DOKUZ EYLÜL UNIVERSITY

GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

A GEOTECHNICAL EARTHQUAKE ENGINEERING INVESTIGATION FOR SOILS OF SOUTHERN COAST OF İZMİR BAY

by

Bülent Halis BOZKURT

November, 2010

İZMİR

A GEOTECHNICAL EARTHQUAKE ENGINEERING INVESTIGATION FOR SOILS OF SOUTHERN COAST OF İZMİR BAY

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M.Sc EXAMINATION RESULT FORM

We have read the thesis entitled **A GEOTECHNICAL EARTHQUAKE ENGINEERING INVESTIGATION FOR SOILS OF SOUTHERN COAST OF İZMİR BAY** completed by **BÜLENT HALİS BOZKURT** under supervision of **PROF. DR. ARİF Ş. 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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Bülent Halis BOZKURT

A GEOTECHNICAL EARTHQUAKE ENGINEERING INVESTIGATION FOR SOILS OF SOUTHERN COAST OF İZMİR BAY

ABSTRACT

In this thesis study it is aimed to investigate the dynamic behavior of soils of south coast of İzmir Bay in terms of Geotechnical Earthquake Engineering. İzmir Fault has been the most critical earthquake source for İzmir city. Thus, a project was evaluated by RADIUS team at 1999. This project includes an earthquake scenario which is due to İzmir fault. However, both the unique acceleration records which belongs to the 1977 İzmir Earthquake (M=5.3), 2003 Urla Earthquake (M=5.6) and 2005 Urla Earthquake (M=5.9), and İzmir Scenario Earthquake (M=6.5) that has been modified for İzmir Scenario Earthquake from the unique acceleration records have been used in computations.

The geotechnical database has been established using various geotechnical reports that have been prepared on the investigation area.

In the study, one dimensional site response analyses method has been used. The equivalent linear model and dynamic site response analyses have been performed by using the EERA computer program (Bardet et al., 2000) on 1977 Izmir Earthquake (M=5.3) 2003 Urla Earthquake (M=5.6), 2005 Urla Earthquake (M=5.9) and its scenario earthquakes.

The liquefaction analyses based on the SPT-N values are made for each boring locations separately. The liquefaction risk computations of the study area are made by two different methods within upper 15 meter depth. The analyses are done for three different earthquakes and three scenario earthquakes. In the liquefaction analyses, the “PGA” values are obtained from the site response analyses.

Keywords: İZMİR Bay, south coast soils, critical earthquake source, site response analysis, equivalent linear method, EERA, liquefaction potential

İZMİR KÖRFEZİ GÜNEY KIYISI ZEMİNLERİ İÇİN BİR GEOTEKNİK DEPREM MÜHENDİSLİĞİ ARAŞTIRMASI

ÖZ

Bu çalışma kapsamında, geoteknik deprem mühendisliği açısından, İzmir körfezinin güney kıyısın dinamik zemin davranışlarının araştırılması amaçlanmıştır. İzmir Fayı, İzmir şehir için en önemli deprem kaynağı olmuştur. Bu yüzden, RADIUS projesi kapsamında, 1999 yılında bir proje geliştirilmiştir. Bu proje, İzmir için İzmir fayının oluşturabileceği M=6,5 büyüklüğünde bir deprem senaryosunu içermektedir. Bu nedenle, 1977 İzmir (M = 5,3), 2003 Urla (M = 5,6) ve 2005 Urla (M = 5,9) depremine ait ivme kayıtlarının yanı sıra, İzmir Senaryo Depremi (M = 6,5) için de bu kayıtlar modifiye edilerek hesaplamalarda kullanılmıştır.

Geoteknik veritabanı, araştırma alanı için daha önceden yapılmış olan çeşitli geoteknik raporlar kullanılarak kurulmuştur.

Çalışmada, tek boyutlu dinamik zemin tepki analiz yöntemi kullanılmıştır. Eşdeğer doğrusal model, EERA bilgisayar programı (Bardet ve diğ., 2000) yardımıyla oluşturulmuş ve 1977 İzmir Depremi (M = 5,3) 2003 Urla Depremi (M = 5,6), 2005 Urla Depremi (M = 5,9) ve senaryoları için zemin tepki analizleri yapılmıştır .

Sıvılaşma analizleri, SPT-N değerlere bağlı olarak her sondaj ve derinlik için ayrı ayrı yapılmıştır. Bölgenin sıvılaşma riski 15 metre derinliğe kadar iki farklı yöntem kullanılarak hesaplanmıştır. Analizler, üç farklı deprem ve üç senaryo deprem için yapılmıştır. Sıvılaşma analizlerinde, dinamik zemin tepki analizlerinden elde edilen "PGA" değeri kullanılmıştır.

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

CONTENTS

APENDICIES

CHAPTER ONE
INTRODUCTION

1.1 General

The human beings have been in need of housing throughout history. With the help of technological advances, housing styles have changed and multi-storey buildings have been constructed. This has brought with it structural security issues. Especially, the 1999 Marmara earthquake has become an important milestone for building safety issues in Turkey. The importance of soil-structure interaction has emerged in a painful way. The behavior of structures under dynamic effects directly depends on the ground properties. Same structure may show different behavior on different soil profiles. Therefore, to determine the behavior of soil is very important in terms of structural security. At that point the necessity of determining the dynamic behaviors of soil layers down to the bedrock has aroused.

In this study it is aimed to investigate the dynamic behavior of soils of south coast of Izmir Bay in terms of Geotechnical Earthquake Engineering. This region possesses important historical, industrial and transportation structures in addition to residential buildings.

Izmir Fault has been the most critical earthquake source for Izmir city. Thus, a project was evaluated by RADIUS team at 1999. An earthquake scenario due to İzmir Fault has been included in the study. The unique acceleration records which belongs to the 1977 Izmir Earthquake (M=5.3), 2003 Urla Earthquake (M=5.6) and 2005 Urla Earthquake (M=5.9) have been used in the study. The records that are modified for Izmir Scenario Earthquake (M=6.5) were chosen as the reference ground motion.

In the computation of dynamic analyses, one dimensional site response analyses method has been used. The equivalent linear model and dynamic site response analyses have been performed by using the EERA computer program (Bardet et al.,

2000) on 1977 Izmir Earthquake (M=5.3) 2003 Urla Earthquake (M=5.6), 2005 Urla Earthquake (M=5.9) and its scenario earthquakes. Chapter two includes structuring, geology, tectonic of the study area and the sources of geotechnical data. In chapter three, site response analyses methods, determination of maximum bedrock acceleration, explanation of EERA computer program and the findings and results of site response analyses have been given. Evaluation of liquefaction potential, results of liquefaction analyses, and the liquefaction potential of the study area have been presented in chapter four.

Results and general discussions in terms of geotechnical earthquake engineering have been given in the last chapter. Soil profiles, dynamic soil properties and the results of analyses have been given in appendices.

1.2 Scope

Recently, earthquake is unchangeable reality in our lives. After the Marmara 1999 earthquake, peoples have seen that, geotechnical researches and improvements are significant and necessary as well as structural engineering. Izmir is the third biggest city of Turkey. Approximately, 3.5 million people are living in the city center. Therefore, medium/strong earthquakes affecting the city of Izmir may cause hazards in some buildings and economical losts.

In this study, dynamic site response analyses have been done for the soils of southern coast of Izmir Bay. Through this aim, the seismicity of the region and critical earthquake source were investigated. Izmir takes place on the important faults which are able to produce strong earthquakes. The important faults producing medium/strong earthquakes are the Izmir Fault, Tuzla Fault, Karaburun Fault, and Gülbahçe Fault. The record of 1977 Izmir Earthquake (M=5.3) as the only acceleration record relating to the Izmir Fault, have been used for analyses. Besides, records of the 2003 Urla Earthquake (M=5.6) close to the Gülbahçe Fault and the 2005 Urla Earthquake (M=5.9) nearby the Tuzla Fault have been used in the analyses.

Geotechnical database have been constructed for calculation of dynamic parameters of soils for site response analyses.

The study area has been introduced; geology and tectonics of the study area have been explained and the sources of geotechnical data and their distribution over the study area have been presented in the following chapter.

CHAPTER TWO
STUDY AREA AND GEOTECHNICAL DATA

2.1 Location of the Study Area

The southern coast of Izmir Bay contains residential buildings and important cultural / entertainment centers of the city of Izmir. The center of the city (Konak) has been located also in this region. There are governmental buildings, the city hall, historical trade centers such as the Kemeraltı bazaar, historical places and mosques, and the clock tower as the symbol of Izmir are located in Konak district. Historical Asansör building, theatre and cultural centers and concert halls of Dokuz Eylül and Ege universities take place in the city center. In addition, main artery of transportation which connects the west and east sides of Izmir is located in this region. Dense population of the city is living also in this region. Therefore the southern coast of the Izmir Bay was selected as the study area for dissertation.

A geotechnical earthquake investigation for the southern coast of Izmir Bay has been performed in this study. Geotechnical earthquake investigations related with this case were done for the northern and southeastern coasts of Izmir Bay (Kuruoğlu, 2004; Yalçın, 2008). Importance of the region (dense population, governmental, historical, traditional and cultural buildings, and main transportation artery) and being critical faults in the vicinity of Izmir has proved the requirement of the geotechnical earthquake investigation at the study area. This study is therefore necessary for overcoming the lack of geotechnical earthquake engineering investigation in the southern coast of the İzmir Bay.

The study area is located between Konak, Cumhuriyet Square and Güzelbahçe. This location of the study area is shown inFigure 2.1.

Figure 2.1 View of the study area and the Izmir Fault on the satellite photograph of Izmir Bay

2.2 General Tectonics

İzmir Gulf is a marin basin controlled by NE-NW, NS and EW trending faults.

There have been intensive earthquake activities in the city beginning the from the historical period. The main graben system which can be a source to this intensive earthquake activity is the Gediz Graben System (RADIUS, 1999). Lots of normal faults are present as parallel to this major graben system (Figure 2.2).

Gediz Graben System is located at the east of Izmir Bay and the common tectonic 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).

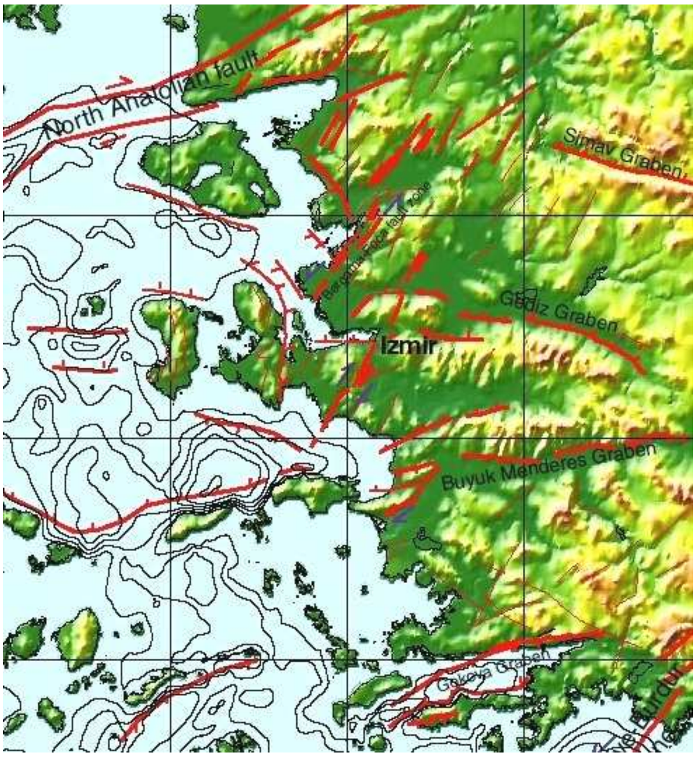

Figure 2.2 Major grabens and fault systems in the vicinity of Izmir (RADIUS, 1999)

The source of the reference earthquake motion is the Izmir Fault and the location of this fault is very close to the study area in the city center. Therefore, the Izmir Fault is more important than the other faults in the study area for this research (Fig.2.3).

The Izmir Fault is located at the southern part of Izmir Bay with east to west direction and the location of fault takes place in a district of 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 Kemalpasa Fault for 35 kilometers (RADIUS, 1999). Since the 1688, 1739 and 1778 earthquakes were on or very near to this fault, the Izmir Fault has been 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.

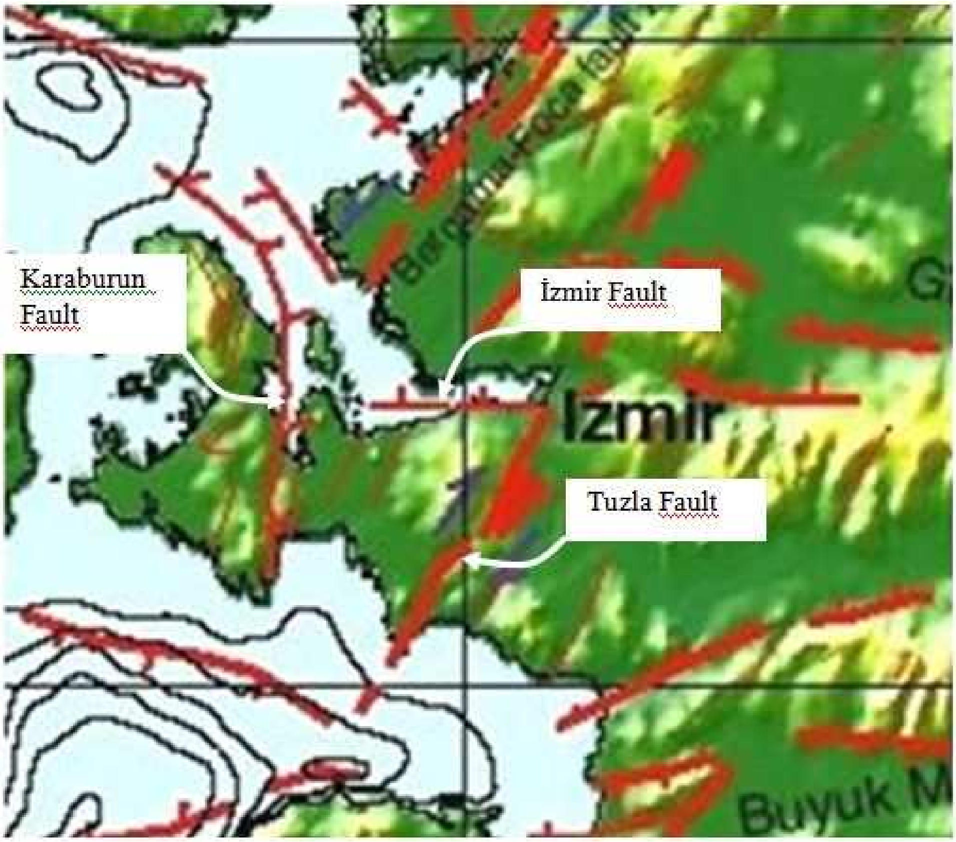

Figure2. 3 Risky earthquake generating faults for the study area

Because of these reasons it is a high possibility that the cause of the 1977 earthquakes is Izmir Fault (Kuruoglu, 2004).

The other two risky earthquake generating faults are NE-SW trending Tuzla Fault and NS trending Karaburun Fault. The locations of these faults are also shown in Fig. 2.3. Earthquakes of these two faults have also been used analyses.

2.3. Examples of earthquake series and major historical (pre-instrumental period) earthquakes in the region

Chios-Karaburun-Aegean Sea Earthquakes:

Earthquake serial of this region which started in 06.05.1984 was effective till the end of June. First of all, the earthquake with the magnitude of M_b = 5.0 affected Chios, Izmir, Lesbos and its surrounding areas. 17th of June dated earthquake (M_b = 5.0) was effective in Samos, Lesbos, Edremit Bay, Izmir and again Chios . At 26th of

June an earthquake of M_b=4.9 took place and seismic effectiveness went on for a while (UDIM, 2005).

Aegean Sea – Karaburun Earthquakes:

November 12, 1992 dated Aegean-Karaburun centered earthquake (M_b=4.4) affected Lesbos, Chios, Karaburun, Izmir and its surroundings. 6 earthquakes with the magnitudes of between 4.1 and 4.5 took place in this region. Event continued intensely till December (UDIM, 2005).

Aegean Sea – Karaburun Earthquakes:

This earthquake (Mb=5.0) started at 24th May 1994 and the serial continues with two other earthquakes with magnitudes M_b= 5.0 and M_b=4.8. Earthquake effectiveness went on till August (UDIM, 2005)

Chios Open Seas – Aegean Sea Earthquakes:

November 14, 1997 dated earthquake (M=5.8) was effective especially in İzmir, Edremit, Buraniye, Akçay, Ayvalık, all Aegean and Marmara Regions. After this earthquake, intense aftershock occurred, (UDIM, 2005).

Major Historical (pre-instrumental period) Earthquakes in İzmir:

İzmir and its neighborhood were exposed to destructive earthquakes from historical ages to recent times due to the tectonic activity in Western Anatolia. The most ancient reported earthquake took place in the year AD 17 (Türkelli et al., 1994). This catastrophic earthquake caused severe damage in 13 major ancient cities including modern time Turkish provinces of İzmir, Manisa, and Aydın (Guidobani et al., 1994). The 1688, 1739 and 1778 earthquakes caused destructive effect in the vicinity of İzmir (Ambraseys & Finkel, 1995). A list of major historical earthquakes affected İzmir and its neighborhood is given in Table 2.1. The dates, epicenter coordinates, intensities in MSK (Medvedev-Spoonheuer-Karnik) scale, equivalent magnitudes, and approximate locations of the earthquakes are given in this table (Kuruoğlu, M., 2004).

Table 2.1 Major historical earthquakes in İzmir (KOERI, 2003)

Date	Latitude	Longitude	Intensity, I_0 (in MSK scale)	Equivalent Magnitude	Approximate Location
AD 17	38.40	27.50	IX	6.9	İzmir, Manisa, Aydın
110	37.00	26.00	IX	6.9	İzmir, Chios
177	38.40	27.10	IX	6.9	İzmir, Efes
688	38.40	27.00	IX	6.9	İzmir
20.03.1389	38.40	26.30	IX	6.9	İzmir, Chios
10.07.1688	38.40	27.20	X	7.5	İzmir
04.04.1739	38.40	27.20	IX	6.9	İzmir
03-05.07.1778	38.40	27.20	IX	6.9	İzmir
01.02.1873	37.75	27.00	IX	6.9	Samos,İzmir
29.07.1880	38.60	27.10	IX	6.9	Menemen, İzmir
03.04.1881	38.25	26.10	X	7.5	Chios, İzmir
25.10.1889	39.30	26.30	IX	6.9	Lesbos&Chios, İzmir

2.3.1.5 Considerable Earthquakes of the region in the last Century

Considerable earthquakes of the region in the last century are listed in Table 2.2.

Table 2. 2 Considerable earthquakes in the region, (UDIM, 2005)

Date	**Place**	**Magnitude**
May 2, 1953	Karaburun	Ms=5.6
February 1, 1974	İzmir	M=5.2
December 16, 1977	İzmir	M=5.3
June 14, 1979	Karaburun	Ms=5.7
November 6, 1992	Seferihisar	Ms=6.0
November 14, 1997	Chios-Agean Sea	M=5.8
April 10, 2003	Urla	Mw=5.6
October 17-21,2005	Urla	Mw=5.9

2.4 Establishing Geotechnical Database

In the scope of this study, firstly, geotechnical database is required to perform dynamic analyses of the southern coast of Izmir Bay. The geotechnical database has been established using the data given in various geotechnical reports that have been done on the investigation area. These geotechnical reports are Final Boring Report of Gümrük–Üçkuyular Coast Road by Ege University (1982), Republic of Turkey Ministry of Public Works and Settlement General Directorate of Highways İzmir–Urla–Çeşme Motorway Boring Report and Boring Report including Balçova and İnciraltı borings which has been done for TUBITAK Research Project (TUBITAK-106G159, 2008). The information such as name of the project, number and depth of borings, sources of in-situ and laboratory tests about the data sources are given in Table 2.3.

The SPT depth, the SPT-N blow count, sieve analyses, consistency limits, unit weight, specific gravity, USCS group symbol and strength parameters are recorded individually for each borehole location. Geotechnical database are given in Appendix A.

The database was established after controlling the geotechnical test results in reports and uploading all of the geotechnical data to the database. While the database has established, errors in some test data have been eliminated by investigating logs of borings and controlling the test results.

Table 2.3 Sources of the geotechnical data

NO	Projet Name	Number of Borings	Depth Intervals (m)	Source of the In-Sıtu Tests	Source of the Laboratory Tests
1	Gümrük - Üçkuyular Coast Road	10	21.00-35.95	Final Boring Report of Gümrük – Üçkuyular Coast Road by Ege University (1982)	Final Boring Report of Gümrük – Üçkuyular Coast Road by Ege University (1982)
2	İkiztepe - Konak Halkapınar İzmir- Urla- Çeşme Motorway	11	36.50-49.95	Republic of Turkey Ministry of Public Works and Settlement General Directorate of Highways İzmir – Urla – Çeşme Motorway Boring Report (1992)	Republic of Turkey Ministry of Public Works and Settlement General Directorate of Highways İzmir – Urla – Çeşme Motorway Boring Report (1992)
3	TUBITAK-106G159 project	3	60.00-120.00	DAUM (2009)	DAUM (2009)

There are three geotechnical reports that contain totally 24 boring logs related with the study area. After controlling SPT and test data, totally 13 boring locations have been selected for site response analyses. Dynamic soil parameters have been determined using the geotechnical data uploaded to the established database. Computation process of dynamic soil parameters have been explained in detail in the following chapter.

CHAPTER THREE

SITE RESPONSE ANALYSES

3.1 Stress- Strain Behavior of Cyclic Loaded Soils

Soils which have been subjected to cyclic loads exhibit quite complex behavior. Determination of cyclic soil behavior needs easy soil modeling because of this situation. But, accuracy of model is very important as well as its easiness. For example, equivalent linear modeling, cyclic non-linear modeling and advanced constitutive modeling are the most important modeling types. Although, equivalent linear models are the simplest and useful models, they are not enough for perfect dynamic modeling of soil due to not considering all of the soil behavior and properties. On the other hand, advanced constitutive models are too complex for solution in spite of including more dynamic soil properties (Kramer, 1996).

Before investigation of the stress-strain models, presentation of some mechanic behavior of granulated materials will be useful. Several important aspects of low-strain soil behavior can be illustrated by considering the soil as an assemblage of discrete elastic particles (Kramer, 1996). Identical spheres behavior of radius (R) that had been applied normal force (N) had been researched and demonstrated with below equation by Hertz (1881):

$$N = \frac{2\sqrt{2}GR^{3/2}}{3(1-\nu)}\delta_N^{3/2} \qquad \textbf{(3.1)}$$

Where; G and ν: Elastic constant of sphere, δ_N: Difference between spheres center

In case of uniaxial loading, average normal stress (σ) is calculated by dividing normal force (N) to dependent area. The spheres are arranged in cubic form.

$$\sigma = \frac{N}{(2R)^2} = \frac{N}{4R^2} \qquad \textbf{(3.2)}$$

Tangent modulus in case of the uniaxial loading;

$$E_{tan} = \frac{d\sigma}{d\varepsilon} = \frac{dN/_{4R^2}}{d\delta_N/_{2R}} = \frac{1}{2R}\frac{dN}{d\delta_N} = \frac{3}{2}\left[\frac{2G}{3(1-\nu)}\right]^{2/3} \sigma^{1/3} \qquad \textbf{(3.3)}$$

When a tangential force, T, is applied, elastic distortion causes the centers of the spheres to be displaced perpendicular to their original axis. δ_T is a nonlinear function of T (Kramer, 1996).

$$\delta_T = \left[1 - \left(1 - \frac{T}{f_N}\right)^{2/3}\right]\left\{\frac{3fN}{4E}(2-\nu)(1+\nu)\left[\frac{3(1-\nu^2)NR}{4E}\right]\right\} \qquad T \le fN \quad \textbf{(3.4)}$$

Where; f: Coefficient of friction between spheres

When T becomes equal to *fN*, gross sliding of the particles constans occurs (though slippage of part of the contact can occur before this point). This gross sliding is required for permanent particle reorientation; consequently, volume changes (drained conditions) cannot occur excess pore pressure (undrained conditions) cannot be generated when gross sliding does not occur. The shear strain corresponding to the initiation of gross sliding (Kramer, 1996);

$$\gamma_{tv} = \frac{\delta_T(T=fN)}{2R} = 2.08\,\frac{(2-\nu)(1+\nu)}{(1-\nu^2)^{1/2}E^{2/3}}\,\sigma^{2/3} \qquad \textbf{(3.5)}$$

Deformation is called *volumetric threshold shear strain* (γ_{tv}) during starting the total collapse.

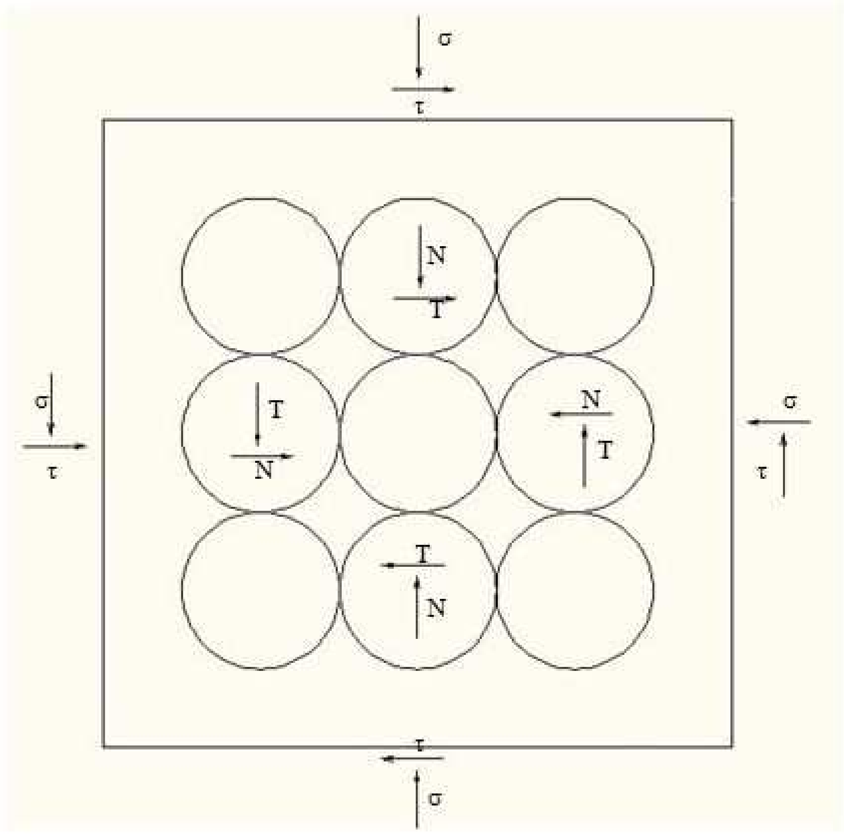

Figure 3.1 Cubically packed assemblage of spheres subjected to normal stress, and share stress, that produce interparticle contact forces N and T (After Dobry et al., 1982).

While practically confining pressure is about 25-200 kPa, volumetric threshold shear strain is about 0.01 and 0.04%.

Undoubtedly, soil particles do not have uniform spheres, but the existence of the threshold shear strength very close to that predicted by equation (3.5) has been observed experimentally for sands under both drained (Drnevich and Richart, 1970; Youd, 1972; Pyke, 1973) and undrained (Park and Silver, 1975; Dobry and Ladd, 1980; Dobry et al, 1982) loading conditions. Experimental evidence suggest that volumetric threshold shear strain increases with plasticity index (Vucetic, 1994).

However, volumetric threshold shear strain (γ_{tv}) is smaller than linear cyclic volumetric threshold shear strain (γ_{lt}) as 30 times approximately. Soils behave linearly under the γ_{lt} value (Vucetic, 1994).

3.1.1 Equivalent Linear Model

Soils behave as shown in Fig. 3.2, if symmetric cyclic loading is applied under the geostatic conditions. This behavior forms a loop that is called as hysteresis loop. Generally, the most important properties of the hysteresis loop are tangent and width of loop shape. Loop tangent depends on stiffness degree of soils that describes modulus of tangent shear (G_{tan}). This value changes on each point of loop that can be seen from below figure easily. But modulus of secant (G_{sec}) describes the general inclination of the hysteresis loop.

$$G_{sec} = \frac{\tau_c}{\gamma_c} \quad \textbf{(3.6)}$$

Where; τ_c: Shear stress, γ_c: Shear strain amplitude

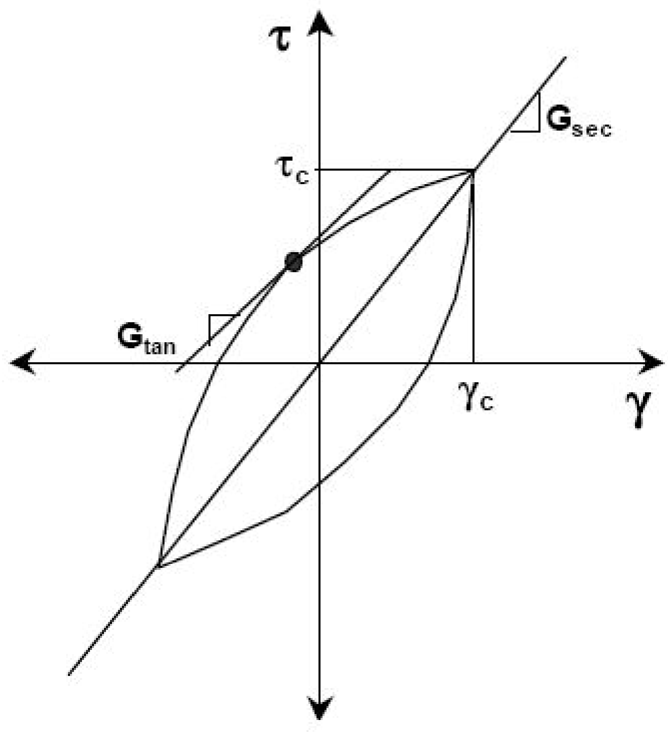

Figure 3.2 Secant and tangent shear modulus

Width of hysteresis loop is related to the area. This area is measured energy dissipation. This can conveniently be described by damping ratio (ζ).

$$\zeta = \frac{w_D}{4\pi w_s} = \frac{1}{2\pi}\frac{A_{loop}}{G_{sec}\gamma_c^2} \quad \textbf{(3.7)}$$

Where; w_D: Damped energy, w_s: Maximum deformation energy, A_{loop}: Area of loop, G_{sec} and ζ: Equivalent linear material parameters.

Equivalent linear modeling is an approximate method for determination of non-linear real soil behavior. Equivalent linear models imply that the strain will always return to zero after cyclic loading and since a linear material has no limiting strength, failure cannot occur. Nevertheless, the assumption of linearity allows a very efficient class of computational models to be used for ground response analyses and it is commonly employed for that reason (Kramer, 1996).

3.1.2 Shear Modulus

Soils stiffness depends on cyclic strain amplitude, void ratio, average principal effective stress, plasticity index, over consolidation ratio and number of cyclic loadings.

Secant shear modulus is high in low strain amplitude. But secant shear modulus is decreased while strain amplitude is increased. Peak point of different loop of various cyclic strain amplitudes forms the backbone (skeleton) curve (Fig. 3.3 a). Tangent of this slope (its slope at the origin, O (τ=0, γ=0)) is maximum value of shear module (G_{max}) (Fig. 3.3 a).

The modulus ratio G/G_{max} drops to a value of less than 1 at greater cyclic strain amplitudes. In formula G/G_{max} , shear module (G) is secant shear module (G_{sec}). The variation of the modulus ratio with shear strain is described graphically by a modulus reduction curve (Fig. 3.3 b), (Kramer, 1996).

3.1.3 Maximum Shear Modulus (G_{max})

G_{max} can be calculated as below by shear wave velocities (v_s).

$$G_{max} = \rho \times v_s^2 \quad \textbf{(3.8)}$$

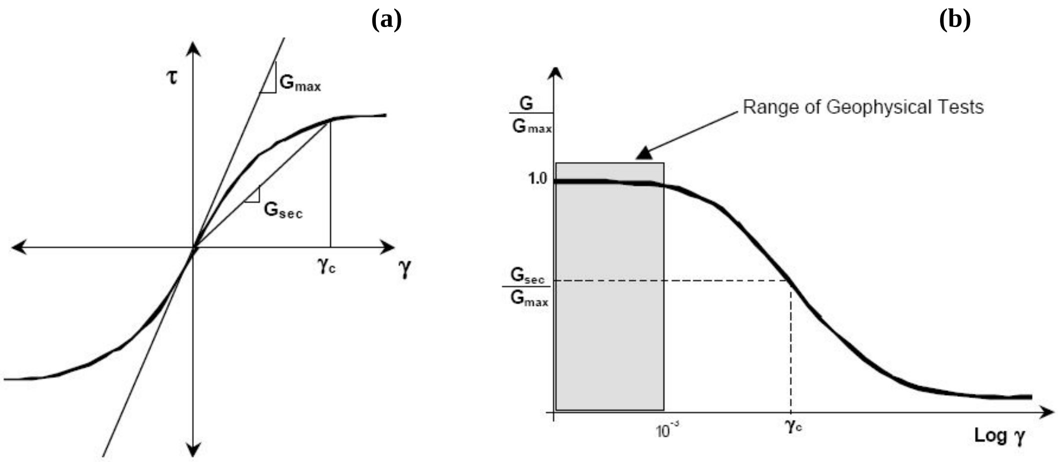

Figure 3.3 (a) Backbone curve and G_{max} (b) Variation of the modulus ratio.

Computation of G_{max} for all types of soils has been presented in formula 3.8 that is the most reliable method. However, shear wave velocities (v_s) may not be determined. Then, G_{max} value for clay can be determined as;

$$G_{max} = 625F(e)(OCR)^K P_a^{1-n}(\sigma_m^{'})^n \quad \textbf{(3.9)}$$

Where; F(e): Function of void ratio [$F(e)=1/(0.3+0.7e^2)$ Hardin, 1978; and $F(e)=1/e^{1,3}$ Jamiolkowski, 1991], OCR: Over consolidation ratio, σ_m': Average principal effective stress [$\sigma_m' = (\sigma_1' + \sigma_2' + \sigma_3')/3$], n: Stress exponent (Generally, n= 0.5), P_a: Atmospheric pressure (Its unite must be same with σ_m' and G_{max}), K: Coefficient of over consolidation ratio (It depends on plasticity index, (Table 3.1))

Table 3.1 Plasticity index and K value relationship (Hardin and Drnevich, 1972)

PI	**K**
0	0
20	0.18
40	0.30
60	0.41
80	0.48
≥ 100	0.50

Maximum shear modulus can be calculated for sands as;

$$G_{max} = 1000K_{2_{max}}(\sigma_m^{'})^{0.5} \quad \textbf{(3.10)}$$

Where; K_{2max}: Coefficient which depends on void ratio (e) or relative density (D_r) and, unite of $\sigma_m^{'}$ is lb/ft^2 (Table 3.2).

Table 3.2 Void ratio, relative density and K_{2max} relationship (Seed and Idriss, 1970)

e	**K_{2max}**	**D_r(%)**	**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

Note: K_{2max} value changes from 80 to 180 for gravels typically.

Maximum shear module can be determined using plasticity index, over consolidation ratio and undrain shear strength as given in Table 3.3 for fine grain soils.

Table 3.3 G_{max}/S_u^a values (Weiler, 1988)

PI	OCR		
	1	2	5
15-20	1100	900	600
20-25	700	600	500
35-45	450	380	300

Where; S_u^a: Value of undrained shear strength from triaxial test

G_{max} can be determined from in-situ test results (Table 3.4). Lots of relations are improved empirically. Determination of G_{max} can be complex due to velocity and time affects (Anderson and Woods, 1975, 1976; Anderson and Stokoe, 1978; Isenhower and Stokoe, 1981). Velocity can cause increasing of G_{max} with increasing strain. Stiffness changing with time is described as;

$$\Delta G_{max} = N_G (G_{max})_{1000} \tag{3.11}$$

where; ΔG_{max}: Increasing value of G_{max} versus at any logarithmic time, $(G_{max})_{1000}$: G_{max} value thereafter 1000 minutes from completed primary consolidation.

N_G value increases with increasing plasticity index and decreasing over consolidation ratio (Kokusho et al, 1982). N_G can be calculated by the below given equation (Anderson and Woods, 1975).

$$N_G \cong 0.027\sqrt{PI} \tag{3.12}$$

Table 3.4 Relationships between G_{max} and in-situ test values (Kramer, 1996)

In-situ Test	Formulation	Soil Type	Source	Description
SPT	$G_{max}=20000(N_1)_{60}^{0.333}(\sigma_m')^{0.5}$ $G_{max}=325N_{60}^{0.68}$	Sand Sand	Ohta and Goto, 1976 Seed et al, 1986	Unite of G_{max} and σ_m' lb/ft^2
CPT	$G_{max}=1634(q_c)^{0.250}(\sigma_m')^{0.375}$ $G_{max}=406(q_c)^{0.695}e^{-1.130}$	Sand of quarts Clay	Rix and Stokoe, 1991 Mayne and Rix, 1993	Unite of G_{max}, q_c and σ_v' KPa Unite of G_{max}, q_c and σ_v' KPa
DMT	$G_{max}/E_d=2.72\pm0.59$ $G_{max}/E_d=2.20\pm0.7$ $G_{max}=\frac{530}{(\sigma_v'/P_a)^{0.25}}\frac{\frac{\gamma_D}{\gamma_w}-1}{2.7-\frac{\gamma_D}{\gamma_w}}K_0^{0.25}(P_a\sigma_v')^{0.5}$	Sand Sand Sand, silt and clay	Baldi et al, 1986 Belloti el al, 1986 Hryciw, 1990	From calibration test From in-situ test value Unite of G_{max}, P_c and σ_v' is same
PMT	$3.6 \leq (\frac{G_{max}}{G_{ur,c}}) \leq 4.8$ $Gmax = 1.68\, {}^{G_{ur}}/_{\alpha_p}$	Sand Sand	Bellotti et al, 1986 Byrne et al, 1991	$G_{ur,c}$: Corrected modulus of unloading-loading G_{ur}: Secant modul α: Factor from theory and test

The damping ratio for the cohesive and cohesionless soils can also be estimated by using equation (3.13).

$$\zeta = 0.333\frac{1+e^{-0.0145Ip^{1.3}}}{2}\left[0.586\left(\frac{G}{G_{max}}\right)^2 - 1.547\frac{G}{G_{max}} + 1\right] \quad \textbf{(3.13)}$$

3.2 Calculation of the Maximum Bedrock Acceleration for the Study Area

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 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).

The maximum bedrock accelerations have been determined for The 1977 İzmir Earthquake (M=5.3), 2003 Urla Earthquake (M=5.6), the 2005 Urla Earthquake (M=5.9) by using the Campbell attenuation relationship (Campbell, 1997) given in Equation 3.14. In using the attenuation relationships the maximum and minimum distance of the earthquake epicenters to the study area were used. Also, the maximum bedrock accelerations have been determined for scenario earthquakes by same attenuation relationships.

Campbell attenuation relationship was considered to be appropriate for prediction of free field amplitudes from earthquakes of which moment magnitude (Mw) 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:

$$\ln(A_h) = -3.512 + 0.904\, M - 1.328 \ln [\mathrm{sqrt}\{ r_{seis}{}^{2} + [0.149 \exp(0.647\, M)]^{2}\}] + [1.125 - 0.112 \ln (r_{seis}) - 0.0957\, M]\, F + [0.44 - 0.171 \ln (r_{seis})]\, S_{SR} + [0.405 - 0.222 \ln (r_{seis})]\, S_{HR} + e \quad \textbf{(3.14)}$$

Where, A_h: PGA (in g), e: 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 SSR=0 otherwise

S_{HR}=1 for hard rock, and SHR=0 otherwise, the standard error (ε) estimation is given by: $\varepsilon = \sigma / 2$

Where, $\sigma = 0.889 - 0.0691\, M$ 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 symbols are given symbolically in Figure 3.4. 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). r_{jb} value has been taken an average distance between boring location and earthquake center for Gümrük-Üçkuyular coast road borings. r_{jb} value has not been taken as the average value for Balçova borings due to the close distance between borings.

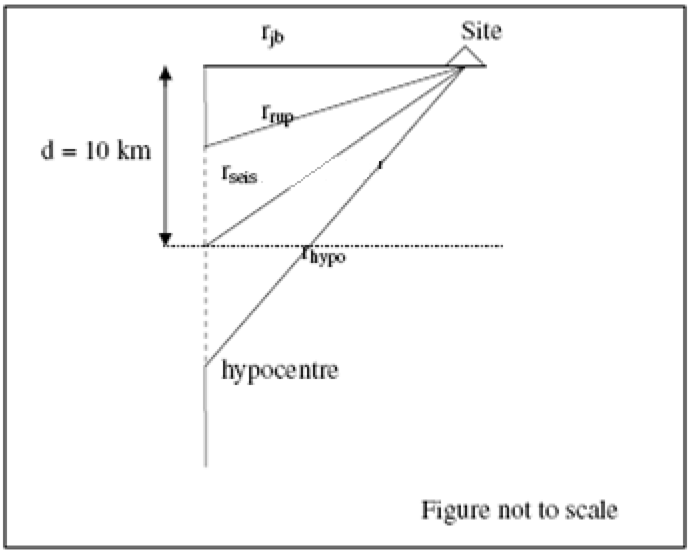

Figure 3.4 Seismogenical distances

The maximum bedrock acceleration values have been calculated for recorded earthquakes and scenario earthquakes by the Campbell (1997) attenuation relationship. The 1977 İzmir Earthquake (M=5.3), 2003 Urla Earthquake (M=5.6), the 2005 Urla Earthquake (M=5.9) location and distances between these earthquake epicenter and study areas have been shown in Figures 3.5 to 3.10. Also, computations of the maximum bedrock acceleration have been presented in Table 3.5 and Table 3.6. Type of rock is andesite in the study area. Shear wave velocity of andesitic rock has been taken as 2400 m/s in EERA (Bardet et al., 2000) program calculations for site response analyses.

Table 3.5 Computation of seismogenical parameters for Üçkuyular-Gümruk coast road borings

Location	**M**	**r**	**d**	**r_{seis}**	**F**	**S_{SR}**	**S_{HR}**	**σ**	**ε**	**$a_{MAX,r}$**
-	-	**km**	**km**	**km**	-	-	-	-	-	**g**
İZMİR 1977	5,3	5,00	10,00	11,18	0,50	0	1	0,53	0,27	**0,179**
URLA 2003	5,6	37,00	12,20	38,96	0,00	0	1	0,51	0,26	**0,031**
URLA2005	5,9	43,00	10,00	44,15	1,00	0	1	0,49	0,25	**0,038**
İZMİR 1977 Scenario	6,5	5,00	10,00	11,18	0,50	0	1	0,45	0,22	**0,360**
URLA 2003 Scenario	6,5	37,00	12,20	38,96	0,00	0	1	0,45	0,22	**0,066**
URLA2005 Scenario	6,5	43,00	10,00	44,15	1,00	0	1	0,45	0,22	**0,059**

Table 3.6 Computation of seismogenical parameters for Balçova borings

Location	M	r_{jb}	d	r_{seis}	F	S_{SR}	S_{HR}	σ	ε	a $_{MAX,r}$
-	-	km	km	km	-	-	-	-	-	g
İZMİR 1977	5,3	10,00	10,00	14,14	0,50	0	1	0,53	0,26	**0,127**
URLA 2003	5,6	28,50	10,00	30,20	0,00	0	1	0,51	0,25	**0,045**
URLA 2005	5,9	39,50	10,00	40,75	0,00	0	1	0,49	0,245	**0,037**
İZMİR 1977 Scenario	6,5	10,00	10,00	14,14	0,50	0	1	0,44	0,22	**0,279**
URLA 2003 Scenario	6,5	28,50	10,00	30,20	0,00	0	1	0,44	0,22	**0,095**
URLA 2005 Scenario	6,5	39,50	10,00	40,75	0,00	0	1	0,44	0,22	**0,061**

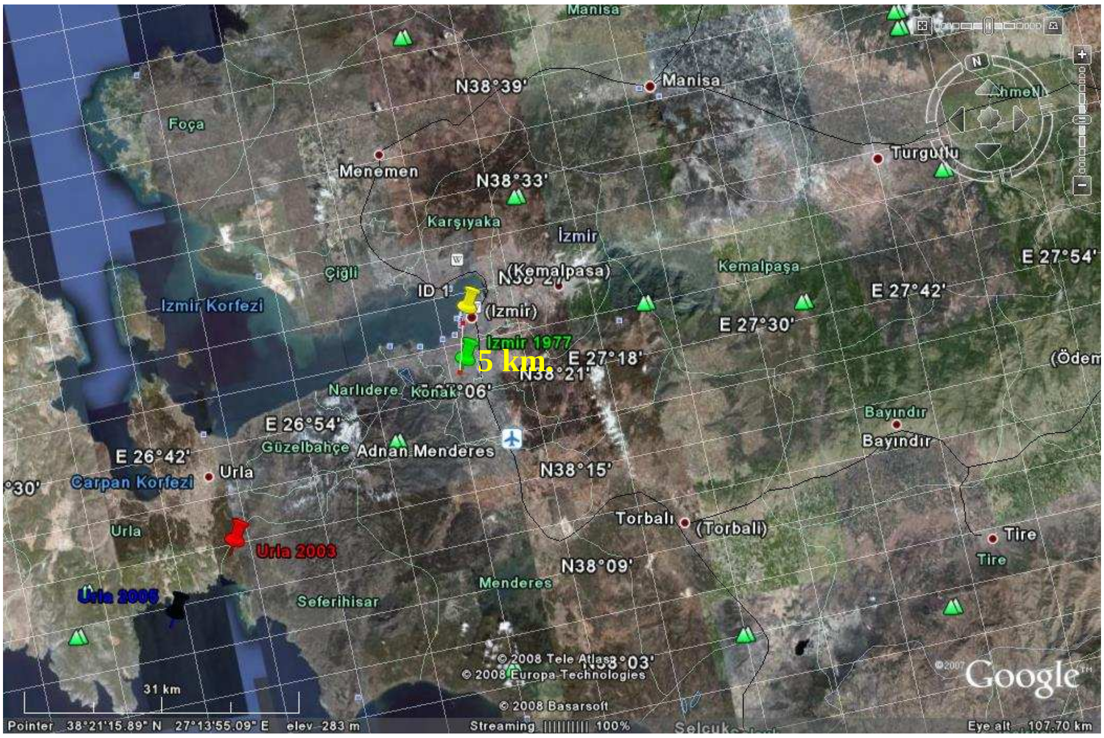

Figure 3.5 Average distance of epicenter of İzmir 1977 earthquake between research area Gümrük-Üçkuyular coast road borings

Figure 3.6 Average distance of epicenter of Urla 2003 earthquake between research area Gümrük-Üçkuyular coast road borings

Figure 3.7 Average distance of epicenter of Urla 2005 earthquake between Gümrük-Üçkuyular coast road borings

Figure 3.8 Distance of epicenter of İzmir 1977 earthquake between Balçova borings

Figure 3.9 Distance of epicenter of Urla 2003 earthquake between Balçova borings

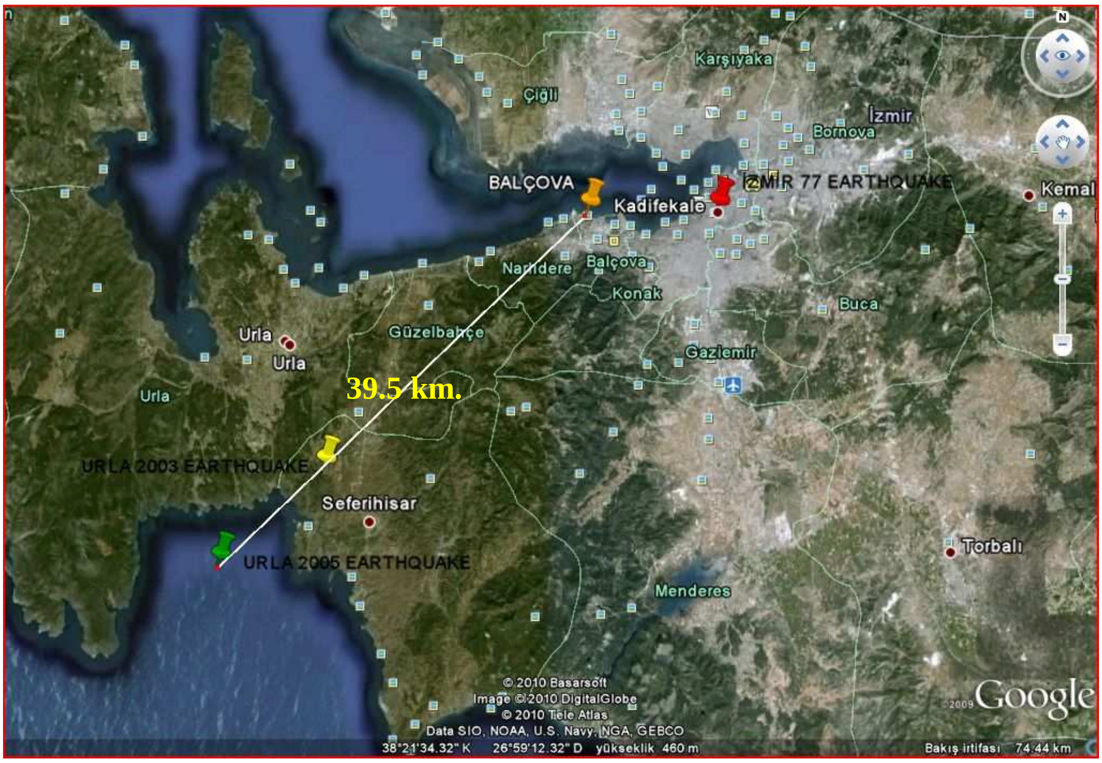

Figure 3.10 Distance of epicenter of Urla 2005 earthquake between Balçova borings

3.3 Description of EERA

The EERA (Bardet et al., 2000) software served as computational kernel for dynamic analyses. The one-dimensional equivalent linear method based EERA (Bardet et al., 2000) software was preferred for dynamic analysis since manipulations and data input can be made easily in spreadsheet format. Advantages of using EERA software are the ability for development of non-limited number of soil models. It is stated in the study of Eker (2002) that similar results of dynamic site response analyses performed by EERA and SHAKE can be obtained for the same profile.

The EERA program is formed by 9 main worksheets. These are earthquake, profile, material, iteration, acceleration, strain, amplification, Fourier, spectra worksheets, respectively. Earthquake data input are done in the earthquake worksheet. The data include recorded acceleration of earthquake versus time.

The properties of the soil layers are determined in the profile worksheet. These properties are number of soil layers, thickness of the layers, maximum shear modulus, unite weights, shear wave velocities, depths at middle of layer and vertical effective stress, respectively.

In the material worksheets, damping ratio versus shear strain and shear modulus versus shear strain curves are given. Main calculations are done in the iteration worksheet.

Time history of acceleration, velocity and displacement are given in the acceleration worksheets. The strain worksheet includes the time history of stress and strain of soil layers. Amplifications between each two sub-layers are given in the amplification worksheet.

Fourier amplitudes versus frequency of earthquake are presented in the Fourier worksheet. Spectra worksheet includes the response spectra. These work sheets are summarized in Table 3.7.

Typical EERA input and output graphics from the analyses results have been presented in Figure 3.11 to Figure 3.21.

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

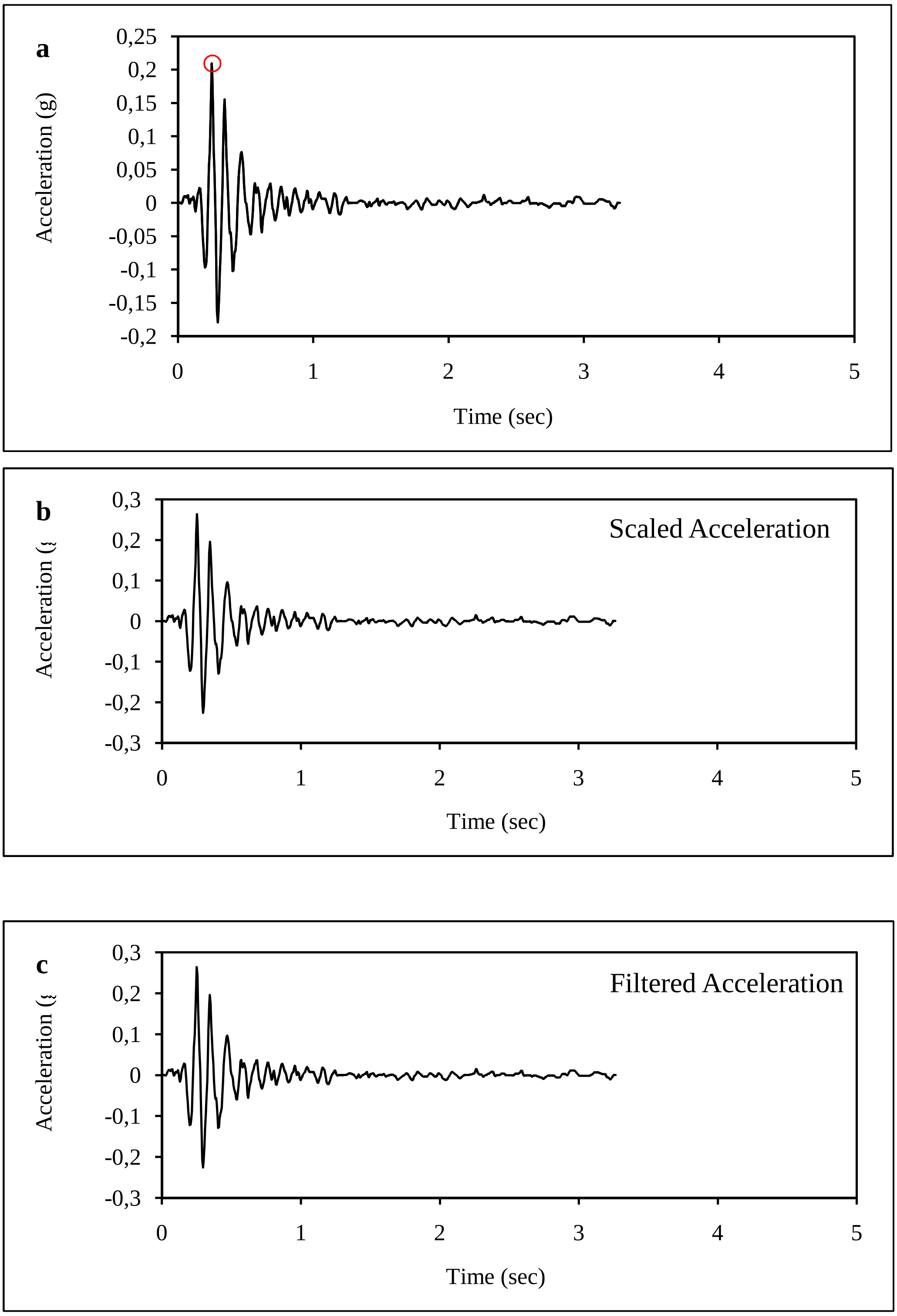

Figure 3.11 EERA acceleration versus time graphs: (a) Original earthquake data, (b) Scaled acceleration, (c) Filtered acceleration.

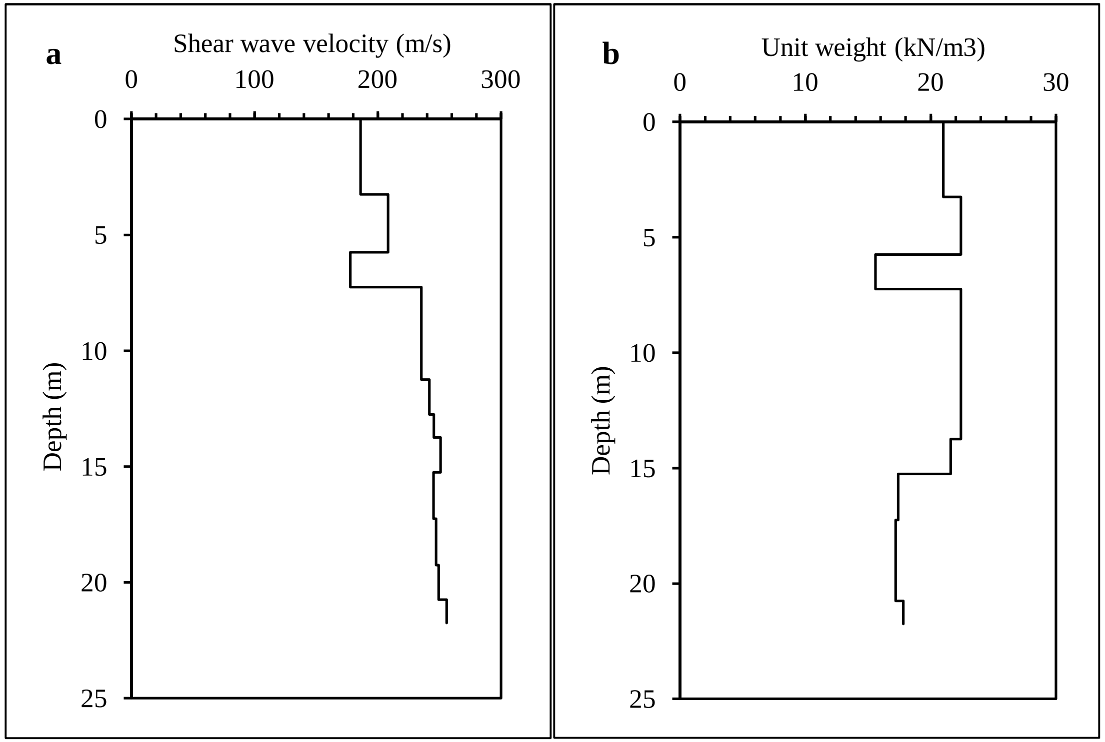

Figure 3.12 EERA (a) Shear wave velocity versus depth, (b) Unit weight versus depth graphs

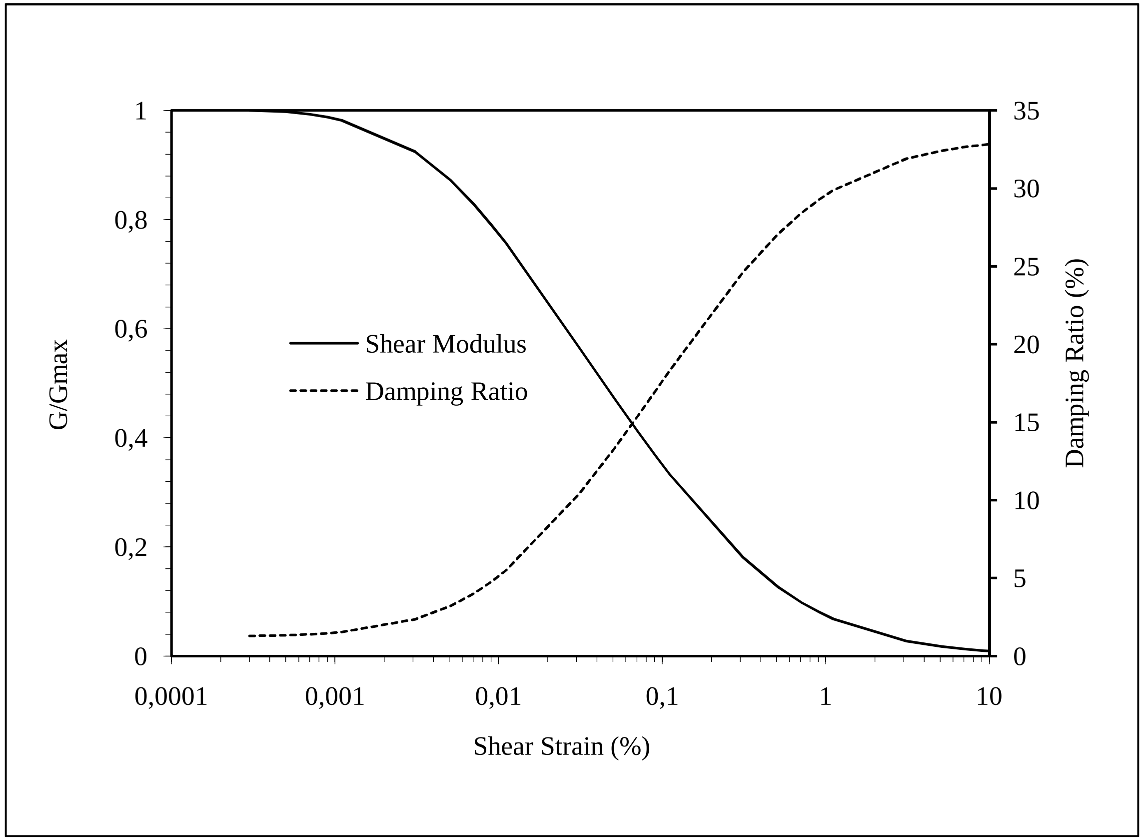

Figure 3.13 EERA Shear strain versus G/G_{max} ratio and damping ratio graphs

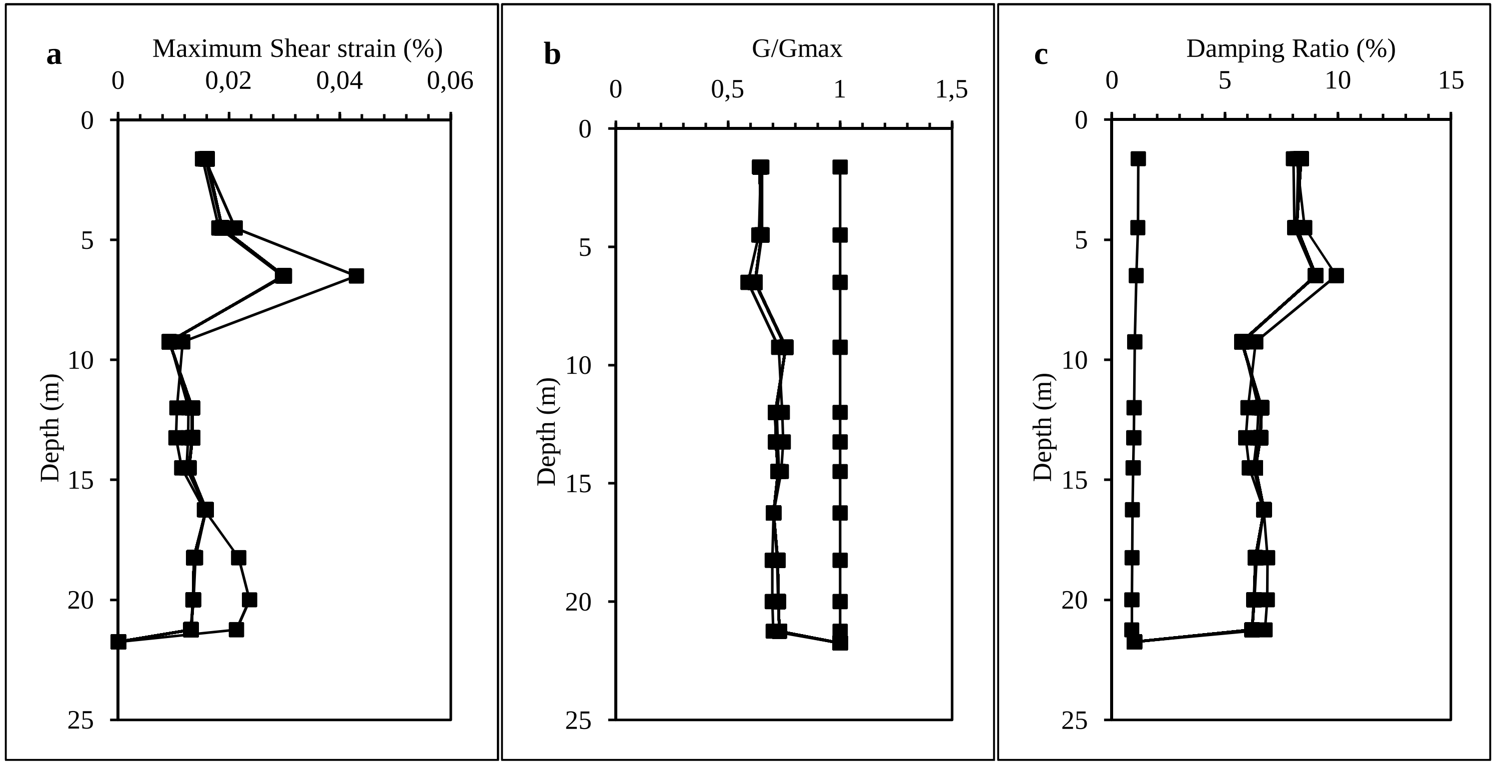

Figure 3.14 EERA (a) Maximum Shear strain versus depth, (b) G/G_{max} ratio versus depth, (c) Damping ratio versus depth graphs

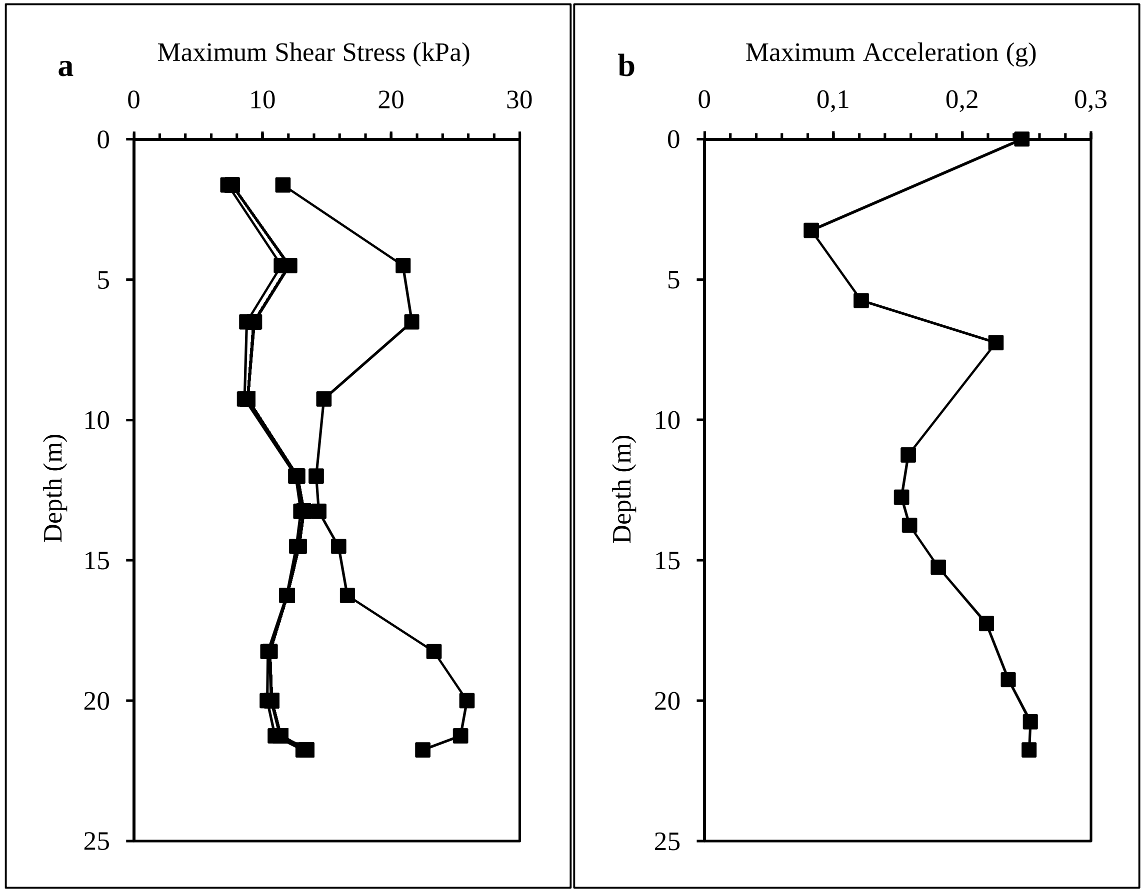

Figure 3.15 EERA (a) Maximum shear stress versus depth, (b) maximum acceleration versus depth graphs

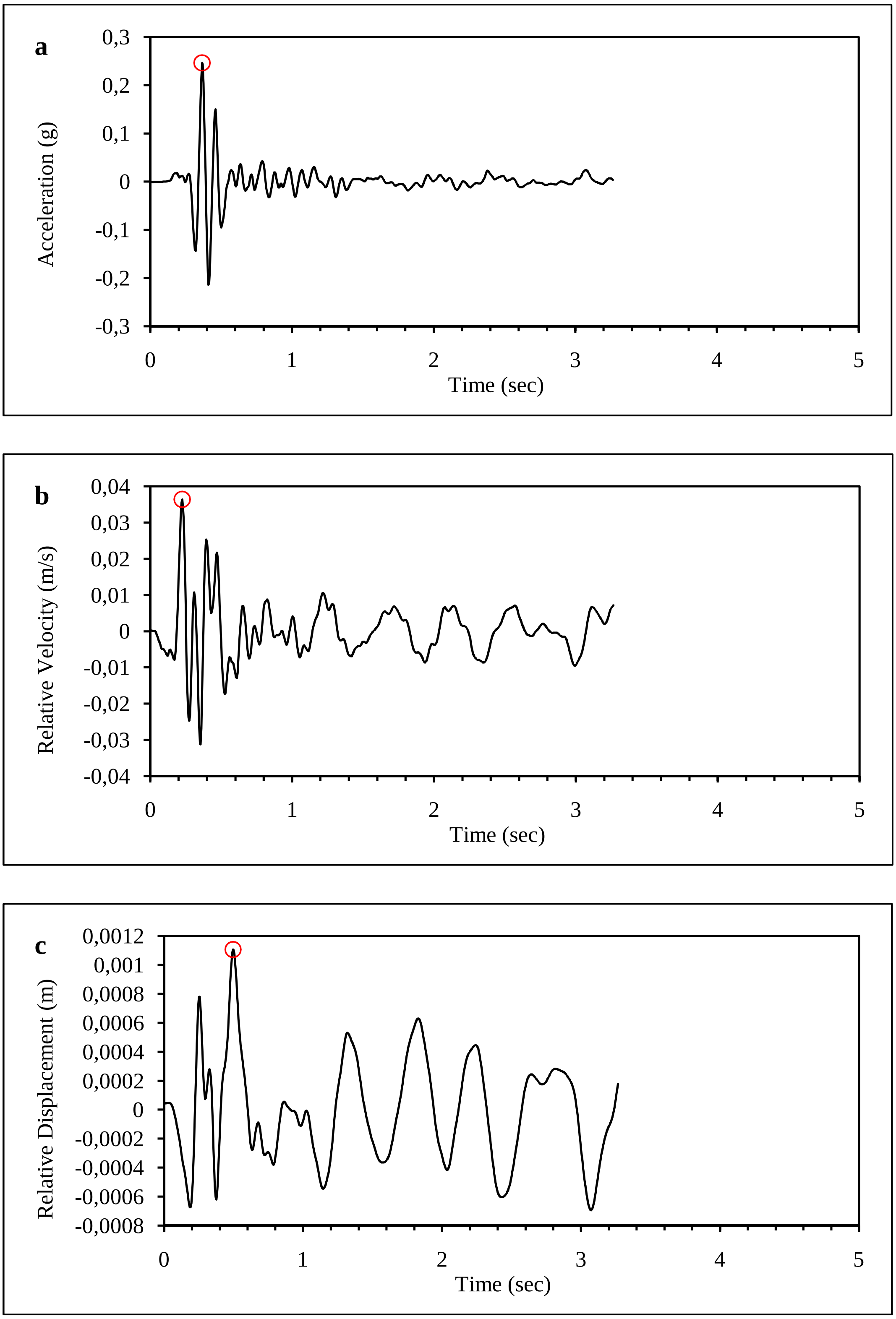

Figure 3.16 EERA (a) Acceleration versus time, (b) Relative velocity versus time, (c) Relative displacement versus time graphs.

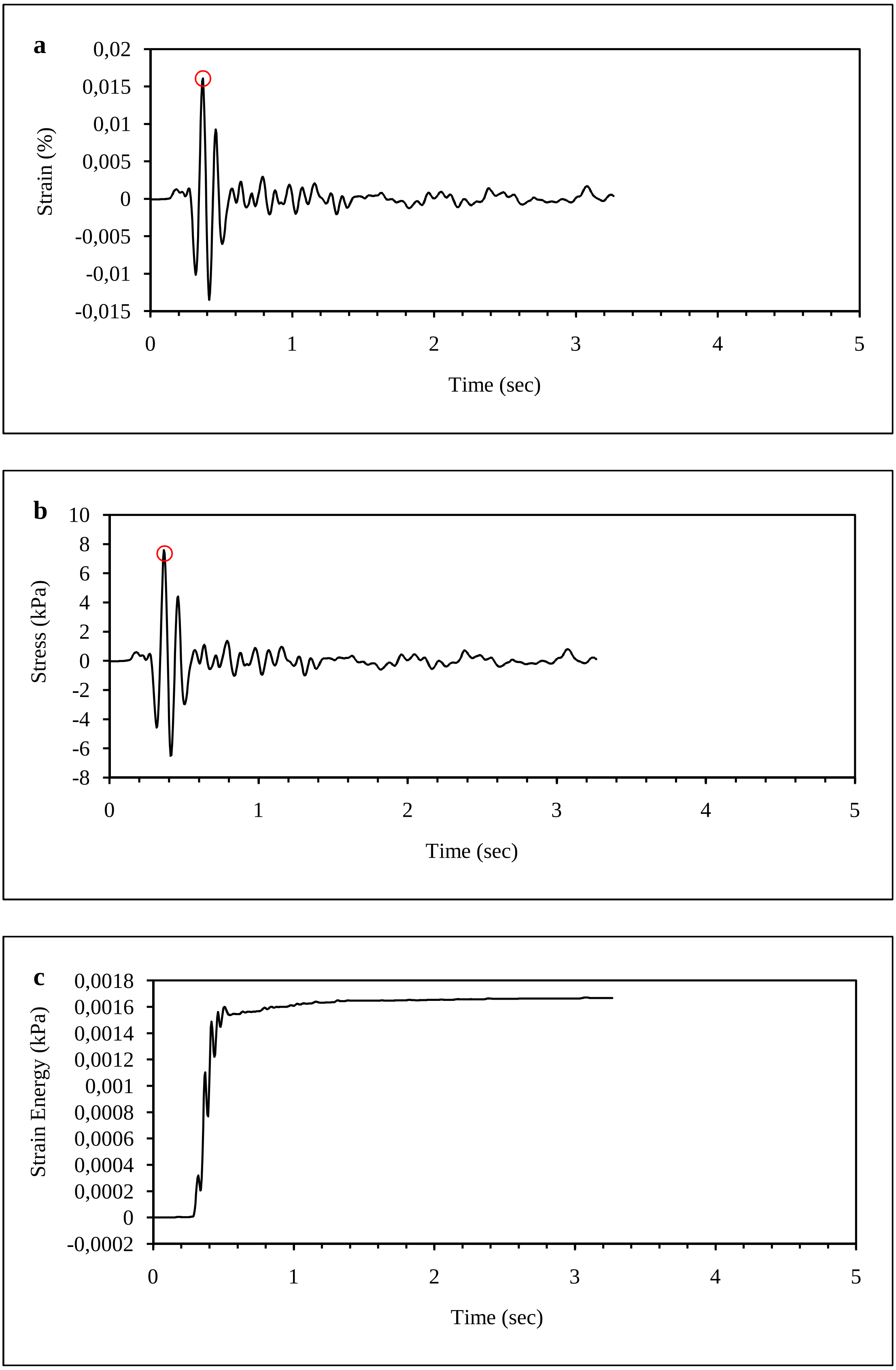

Figure 3.17 EERA (a) Strain versus time, (b) stress versus time, (c) Strain energy versus time graphs.

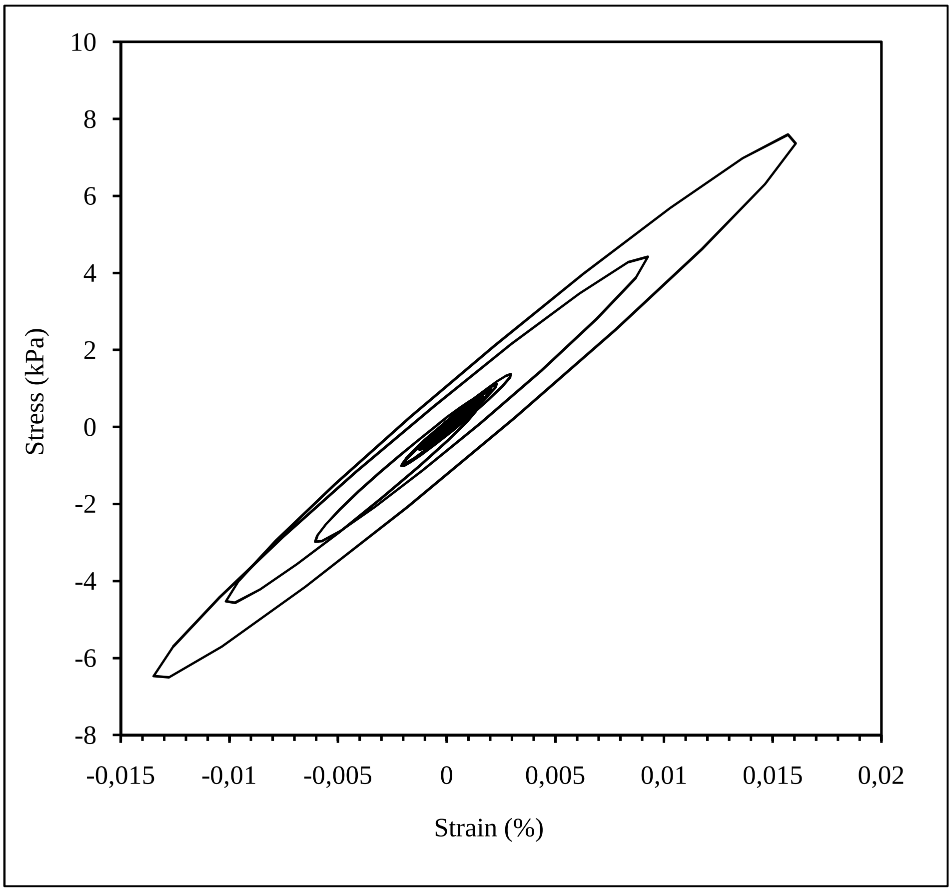

Figure 3.18 EERA Stress-strain graph

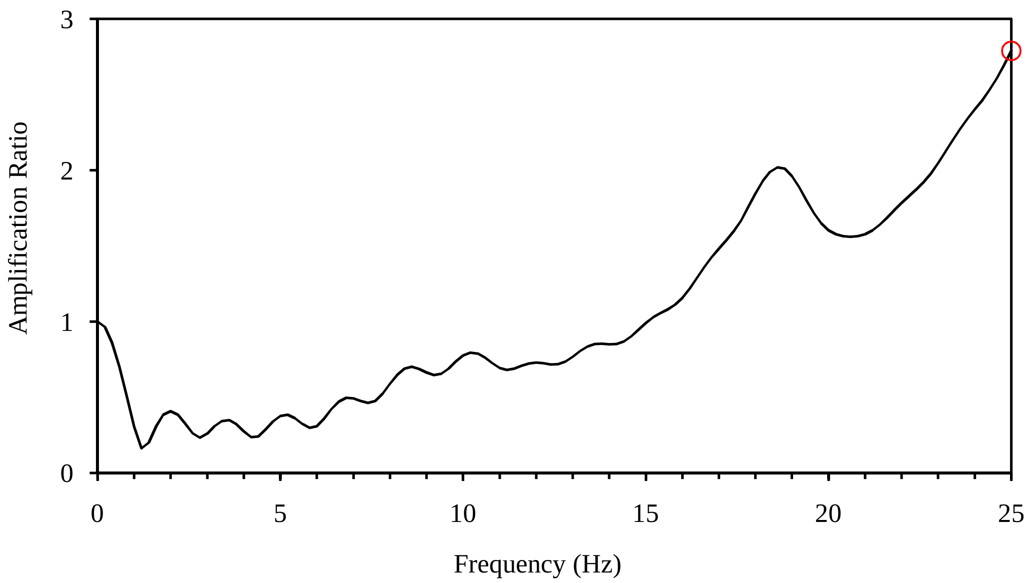

Figure 3.19 EERA amplification ratio-frequency relationship

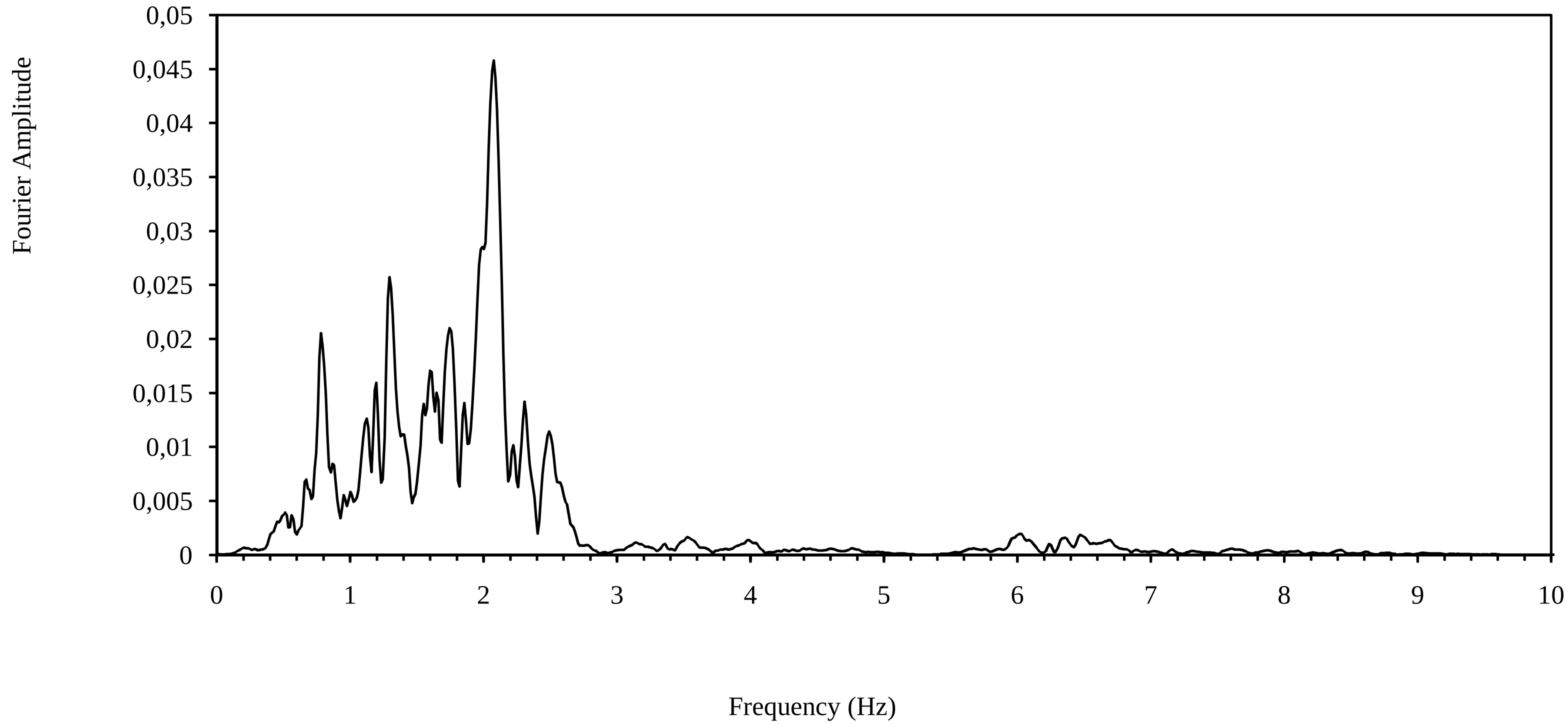

Figure 3.20 EERA Fourier amplitude-frequency relationship

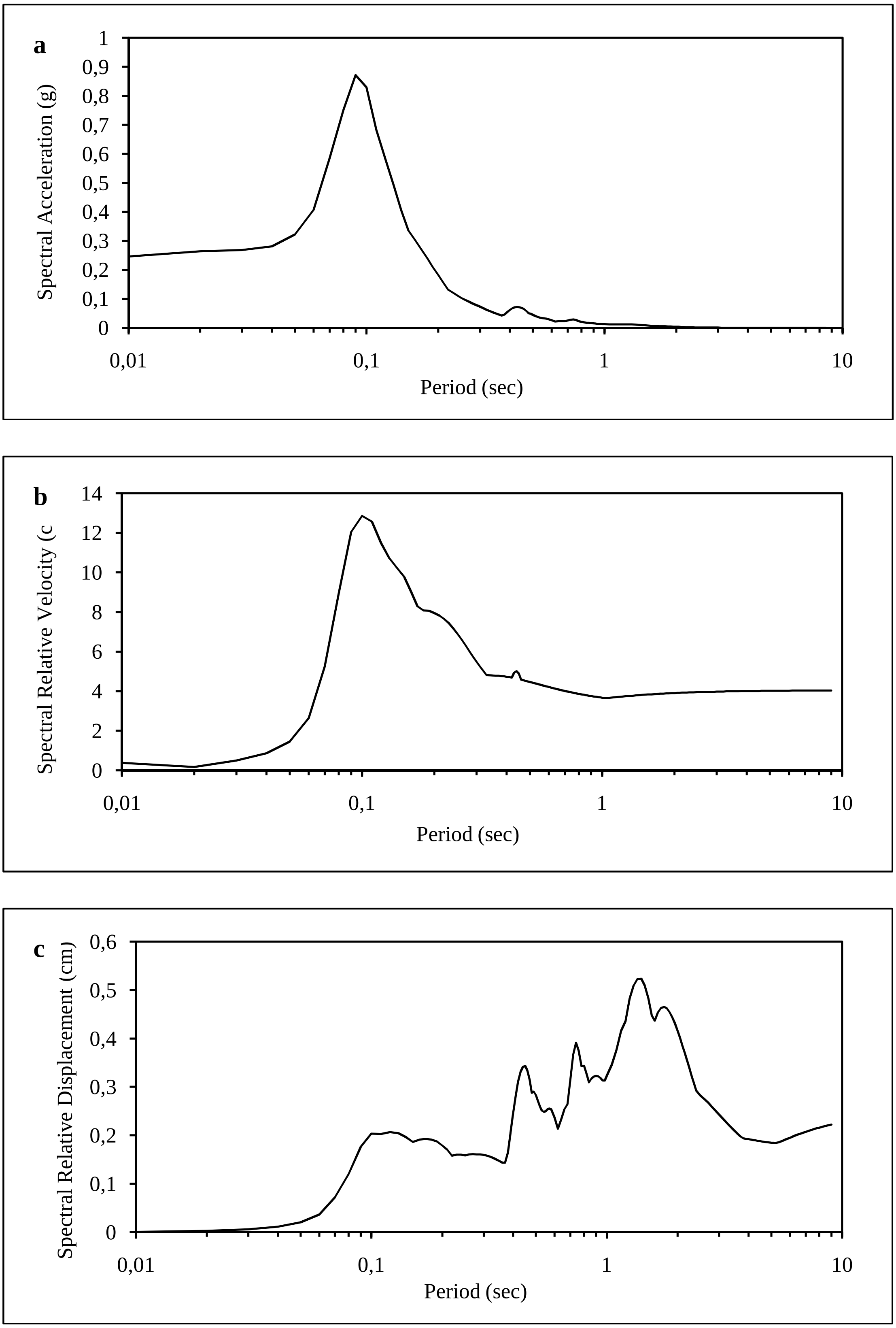

Figure 3.21 EERA (a) Spectral acceleration versus period, (b) Spectral relative velocity versus period, (c) Spectral relative displacement versus period graphs.

3.4 Studies of Site Response Analyses

Bedrock depth of the study area is quite significant parameter for site response analysis. Drillings had been continued until they reach bedrock in the exploration at Balçova. The depth of the bedrock had been found as 113 m. And this value of depth has been considered in the calculations at Balçova region. In the other regions, the depth of bedrock, to be determined by drilling depth has been accepted as the bedrock depth.

Primarily data base has been created according to information obtained from drillings. Using this database, the dynamic parameters of the soil have been calculated and the site responses of the soils have been analyzed.

3.5 Results of Site Response Analyses

Site response analyses findings have been presented below;

a. Gümrük-Üçkuyular Coastal Road and İkiztepe-Konak-Halkapınar Road

For 1977 İzmir earthquake, (M=5.3) with an epicentral distance of 5 km., the ground surface acceleration ($a_{max,s}$) value is between0.09-0,22 (g), and the amplification value is between 0.49- 1.23.

For 2003Urla earthquake, (M=5.6) with an epicentral distance of 37 km., the ground surface acceleration ($a_{max,s}$) value is between 0.03-0,13 (g), and the amplification value is between 1.02- 4.06.

For 2005 Urla earthquake, (M=5.9) with an epicentral distance of 43 km., the ground surface acceleration ($a_{max,s}$) value is between 0.06-0,13 (g), and the amplification value is between 1.57- 3.49.

For 1977 İzmir scenario earthquake, (M=6.5) with an epicentral distance of 5 km., the ground surface acceleration ($a_{max,s}$) value is between 0.16-0,45 (g), and the amplification value is between 0.45-1.24.

For earthquake 2003 Urla scenario earthquake, (M=6.5) with an epicentral distance of 37 km., the ground surface acceleration ($a_{max,s}$) value is between 0.07-0,20 (g), and the amplification value is between 1.03- 2.99.

For 2005 Urla scenario earthquake, (M=6.5) with an epicentral distance of 43 km., the ground surface acceleration ($a_{max,s}$) value is between 0.07-0,15 (g), and the amplification value is between 1.13-2.61.

b. Balçova Borings

For 1977 İzmir earthquake, (M=5.3) with an epicentral distance of 10 km., the ground acceleration values is between 0.30-0.35(g), and the amplification value is between 1.68-1.94.

For 2003 Urla earthquake, (M=5.6) with an epicentral distance of 28.5 km., the ground surface acceleration ($a_{max,s}$) value between 0.13-0,15 (g), and the amplification value is between 4.14-4.94.

For 2005 Urla earthquake, (M=5.9) with an epicentral distance of 39.5 km., the ground surface acceleration ($a_{max,s}$) value is between 0.11-0,12 (g), and the maximum amplification value is between 2.81-3.29.

For 1977 İzmir scenario earthquake, (M=6.5 with an epicentral distance of 10 km., the ground surface acceleration ($a_{max,s}$) value is between 0.49-0,65 (g), and the amplification value is between 1.35-1.82.

For 2003 Urla scenario earthquake, (M=6.5) with an epicentral distance of 28.5 km., the ground surface acceleration ($a_{max,s}$) value is between 0,26-0.34 (g), and the amplification value is between 4.00-5.17.

For 2005 Urla scenario earthquake, (M=6.5) with an epicentral distance of 39.5 km., the ground surface acceleration ($a_{max,s}$) value is between 0.16-0,19 (g), and the amplification value is between 2.77-3.29.

It can be said that dynamic site response analysis results for Balçova boring locations give more realistic results than the other boring locations. Because, deep borings were done in Balçova and bedrock was determined in the area. However, in other boring locations, boring depth has been accepted as the depth of bedrock and the earthquake motion has been accepted at the boring depth.

Soil profiles, values of maximum ground surface acceleration ($a_{max,s}$), maximum bedrock acceleration ($a_{max,r}$), ratio of $a_{max,s}$ and $a_{max,r}$, maximum ground surface spectral acceleration ($S_{max,s,}$), maximum bedrock spectral acceleration ($S_{max,r,}$), ratio of $S_{max,s}$ and $S_{max,r}$, dominant period of soil (T(s)) and natural period of earthquake motion (T_0(s)) of the study area are given in Appendix C. However, computed spectral acceleration graphics and Elastic design spectrum for Z4 type of soil (Seismic Code of Turkey, 1998) have been presented in Appendix D, comparatively.

CHAPTER FOUR
LIQUEFACTION

4.1 Liquefaction Analyses

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, 1996). Shortly, one can say that, liquefaction is an effective stress reduction of soils under any cyclic loads due to increasing pore water pressure suddenly. This also leads to a decrease in shear strength. The first question that comes to mind might be “which soils are liquefiable?”. Previous researches have showed that liquefaction can take place in clean sands. However, recent studies show that liquefaction potential has been demonstrated in clayey and silty soil. This section contains liquefaction analysis according to Youd and Idriss, 2001. Also, recent liquefaction analysis method that was prepared by Earthquake Engineering Research Center (Seed, R.B. et al., 2003) has been used in calculations and results have been compared.

According to Youd and Idriss (2001), to illustrate the influence of magnitude scaling factors on calculated hazard, the equation for factor of safety (FS) against liquefaction is written in terms of CRR, CSR, and MSF as follows.

Seed and Idriss formulated the following equation for calculation of the cyclic stress ratio (Youd and Idriss, 2001) .

$$\mathrm{CSR} = 0.65 \times \left(\frac{a_{max}}{g}\right) \times \frac{\sigma_{vo}}{\sigma_{vo}'} \times r_d \qquad \textbf{(4.1)}$$

$$r_d = \frac{1-0.4113z^{0.5}+0.04052z+0.001753z^{1.5}}{1-0.4177z^{0.5}+0.05729z-0.006205z^{1.5}-0.00121z^{2}} \qquad \textbf{(4.2)}$$

In the original development, Seed et al. noted an apparent increase of CRR with increased fines content. Whether this increase is caused by an increase of liquefaction resistance or a decrease of penetration resistance is not clear. Based on the empirical data available, Seed et al. developed CRR curves for various fines contents reproduced in Fig. 4.1(Youd and Idriss, 2001) .

The following equations were developed by I. M. Idriss with the assistance of R. B. Seed for correction of $(N_1)_{60}$ to an equivalent clean sand value, $(N_1)_{60c}$ (Youd and Idriss, 2001) .

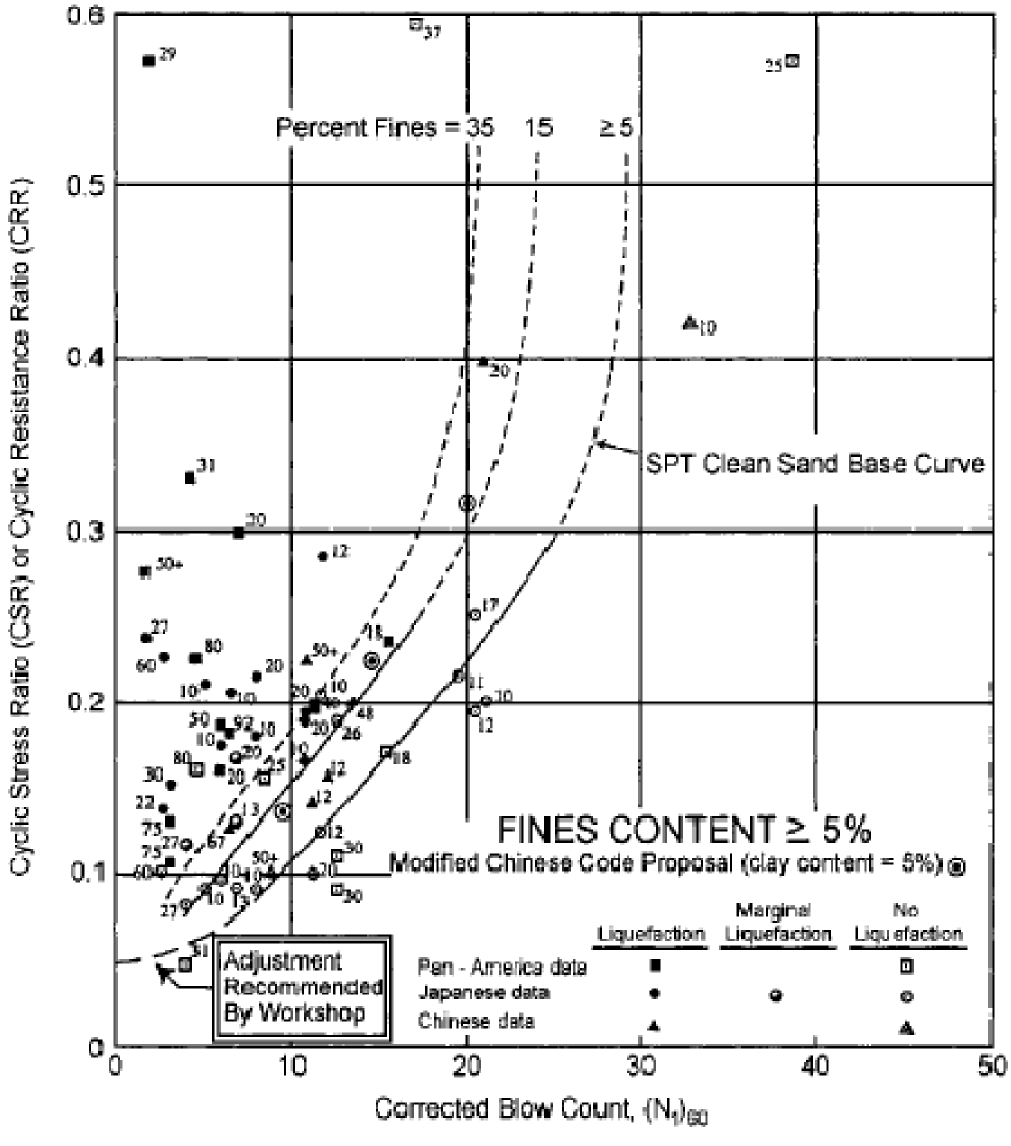

Figure 4.1 SPT Clean-Sand Base Curve for Magnitude 7.5 Earthquakes with Data from Liquefaction Case Histories

$$N_{1,60cs} = \alpha + \beta \times N_{1,60} \quad \textbf{(4.3)}$$

$$\alpha = 5 \quad FC > \%32 \quad \alpha = e^{(1.76 - \frac{190}{FC^2}} \quad \%5 < FC < \%35 \quad \textbf{(4.4)}$$

$$\beta = 1.2 \;\; FC > \%32 \quad \beta = (0.99 + \left(\frac{FC^{1.5}}{1000}\right)) \;\; \%5 < FC < \%35 \quad \textbf{(4.5)}$$

At the University of Texas, A. F. Rauch in 1998, Approximated the clean-sand base curve plotted in Fig. 4.1 by the following equation (Youd and Idriss, 2001) .

$$CRR_{7.5} = \frac{1}{34 - N_{1,60cs}} + \frac{N_{1,60cs}}{135} + \frac{50}{(10 \times N_{1,60cs} + 45)^2} - \frac{1}{200} \quad \textbf{(4.6)}$$

Magnitude scaling factor values have determined with interpolation according to Idriss in Table 4.1 (Youd and Idriss, 2001) .

$$F = \frac{CRR_{7.5}}{CSR} \times MSF \quad \textbf{(4.7)}$$

Table 4.1 Magnitude scaling factor values defined by various investigators (Youd and Idriss, 2001)

Magnetude	Seed and Idriss	Idriss*	Ambraseys	Arango		Andrus and Stokoe	Youd and Noble		
				Distance based	Energy based		PL<20%	PL<32%	PL<50%
M	1982		1988	1996		1997	1997		
5.5	1.43	2.20	2.86	3.00	2.20	2.80	2.86	3.42	4.44
6.0	1.32	1.76	2.20	2.00	1.65	2.10	1.93	2.35	2.92
6.5	1.19	1.44	1.69	1.60	1.40	1.60	1.34	1.66	1.99
7.0	1.08	1.19	1.30	1.25	1.10	1.25	1.00	1.20	1.39
7.5	1.00	1.00	1.00	1.00	1.00	1.00	-	-	1.00
8.0	0.94	0.84	0.67	0.75	0.85	0.80?	-	-	0.73?
8.5	0.89	0.72	0.44	-	-	0.65	-	-	0.56?

Note: ? Very uncertain values

* 1995 Seed Memorial Lecture, University of California at Berkley I.M.Idriss, personal communication to T.L. Youd,1997)

The other liquefaction analysis method suggestion by Seed et al., 2003 is summarized below.

Liquefaction susceptibility of silty and clayey sands is given in Table 4.2. If fine-grained soil (silt and clay) particles control the soil behavior , in other words separate corse grains from each other the soil must be non-plastic or must have low plasticity (PI ≤ 10-12%) for liquefaction (Çetin and Unutmaz, 2004).

Soils with sufficient fines that the fines control their behavior, and falling within Zone A in Fig. 4.2, are considered potentially susceptible to “classic” cyclically-induced soil liquefaction. Soils within Zone B fall into a transition range; they may in some cases be susceptible to liquefaction (especially if their in situ water content is greater than about 85% of their Liquid Limit), but tend to be more ductile and may not “liquefy” in the classic sense of losing a large fraction of their strength and stiffness at relatively low cyclic shear strains. These soils are also, in many cases, not well suited to evaluation based on conventional in-situ “penetration-based” liquefaction hazard assessment methods. These types of soils usually are amenable to reasonably “undisturbed” (e.g.: thin walled, or better) sampling, however, and so can be tested in the laboratory. It should be remembered to check for “sensitivity” of these cohesive soils as well as for potential cyclic liquefiability. Soils in Zone C are generally not susceptible to “classic” cyclically-induced soil liquefaction, but they may be “sensitive” and vulnerable to strength loss with remolding or large shear displacements (Seed et al., 2003).

Table 4.2 Liquefaction susceptibility of silty and clayey sands (Seed et al.,2003)

	Liquid Limit1 < 32	Liquid Limit ≥32
Clay Content[2] < 10%	Susceptible	Further Studies Required (Considering plastic non-clay sized grains – such as Mica)
Clay Content[2] ≥10%	Further Studies Required (Considering nonplastic clay sized grains – such as mine and quarry tailings)	Not Susceptible

Notes:

(1) Liquid limit determined by Casagrande-type percussion apparatus.

(2) Clay defined as grains finer than 0.002 mm.

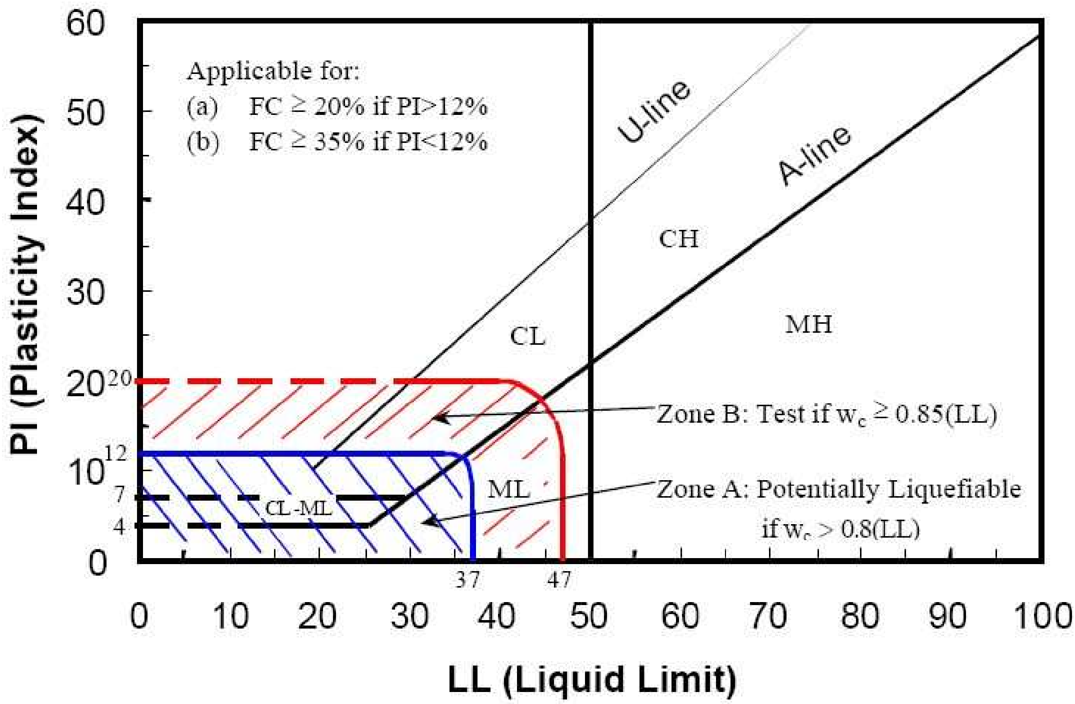

Figure 4.2 Recommendations Regarding Assessment of “Liquefiable” Soil Types

In the recent method (Seed et al., 2003), Formula 4.1 is used for computation of CSR but, r_d formula is different (Formula 4.8 and 4.9). r_d value is defined depending on the d, M_w, a_{max} and $V^*_{s,12m}$

$$r_d\left(d, M_w, a_{max}, V^*_{s,12m}\right) = \frac{\left[1 + \frac{-23.013 - 2.949a_{max} + 0.999M_w + 0.0525V^*_{s,12m}}{16.258 + 0.201e^{0.341(-d+0.0785V^*_{s,12m}+7.586)}}\right]}{\left[1 + \frac{-23.013 - 2.949a_{max} + 0.999M_w + 0.0525V^*_{s,12m}}{16.258 + 0.201e^{0.341(0.0785V^*_{s,12m}+7.586)}}\right]}$$

d≤20m **(4.8)**

$$r_d\left(d, M_w, a_{max}, V^*_{s,12m}\right) = \frac{\left[1 + \frac{-23.013 - 2.949a_{max} + 0.999M_w + 0.0525V^*_{s,12m}}{16.258 + 0.201e^{0.341(-20+0.0785V^*_{s,12m}+7.586)}}\right]}{\left[1 + \frac{-23.013 - 2.949a_{max} + 0.999M_w + 0.0525V^*_{s,12m}}{16.258 + 0.201e^{0.341(0.0785V^*_{s,12m}+7.586)}}\right]} - 0.0046(d - 20)$$

d>20m **(4.9)**

In these equations d: depth, M_w: Moment of earthquake magnitude, $V^{*}_{s,\ 12m}$ average shear wave velocity for the first 12 m.

4.2 Liquefaction Results

Liquefaction analyses have been done and results have been presented comparatively in Appendix E. The results have shown that although there is no liquefaction according to Seed and Idriss (2001), liquefaction is possible according to recent method for the same profile (Seed et al., 2003). An example has been given in Tab 4.3.

It can be said that there is a certain liquefaction risk for some boring locations in the study area. Minimum safety factor values for all earthquakes have been presented in Appendix F according to boring locations.

Table 4.3 An Example Of Analysis Different Result for two Different Liquefaction Calculation method

ID	**Boring Name**	**Depth**	**USCS**	İZMİR 1977 Scenario M=6.5	
				F	
-	**-**	**m**	**-**	**SEED AND IDRİSS, 2001**	**Seed et al., 2003**
8	3	1.25	SP	No Liquefaction	No Liquefaction
	3	5.75	SW	**No Liquefaction**	**0.66**
	3	6.25	SP	0.66	0.45
9	4	2.70	SP	0.49	Absent Data
11	SK-5	9.25	CH	No Liquefaction	Absent Data
	SK-5	10.75	CH	No Liquefaction	Absent Data
	SK-5	12.25	CL	No Liquefaction	No Liquefaction
	SK-5	13.75	ML	No Liquefaction	No Liquefaction

CHAPTER FIVE
CONCLUSION

The aim of this study is to investigate the geotechnical earthquake engineering behavior of soils of southern coast of Izmir Bay.

For this study, geotechnical reports were collected from Dokuz Eylül University Department of Civil Engineering and private soil investigation firms. A geotechnical database has been developed by using geotechnical data in these reports.

In the scope of the study, firstly Alsancak, Konak, Karataş, and Halil Rıfat Paşa, Balçova coastal regions have been evaluated. This study has been achieved by using 24 boring data. One dimensional dynamic site response analysis and liquefaction analyses have been performed using these data and soil properties.

In the site response analyses, the 1977 Izmir Earthquake (M=5.3), 2003 Urla Earthquake (M=5.6),the 2005 Urla Earthquake (M=5.9) and scenario earthquake of all of them have been analyzed as the reference.

Bedrock acceleration has been determined by Campbell attenuation relationship (Campbell, 1997). One dimensional dynamic soil behavior analyses have been done by using the EERA computer program which is based on equivalent linear method. It has been seen that, while the bedrock depth is increasing, peak ground acceleration value decreases. The peak ground acceleration and the amplification values for the earthquakes obtained are summarized below.

a. Gümrük-Üçkuyular Coast Road and İkiztepe-Konak-Halkapınar Road Boring Locations

For the 1977 Izmir Earthquake, (M=5.3) with an epicentral distance of 5 km., the ground surface acceleration ($a_{max,s}$) value is between0.09-0,22 (g), and the amplification value is between 0.49- 1.23.

For the 2003 Urla Earthquake, (M=5.6) with an epicentral distance of 37 km., the ground surface acceleration ($a_{max,s}$) value is between 0.03-0,13 (g), and the amplification value is between 1.02- 4.06.

For the 2005 Urla Earthquake, (M=5.9) with an epicentral distance of 43 km., the ground surface acceleration ($a_{max,s}$) value is between 0.060,13 (g), and the amplification value is between 1.57- 3.49.

For the 1977 Izmir Scenario Earthquake, (M=6.5) with an epicentral distance of 5 km., the ground surface acceleration ($a_{max,s}$) value is between 0.16-0,45 (g), and the amplification value is between 0.45-1.24.

For the 2003 Urla Scenario Earthquake, (M=6.5) with an epicentral distance of 37 km., the ground surface acceleration ($a_{max,s}$) value is between 0.07-0,20 (g), and the amplification value is between 1.03- 2.99.

For the 2005 Urla Scenario Earthquake, (M=6.5) with an epicentral distance of 43 km., the ground surface acceleration ($a_{max,s}$) value is between 0.07-0,15 (g), and the amplification value is between 1.13-2.61.

b. Balçova Boring Locations

For the 1977 Izmir Earthquake, (M=5.3) with an epicentral distance of 10 km., the ground acceleration values is between 0.30-0.35(g), and the amplification value is between 1.68-1.94.

For the 2003 Urla Earthquake, (M=5.6) with an epicentral distance of 28.5 km., the ground surface acceleration ($a_{max,s}$) value between 0.13-0,15 (g), and the amplification value is between 4.14-4.94.

For the 2005 Urla Earthquake, (M=5.9) with an epicentral distance of 39.5 km., the ground surface acceleration ($a_{max,s}$) value is between 0.11-0,12 (g), and the maximum amplification value is between 2.81-3.29.

For the 1977 Izmir Scenario Earthquake, (M=6.5 with an epicentral distance of 10 km., the ground surface acceleration ($a_{max,s}$) value is between 0.49-0,65 (g), and the amplification value is between 1.35-1.82.

For the 2003 Urla Scenario Earthquake, (M=6.5) with an epicentral distance of 28.5 km., the ground surface acceleration ($a_{max,s}$) value is between 0,26-0.34 (g), and the amplification value is between 4.00-5.17.

For the 2005 Urla Scenario Earthquake, (M=6.5) with an epicentral distance of 39.5 km., the ground surface acceleration ($a_{max,s}$) value is between 0.16-0,19 (g), and the amplification value is between 2.77-3.29.

Findings of site response analyses have been presented in Table 4.1.

According to the Seismic Code of Turkey, effective ground acceleration coefficient, Ao, which are to be used for the determination of spectral acceleration coefficient, A (T), is taken as 0.4 (for the Z4-class grounds). This value is exceeded for the scenario earthquakes in the study region. Therefore, for the calculation of the earthquake forces affecting structures, the data obtained from dynamic soil analysis should be used. Seismic Code of Turkey may be insufficient in that repect.

In spite of big amplification values for some earthquakes, values of PGA are considerably small.

Table 4. 1 Site response analyses results

	Gümrük-Üçkuyular Coast Road and İkiztepe-Konak-Halkapınar Road Borings		Balçova Borings	
	PGA ($a_{max,s}$)	Amplification	PGA ($a_{max,s}$)	Amplification
1977 İzmir Earthquake	0.09-0.22 (g)	0.49- 1.23	0.30-0.35(g)	1.68-1.94
2003 Urla Earthquake	0.03-0.13 (g)	1.02- 4.06	0.13-0.15 (g)	4.14-4.94
2005 Urla Earthquake	0.06-0.13 (g)	1.57- 3.49	0.11-0.12 (g)	2.81-3.29
1977 İzmir Earthquake Scenario	0.16-0.45 (g)	0.45-1.24	0.49-0.65 (g)	1.35-1.82
2003 Urla Earthquake Scenario	0.07-0.20 (g)	1.03- 2.99	0.26-0.34 (g)	4.00-5.17
2005 Urla Earthquake Scenario	0.07-0.15 (g)	1.13-2.61	0.16-0.19 (g)	2.77-3.29

Another finding is about the liquefaction potential of the study area. The liquefaction analyses based on the SPT-N_{60} values are made for each boring locations separately. The liquefaction analyses are made using two different methods within upper 15 meter depth. The analyses are done by three different real earthquakes and three scenario earthquakes. In the liquefaction analyses, the “PGA” values obtained from the site response analyses have been used. The study has shown that the study area has certain liquefaction risks for the scenario earthquakes. Liquefaction safety factor values have been determined to be in between 0.1 and 11.

Future studies and recommendations:

Even if Urla 2003 and 2005 scenario earthquake data have been generated with assumed M=6.5 value, Tuzla Fault and Karaburun Fault probably generate earthquakes with different magnitudes. Actually, design earthquake magnitudes of these faults should be obtained by detailed investigation and analyses.

In addition, bigger earthquake magnitudes compared to M=6.5 of RADIUS may be expected considering major historical earthquakes of İzmir.

In liquefaction analyses PGA values from site response analysis have been used and r_d reductions have been applied. Instead, shear stress values obtained from the site response analysis may be directly used in liquefaction analyses.

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APPENDIX A

GEOTECHNICAL DATABASE

Table A.1 Geotechnical data for Gümrük – Üçkuyular Coast Road ID1 and ID2

Sampler ID					SOIL PROPERTIES												STRENGTH PARAMETERS			CONSOLIDATION PARAMETERS	
ID	**Boring Name**	**Location**	**Depth**	**Sampler Type**	N_{60}	**G.W.T**	γ_n	γ_s	w_n	I_L	P_L	I_P	**-No.4**	**-No.200**	**U.S.C.S.**	ϕ'	q_u	C_u	C_c	e_0
-	-	-	-	-	-	**m**	**kN/m³**	**kN/m³**	**%**	**%**	**%**	**%**	-	-	-	**°**	**kN/m²**	**kN/m²**	-	-
		GÜMRÜK-ÜÇKUYULAR COAST ROAD	8.00-8.45		41		-	-	-	-	-	-	100	1,2	SP	-	-	20	1,3	-
			10.50-10.95		>50		-	-	-	-	-	-	100	1,2	SP	-	-	20	1,3	-
			12.00-12.45		4		-	-	-	-	-	-			SP	-	-	-	-	-
			16.00-16.45		>50		-	-	-	-	-	-	100	0,42	SP	-	-	20	1,3	-
			17.50-17.95		>50		-	-	-	-	-	-	-	-	SP	-	-	20	1,3	-
1	1		18.50-18.95		>50	Unknown	-	-	-	-	-	-	-	-	SP	-	-	20	1,3	-
			20.00-20.45		44		-	-	-	-	-	-	-	-	SP	-	-	20	1,3	-
			22.00-22.45	SPT	16		-	-	-	-	-	-	-	-	SP	-	-	-	-	-
			24.00-24.45		15		-	-	-	-	-	-	-	-	SP	-	-	-	-	-
			25.50-25.95		15		-	-	-	-	-	-	-	-	SP	-	-	-	-	-
			26.50-26.95		19			25,80	-	-	-	-	100	4,3	SP	-	-	50	2,2	-
2	1A		6,70		-	3,00	-	2,62	-	-	-	-	91,80	40,40	SM	-	-	-	-	-
			20,80-20,25		-	3,00	-	2,62	-	-	-	-	98,10	52,00	SC	-	-	-	-	-

Table A.2 Geotechnical data for Gümrük – Üçkuyular Coast Road ID3 and ID4

Sampler ID					SOIL PROPERTIES												STRENGTH PARAMETERS			CONSOLIDATION PARAMETERS	
ID	Boring Name	Location	Depth	Sampler Type	N_{60}	G.W.T	γ_n	γ_s	w_n	I_L	P_L	I_P	-No.4	-No.200	U.S.C.S.	ϕ'	q_u	C_u	C_c	e_0
-	-	-	-	-	-	m	kN/m^3	kN/m^3	%	%	%	%	-	-	-	°	kN/m^2	kN/m^2	-	-
3	1B	GÜMRÜK-ÜÇKUYULAR COAST ROAD	15,00-15,95	SPT	-	3,50	-	27,30	-	33	24	9,00	71	-	-	-		-	-	-
			19,10-19,55		-	3,50	-	27,30	-	33	24	9,00	67	-	-	-	-	-	-	-
			21,80-22,25		-	3,50	-	27,30	-	33	24	9,00	65	-	-	-	-	-	-	-
4	2		7,50-7,95		25	Unknown	-	-	-	-	-	-	100	0,45	SP	-	-	2,7	1	-
			9,00-9,45		23		-	-	-	-	-	-	100	0,45	SP	-	-	2,7	1	-
			10,50-10,95		25		-	-	-	-	-	-	100	0,45	SP	-	-	2,7	1	-
			12,00-12,45		18		-	-	-	-	-	-	77	5	SP	-	-	15	0,71	-
			13,50-13,95		22		-	-	-	-	-	-	77	5	SP	-	-	15	0,71	-
			15,00-15,45		20		-	26,30	-	40	22	18,00	96	45	SC	-	-	-	-	-
			16,50-16,95		16		-	-	-	46	25	21,00	65	1,2	SW	-	-	20	1,25	-
			18,00-18,45		21		-	-	-	46	25	21,00	65	1,2	SW	-	-	20	1,25	-
			19,50-19,95		8		-	-	-	46	25	21,00	65	1,2	SW	-	-	20	1,25	-
			21,00-21,45		19		-	-	-	-	-	-	96	6	SW	-	-	3,9	3,1	-
			24,00-24,45		23		-	-	-	-	-	-	96	6	SW	-	-	3,9	3,1	-
			25,50-25,95		24		-	-	-	-	-	-	86	6	SP	-	-	4,2	1,7	-

Table A.3 Geotechnical data for Gümrük – Üçkuyular Coast Road ID5 and ID6

Sampler ID					SOIL PROPERTIES											STRENGTH PARAMETERS			CONSOLIDATION PARAMETERS	
ID	**Boring Name**	**Location**	**Depth**	**Sampler Type**	**N_{60}**	**G.W.T**	**γ_n**	**γ_s**	**w_n**	**I_L**	**P_L**	**I_P**	**-No.4**	**-No.200**	**U.S.C.S.**	**ϕ'**	**q_u**	**C_u**	**C_c**	**e_0**
-	-	-	-	-	-	**m**	**kN/m^3**	**kN/m^3**	**%**	**%**	**%**	**%**	-	-	-	**°**	**kN/m^2**	**kN/m^2**	-	-
5	2A	GÜMRÜK-ÜÇKUYULAR COAST ROAD	11,00	SPT	-	5,00	-	26,20	-	-	-	-	92,6	38	NP	-	-	-	-	-
			13,80-14,25		10	5,00	-	27,50	-	49	22	27,00	96,7	61,2	CL	-	-	-	-	-
			16,80-18,25		>50	5,00	-	26,50	-	49	22	27,00	96,7	61,2	CL	-	-	-	-	-
			25,00		-	5,00	-	-	-	-	-	-	24	1	GW	-	-	-	-	-
			25,50-25,75		-	5,00	-	26,70	-	27	24	3,00	76	40	SM	-	-	-	-	-
			31,40-31,85		-	5,00	-	25,90	-	47	30	17,00	99,1	92,8	CL	-	-	-		-
			35,40-35,85		-	5,00	-	25,80	-	-	-	-	-	-	CL	-	-	-	-	-
6	2B		14,00		-	7,00	-	-	-	-	-	-	23	6	GW	-	-	-	-	-
			28,00-28,40		>50	7,00	-	26,30	-	-	-	-	-	-	CL	-	-	-	-	-
			36,50-36,80		>50	7,00	-	26,30	-	47	29	18,00	99,2	80	CL	-	-	-	-	-

Table A.4 Geotechnical data for Gümrük – Üçkuyular Coast Road ID7 and ID8

Sampler ID					SOIL PROPERTIES											STRENGTH PARAMETERS			CONSOLIDATION PARAMETERS	
ID	Boring Name	Location	Depth	Sampler Type	N_{60}	G.W.T	γ_n	γ_s	w_n	I_L	P_L	I_P	-No.4	-No.200	U.S.C.S.	ϕ'	q_u	C_u	C_c	e_0
-	-	-	-	-	-	m	kN/m^3	kN/m^3	%	%	%	%	-	-	-	°	kN/m^2	kN/m^2	-	-
7	3	GÜMRÜK-ÜÇKUYULAR COAST ROAD	10,00	SPT	-	5,00	-	26,50	-	58	41	17,00	84	40	SM	-	-	-	-	-
			13,00		-	5,00	-	27,10	-	-	-	-	96	62	SC	-	-	-	-	-
			13,60-14,05		15	5,00	-	27,10	-	-	-	-	96	62	SC	-	-	-	-	-
			14,50-14,85		>50	5,00	-	25,90	-	-	-	-	96	62	SC	-	-	-	-	-
			16,00-16,45		>50	5,00	-	-	-	46	30	16,00	96,4	64	OL	-	-	-	-	-
			20,20		-	5,00	-	-	-	-	-	-	58	6	SW	-	-	125	14,5	-
			25,00		-	5,00	-	-	-	-	-	-	58	6	SW	-	-	125	14,5	-
			26,20-26,55		>50	5,00	-	-	-	52	24	28,00	97	77	CH	-	-	-	-	-
			35,50-35,95		25	5,00	-	26,00	-	46	30	16,00	97,1	63	CL	-	-	-	-	-
8			2,00-6,00		-	Unknown	-	-	-	-	-	-	88	2	SP	-	-	-	-	-
			6,00-6,45		31		-	-	-	-	-	-	92,4	1,1	SW	-	-	-	-	-
			10,50-10,95		26		-	-	-	-	-	-	100	1,3	SP	-	-	-	-	-
			11,00-12,45		29		-	-	-	-	-	-	100	2	SP	-	-	-	-	-
			13,00-13,45		-		-	-	-	-	-	-	55	3,7	SW	-	-	-	-	-
			15,15-15,60		29		-	-	-	-	-	-	-	-	SM	-	-	-	-	-
			16,50-16,95		27		-	-	-	-	-	-	-	-	-	-	-	-	-	-
			17,50-17,95		23		-	26,70		28	19	9,00	-	-	CL	-	-	-	-	-
			19,00-19,45		21		-	-		32	18	14,00	-	-	CL	-	-	-	-	-
			23,50-23,95		23		-	-	-	-	-	-	-	-	-	-	-	-	-	-
			26,50-26,95		23		-	-	-	-	-	-	98	2,5	SW	-	-	-	-	-

Table A.5 Geotechnical data for Gümrük – Üçkuyular Coast Road ID9 and ID10

Sampler ID					SOIL PROPERTIES											STRENGTH PARAMETERS			CONSOLIDATION PARAMETERS	
ID	Boring Name	Location	Depth	Sampler Type	N_{60}	G.W.T	γ_n	γ_s	w_n	I_L	P_L	I_P	-No.4	-No.200	U.S.C.S.	ϕ'	q_u	C_u	C_c	e_0
-	-	-	-	-	-	m	kN/m^3	kN/m^3	%	%	%	%	-	-	-	°	kN/m^2	kN/m^2	-	-
9	4	GÜMRÜK-ÜÇKUYULAR COAST ROAD	6,00-6,45	SPT	17	Unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			7,50-7,85		18	Unknown	-	-	-	-	-	-	97,9	74	SP	-	-	38	2,3	-
			9,00-9,45		7	Unknown	-	-	-	-	-	-	-	-	NP	-	-	-	-	-
			10,50-10,95		19	Unknown	-	-	-	-	-	-	-	-	NP	-	-	-	-	-
			12,00-12,45		9	Unknown	-	-	-	-	-	-	-	-	NP	-	-	-	-	-
			13,50-13,95		18	Unknown	-	-	-	-	-	-	-	-	NP	-	-	-	-	-
			15,00-15,45		15	Unknown	-	-	-	-	-	-	-	-	NP	-	-	-	-	-
			16,50-16,95		14	Unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			19,50-19,95		21	Unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			21,00-21,45		23	Unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	5		8,00-11,50		-	8,00	-	26,10	-	46	28	18,00	98	86	-	-	-	-	-	-
			13,10-13,45		43	8,00	-	25,60	-	50	30	20,00	78	54	-	-	-	-	-	-
			14,40-14,45		>50	8,00	-	26,60	-	-	-	-	93	67	-	-	-	-	-	-
			18,00-18,35		>50	8,00	-	26,70	-	40	23	17,00	96	69	-	-	-	-	-	-
			19,00-19,37		>50	8,00	-	23,20	-	-	-	-	100	41	-	-	-	-	-	-
			22,00		-	8,00	-	-	-	-	-	-	43	7	-	-	-	-	-	-
			24,30-24,55		>50	8,00	-	25,20	-	46	26	20,00	98	73	-	-	-	-	-	-
			25,50-25,95		>50	8,00	-	26,20	-	55	31	24,00	99	77	-	-	-	-	-	-
			32,50-32,57		-	8,00	-	-	-	-	-	-	69	19	-	-	-	-	-	-

Table A.6 Geotechnical data for İkiztepe-Konak Halkapinar ID11

Sampler ID					SOIL PROPERTIES											STRENGTH PARAMETERS			CONSOLIDATION PARAMETERS	
ID	Boring Name	Location	Depth	Sampler Type	N_{60}	G.W.T	γ_n	γ_s	w_n	I_L	P_L	I_p	-No.4	-No.200	U.S.C.S.	ϕ'	q_u	C_u	C_c	e_0
-	-	-	-	-	-	m	kN/m^3	kN/m^3	%	%	%	%	-	-	-	°	kN/m^2	kN/m^2	-	-
11	SK-5	İKİZTEPE-KONAK HALKAPINAR	5,50-5,79	SPT	-	4,50	-	-	21,6	-	-	-	-	-	CH	-	-	-	-	-
			7,50-7,90		0	4,50	19,40	-	23,50	0,00	0,00	0,00	14,80	13,00	SC	-	-	-	-	-
			9,00-9,45		3	4,50	16,30	-	58,00	58,00	19,00	39,00	-	-	CH	-	-	-	-	-
			10,50-10,95		8	4,50	16,40	-	56,20	53,00	24,00	29,00	89,20	82,80	CH	-	-	-	-	-
			12,00-12,45		7	4,50	15,70	-	66,70	39,00	22,00	17,00	79,40	71,50	CL	-	-	-	-	-
			13,50-13,95		8	4,50	0,00	-	-	75,00	38,20	36,80	97,50	97,50	MH(OH)	-	-	-	-	-
			16,50-16,80		50	4,50	23,60	-	8,00	0,00	0,00	0,00	65,30	19,50	GC	-	-	-	-	-
			18,00-18,35		69	4,50	22,30	-	13,00	0,00	0,00	0,00	78,90	18,40	GC	-	-	-	-	-
			19,50-19,83		48	4,50	23,00	-	10,00	0,00	0,00	0,00	68,10	11,90	GC	-	-	-	-	-
			25,50-25,95		22	4,50	19,90	-	24,90	45,10	17,10	28,00	98,00	98,00	CL	-	-	-	-	-
			36,00-36,45		30	4,50	19,50	-	27,80	49,40	17,20	32,20	93,00	93,00	CL-CH	-	-	-	-	-
			39,00-39,45		28	4,50	19,30	-	29,40	54,60	16,90	37,70	83,00	83,00	CH	-	-	-	-	-
			42,00-42,35		-	4,50	22,00	-	14,10	0,00	0,00	0,00	-	-	-	-	-	-	-	-
			43,50-43,95		47	4,50	19,20	-	29,70	48,40	15,70	32,70	94,00	94,00	CL	-	-	-	-	-
			46,50-46,95		44	4,50	21,80	-	15,00	24,50	12,80	11,70	97,00	97,00	CL	-	-	-	-	-
			49,50-49,95		45	4,50	20,20	-	23,10	38,40	18,70	19,70	94,00	94,00	CL	-	-	-	-	-

Table A.7 Geotechnical data for İkiztepe-Konak Halkapinar ID12 and ID13

Sampler ID					SOIL PROPERTIES											STRENGTH PARAMETERS			CONSOLIDATION PARAMETERS	
ID	**Boring Name**	**Location**	**Depth**	**Sampler Type**	N_{60}	**G.W.T**	γ_n	γ_s	w_n	I_L	P_L	I_P	**-No.4**	**-No.200**	**U.S.C.S.**	ϕ'	q_u	C_u	C_c	e_0
-	-	-	-	-	-	**m**	**kN/m^3**	**kN/m^3**	**%**	**%**	**%**	**%**	-	-	-	**º**	**kN/m^2**	**kN/m^2**	-	-
12	SK-2	İKİZTEPE-KONAK HALKAPINAR	7,50-7,95	SPT	-	2,50	19,00	-	31,50	-	-		28,30	28,30	PEAT	-	-	-	-	-
	SK-2		9,00-9,45		-	2,50	-	-	-	-	-		18,50	18,50	-	-	-	-	-	-
	SK-2		10,50-10,95		5	2,50	-	-	-	-	-		95,10	95,10	-	-	-	-	-	-
	SK-2		12,50-12,95		8	2,50	20,60	-	21,00	-	-		76,60	76,60	-	-	-	-	-	-
	SK-2		14,00-14,45		10	2,50	-	-	-	-	-		39,60	23,80	SM-SC	-	-	-	-	-
	SK-2		15,50-15,95		15	2,50	-	-	-	32,00	18,00	14,00	57,20	57,20	CL	-	-	-	-	-
	SK-2		25,00-25,45		13	2,50	-	-	-	-	-		87,40	86,60	-	-	-	-	-	-
	SK-2		33,00-33,45		32	2,50	-	-	-	30,00	17,00	13,00	74,70	25,30	CL	-	-	-	-	-
	SK-2		40,50-40,95		42	2,50	-	-	-	35,00	18,00	17,00	74,90	74,70	CL	-	-	-	-	-
	SK-2		43,50-43,95		28	2,50	21,30	-	17,50	34,40	16,40	18,00	63,80	42,00	SC-CL	-	-	-	-	-
13	SK-13		6,50-6,95		3	1,50	-	-	-	45,00	21,00	24,00	-	-	CL	-	-	-	-	-
	SK-13		10,00-10,45		8	1,50	-	-	-	44,00	21,00	23,00	-	-	CL	-	-	-	-	-
	SK-13		11,50-11,95		8	1,50	-	-	-	32,00	18,00	14,00	-	-	CL	-	-	-	-	-
	SK-13		13,00-13,45		7	1,50	-	-	-	53,00	23,00	30,00	-	-	CH	-	-	-	-	-
	SK-13		16,50-16,95		30	1,50	-	-	-	35,00	18,00	17,00	-	-	SC-CL	-	-	-	-	-
	SK-13		33,50-33,95		16	1,50	-	-	-	30,00	17,00	13,00	-	-	-	-	-	-	-	-
	SK-13		36,50-36,95		20	1,50	-	-	-	45,00	22,00	23,00	-	-	CL	-	-	-	-	-

Table A.8 Geotechnical data for İkiztepe-Konak Halkapinar ID14 and ID15

Sampler ID					SOIL PROPERTIES											STRENGTH PARAMETERS			CONSOLIDATION PARAMETERS	
ID	Boring Name	Location	Depth	Sampler Type	N_{60}	G.W.T	γ_n	γ_s	w_n	I_L	P_L	I_P	-No.4	-No.200	U.S.C.S.	ϕ'	q_u	C_u	C_c	e_0
-	-	-	-	-	-	m	kN/m³	kN/m³	%	%	%	%	-	-	-	°	kN/m²	kN/m²	-	-
14	SK-181	İKİZTEPE-KONAK HALKAPINAR	14,00-14,45	SPT	15	7,00	-	-	27,30	34,00	22,00	12,00	38,60	29,20	SC	-	-	-	-	-
			15,50-15,95		13	7,00	-	-	61,60	34,00	22,00	12,00	86,10	82,90	CL	-	-	-	-	-
			17,00-17,45		17	7,00	-	-	36,50	47,00	24,00	23,00	86,30	86,30	CL	-	-	-	-	-
			20,00-20,45		20	7,00	-	-	39,70	47,00	24,00	23,00	97,00	97,00	CL	-	-	-	-	-
			23,00-23,45		33	7,00	-	-	31,30	37,00	21,00	16,00	89,00	89,00	CL	-	-	-	-	-
			27,50-27,45		47	7,00	-	-	24,60	37,00	20,00	17,00	88,00	88,00	CL	-	-	-	-	-
			29,00-29,45		42	7,00	-	-	15,60	27,00	17,00	10,00	54,50	41,70	SC	-	-	-	-	-
			36,50-36,95		50	7,00	-	-	26,30	32,00	19,00	13,00	86,40	86,40	CL	-	-	-	-	-
			38,00-38,45		33	7,00	-	-	18,40	32,00	20,00	12,00	60,70	41,20	SC	-	-	-	-	-
			41,55-42,00		41	7,00	-	-	36,10	27,00	17,00	10,00	89,00	89,00	CL	-	-	-	-	-
15	L-1		3,50-3,95		9	0,70	-	-	23,60	0,00	0,00	0,00	49,30	6,30	GP-GM	-	-	-	-	-
			6,50-6,95		34	0,70	-	-	28,10	0,00	0,00	0,00	54,00	54,00	ML	-	-	-	-	-
			9,50-9,95		37	0,70	-	-	36,70	0,00	0,00	0,00	41,10	41,10	SM	-	-	-	-	-
			10,50-10,95		12	0,70	-	-	41,40	67,00	31,00	36,00	100,00	100,00	CH	-	-	-	-	-
			16,50-16,95		48	0,70	-	-	39,80	58,00	23,00	35,00	41,90	25,90	GC	-	-	-	-	-
			19,50-19,95		27	0,70	-	-	31,60	33,00	20,00	13,00	65,50	62,50	CL	-	-	-	-	-
			22,50-22,95		42	0,70	-	-	26,40	28,00	21,00	7,00	62,40	18,40	GM-GC	-	-	-	-	-
			25,50-25,95		31	0,70	-	-	28,30	35,00	18,00	17,00	69,30	36,30	GC	-	-	-	-	-
			30,00-30,45		49	0,70	-	-	34,40	43,00	19,00	24,00	59,30	37,30	SC	-	-	-	-	-
			36,00-36,45		19	0,70	-	-	25,90	37,00	19,00	18,00	61,50	44,50	SC	-	-	-	-	-
			39,00-39,45		42	0,70	-	-	24,60	41,00	18,00	23,00	31,90	72,90	CL	-	-	-	-	-

Table A.9 Geotechnical data for İkiztepe-Konak Halkapinar ID17

Sampler ID					SOIL PROPERTIES											STRENGTH PARAMETERS			CONSOLIDATION PARAMETERS	
ID	Boring Name	Location	Depth	Sampler Type	N_{60}	G.W.T	γ_n	γ_s	w_n	I_L	P_L	I_P	-No.4	-No.200	U.S.C.S.	ϕ'	q_u	C_u	C_c	e_0
-	-	-	-	-	-	m	kN/m³	kN/m³	%	%	%	%	-	-	-	°	kN/m²	kN/m²	-	-
17	L-7	İKİZTEPE-KONAK HALKAPINAR	3,50-3,95	SPT	7	0,40	-	-	11,80	0,00	0,00	0,00	42,10	5,10	SW-SM	-	-	-	-	-
			6,50-6,95		5	0,40	-	-	21,60	0,00	0,00	0,00	15,70	13,60	SM	-	-	-	-	-
			11,00-11,45		5	0,40	-	-	49,70	56,00	19,00	37,00	90,00	90,00	CH	-	-	-	-	-
			14,00-14,45		6	0,40	-	-	54,60	58,00	27,00	31,00	100,00	100,00	CH	-	-	-	-	-
			17,00-17,45		37	0,40	-	-	57,10	62,00	26,00	36,00	100,00	100,00	CH	-	-	-	-	-
			20,00-20,45		32	0,40	-	-	31,90	42,00	20,00	22,00	100,00	100,00	CL	-	-	-	-	-
			23,00-23,45		71	0,40	-	-	24,30	32,00	19,00	13,00	54,10	47,10	SC	-	-	-	-	-
			26,00-26,45		26	0,40	-	-	35,70	48,00	20,00	28,00	86,90	86,90	CL	-	-	-	-	-
			29,00-29,45		32	0,40	-	-	32,60	46,00	24,00	22,00	100,00	100,00	CL	-	-	-	-	-
			32,00-32,45		52	0,40	-	-	27,40	44,00	19,00	25,00	100,00	100,00	CL	-	-	-	-	-
			35,00-35,45		49	0,40	-	-	23,80	36,00	18,00	18,00	96,40	96,40	CL	-	-	-	-	-
			38,00-38,45		38	0,40	-	-	22,90	33,00	18,00	15,00	85,20	80,10	CL	-	-	-	-	-

Table A.10 Geotechnical data for İkiztepe-Konak Halkapinar ID18

Sampler ID					SOIL PROPERTIES											STRENGTH PARAMETERS			CONSOLIDATION PARAMETERS	
ID	Boring Name	Location	Depth	Sampler Type	N_{60}	G.W.T	γ_n	γ_s	w_n	I_L	P_L	I_P	-No.4	-No.200	U.S.C.S.	ϕ'	q_u	C_u	C_c	e_0
-	-	-	-	-	-	m	kN/m^3	kN/m^3	%	%	%	%	-	-	-	°	kN/m^2	kN/m^2	-	-
18	L-8	İKİZTEPE-KONAK HALKAPINAR	4,50-4,95	SPT	2	1,00	-	-	21,40	0,00	0,00	0,00	62,30	5,30	GP-GM	-	-	-	-	-
			8,50-8,95		5	1,00	-	-	29,70	0,00	0,00	0,00	21,80	21,80	SM	-	-	-	-	-
			11,00-11,45		7	1,00	-	-	38,90	49,00	26,00	23,00	100,00	100,00	CL	-	-	-	-	-
			14,00-14,45		8	1,00	-	-	48,20	56,00	26,00	30,00	100,00	100,00	CH	-	-	-	-	-
			17,00-17,45		13	1,00	-	-	46,40	50,00	27,00	23,00	77,10	77,10	CH	-	-	-	-	-
			20,00-20,45		25	1,00	-	-	43,30	36,00	20,00	16,00	85,00	85,00	CL	-	-	-	-	-
			23,00-23,45		19	1,00	-	-	39,80	34,00	17,00	17,00	100,00	100,00	CL	-	-	-	-	-
			26,00-26,45		45	1,00	-	-	31,60	33,00	18,00	15,00	81,40	81,40	CL	-	-	-	-	-
			29,00-29,45		34	1,00	-	-	28,40	34,00	24,00	10,00	100,00	100,00	ML(OL)	-	-	-	-	-
			30,50-30,95		24	1,00	-	-	26,70	36,00	25,00	11,00	72,50	73,50	ML(OL)	-	-	-	-	-
			33,50-33,95		52	1,00	-	-	26,00	32,00	18,00	14,00	-	-	-	-	-	-	-	-
			36,50-36,95		48	1,00	-	-	25,70	38,00	18,00	20,00	86,40	86,40	CL	-	-	-	-	-
			39,50-39,95		42	1,00	-	-	24,80	35,00	18,00	17,00	88,10	88,10	CL	-	-	-	-	-

Table A.11 Geotechnical data for İkiztepe-Konak Halkapinar ID19

Sampler ID					SOIL PROPERTIES											STRENGTH PARAMETERS			CONSOLIDATION PARAMETERS	
ID	**Boring Name**	**Location**	**Depth**	**Sampler Type**	N_{60}	**G.W.T**	γ_n	γ_s	w_n	I_L	P_L	I_P	**-No.4**	**-No.200**	**U.S.C.S.**	ϕ'	q_u	C_u	C_c	e_0
-	-	-	-	-	-	m	kN/m^3	kN/m^3	%	%	%	%	-	-	-	°	kN/m^2	kN/m^2	-	-
19	L-9	İKİZTEPE-KONAK HALKAPINAR	6,50-6,95	SPT	6	1,30	-	-	19,60	0,00	0,00	0,00	59,10	4,10	GP-GM	-	-	-	-	-
	L-9		11,00-11,45		6	1,30	-	-	42,80	41,00	18,00	23,00	100,00	100,00	CL	-	-	-	-	-
	L-9		12,50-12,95		8	1,30	-	-	53,10	54,00	28,00	26,00	100,00	100,00	CH	-	-	-	-	-
	L-9		15,50-15,95		4	1,30	-	-	47,00	55,00	27,00	28,00	100,00	100,00	CH	-	-	-	-	-
	L-9		18,50-18,95		18	1,30	-	-	41,60	44,00	26,00	18,00	100,00	100,00	CL	-	-	-	-	-
	L-9		21,50-21,95		51	1,30	-	-	38,70	41,00	20,00	21,00	100,00	100,00	CL	-	-	-	-	-
	L-9		24,00-24,95		50	1,30	-	-	35,90	30,00	18,00	12,00	79,20	79,20	CL	-	-	-	-	-
	L-9		26,00-26,40		30	1,30	-	-	30,40	35,00	18,00	17,00	100,00	100,00	CL	-	-	-	-	-
	L-9		29,00-29,45		31	1,30	-	-	26,10	34,00	19,00	15,00	83,80	83,80	CL	-	-	-	-	-
	L-9		32,00-32,45		44	1,30	-	-	26,70	33,00	18,00	15,00	78,20	78,20	CL	-	-	-	-	-
	L-9		35,00-35,45		55	1,30	-	-	26,60	30,00	19,00	11,00	86,10	86,10	CL	-	-	-	-	-
	L-9		36,50-36,95		65	1,30	-	-	25,90	34,00	18,00	16,00	88,20	88,20	CL	-	-	-	-	-

Table A.12 Geotechnical data for İkiztepe-Konak Halkapinar ID20

Sampler ID					SOIL PROPERTIES											STRENGTH PARAMETERS			CONSOLIDATION PARAMETERS	
ID	Boring Name	Location	Depth	Sampler Type	N_{60}	G.W.T	γ_n	γ_s	w_n	I_L	P_L	I_P	-No.4	-No.200	U.S.C.S.	ϕ'	q_u	C_u	C_c	e_0
-	-	-	-	-	-	m	kN/m^3	kN/m^3	%	%	%	%	-	-	-	°	kN/m^2	kN/m^2	-	-
20	L-27	İKİZTEPE-KONAK HALKAPINAR	6,50-6,95	SPT	5	1,77	-	-	28,60	34,00	22,00	12,00	39,70	39,70	SC	-	-	-	-	-
			11,00-11,45		13	1,75	-	-	16,70	0,00	0,00	0,00	19,80	19,80	SM	-	-	-	-	-
			12,50-12,95		6	1,75	-	-	56,30	64,00	25,00	39,00	100,00	100,00	CH	-	-	-	-	-
			15,50-15,95		8	1,75	-	-	54,00	68,00	27,00	41,00	100,00	100,00	CH	-	-	-	-	-
			18,50-18,95		9	1,75	-	-	50,10	47,00	26,00	21,00	100,00	100,00	CL	-	-	-	-	-
			21,50-21,95		18	1,75	-	-	47,50	56,00	26,00	30,00	100,00	100,00	CH	-	-	-	-	-
			24,00-24,95		28	1,75	-	-	39,20	51,00	25,00	26,00	100,00	100,00	CH	-	-	-	-	-
			26,00-26,40		28	1,75	-	-	32,40	58,00	26,00	32,00	100,00	100,00	CH	-	-	-	-	-
			29,00-29,45		24	1,75	-	-	27,10	38,00	18,00	20,00	81,60	81,60	CL	-	-	-	-	-
			32,00-32,45		32	1,75	-	-	24,20	47,00	19,00	28,00	78,40	78,40	CL	-	-	-	-	-
			35,00-35,45		54	1,75	-	-	24,00	36,00	17,00	19,00	66,10	66,10	CL	-	-	-	-	-
			36,50-36,95		52	1,75	-	-	22,80	33,00	18,00	15,00	100,00	100,00	CL	-	-	-	-	-

Table A.13 Geotechnical data for İkiztepe-Konak Halkapinar ID21

Sampler ID					SOIL PROPERTIES											STRENGTH PARAMETERS			CONSOLIDATION PARAMETERS	
ID	Boring Name	Location	Depth	Sampler Type	N_{60}	G.W.T	γ_n	γ_s	w_n	I_L	P_L	I_P	-No.4	-No.200	U.S.C.S.	ϕ'	q_u	C_u	C_c	e_0
-	-	-	-	-	-	m	kN/m^3	kN/m^3	%	%	%	%	-	-	-	°	kN/m^2	kN/m^2	-	-
21	L-28	İKİZTEPE-KONAK HALKAPINAR	6,50-6,95	SPT	2	1,60	-	-	18,40	0,00	0,00	0,00	23,40	23,40	SM	-	-	-	-	-
			11,00-11,45		4	1,60	-	-	26,60	0,00	0,00	0,00	28,40	28,40	SM	-	-	-	-	-
			12,50-12,95		4	1,60	-	-	53,70	68,00	26,00	42,00	100,00	100,00	CH	-	-	-	-	-
			15,50-15,95		5	1,60	-	-	50,30	61,00	16,00	45,00	100,00	100,00	CH	-	-	-	-	-
			18,50-18,95		9	1,60	-	-	44,10	66,00	23,00	43,00	100,00	100,00	CH	-	-	-	-	-
			21,50-21,95		23	1,60	-	-	31,80	36,00	20,00	16,00	66,80	66,80	CL	-	-	-	-	-
			24,00-24,95		19	1,60	-	-	33,70	58,00	21,00	37,00	100,00	100,00	CH	-	-	-	-	-
			26,00-26,40		22	1,60	-	-	44,30	66,00	23,00	43,00	100,00	100,00	CH	-	-	-	-	-
			29,00-29,45		32	1,60	-	-	29,50	48,00	19,00	29,00	100,00	100,00	CL	-	-	-	-	-
			32,00-32,45		38	1,60	-	-	26,00	45,00	17,00	28,00	100,00	100,00	CL	-	-	-	-	-
			35,00-35,45		30	1,60	-	-	21,10	24,00	20,00	4,00	66,40	66,40	CL	-	-	-	-	-
			36,50-36,95		49	1,60	-	-	33,30	47,00	24,00	23,00	68,40	68,40	CL	-	-	-	-	-

Table A.14 Geotechnical data for Balçova ID23

ID	Boring Name	Depth	N_{60}	No.4 (%)	No.200 (%)	C_u	C_c	w_n (%)	w_L (%)	w_P (%)	I_P (%)	g_n (t/m^3)	g_s (t/m^3)	USCS
-														
23	SPT-3	4.8*	4										2,67	
	SPT-4	6,3	15											
	SPT-5	7,8	20	100	87,9				44	21	23			CL
	SPT-6	9,0	50											
	SPT-7	10,5	50											
	SPT-8	12,3	34	81,6	35,7									SC
	SPT-9	13,8	24										2,66	
	SPT-10	15,3	29	100	3,4									SP
	SPT-11	16,8	32	91,2	4,7									SP
	SPT-12	18,3	21	84,6	5,8									SP-SC
	SPT-13	19,8	25	79,1	2,3									SP
	SPT-14	21,0	50											
	SPT-15	22,8	21	83,3	5,8									
	SPT-16	24,3	22										2,66	
	SPT-17	25,5	50											
	SPT-18	27,3	32	73	11,6				28	17	12			SP-SC
	SPT-19	28,5	50											
	SPT-20	30,0	50											
	SPT-21	31,8	34										2,67	
	SPT-22	33,3	36	82,2	31,4									SC
	SPT-23	34,8	37	76,7	2,1									SP
	SPT-24	36,0	50											
	SPT-25	37,8	30	73,7	2,6				29	16	13			SP
	SPT-26	39,3	29	71,9	2,4									SP

APPENDIX B

DYNAMIC PARAMETERS

Table B. 1 Dynamic parameters of boring ID1and ID4

Sampler ID				SOIL PROPERTIES				DYNAMIC PARAMETERS				
ID	Boring Name	Location	Average Depth	N_{60}	G.W.T	U.S.C.S.	SOIL TYPE	$K_{2,max}$	K_0	σ'_m	G_{max}	V_s
-	-	-	m	-	m	-	-	-	-	lb/ft^2	kPa	m/sn
1	1	GÜMRÜK-ÜÇKUYULAR COAST ROAD	3.25	41	0.00	SP	1	59.00	0.36	436	74.076	186
	1	GÜMRÜK-ÜÇKUYULAR COAST ROAD	5.75	50	0.00	SP	1	62.70	0.39	841	99.040	208
	1	GÜMRÜK-ÜÇKUYULAR COAST ROAD	7.25	4	0.00	SP	1	30.00	0.64	1.211	50.229	178
	1	GÜMRÜK-ÜÇKUYULAR COAST ROAD	11.25	50	0.00	SP	1	62.70	0.46	1.692	126.566	235
	1	GÜMRÜK-ÜÇKUYULAR COAST ROAD	12.75	50	0.00	SP	1	62.70	0.47	1.970	133.434	242
	1	GÜMRÜK-ÜÇKUYULAR COAST ROAD	13.75	50	0.00	SP	1	62.70	0.48	2.156	137.681	246
	1	GÜMRÜK-ÜÇKUYULAR COAST ROAD	15.25	44	0.00	SP	1	59.00	0.51	2.466	138.668	251
	1	GÜMRÜK-ÜÇKUYULAR COAST ROAD	17.25	16	0.00	SP	1	42.40	0.60	2.939	106.598	245
	1	GÜMRÜK-ÜÇKUYULAR COAST ROAD	19.25	15	0.00	SP	1	41.40	0.61	3.181	107.206	247
	1	GÜMRÜK-ÜÇKUYULAR COAST ROAD	20.75	15	0.00	SP	1	41.40	0.61	3.356	109.158	250
	1	GÜMRÜK-ÜÇKUYULAR COAST ROAD	21.75	19	0.00	SP	1	45.40	0.60	3.443	118.908	256
4	2	GÜMRÜK-ÜÇKUYULAR COAST ROAD	2.75	25	0.00	SP	1	52.92	0.43	313	56.975	173
	2	GÜMRÜK-ÜÇKUYULAR COAST ROAD	4.25	23	0.00	SP	1	50.20	0.49	509	65.777	187
	2	GÜMRÜK-ÜÇKUYULAR COAST ROAD	5.75	25	0.00	SP	1	52.92	0.50	697	75.268	199
	2	GÜMRÜK-ÜÇKUYULAR COAST ROAD	7.25	18	0.00	SP	1	45.40	0.55	907	74.312	204
	2	GÜMRÜK-ÜÇKUYULAR COAST ROAD	8.75	22	0.00	SP	1	50.20	0.54	1.079	84.030	213
	2	GÜMRÜK-ÜÇKUYULAR COAST ROAD	11.75	16	0.00	SW	1	42.40	0.58	1.466	84.256	218
	2	GÜMRÜK-ÜÇKUYULAR COAST ROAD	13.25	21	0.00	SW	1	49.00		763	65.234	189
	2	GÜMRÜK-ÜÇKUYULAR COAST ROAD	14.75	8	0.00	SW	1	39.60	0.62	1.864	72.919	210
	2	GÜMRÜK-ÜÇKUYULAR COAST ROAD	16.25	19	0.00	SW	1	45.40	0.58	1.973	98.484	233
	2	GÜMRÜK-ÜÇKUYULAR COAST ROAD	19.25	23	0.00	SW	1	50.20	0.57	2.343	111.006	243
	2	GÜMRÜK-ÜÇKUYULAR COAST ROAD	20.75	24	0.00	SP	1	51.40	0.57	2.539	115.652	247

For Soil Type=1 $G_{max}=1000K_{2,max}(\sigma'_m)^{0.5}$ **Seed and Idriss, 1970 and Soil Type=2** $G_{max}=625\,F(e)\,(OCR)^k Pa^{1-n}(\sigma'_m)^n$ **Hardin, 1978** $F(e)=1/(0.3+0.7e^2)$

Table B. 2 Dynamic parameters of boring ID8. ID9 and ID11

Sampler ID				SOIL PROPERTIES				DYNAMIC PARAMETERS				
ID	**Boring Name**	**Location**	**Average Depth**	N_{60}	**G.W.T**	**U.S.C.S.**	**SOIL TYPE**	$K_{2,max}$	K_0	σ'_m	G_{max}	V_s
-	-	-	m	-	m	-	-	-	-	lb/ft^2	kPa	m/sn
8	3	GÜMRÜK-ÜÇKUYULAR COAST ROAD	1.25	31	0.00	SW	1	55.27	0.29	134	44.801	150
	3	GÜMRÜK-ÜÇKUYULAR COAST ROAD	5.75	26	0.00	SP	1	52.93	0.49	730	77.385	201
	3	GÜMRÜK-ÜÇKUYULAR COAST ROAD	6.25	29	0.00	SP	1	57.60	0.48	786	82.123	205
	3	GÜMRÜK-ÜÇKUYULAR COAST ROAD	21.75	23	0.00	SW	1	5.20	0.58	2.866	118.861	252
9	4	GÜMRÜK-ÜÇKUYULAR COAST ROAD	2.70	18	0.00	SP	1	45.40	0.48	287	50.025	167
11	SK-5	İKİZTEPE-KONAK HALKAPINAR	4.75	3	4.50	CH	1		0.64	1.123	44.543	168
	SK-5	İKİZTEPE-KONAK HALKAPINAR	6.25	8	4.50	CH	2		0.62	1.247	40.480	157
	SK-5	İKİZTEPE-KONAK HALKAPINAR	7.75	7	4.50	CL	2		0.62	1.401	56.014	185
	SK-5	İKİZTEPE-KONAK HALKAPINAR	9.25	8	4.50	MH(OH)	2		0.62	1.546	33.236	142
	SK-5	İKİZTEPE-KONAK HALKAPINAR	12.25	50	4.50	GC	1		0.46	1.839	130.297	239
	SK-5	İKİZTEPE-KONAK HALKAPINAR	13.67	69	4.50	GC	1		0.41	1.977	147.207	251
	SK-5	İKİZTEPE-KONAK HALKAPINAR	15.15	48	4.50	GC	1		0.49	2.403	141.186	250
	SK-5	İKİZTEPE-KONAK HALKAPINAR	21.25	22	4.50	CL	2		0.59	3.416	48.920	162
	SK-5	İKİZTEPE-KONAK HALKAPINAR	31.85	30	4.50	CL-CH	2		0.58	4.917	64.765	181
	SK-5	İKİZTEPE-KONAK HALKAPINAR	24.75	28	4.50	CH	2		0.58	3.901	71.269	191
	SK-5	İKİZTEPE-KONAK HALKAPINAR	39.25	47	4.50	CL	2		0.55	6.410	72.481	180
	SK-5	İKİZTEPE-KONAK HALKAPINAR	42.25	44	4.50	CL	2		0.56	6.996	71.379	180
	SK-5	İKİZTEPE-KONAK HALKAPINAR	45.25	45	4.50	CL	2		0.57	7.529	78.549	189

For **Soil Type=1** $G_{max}=1000K_{2,max}(\sigma'_m)^{0.5}$ **Seed and Idriss, 1970** **and** **Soil Type=2** $G_{max}=625\,F(e)\,(OCR)^k Pa^{1-n}(\sigma'_m)^n$ **Hardin, 1978** $F(e)=1/(0.3+0.7e^2)$

Table B. 3 Dynamic parameters of boring ID12. ID13 and ID14

Sampler ID				SOIL PROPERTIES				DYNAMIC PARAMETERS				
ID	**Boring Name**	**Location**	**Average Depth**	**N_{60}**	**G.W.T**	**U.S.C.S.**	**SOIL TYPE**	**$K_{2,max}$**	**K_0**	**σ'$_m$**	**G_{max}**	**V_s**
-	-	-	**m**	-	**m**	-	-	-	-	**lb/ft^2**	**kPa**	**m/sn**
12	SK-2	İKİZTEPE-KONAK HALKAPINAR	8.25	5	2.50	-	1		0.63	1.138	52.942	182
	SK-2	İKİZTEPE-KONAK HALKAPINAR	10.25	8	2.50	-	1		0.62	1.323	64.987	198
	SK-2	İKİZTEPE-KONAK HALKAPINAR	11.75	10	2.50	SM-SC	1		0.61	1.467	72.373	208
	SK-2	İKİZTEPE-KONAK HALKAPINAR	13.25	15	2.50	CL	2		0.59	1.609	88.667	225
	SK-2	İKİZTEPE-KONAK HALKAPINAR	30.75	32	2.50	CL	2		0.57	4.181	449.225	472
	SK-2	İKİZTEPE-KONAK HALKAPINAR	38.25	42	2.50	CL	2		0.56	5.387	101.515	217
	SK-2	İKİZTEPE-KONAK HALKAPINAR	41.25	28	2.50	SC-CL	2		0.59	5.998	280.926	379
13	SK-13	İKİZTEPE-KONAK HALKAPINAR	5.25	3	1.50	CL	2		0.64	697	37.970	156
	SK-13	İKİZTEPE-KONAK HALKAPINAR	8.75	8	1.50	CL	2		0.61	1.028	59.698	190
	SK-13	İKİZTEPE-KONAK HALKAPINAR	10.25	8	1.50	CL	2		0.61	1.180	62.526	195
	SK-13	İKİZTEPE-KONAK HALKAPINAR	11.75	7	1.50	CH	2		0.62	1.333	62.358	196
	SK-13	İKİZTEPE-KONAK HALKAPINAR	15.25	30	1.50	SC-CL	1		0.53	1.707	108.398	234
	SK-13	İKİZTEPE-KONAK HALKAPINAR	32.25	16	1.50	-	1		0.61	3.832	116.579	256
	SK-13	İKİZTEPE-KONAK HALKAPINAR	35.25	20	1.50	CL	2		0.60	4.177	129.062	265
14	SK-181	İKİZTEPE-KONAK HALKAPINAR	7.25	15	7.00	SC	2		0.59	1.863	255.618	382
	SK-181	İKİZTEPE-KONAK HALKAPINAR	8.75	13	7.00	CL	2		0.61	2.042	51.679	174
	SK-181	İKİZTEPE-KONAK HALKAPINAR	10.25	17	7.00	CL	2		0.59	2.191	49.692	167
	SK-181	İKİZTEPE-KONAK HALKAPINAR	13.25	20	7.00	CL	2		0.59	2.551	43.101	153
	SK-181	İKİZTEPE-KONAK HALKAPINAR	16.25	33	7.00	CL	2		0.55	2.903	54.022	164
	SK-181	İKİZTEPE-KONAK HALKAPINAR	20.75	47	7.00	CL	2		0.52	3.608	61.507	166
	SK-181	İKİZTEPE-KONAK HALKAPINAR	22.25	42	7.00	SC	2		0.54	3.918	229.519	326
	SK-181	İKİZTEPE-KONAK HALKAPINAR	29.75	50	7.00	CL	2		0.54	5.271	76.917	184
	SK-181	İKİZTEPE-KONAK HALKAPINAR	31.25	33	7.00	SC	2		0.58	5.709	282.067	374
	SK-181	İKİZTEPE-KONAK HALKAPINAR	34.75	41	7.00	CL	2		0.56	6.215	79.043	192

For **Soil Type=1** $G_{max}=1000K_{2,max}(\sigma'_m)^{0.5}$ **Seed and Idriss, 1970** **and** **Soil Type=2** $G_{max}= 625\ F(e)\ (OCR)^k Pa^{1-n}(\sigma'_m)^n$ **Hardin, 1978** $F(e)=1/(0.3+0.7e^2)$

Table B. 4 Dynamic parameters of boring ID15 and ID16

Sampler ID				SOIL PROPERTIES				DYNAMIC PARAMETERS				
ID	Boring Name	Location	Average Depth	N_{60}	G.W.T	U.S.C.S.	SOIL TYPE	$K_{2,max}$	K_0	σ'_m	G_{max}	V_s
-	-	-	m	-	m	-	-	-	-	lb/ft^2	kPa	m/sn
15	L-1	İKİZTEPE-KONAK HALKAPINAR	3.05	9	0.70	GP-GM	1		0.58	395	44.879	165
	L-1	İKİZTEPE-KONAK HALKAPINAR	6.05	34	0.70	ML	1		0.45	757	85.074	204
	L-1	İKİZTEPE-KONAK HALKAPINAR	9.05	37	0.70	SM	1		0.48	1.210	102.754	222
	L-1	İKİZTEPE-KONAK HALKAPINAR	10.05	12	0.70	CH	2		0.60	1.466	30.853	134
	L-1	İKİZTEPE-KONAK HALKAPINAR	16.05	48	0.70	GC	2		0.49	2.344	328.167	381
	L-1	İKİZTEPE-KONAK HALKAPINAR	19.05	27	0.70	CL	2		0.57	2.940	102.930	231
	L-1	İKİZTEPE-KONAK HALKAPINAR	22.05	42	0.70	GM-GC	2		0.53	3.326	531.114	496
	L-1	İKİZTEPE-KONAK HALKAPINAR	25.05	31	0.70	GC	2		0.57	3.886	279.080	374
	L-1	İKİZTEPE-KONAK HALKAPINAR	29.55	49	0.70	SC	2		0.53	4.549	290.745	358
	L-1	İKİZTEPE-KONAK HALKAPINAR	35.55	19	0.70	SC	2		0.61	5.645	249.587	371
	L-1	İKİZTEPE-KONAK HALKAPINAR	38.55	42	0.70	CL	2		0.56	5.891	110.938	227
16	L-6	İKİZTEPE-KONAK HALKAPINAR	3.40	7	0.35	GP-GM	1		0.63	2.863	80.602	222
	L-6	İKİZTEPE-KONAK HALKAPINAR	6.40	14	0.35	SM	1		0.61	3.142	104.394	245
	L-6	İKİZTEPE-KONAK HALKAPINAR	9.40	4	0.35	SM	1		0.65	3.514	71.750	212
	L-6	İKİZTEPE-KONAK HALKAPINAR	12.40	8	0.35	CL	2		0.63	3.781	49.544	173
	L-6	İKİZTEPE-KONAK HALKAPINAR	15.40	6	0.35	CH	2		0.64	4.088	51.521	179
	L-6	İKİZTEPE-KONAK HALKAPINAR	18.40	13	0.35	CH	2		0.62	4.348	53.129	176
	L-6	İKİZTEPE-KONAK HALKAPINAR	21.40	12	0.35	CH	2		0.63	4.692	55.192	180
	L-6	İKİZTEPE-KONAK HALKAPINAR	25.90	28	0.35	CL	2		0.59	5.172	141.994	269
	L-6	İKİZTEPE-KONAK HALKAPINAR	28.90	26	0.35	CH	2		0.59	5.619	60.398	178
	L-6	İKİZTEPE-KONAK HALKAPINAR	31.90	59	0.35	CL	2		0.52	5.819	101.289	208
	L-6	İKİZTEPE-KONAK HALKAPINAR	34.90	48	0.35	CL	2		0.55	6.528	65.101	170
	L-6	İKİZTEPE-KONAK HALKAPINAR	37.90	59	0.35	CL	2		0.53	6.985	87.598	193

For <u>Soil Type=1</u> $G_{max}=1000K_{2,max}(\sigma'_m)^{0.5}$ Seed and Idriss, 1970 and <u>Soil Type=2</u> $G_{max}= 625\ F(e)\ (OCR)^k Pa^{1-n}(\sigma'_m)^n$ Hardin, 1978 $F(e)=1/(0.3+0.7e^2)$

Table B. 5 Dynamic parameters of boring ID17 and ID18

Sampler ID				SOIL PROPERTIES				DYNAMIC PARAMETERS				
ID	Boring Name	Location	Average Depth	N_{60}	G.W.T	U.S.C.S.	SOIL TYPE	$K_{2,max}$	K_0	σ'_m	G_{max}	V_s
-	-	-	m	-	m	-	-	-	-	lb/ft^2	kPa	m/sn
17	L-7	İKİZTEPE-KONAK HALKAPINAR	3.35	7	0.40	SW-SM	1		0.59	375	40.665	158
	L-7	İKİZTEPE-KONAK HALKAPINAR	6.35	5	0.40	SM	1		0.62	656	44.015	166
	L-7	İKİZTEPE-KONAK HALKAPINAR	10.85	5	0.40	CH	2		0.63	1.071	32.131	142
	L-7	İKİZTEPE-KONAK HALKAPINAR	13.85	6	0.40	CH	2		0.63	1.351	29.616	136
	L-7	İKİZTEPE-KONAK HALKAPINAR	16.85	37	0.40	CH	2		0.50	1.644	32.671	125
	L-7	İKİZTEPE-KONAK HALKAPINAR	19.85	32	0.40	CL	2		0.54	2.133	37.213	136
	L-7	İKİZTEPE-KONAK HALKAPINAR	22.85	71	0.40	SC	2		0.43	2.417	149.448	252
	L-7	İKİZTEPE-KONAK HALKAPINAR	25.85	26	0.40	CL	2		0.58	3.209	59.373	176
	L-7	İKİZTEPE-KONAK HALKAPINAR	28.85	32	0.40	CL	2		0.56	3.615	48.449	155
	L-7	İKİZTEPE-KONAK HALKAPINAR	31.85	52	0.40	CL	2		0.52	4.008	51.011	148
	L-7	İKİZTEPE-KONAK HALKAPINAR	34.85	49	0.40	CL	2		0.53	4.604	58.583	161
	L-7	İKİZTEPE-KONAK HALKAPINAR	37.85	38	0.40	CL	2		0.56	5.227	88.061	205
18	L-8	İKİZTEPE-KONAK HALKAPINAR	3.75	2	1.00	GP-GM	1		0.64	477	29.243	137
	L-8	İKİZTEPE-KONAK HALKAPINAR	7.75	5	1.00	SM	1		0.63	834	47.694	173
	L-8	İKİZTEPE-KONAK HALKAPINAR	10.25	7	1.00	CL	2		0.62	1.069	26.345	127
	L-8	İKİZTEPE-KONAK HALKAPINAR	13.25	8	1.00	CH	2		0.62	1.367	29.791	134
	L-8	İKİZTEPE-KONAK HALKAPINAR	16.25	13	1.00	CH	2		0.60	1.666	53.302	176
	L-8	İKİZTEPE-KONAK HALKAPINAR	19.25	25	1.00	CL	2		0.56	1.991	48.730	160
	L-8	İKİZTEPE-KONAK HALKAPINAR	22.25	19	1.00	CL	2		0.59	2.410	39.555	148
	L-8	İKİZTEPE-KONAK HALKAPINAR	25.25	45	1.00	CL	2		0.51	2.736	61.855	168
	L-8	İKİZTEPE-KONAK HALKAPINAR	28.25	34	1.00	ML(OL)	2		0.55	3.300	46.286	151
	L-8	İKİZTEPE-KONAK HALKAPINAR	29.75	24	1.00	ML(OL)	2		0.59	3.601	85.461	212
	L-8	İKİZTEPE-KONAK HALKAPINAR	32.75	52	1.00	-	1		0.51	3.917	171.291	271
	L-8	İKİZTEPE-KONAK HALKAPINAR	35.75	48	1.00	CL	2		0.53	4.523	71.246	177
	L-8	İKİZTEPE-KONAK HALKAPINAR	38.75	42	1.00	CL	2		0.55	5.114	73.069	184

For **Soil Type=1** $G_{max}=1000K_{2,max}(\sigma'_m)^{0.5}$ **Seed and Idriss, 1970 and** **Soil Type=2** $G_{max}= 625\, F(e)\, (OCR)^k Pa^{1-n}(\sigma'_m)^n$ **Hardin, 1978** $F(e)=1/(0.3+0.7e^2)$

Table B. 6 Dynamic parameters of boring ID19 and ID20

Sampler ID				SOIL PROPERTIES				DYNAMIC PARAMETERS				
ID	Boring Name	Location	Average Depth	N_{60}	G.W.T	U.S.C.S.	SOIL TYPE	$K_{2,max}$	K_0	σ'_m	G_{max}	V_s
-	-	-	m	-	m	-	-	-	-	lb/ft^2	kPa	m/sn
19	L-9	İKİZTEPE-KONAK HALKAPINAR	5.45	6	1.30	GP-GM	1		0.62	705	47.869	172
	L-9	İKİZTEPE-KONAK HALKAPINAR	9.95	6	1.30	CL	2		0.62	1.133	27.123	130
	L-9	İKİZTEPE-KONAK HALKAPINAR	11.45	8	1.30	CH	2		0.62	1.274	28.757	132
	L-9	İKİZTEPE-KONAK HALKAPINAR	14.45	4	1.30	CH	2		0.64	1.575	31.977	142
	L-9	İKİZTEPE-KONAK HALKAPINAR	17.45	18	1.30	CL	2		0.58	1.848	34.642	139
	L-9	İKİZTEPE-KONAK HALKAPINAR	20.45	51	1.30	CL	2		0.48	2.188	37.688	128
	L-9	İKİZTEPE-KONAK HALKAPINAR	22.95	50	1.30	CL	2		0.49	2.663	64.177	168
	L-9	İKİZTEPE-KONAK HALKAPINAR	24.95	30	1.30	CL	2		0.56	3.131	45.086	151
	L-9	İKİZTEPE-KONAK HALKAPINAR	27.95	31	1.30	CL	2		0.57	3.575	67.030	183
	L-9	İKİZTEPE-KONAK HALKAPINAR	30.95	44	1.30	CL	2		0.54	3.987	80.365	191
	L-9	İKİZTEPE-KONAK HALKAPINAR	33.95	55	1.30	CL	2		0.52	4.470	71.290	174
	L-9	İKİZTEPE-KONAK HALKAPINAR	35.45	65	1.30	CL	2		0.50	4.657	69.582	172
20	L-27	İKİZTEPE-KONAK HALKAPINAR	4.99	5	1.77	SC	2		0.62	722	105.951	258
	L-27	İKİZTEPE-KONAK HALKAPINAR	9.50	13	1.75	SM	1		0.59	1.179	73.189	207
	L-27	İKİZTEPE-KONAK HALKAPINAR	11.00	6	1.75	CH	2		0.63	1.362	29.732	136
	L-27	İKİZTEPE-KONAK HALKAPINAR	14.00	8	1.75	CH	2		0.62	1.653	32.763	141
	L-27	İKİZTEPE-KONAK HALKAPINAR	17.00	9	1.75	CL	2		0.62	1.950	35.585	147
	L-27	İKİZTEPE-KONAK HALKAPINAR	20.00	18	1.75	CH	2		0.59	2.250	38.224	146
	L-27	İKİZTEPE-KONAK HALKAPINAR	22.50	28	1.75	CH	2		0.56	2.534	40.564	144
	L-27	İKİZTEPE-KONAK HALKAPINAR	24.50	28	1.75	CH	2		0.56	2.824	42.821	148
	L-27	İKİZTEPE-KONAK HALKAPINAR	27.50	24	1.75	CL	2		0.58	3.270	67.322	188
	L-27	İKİZTEPE-KONAK HALKAPINAR	30.50	32	1.75	CL	2		0.56	3.657	76.613	195
	L-27	İKİZTEPE-KONAK HALKAPINAR	33.50	54	1.75	CL	2		0.51	4.037	109.353	216
	L-27	İKİZTEPE-KONAK HALKAPINAR	35.00	52	1.75	CL	2		0.52	4.353	53.160	151

For **Soil Type=1** $G_{max}=1000K_{2,max}(\sigma'_m)^{0.5}$ **Seed and Idriss, 1970 and** **Soil Type=2** $G_{max}= 625\ F(e)\ (OCR)^k Pa^{1-n}(\sigma'_m)^n$ **Hardin, 1978** $F(e)=1/(0.3+0.7e^2)$

Table B. 7 Dynamic parameters of boring ID21

Sampler ID				SOIL PROPERTIES				DYNAMIC PARAMETERS				
ID	Boring Name	Location	Average Depth	N_{60}	G.W.T	U.S.C.S.	SOIL TYPE	$K_{2,max}$	K_0	σ'm	G_{max}	V_s
-	-	-	m	-	m	-	-	-	-	lb/ft^2	kPa	m/sn
21	L-28	İKİZTEPE-KONAK HALKAPINAR	5.15	2	1.60	SM	1		0.64	692	33.123	146
	L-28	İKİZTEPE-KONAK HALKAPINAR	9.65	4	1.60	SM	1		0.64	1.099	48.621	175
	L-28	İKİZTEPE-KONAK HALKAPINAR	11.15	4	1.60	CH	2		0.64	1.237	28.345	134
	L-28	İKİZTEPE-KONAK HALKAPINAR	14.15	5	1.60	CH	2		0.63	1.509	31.297	140
	L-28	İKİZTEPE-KONAK HALKAPINAR	17.15	9	1.60	CH	2		0.62	1.787	34.059	144
	L-28	İKİZTEPE-KONAK HALKAPINAR	20.15	23	1.60	CL	2		0.57	2.089	77.208	203
	L-28	İKİZTEPE-KONAK HALKAPINAR	22.65	19	1.60	CH	2		0.59	2.431	39.727	148
	L-28	İKİZTEPE-KONAK HALKAPINAR	24.65	22	1.60	CH	2		0.58	2.668	41.617	150
	L-28	İKİZTEPE-KONAK HALKAPINAR	27.65	32	1.60	CL	2		0.55	3.044	44.454	148
	L-28	İKİZTEPE-KONAK HALKAPINAR	30.65	38	1.60	CL	2		0.54	3.484	47.562	150
	L-28	İKİZTEPE-KONAK HALKAPINAR	33.65	30	1.60	CL	2		0.57	4.008	108.093	234
	L-28	İKİZTEPE-KONAK HALKAPINAR	35.15	49	1.60	CL	2		0.52	4.095	103.661	214

For Soil Type=1 $G_{max}=1000K_{2,max}(\sigma'_m)^{0.5}$ Seed and Idriss, 1970 and Soil Type=2 $G_{max}=625\,F(e)\,(OCR)^k Pa^{1-n}(\sigma'_m)^n$ Hardin, 1978 $F(e)=1/(0.3+0.7e^2)$

APPENDIX C

SOIL PROFILES AND SITE REPONSE ANALYSES RESULTS

	Layer Number	Soil Material Type	Number of sublayers in layer	Thickness of layer (m)	Maximum shear modulus G_{max} (MPa)	Initial critical damping ratio (%)	Total unit weight (kN/m^3)	Shear wave velocity (m/sec)	Location and type of earthquake input motion	Location of water table	Depth at middle of layer (m)	Vertical effective stress (kPa)
Surface	1	1		3,25	74,08		21,00	*186,02*		*W*	1,63	18,18
	2	2		2,50	99,04		22,40	*208,26*			4,50	52,10
	3	3		1,50	50,23		15,60	*177,73*			6,50	72,18
	4	4		4,00	126,57		22,40	*235,43*			9,25	101,71
	5	5		1,50	133,43		22,40	*241,74*			12,00	136,33
	6	6		1,00	137,68		22,40	*245,55*			13,25	152,07
	7	7		1,50	138,67		21,60	*250,95*			14,50	167,21
	8	8		2,00	106,60		17,40	*245,15*			16,25	183,64
	9	9		2,00	107,21		17,20	*247,27*			18,25	198,62
	10	10		1,50	109,16		17,20	*249,52*			20,00	211,55
	11	11		1,00	118,91		17,80	*255,99*			21,25	221,09
Bedrock	12	0			14091,74	*1*	24,00	*2400,00*	Outcrop		21,75	225,08

Figure C.1 Soil parameters for ID1

	Layer Number	Soil Material Type	Number of sublayers in layer	Thickness of layer (m)	Maximum shear modulus G_{max} (MPa)	Initial critical damping ratio (%)	Total unit weight (kN/m^3)	Shear wave velocity (m/sec)	Location and type of earthquake input motion	Location of water table	Depth at middle of layer (m)	Vertical effective stress (kPa)
Surface	1	1		2,75	56,97		18,60	*173,35*		*W*	1,38	12,09
	2	2		1,50	65,78		18,40	*187,27*			3,50	30,62
	3	3		1,50	75,27		18,60	*199,24*			5,00	43,65
	4	4		1,50	74,31		17,60	*203,52*			6,50	56,09
	5	5		1,50	84,03		18,20	*212,82*			8,00	68,22
	6	6		3,00	84,26		17,40	*217,95*			10,25	85,90
	7	7		1,50	65,23		18,00	*188,55*			12,50	103,42
	8	8		1,50	72,92		16,20	*210,13*			14,00	114,36
	9	9		1,50	98,48		17,80	*232,97*			15,50	125,14
	10	10		3,00	111,01		18,40	*243,28*			17,75	144,02
	11	11		1,50	115,65		18,60	*246,98*			20,00	163,50
Bedrock	12	0			14091,74	*1*	24,00	*2400,00*	Outcrop		20,75	170,09

Figure C.2 Soil parameters for ID4

	Layer Number	Soil Material Type	Number of sublayers in layer	Thickness of layer (m)	Maximum shear modulus G_{max} (MPa)	Initial critical damping ratio (%)	Total unit weight (kN/m^3)	Shear wave velocity (m/sec)	Location and type of earthquake input motion	Location of water table	Depth at middle of layer (m)	Vertical effective stress (kPa)
Surface	1	1		1,25	44,80		19,60	149,74		W	0,63	6,12
	2	2		4,50	77,39		18,80	200,95			3,50	32,46
	3	3		0,50	82,12		19,20	204,84			6,00	55,04
	4	4		15,50	118,86		18,40	251,74			14,00	123,96
Bedrock	5	0			14091,74	1	24,00	2400,00	Outcrop		21,75	190,53

Figure C.3 Soil parameters for ID8

	Layer Number	Soil Material Type	Number of sublayers in layer	Thickness of layer (m)	Maximum shear modulus G_{max} (MPa)	Initial critical damping ratio (%)	Total unit weight (kN/m^3)	Shear wave velocity (m/sec)	Location and type of earthquake input motion	Location of water table	Depth at middle of layer (m)	Vertical effective stress (kPa)
Surface	1	1		2,70	50,03		17,60	166,98		W	1,35	10,52
Bedrock	2	0			14091,74	1	24,00	2400,00	Outcrop		2,70	21,03

Figure C.4 Soil parameters for ID9

	Layer Number	Soil Material Type	Number of sublayers in layer	Thickness of layer (m)	Maximum shear modulus G_{max} (MPa)	Initial critical damping ratio (%)	Total unit weight (kN/m^3)	Shear wave velocity (m/sec)	Location and type of earthquake input motion	Location of water table	Depth at middle of layer (m)	Vertical effective stress (kPa)
Surface	1	1		9,25	44,54		15,40	168,45		W	4,63	25,85
	2	2		1,50	40,48		16,20	156,57			10,00	56,50
	3	3		1,50	56,01		16,00	185,32			11,50	65,93
	4	4		1,50	33,24		16,20	141,87			13,00	75,37
	5	5		3,00	130,30		22,40	238,88			15,25	99,05
	6	6		1,42	147,21		23,00	250,57			17,46	127,30
	7	7		1,48	141,19		22,20	249,78			18,91	145,83
	8	8		6,10	48,92		18,20	162,38			22,70	180,59
	9	9		10,60	64,77		19,40	180,97			31,05	257,01
	10	10		2,90	71,27		19,20	190,82			37,80	321,45
	11	11		4,50	72,48		22,00	179,78			41,50	362,49
	12	12		3,00	71,38		21,60	180,05			45,25	407,60
Bedrock	13	0			14091,74	1	24,00	2400,00	Outcrop		46,75	425,29

Figure C.5 Soil parameters for ID11

	Layer Number	Soil Material Type	Number of sublayers in layer	Thickness of layer (m)	Maximum shear modulus G_{max} (MPa)	Initial critical damping ratio (%)	Total unit weight (kN/m^3)	Shear wave velocity (m/sec)	Location and type of earthquake input motion	Location of water table	Depth at middle of layer (m)	Vertical effective stress (kPa)
Surface	1	1		10,75	52,94		15,60	182,46		W	5,38	31,12
	2	2		2,00	64,99		16,20	198,38			11,75	68,63
	3	3		1,50	72,37		16,40	208,07			13,50	79,96
	4	4		1,50	88,67		17,20	224,88			15,00	90,45
	5	5		17,50	449,23		19,80	471,77			24,50	183,40
	6	6		7,50	101,52		21,20	216,74			37,00	313,53
	7	7		3,00	280,93		19,20	378,86			42,25	370,33
Bedrock	8	0			14091,74	1	24,00	2400,00	Outcrop		43,75	384,41

Figure C.6 Soil parameters for ID12

	Layer Number	Soil Material Type	Number of sublayers in layer	Thickness of layer (m)	Maximum shear modulus G_{max} (MPa)	Initial critical damping ratio (%)	Total unit weight (kN/m^3)	Shear wave velocity (m/sec)	Location and type of earthquake input motion	Location of water table	Depth at middle of layer (m)	Vertical effective stress (kPa)
Surface	1	1		6,75	37,97		15,40	155,52		W	3,38	18,87
	2	2		3,50	59,70		16,20	190,13			8,50	48,91
	3	3		1,50	62,53		16,20	194,58			11,00	64,89
	4	4		1,50	62,36		16,00	195,53			12,50	74,32
	5	5		3,50	108,40		19,40	234,12			15,00	95,75
	6	6		17,00	116,58		17,40	256,37			25,25	177,05
	7	7		3,00	129,06		18,00	265,22			35,25	253,85
Bedrock	8	0			14091,74	1	24,00	2400,00	Outcrop		36,75	266,13

Figure C.7 Soil parameters for ID13

	Layer Number	Soil Material Type	Number of sublayers in layer	Thickness of layer (m)	Maximum shear modulus G_{max} (MPa)	Initial critical damping ratio (%)	Total unit weight (kN/m^3)	Shear wave velocity (m/sec)	Location and type of earthquake input motion	Location of water table	Depth at middle of layer (m)	Vertical effective stress (kPa)
Surface	1	1		14,25	255,62		17,20	381,83		W	7,13	52,65
	2	2		1,50	51,68		16,80	173,71			15,00	110,55
	3	3		1,50	49,69		17,40	167,38			16,50	121,49
	4	4		3,00	43,10		18,00	153,26			18,75	139,46
	5	5		3,00	54,02		19,80	163,60			21,75	166,73
	6	6		4,50	61,51		22,00	165,61			25,50	209,14
	7	7		1,50	229,52		21,20	325,89			28,50	245,11
	8	8		7,50	76,92		22,40	183,54			33,00	300,87
	9	9		1,50	282,07		19,80	373,83			37,50	355,57
	10	10		3,50	79,04		21,00	192,16			40,00	382,65
Bedrock	11	0			14091,74	1	24,00	2400,00	Outcrop		41,75	402,23

Figure C.8 Soil parameters for ID14

	Layer Number	Soil Material Type	Number of sublayers in layer	Thickness of layer (m)	Maximum shear modulus G_{max} (MPa)	Initial critical damping ratio (%)	Total unit weight (kN/m³)	Shear wave velocity (m/sec)	Location and type of earthquake input motion	Location of water table	Depth at middle of layer (m)	Vertical effective stress (kPa)
Surface	1	1		3,75	44,88		16,20	164,85		W	1,88	11,98
	2	2		3,00	85,07		20,00	204,28			5,25	39,25
	3	3		3,00	102,75		20,40	222,29			8,25	70,42
	4	4		1,00	30,85		16,80	134,22			10,25	89,80
	5	5		6,00	328,17		22,20	380,81			13,75	130,46
	6	6		3,00	102,93		19,00	230,53			18,25	181,42
	7	7		3,00	531,11		21,20	495,75			21,25	212,29
	8	8		3,00	279,08		19,60	373,74			24,25	244,06
	9	9		4,50	290,75		22,20	358,44			28,00	286,62
	10	10		6,00	249,59		17,80	370,88			33,25	338,47
	11	11		3,00	110,94		21,20	226,57			37,75	379,52
Bedrock	12	0			14091,74	1	24,00	2400,00	Outcrop		39,25	396,61

Figure C.9 Soil parameters for ID15

	Layer Number	Soil Material Type	Number of sublayers in layer	Thickness of layer (m)	Maximum shear modulus G_{max} (MPa)	Initial critical damping ratio (%)	Total unit weight (kN/m³)	Shear wave velocity (m/sec)	Location and type of earthquake input motion	Location of water table	Depth at middle of layer (m)	Vertical effective stress (kPa)
Surface	1	1		3,75	80,60		16,00	222,30		W	1,88	11,61
	2	2		3,00	104,39		17,00	245,44			5,25	34,00
	3	3		3,00	71,75		15,60	212,41			8,25	53,47
	4	4		3,00	49,54		16,20	173,21			11,25	71,74
	5	5		3,00	51,52		15,80	178,85			14,25	90,31
	6	6		3,00	53,13		16,80	176,14			17,25	109,78
	7	7		3,00	55,19		16,80	179,52			20,25	130,75
	8	8		4,50	141,99		19,20	269,35			24,00	162,36
	9	9		3,00	60,40		18,80	177,53			27,75	196,97
	10	10		3,00	101,29		23,00	207,85			30,75	230,24
	11	11		3,00	65,10		22,20	169,61			33,75	268,61
	12	11		3,00	87,60		23,00	193,29			36,75	306,98
Bedrock	13	0			22018,35	1	24,00	2400,00	Outcrop		38,25	326,77

Figure C.10 Soil parameters for ID16

	Layer Number	Soil Material Type	Number of sublayers in layer	Thickness of layer (m)	Maximum shear modulus G_{max} (MPa)	Initial critical damping ratio (%)	Total unit weight (kN/m^3)	Shear wave velocity (m/sec)	Location and type of earthquake input motion	Location of water table	Depth at middle of layer (m)	Vertical effective stress (kPa)
Surface	1	1		1,5	54,28		18,0	172,0			0,8	13,5
	2	2		1,7	58,75		18,5	176,5			2,3	42,7
	3	3		1,8	68,94		18,5	191,2			4,1	75,1
	4	4		4,0	122,82		18,5	255,2			7,0	128,8
	5	5		2,0	135,60		19,0	264,6			10,0	184,8
	6	6		0,8	140,03		18,5	272,5			11,4	211,1
	7	7		4,0	165,71		19,0	292,5			13,8	256,5
	8	8		1,5	181,35		19,0	306,0			16,5	308,8
	9	9		3,6	206,09		19,0	326,2		W	19,1	357,3
	10	10		2,6	240,04		19,5	347,5			22,2	404,0
	11	11		1,0	260,49		19,5	362,0			24,0	421,5
	12	12		4,5	334,40		20,0	405,0			26,7	449,3
	13	13		1,0	339,87		19,5	413,5			29,5	477,0
	14	14		2,7	368,52		19,0	436,2			31,3	494,3
	15	15		1,8	410,25		19,5	454,3			33,6	515,4
	16	16		4,5	484,72		20,0	487,6			36,8	547,1
	17	17		3,0	501,92		19,5	502,5			40,5	584,5
	18	18		7,0	584,80		19,5	542,4			45,5	633,0
	19	19		12,0	816,29		20,5	625,0			55	731,0
Bedrock	20	0			14091,74	1	24,0	2400,0	Outcrop		61	795,2

Figure C.11 Soil parameters for ID23

	Layer Number	Soil Material Type	Number of sublayers in layer	Thickness of layer (m)	Maximum shear modulus G_{max} (MPa)	Initial critical damping ratio (%)	Total unit weight (kN/m³)	Shear wave velocity (m/sec)	Location and type of earthquake input motion	Location of water table	Depth at middle of layer (m)	Vertical effective stress (kPa)
Surface	1	1		3,0	56,19		18,0	175,0			1,50	27,0
	2	2		2,6	44,03		18,0	154,0		W	4,28	76,9
	3	3		1,5	50,00		18,0	165,1			6,30	106,0
	4	4		1,4	58,00		18,0	177,6			7,73	117,7
	5	5		1,4	144,52		19,0	273,2			9,08	129,4
	6	6		1,65	150,92		19,0	279,1			10,58	143,2
	7	7		1,65	135,34		18,0	271,0			12,23	157,6
	8	8		1,5	137,68		18,0	273,9			13,80	170,5
	9	9		1,5	136,77		18,0	273,0			15,30	182,8
	10	10		1,5	142,76		18,0	276,9			16,80	195,0
	11	11		1,5	133,23		18,0	260,5			18,30	207,3
	12	12		1,35	151,15		18,0	287,0			19,72	219,0
	13	13		1,5	176,45		19,0	301,8			21,15	231,4
	14	14		1,65	145,24		18,5	277,5			22,72	245,5
	15	15		1,35	157,49		18,5	280,0			24,22	258,5
	16	16		1,5	185,98		19,0	309,0			25,65	271,3
	17	17		1,5	175,26		18,5	304,0			27,15	284,7
	18	18		1,35	192,10		19,0	314,0			28,57	297,4
	19	19		1,65	195,82		19,0	316,0			30,07	311,2
	20	20		1,5	193,22		19,0	315,6			31,65	325,7
	21	21		1,5	199,51		19,0	321,0			33,15	339,4
	22	22		1,5	248,00		19,0	357,8			34,65	353,2
	23	23		1,5	212,13		19,5	326,7			36,15	367,4
	24	24		1,65	272,00		19,0	374,6			37,72	382,2
	25	25		1,4	276,00		19,0	377,5			39,25	396,3
	26	26		4,0	354,83		19,5	422,5			41,95	422,1
	27	27		8,0	474,95		19,0	495,2			47,95	478,2
	28	28		1,5	522,10		19,5	512,5			52,70	522,2
	29	29		1,5	547,04		19,5	524,6			54,20	536,8
	30	30		10,5	740,81		20,0	602,8			60,20	597,5
	31	31		1,5	800,21		20,0	626,5			66,20	658,7
	32	32		1,5	875,20		20,0	655,2			67,70	674,0
	33	33		4,5	1017,33		20,0	706,4			70,70	704,5
	34	34		4,0	1138,55		20,0	747,3			74,95	747,8
	35	35		1,0	1165,83		20,0	756,2			77,45	773,3
	36	36		7,0	1321,81		20,0	805,2			81,45	814,1
	37	37		9,0	1602,57		20,0	886,0			89,45	895,6
	38	38		21,0	2275,19		20,0	1050,4			104,45	1048,4
Bedrock	39	0			14091,74	1	24,0	2400,0	Outcrop		114,95	1155,4

Figure C.12 Soil parameters for ID24

	Layer Number	Soil Material Type	Number of sublayers in layer	Thickness of layer (m)	Maximum shear modulus G_{max} (MPa)	Initial critical damping ratio (%)	Total unit weight (kN/m^3)	Shear wave velocity (m/sec)	Location and type of earthquake input motion	Location of water table	Depth at middle of layer (m)	Vertical effective stress (kPa)
Surface	1	1		1,5	56,19		18,0	175,0			0,75	13,5
	2	2		1,5	62,88		18,5	182,6			2,25	40,9
	3	3		2,5	74,78		19,0	196,5			4,25	78,5
	4	4		0,5	79,25		18,5	205,0			5,75	106,9
	5	5		0,6	85,16		18,5	212,5			6,30	117,1
	6	6		2,0	110,44		18,5	242,0			7,60	141,1
	7	7		3,2	145,62		19,0	274,2		W	10,20	190,0
	8	8		1,2	154,79		18,5	286,5			12,40	225,6
	9	9		0,5	163,00		18,5	294,0			13,25	233,0
	10	10		3,0	204,95		19,0	325,3			15,00	249,0
	11	11		1,5	224,55		19,0	340,5			17,25	269,6
	12	12		2,5	265,19		18,5	375,0			19,25	287,4
	13	13		2,0	281,56		18,5	386,4			21,50	306,9
	14	14		5,5	350,16		19,0	425,2			25,25	340,9
	15	15		2,0	374,11		19,0	439,5			29,00	375,4
	16	16		1,2	395,70		19,0	452,0			30,60	390,1
	17	17		1,8	422,94		19,0	467,3			32,10	403,9
	18	18		4,5	508,94		19,5	506,0			35,25	433,9
	19	19		1,5	526,53		19,0	521,4			38,25	462,6
	20	20		11,0	640,17		19,5	567,5			44,50	522,8
	21	21		23,0	776,97		19,5	625,2			61,50	687,5
	22	22		3,0	841,86		20,0	642,6			74,50	814,3
Bedrock	23	0			14091,74	1	24,0	2400,0	Outcrop		76,00	829,5

Figure C.13 Soil parameters for ID25

Table C.1 EERA results for İzmir 1977 earthquake

D	İZMİR 1977 M=5,3							
	$a_{max,s}$	$a_{max,r}$	$a_{max,s}/a_{max,r}$	$Sa_{max,s}$	$Sa_{max,r}$	$Sa_{max,s}/Sa_{max,r}$	T(s)	T_0(s)
	g	g	-	g	g	-	s	s
1	0,18	0,18	0,99	0,59	0,61	0,96	0,38	0,09
4	0,19	0,18	1,07	0,81	0,61	1,34	0,39	0,10
8	0,15	0,18	0,83	0,65	0,61	1,08	0,42	0,11
9	0,22	0,18	1,20	0,75	0,61	1,23	0,06	0,11
11	0,11	0,18	0,61	0,41	0,61	0,67	1,02	0,10
12	0,18	0,18	0,99	0,78	0,61	1,28	0,55	0,10
13	0,18	0,18	1,02	0,70	0,61	1,15	0,65	0,10
14	0,09	0,18	0,49	0,39	0,61	0,64	0,65	0,10
15	0,13	0,18	0,71	0,40	0,61	0,66	0,51	0,12
16	0,22	0,18	1,23	0,47	0,61	0,78	0,75	0,11
23	0,35	0,18	1,94	1,41	0,43	3,27	0,57	0,10
24	0,34	0,18	1,91	1,11	0,43	2,56	0,76	0,09
25	0,30	0,18	1,68	1,11	0,43	2,56	0,63	0,10

Table C.2 EERA results for Urla 2003 earthquake

ID	URLA 2003 M=5,6							
	$a_{max,s}$	$a_{max,r}$	$a_{max,s}/a_{max,r}$	$Sa_{max,s}$	$Sa_{max,r}$	$Sa_{max,s}/Sa_{max,r}$	T(s)	T_0(s)
	g	g	-	g	g	-	s	s
1	0,07	0,03	2,21	0,30	0,09	3,29	0,38	0,48
4	0,09	0,03	2,76	0,37	0,09	4,05	0,42	0,55
8	0,07	0,03	2,24	0,31	0,09	3,37	0,37	0,48
9	0,03	0,03	1,02	0,09	0,09	1,01	0,06	0,80
11	0,06	0,03	2,05	0,35	0,09	3,83	1,02	1,25
12	0,09	0,03	3,07	0,35	0,09	3,89	0,55	0,58
13	0,09	0,03	3,02	0,42	0,09	4,66	0,65	0,80
14	0,05	0,03	1,62	0,22	0,09	2,38	0,65	0,80
15	0,09	0,03	3,05	0,40	0,09	4,41	0,51	0,56
16	0,13	0,03	4,06	0,32	0,09	3,55	0,75	0,80
23	0,13	0,03	4,14	0,55	0,13	4,14	0,57	0,54
24	0,15	0,03	4,94	0,60	0,13	4,48	0,76	0,80
25	0,13	0,03	4,27	0,57	0,13	4,26	0,63	0,55

Table C.3 EERA results for Urla 2005 earthquake

ID	URLA 2005 M=5,9							
	$a_{max,s}$	$a_{max,r}$	$a_{max,s}/a_{max,r}$	$Sa_{max,s}$	$Sa_{max,r}$	$Sa_{max,s}/Sa_{max,r}$	T(s)	T_0(s)
	g	g	-	g	g	-	s	s
1	0,07	0,04	1,82	0,35	0,12	2,83	0,38	0,51
4	0,10	0,04	2,61	0,56	0,12	4,44	0,42	0,55
8	0,07	0,04	1,81	0,35	0,12	2,81	0,37	0,51
9	0,06	0,04	1,57	0,20	0,12	1,62	0,06	0,07
11	0,09	0,04	2,37	0,43	0,12	3,45	1,02	1,15
12	0,11	0,04	2,93	0,48	0,12	3,87	0,55	0,64
13	0,11	0,04	2,83	0,53	0,12	4,23	0,65	0,88
14	0,08	0,04	2,07	0,37	0,12	2,98	0,65	1,15
15	0,11	0,04	2,83	0,51	0,12	4,11	0,51	0,56
16	0,13	0,04	3,49	0,47	0,12	3,78	0,75	0,88
23	0,12	0,04	3,29	0,61	0,12	4,95	0,57	0,53
24	0,11	0,04	2,99	0,45	0,12	3,69	0,76	0,68
25	0,11	0,04	2,81	0,62	0,12	5,04	0,63	0,55

Table C.4 EERA results for İzmir 1977 scenario earthquake

ID	IZMİR 1977 Scenario M=6,5							
	$a_{max,s}$	$a_{max,r}$	$a_{max,s}/a_{max,r}$	$Sa_{max,s}$	$Sa_{max,r}$	$Sa_{max,s}/Sa_{max,r}$	T(s)	T_0(s)
	g	g	-	g	g	-	s	s
1	0,32	0,36	0,89	1,18	1,22	0,97	0,38	0,09
4	0,30	0,36	0,82	1,28	1,22	1,05	0,39	0,10
8	0,45	0,36	1,24	1,99	1,22	1,62	0,37	0,10
9	0,39	0,36	1,07	1,39	1,22	1,14	0,06	0,11
11	0,20	0,36	0,54	0,78	1,22	0,64	1,02	0,10
12	0,31	0,36	0,85	1,36	1,22	1,11	0,55	0,10
13	0,34	0,36	0,93	1,31	1,22	1,07	0,65	0,10
14	0,16	0,36	0,45	0,73	1,22	0,60	0,65	0,10
15	0,22	0,36	0,61	0,64	1,22	0,52	0,51	0,12
16	0,22	0,36	0,61	0,73	1,22	0,60	0.51	0,12
23	0,64	0,36	1,79	2,77	0,95	2,93	0,57	0,11
24	0,65	0,36	1,82	2,32	0,95	2,45	0,76	0,10
25	0,49	0,36	1,35	1,91	0,95	2,02	0,63	0,10

Table C.5 EERA results for Urla 2003 scenario earthquake

ID	URLA 2003 Scenario M=6,5							
	$a_{max,s}$	$a_{max,r}$	$a_{max,s}/a_{max,r}$	$Sa_{max,s}$	$Sa_{max,r}$	$Sa_{max,s}/Sa_{max,r}$	T(s)	T_0(s)
	g	g	-	g	g	-	s	s
1	0,15	0,07	2,25	0,64	0,19	3,32	0,38	0,48
4	0,17	0,07	2,62	0,71	0,19	3,68	0,42	0,56
8	0,15	0,07	2,26	0,65	0,19	3,38	0,37	0,48
9	0,07	0,07	1,03	0,20	0,19	1,05	0,06	0,80
11	0,13	0,07	2,03	0,74	0,19	3,87	1,02	1,25
12	0,20	0,07	2,99	0,71	0,19	3,69	0,55	0,57
13	0,11	0,07	1,74	0,54	0,19	2,79	0,65	0,80
14	0,11	0,07	1,60	0,57	0,19	2,93	0,65	1,20
15	0,18	0,07	2,70	0,68	0,19	3,54	0,51	0,72
16	0,13	0,07	1,91	0,51	0,19	2,64	0,75	0,82
23	0,26	0,07	4,00	1,15	0,28	4,13	0,57	0,55
24	0,34	0,07	5,17	1,31	0,28	4,71	0,76	0,80
25	0,26	0,07	4,04	1,05	0,28	3,79	0,63	0,56

Table C.6 EERA results for Urla 2005 scenario earthquake

ID	URLA 2005 Scenario M=6,5							
	$a_{max,s}$	$a_{max,r}$	$a_{max,s}/a_{max,r}$	$Sa_{max,s}$	$Sa_{max,r}$	$Sa_{max,s}/Sa_{max,r}$	T(s)	T_0(s)
	g	g	-	g	g	-	s	s
1	0,11	0,06	1,92	0,58	0,20	2,97	0,38	0,53
4	0,15	0,06	2,54	0,82	0,20	4,19	0,42	0,56
8	0,11	0,06	1,90	0,57	0,20	2,91	0,37	0,51
9	0,07	0,06	1,13	0,20	0,20	1,02	0,06	0,56
11	0,13	0,06	2,28	0,63	0,20	3,20	1,02	1,20
12	0,11	0,06	1,87	0,48	0,12	3,87	0,55	0,64
13	0,12	0,06	2,06	0,57	0,20	2,92	0,65	1,15
14	0,12	0,06	1,99	0,55	0,20	2,81	0,65	1,15
15	0,15	0,06	2,61	0,71	0,20	3,64	0,51	0,68
16	0,13	0,06	2,23	0,58	0,20	2,98	0,75	0,88
23	0,19	0,06	3,29	1,03	0,20	5,09	0,57	0,54
24	0,19	0,06	3,17	0,69	0,20	3,41	0,76	0,90
25	0,16	0,06	2,77	0,93	0,20	4,58	0,63	0,55

APPENDIX D

SPECTRAL ACCELERATION GRAPHICS

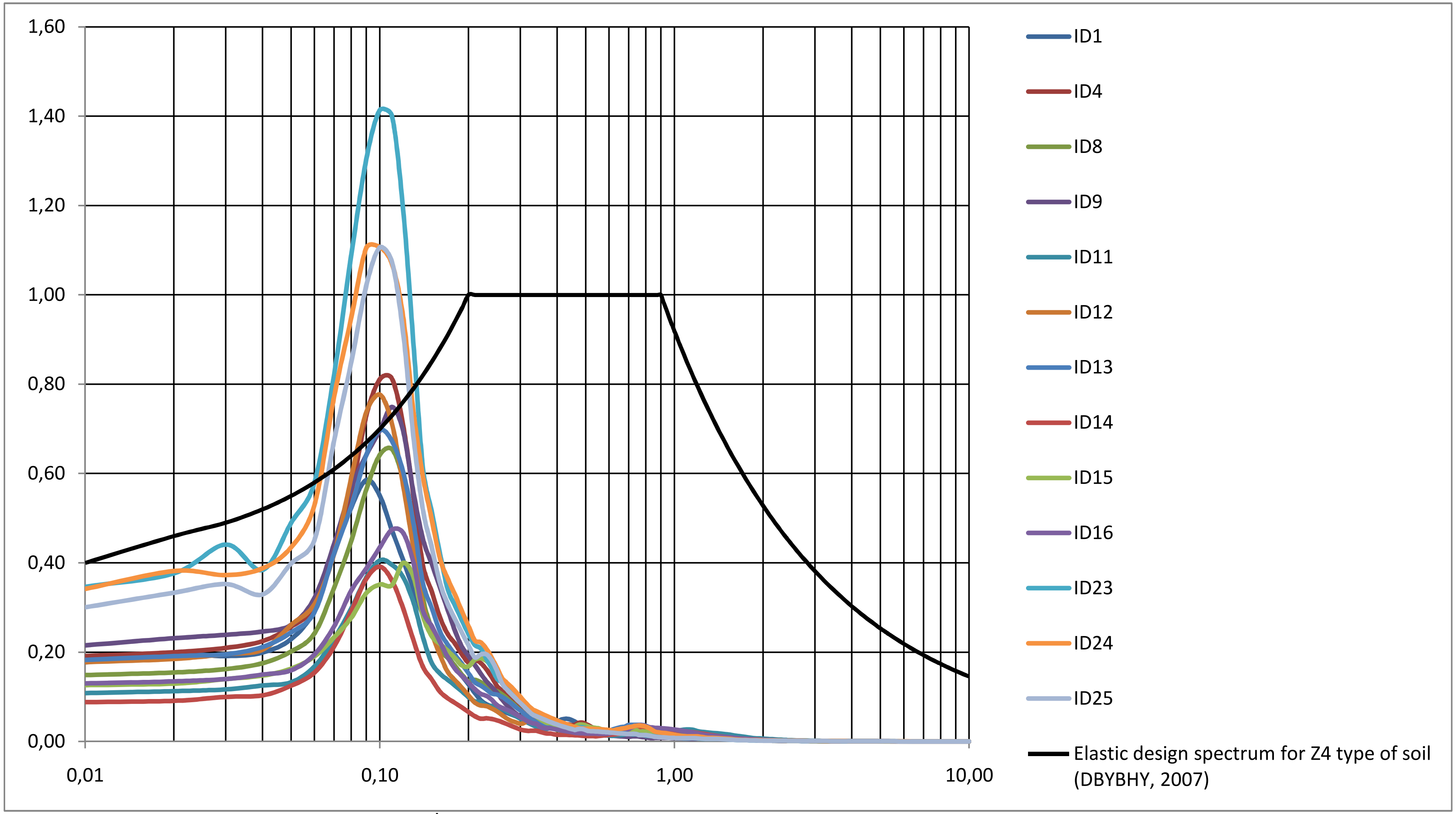

Figure D.1Spectral Acceleration versus Period for İzmir 1977 Earthquake

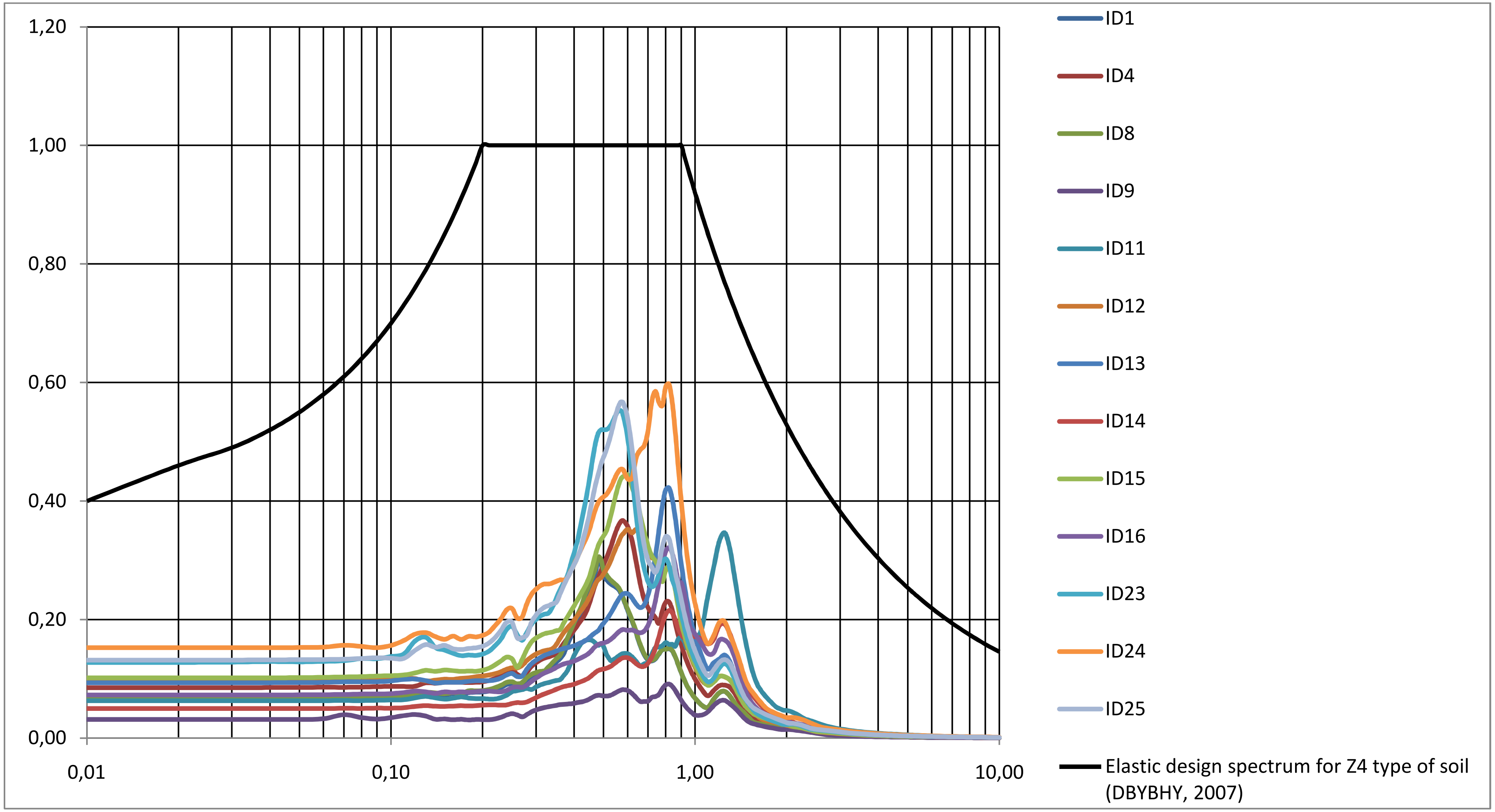

Figure D.2 Spectral Acceleration versus Period for Urla 2003 Earthquake

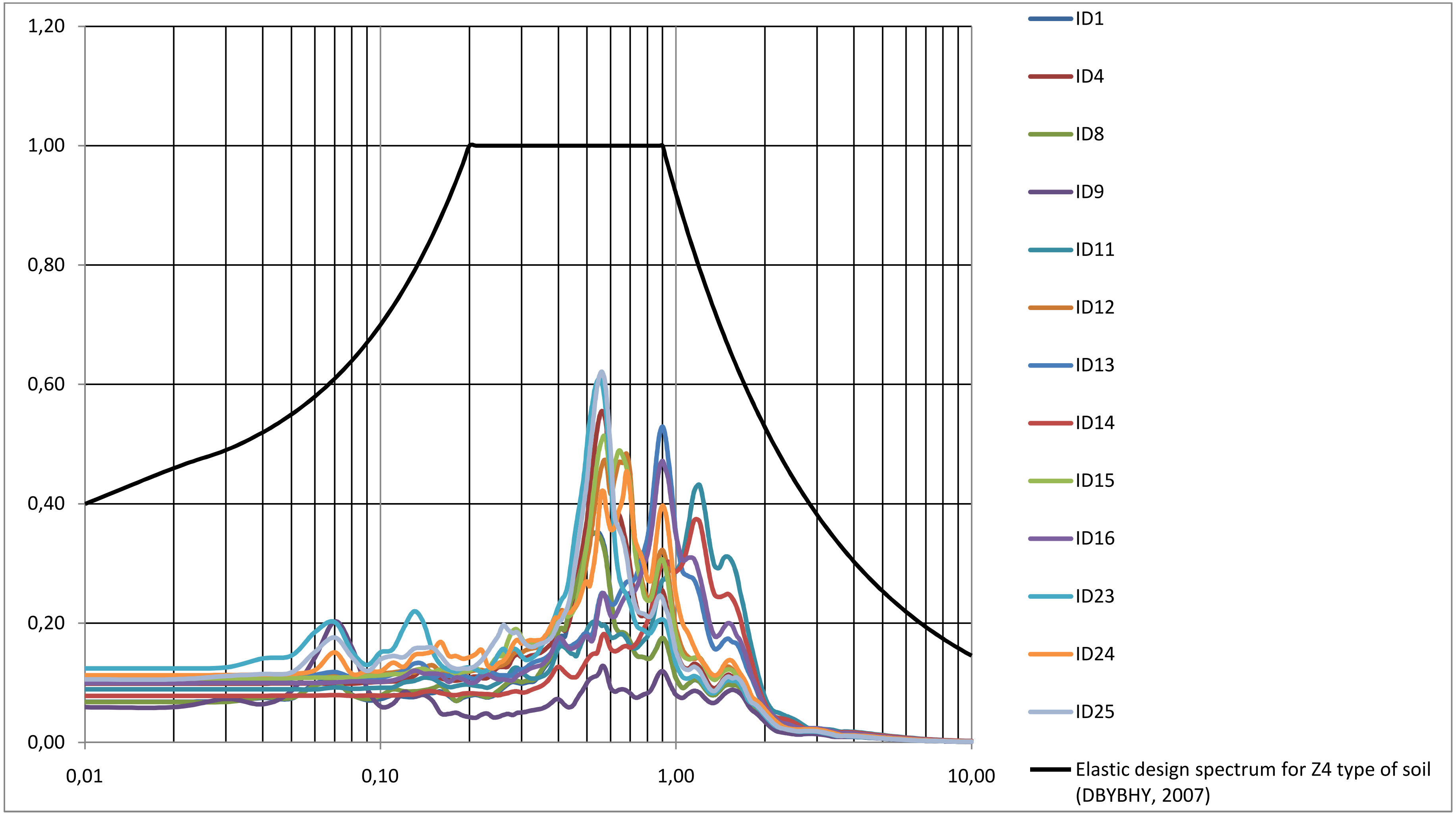

Figure D.3 Spectral Acceleration versus Period for Urla 2005 Earthquake

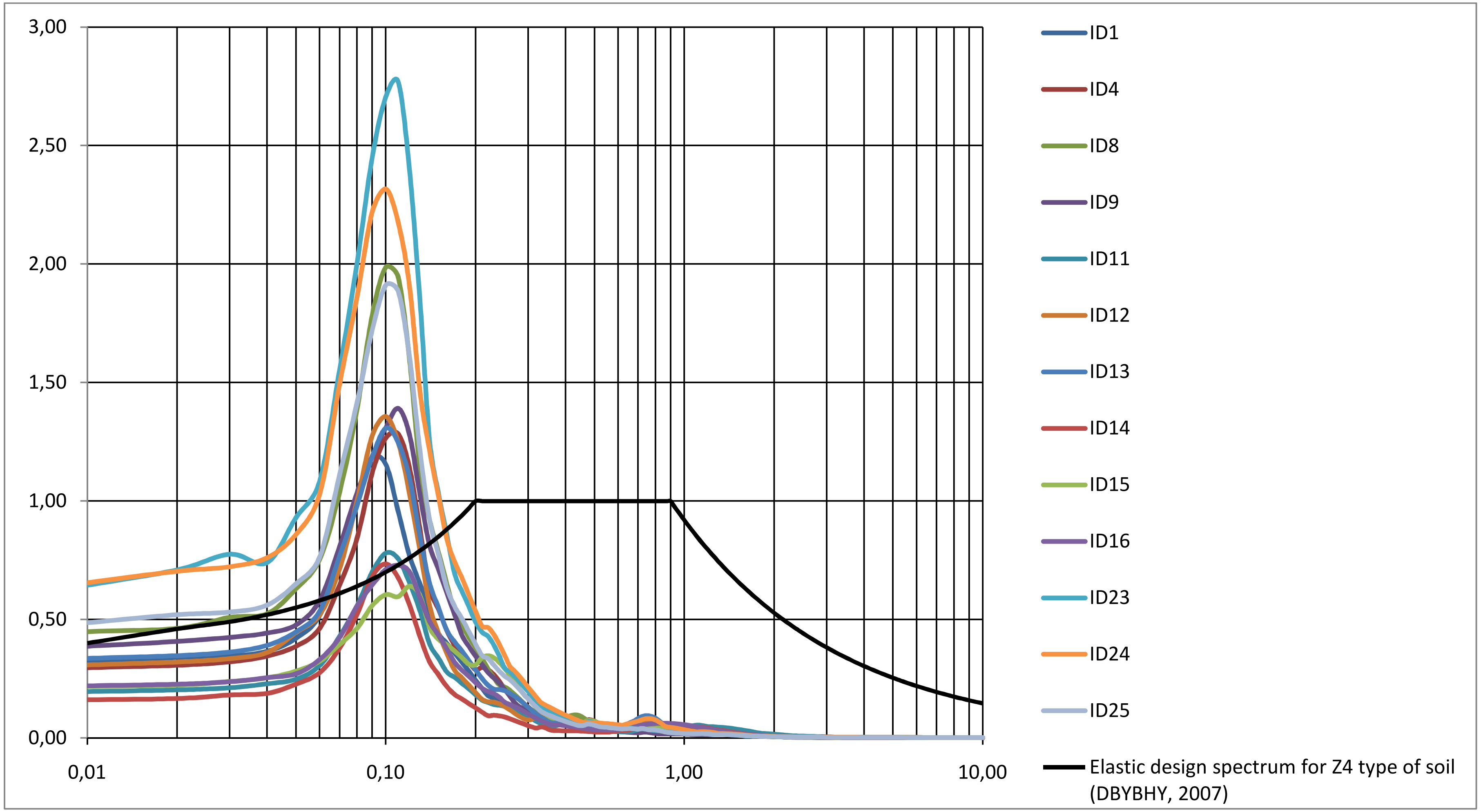

Figure D.4 Spectral Acceleration versus Period for İzmir 1977 Scenario Earthquake

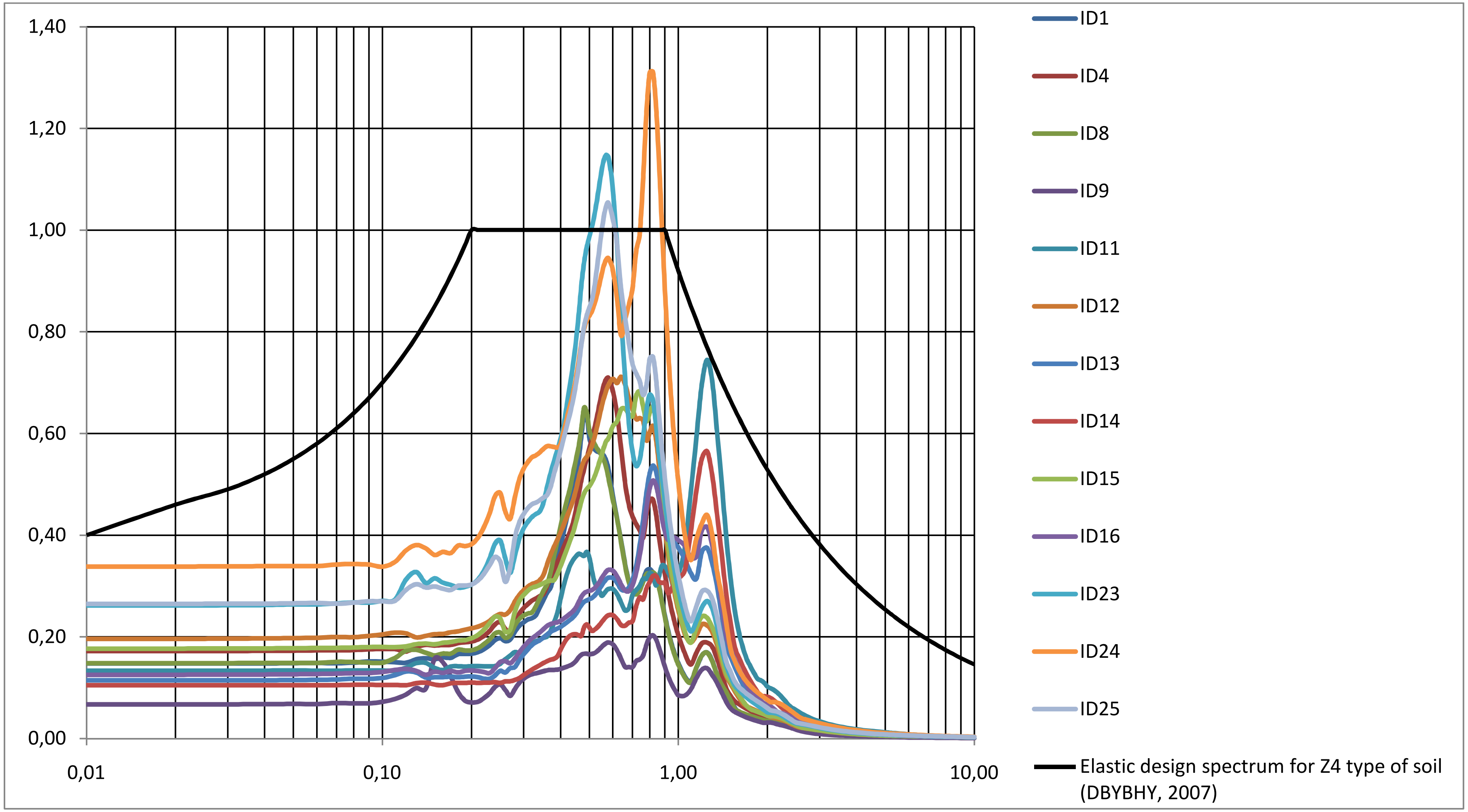

Figure D.5 Spectral Acceleration versus Period for Urla 2003 Scenario Earthquake

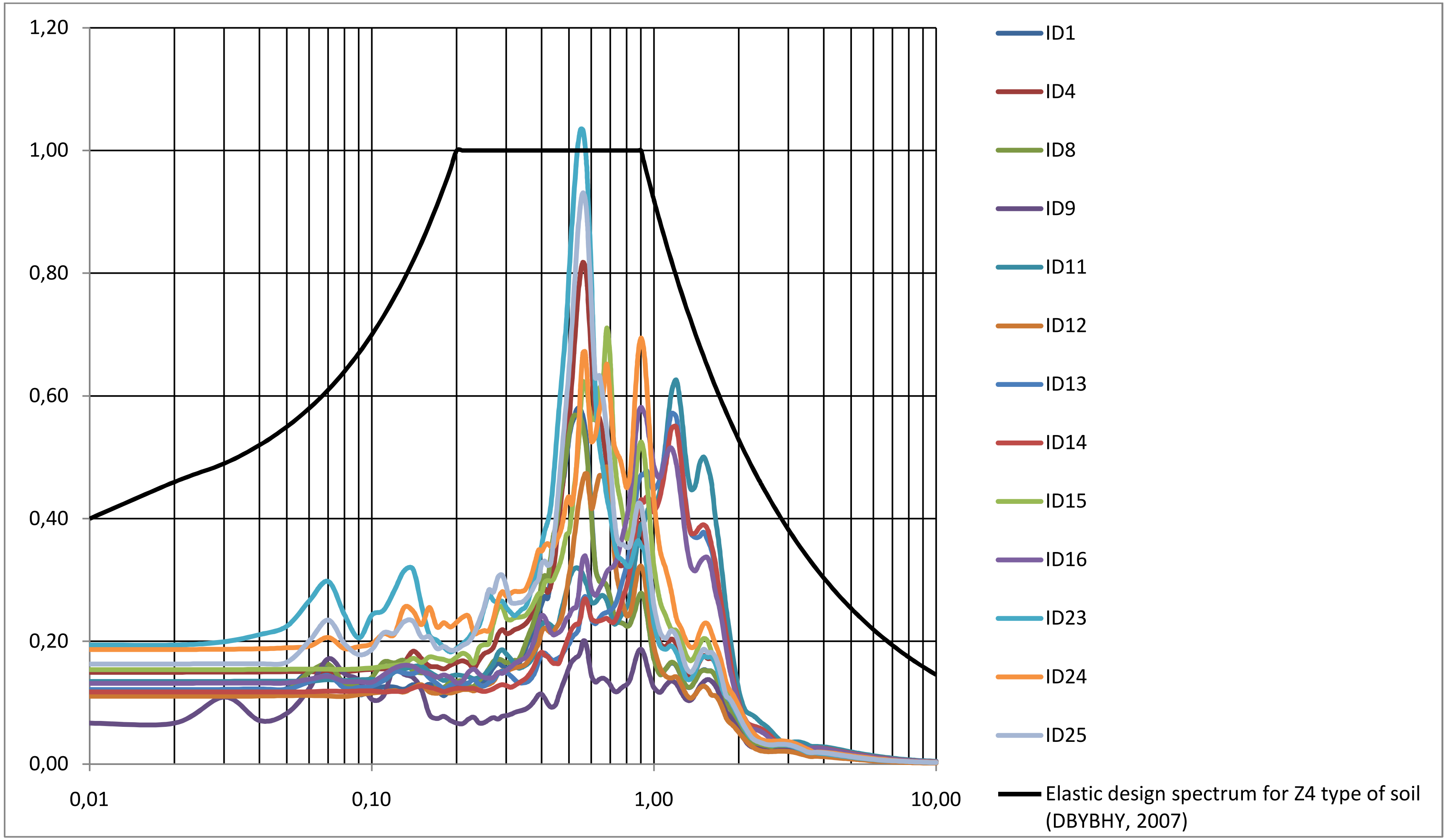

Figure D.6 Spectral Acceleration versus Period for Urla 2005 Scenario Earthquake

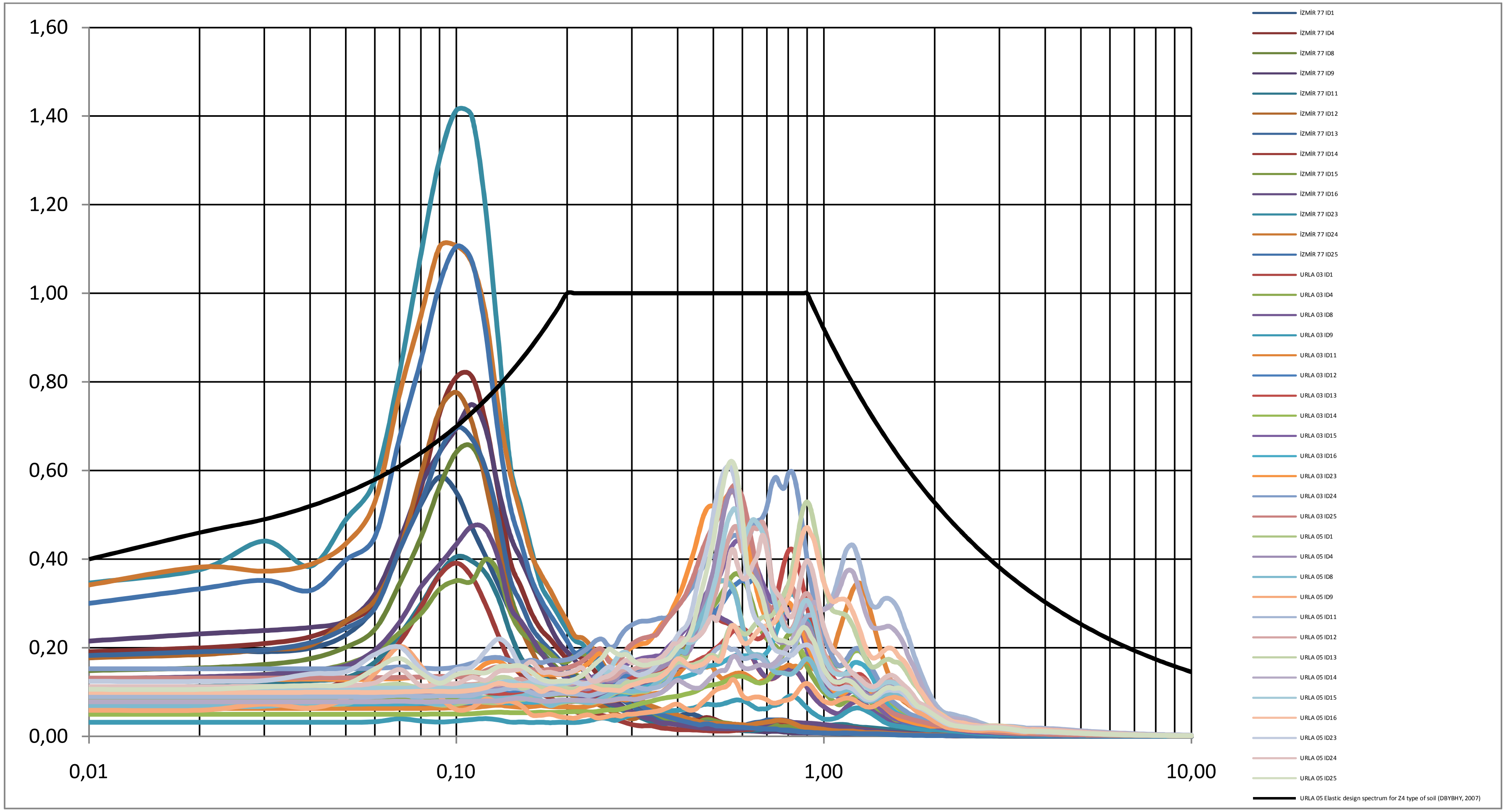

Figure D.7 Real Earthquakes

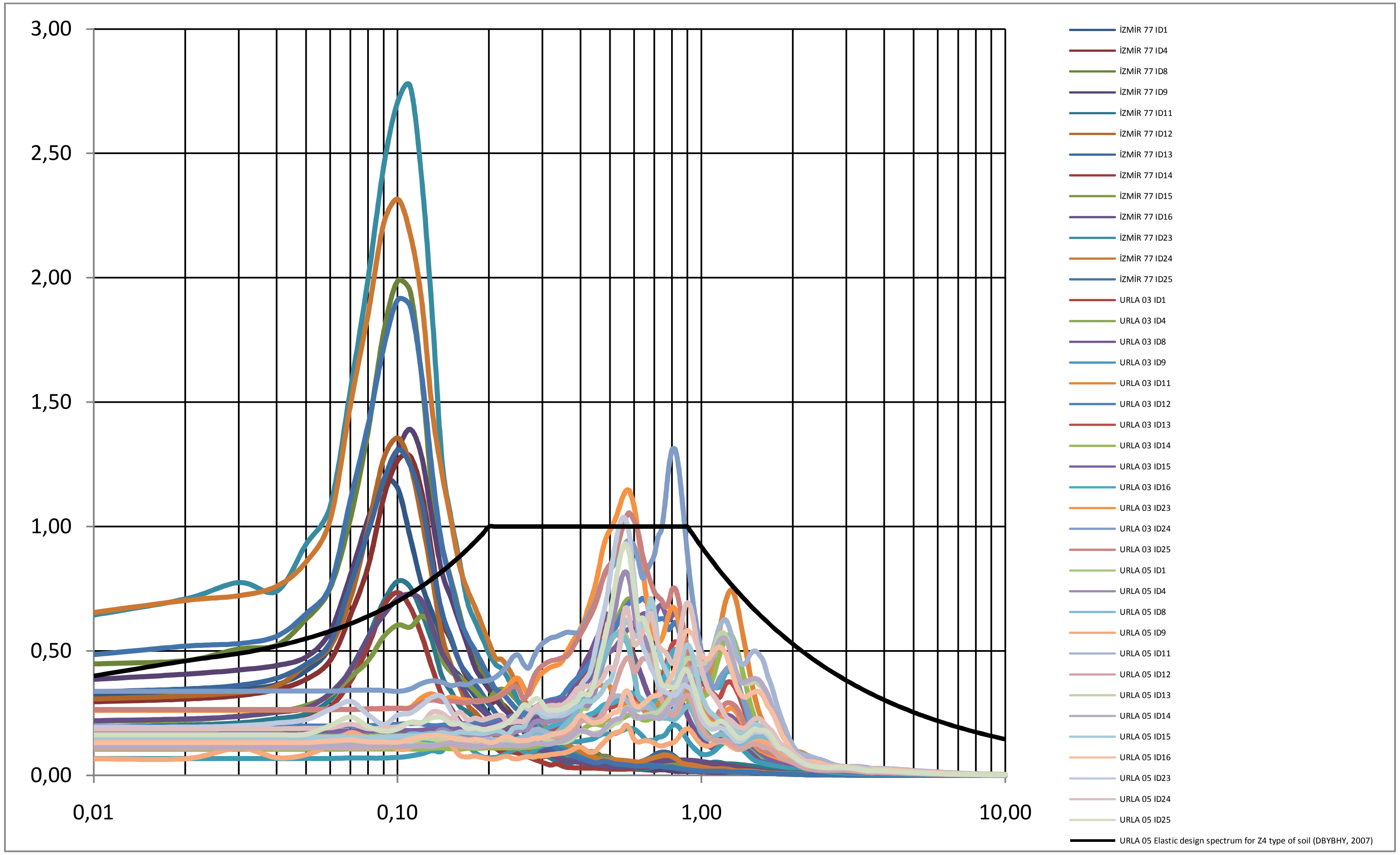

Figure D.8 Scenario Earthquakes

APPENDIX E

LIQUEFACTION RESULTS

Table E. 1 Liquefaction Results for İzmir 1977 Earthquake

ID	Boring Name	Depth	USCS	IZMIR 1977 M=5.3	
				F	
-	-	m	-	Seed and Idriss, 2001	Seed et al., 2003
1	1	3.25	SP	No Liquefaction	No Liquefaction
	1	5.75	SP	No Liquefaction	No Liquefaction
	1	7.25	SP	0.29	0.34
	1	11.25	SP	No Liquefaction	No Liquefaction
	1	12.75	SP	0.71	Absent Data
	1	13.75	SP	0.41	Absent Data
4	2	2.75	SP	0.23	0.23
	2	4.25	SP	No Liquefaction	No Liquefaction
	2	5.75	SP	No Liquefaction	No Liquefaction
	2	7.25	SP	0.58	0.60
	2	8.75	SP	0.55	0.58
	2	11.75	SP	0.36	Absent Data
	2	13.25	SP	0.39	Absent Data
	2	14.75	SP	0.16	Absent Data

Table E. 2 Liquefaction Results for İzmir 1977 Earthquake

ID	Boring Name	Depth	USCS	IZMIR 1977 M=5.3	
				F	
-	-	m	-	Seed and Idriss, 2001	Seed et al., 2003
8	3	1.25	SP	No Liquefaction	No Liquefaction
	3	5.75	SW	No Liquefaction	No Liquefaction
	3	6.25	SP	No Liquefaction	No Liquefaction
9	4	2.70	SP	0.89	Absent Data
11	SK-5	9.25	CH	No Liquefaction	No Liquefaction
	SK-5	10.75	CH	No Liquefaction	No Liquefaction
	SK-5	12.25	CL	No Liquefaction	No Liquefaction
	SK-5	13.75	ML	No Liquefaction	No Liquefaction

Table E. 3 Liquefaction Results for İzmir 1977 Earthquake

ID	Boring Name	Depth	USCS	IZMIR 1977 M=5.3	
-	-	m	-	F	
				Seed and Idriss, 2001	Seed et al., 2003
12	SK-2	10.75	FC=95.1%	No Liquefaction	No Liquefaction
	SK-2	12.75	FC=76.6%	No Liquefaction	No Liquefaction
	SK-2	14.25	SM-SC	No Liquefaction	No Liquefaction
	SK-2	15.75	CL	No Liquefaction	No Liquefaction
13	SK-13	6.75	CL	No Liquefaction	No Liquefaction
	SK-13	10.25	CL	No Liquefaction	No Liquefaction
	SK-13	11.75	CL	No Liquefaction	No Liquefaction
	SK-13	13.25	CH	No Liquefaction	No Liquefaction
14	SK-181	14.25	SC	No Liquefaction	No Liquefaction
	SK-181	15.75	CL	No Liquefaction	No Liquefaction
15	L-1	3.75	GP-GM	No Liquefaction	No Liquefaction
	L-1	6.75	ML	No Liquefaction	No Liquefaction
	L-1	9.75	SM	No Liquefaction	No Liquefaction
	L-1	10.75	CH	No Liquefaction	No Liquefaction
16	L-6	3.75	GP-GM	No Liquefaction	No Liquefaction
	L-6	6.75	SM	No Liquefaction	No Liquefaction
	L-6	9.75	SM	No Liquefaction	No Liquefaction
	L-6	12.75	CL	No Liquefaction	No Liquefaction
	L-6	15.75	CH	No Liquefaction	No Liquefaction

Table E. 4 Liquefaction Results for İzmir 1977 Earthquake

ID	Boring Name	Depth	USCS	IZMIR 1977 M=5.3	
-	-	m	-	F	
				Seed and Idriss, 2001	Seed et al., 2003
22	SPT-3	4.80	Clay	No Liquefaction	Absent Data
	SPT-4	6.30	Clay	No Liquefaction	Absent Data
	SPT-5	7.80	Clay	No Liquefaction	Absent Data
	SPT-6	9.00	Gravel	No Liquefaction	No Liquefaction
	SPT-7	10.50	Gravel	No Liquefaction	No Liquefaction
	SPT-8	12.30	SC	0.93	Absent Data
	SPT-9	13.80	Sand	0.21	Absent Data

Table E. 5 Liquefaction Results for İzmir Scenario 1977 Earthquake

ID	Boring Name	Depth	USCS	İZMİR 1977 Scenario M=6.5	
				F	
-	-	m	-	SEED AND IDRİSS, 2001	Seed et al., 2003
1	1	3.25	SP	No Liquefaction	No Liquefaction
	1	5.75	SP	0.90	0.60
	1	7.25	SP	0.16	0.12
	1	11.25	SP	No Liquefaction	No Liquefaction
	1	12.75	SP	0.39	Absent Data
	1	13.75	SP	0.22	Absent Data
4	2	2.75	SP	0.15	0.10
	2	4.25	SP	No Liquefaction	0.84
	2	5.75	SP	0.79	0.54
	2	7.25	SP	0.37	0.26
	2	8.75	SP	0.36	0.25
	2	11.75	SP	0.23	Absent Data
	2	13.25	SP	0.25	Absent Data
	2	14.75	SP	0.11	Absent Data

Table E. 6 Liquefaction Results for İzmir Scenario 1977 Earthquake

ID	Boring Name	Depth	USCS	İZMİR 1977 Scenario M=6.5	
				F	
-	-	m	-	SEED AND IDRİSS, 2001	Seed et al., 2003
8	3	1.25	SP	No Liquefaction	No Liquefaction
	3	5.75	SW	No Liquefaction	0.66
	3	6.25	SP	0.66	0.45
9	4	2.70	SP	0.49	Absent Data
11	SK-5	9.25	CH	No Liquefaction	Absent Data
	SK-5	10.75	CH	No Liquefaction	Absent Data
	SK-5	12.25	CL	No Liquefaction	No Liquefaction
	SK-5	13.75	ML	No Liquefaction	No Liquefaction

Table E. 7 Liquefaction Results for İzmir Scenario 1977 Earthquake

ID	Boring Name	Depth	USCS	İZMİR 1977 Scenario M=6.5	
				F	
-	-	m	-	SEED AND IDRİSS, 2001	Seed et al., 2003
12	SK-2	10.75	FC=95.1%	No Liquefaction	Absent Data
	SK-2	12.75	FC=76.6%	No Liquefaction	No Liquefaction
	SK-2	14.25	SM-SC	No Liquefaction	No Liquefaction
	SK-2	15.75	CL	No Liquefaction	No Liquefaction
13	SK-13	6.75	CL	No Liquefaction	Absent Data
	SK-13	10.25	CL	No Liquefaction	Absent Data
	SK-13	11.75	CL	No Liquefaction	Absent Data
	SK-13	13.25	CH	No Liquefaction	No Liquefaction
14	SK-181	14.25	SC	No Liquefaction	No Liquefaction
	SK-181	15.75	CL	No Liquefaction	No Liquefaction
15	L-1	3.75	GP-GM	No Liquefaction	No Liquefaction
	L-1	6.75	ML	No Liquefaction	Absent Data
	L-1	9.75	SM	0.26	Absent Data
	L-1	10.75	CH	No Liquefaction	Absent Data
16	L-6	3.75	GP-GM	No Liquefaction	No Liquefaction
	L-6	6.75	SM	No Liquefaction	Absent Data
	L-6	9.75	SM	0.22	Absent Data
	L-6	12.75	CL	No Liquefaction	No Liquefaction
	L-6	15.75	CH	No Liquefaction	No Liquefaction

Table E. 8 Liquefaction Results for İzmir Scenario 1977 Earthquake

ID	Boring Name	Depth	USCS	İZMİR 1977 Scenario M=6.5	
				F	
-	-	m	-	SEED AND IDRİSS, 2001	Seed et al., 2003
22	SPT-3	4.80	Clay	No Liquefaction	Absent Data
	SPT-4	6.30	Clay	No Liquefaction	Absent Data
	SPT-5	7.80	Clay	No Liquefaction	Absent Data
	SPT-6	9.00	Gravel	No Liquefaction	No Liquefaction
	SPT-7	10.50	Gravel	No Liquefaction	No Liquefaction
	SPT-8	12.30	SC	0.59	Absent Data
	SPT-9	13.80	Sand	0.13	Absent Data

Table E. 9 Liquefaction Results for Urla 2003 Earthquake

ID	Boring Name	Depth	USCS	URLA 2003 M=5.6	
				F	
-	-	m	-	SEED AND IDRİSS, 2001	Seed et al., 2003
1	1	3.25	SP	No Liquefaction	No Liquefaction
	1	5.75	SP	No Liquefaction	No Liquefaction
	1	7.25	SP	0.84	0.84
	1	11.25	SP	No Liquefaction	No Liquefaction
	1	12.75	SP	0.82	Absent Data
	1	13.75	SP	0.47	Absent Data
4	2	2.75	SP	0.24	0.50
	2	4.25	SP	No Liquefaction	No Liquefaction
	2	5.75	SP	No Liquefaction	No Liquefaction
	2	7.25	SP	0.62	No Liquefaction
	2	8.75	SP	0.59	No Liquefaction
	2	11.75	SP	0.38	Absent Data
	2	13.25	SP	0.42	No Liquefaction
	2	14.75	SP	0.28	No Liquefaction

Table E. 10 Liquefaction Results for Urla 2003 Earthquake

ID	Boring Name	Depth	USCS	URLA 2003 M=5.6	
				F	
-	-	m	-	SEED AND IDRİSS, 2001	Seed et al., 2003
8	3	1.25	SP	No Liquefaction	No Liquefaction
	3	5.75	SW	No Liquefaction	No Liquefaction
	3	6.25	SP	No Liquefaction	No Liquefaction
9	4	2.70	SP	No Liquefaction	Absent Data
11	SK-5	9.25	CH	No Liquefaction	Absent Data
	SK-5	10.75	CH	No Liquefaction	Absent Data
	SK-5	12.25	CL	No Liquefaction	No Liquefaction
	SK-5	13.75	ML	No Liquefaction	No Liquefaction

Table E. 11 Liquefaction Results for Urla 2003 Earthquake

ID	Boring Name	Depth	USCS	URLA 2003 M=5.6	
				F	
-	-	m	-	SEED AND IDRİSS, 2001	Seed et al., 2003
12	SK-2	10.75	FC=95.1%	No Liquefaction	Absent Data
	SK-2	12.75	FC=76.6%	No Liquefaction	No Liquefaction
	SK-2	14.25	SM-SC	No Liquefaction	No Liquefaction
	SK-2	15.75	CL	No Liquefaction	No Liquefaction
13	SK-13	6.75	CL	No Liquefaction	Absent Data
	SK-13	10.25	CL	No Liquefaction	Absent Data
	SK-13	11.75	CL	No Liquefaction	Absent Data
	SK-13	13.25	CH	No Liquefaction	No Liquefaction
14	SK-181	14.25	SC	No Liquefaction	No Liquefaction
	SK-181	15.75	CL	No Liquefaction	No Liquefaction
15	L-1	3.75	GP-GM	No Liquefaction	No Liquefaction
	L-1	6.75	ML	No Liquefaction	Absent Data
	L-1	9.75	SM	No Liquefaction	Absent Data
	L-1	10.75	CH	No Liquefaction	Absent Data
16	L-6	3.75	GP-GM	No Liquefaction	No Liquefaction
	L-6	6.75	SM	No Liquefaction	Absent Data
	L-6	9.75	SM	No Liquefaction	Absent Data
	L-6	12.75	CL	No Liquefaction	No Liquefaction
	L-6	15.75	CH	No Liquefaction	No Liquefaction

Table E. 12 Liquefaction Results for Urla 2003 Earthquake

ID	Boring Name	Depth	USCS	URLA 2003 M=5.6	
				F	
-	-	m	-	SEED AND IDRİSS, 2001	Seed et al., 2003
22	SPT-3	4.80	Clay	No Liquefaction	Absent Data
	SPT-4	6.30	Clay	No Liquefaction	Absent Data
	SPT-5	7.80	Clay	No Liquefaction	Absent Data
	SPT-6	9.00	Gravel	No Liquefaction	No Liquefaction
	SPT-7	10.50	Gravel	No Liquefaction	No Liquefaction
	SPT-8	12.30	SC	No Liquefaction	Absent Data
	SPT-9	13.80	Sand	0.54	Absent Data

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Table E. 13 Liquefaction Results for Urla 2003 Scenario Earthquake

ID	Boring Name	Depth	USCS	URLA 2003 Scenario M=6.5	
				F	
-	-	m	-	SEED AND IDRİSS, 2001	Seed et al., 2003
1	1	3.25	SP	No Liquefaction	No Liquefaction
	1	5.75	SP	No Liquefaction	No Liquefaction
	1	7.25	SP	0.23	0.26
	1	11.25	SP	No Liquefaction	No Liquefaction
	1	12.75	SP	0.56	No Liquefaction
	1	13.75	SP	0.32	No Liquefaction
4	2	2.75	SP	0.17	0.17
	2	4.25	SP	No Liquefaction	No Liquefaction
	2	5.75	SP	0.89	0.91
	2	7.25	SP	0.42	0.43
	2	8.75	SP	0.40	0.41
	2	11.75	SP	0.26	Absent Data
	2	13.25	SP	0.29	No Liquefaction
	2	14.75	SP	0.19	No Liquefaction

Table E. 14 Liquefaction Results for Urla 2003 Scenario Earthquake

ID	Boring Name	Depth	USCS	URLA 2003 Scenario M=6.5	
				F	
-	-	m	-	SEED AND IDRİSS, 2001	Seed et al., 2003
8	3	1.25	SP	No Liquefaction	No Liquefaction
	3	5.75	SW	No Liquefaction	No Liquefaction
	3	6.25	SP	No Liquefaction	No Liquefaction
9	4	2.70	SP	No Liquefaction	Absent Data
11	SK-5	9.25	CH	No Liquefaction	Absent Data
	SK-5	10.75	CH	No Liquefaction	Absent Data
	SK-5	12.25	CL	No Liquefaction	No Liquefaction
	SK-5	13.75	ML	No Liquefaction	No Liquefaction

Table E. 15 Liquefaction Results for Urla 2003 Scenario Earthquake

ID	Boring Name	Depth	USCS	URLA 2003 Scenario M=6.5	
				F	
-	-	m	-	SEED AND IDRİSS, 2001	Seed et al., 2003
12	SK-2	10.75	FC=95.1%	No Liquefaction	Absent Data
	SK-2	12.75	FC=76.6%	No Liquefaction	No Liquefaction
	SK-2	14.25	SM-SC	No Liquefaction	No Liquefaction
	SK-2	15.75	CL	No Liquefaction	No Liquefaction
13	SK-13	6.75	CL	No Liquefaction	Absent Data
	SK-13	10.25	CL	No Liquefaction	Absent Data
	SK-13	11.75	CL	No Liquefaction	Absent Data
	SK-13	13.25	CH	No Liquefaction	No Liquefaction
14	SK-181	14.25	SC	No Liquefaction	No Liquefaction
	SK-181	15.75	CL	No Liquefaction	No Liquefaction
15	L-1	3.75	GP-GM	No Liquefaction	No Liquefaction
	L-1	6.75	ML	0.91	Absent Data
	L-1	9.75	SM	0.57	Absent Data
	L-1	10.75	CH	No Liquefaction	Absent Data
16	L-6	3.75	GP-GM	No Liquefaction	No Liquefaction
	L-6	6.75	SM	0.93	Absent Data
	L-6	9.75	SM	0.64	Absent Data
	L-6	12.75	CL	No Liquefaction	No Liquefaction
	L-6	15.75	CH	No Liquefaction	No Liquefaction

Table E. 16 Liquefaction Results for Urla 2003 Scenario Earthquake

ID	Boring Name	Depth	USCS	URLA 2003 Scenario M=6.5	
				F	
-	-	m	-	SEED AND IDRİSS, 2001	Seed et al., 2003
22	SPT-3	4.80	Clay	No Liquefaction	Absent Data
	SPT-4	6.30	Clay	No Liquefaction	Absent Data
	SPT-5	7.80	Clay	No Liquefaction	Absent Data
	SPT-6	9.00	Gravel	No Liquefaction	No Liquefaction
	SPT-7	10.50	Gravel	No Liquefaction	No Liquefaction
	SPT-8	12.30	SC	No Liquefaction	Absent Data
	SPT-9	13.80	Sand	0.27	Absent Data

Table E. 17 Liquefaction Results for Urla 2005 Earthquake

ID	Boring Name	Depth	USCS	URLA 2005 M=5.9	
				F	
-	-	m	-	**SEED AND IDRİSS, 2001**	**Seed et al., 2003**
1	1	3.25	SP	No Liquefaction	No Liquefaction
	1	5.75	SP	No Liquefaction	No Liquefaction
	1	7.25	SP	0.63	0.72
	1	11.25	SP	No Liquefaction	No Liquefaction
	1	12.75	SP	No Liquefaction	No Liquefaction
	1	13.75	SP	0.89	No Liquefaction
4	2	2.75	SP	0.37	0.38
	2	4.25	SP	No Liquefaction	No Liquefaction
	2	5.75	SP	No Liquefaction	No Liquefaction
	2	7.25	SP	0.94	0.97
	2	8.75	SP	0.90	0.93
	2	11.75	SP	0.59	Absent Data
	2	13.25	SP	0.64	No Liquefaction
	2	14.75	SP	0.27	No Liquefaction

Table E. 18 Liquefaction Results for Urla 2005 Earthquake

ID	Boring Name	Depth	USCS	URLA 2005 M=5.9	
				F	
-	-	m	-	**SEED AND IDRİSS, 2001**	**Seed et al., 2003**
8	3	1.25	SP	No Liquefaction	No Liquefaction
	3	5.75	SW	No Liquefaction	No Liquefaction
	3	6.25	SP	No Liquefaction	No Liquefaction
9	4	2.70	SP	No Liquefaction	Absent Data
11	SK-5	9.25	CH	No Liquefaction	Absent Data
	SK-5	10.75	CH	No Liquefaction	Absent Data
	SK-5	12.25	CL	No Liquefaction	No Liquefaction
	SK-5	13.75	ML	No Liquefaction	No Liquefaction

Table E. 19 Liquefaction Results for Urla 2005 Earthquake

ID	Boring Name	Depth	USCS	URLA 2005 M=5.9	
				F	
-	-	m	-	SEED AND IDRİSS, 2001	Seed et al., 2003
12	SK-2	10.75	FC=95.1%	No Liquefaction	Absent Data
	SK-2	12.75	FC=76.6%	No Liquefaction	No Liquefaction
	SK-2	14.25	SM-SC	No Liquefaction	No Liquefaction
	SK-2	15.75	CL	No Liquefaction	No Liquefaction
13	SK-13	6.75	CL	No Liquefaction	Absent Data
	SK-13	10.25	CL	No Liquefaction	Absent Data
	SK-13	11.75	CL	No Liquefaction	Absent Data
	SK-13	13.25	CH	No Liquefaction	No Liquefaction
14	SK-181	14.25	SC	No Liquefaction	No Liquefaction
	SK-181	15.75	CL	No Liquefaction	No Liquefaction
15	L-1	3.75	GP-GM	No Liquefaction	No Liquefaction
	L-1	6.75	ML	No Liquefaction	Absent Data
	L-1	9.75	SM	No Liquefaction	Absent Data
	L-1	10.75	CH	No Liquefaction	Absent Data
16	L-6	3.75	GP-GM	No Liquefaction	No Liquefaction
	L-6	6.75	SM	No Liquefaction	Absent Data
	L-6	9.75	SM	No Liquefaction	Absent Data
	L-6	12.75	CL	No Liquefaction	No Liquefaction
	L-6	15.75	CH	No Liquefaction	No Liquefaction

Table E. 20 Liquefaction Results for Urla 2005 Earthquake

ID	Boring Name	Depth	USCS	URLA 2005 M=5.9	
				F	
-	-	m	-	SEED AND IDRİSS, 2001	Seed et al., 2003
22	SPT-3	4.80	Clay	No Liquefaction	Absent Data
	SPT-4	6.30	Clay	No Liquefaction	Absent Data
	SPT-5	7.80	Clay	No Liquefaction	Absent Data
	SPT-6	9.00	Gravel	No Liquefaction	No Liquefaction
	SPT-7	10.50	Gravel	No Liquefaction	No Liquefaction
	SPT-8	12.30	SC	No Liquefaction	Absent Data
	SPT-9	13.80	Sand	0.45	Absent Data

Table E. 21 Liquefaction Results for Urla 2005 Scenario Earthquake

ID	Boring Name	Depth	USCS	URLA 2005 Scenario M=6.5	
				F	
-	-	m	-	SEED AND IDRİSS, 2001	Seed et al., 2003
1	1	3.25	SP	No Liquefaction	No Liquefaction
	1	5.75	SP	No Liquefaction	No Liquefaction
	1	7.25	SP	0.30	0.33
	1	11.25	SP	No Liquefaction	No Liquefaction
	1	12.75	SP	0.73	No Liquefaction
	1	13.75	SP	0.42	No Liquefaction
4	2	2.75	SP	0.19	0.19
	2	4.25	SP	No Liquefaction	No Liquefaction
	2	5.75	SP	No Liquefaction	No Liquefaction
	2	7.25	SP	0.48	0.50
	2	8.75	SP	0.46	0.47
	2	11.75	SP	0.30	Absent Data
	2	13.25	SP	0.33	No Liquefaction
	2	14.75	SP	0.14	No Liquefaction

Table E. 22 Liquefaction Results for Urla 2005 Scenario Earthquake

ID	Boring Name	Depth	USCS	URLA 2005 Scenario M=6.5	
				F	
-	-	m	-	SEED AND IDRİSS, 2001	Seed et al., 2003
8	3	1.25	SP	No Liquefaction	No Liquefaction
	3	5.75	SW	No Liquefaction	No Liquefaction
	3	6.25	SP	No Liquefaction	No Liquefaction
9	4	2.70	SP	No Liquefaction	Absent Data
11	SK-5	9.25	CH	No Liquefaction	Absent Data
	SK-5	10.75	CH	No Liquefaction	Absent Data
	SK-5	12.25	CL	No Liquefaction	No Liquefaction
	SK-5	13.75	ML	No Liquefaction	No Liquefaction

Table E. 23 Liquefaction Results for Urla 2005 Scenario Earthquake

ID	Boring Name	Depth	USCS	URLA 2005 Scenario M=6.5	
				F	
-	-	m	-	SEED AND IDRİSS, 2001	Seed et al., 2003
12	SK-2	10.75	FC=95.1%	No Liquefaction	Absent Data
	SK-2	12.75	FC=76.6%	No Liquefaction	No Liquefaction
	SK-2	14.25	SM-SC	No Liquefaction	No Liquefaction
	SK-2	15.75	CL	No Liquefaction	No Liquefaction
13	SK-13	6.75	CL	No Liquefaction	Absent Data
	SK-13	10.25	CL	No Liquefaction	Absent Data
	SK-13	11.75	CL	No Liquefaction	Absent Data
	SK-13	13.25	CH	No Liquefaction	No Liquefaction
14	SK-181	14.25	SC	No Liquefaction	No Liquefaction
	SK-181	15.75	CL	No Liquefaction	No Liquefaction
15	L-1	3.75	GP-GM	No Liquefaction	No Liquefaction
	L-1	6.75	ML	No Liquefaction	Absent Data
	L-1	9.75	SM	0.31	Absent Data
	L-1	10.75	CH	No Liquefaction	Absent Data
16	L-6	3.75	GP-GM	No Liquefaction	No Liquefaction
	L-6	6.75	SM	0.88	Absent Data
	L-6	9.75	SM	0.33	Absent Data
	L-6	12.75	CL	No Liquefaction	No Liquefaction
	L-6	15.75	CH	No Liquefaction	No Liquefaction

Table E. 24 Liquefaction Results for Urla 2005 Scenario Earthquake

ID	Boring Name	Depth	USCS	URLA 2005 Scenario M=6.5	
				F	
-	-	m	-	SEED AND IDRİSS, 2001	Seed et al., 2003
22	SPT-3	4.80	Clay	No Liquefaction	Absent Data
	SPT-4	6.30	Clay	No Liquefaction	Absent Data
	SPT-5	7.80	Clay	No Liquefaction	Absent Data
	SPT-6	9.00	Gravel	No Liquefaction	No Liquefaction
	SPT-7	10.50	Gravel	No Liquefaction	No Liquefaction
	SPT-8	12.30	SC	No Liquefaction	Absent Data
	SPT-9	13.80	Sand	0.22	Absent Data

APPENDIX F

SAFETY FACTORS AGAINST LIQUEFACTION, BORING LOCATIONS AND CROSS-SECTIONS

Figure F. 1 Boring Locations

Figure F. 2 Minimum liquefaction factors