can affect the liquefaction potential. Some of the major thoughts are:

In the "loose to medium dense granular soils" if the normalized standard penetration test (SPT) blow counts $(N_1)_{60}$ are below 30 then there is liquefaction potential (T. L. Youd, I. M. Idriss, 2001).

In the cases where the ground water level is in 10 m. depth below the surface, it is needed to determine the liquefaction potential for the D group soils. Here, the D group soils are defined as loose sand whose SPT-N value is below 10 and the relative density is smaller than 35% or soft clay and silty clay whose SPT-N values are smaller than 8 and unconfined compressive strength (q_u) is smaller than 100 kPa (DBYBHY,2007).

It is stated that liquefaction may occur in the soils having less than 15% fines (by weight), whose liquid limit is less than 35%, degree of saturation is more than 80% and corrected standard penetration resistance is below 30. It is cited that the liquefaction potential should be determined up to 30 m. depth; however, in case of the shallow foundations 15 m. depth will be satisfactory (Kavazanjian,E. et al.1997).

In addition to this; there have been recent publications on which the liquefaction potential may occur in fine grained soils depending on the water content, plasticity index and liquid limit (Figure 4.1) (R.B.Seed, et al. 2003).

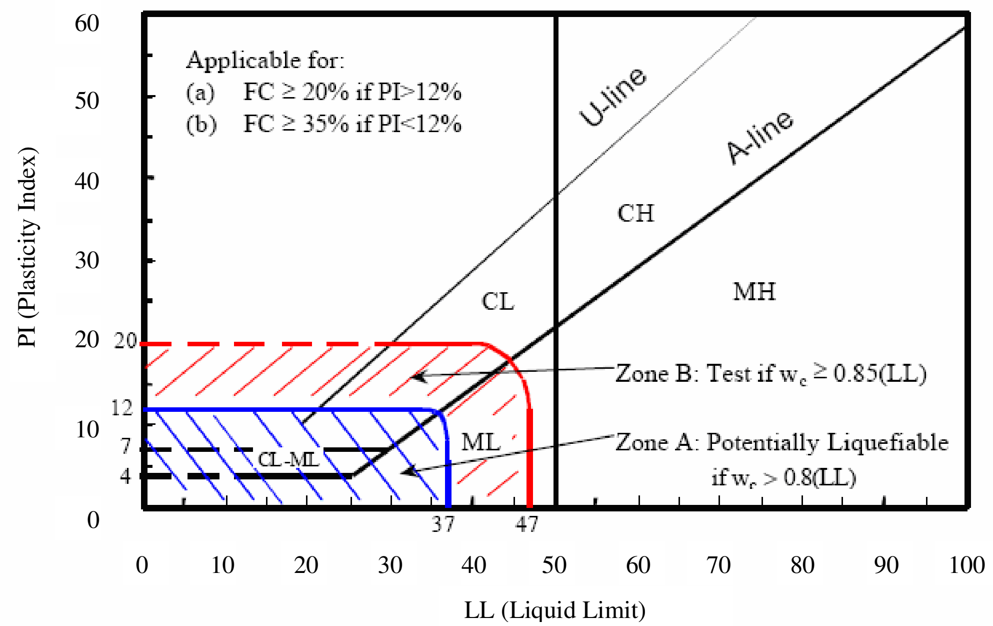


Figure 4 .1 Recommendations Regarding Assessment of Liquefiable Soil Types (Seed, R B. et al. 2003)

Liquefiable soil types presented in Figure 4.1 have the following parameters:

Zone A: soils in this zone ($w_L \leq 37$, $Ip \leq 12$, $w > 0.8w_L$ and $FC \geq 35\%$) are considered potentially susceptible to "classic" cyclically induced liquefaction

Zone B: These soils ($37 \leq w_L \leq 47$, $12 \leq Ip \leq 20$, $w > 0.85w_L$ and $FC \geq 20\%$) may be liquefiable

Zone C: soils in this zone ($w_L \geq 47$, $Ip > 20$) are not generally susceptible to 'classic' cyclic liquefaction, but should be checked for potential sensitivity (loss of strength with remoulding or monotonic accumulation of shear deformation) (Seed, R B. et al. 2003)

4.3 Evaluation of Liquefaction Potential

Primarily, two parameters should be known in order to evaluate the liquefaction potential. The first one is the seismic demand on a soil layer (CSR: cyclic stress ratio) and the other is the capacity of the soil to resist liquefaction (CRR: cyclic resistance ratio) (T. L. Youd, I. M. Idriss, 2001).

The toleration rate of soil's cyclic resistance ratio to the cyclic stress ratio displays its liquefaction potential. The CSR parameter is calculated with the help of the Formula 4.1.

$$CSR = (\tau_{av} / \sigma'_{vo}) = 0.65\ (a_{max}/g)\ (\sigma_{vo}/\sigma'_{vo})\ r_d \qquad (4.1)$$

Here a_{max} is maximum surface acceleration, g is gravitational acceleration; σ_{vo} is total overburden stress; σ'_{vo} is effective overburden stress and r_d is stress reduction coefficient. The stress reduction coefficients can be calculated with following expressions (Youd, T.L., Idriss, I.M., 2001).

$$r_d = 1.0 - 0.00765\ z \qquad \text{for } z \le 9.15 \text{ m} \qquad (4.2a)$$

$$r_d = 1.174 - 0.0267\ z \qquad \text{for } 9.15 < z \le 23 \text{ m} \qquad (4.2b)$$

Here, z is the depth from the ground surface.

Cyclic resistance ratio on the other hand can be calculated with soil resistance obtained by various in situ tests such as SPT (standard penetration test), CPT (cone penetration test), Vs (shear wave velocity measurements), and BPT (Becker penetration test). In this study, the soil penetration resistance is determined via SPT. In the calculation of cyclic resistance ratio for the M= 7.5 earthquake Formula 4.3 was used which is in terms of SPT blow count.

$$CRR_{7.5} = 1 / (34 - (N_1)_{60}) + (N_1)_{60} / 135 + 50 / [10^*(N_1)_{60}+45]^2 - 1 / 200 \qquad (4.3)$$

This equation is valid for $(N_1)_{60} < 30$. For $(N_1)_{60} \ge 30$, clean granular soils are too dense to liquefy and they are classed as non-liquefiable (Youd, T.L., Idriss, I.M., 2001). Formula 4.3 has been developed for clean sands and in the case of soils having some fine content the following corrections should be made (Youd, T.L., Idriss, I.M., 2001).

$$(N_1)_{60cs} = \alpha + \beta\ (N_1)_{60} \tag{4.4}$$

In this formula α and β coefficients are calculated as:

$\alpha = 0$	for $FC \leq 5\%$	(4.5a)
$\alpha = \exp\ [1.76 - (190 / FC^2)]$	for $5\% < FC < 35\%$	(4.5b)
$\alpha = 5.0$	for $FC \geq 35\%$	(4.5c)
$\beta = 1.0$	for $FC \leq 5\%$	(4.5d)
$\beta = [0.99 + (FC^{1.5} / 1000)]$	for $5\% < FC < 35\%$	(4.5e)
$\beta = 1.2$	for $FC \geq 35\%$	(4.5f)

In addition to these corrections, there are other SPT correction factors as given in Table 3.3. After these corrections the standard penetration resistance is named as corrected standard penetration resistance and formulated as ($(N_1)_{60}$);

$$(N_1)_{60} = N_m * C_N * C_E * C_B * C_R * C_S \tag{4.6}$$

Where N_m is standard penetration resistance, C_E is correction for hammer energy ratio, C_B is correction factor for borehole diameter, C_R is correction factor for rod length, and C_S is correction for sampler with or without liners, C_N is a factor to normalize N_m to a common reference effective overburden stress. C_N is commonly estimated from the following equation and the value of C_N should not exceed 1.7.

$$C_N = (P_a / \sigma'_{vo})^{0.5} \tag{4.7}$$

Where P_a is atmospheric pressure and σ'_{vo} is effective vertical overburden pressure.

In the cyclic resistance ratio calculation stated above the magnitude of the earthquake is M = 7.5. In the cases when the magnitude of the earthquake is different than 7.5 the magnitude scaling factors (MSF) should be used. The magnitude scaling factors (MSF) are presented in Table 4.1. (Youd, T.L., Idriss, I.M., 2001).

Table 4.1 Magnitude Scaling Factor defined by Idriss (Youd, T.L., Idriss, I.M., 2001)

Magnitude (M)	MSF
5.5	2.20
6.0	1.76
6.5	1.44
7.0	1.19
7.5	1.00
8.0	0.84
8.5	0.72

As a result, after the calculation of the needed two parameters in order to evaluate the liquefaction potential of soils, the liquefaction potential is designated with a safety factor value with the use of following Formula 4.8.

$$FS = (CRR_{7.5} / CSR) * MSF \quad (4.8)$$

In the cases where this ratio is smaller than 1, it is said that the soil has a potential for liquefaction.

4.4 Liquefaction Analyses and Liquefaction Potential of the Study Area

It is obligatory for all the structures which will be constructed in Turkey to comply with the national earthquake regulation. In the cases where the ground water level is in 10 meters below the ground surface, it is needed to determine the liquefaction potential (DBYBHY, 2007).

The ground water level in the study area varies in between 1.00 m. to 6.50 meters from the surface. In this case there is a risk of liquefaction potential in the study area and there is a need of liquefaction analysis.

The liquefaction analysis will be done based on the SPT-N values. Since SPT tests present varying results depending on soil type and depth, it is decided to perform the liquefaction analysis for every boring separately.

It has been proposed to apply the liquefaction analysis down to 15 m. depth (Youd,T.L., Idriss, I.M.2001). Because of this, it is accepted to run the liquefaction analyses down to 15 m. depth for the 81 boring positions in the study area. However, in the construction of Konak-Alsancak Shore Road Fill, the sea has been filled to the elevation of +2.00 m. It has been taken into consideration that the existing geotechnical data have been collected before the construction of the road fill and the analyses have been held for the soil below the surface including the fill layer in 15 meters.

In order to determinate the liquefaction potentials of the soil first of all the CSR (cyclic resistance ratio) values should be calculated. The CSR value is the ratio of average shear stress to the effective vertical stress. In the cases where the average shear stress cannot be determined, the CSR value can be calculated by using the Formula 4.1 depending on the peak ground acceleration.

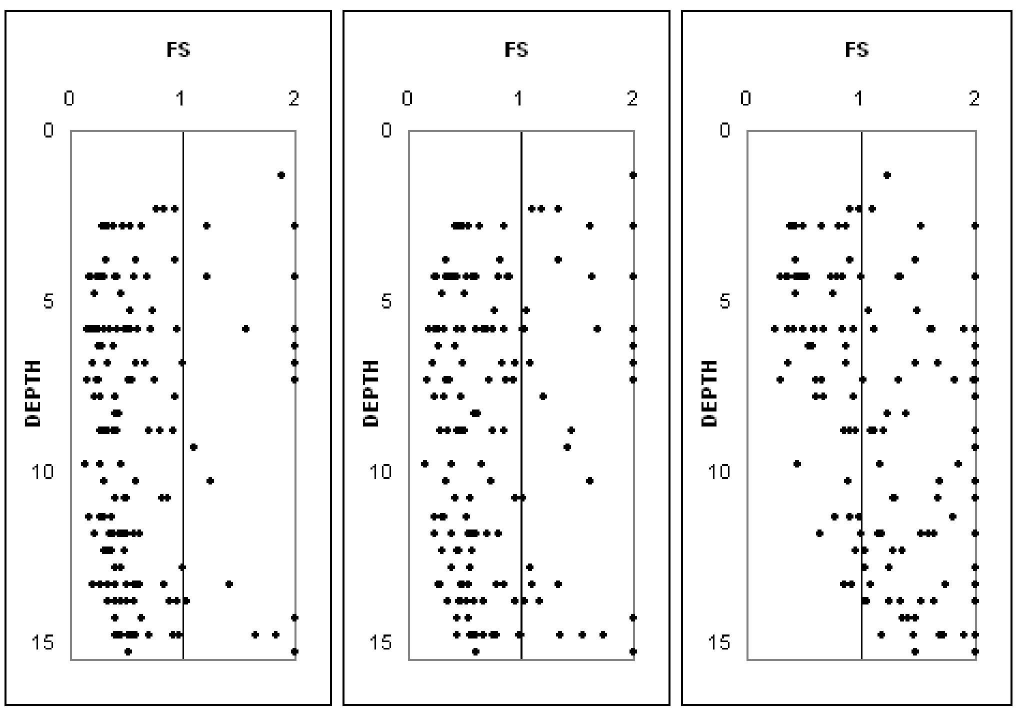
In this case the CSR can be calculated either by using the average shear stress or peak ground acceleration. Moreover, in the cases where the peak ground acceleration cannot be calculated, this value is accepted as 0.40 g according to the national earthquake regulation.

In this study all of the above mentioned three methods have been used, in order to see the effects of the peak ground acceleration values on factor of safety of liquefaction and to expose how the use of the average shear stress values affects the results.

Liquefaction analyses have been done for the soils at 160 SPT test points with the three different methods given above. The factor of safety versus depth graphs are given in Figure 4.2.

The total number of points displaying liquefaction risk in the analyses made by using the PGA, the national earthquake regulation value (0.40 g) or average shear stresses from EERA have been determined to be 135, 123 and 62, respectively. It can be said that there is a general liquefaction risk in the study area. This can clearly be seen in Figure 4.2.

Following results can be concluded from Figure 4.2. There is liquefaction risk at all depths. However, in 3 ~ 8 and 12 ~ 15 meter depth intervals, liquefaction potential is higher. In addition to this, in the analyses done by using the average shear stress values, liquefaction potential decreases with depth and on contrary to the other two methods the liquefaction risk markedly decreases below 8 meters.



(a) (b) (c)

Figure 4.2 Scatter diagrams of safety factors of liquefaction analyses by using : (a) PGA, (b) ground surface acceleration value stated by the national earthquake regulation (0.40g), (c) average shear stress value.

As it has been expected, liquefaction factor of safety increase with a decrease in peak ground acceleration. On the other hand, use of average shear stress values resulted noticeable decrease in the liquefaction potential. It will not be wrong to say that this result is related to the stress reduction coefficient (r_d) given in the Formula 4.1. This result shows that the stress reduction coefficient has a great affect on the results of the liquefaction analysis.

The stress reduction coefficient is actually a function of earthquake magnitude, intensity of shaking, and site stiffness with the depth (Seed,R.B. et al., 2003).

The results of the liquefaction analysis by the above mentioned three methods with FS (factor of safety) < 1 have been presented in Appendix F.

The fine grained soils within the upper 15 m. have been classified using Figure 4.1. There are 128 fine grained soil samples from SPT tests to be taken into account in terms of this classification. The distribution of number these soil samples into zones C, B and A are 104, 17 and 7, respectively.

Liquefaction analysis has been done with the peak ground acceleration values (by the method given in section 4.3) for the soil samples in Zone B and Zone A. In 23 cases out of 24 the liquefaction safety factor is smaller than 1. This classification and the results of the liquefaction analyses for the fine grained soils are presented in Appendix G.

CHAPTER FIVE
RESULTS & CONCLUSIONS

The aim of this study is to investigate the soils of south eastern coast of Izmir Bay which has a dense urban settlement and important coastal structures, in the frame of geotechnical earthquake engineering.

In the scope of this thesis study, geological and geotechnical reports which are prepared by either private firms or governmental institutions, and subjects the study area have been collected. A data bank has been formed by making use of these reports.

The distribution of the boring locations gathered from the investigation reports to the study area has been determined. By evaluating their positions and contents of these borings 20 idealized soil profiles have been prepared.

One dimensional dynamic site response analysis and liquefaction analyses have been performed using idealized soil profiles and soil properties.

In the site response analyses, the Izmir Fault has been chosen as the critical earthquake source. Contents of 1977 Izmir Earthquake (M=5.3), Izmir Scenario Earthquake (M=6.5) and 2005 Urla Earthquake (M=5.9) have been analyzed as the reference, scenario and critical long distance earthquakes, respectively.

One dimensional dynamic soil behavior analyses have been done by using the EERA computer program which is based on equivalent linear method. Since there are no concrete data about the depth of the bedrock in the study area, several presuppositions have been made. Dynamic soil behavior analyses have been done beforehand in a selected location with these presuppositions.

In these analyses it has been seen that the peak ground acceleration is affected by several parameters. These are bedrock depth, maximum bedrock acceleration, and soil stratigraphy. It has been understood that, without determining these factors, it is not possible to conduct a reliable site response analysis.

The lack of the bedrock depth results in the deficiency of favorable results in terms of both amplification and peak ground acceleration values. Required minimum 30 m. depth of soil to be taken into account in the analysis has been provided and bedrock depth has been assumed to be at the bottom of borehole.

Results of the site response analyses revealed that the peak ground acceleration and the amplification factor values are randomly scattered in the study area and it was not possible to draw a contour map.

The peak ground acceleration and the amplification values for the subject matter earthquakes obtained are summarized below.

For the reference earthquake (1977 Izmir Earthquake, M=5.3) with an epicenteral distance of 13 km., the peak ground acceleration values is in the interval of 0.14 ~ 0.29 (g), and the amplification values change between 1.4 ~ 2.1. For the same earthquake, with an epicenteral distance of 1 km to the study area, the peak ground acceleration and the amplifications values have been determined to be in the intervals of 0.25 ~ 0.39 (g), and 1.2 ~ 1.9, respectively.

For the Izmir Scenario Earthquake (M=6.5) with an epicenteral distance of 13 km., the peak ground acceleration values are between 0.26 ~ 0.42 (g), and the amplifications are between 1.2 ~ 1.8. For the same earthquake, with an epicenteral distance of 1 km to the study area, the peak ground acceleration the amplifications values change between 0.33 ~ 0.63 (g), and 0.8 ~ 1.6, respectively.

For the critical long distance earthquake (2005 Urla Earthquake, M=5.9) the peak ground acceleration values change between 0.09 ~ 0.15 (g), and the amplification values change between 3.0 ~ 5.0.

The earthquake with the highest magnitude and the closest epicenter position resulted the highest value of peak ground acceleration. The distance between the epicenter of the earthquake and the study area dramatically affected the value of peak ground acceleration. In relation with peak ground acceleration value, the Izmir Scenario Earthquake (M=6.5, r_{jb}=1km) can be accepted as the project earthquake for the study area. Site response analysis with this earthquake resulted the highest peak ground acceleration value as 0.63g. The lowest and the average values are 0.33g and 0.49g, respectively. It is noticeable that the average value is above the 0.40g value of the national earthquake regulation.

Analyses revealed that an increase in maximum bedrock acceleration results in a decrease in peak ground acceleration. For the distant epicentered Urla Earthquake (M=5.9, r_{jb}=48km) the average of the peak ground acceleration amplifications is 3.6. On the other hand, the close epicentered Izmir Scenario Earthquake (M=6.5, r_{jb}=1km) this value is calculated as 1.2. However, although the peak ground acceleration amplification values of the distant epicentered earthquake is higher than the close epicentered earthquake; the peak ground acceleration values of this earthquake are very lower than the values of the close epicentered earthquake.

In the site response analyses it has been seen that an increase in bedrock depth resulted in a decrease in peak ground acceleration. Because of absence of depth data, bedrock is accepted to be at the bottom of the soil profile. But, in the case that the bedrock is in 100 ~ 150 m. depth interval, lower surface acceleration values than the ones obtained with this study may be expected.

It has been observed that not only bedrock depth but also soil stratigraphy, bedrock acceleration and even thickness of layers have important effects on surface acceleration. Results of a site response analysis will be more realistic if one has detailed information for bedrock depth, stratigraphy and soil properties.

Another finding is on the liquefaction potential of the study area. In the scope of this study, the liquefaction analyses based on the SPT-N values are made for each boring locations separately. The liquefaction analyses are made for the saturated sandy layers and non plastic silt layers within upper 15 meter depth. Fine grained soils that have a risk of liquefaction, have also been detected by taking into consideration the latest proposal in the literature.

The liquefaction analyses based on the SPT-N values are done by three different methods. In these analyses, the “PGA” and the “average shear stress” values obtained from the site response analyses, and the peak ground acceleration value (0.40g) proposed in the national earthquake regulation are used.

Liquefaction risk is seen at all the depths below ground water table. However; liquefaction potential is higher in 3 ~ 8 and 12 ~ 15 meter depth intervals. In the analyses done by using the average shear stress values, it can be observed that, the liquefaction potential decreases with depth and on contrary to the other two analysis methods the liquefaction risk dramatically decreases below 8 meter depth.

Liquefaction analyses revealed that the liquefaction potential in the study area is high. On the other hand, the liquefaction safety factor values vary according to the method in use. The liquefaction safety factor values obtained by using the average shear stresses are the highest.

As a result there is liquefaction risk in the study area and the calculated peak ground accelerations are somewhat above the value (0.40 g) proposed in the national earthquake regulation.

It is necessary to take precautions for avoiding liquefaction for the projects which will be applied in this region.

It is also recommended that site response analyses should be done for the projects to be applied in this area. Calculated peak ground acceleration value should be used if it exceeds value (0.40 g) given in the national earthquake regulation.

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APPENDICES

APPENDIX A
SOIL INVESTIGATION DATA

Table A. Soil Investigation Data

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / Cu,$_T$ (kN/m^2)	e
Location 1												
1	1.50-1.95	8	SM			19.7		NP	79	15		
1	3.00-3.45	9										
1	4.50-4.95	14										
1	6.00-6.45	26	SW/SM			14.0		NP	71	10		
1	7.50-7.95	10										
1	9.00-9.45	16	SP/SM			28.6		NP	100	6		
1	10.50-10.95	7										
1	12.00-12.45	9										
1	13.50-13.95	11	CH			43.3	51	30	100	95		
1	15.00-15.45	14										
1	16.50-16.95	21	CL			26.2	34	14	100	96		
1	18.00-18.45	26										
1	19.50-19.95	31										
1	21.00-21.45	41	SC			10.6	28	15	75	29		
1	22.50-22.95	43										
1	24.00-24.45	45										
1	25.50-25.57	50										
1	27.00-27.45	41										
1	28.50-28.95	42										
1	30.00-30.45	41	SM			8.5		NP	86	36		
2	3.00-3.45	9	SP/SM			9.4		NP	98	8		
2	4.50-4.95	8										
2	6.00-6.45	12	SP/SM			12.0		NP		11		
2	7.50-7.95	10										
2	9.00-9.45	10	CL	1.76		41.2	37	19	100	84		
2	10.50-10.95	14										
2	12.00-12.45	16										
2	13.50-14.00		CH	1.75		36.0	64	36		96	22#	
2	14.00-14.45	21										
2	15.00-15.45	18										
2	16.50-16.95	24	CL	1.85		40.0	40	22	100	79		
2	18.00-18.45	31	SC	2.04		17.4	28	12	79	35		
2	19.50-19.95	31	SC			18.0	28	9		45		
2	21.00-21.45	35										
2	22.50-22.95	39	SM					NP	69	29		
2	24.00-24.45	42	CH	1.84		32.1	53	32	100	91		
2	25.50-25.59	50										
2	27.00-27.05	50										
2	28.50-28.95	38										
2	30.00-30.45	41	SM			20.5		NP	97	28		
3	1.50-1.54	50										
3	3.00-3.45	22	GP/GM			9.6		NP	53	11		
3	4.50-4.95	13										
3	6.00-6.45	14										
3	7.50-7.95	15	SM			21.0		NP		17		
3	9.00-9.45	7	CL	1.77		39.7	37	18	100	75		
3	10.50-10.95	10										
3	12.00-12.45	14	CL			42.9	48	25	100	98		
3	13.50-13.95	16										

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / Cu,$_T$ (kN/m^2)	e
3	15.50-15.95	13	CL	1.74		43.0	43	19	100	76		
3	16.50-16.95	18	CL			36.9	39	21	100	62		
3	18.00-18.45	37	SM			10.0		NP	62	20		
3	19.50-19.95	44	GM			8.0		NP		40		
3	21.00-21.23	50										
3	22.50-22.55	50										
3	24.00-24.07	50										
3	25.50-25.52	50										
3	27.00-27.45	26	CL	1.92		27.3	38	24	100	82		
3	28.50-28.95	28										
3	30.00-30.45	25										
3	31.50-31.95	25										
3	33.00-33.45	40	SC			10.0	27	13	77	41		
3	34.50-34.95	50	CL	1.95		24.1	40	23	95	74		
4	4.50-4.95	10	SP/SM			20.8		NP	99	9		
4	6.00-6.45	8	CL	1.75		36.0	39	20	100	79		
4	7.50-7.95	9										
4	9.00-9.45	12										
4	10.50-10.95	11										
4	12.50-12.95	15										
4	13.50-13.95	15										
4	15.00-15.45	16										
4	16.50-16.95	22	CL	2.01		23.2	27	14	100	63		
4	18.00-18.45	36	SC			12.7	22	9	65	18		
4	19.50-19.95	35	SC	2.02		23.7	28	13	99	40		
4	21.00-21.45	44										
4	22.50-22.95	50	SC	2.20		10.6	24	11	66	23		
4	24.00-24.07	50										
4	25.50-25.95	42										
4	27.00-27.45	45	CL			28.0	28	10	100	81		
4	28.50-28.95	46										
4	30.00-30.45	45	SM			17.6		NP	99	31		
5	4.50-4.95	10	SP/SM			17.7		NP	100	10		
5	6.00-6.50		CH	1.78		37.2	53	29	100	92		1.209
5	6.50-6.95	10	CL	1.84		39.8	42	22	100	92		
5	7.50-7.95	11										
5	9.00-9.50		CH	1.85		39.0	62	37		95	22#	
5	9.50-9.95	14										
5	10.50-10.95	13										
5	12.00-12.45	14										
5	13.50-13.95	18	CL			23.4	46	26	100	93		
5	15.00-15.45	22										
5	16.50-16.95	26	GC	2.04		20.3	31	16	74	49		
5	18.00-18.45	31	ML			22.0	31	6		79		
5	19.50-19.95	37										
5	21.00-21.45	36	SC			13.4	28	13	100	49		
5	22.50-22.95	45										
5	24.00-24.45	48	CL			14.0	26	7		64		
5	25.50-25.57	50										
5	27.00-27.04	50										
5	28.50-28.95	35										
5	30.00-30.45	37	CL			16.8	30	14	99	63		

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / Cu,$_T$ (kN/m^2)	e
6	6.00-6.45	13	SM			23.5		NP	99	22		
6	7.50-7.95	10	CL			44.7	45	26	100	91		
6	9.00-9.45	13										
6	10.50-10.95	12										
6	12.00-12.45	13										
6	13.50-13.95	14										
6	15.00-15.45	15										
6	16.50-16.95	16	CL			28.4	43	26	100	63		
6	18.00-18.45	25	SC			15.1	28	12	87	48		
6	19.50-19.95	29										
6	21.00-21.45	34	SM			8.9		NP	84	35		
6	22.50-22.95	38										
6	24.00-24.45	41	SC			16.6	29	16	81	35		
6	25.50-25.95	44	SC			14.1	29	16	81	25		
6	27.00-27.45	47	SC			10.6	23	9	86	39		
6	28.50-28.95	50										
6	30.00-30.45	50										
6	31.50-31.56	50										
6	33.00-33.11	50										
6	34.50-34.52	50										
7	6.00-6.45	7	SP/SM			20.8		NP	100	7		
7	7.50-7.95	9	CL			35.5	28	8	100	83		
7	9.00-9.45	12										
7	10.50-10.95	12										
7	12.00-12.45	16										
7	13.00-13.50		CL	1.88		34.1	42	23	100	83		
7	13.50-13.95	21										
7	15.00-15.45	21	SM	1.79		46.1	38	10	87	24		
7	16.50-16.95	21										
7	18.00-18.45	30										
7	19.50-19.95	34	SC			10.6	28	15	76	29		
7	21.00-21.45	40										
7	22.50-22.95	44	CL			18.1	31	16	98	58		
7	24.00-24.06	50										
7	25.50-25.55	50										
7	27.00-27.45	31	CL			25.3	32	18	100	79		
7	28.50-28.95	34										
7	30.00-30.45	39	SC			25.2	27	8	97	36		
8	4.50-4.95	8	SW			10.8		NP	99	3		
8	6.00-6.45	8										
8	7.50-7.95	9										
8	9.00-9.45	13										
8	10.50-10.95	15	CH			46.1	51	27	100	99		
8	12.00-12.45	17										
8	13.50-13.95	22	SM			27.6		NP	89	28		
8	15.00-15.45	24										
8	16.50-16.95	22										
8	18.00-18.45	30	SC			12.6	26	10	73	29		
8	19.50-19.95	32										
8	21.00-21.45	30										
8	22.50-22.95	31	GC			13.9	27	14	55	28		

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / $Cu_{,T}$ (kN/m^2)	e
8	24.00-24.45	32	CL			21.8	35	22	100	73		
8	25.50-25.95	34										
8	27.00-27.06	50										
8	28.50-28.95	38										
8	30.00-30.45	34										
Location 2												
1	7.50-7.95	20	SM			24.9		NP	100	17		
1	9.00-9.45	8	SM	1.81		30.1		NP	96	32		
1	10.50-10.95	14	SC	1.96		30.9	29	8	100	47		
1	12.00-12.45	13	SC	1.93		28.7	30	13	74	44		
1	13.50-13.95	7	CL	2.00		33.4	34	20	100	88	55*	
1	14.00-14.50		CL	1.83	2.63	37.0	40	24	100	97	30*	
1	15.50-15.95	7	CL	2.24		27.6	36	21	98	67		
1	17.00-17.45	48	SW-SP			9.9		NP	56	6		
1	19.00-19.45	50										
1	21.00-21.45	17	CL	2.27		18.8	33	18	96	62		
1	23.00-23.45	15	CL	2.18		19.2	33	19	82	46	65*	
1	25.00-25.45	50										
1	27.00-27.45	50	SC	2.45		9.9	23	8	75	24		
2	6.00-6.50		SM-SC			11.1		NP	72	9		
2	7.50-7.95	42	GW			12.6		NP	46	4		
2	9.00-9.45	11	SM			28.1		NP	98	18		
2	10.50-10.95	7	CL	1.88		35.0	34	18	100	77		
2	12.00-12.45	6	CL	1.59		34.4	45	22	96	74	44*	
2	13.00-13.50		ML	1.95		31.4		NP	100	62	55#	
2	14.00-14.45	16	CL	1.90		34.1	36	20	100	92	46*	
2	16.50-16.95	25	GC			17.9	35	19	67	38		
2	20.00-20.45	50	SW-SP			9.3		NP	60	11		
2	22.50-22.95	50	SC	2.24		10.7	25	10	85	19		
Location 3												
1	0.50-0.95	9	GP-GM			18.5		NP	36	9		
1	2.00-2.45	22	SP-SM			18.3		NP	67	11		
1	3.50-3.95	20	GP-GM			14.6		NP	52	8		
1	5.00-5.45	15	SM			8.1		NP	67	27		
1	6.50-6.95	37	SM			10.2		NP	69	46		
1	8.00-8.45	10	CL		2.66	31.0	52	22	100	75		
1	9.50-9.95	14	MH			36.4	52	22	100	96		
1	12.50-12.95	9	OL			41.3	49	18	100	67		
1	14.00-14.45	10	OL			44.0	49	18	100	93		
1	15.50-15.95	8	CL	1.90	2.61	29.3	31	17	100	73	78*	
1	17.00-17.45	15	SC			18.4	31	17	70	42		
1	18.50-18.95	9	CL			24.2	31	17	98	84		
1	20.00-20.45	14	CL			22.3	36	24	100	70		
1	21.50-21.95	21	CL			25.1	45	23	98	78		
1	23.00-23.45	18	CL			20.5	35	17	100	77		
1	24.50-24.95	22	CL		2.66	24.1	45	21	100	80		
1	26.00-26.45	14	CL			27.2	45	21	100	96		
1	27.50-27.95	21	CL			27.5	45	21	100	90		
1	30.50-30.95	19	CL			27.0	47	22	100	78		
1	31.50-31.95	26				25.1						
2	0.50-0.95	16	GC			16.5	36	16	66	28		
2	2.00-2.45	18	SM			16.9		NP	62	15		

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / $Cu_{,T}$ (kN/m^2)	e
2	3.50-3.95	19	SM			23.5		NP	88	31		
2	5.00-5.45	18	GP			7.4		NP	35	4		
2	6.50-6.95	46	GP-GC			3.7		NP	23	10		
2	8.00-8.45	7	CL			37.6	41	23	100	96		
2	9.50-9.95	0										
2	11.00-11.45	9	CL			43.6	41	23	100	94		
2	12.50-12.95	8	CH			46.8	57	34	92	87		
2	14.00-14.45	9	CH			45.7	57	37	100	99		
2	15.50-15.95	4	CL	1.94	2.63	30.9	33	14	96	82		
2	17.00-17.45	35	SM		2.55	16.9		NP	65	13		
2	18.50-18.95	13	CL			31.6	44	22	100	92		
2	20.00-20.45	26	CL			22.5	42	23	100	73		
2	21.50-21.95	27	SC			24.2	40	20	84	39		
2	23.00-23.45	13	CL			22.6	40	21	98	67		
2	24.50-24.95	8	CL			26.9	40	21	100	86		
2	26.00-26.45	10	CL			23.8	40	21	100	86		
2	27.50-27.95	21	CL			28.1	40	21	100	90		
2	29.00-29.45	22	CH			25.5	42	23	100	94		
2	30.50-30.95	23	CH			30.5	42	23	99	81		
2	31.50-31.95	26	CH			25.3	42	23	99	79		
3	0.50-0.95	13	Fill									
3	2.00-2.45	17	Fill									
3	3.50-3.95	17	Fill									
3	5.00-5.45	21	SM			11.5		NP	89	21		
3	6.50-6.95	12	SM			13.5		NP	64	13		
3	8.00-8.45	11	SM			23.2		NP	96	39		
3	9.50-9.95	8	SM			23.0		NP	79	29		
3	11.00-11.45	11	SM-SC			27.1	29	7	83	38		
3	12.50-12.95	9	CL			30.3	40	19	100	96		
3	14.00-14.45	10	CL			45.9	40	19	100	99		
3	15.50-15.95	11	CL	1.91	2.60	33.8	40	19	100	83		
3	17.00-17.45	8	SM-SC			21.4	39	17	100	48		
3	18.50-18.95	17	SC			18.8	36	12	96	44		
3	20.00-20.45	15	CL			16.5	40	20	84	55		
3	21.50-21.95	13	SC			22.3	38	20	87	30		
3	23.00-23.45	19	CL			23.1	37	16	99	57		
3	24.50-24.95	22	CL		2.65	24.3	37	16	100	97		
3	26.00-26.45	18	CL			25.2	37	16	99	79		
3	27.50-27.95	22	CL			26.2	37	16	100	89		
3	29.00-29.45	23	CL			29.2	37	16	100	91		
3	29.50-29.95	24	CL			23.2	37	16	99	70		
4	0.50-0.95	0	Fill									
4	2.00-2.45	15	Fill			16.4						
4	3.50-3.95	11	GM			14.5		NP	55	14		
4	5.00-5.45	19	GP-GC			9.5		NP	47	5		
4	6.50-6.95	17	SC			9.0	39	20	75	26		
4	8.00-8.45	0										
4	9.50-9.95	7	CH			37.9	59	32	100	87		
4	11.00-11.45	10	CH			49.8	59	32	100	94		
4	14.00-14.45	8	CH			41.9	58	30	97	80		
4	17.00-17.45	10	CL			38.4	37	18	100	60		
4	18.50-18.95	8	CL			24.6	37	18	88	51		

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / $Cu_{,T}$ (kN/m^2)	e
4	20.00-20.45	17	SM			12.3		NP	92	13		
4	21.50-21.95	17	CL			23.8	36	16	95	60		
4	23.00-23.45	17	SC			21.1	36	16	77	41		
4	24.50-24.95	18	SC			22.6	30	10	72	37		
4	26.00-26.45	13	CL			25.8	32	12	98	80		
4	27.50-27.95	16	CL			23.8	31	10	100	76		
4	29.00-29.45	18	CL			25.7	31	10	100	82		
4	30.50-30.95	22	CL			31.8	46	21	100	97		
4	31.50-31.95	19	CL			26.9	46	21	100	90		
5	0.50-0.95	0	Fill									
5	2.00-2.45	37	SC			11.8	38	18	91	18		
5	3.50-3.95	34	GP-GC			11.8	38	18	44	9		
5	5.00-5.45	44	GP			10.2		NP	42	1		
5	6.50-6.95	36	SW			14.2		NP	100	4		
5	8.00-8.45	17	SM			20.7		NP	96	17		
5	9.50-9.95	19	SM			15.3		NP	91	15		
5	11.00-11.45	0	SC			30.1	40	19	80	43		
5	12.50-12.95	5	CL		2.67	46.0	48	28	100	99		
5	14.00-14.50		CL			43.0	48	28	95	85		
5	15.50-15.95	7	CL		2.67	44.5	48	28	100	77	64*	
5	17.00-17.50		SC			27.6	48	28	98	49		
5	18.50-18.95	49	SM			19.6		NP	90	36		
5	20.00-20.45	14	CL			28.4	40	20	98	89		
5	21.50-21.95	19	CL			24.7	40	20	100	82		
5	23.00-23.45	15	CL			25.8	40	20	99	66		
5	24.50-24.95	10	CL			28.0	39	21	100	88		
5	26.00-26.45	15	CL			24.4	39	21	98	80		
5	27.50-27.95	13	CL			29.0	39	21	98	74		
5	29.00-29.45	18	CL			29.3	39	21	100	93		
5	30.50-30.95	22	SC			23.1	39	21	88	46		
5	32.00-32.45	26	CL			29.2	39	21	100	96		
5	33.50-33.95	18	SC			32.0	36	18	100	25		
5	35.00-35.45	18	CL			24.2	36	18	100	59		
5	36.50-36.95	37	SC			15.7		NP	92	30		
5	38.00-38.45	38	SC			17.1		NP	100	28		
5	39.50-39.95	30	CL			26.1	39	18	100	95		
5	41.00-41.45	30	CL			24.0	39	18	100	90		
5	42.50-42.95	19	CL			31.8	39	18	98	91		
5	44.00-44.45	28	CL			33.9	39	18	100	96		
5	45.50-45.95	28	CL			35.8	40	19	100	90		
5	47.00-47.45	18	CL			28.2	40	19	100	93		
5	48.50-48.95	19	CL			26.0	40	19	96	87		
5	50.00-50.45	42	SC			20.2		NP	100	37		
5	51.50-51.95	48	CL			19.2		NP	97	55		
6	1.00-1.45	3	Fill									
6	2.50-2.95	5	SC			33.2	42	21	70	24		
6	4.00-4.45	0										
6	5.50-5.95	0	CL			49.6	49	22	100	76		
6	7.00-7.45	0	CH			50.4	52	26	100	96		
6	8.50-8.95	5		1.76	2.82							
6	10.00-10.45	2	CH	1.76		50.9	52	26	100	99		
6	11.50-11.95	12	CH			53.8	52	26	100	99		

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / $Cu_{,T}$ (kN/m^2)	e
6	13.00-13.45	10	CH			35.2	52	26	99	64		
6	14.50-14.95	13	CH			2.4	52	26	100	96		
6	16.00-16.45	0										
6	17.50-17.95	29	CH			26.1	52	26	90	62		
6	19.00-19.45	23	CL			35.5	38	15	100	88		
6	20.50-20.95	50	SC			20.8		NP	97	48		
6	22.00-22.45	50	GP-GC			10.1	39	17	49	8		
6	23.50-23.95	21	SW			12.0		NP	84	1		
6	25.00-25.45	20										
6	26.50-26.95	50				22.4	42	18	96	72		
6	28.00-28.45	26	SM			19.9		NP	71	14		
6	29.50-29.95	50	CL			24.5	42	22	100	81		
6	31.00-31.45	50	SP-SM			12.3		NP	60	11		
7	1.00-1.45	31	Fill			28.7		NP	61	22		
7	2.50-2.95	5										
7	4.00-4.45	0	SM			48.0		NP	95	43		
7	5.50-5.95	0	GM			47.3		NP	67	48		
7	7.00-7.45	3	CL			44.6	62	32	100	96		
7	8.50-8.95	4	CL			45.3	62	32	100	92	55*	
7	10.00-10.45	8	CL	1.70	2.57	51.8	62	32	93	83		
7	11.50-11.95	6	CL			54.8	62	32	100	97		
7	13.00-13.45	9	SC			36.7	41	20	95	45		
7	14.50-14.95	13	CL			38.3	60	30	100	75		
7	16.00-16.45	35	SC			23.3	40	19	100	28		
7	17.50-17.95	50	SC			14.5	40	19	90	23		
7	19.00-19.45	28										
7	20.50-20.95	50	GC			10.0	36	16	54	16		
7	22.00-22.45	20	CL			29.5	43	24	99	92		
7	23.50-23.95	42	CL		2.65	23.7	43	24	98	78		
7	25.00-25.45	34	CL			21.4	43	24	100	76		
7	26.50-26.95	35	CL		2.65	21.1	38	19	89	68		
7	28.00-28.45	23	CL			26.6	38	19	100	90		
7	29.50-29.95	50										
7	31.00-31.45	50	CL			22.9	38	19	100	89		
Location 4												
1	1.50-1.95	8										
1	3.00-3.45	7										
1	4.50-4.95	7										
1	6.00-6.45	12	SM			29.2		NP	97	25		
1	7.50-7.95	45	GP/GM			7.5		NP	47	6		
1	9.00-9.45	46										
1	10.50-10.95	8	CL			39.5	34	15	99	85		
1	12.00-12.45	8										
1	13.50-13.95	9										
1	15.00-15.45	8	SM			21.3		NP	79	49		
1	16.50-16.95	9										
1	18.00-18.45	9										
1	19.50-19.95	12	CL		2.71	21.3	36	15	99	73		
1	21.00-21.45	16										
1	22.50-22.95	18	SM			13.6		NP	76	26		
1	24.00-24.45	9										
1	25.50-25.57	8										

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / Cu,$_T$ (kN/m^2)	e
1	27.00-27.45	10	ML		2.69	23.1	44	16	98	77		
1	28.50-28.95	8										
1	30.00-30.45	7										
1	31.50-31.95	50										
1	33.00-33.45	50	GM			10.8		NP	42	18		
1	34.50-34.95	50										
2	1.50-1.95	10										
2	3.00-3.45	9										
2	4.50-4.95	50										
2	6.00-6.45	11	CL			39.9	34	15	90	63		
2	7.50-7.95	36	SM			21.9		NP	82	41		
2	9.00-9.45	40										
2	10.50-10.95	13										
2	12.00-12.45	14	CH			19.8	54	27	91	70		
2	13.50-13.95	12										
2	15.00-15.45	12	SC		2.00	19.6	33	15	79	49		
2	16.50-16.95	11										
2	18.00-18.45	10										
2	19.50-19.95	10	SM			19.2		NP	93	43		
2	21.00-21.45	13										
2	22.50-22.95	12	SM			22.1		NP	88	45		
2	24.00-24.45	13										
2	25.50-25.57	20	SM			13.1		NP	91	41		
2	27.00-27.45	50	SM			12.2		NP	65	21		
2	28.50-28.95	50										
2	30.00-30.45	50										
2	31.50-31.95	50										
2	33.00-33.45	50										
2	34.50-34.95	50										
3	1.50-1.95	9										
3	3.00-3.45	8										
3	4.50-4.95	10										
3	6.00-6.45	28										
3	7.50-7.95	29	SM			13.5		NP	95	36		
3	9.00-9.45	35										
3	10.50-10.95	33										
3	12.00-12.45	9										
3	13.50-13.95	10										
3	15.50-15.95	11	CL		2.68	30.2	35	15	90	70		
3	17.00-17.50	11										
3	18.50-18.95	10										
3	20.00-20.45	11										
3	21.50-21.95	12										
3	23.00-23.45	11	CL			29.8	34	15	98	73		
3	24.50-24.95	11										
3	26.00-26.45	12	CL			31.3	34	14	99	68		
3	27.50-27.95	13										
3	29.00-29.45	50										
3	30.50-30.95	50	SM			10.9		NP	70	32		
3	32.50-32.95	50										
3	34.50-34.95	50										
4	1.50-1.95	8										

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / Cu,$_T$ (kN/m^2)	e
4	3.00-3.45	9										
4	4.50-4.95	8										
4	6.00-6.45	25	GM			16.5		NP	55	18		
4	7.50-7.95	27										
4	9.00-9.45	25										
4	10.50-10.95	26	SM			12.9		NP	93	40		
4	12.00-12.45	24										
4	13.50-13.95	9										
4	15.00-15.45	10										
4	16.50-16.95	10										
4	18.00-18.45	11										
4	19.50-19.95	11	CL			29.8	35	16	97	68		
4	21.00-21.45	10										
4	22.50-22.95	11										
4	24.00-24.45	12										
4	25.50-25.95	12										
4	27.00-27.45	13										
4	28.50-28.95	12										
4	30.00-30.45	43										
4	31.50-31.95	45	SM			11.0		NP	73	29		
4	33.00-33.45	50										
4	34.50-34.95	50										
5	1.50-1.95	8										
5	3.00-3.45	8										
5	4.50-4.95	9										
5	6.00-6.45	10										
5	7.50-7.95	23	GM			15.4		NP	58	20		
5	9.00-9.45	24	SM			12.1		NP	92	43		
5	10.50-10.95	8										
5	12.00-12.45	12										
5	13.50-13.95	10										
5	15.00-15.45	11	CL			28.2	34	15	96	70		
5	16.50-16.95	12										
5	18.00-18.45	12										
5	19.50-19.95	12										
5	21.00-21.45	12										
5	22.50-22.95	11										
5	24.00-24.45	11										
5	25.50-25.95	12										
5	27.00-27.45	13	CL			27.0	34	14	92	65		
5	28.50-28.95	13										
5	30.00-30.45	50										
5	31.50-31.95	50	GM			11.7		NP	59	29		
5	33.00-33.45	50										
5	34.50-34.95	50										
Location 5												
1	1.50-1.95	6	CH			33.2	51	24	79	60		
1	3.00-3.45	25	SP-SM			12.5		NP	80	11		
1	4.50-4.95	28	SP-SM			10.8		NP	65	7		
1	6.00-6.45	37										
1	7.50-7.95	4	CL			39.8	40	19	100	80	14'	
1	9.50-9.95	10										

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / Cu,$_T$ (kN/m^2)	e
1	11.00-11.45	10	CL			34.8	39	19	100	74		
1	12.50-12.95	2										
1	14.50-15.00		CL	1.72	2.61	46.3	38	18	100	98	36*	1.129
1	15.00-15.45	3	CL			44.3	47	23	100	98		
1	16.50-16.95	26										
1	18.00-18.45	41	SM			7.2		NP	68	24		
1	19.50-19.95	29	SM			12.6		NP	69	19		
1	21.00-21.45	16	SM			18.7		NP	72	26		
1	22.50-22.95	20										
1	24.00-24.45	15	SM			23.3		NP	75	40		
1	25.50-25.95	29	SM			15.5		NP	76	23		
1	27.00-27.45	25	SM			11.8		NP	73	31		
1	28.50-28.95	23	CL			34.0	44	21	100	84		
1	30.00-30.45	49	SM			16.3		NP	99	39		
2	1.50-1.95	10	SP-SM			15.5		NP	76	11		
2	3.00-3.45	23										
2	4.50-4.95	3	CL			34.7	37	18	100	66		
2	6.00-6.45	5										
2	8.50-8.95	5	CL			30.5	38	18	100	64	16**	
2	10.00-10.45	5										
2	11.50-11.95	6	CH			50.1	52	28	100	98		
2	13.00-13.50		CL	1.73	2.58	44.8	49	24	100	99	46*	1.157
2	14.00-14.45	7										
2	15.50-15.95	6	CL			47.9	37	18	100	99		
2	17.00-17.45	13										
2	18.50-18.95	44	SM			8.6		NP	86	29		
2	20.00-20.45	31	SM			8.3		NP	81	28		
2	21.50-21.95	50	GW-GM			8.2		NP	43	9		
2	23.00-23.45	16	CL			32.5	40	18	100	89	21**	
2	25.00-25.45	27										
2	26.50-26.95	50	SM			9.3		NP	62	21		
2	28.00-28.45	50										
2	29.50-29.95	50	SM			8.4		NP	74	30		
3	1.50-1.95	12	SP-SM			16.2		NP	70	8		
3	3.00-3.45	16	SM			15.3		NP	88	16		
3	5.00-5.45	2	SM			23.1		NP	73	36		
3	6.50-6.95	3										
3	8.00-8.45	2	CL			33.8	33	16	100	54		
3	9.50-9.95		CL	1.80	2.57	37.0	44	22	100	85	44*	1.061
3	10.50-10.95	2										
3	12.00-12.45	4	CL			36.1	36	18	100	62		
3	14.50-14.95	3										
3	16.00-16.45	4	CL			47.4	48	25	100	97		
3	17.50-17.95	4										
3	19.00-19.45	37	GM			11.6		NP	55	16		
3	20.50-20.95	50	SM			9.4		NP	67	22		
3	22.00-22.45	16	CL			25.6	37	18	100	77		
3	24.00-24.45	39	SM			8.7		NP	71	28		
3	25.50-25.95	50										
3	27.00-27.45	50	SM			8.8		NP	71	29		
3	28.50-28.95	50										
3	30.00-30.45	50	SM			10.0		NP	70	28		

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / $Cu_{,T}$ (kN/m^2)	e
Location 6												
1	3.00-3.45	5	CL	1.90		28.7	40	21	100	69		
1	4.50-4.95	17	SM			16.4		NP	95	27		
1	6.00-6.45	4	CH			50.6	53	26	100	99		
1	7.50-8.00		CH	1.75	2.62	46.7	51	25	100	98	26**	1.280
1	8.15-8.60	2	CH			50.3	52	26	100	97		
1	9.80-10.25	4	CH	1.70		42.9	51	24	100	96		
1	11.50-11.95	5	CH	1.70		47.8	50	25	100	98		
1	13.15-13.60	8	CH	1.80		40.9	50	25	100	91		
1	14.50-14.95	7	CL			52.0	45	25	97	69		
1	16.00-16.45	14	CL	2.00		25.5	35	16	100	77		
1	17.60-18.05	19	CL	1.98		25.5	42	25	100	79		
1	19.00-19.50		CL	1.99	2.60	23.6	47	23	96	73	68**	0.754
1	19.65-20.10	19	CL			23.7	35	16	96	62		
1	21.00-21.45	30	GM			13.8		NP	62	33		
1	22.50-22.95	38	SM	1.75		11.9		NP	96	40		
1	24.50-24.95	44	GM			12.2		NP	45	16		
2	3.00-3.45	30	SM			14.1		NP	83	23		
2	4.50-4.95	33	SM			16.3		NP	89	34		
2	6.00-6.45	2	CL			40.2	37	17	100	61		
2	7.00-7.50		CH	1.67		24.1	60	35	100	98		
2	7.65-8.10	3	CH	1.76		44.5	56	33	100	94		
2	9.10-9.55	5	CL			34.2	38	19	100	65		
2	10.60-11.05	5	CL			37.3	43	23	100	85		
2	11.50-12.00		CH	1.69	2.62	27.0	60	35	100	98	32**	1.329
2	12.15-12.60	18	GM			20.0		NP	60	39		
2	13.60-14.05	5	CH			51.8	50	24	100	86		
2	15.00-15.45	4	CH			48.5	52	27	100	95		
2	16.50-16.95	35	GM			15.6		NP	62	30		
2	17.00-17.50		CL	1.97		24.0	42	23	100	83	64**	
2	17.65-18.10	16	CL			26.7	42	23	100	82		
2	19.00-19.45	28	SM			14.2		NP	89	35		
2	20.50-20.95	31	SM			14.8		NP	93	38		
2	22.15-22.60	50	SM			12.2		NP	66	16		
2	23.50-23.95	50	GM			12.3		NP	53	19		
2	25.00-25.45	50	SM			13.0		NP	78	33		
Location 7												
1	3.00-3.45	10	CL	1.95		23.5	40	20	88	54		
1	4.50-4.95	4	CH	1.75		38.1	50	24	100	80		
1	6.00-6.50		CH	1.75	2.60	44.4	52	25	100	99	65*	1.193
1	6.50-6.95	2	CH	1.70		35.6	51	25	100	76		
1	8.00-8.45	6										
1	9.50-9.95	8	CL			20.7	48	23	85	62		
1	11.00-11.45	8	CL			22.1	48	23	72	54		
1	12.50-12.95	9	SC			18.9	43	23	88	48		
1	14.00-14.45	10	SC			17.5	38	20	81	45		
1	15.50-15.95	11	CL			21.5	42	22	94	76		
1	17.00-17.45	13	SM			18.4		NP	76	42		
1	18.00-18.50		CL	1.94		30.0	47	23	100	98	170*	
1	18.50-18.95	14	CL			28.4	42	24	100	95		
1	20.00-20.45	12										
1	21.50-21.95	12	CL			20.7	36	16	93	50		

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / $Cu_{,T}$ (kN/m^2)	e
1	23.00-23.45	9										
1	24.50-24.95	17	SM	1.99		14.7		NP	93	42		
1	26.00-26.45	16										
1	27.50-27.95	17	SM			12.1		NP	76	44		
Location 8												
1	3.00-3.45	13	ML			30.5	48	19	90	72		
1	4.50-4.95	7	CL			16.5	39	21	100	69		
1	6.00-6.50	31	SM			17.6		NP	75	40		
1	7.50-7.95	11	CL			7.4	35	15	95	80		
1	9.00-9.45	10										
1	10.50-10.95	10										
1	12.00-12.45	24	CL			16.5	37	17	68	60		
1	13.50-13.95	47	ML			11.1		NP	95	80		
1	15.00-15.45	50										
1	16.50-16.95	17	SP-SM			25.9		NP	100	8		
1	18.00-18.45	41										
1	19.50-19.95	45	SP-SM			7.2		NP	99	12		
1	21.00-21.45	43	SM			24.5		NP	100	16		
1	22.50-22.95	46										
1	24.00-24.45	45										
1	25.50-25.95	45	SM			9.6		NP	68	20		
1	29.00-29.45	50										
1	32.00-32.45	50										
1	35.00-35.45	50	SM			28.6		NP	100	18		
2	1.50-1.95	5	CL			13.0	44	26	92	75		
2	3.00-3.45	12										
2	4.50-4.95	14	CL			7.3	44	26	95	78		
2	6.00-6.50	16	CL			8.9	36	15	93	80		
2	7.50-7.95	15										
2	9.00-9.45	13	CL			10.1	34	15	98	73		
2	10.50-10.95	18	CL			13.2	35	16	89	75		
2	12.00-12.45	12	ML			19.2		NP	90	52		
2	13.50-13.95	15	CL			24.7	35	14	92	83		
2	15.00-15.45	50										
2	16.50-16.95	50										
2	19.00-19.45	50										
2	22.00-22.45	50										
2	25.00-25.45	50										
2	28.00-28.45	50										
2	31.00-31.45	50										
2	34.50-34.95	50										
3	1.50-1.95	13	SM			28.1		NP	70	28		
3	3.00-3.45	8										
3	4.50-4.95	11	GM			20.2		NP	66	43		
3	6.00-6.50	14	SM			25.4		NP	100	19	51*	
3	7.50-7.95	14										
3	9.00-9.45	16										
3	10.50-10.95	15										
3	12.00-12.45	14	SM			15.6		NP	94	27		
3	13.50-13.95	17	SM			15.3		NP	83	35		
3	15.00-15.45	16	SM			16.4		NP	75	20		
3	16.50-16.95	50										

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / $Cu_{,T}$ (kN/m^2)	e
3	18.00-18.45	50										
3	21.00-21.45	50										
3	24.00-24.45	50										
3	27.00-27.45	50										
3	30.00-30.45	50										
3	34.50-34.95	50										
4	3.00-3.45	5	SM			14.3		NP	79	44		
4	4.50-4.95	6	CL			10.7	44	26	86	50	35*	
4	6.00-6.50	7	MH			12.4	50	10	100	61		
4	7.50-7.95	14	SM			19.2		NP	97	32		
4	9.00-9.45	11	CL			26.2	34	15	100	84		
4	10.50-10.95	13	CL			35.6	39	21	100	78		
4	12.00-12.45	10	SC		2.69	22.4	44	26	99	39		
4	13.50-13.95	15	CL	2.08		13.3	35	16	87	70		
4	15.00-15.45	50										
4	18.00-18.45	50										
4	21.00-21.45	50										
4	24.00-24.45	50										
4	27.00-27.45	50										
4	30.00-30.45	50										
4	33.00-33.45	50										
4	34.50-34.95	50										
5	4.50-4.95	6	SP-SM			22.7		NP	96	12		
5	6.00-6.50	6	SM			31.3		NP	97	44		
5	7.50-7.95	7	CL	2.00	2.72	27.5	35	17	100	72		
5	9.00-9.45	6										
5	10.50-10.95	11	CL	2.06	2.73	18.3	39	21	88	51		
5	13.00-13.50	12	CL			24.7	33	15	100	83	125*	1.288
5	15.00-15.45	28	SM			17.6		NP	90	45		
5	16.50-16.95	34	SP-SM			9.1		NP	56	11		
5	18.00-18.45	50										
5	21.00-21.45	50										
5	24.00-24.45	50										
5	27.00-27.45	50										
5	30.00-30.45	50										
5	34.50-34.95	50										
Location 9												
1	3.00-3.45	17	SP-SM					NP	81	10		
1	4.50-4.95		GW-GM					NP	51	8		
1	6.00-6.50	17	SM					NP	99	30		
1	7.50-7.95	25	SP						71	2		
1	9.00-9.45	32	SP-SM					NP	63	9		
1	10.50-10.95		GP						26	2		
1	12.00-12.50		SM	2.01		18.5	57	22	72	31		
1	13.00-13.50		OH	1.77	2.66	37.2	60	33	76	66		1.328
1	13.50-13.95	4	OH			35.3			82	71		
1	15.00-15.45	5	OH			36.7			86	71		
1	15.50-16.00		OH	1.88		27.3	60	29	71	52		
1	17.50-17.95	13	SM						63	29		
1	19.00-19.45	17	SC						89	25		
1	20.00-20.45	11	SC			16.8			93	50		
1	21.50-22.00		CL	2.11	2.73	27.2	35	16	100	65	206*	

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / $Cu_{,T}$ (kN/m^2)	e
1	22.00-22.45	12	CL			27.2			97	77		
1	23.00-23.50		CL			32.4	43	21	95	75		
1	25.00-25.45	50	SC						76	25		
1	26.50-26.95	50										
1	28.00-28.45	50										
1	29.00-30.00		CL	1.99	2.72	28.0	46	24	100	93	312*	
1	30.00-30.45	12	SC						70	32		
2	1.50-1.95		GW						24	2		
2	3.00-3.45	9	SP-SM					NP	87	10		
2	4.50-4.95	15	GM					NP	55	31		
2	6.00-6.50		GP-GM					NP	24	8		
2	7.50-7.95	27										
2	9.00-9.45	4	GM			16.4		NP	48	33		
2	10.00-10.50		OH	1.74	2.62	47.5	57	33	100	96	28*	1.203
2	10.50-10.95	4	OH			49.1			100	97		
2	11.50-12.00		OH	1.78	2.62	40.1	55	31	100	97	63*	1.199
2	12.00-12.45	3	OH			51.2			100	97		
2	15.00-15.45	3	OH			45.6	57	32	100	100		
2	16.00-16.50		OH	1.69	2.63	45.9	45	24	100	93	28*	1.323
2	16.50-16.95	8	OH			43.1			76	69		
2	18.00-18.45	5	CH			54.3	61	33	100	99		
2	19.50-19.95	20	SW						54	5		
2	22.50-22.95	33	SC						66	29		
2	23.50-24.00		SC						80	30		
2	24.00-24.45	20	SC			12.6			76	28		
2	25.50-25.95	26	SW						69	4		
2	27.00-27.45	15	CL			26.4			93	84		
2	30.00-30.45	21	CL			18.6			88	56		
2	31.50-31.95	21	CL			22.6			94	75		
2	33.00-33.45	50	SC			18.6	37	19	77	46		
2	34.50-35.00		CL			18.8	33	16	100	69		
Location 10												
1	0.50-0.95	50										
1	2.00-2.45	50										
1	2.50-3.00		GW-GM			18.0		NP	47	8		
1	6.00-6.45	32	SM			19.2		NP	100	15		
1	7.00-7.45	50	SM			23.4		NP	59	12		
1	9.00-9.45	50										
1	11.50-11.95	8	SM			40.0		NP	74	12		
1	14.00-14.45	33	CL			29.0	44	21	88	56		
1	17.00-17.45	17	SC			21.0	48	28	95	43		
1	20.00-20.45	42	SC			22.9	46	25	92	42		
2	2.50-2.95	50										
2	9.00-9.45	32				18.0		NP				
2	14.50-14.95	9	SC			17.0			79	26		
2	18.00-18.45	45	CL		2.68	20.3	45	25	92	60		
2	20.00-20.45	50	CL		2.70	22.1	43	23	92	61		
3	1.50-1.95	50	SM			12.0		NP	86	24		
3	14.00-14.45	22	SC		2.66	21.0			93	35		
3	16.50-16.95	50	CL		2.65	25.5	39	18	100	76		
3	18.00-18.45	50	SC			20.9	44	23	88	43		
4	2.50-2.95	50										

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / Cu,$_T$ (kN/m^2)	e
4	6.50-6.95	2	SM			22.0		NP	86	36		
4	11.00-11.45	8	ML		2.68	47.7		NP	99	84		
4	17.00-17.45	38	SC		2.65	16.5	39	21	85	48		
4	19.50-19.95	48	CL		2.70	14.0	38	19	91	52		
5	6.00-6.45	7	SW			17.4			83	4		
5	11.00-11.45	12	ML		2.66	40.4		NP	100	87		
5	15.00-15.45	18	CL			15.7			96	63		
5	18.99-18.45	46	SC		2.68	15.5	42	22	75	35		
5	20.50-20.95	50										
6	1.00-1.45	20	SM			15.7		NP	82	15		
6	5.00-5.45	14	SW			22.5			67	3		
6	9.00-9.45	4	GM			46.8		NP	52	25		
6	11.00-11.45	8	ML			73.1		NP	100	86		
6	13.00-13.45	23	SM			38.4		NP	100	49		
6	15.00-15.45	25	GC			16.2			61	26		
6	17.00-17.45	41	SC		2.69	13.0	46	27	75	41		
6	19.00-19.50	49	SC			19.8	46	27	75	41		
6	21.50-22.00		SC			19.1			75	47		
7	6.00-6.45	16	GM			18.0		NP	53	12		
7	9.50-9.95	15										
7	11.50-11.95	5	SC			25.4	36	14	93	35		
7	13.50-13.95	3	SC			51.4	36	14	93	35		
7	15.50-15.95	10	CL			69.8			100	75		
7	17.50-17.95	32	CL			13.2	36	16	85	52		
7	19.50-19.95	43	CL			15.0	36	16	85	52		
8	2.00-2.45	13										
8	4.50-4.95	50										
8	6.00-6.45	13										
8	8.00-8.45	6	SW-SM			26.9		NP	87	7		
8	9.00-9.45	8										
8	10.00-10.50		SW			28.9			92	2		
8	11.00-11.45	5	CL			47.4	38	18	95	60		
8	13.00-13.45	7	CL			32.1	38	18	95	60		
8	15.00-15.45	50										
8	17.00-17.45	24	SC			17.7	43	24	69	30		
8	18.50-18.95	36	SC			14.4	43	24	69	30		
9	1.50-1.95	31	GP-GM			15.8		NP	51	8		
9	4.50-4.95	4	ML			47.0		NP	100	63		
9	6.50-6.95	7	ML			39.6		NP	100	60		
9	9.00-9.45	6	ML			43.3		NP	100	63		
9	12.00-12.45	6										
9	13.50-13.95	50										
10	2.50-2.95	9	GW			20.0			51	4		
10	6.00-6.45	29	ML			23.1		NP	100	81		
10	9.00-9.45	16	ML			44.9		NP	100	60		
10	12.00-12.45	6	ML			52.2		NP	100	81		
10	14.00-14.45	37	CL		2.64	26.4	40	16	100	53		
11	6.00-6.45	22	ML			43.9		NP	100	86		
11	9.00-9.45	4	ML			45.5		NP	100	70		
11	12.00-12.45	6	CL		2.64	43.5	34	12	100	85		
11	14.00-14.45	39	CL		2.64	23.6	38	17	100	65		
11	16.00-16.45	44	CL		2.67	26.0	46	22	100	69		

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / $Cu_{,T}$ (kN/m^2)	e
12	3.00-3.45	18										
12	6.00-6.45	19	ML			43.1		NP	100	60		
12	9.00-9.45	18	ML			40.4		NP	100	78		
12	12.00-12.45	5	CL		2.63	58.8	36	13	100	75		
12	15.50-15.95	27	SC			16.1			100	47		
12	17.50-18.00		CL		2.69		46	20				
12	22.00-22.45	50	CL			21.3			98	63		
Location 11												
1	3.00-3.45	10										
1	4.50-4.95	11	SM						99	14		
1	6.00-6.50	6	OH			40.3						
1	7.50-7.95	7	OH			47.0						
1	9.00-9.45	5	OH			46.7						
1	10.50-10.95	8	OH				52	21	100	93		
1	12.00-12.45	13	OH			32.7						
1	13.50-13.95	24	SM						99	33		
1	15.00-15.45	13	SM			30.7						
1	16.50-16.95	50	SC			9.2			65	15		
1	18.00-18.45	8	SC			14.2						
1	19.50-19.95	12	GW						36	3		
1	21.00-21.45	19	CL			26.2						
1	23.00-23.50		CL									
1	23.50-23.95	20	CL			27.6	40	19	100	87		
1	25.50-25.95	13	CL			27.7						
1	27.50-27.95	28	CL			20.0			80	55		
1	29.00-29.45	32	CL			17.2						
1	31.50-31.95	19	CL			31.8	37	15	98	56		
1	33.00-33.45	24	CL			30.4						
1	34.00-34.50		SC			10.4						
1	34.50-34.95	50	SC						95	27		
2	4.50-4.95	9	SM			28.6			98	36		
2	6.00-6.50	8	OH			34.4						
2	7.50-8.00		OH	1.76	2.59	45.3	58	25	100	97	59*	1.294
2	8.00-8.45	6	OH			46.1						
2	10.50-10.95	8	OH				57	23	100	82		
2	12.00-12.45	9	OH			35.6						
2	13.50-13.95	36	SM			23.8			99	36		
2	15.00-15.45	20	SM			36.8						
2	16.50-16.95	41	SC						98	16		
2	17.50-18.00		SC			18.0						
2	18.00-18.45	19	SC									
2	21.00-21.45	20	CL			19.5	36	13	97	58		
2	22.00-22.50		CL			27.2	47	22	100	96	192*	0.666
2	22.50-22.95	46	CL			23.2						
2	23.50-24.00		CL			17.9						
2	24.00-24.45	18	CL			32.3						
2	25.50-25.95	38	CL			23.4						
2	27.50-27.95	22	CL			23.1	35	15	100	70		
2	29.50-29.95	26	CL			20.1						
3	4.50-4.95	4	SP-SM						99	9		
3	6.00-6.50	9	OH			35.3						
3	7.50-7.95	8	OH			35.5						

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / Cu,$_T$ (kN/m^2)	e
3	9.00-9.45	4										
3	10.50-11.00		OH	1.71	2.59	49.0	49	19	100	98	38*	
3	11.00-11.45	6	OH			33.4						
3	13.00-13.45	8	OH				53	21	100	70		
3	14.50-14.95	12	OH			32.4						
3	16.00-16.45	18	SC			27.1						
3	17.50-18.00	26	CL			23.8			92	71		
3	19.00-19.50		CL			18.2						
3	19.50-19.95	21	CL			28.3	40	18	89	71		
3	21.50-22.00		CL			17.4						
3	22.00-22.45	19	CL			23.7						
3	23.50-23.95	21	CL				42	18	91	50		
3	25.00-25.45	21	SC			32.9						
Location 12												
1	1.50-1.95	50										
1	3.00-3.45	25										
1	4.50-4.95	50										
1	6.00-6.45	50										
1	7.50-7.95	10	ML						100	67		
1	9.00-9.50		ML						97	82		
1	10.5-10.95	20	SC						64	31		
1	12.00-12.45	16	CL			29.0	32	17	82	50		
1	13.50-13.95	16	SC						78	47		
1	15.00-15.50		SC						84	39		
1	16.50-16.95	16	GC						61	22		
1	18.00-18.45	16	SC						77	32		
1	19.50-19.95	16	CL			23.6	39	25	87	67		
2	6.00-6.50		GP						43	9		
2	9.00-9.45	17	ML						100	83		
2	10.50-10.95	19	ML						100	64		
2	12.00-12.45	16	SC						72	16		
2	13.50-13.95	18	SC-SM						67	14		
2	15.00-15.45	16	SC						59	19		
2	16.50-16.95	40	SC						75	44		
2	18.00-18.45	43	SC						80	39		
2	19.50-19.95	28	SC						85	33		
2	22.50-22.95	24	SC						71	22		
2	25.50-25.95	19	CL			22.7	41	26	81	52		
2	27.00-27.45	19	SC						79	35		
2	28.50-28.95	33	SC						92	27		
2	30.00-30.50		SP-SM						98	11		
2	31.50-31.95	18	GC						56	33		
2	33.00-33.50		SC						100	37		
2	34.50-34.95	21	CL			26.0	37	22	96	52		
2	36.00-36.50		CH						100	87		
2	37.50-37.95	25	CL			31.0	43	28	100	91		
2	39.00-39.50		CL						99	84		
2	40.50-40.95	32	CL			26.0	34	14	98	79		
2	42.00-42.50		CL			32.2	45	30	100	84		
2	43.50-43.95	33	CL			22.8	45	30	97	64		
2	45.50-46.00											
2	46.50-46.95	50	SC						75	35		

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / Cu,$_T$ (kN/m^2)	e
2	48.00-48.45	50										
2	49.50-49.95	50	SC						72	41		
2	51.00-51.45											
3	1.50-1.95	19										
3	3.00-3.45	22										
3	7.50-7.95	8	GM						61	26		
3	9.00-9.45	5	ML						100	69		
3	10.50-10.95	9	CL			30.1	32	16	92	57		
3	12.00-12.45	8	SC						94	36		
3	13.50-13.95	10	SC						93	36		
3	15.00-15.50		SC						88	49		
3	16.50-16.95	13	SC						87	47		
3	18.00-18.50		SC									
3	19.50-19.95	35	CL			22.3	36	21	100	84		
4	3.00-3.45	24										
4	6.00-6.45	32	SM						82	22		
4	7.50-7.95	5	CL			28.0	30	18	100	66		
4	9.00-9.45	5	CL			29.1	33	12	100	67		
4	10.50-10.95	12	SC						71	26		
4	12.00-12.45	6	CL			12.4	27	13	92	55		
4	13.50-13.95	15	SC						89	34		
4	15.00-15.45	39										
4	16.50-16.95	14	CL			39.7	40	23	81	55		
4	18.00-18.50		SC			28.2	34	18	100	87		
4	19.50-19.95	34	CL			33.1	37	21	91	68		
5	7.50-7.95	5	ML						100	84		
5	9.00-9.50		GC						55	14		
5	10.50-10.95	20	GC						67	35		
5	12.00-12.50		CL						90	70		
5	13.50-13.95	8	SC						81	40		
5	15.00-15.45	38	SM						66	21		
5	16.50-16.95	13	CL			16.8	39	24	100	83		
5	18.00-18.50											
5	19.50-19.95	12	CL			32.6	37	22	100	80		
6	6.00-6.50		ML						100	76		
6	7.50-8.00		SM						100	29		
6	9.00-9.45	17	CL						100	87		
6	10.50-10.95	19	ML						95	77		
6	12.00-12.45	16										
6	13.50-13.95	18	CL			34.5	50	27	100	84		
6	15.00-15.45	16	GW-GM						51	11		
6	16.50-16.95	40	GC						49	22		
6	18.00-18.50		CL			32.5	40	24	95	82		
6	19.50-19.95	28	CL			21.6	42	26	99	80		
6	21.00-21.50		CL			23.0	40	23	100	83		
6	22.00-22.45	24	SC						56	13		
6	24.00-24.50		CL			29.9	43	28	92	72		
6	25.50-25.95	19	SC						63	22		
6	27.00-27.45	19	SC						67	31		
6	28.50-28.95	33										
6	30.00-30.50		SC						75	39		
6	31.50-31.95	18	CL			27.2	42	27	97	67		

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / $Cu_{,T}$ (kN/m^2)	e
6	33.00-33.50		CL						99	77		
6	34.50-34.95	21	CL			26.4	47	31	100	95		
6	36.00-36.50		SC			28.6	42	28	85	47		
6	37.00-37.45	25	CL			24.4	42	27	99	65		
6	40.50-40.95	32	SC						73	29		
6	43.50-43.95	33										
6	46.50-46.95	50	SC						77	37		
6	48.00-48.45	50	CL			18.6	37	23	95	61		
6	49.50-49.95	50	SC						92	49		
6	51.00-51.50		CL			21.5	37	23				
7	7.50-7.95	3	SM						100	45		
7	10.50-10.95	5	ML						94	76		
7	12.00-12.50		GC						48	13		
7	13.50-13.95	41	SC									
7	15.00-15.45	20	CL			24.0	35	20	98	62		
7	16.50-16.95	19	SC						87	43		
7	18.00-18.45	18	SC						71	27		
7	19.50-20.00		CH						71	53		
Location 13												
1	6.50-6.95	0										
1	7.50-7.95	0										
1	9.50-9.95	12	SP			79.9	21	10	100	1		
1	11.00-11.45	4	CL	1.69		52.6	30	14	100	57		
1	12.50-12.95	6	CL	1.90		31.1	47	28	100	65		
1	14.00-14.45	3	CH	1.60		71.1	58	30	100	74		
1	15.50-15.95	5	CL	1.60		67.1	45	27	100	87		
1	16.50-16.95	21	CL	1.95		27.7	45	30	100	88	53#	
1	18.50-18.95	27										
1	20.50-20.95	29										
1	22.00-22.45	42	CL	2.06		20.8	37	20	99	67		
1	23.50-23.95	46	SC	2.14		17.1	30	20	92	47		
1	25.00-25.45	32									67#	
1	26.50-26.95	25	CL	1.96		26.8	37	21	100	86		
1	28.00-28.45	17									43#	
1	29.50-29.95	21	CL	1.98		25.5	46	26	100	86		
1	31.00-31.45	28										
1	32.50-32.95	27	CH	1.98		25.9	56	34	100	97		
1	34.00-34.45	39		1.90		27.1					70#	
2	9.00-9.45	2	CL	1.81		39.0	45	22	99	64		
2	10.50-10.95	3	SC	2.04		22.3	44	21	96	30		
2	12.00-12.45	5	CL	2.02		23.6	28	9	96	61		
2	13.50-13.95	6	CL	2.03		22.6	29	10	90	57		
2	15.00-15.45	16										
2	17.00-17.45	18	CL	1.97		26.3	44	21	91	68		
2	18.50-18.95	19										
2	20.00-20.45	50	GW-GP			5.4		NP	35	2		
2	21.50-21.95	50										
2	22.50-22.95	8	CL	1.87		33.6	39	17	95	69		
2	24.50-24.95	14	CL	1.92		24.7	35	18	92	66		
2	26.00-26.45	18										
2	27.50-27.95	14										
2	29.00-29.45	32										

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / Cu,$_T$ (kN/m^2)	e
2	30.00-30.45	38									66#	
2	32.00-32.45	35										
2	33.50-33.95	34									71#	
2	35.00-35.95	38										
2	36.50-36.95	50	CL	2.06		21.2	39	20	86	66		
2	38.00-38.45	50										
2	39.00-39.45	50										
2	41.50-41.95	50										
2	43.00-43.45	50										
2	44.50-44.95	50	SC	2.16		16.0	36	16	82	32		
2	46.00-46.45	38										
2	47.50-47.95	50	CL	2.07		20.5	36	16	98	60		
2	49.00-49.45	50										
2	50.50-50.95	50									42#	
2	52.00-52.95	50	CL	2		25.9	37	17	96	64		
64	9.50-9.95	0										
64	11.00-11.45	4										
64	12.50-12.95	5										
64	14.00-14.45	6										
64	15.50-15.95	50										
64	17.00-17.45	23										
64	18.50-18.95	23										
64	20.00-20.45	32										
64	21.50-21.95	41										
64	23.00-23.45	50										
64	24.50-24.95	34										
64	26.00-26.45	40										
64	27.50-27.95	27										
64	29.00-29.45	50										
64	30.50-30.95	50										
64	32.50-32.95	50										
64	34.00-34.45	37										
64	36.00-36.45	47										
64	37.50-37.95	38										
64	39.00-39.45	31										
64	40.50-40.95	22										
64	42.00-42.45	40										
181	11.00-11.45	0										
181	12.00-12.50		SM				40	4	88	39		
181	12.50-12.95	0										
181	14.00-14.45	15	SC			27.3	34	12	91	29		
181	15.50-15.95	13	CL			61.6	34	12	97	83		
181	17.00-17.45	17	CL			36.1	47	23	100	86		
181	18.00-18.50		CH	1.91		30.8	58	33	100	98	57#	
181	18.50-18.95	14										
181	20.00-20.45	20	CL			39.7	47	23	100	97		
181	21.50-21.95	22										
181	23.00-23.45	33	CL			31.3	37	16	100	89		
181	24.00-24.50		CH	1.86		34.3	56	32	100	92	131#	
181	26.00-26.45	44										
181	27.00-27.50	50										
181	27.50-27.95	47	CL			24.6	37	17	100	88		

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / Cu,T (kN/m²)	e
181	29.00-29.45	42	SC			15.6	27	10	89	42		
181	30.00-30.50		CL	2.09		20.1	38	16	98	62	10#	
181	30.50-30.95	48										
181	32.50-32.95	37										
181	33.50-33.95	38										
181	35.00-35.45	38										
181	36.50-36.95	50	CL			26.3	32	13	100	86		
181	38.00-38.45	33	SC			18.4	32	12	80	41		
181	39.50-39.95	38										
181	41.55-42.00	41	CL			36.1	27	10	100	89		
184	12.00-12.50		CH	1.75		48.5	57	30	100	99	13#	
184	12.50-12.95	3										
184	14.00-14.45	8										
184	15.00-15.50		CL			47.5	47	21	98	90		
184	15.50-15.95	14										
184	17.00-17.45	14										
184	18.00-18.50		CH	1.60		71.0	55	27	98	83		
184	18.50-18.95	13	CL			46.6	34	12	96	51		
184	20.00-20.45	15										
184	21.00-21.50		CL			63.0	45	22	97	59		
184	21.50-21.95	14	CL			54.8	47	23	100	76		
184	23.00-23.45	30	CL			31.0	37	16	96	59		
184	24.00-24.50		CL	1.99		26.0	37	17	100	86	70#	
184	24.50-24.95	41										
184	26.00-26.45	45										
184	27.00-27.50		CL			27.8	31	11	100	97		
184	27.50-27.95	47	CL			24.5	26	9	100	87		
184	29.00-29.45	35				48.1			100	79		
184	30.00-30.50		CL				37	16	100	79		
184	30.50-30.95	45	SC			16.2	26	9	69	25		
184	32.00-32.45	50										
184	33.50-33.95	50										
184	35.00-35.45	30	ML			31.0	40	7	96	70		
184	36.50-36.95	33										
184	38.00-38.45	50	SC			15.3	27	10	78	30		
184	39.50-39.95	50										
184	41.00-41.45	45										
184	42.35-42.70	50	SC			18.2	27	11	78	32		
185	7.80-8.25	1	CL			27.6	40	16	83	52		
185	9.00-9.45	5										
185	10.00-10.50		OH	1.38		104.5	61	9	97	84		
185	10.50-10.95	7										
185	12.00-12.45	8	SC			34.1	39	17	70	40		
185	13.00-13.45		OL			74.1	36	6	96	59		
185	13.50-13.95	13										
185	15.00-15.45	12	CL			42.3	48	26	100	91		
185	16.00-16.50		CL	1.91		29.5	39	20	100	94	68#	
185	16.50-16.95	14	CL			34.8	48	22	100	92		
185	18.00-18.45	18										
185	19.50-19.95	16										
185	21.00-21.45	19										
185	22.50-22.95	19	CL			31.1	35	15	92	72		

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / Cu,$_T$ (kN/m^2)	e
185	24.00-24.45	25										
185	25.00-25.50		CH	2.00		26.2	51	30	99	90	41#	
185	25.50-25.95	32	CL			21.3	36	16	96	68		
185	27.00-27.45	29	CL			34.5	36	16	100	84		
185	28.50-28.95	37	CL			25.7	37	16	99	77		
185	30.00-30.45	41	SC			13.7	36	13	72	35		
185	31.50-31.95	32	CL			24.2	36	13	95	59		
Location 14												
54	10.50-10.50	0										
54	11.50-11.75	0										
54	13.00-13.30	0		1.97		26.6						
54	14.50-14.95	24	SC	1.99		25.2	39	15	86	47		
54	16.00-16.50		CL	2.17		24.4	30	10	100	76	42#	
54	16.60-16.95	30	CL	2.02		23.4	34	15	90	51		
54	18.00-18.45	23	CL	2.02		23.5	43	23	85	51		
54	19.50-19.95	35	CL	1.90		31.6	47	26	100	92		
54	21.00-21.45	37	CH	2.87		33.6	74	48	100	92		
54	22.50-22.95	35	CL	1.90		31.3	30	13	100	87		
54	24.00-24.45	40										
54	25.50-25.95		SM-SC	2.09		19.1		NP	66	47		
54	26.00-26.45	23										
54	27.50-27.95	33	CL	1.94		28.7	30	13	100	84		
54	29.00-29.45	33										
54	30.50-30.95	28	CL	1.94		28.8	43	23	100	71		
54	32.00-32.45	23							100	61		
54	33.50-33.95	22										
54	35.00-35.45	21										
54	36.50-37.00		CL	1.71		31.2	44	21	92	67	102*	
54	37.00-37.45	26										
54	38.50-38.95	22	CL	1.95		28.1	40	21	100	29		
54	40.00-40.45	28	CL	1.92		30.2	41	21	100	88		
54	41.50-41.95	29										
54	43.00-43.45	27										
54	44.50-44.95	25										
54	46.00-46.45	20	CL	1.94		28.3	41	22	99	75		
54	48.00-48.45	37										
54	49.50-49.95	49	SC	2.19		14.7		NP	72	25		
54	51.00-51.45	35										
54	52.50-52.95	40										
54	54.00-54.45	36	CL	1.99		24.9	39	21	96	74		
54	55.50-55.95	41										
3	6.00-6.45	1	SC	1.74		46.4	28	6	84	9		
3	9.00-9.45	3	CL	1.89		31.9	34	18	100	51		
3	10.50-10.95	12										
3	12.00-12.45	14										
3	13.00-13.50		CL	1.89		31.4	43	21	99	84	37#	
3	13.50-13.95	12										
3	15.00-15.45	18	CL	1.93		29.3	34	12	95	87		
3	16.50-16.95	21										
3	18.00-18.50		CL	1.94		29.4	51	25	90	82	28#	
3	18.50-18.95	39										
3	19.50-19.95	50	SC	2.26		11.6	34	17	72	18		

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / $Cu_{,T}$ (kN/m^2)	e
3	21.00-21.45	50										
3	22.00-22.50		CL	1.93		27.6	38	19	100	80	11#	
3	22.50-22.95	14										
3	24.00-24.50		CL	2.08		21.7	26	7	99	67	15#	
3	24.50-24.95	21										
3	25.50-25.95	25	CL	1.99		25.4	33	16	98	88		
3	27.00-27.45	37										
3	28.50-28.95	34										
3	30.00-30.45	20	CL	1.99		25.3	34	17	100	75		
3	31.50-31.95	18										
3	32.50-33.00		CL	2.17		22.6	46	26	100	83		
3	33.00-33.50		CL	1.97		27.1	37	16	99	76	76#	
3	33.50-33.95	50										
3	35.00-35.50		CL	2.25		13.4	26	9	90	51	55#	
3	36.00-36.45	33										
3	37.00-37.50		CL	2.24		12.5	33	10	80	37	81#	
3	37.50-37.95	36	CL	2.14		16.8	34	19	95	67		
3	39.00-39.45	32										
3	40.50-40.95	40										
3	42.00-42.45	34										
3	43.00-43.50		CL	2.06		22.1	35	25	100	74	63#	
3	43.50-43.95	36										
3	45.00-45.50	50										
3	46.00-46.50	50										
3	47.50-47.95	44	CL	2.15		16.3	33	16	91	66		
3	50.50-50.95	46										
4	9.50-9.95	1										
4	11.00-11.50		CL	1.94		28.7	47	24	100	96	50#	
4	12.00-12.45	13	CL	1.83		37.1	40	21	97	95		
4	13.50-13.95	21										
4	15.00-15.45	18										
4	16.50-16.95	22	CL	1.91		30.7	45	23	85	75		
4	18.00-18.45	27										
4	19.00-19.50		CH	1.94		31.5	68	46	100	88		
4	19.50-19.95	30										
4	21.00-21.45	50	GC-SC	2.31		9.8	43	19	65	29		
4	22.50-22.95	50										
4	24.00-24.45	22										
4	25.00-25.45	28	CL	2.14		16.7	31	13	93	50		
4	27.00-27.45	34	CL	1.97		26.3	38	20	98	80		
4	28.50-28.95	28	CL	1.93		29.4	49	25	100	85		
4	30.00-30.45	30										
4	31.00-31.50		CL	1.98		25.2	37	17	95	63		
4	31.50-31.95	16	CL	2.04		22.1	32	21	99	65		
4	33.00-33.45	28										
4	34.50-34.95	34										
4	36.00-36.50		CL	2.05		19.6	38	19	99	77		
4	36.50-36.95	25	CL	2.05		21.3	36	20	99	18		
4	37.50-37.95	29										
4	39.00-39.45	32										
4	40.50-40.95	36	SC	2.21		13.6	30	17	69	28		
4	42.00-42.50		CL	2.08		21.7	33	16	91	77		

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / $Cu,_{T}$ (kN/m^2)	e
4	42.50-42.95	38										
4	44.00-44.45	42										
4	45.50-45.95	50	GC-GP	2.30		10.2	33	13	60	22		
4	47.00-47.45	28	CL	2.05		21.7	35	15	96	74		
4	48.50-48.95	33	CL	1.99		24.9	40	20	100	80		
4	50.00-50.45	39										
4	51.50-51.95	30	CL	1.96		26.9	45	23	100	88		
4	53.00-53.45	45	CL	1.99		24.9	48	26	100	73		
Location 15												
5	5.50-5.79	1	CH									
5	7.50-7.90	0	SC	1.94		23.5		NP	98	13		
5	9.00-9.45	3	CH	1.63		58.0	58	39				
5	10.00-10.50		CH	1.74		47.0	63	39	100	96	28#	
5	10.50-10.95	8	CH	1.64		56.2	53	29	94	83		
5	12.00-12.45	7	CL	1.57		66.7	39	17	92	72		
5	13.50-13.95	8	MH				75	37	100	97		
5	14.50-15.00		CL	1.68		48.8	48	26	100	91	4#	
5	15.00-15.45	8										
5	16.50-16.80	50	GC	2.36		8.0		NP	54	20		
5	18.00-18.35	50	GC	2.23		13.0		NP	40	18		
5	19.50-19.83	48	GC	2.30		10.0		NP	44	12		
5	21.00-21.45	22										
5	22.00-22.50		CL	2.06		22.7	39	23	99	70	47#	
5	22.50-22.95	32										
5	24.00-24.45	24										
5	25.50-25.95	22	CL	1.99		24.9	45	28	100	98		
5	27.00-27.45	31										
5	28.50-28.95	20										
5	30.00-30.45	37										
5	31.50-31.95	32										
5	33.00-33.45	32										
5	34.00-34.50		CH	2.00		27.8	49	31	99	71	61#	
5	34.50-34.95	29										
5	36.00-36.45	30	CH	1.95		27.8	49	32	100	93		
5	37.50-37.95	50										
5	39.00-39.45	28	CH	1.93		29.4	55	38	100	83		
5	40.50-40.95	31										
5	42.00-42.35	50		2.20		14.1		NP	63	27		
5	43.50-43.95	47	CL	1.92		29.7	48	32	100	94		
5	45.00-45.45	42										
5	46.50-46.95	44	CL	2.18		15.0	25	12	100	97		
5	48.00-48.45	38										
5	49.50-49.95	45	CL	2.02		23.1	38	19	100	94		
6	7.00-7.25	0	SC				41	13	85	22		
6	9.50-9.80	0	CL	1.60		63.9	48	24	93	75		
6	11.00-11.45	2	ML				41	14	100	78		
6	12.50-12.95	4	MH	1.60		62.6	50	21	91	63		
6	14.00-14.45	17	SM				40	14	73	22		
6	15.50-15.95	33										
6	17.00-17.50			1.96		26.3			99	81	59#	
6	17.50-17.95	16										
6	19.50-19.95	18										

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / Cu,$_T$ (kN/m^2)	e
6	21.00-21.45	39	SC				28	8	100	33		
6	22.50-22.95	24										
6	24.00-24.50			2.07		15.9			91	60	46#	
6	26.00-26.45	33										
6	27.50-27.95	43										
6	29.50-30.00		CL	1.86		26.8	38	18	100	75	17#	
6	31.00-31.50	33										
6	32.00-32.45	50	SC				30	9	89	33		
6	34.00-34.45	41										
6	35.50-35.95	48	CL				31	11	99	72		
6	37.00-37.50	50										
6	38.50-38.95	50										
6	40.00-40.50		CL	2.13		16.3	27	12	100	64	69#	
6	40.50-40.95	50										
6	42.00-42.45	50										
6	43.50-43.95	50										
6	45.00-45.50		GC	1.89		13.6	27	13	72	47	126#	
6	45.50-45.70	50										
6	47.00-47.45	50										
6	48.50-48.95	50										
6	50.50-50.95	50										
66	10.00-10.45	0										
66	11.00-11.45	4	CL			66.4	32	11	100	57		
66	13.00-13.50			1.70		56.7	45	23			7#	
66	13.50-13.95	7	SC			47.5	31	10	100	47		
66	15.00-15.45	10	SM-SC			23.1	23	5	89	46		
66	16.50-16.95	10	CL			24.3	33	14	100	74		
66	18.00-18.50		SC	1.87		29.1	28	11	100	44	21#	
66	18.50-18.95	8	CL			27.3	30	12	100	56		
66	20.00-20.45	8	SC			66.4	33	15	92	49		
66	21.50-21.95	50	SC			9.2	33	13	75	15		
66	23.00-23.45	50	GW-GM			9.0	22	5	43	10		
66	24.00-24.50		SC				28	11	77	28		
66	24.50-24.95	50	SW-SC			8.8	24	8	72	12		
66	26.00-26.95	30	SC			21.2	33	14	91	28		
66	27.00-27.50		CL	2.06		21.3	37	18	92	55	39#	
66	27.50-27.95	26										
66	29.00-29.45	17	CL			27.5	34	14	100	91		
66	30.00-30.50		CL				34	16	96	61		
66	30.50-30.95	19										
66	32.00-32.45	18										
66	33.50-33.95	20										
66	35.00-35.35	50										
66	36.50-37.00		CL	1.90		27.5	38	20	100	90	56#	
66	37.00-37.45	22										
66	38.50-38.95	50										
66	40.00-40.45	50										
66	41.50-42.00		CL				35	17	98	75		
66	42.00-42.45	50										
66	43.50-43.95	50	CL				45	22	98	60		
66	45.05-45.55		CL				37	18	92	62		
66	45.55-46.00	50										

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / $Cu_{,T}$ (kN/m^2)	e
Location 16												
67	6.50-7.00		SC			92.9	45	22	93	49		
67	9.00-9.45	0										
67	10.50.10.95	1	CL			99.1	45	23	85	57		
67	12.00-12.50		OL			46.8	45	15	100	89		
67	12.50-12.95	1	CL			72.3	44	21	88	60		
67	13.50-13.95	50	SC			13.2	28	11	62	13		
67	15.00-15.45	50	SM-SC			10.5	20	5	84	32		
67	18.00-18.50		SM-SC			11.1	19	4	71	16		
67	18.50-18.95	50	CL			27.6	38	15	100	94		
67	19.50-19.95	50	SM-SC			11.5	21	6	90	24		
67	21.00-21.45	50										
67	22.50-22.95	26										
67	24.00-24.50		CL	2.03		23.1	45	21	98	84		
67	24.50-24.95	30										
67	26.00-26.45	24										
67	27.50-27.95	48	SC			14.5	25	8	70	31		
67	29.00-29.45	40										
67	30.00-30.50		CL	1.98		26.6	44	22	100	94		
67	31.50-31.95	28										
67	33.00-33.45	50	SC			14.4	25	8	93	32		
67	34.50-34.95	50										
67	36.00-36.50		CL	2.05		24.2	37	15	100	80		
67	36.50-36.95	41	SC			22.3	26	9	100	47		
67	37.50-37.95	32										
67	39.00-39.50		CL	2		27.9	34	14	100	92		
67	39.50-39.95	32										
67	41.05-41.50	48	CL			21.0	38	16	100	56		
68	9.00-9.45	0	CL			61.7	44	21	100	87		
68	10.00-10.50		OL			71.1	43	13	100	78		
68	10.50-10.95	1	CL			49.0	44	21	100	88		
68	12.00-12.45	3										
68	13.00-13.50		SM-SC			18.4	22	5	93	47		
68	13.50-13.95	4	CL			17.4	35	17	96	51		
68	15.00-15.45	50	SM-SC			17.1	21	6	91	28		
68	16.50-16.95	50	SC			12.8	28	10	69	23		
68	18.00-18.45	50	SW-SC			9.4	27	11	50	11		
68	19.50-19.95	50										
68	21.00-21.50		CL			29.5	35	16	100	69		
68	21.50-21.95	22	CL			33.4	36	18	100	58		
68	23.00-23.45	27	CL			25.8	38	20	100	75		
68	24.00-24.50		CL	1.89		28.4	40	16	95	72		
68	24.50-24.95	36										
68	26.00-26.45	36										
68	27.50-27.95	42	CL			7.3	28	10	100	76		
68	29.00-29.45	50										
68	30.00-30.50		ML	1.87		34.4	43	13	100	8		
68	30.50-30.95	22										
68	32.00-32.45	26										
68	33.50-33.95	50										
68	35.00-35.45	50	SM-SC			7.4	20	5	75	28		
68	36.00-36.50		ML	1.81		39.7	44	14	100	95		

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / Cu,T (kN/m^2)	e
68	36.50-36.95	32										
68	37.50-37.95	50										
68	39.00-39.50		CL	2.01		25.1	44	19	100	78		
68	39.50-39.95	32										
68	41.00-41.45	50										
68	42.50-42.95	47	ML-MC			23.8	25	7	93	57		
68	44.05-44.50	50	ML-MC			25.9	26	6	100	69		
Location 17												
7	9.00-9.45	3	CL	1.81		39.1	48	27	90	57		
7	10.50-10.95	4	CL	1.74		46.7	42	19	100	90		
7	11.50-12.00		CL	1.75		44.9	49	27	100	97	6#	
7	12.50-12.95	9		1.71		49.8			100	97		
7	14.00-14.45	10	CL	1.67		51.2	43	21	95	92		
7	15.50-16.00		CL	2.08		20.5	33	12	97	68	27#	
7	17.00-17.45	50	GM-GC	2.34		8.6	31	11	65	24		
7	18.50-18.75	50										
7	20.00-20.40	50										
7	21.50-21.95	19										
7	22.50-23.00		CL	2.11		18.4	35	16	95	57	38#	
7	23.00-23.45	34										
7	24.50-24.95	50										
7	26.00-26.45	36										
7	27.00-27.50		CL	2.16		15.4	35	16	98	63	16#	
7	27.50-27.95	38										
7	29.00-29.45	41										
7	30.00-30.45	43										
7	32.00-32.45	50										
7	33.00-33.50		CL	2.86		43.4	31	11	100	61	30#	
7	33.50-33.95	41										
7	35.00-35.45	44	CL	2.16		15.7	31	12	94	59		
7	36.50-36.95	39										
7	38.00-38.45	50										
7	39.00-39.50		CL	2.04		23.1	32	12	99	69	43#	
7	39.50-39.95	50										
7	41.00-41.45	47										
7	42.50-42.95	44	CL	2.12		18.1	40	17	99	69		
7	44.00-44.45	41										
7	45.50-45.95	47										
7	47.00-47.45	48	CL	1.98		26.2	39	16	100	82		
7	48.50-48.95	46	CL	1.95		28.0	40	16	100	93		
8	6.50-6.70	0	CO	1.52		76.9			100	67		
8	8.00-8.00	0										
8	9.00-9.10	1										
8	11.00-11.45	2	CL	1.64		55.8	42	20	100	93		
8	12.50-12.95	3	MH-CH	1.66		56.8	56	24	98	95		
8	14.50-14.95	4	CL	1.68		50.6	45	21	98	54		
8	15.00-15.50		SC	2.11		18.2	29	10	96	41	28#	
8	17.00-17.45	26										
8	19.00-19.45	21	CL	1.82		37.9	45	23	100	84		
8	21.00-21.50			1.82		38.4					44#	
8	21.50-21.95	13		1.82		37.9			100	91		
8	23.50-23.95	16	MH-CH	1.82		38.5	57	23	100	94		

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / Cu,T (kN/m²)	e
8	25.50-25.95	24	SC	2.15		16.3	37	18	81	29		
8	27.50-28.00			1.92		28.5					37#	
8	28.00-28.45	36										
8	30.00-30.45	33										
8	30.50-31.00		CL	1.85		35.8	38	14	100	74		
8	31.50-31.95	29										
8	33.00-33.45	28										
8	34.50-34.95	35										
8	35.50-36.00		CL	2.06		23.6	43	27	80	80	48#	
8	36.00-36.45	39										
8	37.50-37.95	43	CL	2.01		23.7	43	25	98	80		
8	39.00-39.45	46							89	59		
8	40.50-40.95	44							94	35		
8	41.00-41.50		CH	1.91		28.1	59	39	93	93	65#	
8	42.00-42.45	38										
8	43.50-43.95	36										
8	45.00-45.45	34										
8	46.50-46.95	39										
8	48.50-48.95	36	CL	2.02		23.2	41	20	100	100		
8	49.50-49.95	41										
8	51.00-51.45	38										
55	8.50-8.50	0										
55	10.00-10.25	0										
55	12.50-12.95	2	SC	1.57		67.9	37	12	80	49		
55	14.00-14.45	3	SC	1.61		60.2	38	13	79	47		
55	15.50-15.95	1	CL	1.60		61.2	38	14	92	64		
55	17.00-17.50		CL	2.16		32.5	37	23	98	81	30#	
55	19.00-19.45	39	CL	1.90		31.5	42	21	100	92		
55	21.50-21.95	35	SC	2.03		22.6	37	20	98	45		
55	23.50-23.95	30										
55	25.00-25.50		CH	2.01		31.5	52	30	100	95	67#	
55	27.00-27.45	24	CL	2.01		23.7	36	18	93	53		
55	28.50-28.95	19										
55	30.00-30.45	21	CL	1.88		33.3	35	18	100	76		
55	31.50-31.95	26							89	68		
55	33.00-33.50		CL	1.99		27.1	44	23	100	86	152*	
55	33.50-33.95	27										
55	35.00-35.45	33	CL	1.95		27.5	43	25	97	70		
55	36.50-36.95	32										
55	38.00-38.45	33	CL	1.87		33.9	36	17	100	88		
55	39.50-39.95	30										
55	41.00-41.45	32										
55	42.50-42.95	38		2.15		16.4		NP	98	76		
55	44.50-44.95	40										
55	46.00-46.45	50	SC-GC	2.32		9.5		NP	68	25		
55	47.50-47.95	36	CL	1.99		25.0	32	14	100	80		
55	49.00-49.45	29	SC	2.19		14.8		NP	99	38		
55	50.50-50.95	33										
55	52.00-52.45	40										
55	53.50-53.95	37										
Location 18												
9	6.00-6.00	0										

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / $Cu_{,T}$ (kN/m^2)	e
9	7.00-7.30	0	OL						100	71	10#	
9	8.50-8.75	0										
9	10.00-10.45	2										
9	11.50-12.00		CL	1.73		48.8	50	22	100	93		
9	12.00-12.45	4										
9	13.50-13.95	5	CL	1.74		46.8	40	17	100	94		
9	15.00-15.45	18										
9	16.50-16.95	24	CL	2.03		22.5	37	17	95	67		
9	18.00-18.50		CL	1.94		28.3	36	16	100	57	51#	
9	18.50-18.95	37										
9	20.00-20.45	45										
9	21.50-21.95	22	CL	1.95		28.1	37	17	100	74		
9	23.00-23.50		SC	2.23		13.6			93	46	156#	
9	23.50-23.95	50										
9	25.00-25.45	50	GC	2.13		17.4		NP	58	24		
9	26.50-26.95	50										
9	28.00-28.45	50										
9	29.50-29.95	38										
9	31.00-31.50		CH	1.92		24.3	54	37	100	75	87#	
9	31.50-31.95	42										
9	33.00-33.45	50										
9	34.50-34.95	50										
9	36.00-36.45	46	CL	2.13		17.3	32	14	86	50		
9	37.50-37.95	50										
9	39.00-39.45	50										
9	40.50-41.00		GC	2.22		15.0	32	17	54	33	112#	
9	41.00-41.45	50										
9	4250-42.95	50										
9	44.00-44.45	50										
9	45.50-45.95	50										
9	47.00-47.45	50	SM	2.16		15.9		NP	75	33		
9	47.50-48.00											
9	48.50-48.95	50										
10	7.00-7.20		PEAT	1.52		74,9			100	83		
10	8.50-8.80	0							84	74		
10	10.00-10.45	2							99	82		
10	11.50-11.95	3	PEAT	1.45		92,9			100	100		
10	13.00-13.45	4							98	71		
10	14.50-14.95	9	SC				29	13	88	28		
10	16.00-16.45	24										
10	17.50-18.00		CL	2.05		18.4	28	9	85	51	69#	
10	18.00-18.45	41										
10	19.50-19.95	50										
10	21.00-21.45	50										
10	22.50-22.95	50										
10	24.00-24.50		CL	2.05		20.9	30	9	98	73	49#	
10	24.50-24.95	32										
10	26.00-26.45	36	CL				35	16	96	57		
10	27.50-28.00		CL	2.12		18.7	29	10	100	61	78#	
10	28.00-28.45	50										
10	29.50-29.95	50										
10	31.00-31.45	38	CL				37	18	100	89		

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / Cu,$_T$ (kN/m^2)	e
10	32.50-32.95	40										
10	34.00-34.50		CL	2.10		20.4	30	14	100	60	45#	
10	34.50-34.95	33										
10	36.00-36.45	50	GM	2.29		10.4		NP	33	9		
10	37.50-37.95	50	CL	1.96		26.8	42	25	100	75		
10	39.00-39.45	33										
10	40.50-41.00		CH	1.91		32.8	62	40	100	85	77#	
10	41.00-41.45	46										
10	42.50-42.95	38										
10	44.00-44.45	48										
10	45.50-45.95	44										
10	47.00-47.45	50										
10	48.50-48.95	50										
10	50.00-50.45	50										
10	51.50-51.95	50	SC	2.15		16.2	33	17	84	46		
Location 19												
11	2.50-2.50	0										
11	4.00-4.20	0										
11	5.50-5.70	0										
11	7.50-7.95	0	PEAT	1.90		31.5		NP	100	28		
11	9.00-9.45	0							100	19		
11	10.50-10.95	5							100	95		
11	12.00-12.50		CL	1.76		34.4	50	20	100	97	9#	
11	12.50-12.95	8							100	77		
11	14.00-14.45	10	SM-SC	2.06		21.0		NP	84	24		
11	15.50-15.95	15	CL				32	14	100	57		
11	17.00-17.45	15										
11	18.50-19.00		CL	2.04		23.3	27	6	95	72	30#	
11	19.00-19.45	28										
11	20.50-20.95	21										
11	22.00-22.45	24										
11	24.00-24.50		CL	1.98		26.1	43	34	100	100		
11	25.00-25.45	13							100	87		
11	26.50-26.95	15										
11	28.00-28.50		ML	1.93		30.9	42	15	100	86	47#	
11	28.50-28.95	31										
11	30.00-30.45	25										
11	31.50-31.95	39										
11	33.00-33.45	32	CL				30	13	98	73		
11	34.50-34.95	39										
11	36.00-36.45	42										
11	37.00-37.50		CL	1.95		24.0	42	26	100	79	67#	
11	37.50-37.95	37										
11	39.00-39.45	50										
11	40.50-40.95	42	CL				35	17	100	75		
11	42.00-42.45	32										
11	43.50-43.95	28	SC	2.13		17.5	34	18	78	42		
11	45.00-45.45	30										
12	4.50-4.50	0										
12	6.00-6.25	0										
12	7.50-7.95	0										
12	9.00-9.45	2	CL	1.78		41.7	39	17	100	56		

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / Cu,$_T$ (kN/m^2)	e
12	10.50-10.95	5	PEAT	1.78		41.9			100	67		
12	12.00-12.45	8	CL	1.80		40.1	35	17	100	71		
12	13.50-13.95	11	CL	1.73		47.7	44	21	100	93		
12	15.00-15.50		CH	1.83		40.8	51	31	100	79	10#	
12	15.50-15.95	23	GC	2.17		15.6	33	14	46	18		
12	17.00-17.45	5		2.01		23.9			97	35		
12	18.50-18.95	11										
12	20.50-20.95	8	SC	2.08		20.0	29	12	89	45		
12	22.00-22.45	29										
12	23.50-24.00		CL	1.99		26.9	44	29	100	70	69#	
12	24.00-24.45	27										
12	25.50.25.95	28										
12	27.00-27.45	30										
12	28.50-28.95	22	CH	1.90		31.1	51	29	100	10		
12	30.00-30.45	28										
12	31.50-31.95	31										
12	33.00-33.45	21										
12	34.50-34.95	17										
12	36.50-36.95	33										
12	38.00-38.45	29										
12	39.50-39.95	32							100	83		
12	41.00-41.45	39										
12	44.50-44.95	41	SM	2.11		18.4		NP	96	30		
12	47.00-47.45	44										
12	48.50-48.95	40	CH	1.87		33.1	50	31	100	90		
12	50.00-50.45	48										
56	5.50-5.50	0										
56	7.00-7.20	0										
56	9.00-9.30	1	OH	1.80		39.9	51	22	97	62		
56	10.50-10.95	2										
56	12.00-12.45	4	PEAT	1.79		41.0		NP	84	30		
56	13.50-13.95	5	CL	2.03		22.5	26	8	100	67		
56	15.00-15.50		CH	1.78		42.7	70	47	91	63	12#	
56	15.50-15.95	13	CL	2.04		21.8	31	14	100	59		
56	17.00-17.45	9	CL	2.02		23.6	25	8	100	55		
56	18.50-18.95	12	CL	2.01		24.1	25	7	100	69		
56	20.00-20.50		CL	2.19		23.8	30	14	94	66	66#	
56	20.50-20.95	33										
56	21.50-21.95	23	CL	2.01		24.0	41	22	91	76		
56	23.00-23.45	22										
56	24.50-24.95	23	CL	2.00		24.5	36	16	100	90		
56	26.00-26.45	26	GC	2.28		10.9		NP	53	19		
56	27.50-27.95	29	GC-GM	2.13		17.6	39	18	58	28		
56	29.00-29.50		CH	1.96		26.3	43	23	100	94	234*	
56	29.50-29.95	29										
56	31.00-31.45	30	CL	1.91		30.5	49	24	100	86		
56	32.50-32.95	28	CL	1.92		29.6	25	7	100	83		
56	34.00-34.45	33										
56	35.50-35.95	28										
56	37.00-37.45	29										
56	38.00-38.50			1.82		34.6			99	83	96*	
56	38.50-38.95	26	CL	1.84		36.2	39	18	99	66		

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / $Cu_{,T}$ (kN/m^2)	e
56	40.00-40.45	25										
56	41.50-41.95	20	CH	1.83		37.3	54	28	100	91		
56	43.00-43.45	22										
56	44.50-44.95	20										
56	46.00-46.45	28										
56	47.50-47.95	28	CL	2.01		23.7	32	14	100	66		
56	49.00-49.45	30										
Location 20												
13	5.00-5.45	2										
13	6.50-6.95	3	CL				45	24	100	91		
13	8.00-8.50		CL	1.82		39.8	36	16	100	90	6#	
13	8.50-8.95	5										
13	10.00-10.45	8	CL				44	23	100	99		
13	11.50-11.95	8	CL				32	14	100	99		
13	13.00-13.45	7	CH				53	30	100	99		
13	14.50-15.00		CH	1.60		54.7	81	53	98	95	14#	
13	15.00-15.45	15										
13	16.50-16.95	30	SC				35	17	56	12		
13	18.00-18.45	27										
13	19.50-19.95	21										
13	21.00-21.45	33										
13	22.50-22.95	26										
13	24.00-24.50		CH	1.91		28.1	53	34	100	89	74#	
13	24.50-24.95	23										
13	26.00-26.45	25										
13	27.50-27.95	23										
13	29.00-29.45	28										
13	30.50-30.95	22										
13	32.00-32.45	28										
13	33.00-33.50		CL	1.95		25.2	43	24	100	80	70#	
13	33.50-33.95	16					30	13				
13	35.00-35.45	17										
13	36.50-36.95	20	CL				45	23	100	89		
13	38.00-38.45	22										
13	39.50-39.95	26										
13	41.00-41.45	27										
13	42.50-42.95	32										
13	44.00-44.45	22										
13	45.50-45.95	32										
13	47.00-47.45	23										
14	5.50-5.80	0										
14	7.00-7.45	3							100	95		
14	8.50-8.95	5							100	94		
14	10.00-10.45	4							100	98		
14	11.50-11.95	6										
14	13.00-13.50		CH	1.71		49.3	79	52	97	91	8#	
14	13.50-13.95	6							100	95		
14	15.00-15.45	5							100	94		
14	16.50-16.95	4	CH				55	22	100	99		
14	18.00-18.50			1.67		50.7			97	88	33*	
14	18.50-18.95	7	CH				52	29	95	92		
14	20.00-20.45	20							96	67		

Table A. Soil Investigation Data (continued)

# of Boring	Depth	SPT-N	USCS	γs	Gs	wn	wL	IP	-No4	-No200	Cu / qu / Cu,$_T$ (kN/m^2)	e
14	21.50-21.95	33										
14	23.00-23.50		CL	2.18		22.8	26	12	94	59	85#	
14	23.50-23.95	29	SC				38	19	80	32		
14	25.00-25.45	35										
14	26.50-26.95	23	CH	1.71		49.3	61	40	100	98		
14	28.00-28.45	26							100	96		
14	29.50-29.95	33										
14	31.00-31.45	30							87	41		
14	32.50-32.95	39										
14	34.00-34.45	39										
14	35.50-35.95	49							97	81		
14	37.00-37.45	45										
14	38.50-38.95	23							100	97		
14	40.00-40.45	30	SC	2.14		16.8		NP	84	46		
14	42.00-42.45	38										
14	43.50-43.95	35										
14	45.00-45.45	33										
14	46.50-46.95	39	CL	2.03		22.7	38	22	94	66		
14	48.00-48.45	39										

#c_u = Undrained Triaxial Compression Test Data

*q_u = Unconfined Compression Test Data

**$c_{u,T}$ = Vane Shear Test Data

APPENDIX B

SOIL PROFILES AND SOIL MODELS

COLOR SCALE

GRAVEL

GW	
GM	
GC	
GP	
GW-GM	
GP-GM	
GP-GC	
GC-GM	
GW-GC	

SAND

SM	
SP	
SW	
SC	
SW-SM	
SP-SM	
SM-SC	
SW-SC	
SP-SC	

SILT

ML	
MH	

CLAY

CL	
CH	

ORGANIC CLAY

OL	
OH	

FILL	

PEAT	

SEA	

ANDEZIT	

	SK-1	SK-2	SK-3	SK-4	SK-5	SK-6	SK-7	SK-8
0.50	-	-	-	-	-	-	-	-
1.00	-	-	-	-	-	-	-	-
1.50	-	-	-	-	-	-	-	-
2.00	SM	-	-	-	-	-	-	-
2.50	-	-	-	-	-	-	-	-
3.00	-	-	-	-	-	-	-	-
3.50	SM	SP	GP	-	-	-	-	-
4.00	-	-	-	-	-	-	-	-
4.50	-	-	-	-	-	-	-	-
5.00	SW	SP	SM	SP	SP	-	-	SW
5.50	-	-	-	-	-	-	-	-
6.00	-	-	-	-	-	-	-	-
6.50	SW	SP	SM	CL	CH	SM	SP	SW
7.00	-	-	-	-	CL	-	-	-
7.50	-	-	-	-	-	-	-	-
8.00	SP	SP	SM	CL	CL	CL	CL	SW
8.50	-	-	-	-	-	-	-	-
9.00	-	-	-	-	-	-	-	-
9.50	SP	CL	CL	CL	CH	CL	CL	SW
10.00	-	-	-	-	CL	-	-	-
10.50	-	-	-	-	-	-	-	-
11.00	CH	CL	CL	CL	CL	CL	CL	CH
11.50	-	-	-	-	-	-	-	-
12.00	-	-	-	-	-	-	-	-
12.50	CH	CL	CL	-	CL	CL	CL	CH
13.00	-	-	-	CL	-	-	-	-
13.50	-	-	-	-	-	-	-	-
14.00	CH	CH	CL	CL	CL	CL	CL	SM
14.50	-	CL	-	-	-	-	-	-
15.00	-	-	-	-	-	-	-	-
15.50	CH	CL	CL	CL	CL	CL	SM	SM
16.00	-	-	-	-	-	-	-	-
16.50	-	-	-	-	-	-	-	-
17.00	CL	CL	CL	CL	GC	CL	SM	SM
17.50	-	-	-	-	-	-	-	-
18.00	-	-	-	-	-	-	-	-
18.50	CL	SC	SM	SC	ML	SC	SM	SC
19.00	-	-	-	-	-	-	-	-
19.50	-	-	-	-	-	-	-	-
20.00	CL	SC	GM	SC	ML	SC	SC	SC
20.50	-	-	-	-	-	-	-	-
21.00	-	-	-	-	-	-	-	-
21.50	SC	SC	GM	SC	SC	SM	SC	SC
22.00	-	-	-	-	-	-	-	-
22.50	-	-	-	-	-	-	-	-
23.00	CL	SM	GM	SC	SC	SC	CL	GC
23.50	-	-	-	-	-	-	-	-
24.00	-	-	-	-	-	-	-	-
24.50	CL	CH	GM	SC	CL	SC	GM	CL
25.00	-	-	-	-	-	-	-	-
25.50	-	-	-	-	-	-	-	-
26.00	CL	GM	GM	CL	GC	SC	GM	CL
26.50	-	-	-	-	-	-	-	-
27.00	-	-	-	-	-	-	-	-
27.50	CL	GM	CL	CL	GC	SC	CL	CL
28.00	-	-	-	-	-	-	-	-
28.50	-	-	-	-	-	-	-	-
29.00	CL	CH	CL	CL	CL	SC	CL	CL
29.50	-	-	-	-	-	-	-	-
30.00	-	-	-	-	-	-	-	-
30.50	SM	SM	CL	SM	CL	SC	SC	CL
31.00			-			-		
31.50			-			-		
32.00			CL			GC		
32.50			-			-		
33.00			-			-		
33.50			SC			GC		
34.00			-			-		
34.50			-			-		
35.00			CL			GC		

MODEL

- FILL
- SAND
- CLAY
- CLAY
- SAND
- CLAY
- SAND

Figure B.1 Soil profiles and soil model at location 1

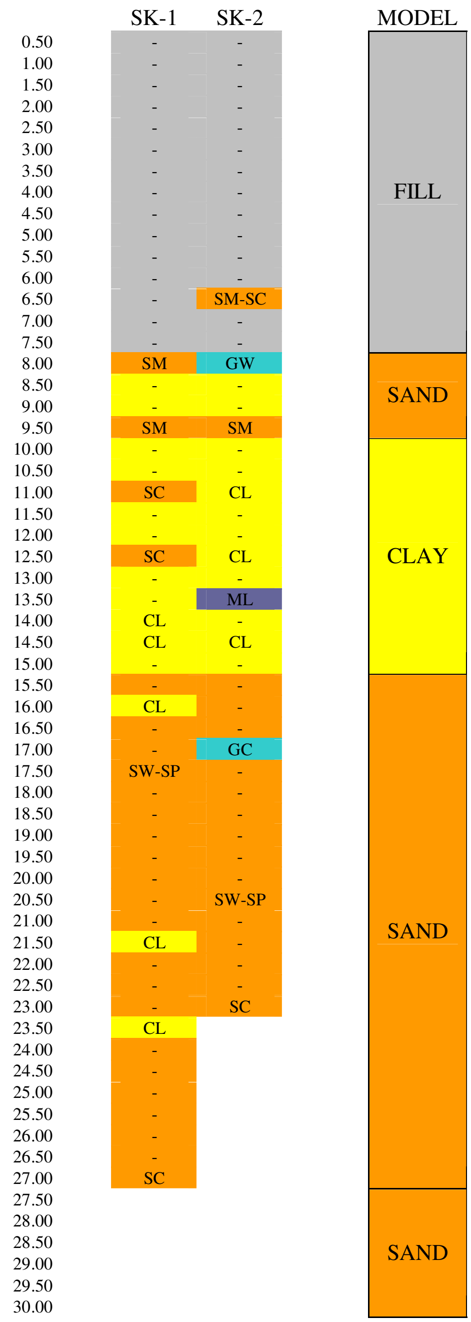

Figure B.2 Soil profiles and soil model at location 2

	SK-1	SK-2	SK-3	SK-4	SK-5	SK-D1	SK-D2	MODEL
0.50	-	-	-	-	-	-	-	
1.00	-	Fill	Fill	Fill	Fill	-	-	FILL
1.50	Fill	-	-	-	-	Fill	Fill	
2.00	-	-	-	-	-	-	-	
2.50	-	SM	Fill		SC	-	-	
3.00	SP-SM	-	-	-	-	SC	-	
3.50	-	-	-	-	-	-	-	
4.00	-	SM		GM	GP-GC	-	-	
4.50	GP-GM	-	-	-	-	-	SM	GRAVEL
5.00	-	-	-	-	-	-	-	
5.50	-	GP	SM	GP-GC	GP	-	-	
6.00	SM	-	-	-	-	CL	GM	
6.50	-	-	-	-	-	-	-	
7.00	-	GP-GC	SM	SC	SW	-	-	
7.50	SM	-	-	-	-	CH	CL	
8.00	-	-	-	-	-	-	-	
8.50	-	CL	SM	-	SM	-	-	SAND
9.00	CL	-	-	-	-	-	CL	
9.50	-	-	-	-	-	-	-	
10.00	-	-	SM	CH	SM	-	-	
10.50	MH	-	-	-	-	CH	CL	
11.00	-	-	-	-	-	-	-	
11.50	-	CL	SM-SC	CH	SC	-	-	
12.00	-	-	-	-	-	CH	CL	
12.50	-	-	-	-	-	-	-	
13.00	-	CH	CL	-	CL	-	-	
13.50	OL	-	-	-	-	CH	SC	CLAY
14.00	-	-	-	-	-	-	-	
14.50	-	CH	CL	CH	CL	-	-	
15.00	OL	-	-	-	-	CH	CL	
15.50	-	-	-	-	-	-	-	
16.00	-	CL	CL	-	CL	-	-	
16.50	CL	-	-	-	-	-	SC	
17.00	-	-	-	-	-	-	-	
17.50	-	SM	SM-SC	CL	SC	-	-	
18.00	SC	-	-	-	-	CH	SC	
18.50	-	-	-	-	-	-	-	
19.00	-	CL	SC	CL	SM	-	-	
19.50	CL	-	-	-	-	CL	-	
20.00	-	-	-	-	-	-	-	SAND
20.50	-	CL	CL	SM	CL	-	-	
21.00	CL	-	-	-	-	SC	GC	
21.50	-	-	-	-	-	-	-	
22.00	-	SC	SC	CL	CL	-	-	
22.50	CL	-	-	-	-	GP-GC	CL	
23.00	-	-	-	-	-	-	-	
23.50	-	CL	CL	SC	CL	-	-	
24.00	CL	-	-	-	-	SW	CL	
24.50	-	-	-	-	-	-	-	
25.00	-	CL	CL	SC	CL	-	-	
25.50	CL	-	-	-	-	-	CL	
26.00	-	-	-	-	-	-	-	
26.50	-	CL	CL	CL	CL	-	-	
27.00	CL	-	-	-	-	-	CL	
27.50	-	-	-	-	-	-	-	
28.00	-	CL	CL	CL	CL	-	-	
28.50	CL	-	-	-	-	SM	CL	
29.00	-	-	-	-	-	-	-	
29.50	-	CH	CL	CL	CL	-	-	CLAY
30.00	-	-	CL	-	-	CL	-	
30.50	-	-		-	-	-	-	
31.00	-	CH		CL	SC	-	-	
31.50	CL	-		-	-	SP-SM	CL	
32.00	-	CH		CL	-	-	-	
32.50					CL			
33.00					-			
33.50					-			
34.00					SC			
34.50					-			
35.00					-			
35.50					CL			
36.00					-			
36.50					-			

Figure B.3 Soil profiles and soil model at location 3

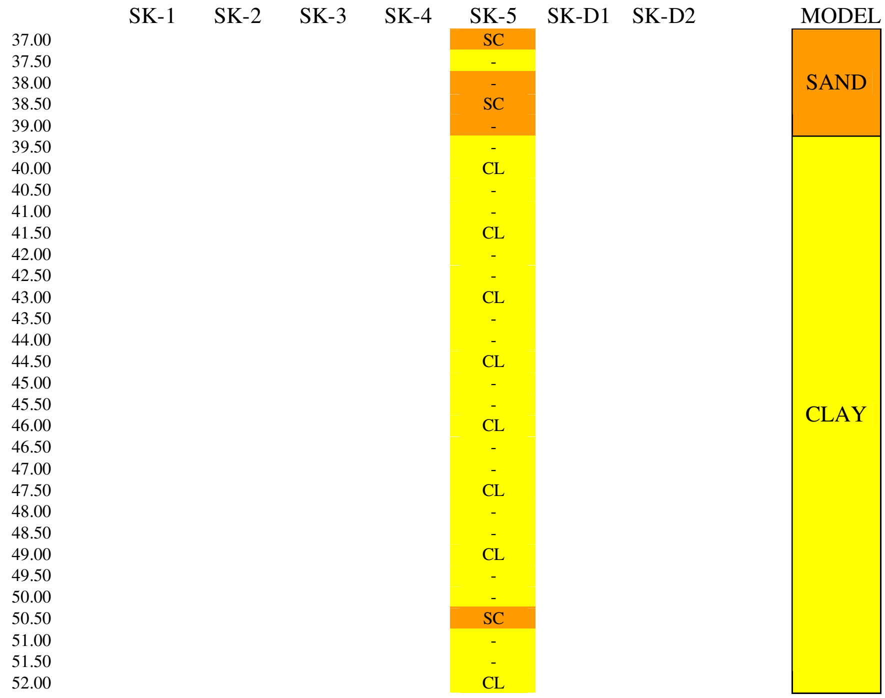

Figure B.3 Soil profiles and soil model at location 3 (continued)

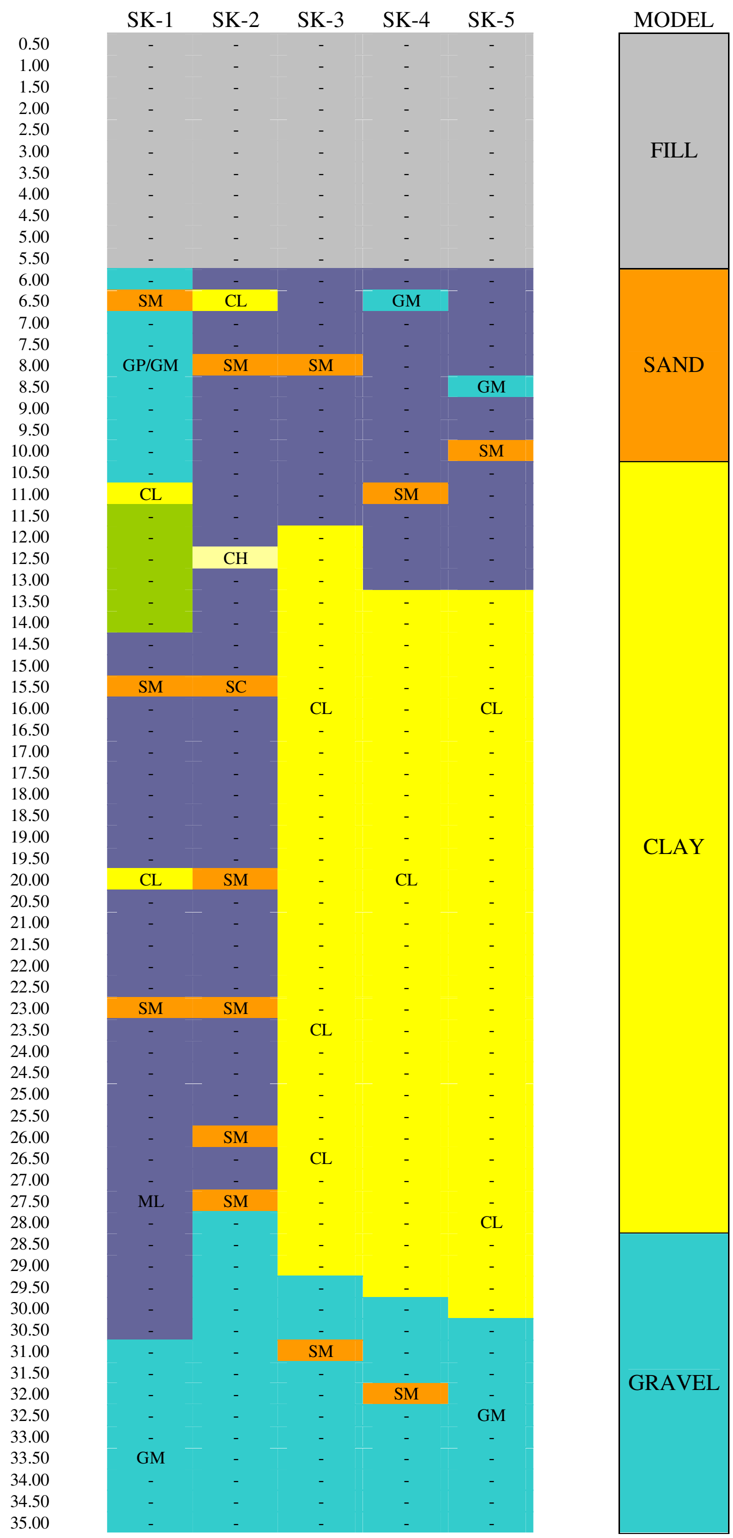

Figure B.4 Soil profiles and soil model at location 4

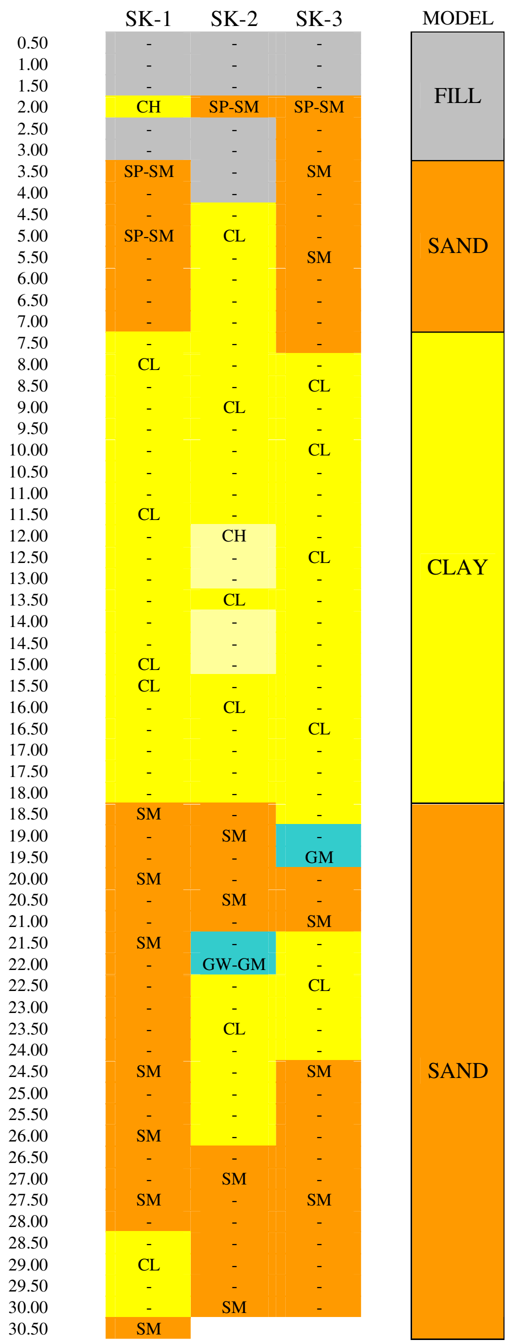

Figure B.5 Soil profiles and soil model at location 5

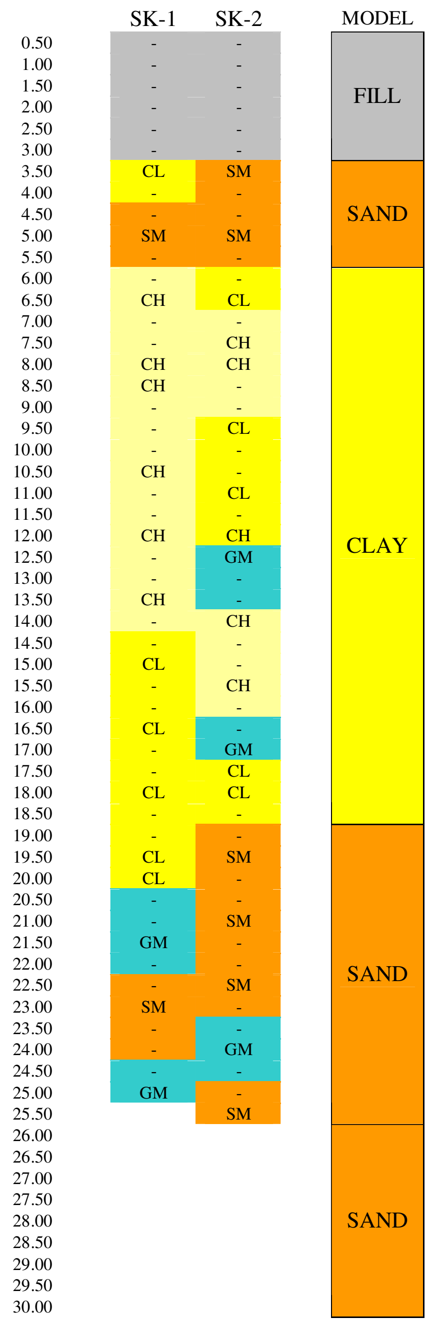

Figure B.6 Soil profiles and soil model at location 6

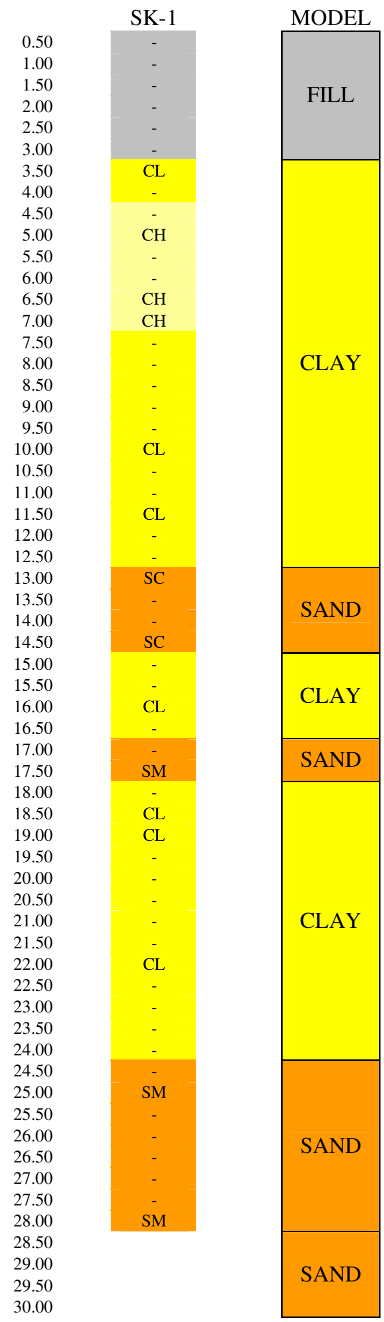

Figure B.7 Soil profiles and soil model
at location 7

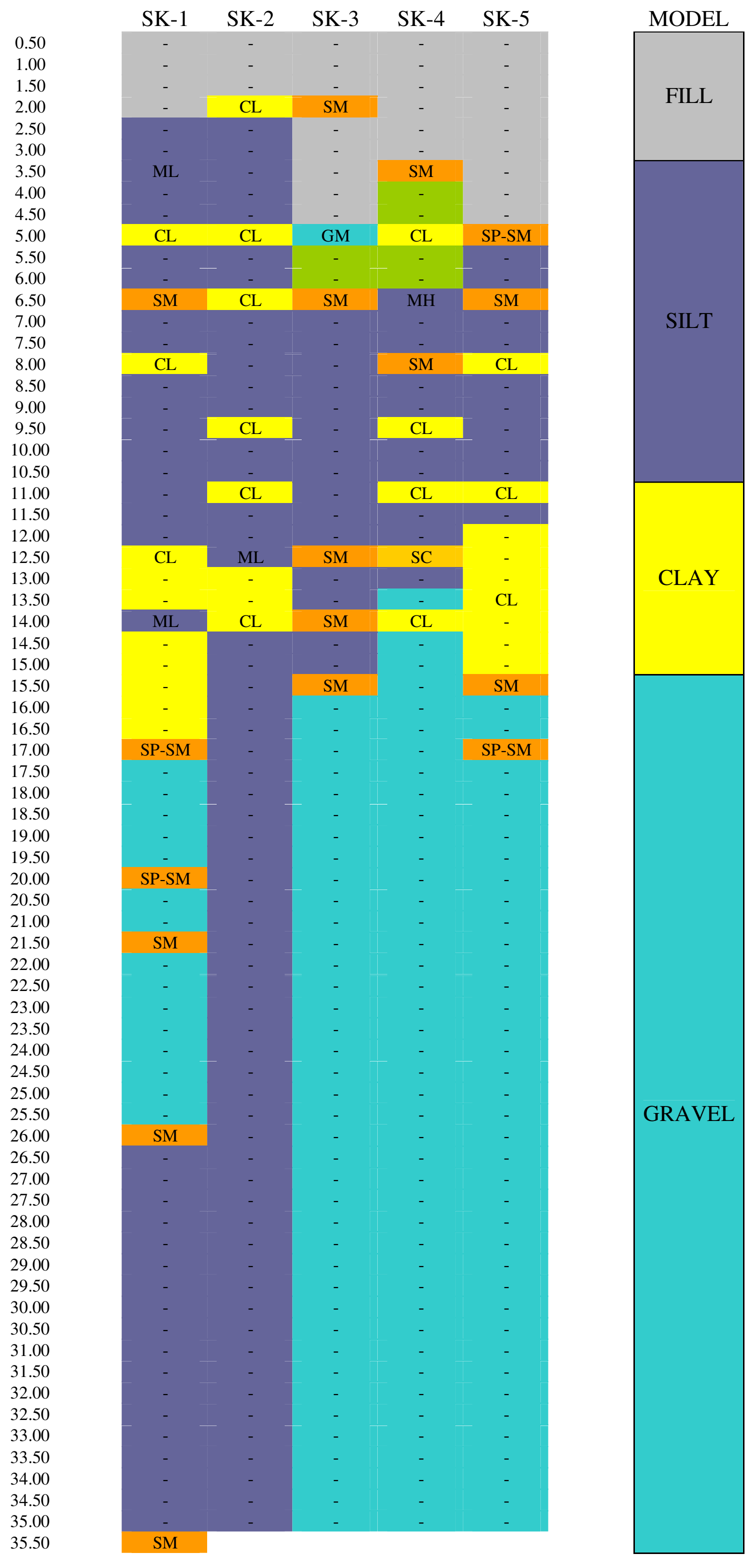

Figure B.8 Soil profiles and soil model at location 8

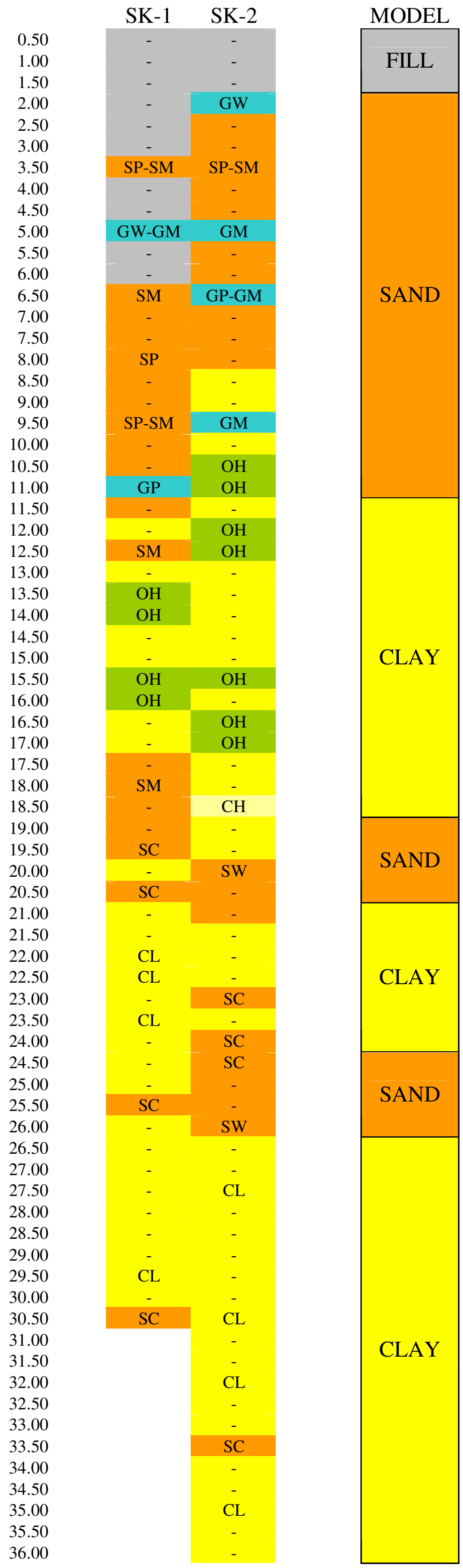

Figure B.9 Soil profiles and soil model at location 9

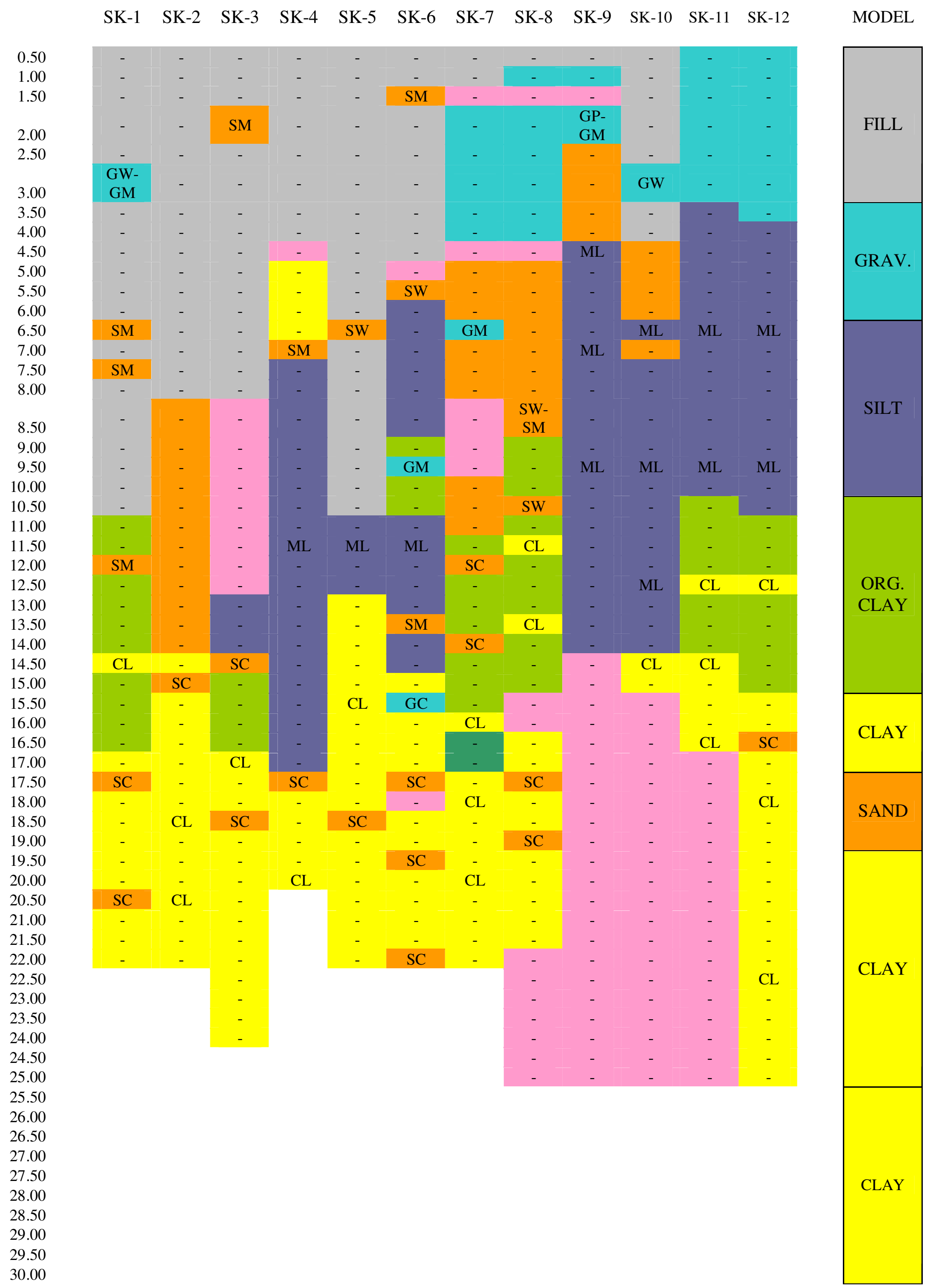

Figure B.10 Soil profiles and soil model at location 10

	SK-1	SK-2	SK-3	MODEL
0.50	-	-	-	
1.00	-	-	-	
1.50	-	-	-	FILL
2.00	-	-	-	
2.50	-	-	-	
3.00	-	-	-	
3.50	-	-	-	
4.00	-	-	-	
4.50	-	-	-	SAND
5.00	SM	SM	SP-SM	
5.50	-	-	-	
6.00	-	-	-	
6.50	OH	OH	OH	
7.00	-	-	-	
7.50	-	-	-	
8.00	OH	OH	OH	
8.50	-	OH	-	
9.00	-	-	-	
9.50	OH	-	-	
10.00	-	-	-	
10.50	-	-	-	ORGANIC CLAY
11.00	OH	OH	OH	
11.50	-	-	OH	
12.00	-	-	-	
12.50	OH	OH	-	
13.00	-	-	-	
13.50	-	-	OH	
14.00	SM	SM	-	
14.50	-	-	-	
15.00	-	-	OH	
15.50	SM	SM	-	
16.00	-	-	-	
16.50	-	-	SC	
17.00	SC	SC	-	SAND
17.50	-	-	-	
18.00	-	SC	CL	
18.50	SC	SC	-	
19.00	-	-	-	
19.50	-	-	CL	
20.00	GW	-	CL	
20.50	-	-	-	
21.00	-	-	-	
21.50	CL	CL	-	
22.00	-	-	CL	
22.50	-	CL	CL	
23.00	-	CL	-	
23.50	CL	-	-	
24.00	CL	CL	CL	
24.50	-	CL	-	
25.00	-	-	-	
25.50	-	-	SC	
26.00	CL	CL		
26.50	-	-		CLAY
27.00	-	-		
27.50	-	-		
28.00	CL	CL		
28.50	-	-		
29.00	-	-		
29.50	CL	-		
30.00	-	CL		
30.50	-			
31.00	-			
31.50	-			
32.00	CL			
32.50	-			
33.00	-			
33.50	CL			
34.00	-			
34.50	SC			SAND
35.00	SC			

Figure B.11 Soil profiles and soil model at location 11

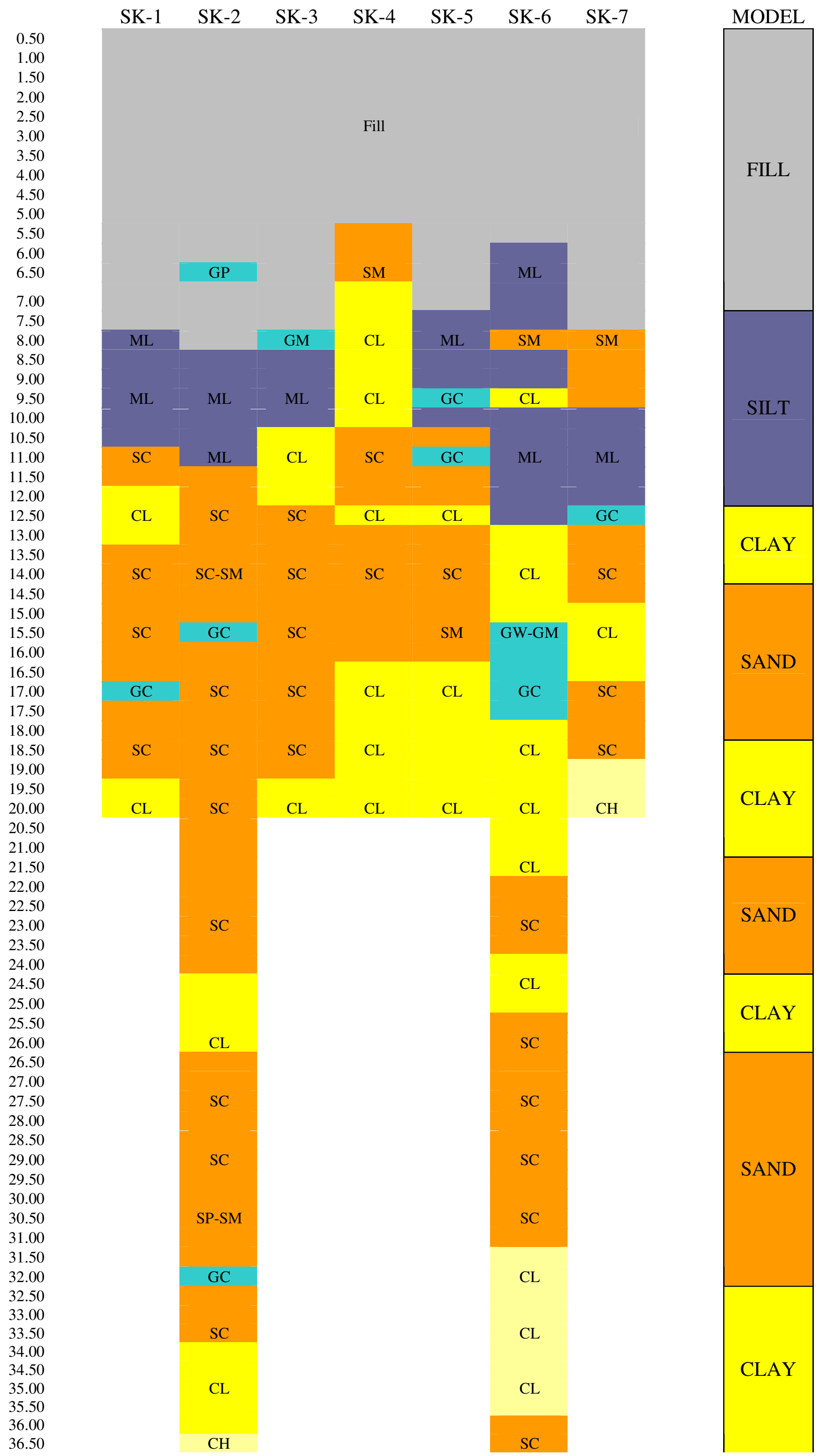

Figure B.12 Soil profiles and soil model at location 12

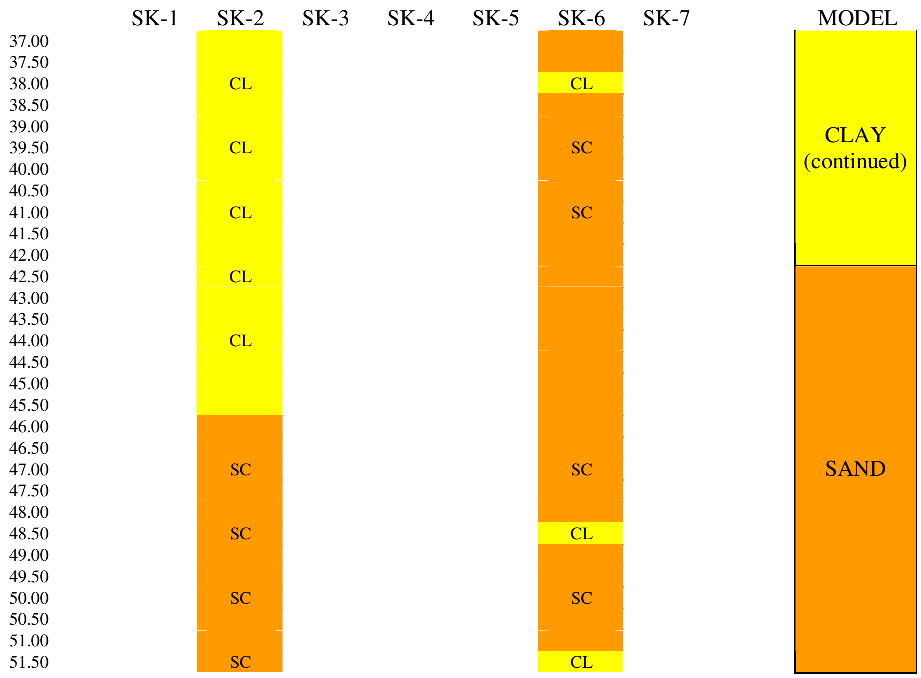

Figure B.12 Soil profiles and soil model at location 12 (continued)

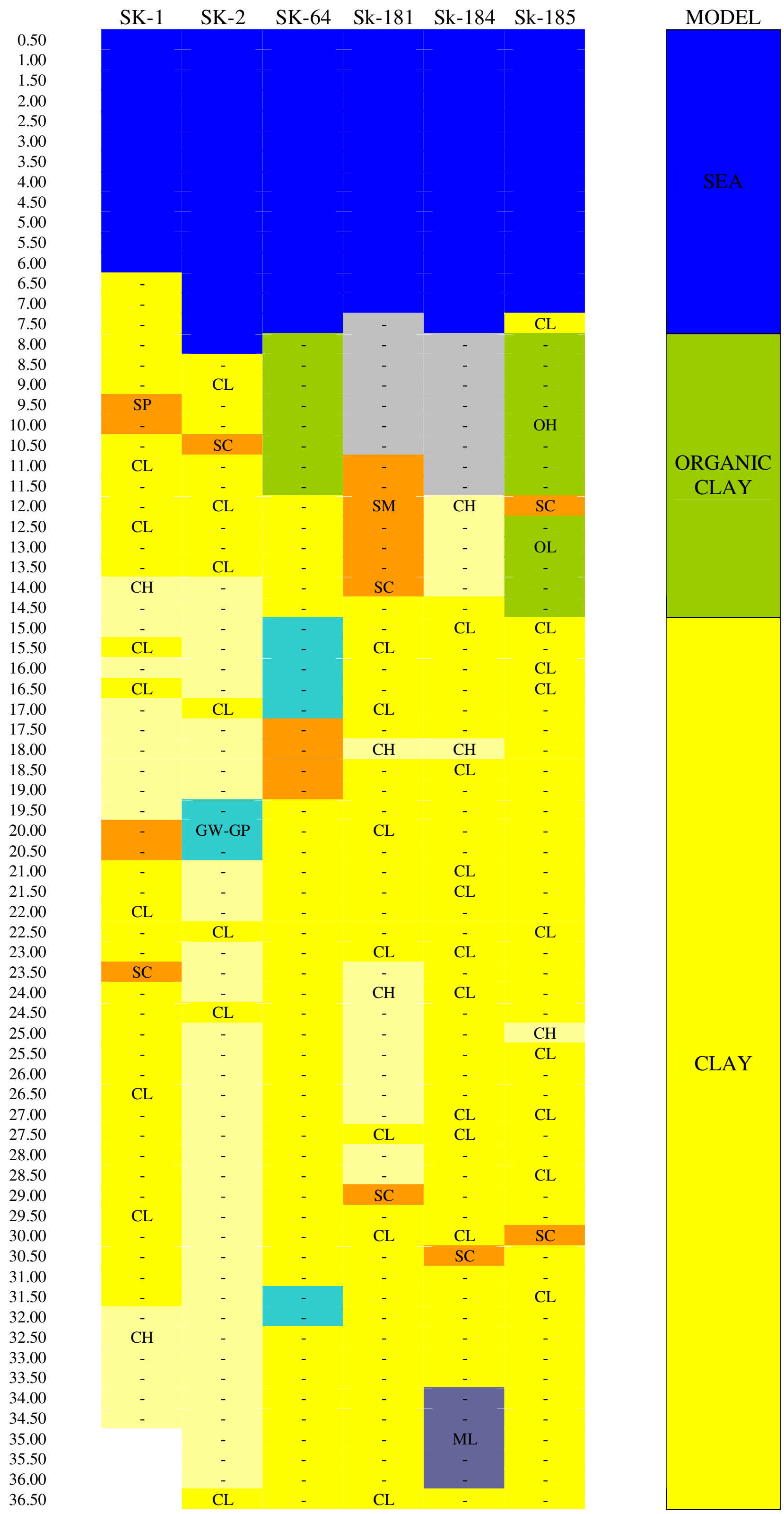

Figure B.13 Soil profiles and soil model at location 13

	SK-1	SK-2	SK-64	Sk-181	Sk-184	Sk-185	MODEL
37.00		-	-	-	-	-	
37.50		-	-	-	-	-	
38.00		-	-	SC	SC	-	
38.50		-	-	-	-	-	
39.00		-	-	-	-	-	CLAY
39.50		-	-	-	-	-	(continued)
40.00		-	-	-	-	-	
40.50		-	-	-	-	-	
41.00		-	-	-	-	-	
41.50		-	-	CL	-	-	
42.00		-	-		SC		
42.50		-					
43.00		-					
43.50		-					
44.00		-					
44.50		SC					
45.00		-					CLAY
45.50		-					
46.00		-					
46.50		-					
47.00		-					
47.50		CL					
48.00		-					
48.50		-					
49.00		-					
49.50		-					SILT
50.00		-					
50.50		-					
51.00		-					
51.50		-					
52.00		CL					
52.50		-					CLAY
53.00		-					

Figure B.13 Soil profiles and soil model at location 13 (continued)

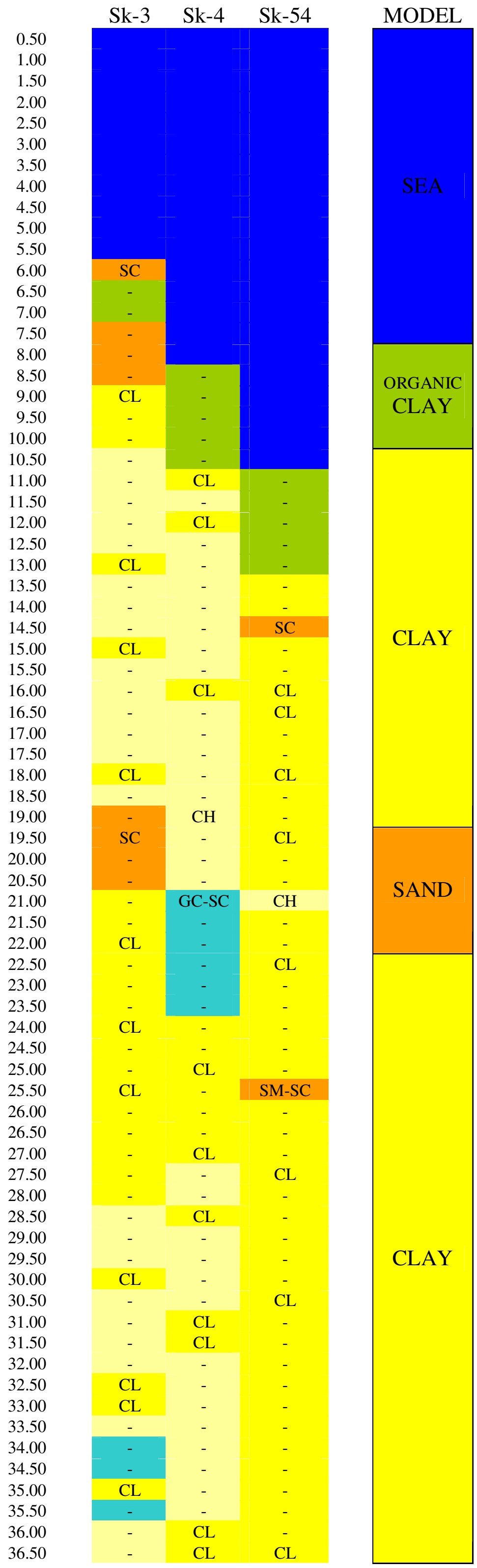

Figure B.14 Soil profiles and soil model at location 14

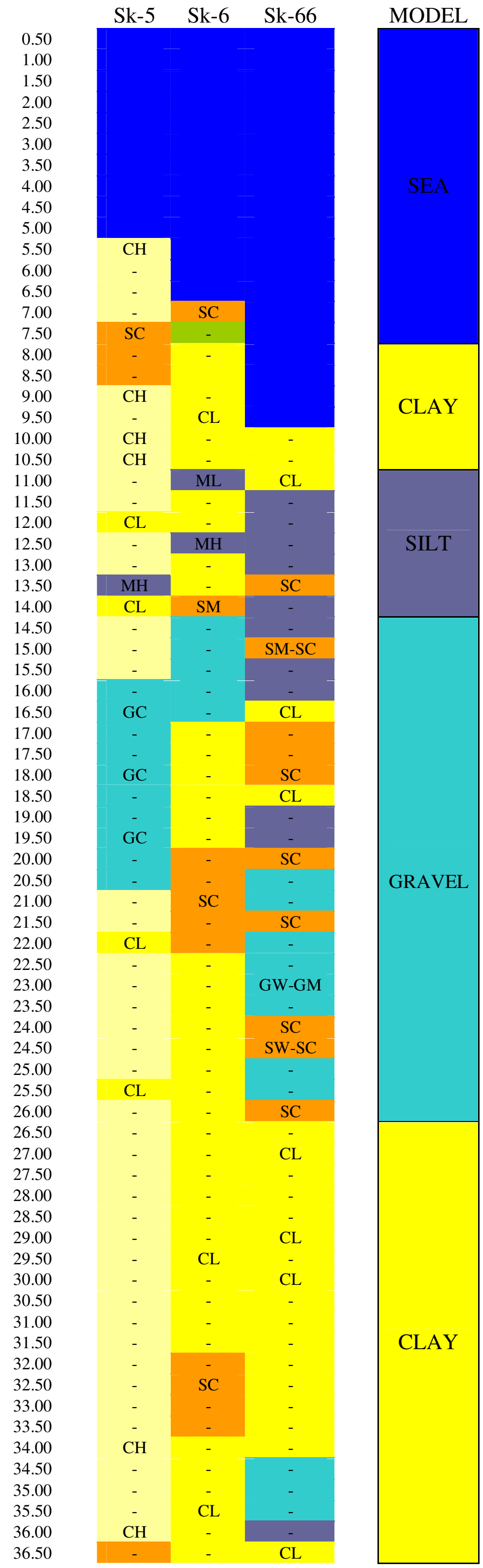

Figure B.15 Soil profiles and soil model at location 15

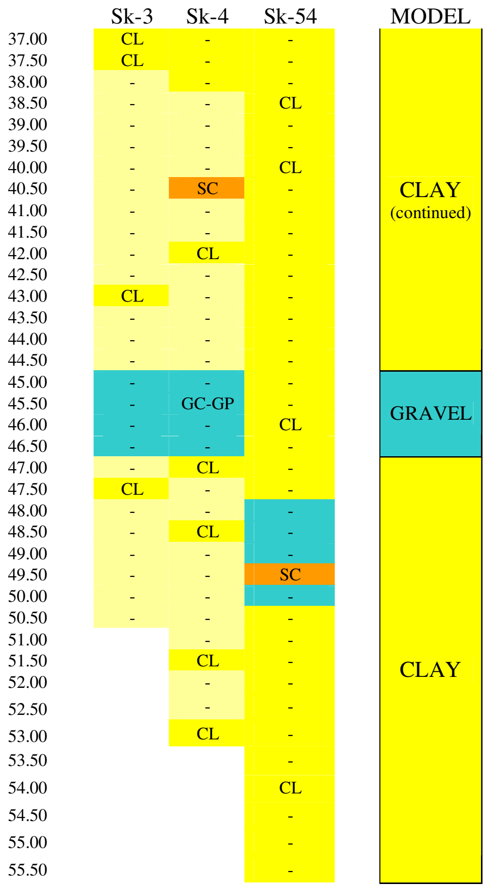

Figure B.14 Soil profiles and soil model at location 14 (continued)

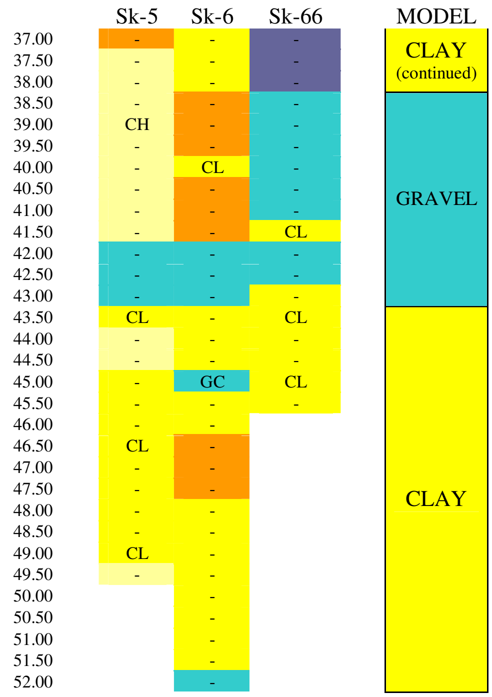

Figure B.15 Soil profiles and soil model at location 15 (continued)

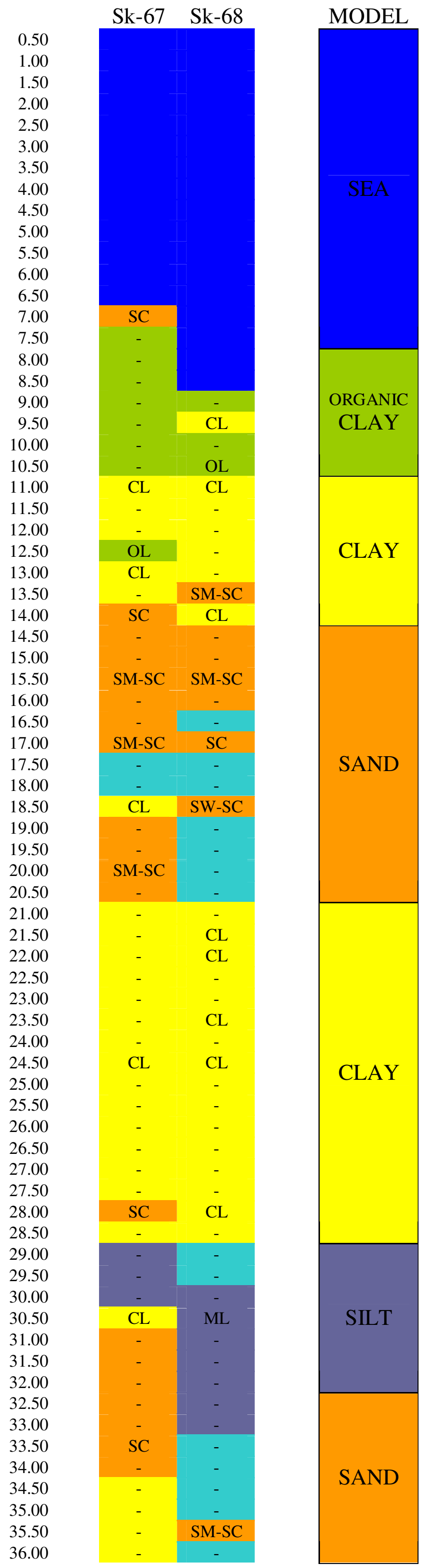

Figure B.16 Soil profiles and soil model at location 16

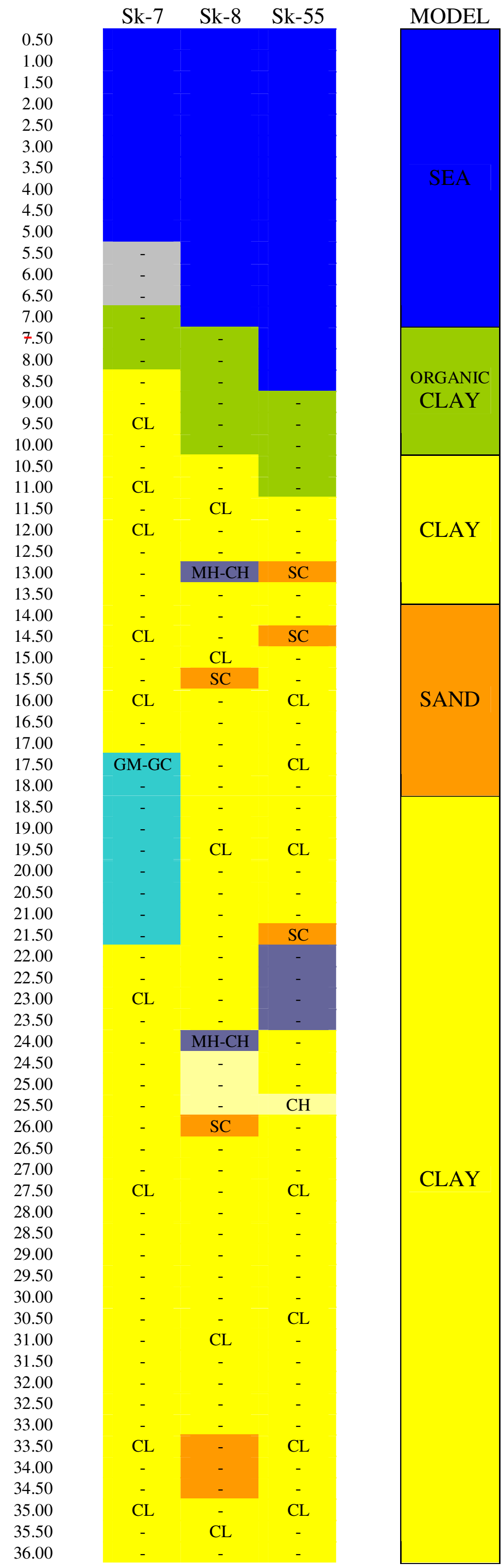

Figure B.17 Soil profiles and soil model at location 17

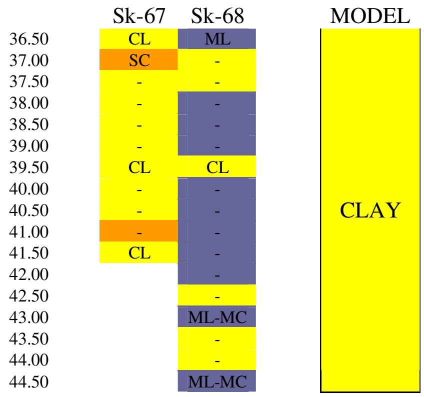

Figure B.16 Soil profiles and soil model at location 16 (continued)

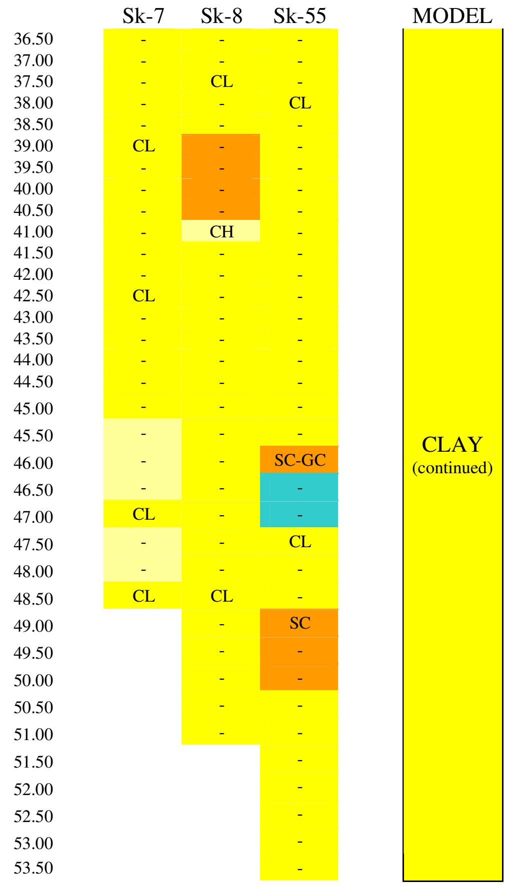

Figure B.17 Soil profiles and soil model at location 17 (continued)

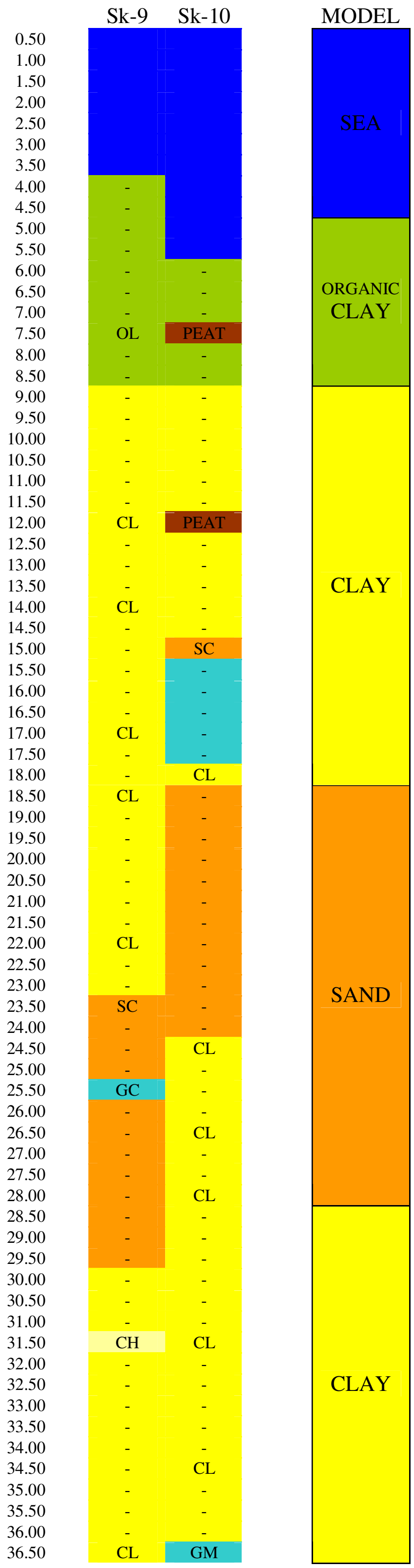

Figure B.18 Soil profiles and soil model at location 18

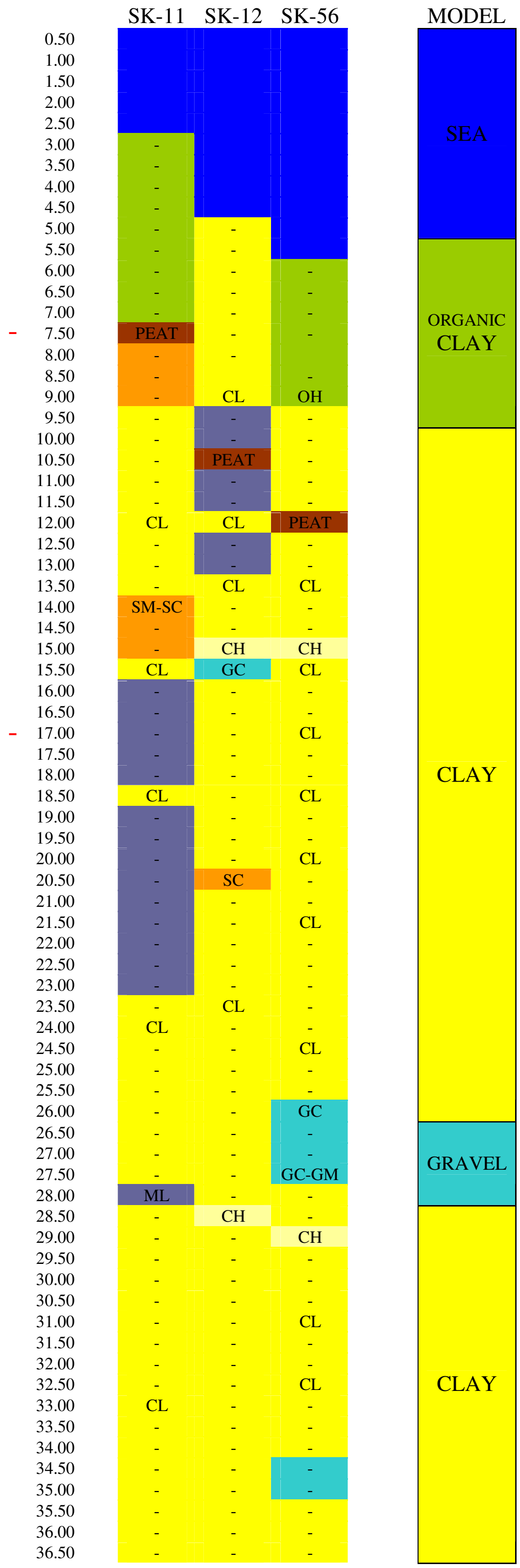

Figure B.19 Soil profiles and soil model at location 19

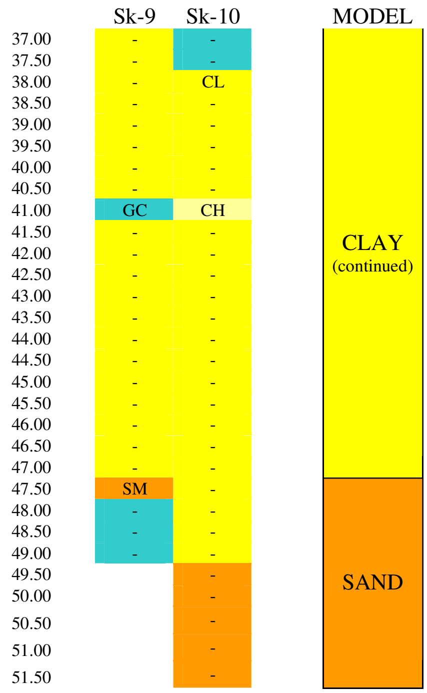

Figure B.18 Soil profiles and soil model at location 18 (continued)

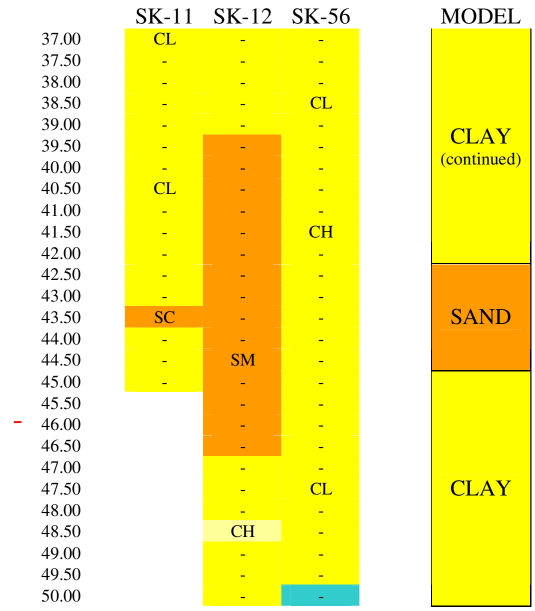

Figure B.19 Soil profiles and soil model at location 19 (continued)

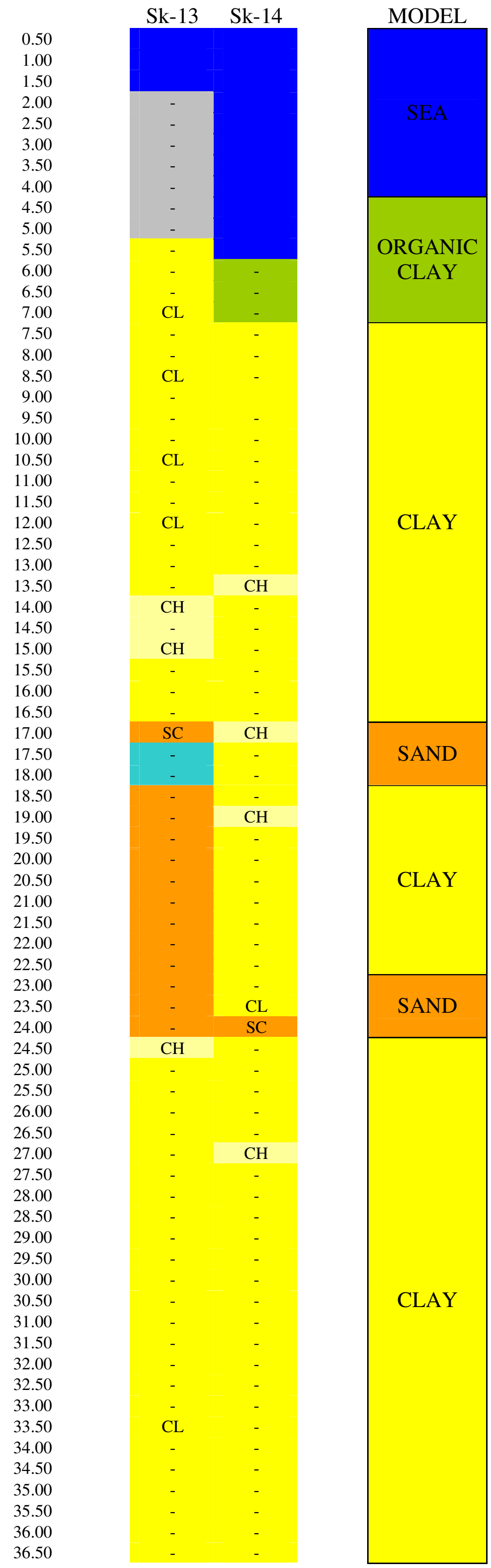

Figure B.20 Soil profiles and soil model at location 20

	Sk-13	Sk-14	MODEL
37.00	CL	-	
37.50	-	-	
38.00	-	-	
38.50	-	-	
39.00	-	-	
39.50	-	-	
40.00	-	-	
40.50	-	SC	
41.00	-	-	CLAY
41.50	-	-	(continued)
42.00	-	-	
42.50	-	-	
43.00	-	-	
43.50	-	-	
44.00	-	-	
44.50	-	-	
45.00	-	-	
45.50	-	-	
46.00	-	-	
46.50	-	-	
47.00	-	CL	SAND
47.50	-	-	
48.00		-	
48.50		-	

Figure B.20 Soil profiles and soil model
at location 20 (continued)

APPENDIX C
IDEALIZED SOIL PROFILES

0.0							
							WT=1.80m
	BACKFILL	γ_n=18.0 kN/m^3 ,	Ip= NP				N=12
3.50							
	SAND (SM)	γ_n=18.0 kN/m^3 ,	Ip = 7				N=11
7.50							
	CLAY (CL)	γ_n=18.0 kN/m^3,	Ip = 19,	c_u=22 kN/m^2,		w_n = 35%	N=13
15.50							
	CLAY (CL)	γ_n=19.0 kN/m^3,	Ip = 19 ,			w_n = 37%	N=23
17.50							
	SAND (SC)	γ_n=20.0 kN/m^3,	Ip = 11				N=38
25.50							
	CLAY (CL)	γ_n=19.0 kN/m^3,	Ip = 15			w_n = 20%	N=37
30.00							
	SAND (SC)	γ_n=19.0 kN/m^3,	Ip = 10				N=46
35.00							End of Borehole

Figure C.1. Idealized soil profile at Location 1

0.0						
						GWT=3.50m
	BACKFILL	*γ_n=18.0 kN/m^3* ,	Ip= NP ,			*N=12*
7.50						
	SAND (SM)	γ_n=18.0 kN/m^3 ,	Ip = NP,			N=20
9.50						
	CLAY (CL)	γ_n=19.0 kN/m^3,	Ip = 17,	c_u=45 kN/m^2,	w_n = 33%	N=10
15.00						
	SAND (SC)	γ_n=20.0 kN/m^3,	Ip = 11 ,			N=40
27.00						End of Borehole

Figure C.2. Idealized soil profile at Location 2

0.0					
					GWT=1.75m
2.00	BACKFILL	γ_n=18.0 kN/m^3 ,	Ip= NP	w_n = 21%	N=11
6.00	GRAVEL (GP-GC)	γ_n=18.0 kN/m^3 ,	Ip = NP	w_n = 19%	N=20
10.00	SAND (SC)	γ_n=18.0 kN/m^3,	Ip = 15,	w_n = 18% ,	N=16
17.00	CLAY (CL)	γ_n=19.0 kN/m^3,	Ip = 7 ,	w_n = 40%	N=25
22.50	SAND (SC)	γ_n=19.0 kN/m^3,	Ip = 18	w_n = 18%	N=24
33.50	CLAY (CL)	γ_n=19.0 kN/m^3,	Ip = 20	w_n = 24%	N=21
39.00	SAND (SC)	γ_n=20.0 kN/m^3,	Ip = NP		N=28
50.00	CLAY (CL)	γ_n=20.0 kN/m^3,	Ip = 18 ,	w_n = 29%	N=25
52.00	SAND (SC)	γ_n=20.0 kN/m^3,	Ip = NP ,	w_n = 20%	N=45 End of Borehole

Figure C.3. Idealized soil profile at Location 3

0.0					
5.50	BACKFILL	γ_n=18.0 kN/m^3 ,	Ip= NP ,		N=11
					GWT=6.40m
10.00	SAND (SM)	γ_n=18.0 kN/m^3 ,	Ip = NP,	w_n = 20%	N=28
28.50	CLAY (CL)	γ_n=18.0 kN/m^3,	Ip = 15,	w_n = 23%	N=12
35.00	GRAVEL (GM-SM)	γ_n=19.0 kN/m^3,	Ip = NP ,	w_n = 11%	N=42 End of Borehole

Figure C.4. Idealized soil profile at Location 4

0.0						GWT=1.80m
	BACKFILL	γ_n=*18.0 kN/m^3* ,	Ip= 10 ,		w_n = 22%	N=12
3.00	SAND (SM)	γ_n=18.0 kN/m^3 ,	Ip = NP,		w_n = 19%	N=17
7.00	CLAY (CL)	γ_n=17.0 kN/m^3,	Ip = 20,	c_u=17 kN/m^2,	w_n = 41%	N=6
18.00	SAND (SM)	γ_n=19.0 kN/m^3,	Ip = NP ,		w_n = 14%	N=36
30.50					End of Borehole	

Figure C.5. Idealized soil profile at Location 5

0.0						GWT=1.00m
	BACKFILL	γ_n=*18.0 kN/m^3* ,	*Ip= NP* ,			*N=12*
3.00	SAND (SM)	γ_n=19.0 kN/m^3 ,	Ip = NP,			N=21
5.50	CLAY (CL)	γ_n=18.0 kN/m^3,	Ip = 22,	c_u=54 kN/m^2,	w_n = 37%	N=9
18.50	SAND (SM)	γ_n=19.0 kN/m^3,	Ip = NP ,			N=38
25.50						End of Borehole

Figure C.6. Idealized soil profile at Location 6

0.0				GWT=1.00m
3.00	BACKFILL	*γ_n=18.0 kN/m^3 , Ip= NP*		*N=12*
12.50	CLAY (CL)	γ_n=18.0 kN/m^3 , Ip = 23, c_u=61 kN/m^2,	w_n = 31%	N=6
14.50	SAND (SC)	γ_n=18.0 kN/m^3, Ip = 22,		N=10
16.50	CLAY (CL)	γ_n=19.0 kN/m^3, Ip = 22 ,	w_n = 22%	N=11
17.50	SAND (SM)	γ_n=19.0 kN/m^3, Ip = NP		N=13
24.00	CLAY (CL)	γ_n=19.0 kN/m^3, Ip = 21	w_n = 26%	N=12
28.00	SAND (SM)	γ_n=20.0 kN/m^3, Ip = NP		N=17 End of Borehole

Figure C.7. Idealized soil profile at Location 7

0.0				
3.00	BACKFILL	*γ_n=18.0 kN/m^3* , Ip= NP , w_n = 21%		N=9
				GWT=3.80m
10.50	CLAY (CL)	γ_n=20.0 kN/m^3 , Ip = 9,	w_n = 20%	N=11
15.00	CLAY (CL)	γ_n=20.0 kN/m^3, Ip = 13,	w_n = 19%	N=15
35.50	SAND (SP-SM)	γ_n=21.0 kN/m^3, Ip = NP ,		N=47 End of Borehole

Figure C.8. Idealized soil profile at Location 8

0.0				
1.50	BACKFILL	*γ_n=18.0 kN/m^3 , Ip= NP*		*N=12* GWT=1.50m
11.00	SAND (SP-SM)	γ_n=17.0 kN/m^3 , Ip = NP		N=20
18.50	CLAY (CH)	γ_n=18.0 kN/m^3, Ip = 27, c_u=30 kN/m^2,	w_n = 41%	N=5
20.50	SAND (SC)	γ_n=20.0 kN/m^3, Ip = NP ,		N=16
24.00	CLAY (CL)	γ_n=21.0 kN/m^3, Ip = 19, c_u=100 kN/m^2,	w_n = 29%	N=12
26.00	SAND (SC)	γ_n=20.0 kN/m^3, Ip = NP		N=29
36.00	CLAY (CL)	γ_n=20.0 kN/m^3, Ip = 19,c_u=160 kN/m^2,	w_n = 22%	N=30 End of Borehole

Figure C.9. Idealized soil profile at Location 9

0.0				GWT=1.20m
3.00	BACKFILL	*γ_n=18.0 kN/m^3* , Ip = NP	w_n = 16%	N=33
6.00	GRAVEL (GM-SM)	γ_n=18.0 kN/m^3 , Ip = NP	w_n = 35%	N=19
10.00	SILT (ML)	γ_n=18.0 kN/m^3, Ip = NP	w_n = 32%	N=12
15.00	CLAY (OL)	γ_n=19.0 kN/m^3, Ip = 13	w_n = 39%	N=6
17.00	CLAY (CL)	γ_n=19.0 kN/m^3, Ip = 19	w_n = 28%	N=31
19.00	SAND (SC)	γ_n=19.0 kN/m^3, Ip = 22	w_n = 17%	N=39
25.00	CLAY (CL)	γ_n=19.0 kN/m^3, Ip = 23	w_n = 19%	N=30 End of Borehole

Figure C.10. Idealized soil profile at Location 10

0.0							GWT=1.60m
3.00	BACKFILL		γ_n=18.0 kN/m^3 ,	Ip= NP			N=12
5.50	SAND	(SM)	γ_n=18.0 kN/m^3 ,	Ip = NP			N=8
15.00	CLAY	(OH)	γ_n=17.0 kN/m^3,	Ip = 22,	c_u=67 kN/m^2,	w_n = 38%	N=10
18.50	SAND	(SC)	γ_n=19.0 kN/m^3,	Ip = NP			N=25
34.00	CLAY	(CL)	γ_n=19.0 kN/m^3,	Ip = 18,	c_u=135 kN/m^2,	w_n = 24%	N=23
35.00	SAND	(SC)	γ_n=19.0 kN/m^3,	Ip = NP			N=50 End of Borehole

Figure C.11. Idealized soil profile at Location 11

0.0						GWT=2.50m
7.00	BACKFILL		γ_n=18.0 kN/m^3 ,	Ip= NP		N=34
12.00	SILT	(ML)	γ_n=18.0 kN/m^3 ,	Ip = 13	w_n = 29%	N=11
14.00	CLAY	(CL)	γ_n=18.0 kN/m^3,	Ip = 19,	w_n = 28% ,	N=13
18.00	SAND	(SC)	γ_n=18.0 kN/m^3,	Ip = NP		N=26
21.00	CLAY	(CL)	γ_n=18.0 kN/m^3,	Ip = 23	w_n = 27%	N=24
24.00	SAND	(SC)	γ_n=19.0 kN/m^3,	Ip = NP		N=24
26.00	CLAY	(CL)	γ_n=19.0 kN/m^3,	Ip = 26 ,	w_n = 26%	N=19
32.00	SAND	(SC)	γ_n=19.0 kN/m^3,	Ip = NP		N=23
42.00	CLAY	(CL)	γ_n=20.0 kN/m^3,	Ip = 25 ,	w_n = 26%	N=27
50.00	SAND	(SC)	γ_n=20.0 kN/m^3,	Ip = NP		N=46 End of Borehole

Figure C.12. Idealized soil profile at Location 12

Depth (m)	Soil	Properties				
0.0						WT=2.00m
10.00	BACKFILL	γ_n=20.0 kN/m^3 ,				
17.00	CLAY (OL)	γ_n=18.0 kN/m^3 ,	Ip = 16,	c_u=10 kN/m^2,	w_n = 47%	N=5
44.00	CLAY (CL)	γ_n=19.0 kN/m^3,	Ip = 18,	c_u=75 kN/m^2,	w_n = 31%	N=33
50.00	CLAY (CH)	γ_n=21.0 kN/m^3,	Ip = 16		w_n = 16%	N=47
54.00	SILT (ML)	γ_n=20.0 kN/m^3,	Ip = 16,	c_u=42 kN/m^2,	w_n = 21%	N=50
55.50	CLAY (CL)	γ_n=20.0 kN/m^3,	Ip = 17		w_n = 26% End of Borehole	N=50

Figure C.13. Idealized soil profile at Location 13

Depth (m)	Soil	Properties				
0.0						GWT=2.00m
10.00	BACKFILL	γ_n=20.0 kN/m^3 ,				
12.50	CLAY (OL)	γ_n=18.0 kN/m^3 ,	Ip = 12		w_n = 39%	N=1
21.50	CLAY (CL)	γ_n=19.0 kN/m^3,	Ip = 24,	c_u=40 kN/m^2,	w_n = 28%	N=21
24.50	SAND (SC)	γ_n=20.11 kN/m^3,	Ip = 26 ,		w_n = 23%	N=42
47.00	CLAY (CL)	γ_n=20.0 kN/m^3,	Ip = 13,	c_u=69 kN/m^2,	w_n = 23%	N=30
49.00	GRAVEL (GP-GC)	γ_n=21.0 kN/m^3,	Ip = 17		w_n = 10%	N=50
58.00	CLAY (CL)	γ_n=20.11 kN/m^3,	Ip = 16		w_n = 23%	N=37 End of Borehole

Figure C.14. Idealized soil profile at Location 14

Depth (m)	Soil	Unit weight	Ip	c_u	w_n	N
0.0						GWT=2.00m
10.00	BACKFILL	γ_n=20.0 kN/m^3 ,				
13.00	CLAY (CL)	γ_n=17.0 kN/m^3 ,	Ip = 24 ,	c_u=28 kN/m^2,	w_n = 50%	N=2
16.50	SILT (ML)	γ_n=17.0 kN/m^3,	Ip = 19		w_n = 58%	N=9
28.50	GRAVEL(GC)	γ_n=21.0 kN/m^3,	Ip = 10		w_n = 21%	N=29
40.50	CLAY (CL)	γ_n=19.0 kN/m^3,	Ip = 19,	c_u=47 kN/m^2,	w_n = 27%	N=33
45.50	GRAVEL(GC)	γ_n=20.0 kN/m^3,	Ip = 17		w_n = 20%	N=45
54.50	CLAY (CL)	γ_n=20.0 kN/m^3,	Ip = 19,	c_u=98 kN/m^2,	w_n = 20%	N=45 End of Borehole

Figure C.15. Idealized soil profile at Location 15

Depth (m)	Soil	Unit weight	Ip	w_n	N
0.0					GWT=2.00m
9.50	BACKFILL	γ_n=20.0 kN/m^3 ,			
12.50	CLAY (CL)	γ_n=17.0 kN/m^3 ,	Ip = 19	w_n = 75%	N=0
16.00	CLAY (CL)	γ_n=18.0 kN/m^3,	Ip = 16	w_n = 45%	N=2
22.50	SAND (SM-SC)	γ_n=19.0 kN/m^3,	Ip = 8	w_n = 14%	N=50
30.50	CLAY (CL)	γ_n=19.0 kN/m^3,	Ip = 16	w_n = 28%	N=34
34.00	SILT (ML)	γ_n=19.0 kN/m^3,	Ip = 18	w_n = 30%	N=35
38.00	SAND (SC)	γ_n=19.0 kN/m^3,	Ip = 7	w_n = 11%	N=45
46.50	CLAY (CL)	γ_n=19.0 kN/m^3,	Ip = 13	w_n = 26%	N=41 End of Borehole

Figure C.16. Idealized soil profile at Location 16

Depth (m)	Soil	Properties			w_n	N
0.0						WT=2.00m
	BACKFILL	γ_n=20.0 kN/m^3 ,				
9.00						
	CLAY (CL)	γ_n=17.0 kN/m^3 ,	Ip = 22		w_n = 58%	N=0
12.00						
	CLAY (CL)	γ_n=17.0 kN/m^3,	Ip = 22,	c_u=20 kN/m^2,	w_n = 54%	N=3
16.00						
	SAND (SC)	γ_n=19.0 kN/m^3,	Ip = 16 ,		w_n = 38%	N=16
20.00						
	CLAY (CL)	γ_n=20.0 kN/m^3,	Ip = 18,	c_u=47 kN/m^2,	w_n = 26%	N=36
56.00					End of Borehole	

Figure C.17. Idealized soil profile at Location 17

Depth (m)	Soil	Properties			w_n	N
0.0						GWT=2.00m
	BACKFILL	γ_n=20.0 kN/m^3 ,				
6.50						
	CLAY (CL)	γ_n=16.5 kN/m^3 ,	Ip = 13		w_n = 75%	N=0
10.50						
	CLAY (CL)	γ_n=18.0 kN/m^3,	Ip = 13,	c_u=72 kN/m^2,	w_n = 46%	N=10
20.00						
	SAND (SC)	γ_n=20.0 kN/m^3,	Ip = 11		w_n = 21%	N=43
30.00						
	CLAY (CL)	γ_n=20.0 kN/m^3,	Ip = 21,	c_u=75 kN/m^2,	w_n = 21%	N=46
49.00						
	SAND (SC)	γ_n=21.0 kN/m^3,	Ip = 9		w_n = 16%	N=50
54.00						End of Borehole

Figure C.18. Idealized soil profile at Location 18

0.0						
						GWT=2.00m
	BACKFILL	γ_n=20.0 kN/m^3 ,				
7.00						
	CLAY (CL)	γ_n=18.0 kN/m^3 ,	Ip = 13		w_n = 38%	N=0
11.50						
	CLAY (CL)	γ_n=19.0 kN/m^3,	Ip = 17,	c_u=44 kN/m^2,	w_n = 29%	N=15
28.00						
	GRAVEL (GC-GM)	γ_n=21.0 kN/m^3,	Ip = 9		w_n = 14%	N=25
30.00						
	CLAY (CL)	γ_n=19.0 kN/m^3,	Ip = 20,	c_u=60 kN/m^2,	w_n = 31%	N=31
44.50						
	SAND (SM)	γ_n=21.0 kN/m^3,	Ip = 9		w_n = 18%	N=28
47.00						
	CLAY (CL)	γ_n=19.0 kN/m^3,	Ip = 15		w_n = 28%	N=35
52.50						End of Borehole

Figure C.19. Idealized soil profile at Location 19

0.0						
						WT=2.00m
	BACKFILL	γ_n=20.0 kN/m^3 ,				
6.00						
	CLAY (CL)	γ_n=17.0 kN/m^3 ,	Ip = 29		w_n = 48%	N=1
9.00						
	CLAY (CL)	γ_n=17.0 kN/m^3,	Ip = 29,	c_u=25 kN/m^2,	w_n = 48%	N=6
18.50						
	SAND (SC)	γ_n=19.0 kN/m^3,	Ip = 19			N=27
26.00						
	CLAY (CL)	γ_n=19.0 kN/m^3,	Ip = 26,	c_u=72 kN/m^2,	w_n = 30%	N=29
47.50						
	SAND (SC)	γ_n=20.0 kN/m^3,	Ip = NP			N=33
50.50						End of Borehole

Figure C.20. Idealized soil profile at Location 20

APPENDIX D
RESULTS OF SITE RESPONSE ANALYSES

Table D.1 Results of Site Response Analyses for 1977 Izmir Earthquake M = 5.3 (rjb =1km)

Location				Depth	Number of Borings	GWT(m)	$T_{0\ (s)}$	$T_{(s)}$	$a_{max,s\ (g)}$	$a_{max,r(g)}$	$a_{max,s}$ / $a_{max,r}$	$S_{amax,s\ (g)}$	$S_{amax,r(g)}$	$S_{amax,s}$ / $S_{amax,r}$
No	Coordinates		Identification											
	X	Y												
1	512591.5	4256620.5	Alsancak	35.0	8	1.80	0.10	0.633	0.370	0.210	1.76	1.553	0.713	2.18
2	512076.5	4255649.0	Çankaya	27.0	2	3.50	0.09	0.539	0.319	0.210	1.52	1.090	0.713	1.53
3	513349.5	4256730.0	Als-Liman	52.0	7	1.75	0.10	0.876	0.372	0.210	1.77	1.411	0.713	1.98
4	512260.0	4255621.0	Çankaya	35.0	5	6.40	0.10	0.564	0.342	0.210	1.63	1.228	0.713	1.72
5	512677.0	4256747.0	Alsancak	30.5	3	1.80	0.10	0.608	0.341	0.210	1.62	1.173	0.713	1.64
6	512424.0	4255497.0	Alsancak	25.5	2	1.00	0.11	0.594	0.352	0.210	1.68	1.336	0.713	1.87
7	512506.0	4255699.0	Alsancak	28.0	1	1.00	0.11	0.584	0.371	0.210	1.77	1.595	0.713	1.24
8	512311.0	4254994.5	Çankaya	35.5	5	3.80	0.11	0.573	0.390	0.210	1.86	1.730	0.713	1.42
9	512527.5	4256711.5	Alsancak	36.0	2	1.10	0.10	0.657	0.393	0.210	1.87	1.704	0.713	2.39
10	511530.0	4254351.0	Konak	25.0	12	1.20	0.10	0.540	0.291	0.210	1.39	1.049	0.713	1.47
11	514193.5	4256374.5	Liman	35.0	3	1.60	0.10	0.641	0.348	0.210	1.66	1.436	0.713	2.01
12	511415.5	4254407.5	Konak	50.0	7	2.50	0.10	0.815	0.307	0.210	1.46	1.163	0.713	1.63
13	511523.5	4254767.0	Kordon Y.	55.5	6	2.00	0.10	0.923	0.288	0.210	1.37	1.158	0.713	1.62
14	511567.0	4255506.5	Kordon Y.	58.0	3	2.00	0.10	0.879	0.311	0.210	1.48	1.299	0.713	1.82
15	511725.5	4255842.0	Kordon Y.	54.5	3	2.00	0.10	0.877	0.285	0.210	1.36	1.085	0.713	1.52
16	511890.5	4255548.0	Kordon Y.	46.5	2	2.00	0.10	0.933	0.259	0.210	1.23	1.057	0.713	1.48
17	512020.0	4255720.5	Kordon Y.	56.0	3	2.00	0.11	0.902	0.277	0.210	1.32	1.166	0.713	1.63
18	512280.0	4256027.0	Kordon Y.	54.0	2	2.00	0.10	0.905	0.252	0.210	1.20	1.155	0.713	1.62
19	512433.0	4256474.5	Kordon Y.	52.5	3	2.00	0.10	0.915	0.303	0.210	1.44	1.279	0.713	1.79
20	512588.5	4256802.0	Kordon Y.	50.5	2	2.00	0.10	0.810	0.305	0.210	1.45	1.210	0.713	1.70

Table D.2 Results of Site Response Analyses for 1977 Izmir Earthquake M = 5.3 (r_{jb} =13km)

No	Location			Depth	Number of Borings	GWT(m)	$T_{0\ (s)}$	$T_{(s)}$	$a_{max,s\ (g)}$	$a_{max,r(g)}$	$a_{max,s}$ / $a_{max,r}$	$S_{amax,s\ (g)}$	$S_{amax,r(g)}$	$S_{amax,s}$ / $S_{amax,r}$
	Coordinates		Identification											
	X	Y												
1	512591.5	4256620.5	Alsancak	35.0	8	1.80	0.10	0.633	0.207	0.100	2.07	0.824	0.340	2.42
2	512076.5	4255649.0	Çankaya	27.0	2	3.50	0.10	0.539	0.179	0.100	1.79	0.676	0.340	1.99
3	513349.5	4256730.0	Als-Liman	52.0	7	1.75	0.10	0.876	0.203	0.100	2.03	0.767	0.340	2.25
4	512260.0	4255621.0	Çankaya	35.0	5	6.40	0.10	0.564	0.190	0.100	1.90	0.673	0.340	1.98
5	512677.0	4256747.0	Alsancak	30.5	3	1.80	0.10	0.608	0.190	0.100	1.90	0.624	0.340	1.84
6	512424.0	4255497.0	Alsancak	25.5	2	1.00	0.10	0.594	0.203	0.100	2.03	0.734	0.340	2.16
7	512506.0	4255699.0	Alsancak	28.0	1	1.00	0.10	0.584	0.206	0.100	2.06	0.900	0.340	2.64
8	512311.0	4254994.5	Çankaya	35.5	5	3.80	0.10	0.573	0.230	0.100	2.30	0.975	0.340	2.87
9	512527.5	4256711.5	Alsancak	36.0	2	1.10	0.10	0.657	0.206	0.100	2.06	0.837	0.340	2.47
10	511530.0	4254351.0	Konak	25.0	12	1.20	0.09	0.540	0.175	0.100	1.75	0.603	0.340	1.78
11	514193.5	4256374.5	Liman	35.0	3	1.60	0.10	0.641	0.289	0.100	1.89	0.765	0.340	2.25
12	511415.5	4254407.5	Konak	50.0	7	2.50	0.10	0.815	0.171	0.100	1.71	0.647	0.340	1.90
13	511523.5	4254767.0	Kordon Y.	55.5	6	2.00	0.10	0.923	0.163	0.100	1.63	0.638	0.340	1.88
14	511567.0	4255506.5	Kordon Y.	58.0	3	2.00	0.10	0.879	0.176	0.100	1.76	0.725	0.340	2.13
15	511725.5	4255842.0	Kordon Y.	54.5	3	2.00	0.10	0.877	0.161	0.100	1.62	0.583	0.340	1.72
16	511890.5	4255548.0	Kordon Y.	46.5	2	2.00	0.11	0.933	0.143	0.100	1.43	0.641	0.340	1.89
17	512020.0	4255720.5	Kordon Y.	56.0	3	2.00	0.10	0.902	0.152	0.100	1.52	0.657	0.340	1.93
18	512280.0	4256027.0	Kordon Y.	54.0	2	2.00	0.10	0.905	0.148	0.100	1.48	0.657	0.340	1.93
19	512433.0	4256474.5	Kordon Y.	52.5	3	2.00	0.10	0.915	0.168	0.100	1.68	0.694	0.340	2.04
20	512588.5	4256802.0	Kordon Y.	50.5	2	2.00	0.10	0.810	0.166	0.100	1.66	0.628	0.340	1.85

Table D.3 Results of Site Response Analyses for Izmir Scenario Earthquake M = 6.5 (rjb =1km)

No	Location			Depth	Number of Borings	GWT(m)	$T_{0\ (s)}$	$T_{(s)}$	$a_{max,s\ (g)}$	$a_{max,r(g)}$	$a_{max,s}$ / $a_{max,r}$	$S_{amax,s\ (g)}$	$S_{amax,r(g)}$	$S_{amax,s}$ / $S_{amax,r}$
	Coordinates		Identification											
	X	Y												
1	512591.5	4256620.5	Alsancak	35.0	8	1.80	0.10	0.633	0.570	0.400	1.43	2.368	1.359	1.74
2	512076.5	4255649.0	Çankaya	27.0	2	3.50	0.10	0.539	0.498	0.400	1.25	1.813	1.359	1.33
3	513349.5	4256730.0	Als-Liman	52.0	7	1.75	0.10	0.876	0.571	0.400	1.43	2.284	1.359	1.68
4	512260.0	4255621.0	Çankaya	35.0	5	6.40	0.10	0.564	0.517	0.400	1.29	1.990	1.359	1.46
5	512677.0	4256747.0	Alsancak	30.5	3	1.80	0.10	0.608	0.536	0.400	1.34	1.980	1.359	1.46
6	512424.0	4255497.0	Alsancak	25.5	2	1.00	0.11	0.594	0.526	0.400	1.32	1.991	1.359	1.47
7	512506.0	4255699.0	Alsancak	28.0	1	1.00	0.11	0.584	0.545	0.400	1.36	2.243	1.359	1.65
8	512311.0	4254994.5	Çankaya	35.5	5	3.80	0.11	0.573	0.558	0.400	1.40	2.388	1.359	1.76
9	512527.5	4256711.5	Alsancak	36.0	2	1.10	0.10	0.657	0.634	0.400	1.59	2.859	1.359	2.10
10	511530.0	4254351.0	Konak	25.0	12	1.20	0.10	0.540	0.430	0.400	1.08	1.615	1.359	1.19
11	514193.5	4256374.5	Liman	35.0	3	1.60	0.10	0.641	0.535	0.400	1.34	2.328	1.359	1.71
12	511415.5	4254407.5	Konak	50.0	7	2.50	0.10	0.815	0.465	0.400	1.16	1.822	1.359	1.34
13	511523.5	4254767.0	Kordon Y.	55.5	6	2.00	0.10	0.923	0.453	0.400	1.13	1.847	1.359	1.36
14	511567.0	4255506.5	Kordon Y.	58.0	3	2.00	0.11	0.879	0.489	0.400	1.22	2.022	1.359	1.49
15	511725.5	4255842.0	Kordon Y.	54.5	3	2.00	0.11	0.877	0.434	0.400	1.09	1.755	1.359	1.29
16	511890.5	4255548.0	Kordon Y.	46.5	2	2.00	0.11	0.933	0.376	0.400	0.94	1.498	1.359	1.10
17	512020.0	4255720.5	Kordon Y.	56.0	3	2.00	0.11	0.902	0.417	0.400	1.04	1.792	1.359	1.32
18	512280.0	4256027.0	Kordon Y.	54.0	2	2.00	0.10	0.905	0.330	0.400	0.83	1.567	1.359	1.15
19	512433.0	4256474.5	Kordon Y.	52.5	3	2.00	0.10	0.915	0.460	0.400	1.15	1.957	1.359	1.44
20	512588.5	4256802.0	Kordon Y.	50.5	2	2.00	0.10	0.810	0.483	0.400	1.21	1.972	1.359	1.45

Table D.4 Results of Site Response Analyses for Izmir Scenario Earthquake M = 6.5 (rjb =13km)

Location				Depth	Number of Borings	GWT(m)	$T_{0\,(s)}$	$T_{(s)}$	$a_{max,s\,(g)}$	$a_{max,r(g)}$	$a_{max,s}$ / $a_{max,r}$	$S_{amax,s\,(g)}$	$S_{amax,r(g)}$	$S_{amax,s}$ / $S_{amax,r}$
No	Coordinates		Identification											
	X	Y												
1	512591.5	4256620.5	Alsancak	35.0	8	1.80	0.10	0.633	0.401	0.230	1.74	1.655	0.713	2.12
2	512076.5	4255649.0	Çankaya	27.0	2	3.50	0.09	0.539	0.346	0.230	1.50	1.176	0.713	1.51
3	513349.5	4256730.0	Als-Liman	52.0	7	1.75	0.10	0.876	0.397	0.230	1.73	1.538	0.713	1.97
4	512260.0	4255621.0	Çankaya	35.0	5	6.40	0.10	0.564	0.367	0.230	1.60	1.329	0.713	1.70
5	512677.0	4256747.0	Alsancak	30.5	3	1.80	0.10	0.608	0.364	0.230	1.58	1.259	0.713	1.61
6	512424.0	4255497.0	Alsancak	25.5	2	1.00	0.11	0.594	0.372	0.230	1.62	1.423	0.713	1.82
7	512506.0	4255699.0	Alsancak	28.0	1	1.00	0.11	0.584	0.392	0.230	1.70	1.688	0.713	2.16
8	512311.0	4254994.5	Çankaya	35.5	5	3.80	0.11	0.573	0.410	0.230	1.78	1.839	0.713	2.35
9	512527.5	4256711.5	Alsancak	36.0	2	1.10	0.10	0.657	0.424	0.230	1.84	1.854	0.713	2.37
10	511530.0	4254351.0	Konak	25.0	12	1.20	0.10	0.540	0.305	0.230	1.33	1.126	0.713	1.44
11	514193.5	4256374.5	Liman	35.0	3	1.60	0.10	0.641	0.370	0.230	1.61	1.554	0.713	1.99
12	511415.5	4254407.5	Konak	50.0	7	2.50	0.10	0.815	0.328	0.230	1.43	1.242	0.713	1.59
13	511523.5	4254767.0	Kordon Y.	55.5	6	2.00	0.10	0.923	0.311	0.230	1.35	1.247	0.713	1.60
14	511567.0	4255506.5	Kordon Y.	58.0	3	2.00	0.11	0.879	0.331	0.230	1.44	1.392	0.713	1.78
15	511725.5	4255842.0	Kordon Y.	54.5	3	2.00	0.10	0.877	0.303	0.230	1.32	1.153	0.713	1.48
16	511890.5	4255548.0	Kordon Y.	46.5	2	2.00	0.11	0.933	0.272	0.230	1.18	1.119	0.713	1.43
17	512020.0	4255720.5	Kordon Y.	56.0	3	2.00	0.11	0.902	0.298	0.230	1.30	1.248	0.713	1.60
18	512280.0	4256027.0	Kordon Y.	54.0	2	2.00	0.10	0.905	0.264	0.230	1.15	1.210	0.713	1.55
19	512433.0	4256474.5	Kordon Y.	52.5	3	2.00	0.10	0.915	0.327	0.230	1.42	1.362	0.713	1.74
20	512588.5	4256802.0	Kordon Y.	50.5	2	2.00	0.10	0.810	0.325	0.230	1.41	1.302	0.713	1.67

Table D.5 Results of Site Response Analyses for Urla Earthquake M = 5.9 (rjb =48km)

Location				Depth	Number of Borings	GWT(m)	$T_{0\ (s)}$	$T_{(s)}$	$a_{max,s\ (g)}$	$a_{max,r(g)}$	$a_{max,s}$ / $a_{max,r}$	$S_{amax,s\ (g)}$	$S_{amax,r(g)}$	$S_{amax,s}$ / $S_{amax,r}$
No	Coordinates		Identification											
	X	Y												
1	512591.5	4256620.5	Alsancak	35.0	8	1.80	0.58	0.633	0.10	0.03	3.33	0.69	0.10	6.90
2	512076.5	4255649.0	Çankaya	27.0	2	3.50	0.54	0.539	0.11	0.03	3.67	0.63	0.10	6.30
3	513349.5	4256730.0	Als-Liman	52.0	7	1.75	0.90	0.876	0.10	0.03	3.33	0.51	0.10	5.10
4	512260.0	4255621.0	Çankaya	35.0	5	6.40	0.56	0.564	0.11	0.03	3.67	0.68	0.10	6.80
5	512677.0	4256747.0	Alsancak	30.5	3	1.80	0.57	0.608	0.09	0.03	3.00	0.51	0.10	5.10
6	512424.0	4255497.0	Alsancak	25.5	2	1.00	0.58	0.594	0.09	0.03	3.00	0.61	0.10	6.10
7	512506.0	4255699.0	Alsancak	28.0	1	1.00	0.57	0.584	0.11	0.03	3.67	0.71	0.10	7.10
8	512311.0	4254994.5	Çankaya	35.5	5	3.80	0.57	0.573	0.09	0.03	3.00	0.56	0.10	5.60
9	512527.5	4256711.5	Alsancak	36.0	2	1.10	0.64	0.657	0.09	0.03	3.00	0.59	0.10	5.90
10	511530.0	4254351.0	Konak	25.0	12	1.20	0.57	0.540	0.09	0.03	3.00	0.57	0.10	5.70
11	514193.5	4256374.5	Liman	35.0	3	1.60	0.58	0.641	0.10	0.03	3.33	0.67	0.10	6.70
12	511415.5	4254407.5	Konak	50.0	7	2.50	0.92	0.815	0.09	0.03	3.00	0.37	0.10	3.70
13	511523.5	4254767.0	Kordon Y.	55.5	6	2.00	0.92	0.923	0.13	0.03	4.33	0.61	0.10	6.10
14	511567.0	4255506.5	Kordon Y.	58.0	3	2.00	0.92	0.879	0.10	0.03	3.33	0.45	0.10	4.50
15	511725.5	4255842.0	Kordon Y.	54.5	3	2.00	0.92	0.877	0.13	0.03	4.33	0.60	0.10	6.00
16	511890.5	4255548.0	Kordon Y.	46.5	2	2.00	0.90	0.933	0.13	0.03	4.33	0.64	0.10	6.40
17	512020.0	4255720.5	Kordon Y.	56.0	3	2.00	0.90	0.902	0.11	0.03	3.67	0.45	0.10	4.50
18	512280.0	4256027.0	Kordon Y.	54.0	2	2.00	0.90	0.905	0.12	0.03	4.00	0.62	0.10	6.20
19	512433.0	4256474.5	Kordon Y.	52.5	3	2.00	0.90	0.915	0.15	0.03	5.00	0.69	0.10	6.90
20	512588.5	4256802.0	Kordon Y.	50.5	2	2.00	0.90	0.810	0.11	0.03	3.67	0.50	0.10	5.00

APPENDIX E

DISTRIBUTION OF AMPLICATION FACTORS & PGAs AT THE STUDY AREA

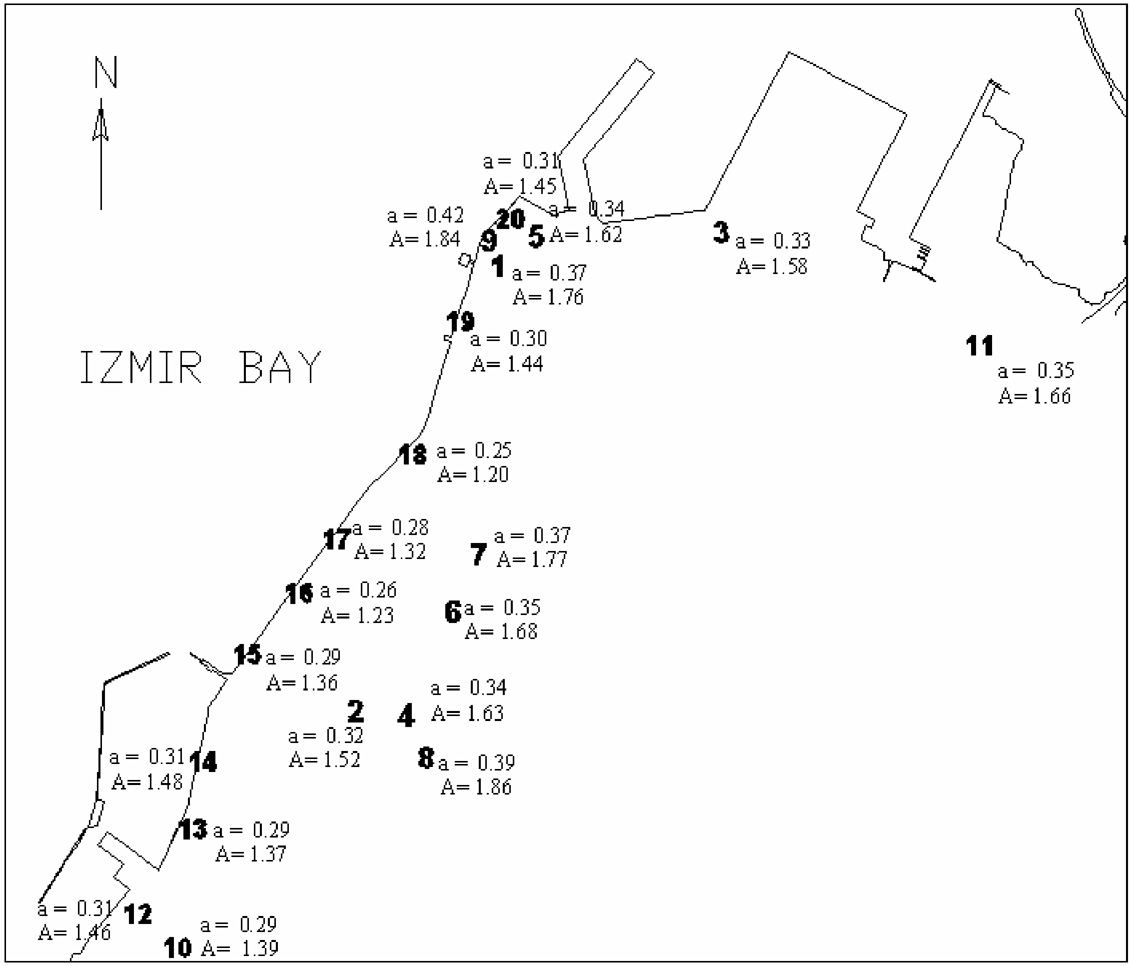

Figure E.1 Distribution of amplification factors (A) & PGAs at the study area for M=5.3, r_{jb} = 1 km

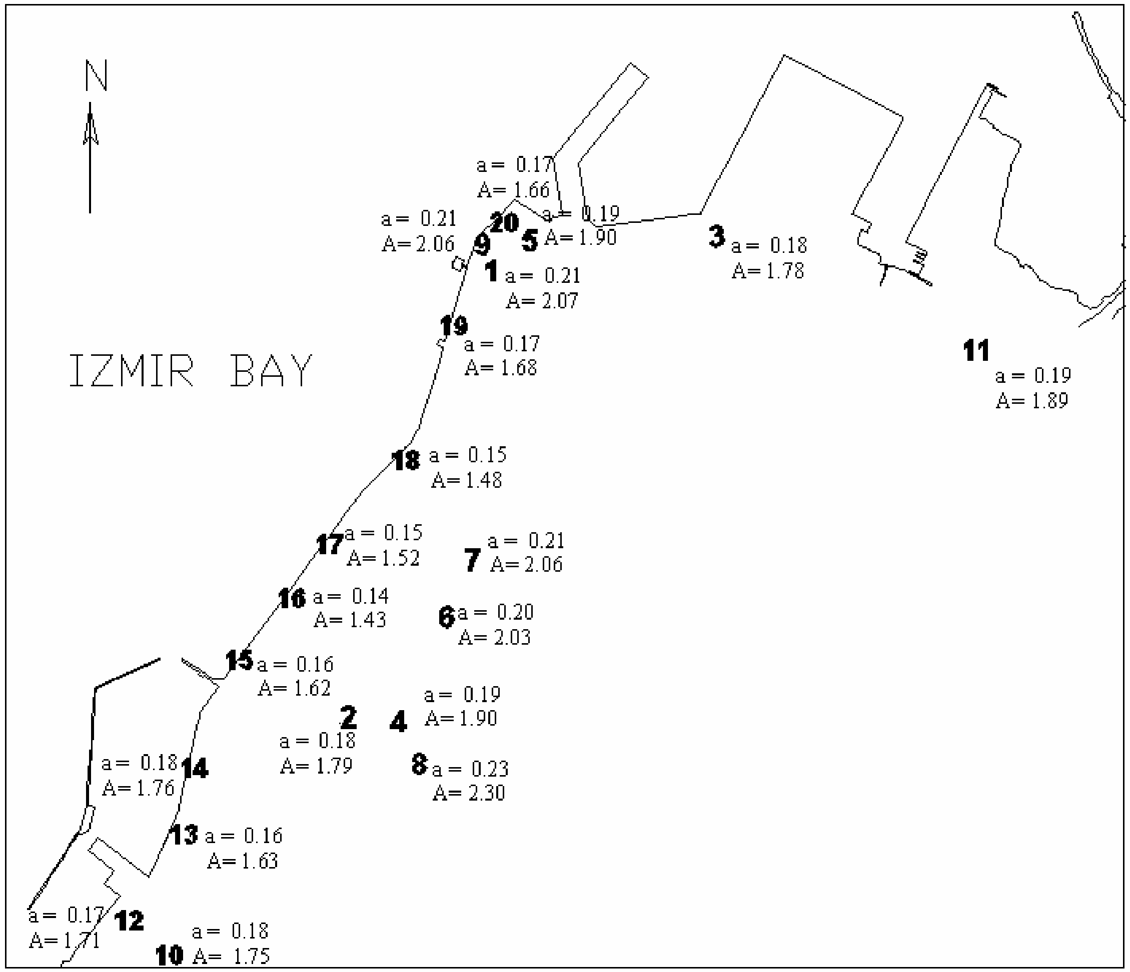

Figure E.2 Distribution of amplification factors (A) & PGAs at the study area for M=5.3, r_{jb} =13 km

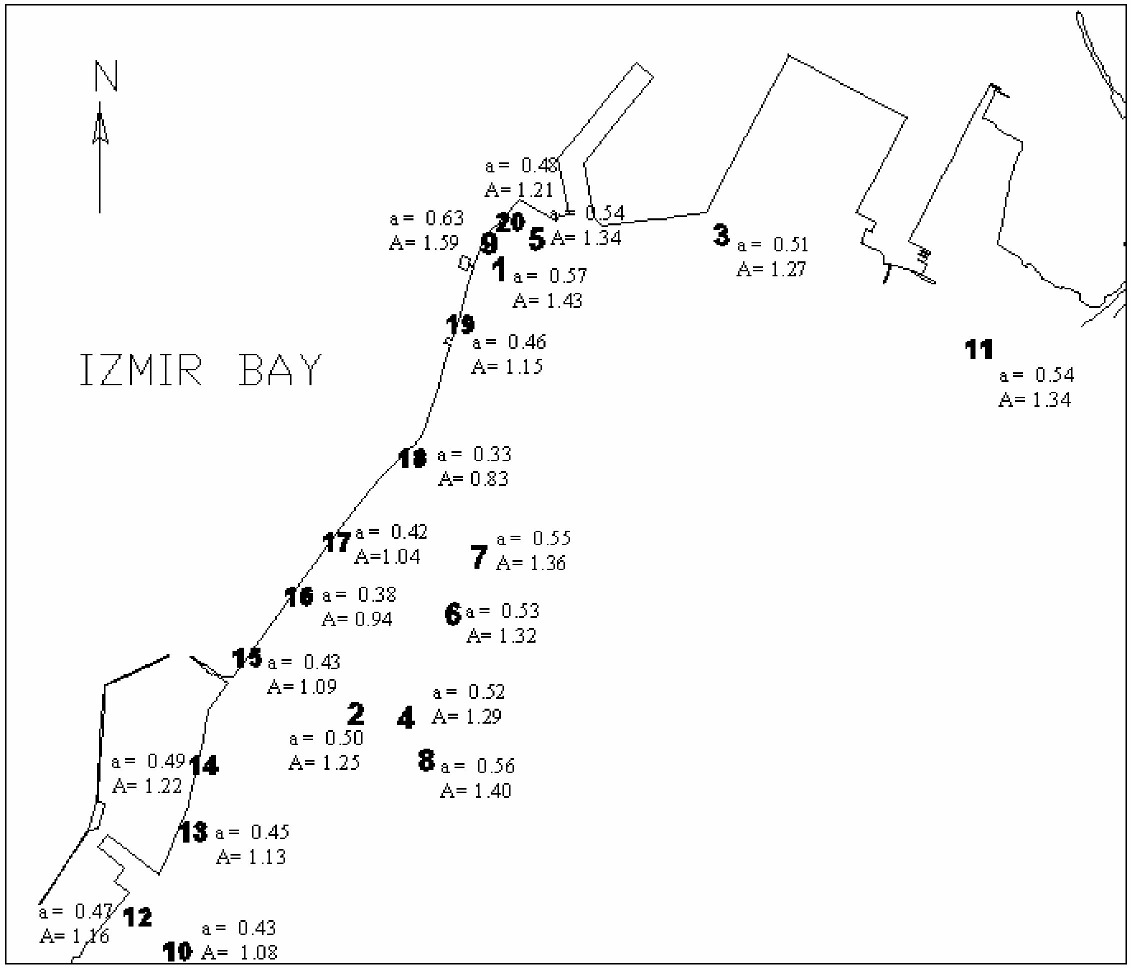

Figure E.3 Distribution of amplification factors (A) & PGAs at the study area for M=6.5, r_{jb} = 1 km

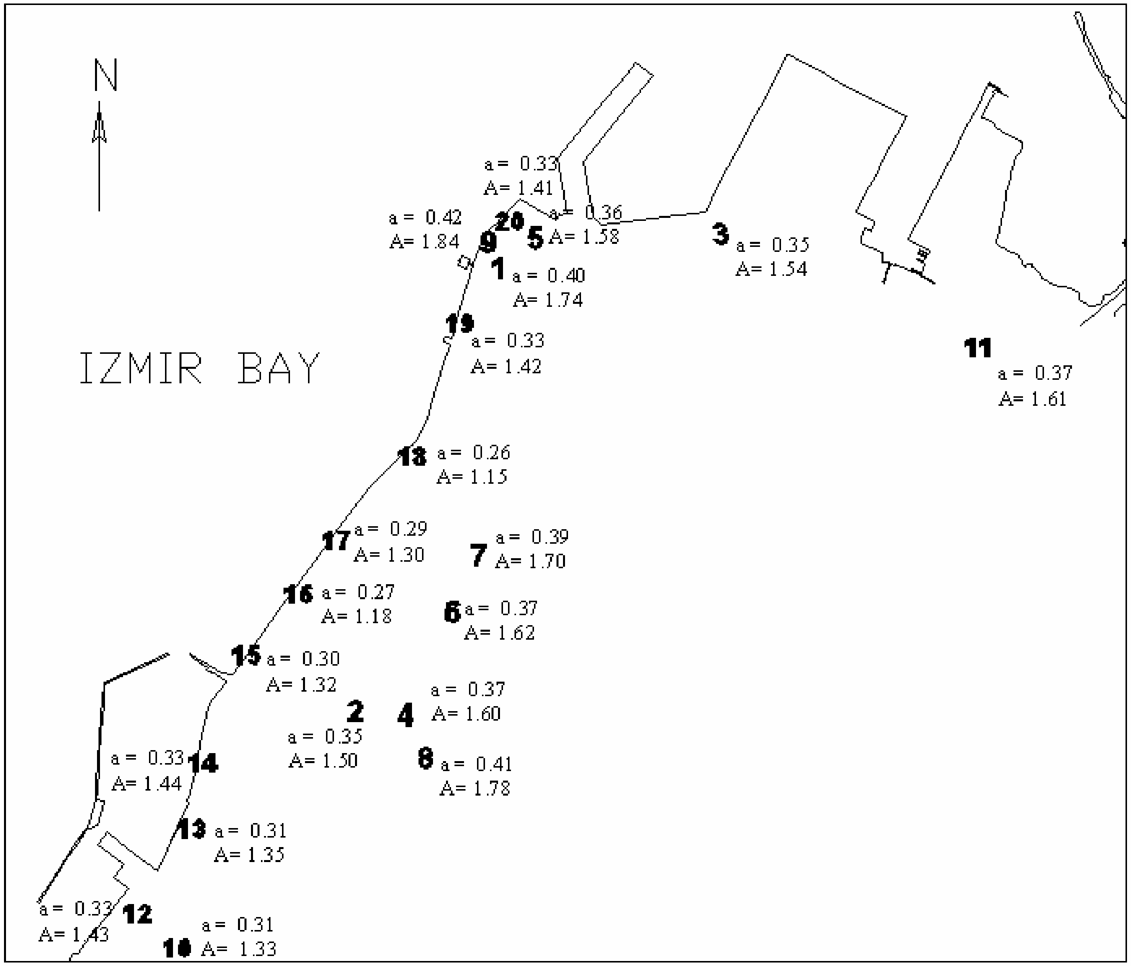

Figure E.4 Distribution of amplification factors (A) & PGAs at the study area for M=6.5, r_{jb} =13 km

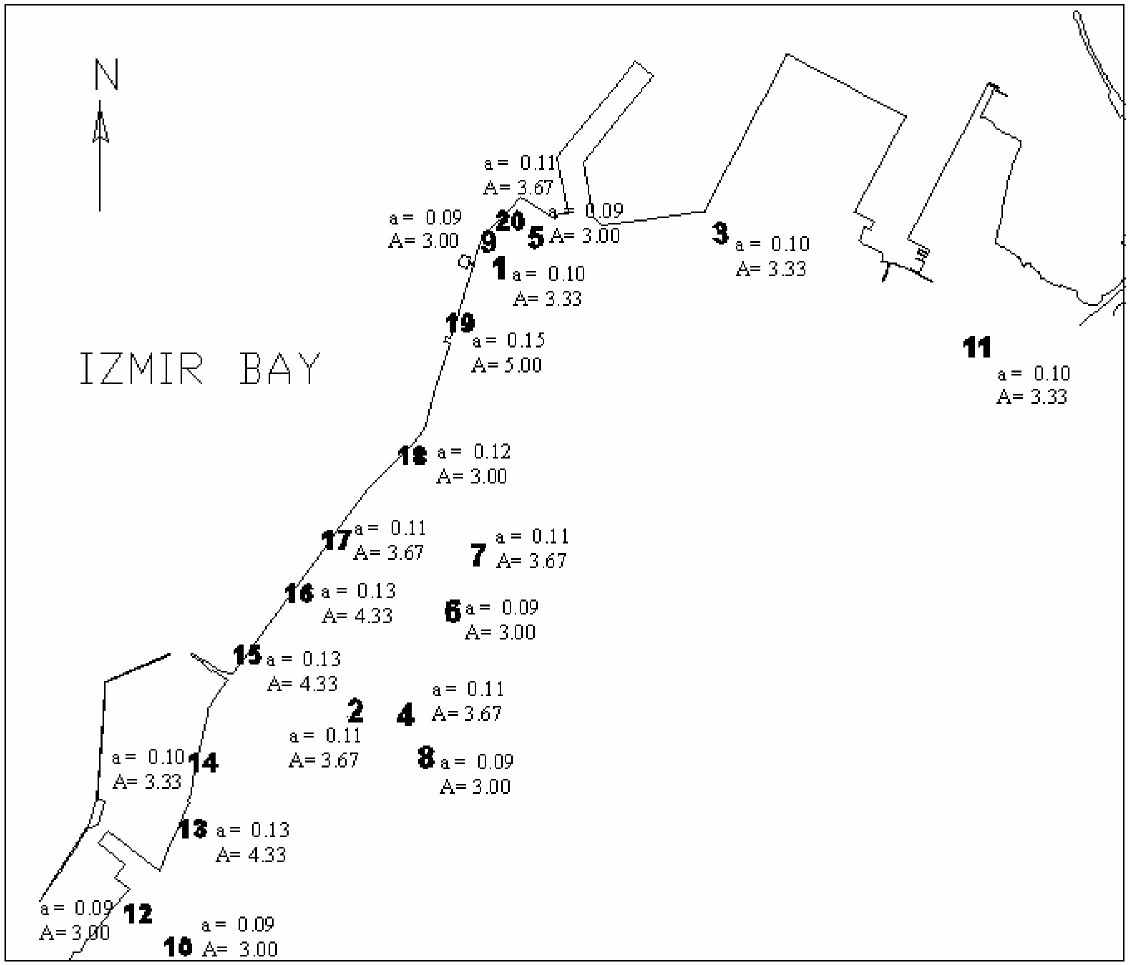

Figure E.5 Distribution of amplification factors (A) & PGAs at the study area for M=5.9, r_{jb} =48 km

APPENDIX F

RESULTS OF LIQUEFACTION ANALYSES

Table F.1 Results of Liquefaction Analyses Done By Using PGA (from SRA) of Izmir Scenario Earthquake M = 6.5 for Fs<1 Soils

Location No	Boring No	GWT(m)	Depth	USCS	(N1)60	amax,s (g)	rd	CSR	CRR	Fs
1	1	1.80	2.80	SM	10	0.570	0.98	0.52	0.12	0.34
			4.30	SW	15		0.97	0.59	0.17	0.42
			5.80	SW	25		0.96	0.62	0.31	0.72
			7.30	SP	9		0.95	0.65	0.10	0.23
			8.80	SP	14		0.94	0.66	0.15	0.33
	2		2.80	SP	10		0.98	0.52	0.11	0.31
			4.30	SP	8		0.97	0.59	0.10	0.26
			5.80	SP	11		0.96	0.62	0.13	0.30
			7.30	SP	9		0.95	0.65	0.11	0.25
	3		4.30	SM	14		0.97	0.59	0.23	0.56
			5.80	SM	13		0.96	0.62	0.22	0.50
			7.40	SM	14		0.95	0.65	0.23	0.51
	4		4.30	SP	10		0.97	0.59	0.11	0.28
	5		4.30	SP	10		0.97	0.59	0.12	0.30
	6		5.80	SM	12		0.96	0.62	0.18	0.42
	7		5.80	SP	6		0.96	0.62	0.08	0.18
			14.80	SM	16		0.79	0.59	0.23	0.55
	8		4.30	SW	8		0.97	0.59	0.10	0.24
			5.80	SW	7		0.96	0.62	0.10	0.22
			7.30	SW	8		0.95	0.65	0.10	0.23
			8.80	SW	12		0.94	0.66	0.14	0.31
			13.30	SM	17		0.83	0.62	0.26	0.60
			14.80	SM	18		0.79	0.59	0.29	0.71
2	1	3.50	7.50	SM	17	0.494	0.95	0.44	0.23	0.75
			8.80	SM	6		0.94	0.46	0.12	0.38
			10.30	SC	11		0.91	0.47	0.19	0.59
			11.80	SC	10		0.87	0.46	0.18	0.56
	2		5.80	SM-SC	16		0.96	0.41	0.17	0.61
			8.80	SM	9		0.94	0.46	0.13	0.41
			12.80	ML	7		0.85	0.46	0.14	0.44
3	1	1.75	2.30	SP-SM	25	0.571	0.99	0.48	0.31	0.93
			3.80	GP-GM	21		0.97	0.57	0.23	0.58
			5.30	SM	15		0.96	0.61	0.23	0.54
	2		2.30	SM	20		0.99	0.48	0.26	0.77
			3.80	SM	20		0.97	0.57	0.37	0.93
	3		5.30	SM	21		0.96	0.61	0.31	0.74
			6.80	SM	12		0.95	0.63	0.15	0.34
			8.30	SM	10		0.94	0.64	0.18	0.40
			9.80	SM	6		0.93	0.65	0.12	0.27
			11.30	SM-SC	9		0.89	0.63	0.16	0.37
	4		6.80	SC	17		0.95	0.63	0.26	0.58
	5		8.30	SM	15		0.94	0.64	0.19	0.43
			9.80	SM	16		0.93	0.65	0.20	0.45

Table F.1 Results of Liquefaction Analyses Done By Using PGA (from SRA) of Izmir Scenario Earthquake M = 6.5 for Fs<1 Soils (continued)

Location No	Boring No	GWT(m)	Depth	USCS	(N1)60	amax,s (g)	rd	CSR	CRR	Fs
3	5	1.75	11.30	SC	19	0.571	0.89	0.63	0.07	0.17
	6		2.80	SC	5		0.98	0.52	0.10	0.29
	7		4.30	SM	0		0.97	0.59	0.07	0.18
			5.80	GM	0		0.96	0.62	0.07	0.17
			13.30	SC	7		0.83	0.6	0.14	0.34
4	1	6.40	14.80	SM	5	0.517	0.79	0.39	0.12	0.45
	2		14.80	SC	7		0.79	0.39	0.14	0.52
	5		7.80	GM	17		0.94	0.36	0.23	0.93
5	3	1.80	2.80	SM	17	0.536	0.98	0.49	0.22	0.64
			4.80	SM	2		0.97	0.57	0.09	0.22
			6.30	SM	3		0.96	0.60	0.07	0.17
6	1	1.00	4.30	SM	3	0.526	0.97	0.58	0.27	0.68
	2		11.80	GM	15		0.87	0.60	0.26	0.61
7	1	1.00	12.30	SC	7	0.546	0.86	0.62	0.14	0.33
			13.80	SC	7		0.82	0.59	0.14	0.34
8	1	2.80	2.80	ML	12	0.558	0.98	0.40	0.20	0.74
	2		11.80	ML	9		0.87	0.54	0.16	0.43
	3		5.80	SM	12		0.96	0.51	0.17	0.48
			11.80	SM	10		0.87	0.54	0.16	0.43
			13.30	SM	12		0.83	0.52	0.20	0.56
			14.80	SM	10		0.79	0.50	0.15	0.43
	4		2.80	SM	4		0.98	0.40	0.10	0.38
			7.30	SM	9		0.95	0.53	0.19	0.52
			11.80	SC	7		0.87	0.54	0.14	0.38
	5		4.30	SP-SM	5		0.97	0.47	0.08	0.24
			5.80	SM	5		0.96	0.51	0.12	0.34
			14.80	SM	19		0.79	0.50	0.34	0.97
9	1	1.50	2.80	SP-SM	19	0.634	0.98	0.58	0.22	0.54
			5.80	SM	16		0.96	0.69	0.26	0.53
			7.30	SP	24		0.95	0.72	0.27	0.55
			8.80	SP-SM	29		0.94	0.73	0.47	0.92
	2		2.80	SP-SM	10		0.98	0.58	0.12	0.30
			4.30	GM	31		0.97	0.65	0.26	0.57
10	1	1.20	11.30	SM	7	0.430	0.89	0.51	0.10	0.27
	2		14.30	SC	7		0.81	0.46	0.13	0.41
	3		13.80	SC	17		0.82	0.47	0.29	0.89
	4		6.30	SM	2		0.96	0.52	0.09	0.24
			10.80	ML	7		0.90	0.51	0.14	0.39
	5		5.80	SW	7		0.96	0.51	0.09	0.25
			10.80	ML	10		0.90	0.51	0.18	0.51
	6		4.80	SW	15		0.97	0.50	0.16	0.46
			10.80	ML	7		0.90	0.51	0.14	0.39
			14.80	GC	19		0.79	0.46	0.29	0.92

Table F.1 Results of Liquefaction Analyses Done By Using PGA (from SRA) of Izmir Scenario Earthquake M = 6.5 for Fs<1 Soils (continued)

Location No	Boring No	GWT(m)	Depth	USCS	(N1)60	amax,s (g)	rd	CSR	CRR	Fs
10	7	1.20	11.30	SC	4	0.430	0.89	0.51	0.10	0.3
			13.30	SC	2		0.83	0.48	0.09	0.26
	8		7.80	SW-SM	6		0.94	0.49	0.08	0.23
			9.80	SW	0		0.93	0.49	0.05	0.14
	9		3.80	ML	4		0.97	0.49	0.10	0.31
			6.30	ML	7		0.96	0.52	0.14	0.39
			8.80	ML	5		0.94	0.53	0.12	0.33
			8.80	ML	15		0.94	0.53	0.26	0.70
			11.80	ML	5		0.87	0.50	0.12	0.35
	11		8.80	ML	3		0.94	0.53	0.10	0.26
	12		5.80	ML	19		0.96	0.51	0.34	0.95
			8.80	ML	17		0.94	0.53	0.29	0.79
11	1	1.60	2.80	SM	11	0.535	0.98	0.49	0.16	0.47
			4.30	SM	12		0.97	0.55	0.15	0.39
			13.30	SM	19		0.83	0.59	0.34	0.83
			14.80	SM	10		0.79	0.57	0.16	0.41
	2		4.30	SM	9		0.97	0.55	0.16	0.42
			14.80	SM	15		0.79	0.57	0.23	0.58
	3		4.30	SP-SM	4		0.97	0.55	0.06	0.17
12	1	2.50	7.80	ML	9	0.465	0.94	0.47	0.16	0.49
			10.80	SC	12		0.90	0.48	0.27	0.82
	2		9.30	ML	14		0.93	0.48	0.23	0.68
			12.30	SC	12		0.86	0.47	0.16	0.49
			13.80	SC	13		0.82	0.46	0.16	0.50
			15.30	SC	11		0.78	0.44	0.16	0.52
	3		7.80	GM	7		0.94	0.47	0.13	0.40
			9.30	ML	4		0.93	0.48	0.10	0.31
			12.30	SC	6		0.86	0.47	0.12	0.37
	4		10.80	SC	10		0.90	0.48	0.16	0.48
			13.80	SC	11		0.82	0.46	0.18	0.57
	5		7.80	ML	4		0.94	0.47	0.10	0.32
			10.80	GC	17		0.90	0.48	0.29	0.87
			13.30	SC	6		0.83	0.46	0.13	0.41
	6		10.80	ML	16		0.90	0.48	0.27	0.42
			12.30	ML	12		0.86	0.47	0.20	0.62
	7		7.80	SM	2		0.94	0.47	0.09	0.27
			10.80	ML	4		0.90	0.48	0.10	0.31
13	1	2.00	13.80	SP	1	0.453	0.87	0.46	0.15	0.47
	2		12.30	SC	3		0.91	0.47	0.10	0.30
	181		13.80	SM	0		0.87	0.49	0.07	0.21
	185		13.80	SC	9		0.87	0.46	0.16	0.50
14	3	2.00	7.80	SC	1	0.489	0.96	0.47	0.05	0.15

Table F.1 Results of Liquefaction Analyses Done By Using PGA (from SRA) of Izmir Scenario Earthquake M = 6.5 for Fs<1 Soils (continued)

Location No	Boring No	GWT(m)	Depth	USCS	(N1)60	amax,s (g)	rd	CSR	CRR	Fs
15	5	2.00	9.30	SC	0	0.434	0.95	0.45	0.05	0.16
	6		8.80	SC	0		0.95	0.43	0.06	0.20
			12.80	ML	2		0.90	0.46	0.09	0.27
	66		15.30	SC	8		0.83	0.43	0.15	0.50
16	67	2.00	8.30	SC	0	0.376	0.96	0.36	0.07	0.28
	68		14.80	SM-SC	4		0.85	0.37	0.10	0.41
17	55	2.00	15.30	SC	2	0.417	0.86	0.43	0.09	0.29

Table F.2 Results of Liquefaction Analyses Done By Using PGA (from Turkish Earthquake Regulations) of Izmir Scenario Earthquake M = 6.5 for Fs<1 Soils

Location No	Boring No	GWT(m)	Depth	USCS	$(N_1)60$	amax,s (g)	rd	CSR	CRR	Fs
1	1	1.80	2.80	SM	10	0.400	0.98	0.36	0.12	0.48
			4.30	SW	15		0.97	0.41	0.17	0.59
			7.30	SP	9		0.95	0.45	0.10	0.33
			8.80	SP	14		0.94	0.46	0.15	0.47
	2		2.80	SP	10		0.98	0.36	0.11	0.45
			4.30	SP	8		0.97	0.41	0.10	0.36
			5.80	SP	11		0.96	0.44	0.13	0.43
			7.30	SP	9		0.95	0.45	0.11	0.36
	3		4.30	SM	14		0.97	0.41	0.23	0.80
			5.80	SM	13		0.96	0.44	0.22	0.71
			7.30	SM	14		0.95	0.45	0.23	0.72
	4		4.30	SP	9		0.97	0.41	0.11	0.40
	5		4.30	SP	10		0.97	0.41	0.12	0.43
	6		5.80	SM	12		0.96	0.44	0.18	0.59
	7		5.80	SP	6		0.96	0.44	0.08	0.26
			14.80	SM	16		0.79	0.42	0.23	0.79
	8		4.30	SW	8		0.97	0.41	0.10	0.34
			5.80	SW	7		0.96	0.44	0.10	0.32
			7.30	SW	8		0.95	0.45	0.10	0.33
			8.80	SW	12		0.94	0.46	0.14	0.44
			13.30	SM	17		0.83	0.43	0.26	0.85
2	1	3.50	7.30	SM	17		0.95	0.35	0.23	0.93
			8.80	SM	6		0.94	0.37	0.12	0.47
			10.30	SC	11		0.91	0.38	0.19	0.73
			11.80	SC	10		0.87	0.38	0.18	0.69
	2		5.80	SM-SC	16		0.96	0.33	0.17	0.75
			8.80	SM	9		0.94	0.37	0.13	0.51
			12.80	ML	7		0.85	0.37	0.14	0.55
3	1	1.75	3.80	GP-GM	21		0.97	0.40	0.23	0.82
			5.30	SM	15		0.96	0.43	0.23	0.77
	3		6.80	SM	12		0.95	0.44	0.15	0.49
			8.30	SM	10		0.94	0.45	0.18	0.58
			9.80	SM	6		0.93	0.45	0.12	0.39
			11.30	SM-SC	9		0.89	0.44	0.16	0.52
	4		6.80	SC	17		0.95	0.44	0.26	0.83
	5		8.30	SM	15		0.94	0.45	0.19	0.61
			9.80	SM	16		0.93	0.45	0.20	0.65
			11.30	SC	19		0.89	0.89	0.07	0.24
	6		2.80	SC	5		0.98	0.36	0.10	0.41
	7		4.30	SM	0		0.97	0.41	0.07	0.25
			5.80	GM	0		0.96	0.44	0.07	0.24
			13.30	SC	7		0.83	0.42	0.14	0.48

Table F.2 Results of Liquefaction Analyses Done By Using PGA (from Turkish Earthquake Regulations) of Izmir Scenario Earthquake M = 6.5 for Fs<1 Soils (continued)

Location No	Boring No	GWT(m)	Depth	USCS	$(N_1)60$	amax,s (g)	rd	CSR	CRR	Fs
4	1	6.40	14.80	SM	5	0.400	0.79	0.30	0.12	0.59
	2		14.80	SC	7		0.79	0.30	0.14	0.67
5	3	1.80	2.80	SM	17		0.98	0.36	0.22	0.85
			4.80	SM	2		0.97	0.42	0.09	0.30
5	3	1.80	6.30	SM	3		0.96	0.44	0.07	0.23
6	1	1.00	4.30	SM	3		0.97	0.44	0.27	0.89
	2		11.80	GM	15		0.87	0.46	0.26	0.81
7	1	1.00	12.30	SC	7		0.86	0.45	0.14	0.45
		1.00	13.80	SC	7		0.82	0.44	0.14	0.46
8	2	2.80	11.80	ML	9		0.87	0.39	0.16	0.60
	3		5.80	SM	12		0.96	0.37	0.17	0.67
			11.80	SM	10		0.87	0.39	0.16	0.60
			13.30	SM	12		0.83	0.83	0.20	0.78
			14.80	SM	10		0.79	0.36	0.15	0.60
	4		2.80	SM	4		0.98	0.28	0.10	0.53
			7.30	SM	9		0.95	0.38	0.19	0.72
			11.80	SC	7		0.87	0.39	0.14	0.53
	5		4.30	SP-SM	5		0.97	0.34	0.08	0.34
			5.80	SM	5		0.96	0.37	0.12	0.48
9	1	1.50	2.80	SP-SM	19		0.98	0.36	0.22	0.85
			5.80	SM	16		0.96	0.44	0.26	0.84
			7.30	SP	24		0.95	0.45	0.27	0.87
	2		2.80	SP-SM	10		0.98	0.36	0.12	0.48
			4.30	GM	31		0.97	0.41	0.26	0.90
10	1	1.20	11.30	SM	7		0.89	0.47	0.10	0.29
	2		14.30	SC	7		0.81	0.43	0.13	0.44
	3		13.80	SC	17		0.82	0.44	0.29	0.96
	4		6.30	SM	2		0.96	0.48	0.09	0.26
			10.80	ML	7		0.90	0.48	0.14	0.42
	5		5.80	SW	7		0.96	0.48	0.09	0.26
			10.80	ML	10		0.90	0.48	0.18	0.54
	6		4.80	SW	15		0.97	0.47	0.16	0.49
			10.80	ML	7		0.90	0.48	0.14	0.42
			14.80	GC	19		0.79	0.43	0.29	0.99
	7		11.30	SC	4		0.89	0.47	0.10	0.32
			13.30	SC	2		0.83	0.45	0.09	0.28
	8		7.80	SW-SM	6		0.94	0.49	0.08	0.23
			9.80	SW	0		0.93	0.49	0.05	0.14
	9		3.80	ML	4		0.97	0.45	0.10	0.33
			6.30	ML	7		0.96	0.48	0.14	0.42
			8.80	ML	5		0.94	0.49	0.12	0.36
	10		8.80	ML	15		0.94	0.49	0.26	0.75
			11.80	ML	5		0.87	0.47	0.12	0.38
	11		8.80	ML	3		0.94	0.53	0.10	0.26

Table F.2 Results of Liquefaction Analyses Done By Using PGA (from Turkish Earthquake Regulations) of Izmir Scenario Earthquake M = 6.5 for Fs<1 Soils (continued)

Location No	Boring No	GWT(m)	Depth	USCS	$(N_1)60$	amax,s (g)	rd	CSR	CRR	Fs
10	12	1.20	5.80	ML	19	0.400	0.96	0.51	0.34	0.95
			8.80	ML	17		0.94	0.53	0.29	0.79
11	1	1.60	2.80	SM	11		0.98	0.36	0.16	0.63
			4.30	SM	12		0.97	0.41	0.15	0.52
11	1	1.60	14.80	SM	10		0.79	0.43	0.16	0.54
	2		4.30	SM	9		0.97	0.41	0.16	0.56
			14.80	SM	15		0.79	0.43	0.23	0.77
	3		4.30	SP-SM	4		0.97	0.41	0.06	0.23
12	1	2.50	7.80	ML	9		0.94	0.40	0.16	0.57
			10.80	SC	12		0.90	0.42	0.27	0.95
	2		9.30	ML	14		0.93	0.42	0.23	0.79
			12.30	SC	12		0.86	0.41	0.16	0.57
			13.80	SC	13		0.82	0.39	0.16	0.58
			15.30	SC	11		0.78	0.38	0.16	0.61
	3		7.80	GM	7		0.94	0.40	0.13	0.47
			9.30	ML	4		0.93	0.42	0.10	0.36
			12.30	SC	6		0.86	0.41	0.12	0.43
	4		10.80	SC	10		0.90	0.42	0.16	0.55
			13.80	SC	11		0.82	0.39	0.18	0.66
	5		7.80	ML	4		0.94	0.40	0.10	0.37
			13.30	SC	6		0.83	0.40	0.13	0.47
	6		10.80	ML	16		0.90	0.42	0.27	0.95
			12.30	ML	12		0.86	0.41	0.20	0.72
	7		7.80	SM	2		0.94	0.40	0.09	0.31
			10.80	ML	4		0.90	0.42	0.10	0.36
13	1	2.00	13.80	SP	1		0.87	0.41	0.15	0.53
	2		12.30	SC	3		0.91	0.41	0.10	0.33
	181		13.80	SM	0		0.87	0.43	0.07	0.24
	185		13.80	SC	9		0.87	0.41	0.16	0.57
14	3	2.00	7.80	SC	1		0.96	0.38	0.05	0.19
15	5	2.00	9.30	SC	0		0.95	0.41	0.05	0.17
	6		8.80	SC	0		0.95	0.39	0.06	0.21
			12.80	ML	2		0.90	0.42	0.09	0.30
	66		15.30	SC	8		0.83	0.40	0.15	0.54
16	67	2.00	8.30	SC	0		0.96	0.39	0.07	0.27
	68		14.80	SM-SC	4		0.85	0.39	0.10	0.38
17	55	2.00	15.30	SC	2		0.86	0.41	0.09	0.31

Table F.3 Results of Liquefaction Analyses Done By Using Shear Stresses (from SRA) of Izmir Scenario Earthquake M = 6.5 for Fs<1 Soils

Location No	Boring No	GWT(m)	Depth	USCS	$(N_1)60$	Tav	CSR	CRR	Fs
1	1	1.80	2.80	SM	10	14.72	0.42	0.12	0.41
			4.30	SW	15	15.35	0.33	0.17	0.74
			7.30	SP	9	17.25	0.25	0.10	0.61
			8.80	SP	14	18.51	0.23	0.15	0.96
	2		2.80	SP	10	14.72	0.42	0.11	0.38
			4.30	SP	8	15.35	0.33	0.10	0.46
			5.80	SP	11	16.20	0.28	0.13	0.68
			7.30	SP	9	17.25	0.25	0.11	0.66
	4		4.30	SP	9	15.35	0.33	0.11	0.49
	5		4.30	SP	10	15.35	0.33	0.12	0.53
	6		5.80	SM	12	16.20	0.28	0.18	0.94
	7		5.80	SP	6	16.20	0.28	0.08	0.41
	8		4.30	SW	8	15.35	0.33	0.10	0.42
			5.80	SW	7	16.20	0.28	0.10	0.50
			7.30	SW	8	17.25	0.25	0.10	0.61
			8.80	SW	12	18.51	0.23	0.14	0.89
3	1	1.75	3.80	GP-GM	21	15.40	0.36	0.23	0.91
	2		2.30	SM	20	12.47	0.41	0.26	0.90
	3		6.80	SM	12	17.13	0.23	0.14	0.86
	5		11.30	SC	19	14.44	0.13	0.07	0.78
	6		2.80	SC	5	13.72	0.40	0.10	0.38
	7		4.30	SM	0	16.30	0.34	0.07	0.30
			5.80	GM	0	17.11	0.29	0.07	0.36
5	3	1.80	2.80	SM	17	13.49	0.39	0.22	0.80
			4.80	SM	2	14.85	0.29	0.09	0.43
			6.30	SM	3	15.73	0.25	0.07	0.41
8	1	2.80	2.80	ML	12	15.74	0.35	0.20	0.83
	3		5.80	SM	12	21.80	0.29	0.17	0.83
	4		2.80	SM	4	15.74	0.35	0.10	0.43
	5		4.30	SP-SM	5	19.06	0.32	0.08	0.36
			5.80	SM	5	21.80	0.29	0.12	0.60
9	1	1.50	2.80	SP-SM	19	12.31	0.35	0.22	0.88
	2		2.80	SP-SM	10	12.31	0.35	0.12	0.50
10	1	1.20	11.30	SM	7	14.94	0.15	0.10	0.91
	4		6.30	SM	2	13.46	0.23	0.09	0.54
	5		5.80	SW	7	13.73	0.26	0.09	0.49
	6		4.80	SW	15	13.85	0.30	0.16	0.76
	7		11.30	SC	4	14.94	0.15	0.10	0.99
			13.30	SC	2	15.82	0.14	0.09	0.92
	8		7.80	SW-SM	6	11.79	0.17	0.08	0.67
			9.80	SW	0	13.67	0.16	0.05	0.44
	9		3.80	ML	4	13.39	0.36	0.10	0.42
			6.30	ML	7	13.46	0.23	0.14	0.86
	11		8.80	ML	3	12.54	0.16	0.10	0.85

Table F.3 Results of Liquefaction Analyses Done By Using Shear Stresses (from SRA) of Izmir Scenario Earthquake M = 6.5 for Fs<1 Soils (continued)

Location No	Boring No	GWT(m)	Depth	USCS	$(N_1)60$	Tav	CSR	CRR	Fs
11	1	1.60	2.80	SM	11	12.31	0.35	0.16	0.65
			4.30	SM	12	11.84	0.28	0.15	0.78
	2		4.30	SM	9	11.84	0.28	0.16	0.83
	3		4.30	SP-SM	4	11.84	0.28	0.06	0.34
12	3	2.50	7.80	GM	7	17.22	0.20	0.13	0.94
			9.30	ML	4	16.60	0.17	0.10	0.88
	5		7.80	ML	4	17.22	0.21	0.10	0.73
	7		7.80	SM	2	17.22	0.21	0.09	0.61
			10.80	ML	4	19.31	0.18	0.10	0.84
13	2	2.00	12.30	SC	3	17.53	0.16	0.10	0.89
	181		13.80	SM	0	17.45	0.16	0.07	0.64
14	3	2.00	7.80	SC	1	21.03	0.29	0.05	0.25
15	5	2.00	9.30	SC	0	19.51	0.25	0.05	0.29
	6		8.80	SC	0	19.30	0.23	0.06	0.36
			12.80	ML	2	17.68	0.16	0.09	0.77
16	67	2.00	8.30	SC	0	14.03	0.18	0.07	0.58
17	55	2.00	15.30	SC	2	16.29	0.13	0.09	0.95

APPENDIX G

LIQUEFACTION SUSPECTIBILITY & RESULTS OF LIQUEFACTION ANALYSES FOR FINE GRAINED SOILS

Table G Liquefaction Suspectibility and Results of Liquefaction Analyses (Done By Using PGA from SRA of Izmir Scenario Earthquake M = 6.5) for Fine Grained Soils

Location	Boring	Depth	SPT	USCS	w_L	w_P	I_P	- No 4	- No 200	w_n	ZONE			Fs
1	SK-1	13.50	11	CH	51	21	30	100	95	43.3	zone C	-	-	0.35
	SK-2	9.00	10	CL	37	18	19	100	84	41.2	-	zone B	-	0.35
	SK-3	9.00	7	CL	37	19	18	100	75	39.7	-	zone B	-	0.29
		12.00	14	CL	48	23	25	100	98	42.9	zone C	-	-	0.46
		15.00	13	CL	43	24	19	100	76	43.0	-	zone B	-	0.44
	SK-4	6.00	8	CL	39	19	20	100	79	36.0	-	zone B	-	0.32
	SK-5	6.50	10	CL	42	20	22	100	92	39.8	zone C	-	-	0.41
		13.50	18	CL	46	20	26	100	93	23.4	zone C	-	-	0.53
	SK-6	7.50	10	CL	45	19	26	100	91	44.7	zone C	-	-	0.36
	SK-7	7.50	9	CL	28	20	8	100	83	35.5	-	-	zone A	0.88
	SK-8	10.50	15	CH	51	24	27	100	99	46.1	zone C	-	-	0.47
2	SK-1	13.50	7	CL	34	14	20	100	88	33.4	zone C	-	-	0.39
	SK-2	10.50	7	CL	34	15	18	100	77	35.0	zone C	-	-	0.37
		12.00	6	CL	45	23	22	96	74	34.4	zone C	-	-	0.32
		14.00	16	CL	36	16	20	100	92	34.1	zone C	-	-	0.61
3	SK-1	8.50	10	CL	52	30	22	100	75	31.0	zone C	-	-	0.36
		10.00	14	MH	52	30	22	100	96	36.4	zone C	-	-	0.45
	SK-2	8.50	7	CL	41	18	23	100	96	37.6	zone C	-	-	0.29
		11.50	9	CL	41	18	23	100	94	43.6	zone C	-	-	0.32
		13.00	8	CH	57	23	34	92	87	46.8	zone C	-	-	0.31
		14.50	9	CH	57	20	37	100	99	45.7	zone C	-	-	0.32
	SK-3	13.00	9	CL	40	21	19	100	96	30.3	zone C	-	-	0.33
		14.50	10	CL	40	21	19	100	99	45.9	-	zone B	-	0.35
	SK-4	10.00	7	CH	59	27	32	100	87	37.9	zone C	-	-	0.29
		11.50	10	CH	59	27	32	100	94	49.8	zone C	-	-	0.34
		14.50	8	CH	58	28	30	97	80	41.9	zone C	-	-	0.32
	SK-5	13.00	5	CL	48	20	28	100	99	46.0	zone C	-	-	>1
		14.50	0	CL	48	20	28	95	85	43.0	zone C	-	-	0.92
	SK-6	6.00	0	CL	49	27	22	100	76	49.6	zone C	-	-	0.17
		7.50	0	CH	52	26	26	100	96	50.4	zone C	-	-	0.16
		10.50	2	CH	52	26	26	100	99	50.9	zone C	-	-	0.18
		12.00	12	CH	52	26	26	100	99	53.8	zone C	-	-	0.37
		13.50	10	CH	52	26	26	99	64	35.2	zone C	-	-	0.34
		15.00	13	CH	52	26	26	100	96	2.4	zone C	-	-	0.40
	SK-7	7.50	3	CL	62	30	32	100	96	44.6	zone C	-	-	0.20
		9.00	4	CL	62	30	32	100	92	45.3	zone C	-	-	0.21
		10.50	8	CL	62	30	32	93	83	51.8	zone C	-	-	0.32
		12.00	6	CL	62	30	32	100	97	54.8	zone C	-	-	0.24
		15.00	13	CL	60	30	30	100	75	38.3	zone C	-	-	0.40
4	SK-1	10.50	8	CL	34	19	15	99	85	39.5	zone C	-	-	>1
	SK-2	6.00	11	CL	34	19	15	90	63	39.9	zone C	-	-	>1
		12.00	14	CH	54	27	27	91	70	19.8	zone C	-	-	>1
	SK-3	15.50	11	CL	35	20	15	90	70	30.2	zone C	-	-	0.52
	SK-5	15.50	11	CL	34	19	15	96	70	28.2	zone C	-	-	0.52

Table G Liquefaction Suspectibility and Results of Liquefaction Analyses (Done By Using PGA from SRA of Izmir Scenario Earthquake M = 6.5) for Fine Grained Soils (continued)

Location	Boring	Depth	SPT	USCS	w_L	w_P	I_P	- No 4	- No 200	w_n	ZONE			Fs
5	SK-1	7.50	4	CL	40	21	19	100	80	39.8	-	zone B	-	0.64
		11.00	10	CL	39	20	19	100	74	34.8	-	zone B	-	>1
		15.00	3	CL	47	24	23	100	98	44.3	zone C	-	-	0.78
	SK-2	4.50	3	CL	37	19	18	100	66	34.7	-	zone B	-	0.25
		8.50	5	CL	38	19	18	100	64	30.5	zone C	-	-	0.24
		11.50	6	CH	52	24	28	100	98	50.1	zone C	-	-	0.28
		15.50	6	CL	37	19	18	100	99	47.9	-	zone B	-	0.27
	SK-3	8.00	2	CL	33	17	16	100	54	33.8	zone C	-	-	0.19
		12.00	4	CL	36	18	18	100	62	36.1	zone C	-	-	0.23
6	SK-1	3.00	5	CL	40	19	21	100	69	28.7	zone C	-	-	0.46
		6.00	4	CH	53	27	26	100	99	50.6	zone C	-	-	0.56
		8.00	2	CH	52	26	26	100	97	50.3	zone C	-	-	0.55
		10.00	4	CH	51	27	24	100	96	42.9	zone C	-	-	0.77
		11.50	5	CH	50	25	25	100	98	47.8	zone C	-	-	0.93
		13.00	8	CH	50	25	25	100	91	40.9	zone C	-	-	>1
		14.50	7	CL	45	20	25	97	69	52.0	zone C	-	-	>1
	SK-2	6.00	2	CL	37	20	17	100	61	40.2	-	zone B	-	0.19
		7.50	3	CH	56	23	33	100	94	44.5	zone C	-	-	0.20
		9.00	5	CL	38	19	19	100	65	34.2	-	zone B	-	0.24
		10.50	5	CL	43	20	23	100	85	37.3	zone C	-	-	0.24
		13.50	5	CH	50	26	24	100	86	51.8	zone C	-	-	0.26
		15.00	4	CH	52	25	27	100	95	48.5	zone C	-	-	0.25
7	SK-1	3.00	10	CL	40	20	20	88	54	23.5	zone C	-	-	0.50
		4.50	4	CH	50	26	24	100	80	38.1	zone C	-	-	0.25
		6.50	2	CH	51	26	25	100	76	35.6	zone C	-	-	0.20
		9.50	8	CL	48	25	23	85	62	20.7	zone C	-	-	0.31
		11.00	8	CL	48	25	23	72	54	22.1	zone C	-	-	0.32
8	SK-1	3.00	13	ML	48	29	19	90	72	30.5	zone C	-	-	0.74
		4.50	7	CL	39	18	21	100	69	16.5	zone C	-	-	0.40
		7.50	11	CL	35	20	15	95	80	7.4	zone C	-	-	0.43
		12.00	24	CL	37	20	17	68	60	16.5	zone C	-	-	0.84
	SK-2	4.50	14	CL	44	18	26	95	78	7.3	zone C	-	-	0.66
		6.00	16	CL	36	21	15	93	80	8.9	zone C	-	-	0.61
		9.00	13	CL	34	19	15	98	73	10.1	zone C	-	-	0.47
		10.50	18	CL	35	19	16	89	75	13.2	zone C	-	-	0.60
		13.50	15	CL	35	21	14	92	83	24.7	zone C	-	-	0.50
	SK-4	4.50	6	CL	44	18	26	86	50	10.7	zone C	-	-	0.37
		6.00	7	MH	50	40	10	100	61	12.4	zone C	-	-	0.37
		9.00	11	CL	34	19	15	100	84	26.2	zone C	-	-	0.42
		10.50	13	CL	39	18	21	100	78	35.6	zone C	-	-	0.47
		13.50	15	CL	35	19	16	87	70	13.3	zone C	-	-	0.50
	SK-5	7.50	7	CL	35	18	17	100	72	27.5	zone C	-	-	0.35
		10.50	11	CL	39	18	21	88	51	18.3	zone C	-	-	0.39
		13.00	12	CL	33	18	15	100	83	24.7	zone C	-	-	0.41

Table G Liquefaction Suspectibility and Results of Liquefaction Analyses (Done By Using PGA from SRA of Izmir Scenario Earthquake M = 6.5) for Fine Grained Soils (continued)

Location	Boring	Depth	SPT	USCS	w_L	w_P	I_P	- No 4	- No 200	w_n	ZONE			Fs
10	SK-1	14.00	33	CL	44	23	21	88	56	29.0	zone C	-	-	>1
	SK-8	11.00	5	CL	38	20	18	95	60	47.4	-	zone B	-	0.31
		13.00	7	CL	38	20	18	95	60	32.1	zone C	-	-	0.39
	SK-10	14.00	37	CL	40	24	16	100	53	26.4	zone C	-	-	0.26
	SK-11	12.00	6	CL	34	22	12	100	85	43.5	-	-	zone A	0.35
		14.00	39	CL	38	21	17	100	65	23.6	zone C	-	-	0.55
	SK-12	12.00	5	CL	36	23	13	100	75	58.8	zone C	-	-	0.30
12	SK-1	12.00	16	CL	32	15	17	82	50	29.0	zone C	-	-	0.62
	SK-3	10.50	9	CL	32	16	16	92	57	30.0	zone C	-	-	>1
	SK-4	7.50	5	CL	30	18	12	100	66	28.0	-	-	zone A	0.32
		9.00	5	CL	33	21	12	100	67	29.0	-	-	zone A	0.31
		12.00	12	CL	27	14	13	92	55	21.0	zone C	-	-	0.32
	SK-6	13.50	18	CL	50	23	27	100	84	35.0	zone C	-	-	0.68
	SK-7	15.00	20	CL	35	15	20	98	62	24.0	zone C	-	-	0.74
13	SK-1	13.00	4	CL	30	16	14	100	57	52.6	zone C	-	-	0.39
		14.50	6	CL	47	19	28	100	65	31.1	zone C	-	-	0.46
	SK-2	11.00	2	CL	45	23	22	99	64	39.0	zone C	-	-	0.41
		14.00	5	CL	28	19	9	96	61	23.6	-	-	zone A	0.45
		15.50	6	CL	29	19	10	90	57	22.6	zone C	-	-	0.46
14	SK-3	11.00	3	CL	34	16	18	100	51	31.9	zone C	-	-	0.27
	SK-4	14.00	13	CL	40	19	21	97	95	37.1	zone C	-	-	0.84
15	SK-5	12.50	8	CH	53	24	29	94	83	56.2	zone C	-	-	0.49
		14.00	7	CL	39	22	17	92	72	66.7	-	zone B	-	0.44
	SK-6	11.50	0	CL	48	24	24	93	75	63.9	zone C	-	-	0.23
		14.50	4	MH	50	29	21	91	63	62.6	zone C	-	-	0.33
	SK-66	11.00	4	CL	32	21	11	100	57	66.4	-	-	zone A	0.34
16	SK-67	12.50	1	CL	45	22	23	85	57	99.1	zone C	-	-	0.29
		14.50	1	CL	44	23	21	88	60	72.3	zone C	-	-	0.30
	SK-68	11.00	0	CL	44	23	21	100	87	61.7	zone C	-	-	0.27
		12.50	1	CL	44	23	21	100	88	49.0	zone C	-	-	0.30
		15.50	4	CL	35	18	17	96	51	17.4	zone C	-	-	0.41
17	SK-7	11.00	3	CL	48	21	27	90	57	39.1	zone C	-	-	0.31
		12.50	4	CL	42	23	19	100	90	46.7	-	zone B	-	0.34
	SK-8	13.00	2	CL	42	22	20	100	93	55.8	-	zone B	-	0.28
		14.50	3	MH-CH	56	32	24	98	95	56.8	zone C	-	-	0.34
18	SK-9	15.50	5	CL	40	23	17	100	94	46.8	-	zone B	-	0.50
19	SK-12	11.00	2	CL	39	22	17	100	56	41.7	-	zone B	-	0.26
		14.00	8	CL	35	18	17	100	71	40.1	zone C	-	-	0.48
		15.50	11	CL	44	23	21	100	93	47.7	zone C	-	-	0.59
	SK-56	15.50	5	CL	26	18	8	100	67	22.5	-	-	zone A	0.38