SLOPE STABILITY ASSESSMENT ALONG THE BURSA-İNEGÖL-BOZÜYÜK ROAD AT KM: 72+000-72+200

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ABSTRACT

SLOPE STABILITY ASSESSMENT ALONG THE BURSA-İNEGÖL-BOZÜYÜK ROAD AT KM: 72+000-72+200

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The purpose of this study is to determine the most suitable remediation technique via geotechnical assessment of the landslide that occurred during the construction of Bursa-İnegöl-Bozüyük Road at KM: 72+000-72+200 in an ancient landslide area.

For this purpose, the geotechnical parameters of the mobilized soil along the slide surface was determined by back analyses of the landslide at four profiles by utilizing the Slope/W software. The landslide was then modeled using coupled analyses (with the Seep/W and Slope/W softwares) along the most representative profile of the study area by considering the landslide mechanism, the parameters determined from the geotechnical investigations, the size of the landslide and the location of the slip circle. In addition, since the study area is located in a second degree earthquake hazard region, pseudo-static stability analyses using the Slope/W software were performed incorporating the earthquake potential. The most suitable slope remediation technique was determined to be a combination of surface and subsurface drainage, application of rock buttress at the toe of the slide and unloading of the landslide material.

A static and dynamic analyses of the landslide was also performed through utilizing finite element analyses. The static analyses were calibrated using the inclinometer readings in the field. After obtaining a good agreement with the inclinometer readings and finite element analyses results, the dynamic analyses were performed using acceleration time histories, which were determined considering the seismic characteristics of the study area.

Keywords: Landslide, Back analysis, Coupled analysis, Pseudo-static analysis, Dynamic analysis, Slope stabilization techniques.

ÖZ

BURSA-İNEGÖL-BOZÜYÜK YOLU KM: 72+000-72+200 ARASI ŞEV DURAYLILIĞININ DEĞERLENDİRİLMESİ

ÖZTEPE, Damla Gaye
Yüksek Lisans, Jeoloji Mühendisliği Bölümü
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Eylül 2009, 183 sayfa

Bu çalışmanın amacı, Bursa-İnegöl-Bozüyük Yolu inşaatı sırasında eski heyelan bölgesindeki KM: 72+000-72+200'de meydana gelen heyelanın jeoteknik değerlendirilmesinin yapılarak en uygun iyileştirme tekniğini belirlemektir.

Bu amaçla, öncelikli olarak heyelan geometrisi 4 adet profil üzerinde geriye dönük analiz yöntemi ile incelenerek kayma yüzeyi boyunca mobilize olmuş zeminin parametreleri Slope/W yazılımı kullanılarak bulunmuştur. Çalışma sahasını en iyi şekilde temsil eden profil üzerinde birleştirilmiş analiz yapılarak (Seep/W ve Slope/W yazılımları ile) heyelanın mekanizması, jeoteknik değerlendirmelerden elde edilen parametreler, heyelanın büyüklüğü ve kayma dairesinin konumu göz önüne alınarak heyelan modellenmiştir. Ayrıca çalışma sahasının ikinci derece deprem bölgesinde bulunmasından dolayı deprem durumu için sözde statik analizi Slope/W program kullanlarak yapılmış ve en uygun iyileştirme tekniği olarak yüzey ve yeraltı sularının drenajı, kaya topuk dolgusu ve yük hafifletmesi önerilmiştir.

Heyelanın statik ve dinamik koşullardaki analizi sonlu eleman yöntemi kullanılarak yapılmıştır. Statik koşuldaki analiz, arazide yapılan inklinometre ölçümleri kullanılarak kalibre edilmiştir. Dinamik analiz, inklinometre sonuçları ve sonlu eleman yöntemi kullanılarak elde edilen sonuçların iyi uyum sağlaması ile çalışma alanının sismik karakteri gözönüne alınarak seçilen ivme kayıtları kullanılarak yapılmıştır.

Anahtar Kelimeler: Heyelan, Geriye dönük analiz, Birleştirilmiş analiz, Sözde statik analizi, Dinamik analiz, Şev stabilizasyon teknikleri

In Loving Memory of My Dear Grandmother,
Elmas CEYHAN

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CHAPTER 1

INTRODUCTION

Slope failures, such as landslides and avalanches, can occur in almost any hilly or mountainous terrain, or offshore, often with a very frequent incidence of occurrence, and can be very destructive, at times catastrophic. The potential for failure is identifiable, and therefore forewarning is possible, but the actual time of occurrence is not predictable. Most slopes can be stabilized, but under some conditions failure cannot be prevented by reasonable means (Hunt, 2005).

Landslides are one of the important natural hazards in Turkey. Apart from causing life loss and destroying agricultural areas and roads, statistics indicate that landslides have damaged 11.70% of a total of 35,570 residential areas (recorded in the database of the General Directorate of Disaster Affairs and Damage Assessment Department) throughout Turkey between the period of 1950-2005. A large proportion of the landslides took place in Eastern, Middle and Western Black Sea Region, and along active faults and fault zones in Turkey (Gökçe et al., 2006).

1.1. Purpose and Scope

The purpose of this study is to analyze the stability of a landslide that occurred in the Bursa-Bozüyük-İnegöl Road between the kilometers 72+000 and 72+200 and to find the most appropriate stabilization mechanism to this landslide.

Within the scope of this study, first of all a detailed literature survey including geological and geotechnical data about the study area was performed and slope stability analysis and remediation methods were reviewed. As a second stage the collected data regarding the geology, hydrogeology, seismicity, site investigation tests and results of both field and laboratory tests were evaluated in order to understand the failure mechanism of the landslide. In the final stage the landslide was modeled using back analysis and the most suitable stabilization technique under static and dynamic conditions due to earthquake loading were discussed.

1.2. Location and Accessibility of the Study Area

The study area is located 75 km away from the city center of Bursa. The site is located 2 km away from the Güneykestane Village and 26 km away from the İnegöl District. The site is accessible through the Bursa-İnegöl-Bozüyük E90 State highway. A location map of the study area is shown in Figure 1.1.

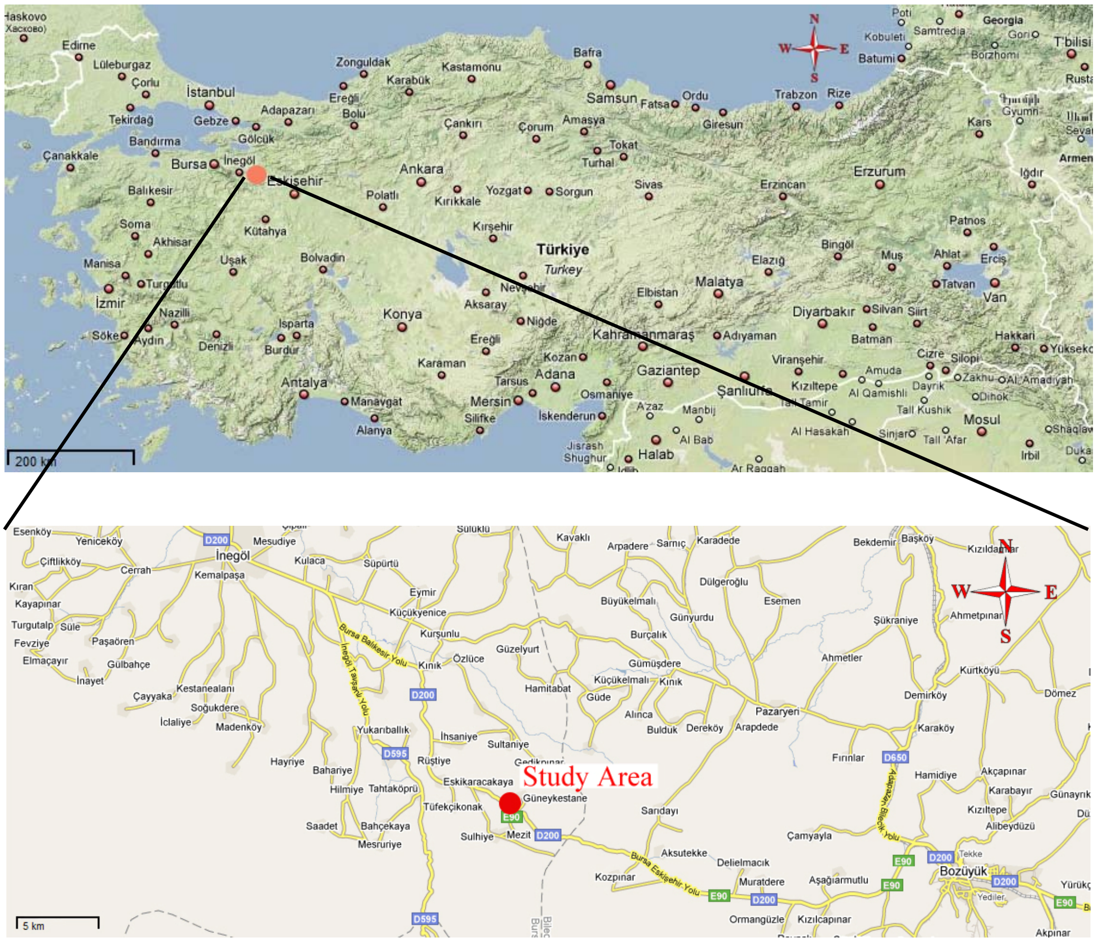


Figure 1.1. Location map of the study area

1.3. Climate

The study area is influenced by the Marmara Sea due to its close proximity. Marmara region’s climate in which the summers are warm and dry and the winters are lukewarm and rainy prevails in the study area. The annual mean precipitation according to the Turkish State Meteorological Service was 673.5 mm in the period of 1971-2000 and annual mean temperature was 14.5°C in the period of 1975-2006. Figures 1.2 and 1.3 show the total rainfall quantities for each month of the year (from 1971 to 2000) and the average temperatures for each month of the year between 1975-2006, respectively.

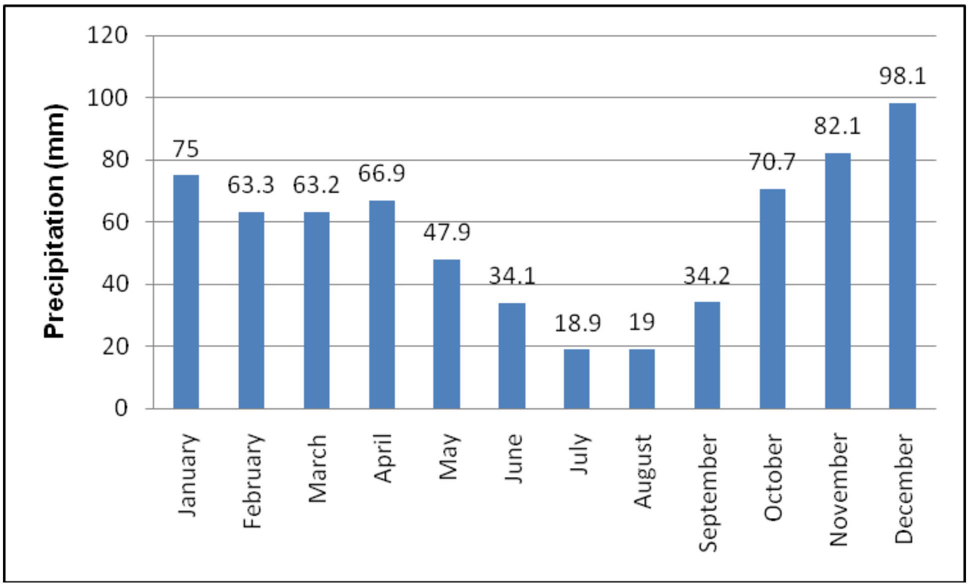


Figure 1.2. Total rainfall quantities for each month of the year (from 1971 to 2000) for the Bursa city center

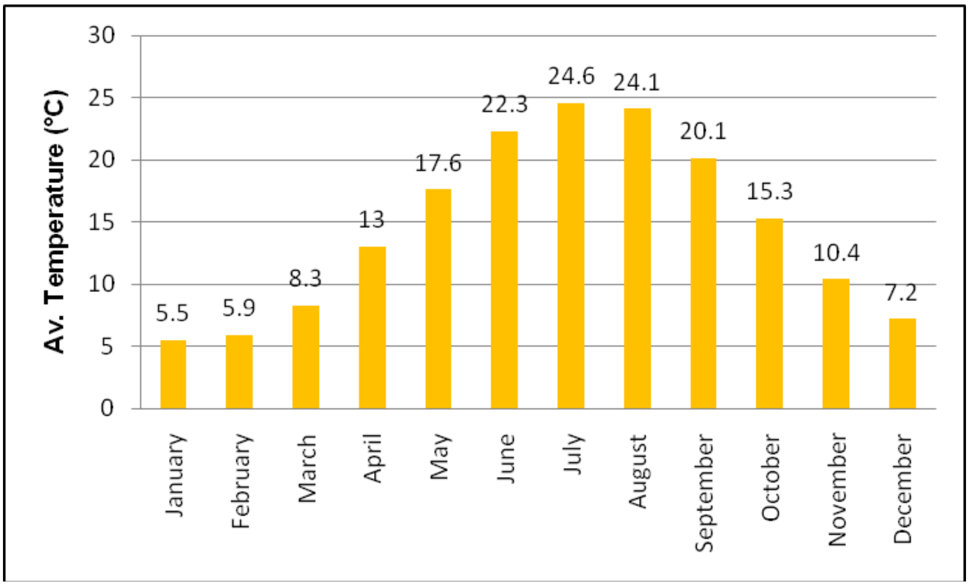


Figure 1.3. Average temperature for each month of the year (from 1975 to 2006) for the Bursa city center

1.4. Previous Studies

The general geological aspects and geological evalution of the İnegöl District were studied by Eroskay (1965); Bingöl et al. (1975); Brinkman (1976); Yılmaz (1981); Bargu (1982); Ketin (1984); Genç (1986); Genç et al. (1986); and Koçyiğit et al. (1991). The metamorphic rocks of the İnegöl Basin and their relationships with the plutonic rock assemblages of the region were studied by Ketin (1947); Kaaden (1960); Öztunalı (1973); Ayaroğlu (1979); Yılmaz (1979); Tekeli (1981); Servais (1982); Şentürk and Karaköse (1982); and Okay (1984). Granit and Titant (1960); Altınlı (1965); (1966); (1975a,b); Altınlı and Yetiş (1972); Altınlı et al. (1970); Görür et al. (1983); and Altıner et al. (1989) carried out studies on the Post Triassic cover rocks and their paleogeographic distribution in the İnegöl Basin. Bürküt (1966), Çoğulu et al. (1965), Çoğulu and Krummenacher (1967); Ataman (1973) and Bingöl et al. (1982) carried out studies on the geochemistry and geochronology of the plutonic rock assemblages of the region.

Sönmez (2003) studied the liquefaction potential of the İnegöl district and prepared its liquefaction potential map. According to Sönmez (2003), the geology of the İnegöl basin includes three main geological units, which are the Pre-Neogene aged basement rocks, Neogene aged units and Quaternary alluvial deposits. Pre-Neogene is represented by the Permian–Trias aged schist and marble, Trias-aged igneous rock, Dogger–Lower Cretaceous-aged limestone, Upper Cretaceous-aged marl and Lutetian-aged andesite and trachite from the lowermost to the uppermost of the unit. The sedimentary rocks of Neogene are composed of an alternation of mudstone, sandstone, limestone and marl. The Quaternary alluvial deposits overlie the basement and sedimentary rocks at the central part of the İnegöl basin. They are composed of gravel, sand, silt and clay layers in different thicknesses.

CHAPTER 2

REGIONAL GEOLOGY

2.1. Stratigraphy

The study area is divided into two main tectonic belts on the basis of deposition type, age, deposition environment, geological evolution and metamorphism conditions of the outcropped rock masses. These belts are the North and South Tectonic belts respectively. These belts are separated from each other with İzmir – Ankara suture zone of approximately Cretaceous age. The belt located towards the north of the İzmir – Ankara Suture Zone is named as “North Tectonic Belt” and is situated towards the southwest part of the West Pontides. The units that compose the North Tectonic Belt are the Devonian – Carboniferous Pazarcık mélange, Mahmudiye mafic – ultramafics, the Upper Carboniferous Bozüyük granitoid, the Lower – Middle and Upper Triassic Karakaya group and these units are unconformably overlain by the Lower Jurassic (Hettangian – Pleinsbachian) Bakırköy formation, the Middle Jurassic – Lower Cretaceous (Callovian – Hauterivian) Bilecik group, the Cretaceous (Aptian – Maastrichtian) Kabalar group. The common cover rock units of both the North and South Tectonic Belts are the Middle – Upper Miocene İnegöl group and the Pliocene – Quaternary loosely consolidated river clastics (Yüksel Proje Uluslararası A.Ş., 2007). A 1:1,000 scale geological map of the study area is given in Appendix A, Figure A1.

2.1.1. The Pazarcık Mélange (Pzp)

The Pazarcık Mélange is composed of structurally stacked rock packages with different thicknesses that are metamorphosed in green schist facies. This unit shows erosional and some fault contact relationship with the overlying Karakaya group, an erosional relationship with the Bakırköy formation and a tectonic contact relation with the Mahmudiye mafic – ultramafics. This unit is also intruded by the

Bozüyük granitoide and has undergone contact metamorphism. It shows a younger relation both regarding erosional and thrust type tectonism with the İnegöl group that is formed of continental clastics. Scaled type and reference cross-sections have shown that the Pazarcık mélange is formed from a variety of rock types and it was also observed that these show thrust type structure. Some of these facies are packages of different thicknesses that show sequential relationship and some others show a thrust structure of up to 2,500 m thickness with tectonic contact relation either individually or with each other. The source rock of all these facies can be divided in three groups. These three groups are: ocean floor sediments, upper mantle – oceanic crust and dominantly continental margin deposits like accretionary prism – fore-arc basin units. Schist, graphite-schist, meta-sandstone, calc-schist, marble, meta-basalt, meta-serpentine, chert, meta-ryhodacite, meta-tracite, meta-andesite, meta-diorite, meta-peridotide and slate type rocks can commonly be in this unit. On the other hand, these three different rock assemblages exhibit a chaotic assemblage within thrust structure in some places and show the characteristics of a typical acretionary prism. Although some deposits and facies within these deposits have gone through metamorphism and active tectonism of several stages, they preserved their primary sedimentary structure and stratigraphic relations in some places. The Pazarcık mélange is thought to be of Devonian – Carboniferous age (Yüksel Proje Uluslararası A.Ş., 2007).

2.1.2. Talus (Qym)

The rocks that have disintegrated from highly inclined natural slopes because of the topographic properties of the region have been deposited at the slope bottoms and flat areas as a result of precipitation, gravity, topographic inclination and mostly of tectonism. This talus unit contains angular – moderately angular material up to block size (Yüksel Proje Uluslararası A.Ş., 2007).

2.1.3. Recent Alluvium (Qal)

This formation that is observed at the base of the Mezit and Aksu stream valleys is formed of sandy silty gravel, gravelly silty sand, large gravel and blocks (Yüksel Proje Uluslararası A.Ş., 2007).

2.2. Structural Geology and Tectonism

The main structural elements in the study area can be can be put into two main groups. These are the Paleotectonic structures that have formed before Pliocene and the Neotectonic period structures that have developed after Pliocene or that have changed their characteristics and continued to be active. The Paleotectonic period structures contain foliation, cleavage, folding, thrust and drag faults and along with these different type of unconformities can be included in the structures of this period. On the other hand, most of the neotectonic structures are oblique slip steeply dipping normal faults. Some of these faults are inherited from the previous tectonic period and they changed their characteristics at the Neotectonic period, some others are subsequently formed fractures that are still active. Considering that the Neotectonic structures are formed concentrated in the İzmir – Ankara Suture Zone that joins the North and South Tectonic Belts clearly shows without a doubt that the old weakness planes play an important role in the formation of these structures. At this section, structural periods are assessed for the North Tectonic Belt and the cover units (Yüksel Proje Uluslararası A.Ş., 2007).

2.2.1. The Paleotectonic Period Structures

These structures are various unconformities, foliation, cleavage, folding, thrust and drag faults. The important ones are explained below in detail (Yüksel Proje Uluslararası A.Ş., 2007).

2.2.1.1. Unconformities

Regional unconformities are observed between the Karakaya group and metamorphic units of the Pazarcık mélange that form the basement; at the base – top of Bakırköy formation and base of İnegöl group. Apart from these, these is a short hiatus between the Bilecik group that is formed of platform carbonates and the Soğukçam pelagic limestone that is a unit of the Kabalar group, and erosion related unconformities not of regional extent is observed between the flysch clastics that form the upper half of the Kabalar group and the older units.

2.2.1.2. Foliation and Cleavage

The foliation and cleavage that is formed parallel to the primary stratification at different outcropping metamorphic units of the North Tectonic Belt is especially observed at the Pazarcık mélange. The Pazarcık mélange is the most dominant unit of the North Tectonic Belt and is generally metamorphosed in greenschist facies conditions. Although the strike of the unit shows variations, the dominant foliation strike is NE – SW and WNW – ESE. The general trend of the foliation can also easily be understood from the trend of the axes of the folds. The foliation that is formed parallel to the primary lamination and the bedding has undergone different type and scale of (microscopic – mapable scale) folding and cleavage and finally undergone a deformation of cataclastic type. The type and phases of these deformations are reflected on the mineral groups that the rock contains, microscopic – mesoscopic scale texture and structure as well.

2.2.1.3. Folds

The Paleotectonic period units of pre-Pliocene have folded effectively in different dimensions and types. The first of the oldest units that have folded effectively is the Pazarcık mélange. The folds are ranging between microscopic to 20 km in length, open folds to mesoscopic scale close – vertical, box, angular, recumbent and regional scale anticlinorium and synclinorium. The strike and dip values of the axes of folds are frequently changing. The general strike direction of the fold axes definitively show that these have formed under an approximately NNW – SSE trending compressional stress system.

The other outcropping units in the North Tectonic Belt that show regional scale folding are the Bakırköy formation, the Bilecik group and the Kabalar group. The youngest paleotectonic unit that the folds are formed extensively is the İnegöl group. Folds within the İnegöl group are cut by oblique slip normal faults at some locations. These folds are the youngest folds that have formed during the paleotectonic period and have formed connected to an approximately N – S trending compressional stress system that is effective at the region at late Miocene, Pre-Pliocene.

2.2.1.4. Drag and Thrust Faults

The Pazarcık mélange has undergone metamorphism under green schist facies conditions and is mainly formed of ocean floor and dominant continental margin rock assemblages. These assemblages are present within a SSE dipping thrust fault zone along with either each other or with the Mahmudiye mafic – ultramafics that is formed of a missing oceanic crust slice.

2.2.2. Neotectonic Period Structures

The Neotectonic period structures are characterized dominantly by oblique slip normal faults. Besides from these, left-lateral faults with significant dip slip component have also been developed. Angular unconformity that is between the Pliocene formations and the İnegöl group discern the Paleotectonic period Late Miocene compression stage from the Neotectonic period subsidence – extension at Pliocene.

2.3. Hydrogeology

The study area is located in the İnegöl Plain which is situated in the southeast of the Bursa province, between 29°19' - 29°46' longitude and 39°00' - 40°10' latitude. The most important streams at and in the vicinity of the study area are the Mezit and Aksu streams. These streams can include groundwater according to the properties of the rock groups of the Pazarcık mélange that outcrops in this area. Although the units can be accepted as low permeable to impervious, they can presumably allow groundwater to circulate through the fracture systems and fault lines that they contain. On the other hand, colluvial deposits that can be observed at the river valley bottoms and slope bottoms may contain groundwater.

Recharge of the groundwater in the İnegöl Plain occurs through infiltration from precipitation and surface run-off and groundwater discharge occurs through artificial discharge with the wells and streams. According to the Hydrogeological Investigation Report of İnegöl Plain prepared by General Directorate of State Hydraulic Works (1981), the annual safe yield in the İnegöl Plain was estimated to be 40 x 10^6 m^3/year. The annual groundwater budget of İnegöl Plain is given in Table 2.1.

Table 2.1. The annual groundwater budget of İnegöl Plain (General Directorate of State Hydraulic Works, 1981)

Recharge x 10^6 m^3/year		**Discharge x 10^6 m^3/year**	
a) Infiltration from precipitation	11.0	a) Discharge to stream	35.0
b) Infiltration from surface run-off	25.0	b) Artificial discharge	5.0
c) Through side discharge	4.0		
TOTAL	**40.0**	**TOTAL**	**40.0**

2.4. Seismicity

The study area is located in a second degree earthquake zone according to Turkish Earthquake Zoning Map prepared by the Earthquake Research Department (2009). The expected acceleration values in the study area are between 0.3 g and 0.4 g (Figures 2.1 and 2.2).

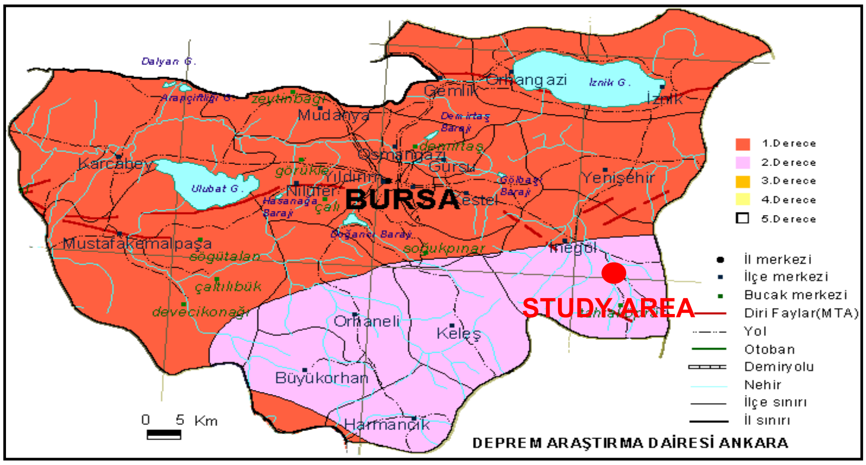


Figure 2.1. Zone of earthquake for Bursa Province (Earthquake Research Department, 2009)

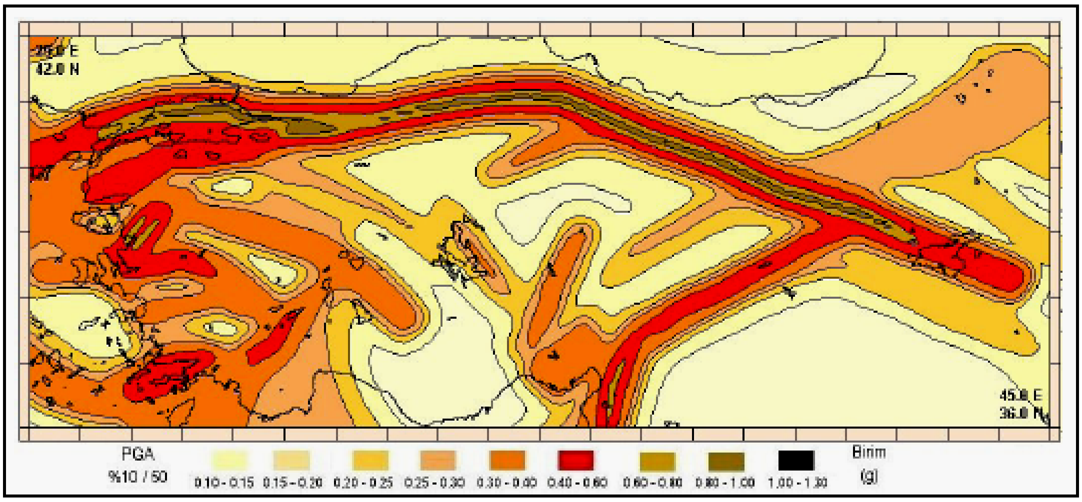


Figure 2.2. PGA values with 10% probability of exceedance in 50 years (Erdik et al., 2006)

The study area is located in the Eskişehir fault zone which is also known as the İnönü - Eskişehir fault zone (Figure 2.3).

The Eskişehir fault zone defines the boundary between the strike-slip North Anatolian Fault Zone (NAFZ) and the Western Anatolian extensional region which is represented dominantly by normal faults (Barka et al., 1995; Altunel and Barka, 1998). The Eskişehir fault zone is defined as a right-lateral strike-slip fault with a normal component (Şengör et al., 1985; Şaroğlu et al., 1992; Barka et al., 1995; Altunel and Barka, 1998). The faults that form the Eskişehir fault zone are mostly active and have the capacity of producing small to medium-sized earthquakes (Koçyiğit, 2003). During the instrumental period in the 20th century, in the area between Eskişehir and Bursa (39.5°-40.3°N and 29.0°-31.0°E) 53 earthquakes with M≥4 have occurred. The largest event recorded on the Eskişehir fault zone is the 20 February 1956 Eskişehir (Çukurhisar) earthquake with M=6.4. The epicentral distribution of these earthquakes displays a seismic activity in the area (Okay et al., 2008).

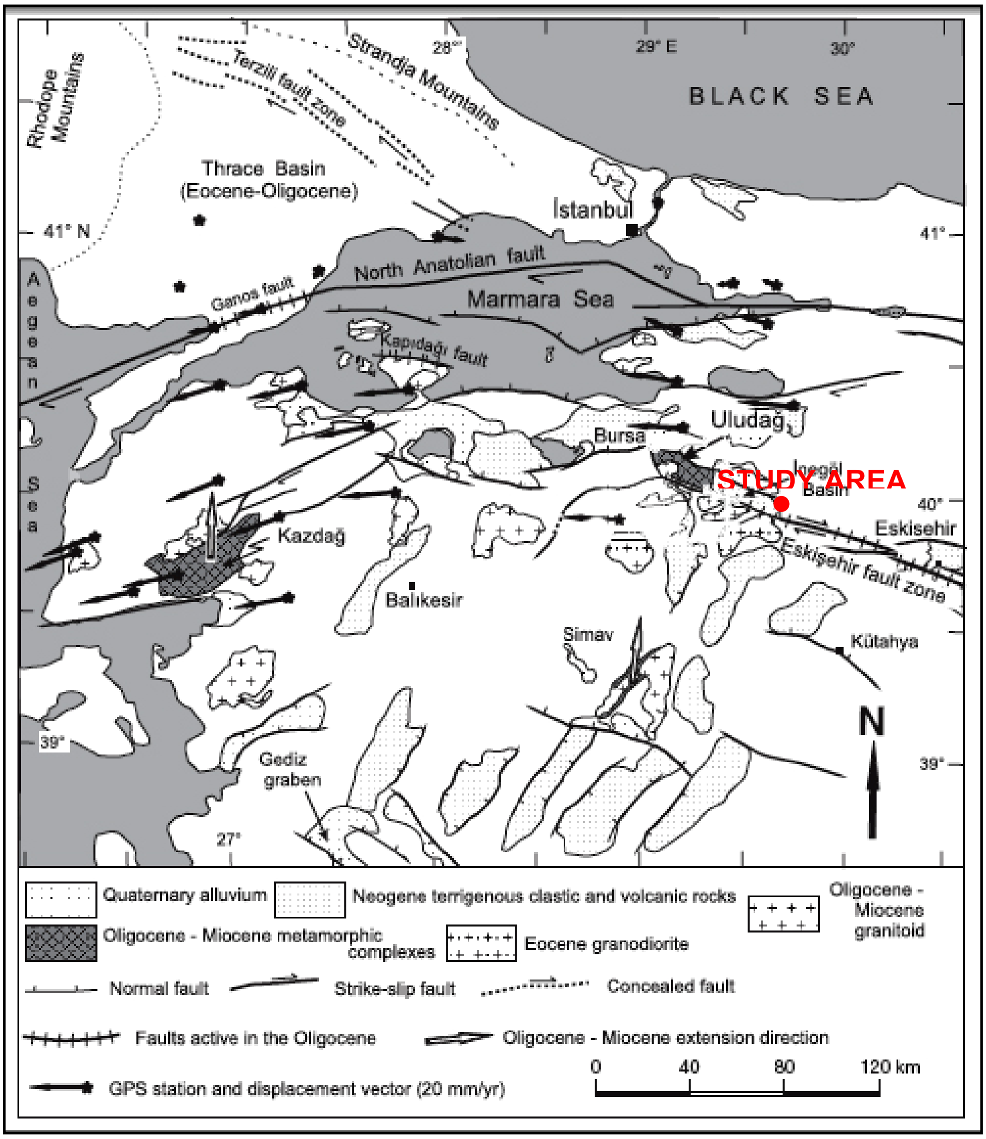


Figure 2.3. Tectonic map of northwestern Turkey (Okay et al., 2008)

As shown on the tectonic map of Northwestern Turkey in Figure 2.3, the seismicity of the Marmara region is very high due to the presence of the active fault segments of the North Anatolian Fault Zone (NAFZ). It is evident that the earthquakes are generally associated with active faults.

The major earthquakes (M>6.5) such as the Kocaeli Earthquake with Ms=7.4 and the Hendek Adapazarı Earthquake with surface magnitude (Ms) 6.6 occurred on the northern branch of NAFZ. Although large earthquakes such as the Kocaeli and the Manyas (Ms=7.0) earthquakes occurred nearly 100 km from İnegöl, many earthquakes with magnitudes between 5.0 and 6.0 occurred around İnegöl (Sönmez, 2003). The earthquakes that occurred at a 100 km radius around the study area between 1900 and 2009 with a magnitude greater than 4.0 is shown in Figure 2.4.

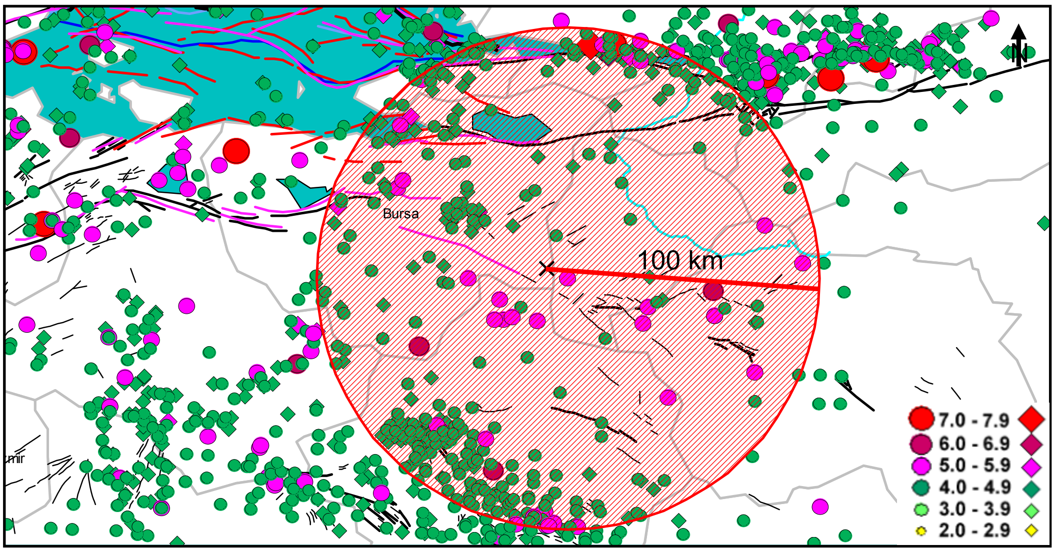


Figure 2.4. Epicentral distribution of earthquakes having a magnitude greater than 4.0 around the İnegöl District (Sayısal Grafik Ltd., 2009)

CHAPTER 3

ENGINEERING GEOLOGICAL ASSESSMENT OF THE STUDY AREA

Within the scope of “the Bursa – İnegöl – Bozüyük Highway (Section II) Construction Job (between KM: 69+400 – 81+700)”; geological and geotechnical investigation studies have been conducted by Yüksel Proje Uluslararası A.Ş. comprising engineering geological mapping, borehole drillings, in-situ and laboratory tests in order to determine the physical and mechanical properties, mass movement geometry, the reasons and mechanisms for the movement of the units that were observed at the left side of the Bursa – İnegöl – Bozüyük Road between KM: 72+000 – 72+200 of the project route. In this context, an engineering geological map of the landslide area has been prepared, geological model studies have been conducted, weathering zones have been determined with the aid of borehole data and the history of the mass movement and its consecutive formation in the area have been examined. According to the acquired data; the lithological and geotechnical properties of the units are analyzed in this section.

3.1. Site Investigations

For the purpose of subsurface characterization, a total of about 276.0 m of boring (a total of 13 boreholes, max 36.0 m and min 15.0 m deep) was performed by Yüksel Proje Uluslararası A.Ş. at the landslide area in between November-December 2006. A list of the boreholes including the coordinates, borehole depth and depth to the groundwater are summarized in Table 3.1. The boreholes that contain a “i” letter at the end of borehole number are the boreholes with inclinometers. The coordinates of the boreholes are given by Gauss Krüger coordinate system.

Table 3.1. List of boreholes

Borehole ID	Coordinate			Depth (m)	Groundwater Depth (m)
	N (X)	E (Y)	Elevation (m)		
IBH72 – 1	4 423 358.15	475 294.60	520.65	15.45	2.05
IBH72 – 2i	4 423 311.77	475 292.73	512.95	15.00	1.70
IBH72 – 3i	4 423 337.98	475 327.38	528.70	21.00	7.40
IBH72 – 4	4 423 365.60	475 366.73	538.69	22.45	13.45
IBH72 – 5	4 423 389.41	475 399.26	543.75	17.30	4.60
IBH72 – 6i	4 423 281.52	475 318.08	514.70	15.25	2.15
IBH72 – 7i	4 423 311.61	475 348.09	529.70	27.05	8.50
IBH72 – 8i	4 423 335.09	475 374.62	542.32	36.00	13.00
IBH72 – 9i	4 423 362.45	475 403.16	545.97	30.00	11.00
IBH72 – 10i	4 423 398.81	475 441.25	553.53	21.13	8.90
IBH72 – 11	4 423 426.14	475 470.53	566.04	15.25	13.90
IBH72 – 12	4 423 285.90	475 377.29	525.90	15.00	8.75
IBH72 – 13	4 423 310.72	475 399.30	537.45	25.00	16.00

3.1.1. Standard Penetration Test (SPT)

Standard Penetration Testing (SPT) was performed in each borehole, at every 1.5 m interval in order to determine the engineering classification of subsurface soils. ASTM compliant standard penetration and coring test equipments were used throughout the insitu tests. The energy delivered to the rods were estimated as 60% consistent with the energy requirements of a safety hammer. A total of 265 standard penetration tests were performed at selected depths. The 13 borehole logs are given in Appendix B. Additionally, core samples were taken at stiff soil or rock layers and the photos of the core boxes are given in Appendix C. The results of the sieve analysis tests and the Atterberg limit tests performed by Yüksel Proje Uluslararası A.Ş. are given in Appendix D.

3.1.2. Pressuremeter Test

A pressuremeter consists of a probe that, when placed in a borehole, can be inflated. The volume changes of the probe can be measured by means of a surface volume meter to which the probe is connected. A pressure versus volume change graph can be plotted and converted into a stress-strain curve. From the test results a limit pressure and a deformation modulus are determined (Abramson et al., 2002).

The pressuremeter tests were performed in the study area by Yüksel Proje Uluslararası A.Ş. using Louis Menard GA type pressuremeter with a 60 mm N type probe. The deformation modulus (E_p) with limit (P_l) and net limit $(P_l)_{net}$ pressures varying with depth are plotted and given in Appendix E.

3.1.3. Inclinometers

Inclinometers provide information on the depth of landslide movements, thickness of the shear zone, amount of movements, rate of movements and direction of movements. Lateral movements below the ground surface can be measured by an inclinometer system. A special casing is installed in a borehole. The inside of the casing has four longitudinal grooves at the four quadrants and the inclinometer probe has wheels that truck along a diametrically opposite pair of grooves. An accelerometer within the probe aligned in the plane of wheels, measures the tilt of the probe and casing at any position along its length. By taking successive incremental readings as the probe is pulled up the casing, the in-ground shape of the casing is obtained. If landslide movements occur after the casing has been installed and initially read, the tilt of the casing in the shear zone of the landslide will change. The depth and amount of shear movement is obtained by subtracting the initial set of tilt readings from the subsequent readings (Cornforth, 2005).

During the site investigations, 7 inclinometer boreholes have been placed in the study area and inclinometer readings were taken periodically. The inclinometer measurements were recorded and plotted as depth vs. cumulative displacement and depth vs. incremental displacement graphs that are given in Appendix F. The results of the inclinometer measurements are summarized in Table 3.2.

Table 3.2. Results of the inclinometer measurements

Borehole ID	Depth of Borehole (m)	Landslide Movement			
		Measurement Duration (days)	Amount (mm)	Depth (m)	Rate (mm/day)
IBH72 – 2i	15.00	67	–	–	–
IBH72 – 3i	21.00	37	76.0	5.70	2.05
IBH72 – 6i	15.25	73	–	–	–
IBH72 – 7i	27.05	9	41.0	23.2	4.56
IBH72 – 8i	36.00	5	38.0	29.1	7.60
IBH72 – 9i	30.00	6	34.0	23.6	5.67
IBH72 – 10i	21.13	6	26.0	5.70	4.33

As it can be seen from Table 3.2, the critical slip surface moves with a mean speed ranging from 2.05 to 7.60 mm/day.

3.1.4. Discontinuity Scanline Survey

Although many different techniques have been proposed for sampling discontinuities in rock exposures, the line or scanline approach is preferred on the basis that it is indiscriminate (all discontinuities whether large or small are recorded) and provides more detail on discontinuity spacing and attitude than the other methods. However there is currently no universally accepted standard for scanline sampling. In practice, a scanline survey is carried out by fixing a measuring tape to the rock face by short lengths of wire attached to masonry nails hammered into the rock. The nails should be spaced at approximately 3 m intervals along the tape which must be kept as taut and as straight as possible. The face orientation and the scanline orientation should be recorded along with other information such as the location and date (ISRM, 1981).

In order to get detail information about the discontinuities in rock exposures, a scanline survey was performed in August 2008 in the study area. A photograph taken during the scanline survey is given in Figure 3.1.

Figure 3.1. Photograph of a schist block of the Pazarcık mélange taken during the scanline survey

Since the area was almost entirely covered with the landslide material and soil, a scanline survey was performed only on one rock exposure, a schist block from the Pazarcık mélange, and 22 discontinuity measurements were taken. The analysis of the discontinuity data was performed with the DIPS software (Diederichs and Hoek, 1989) and the general trend of the pole concentrations were plotted on an equatorial equal angle net (Figure 3.2). The contour plot of the pole concentration data led to one dominant discontinuity set with an orientation of 58°/064° (dip/dip direction) as shown in Figure 3.3.

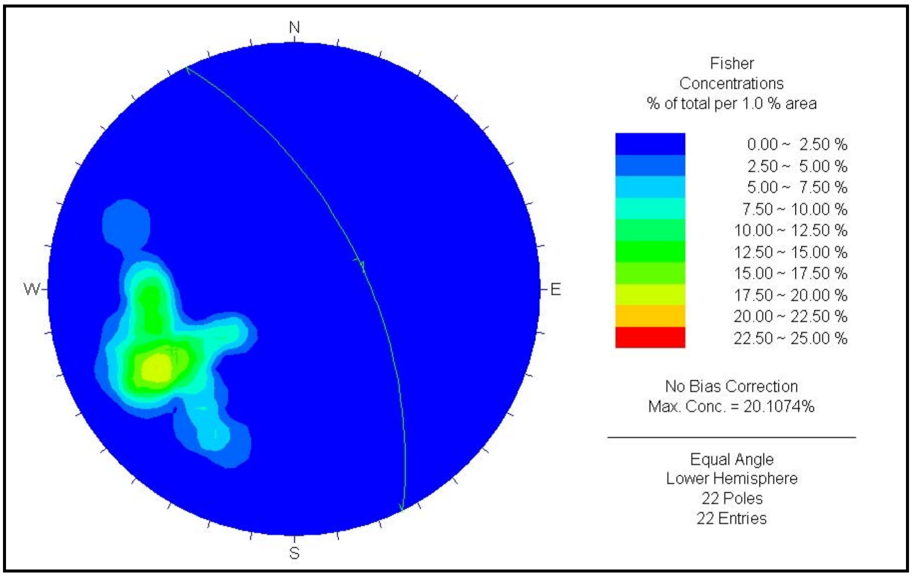


Figure 3.2. Contour plot of the pole concentration of the discontinuities

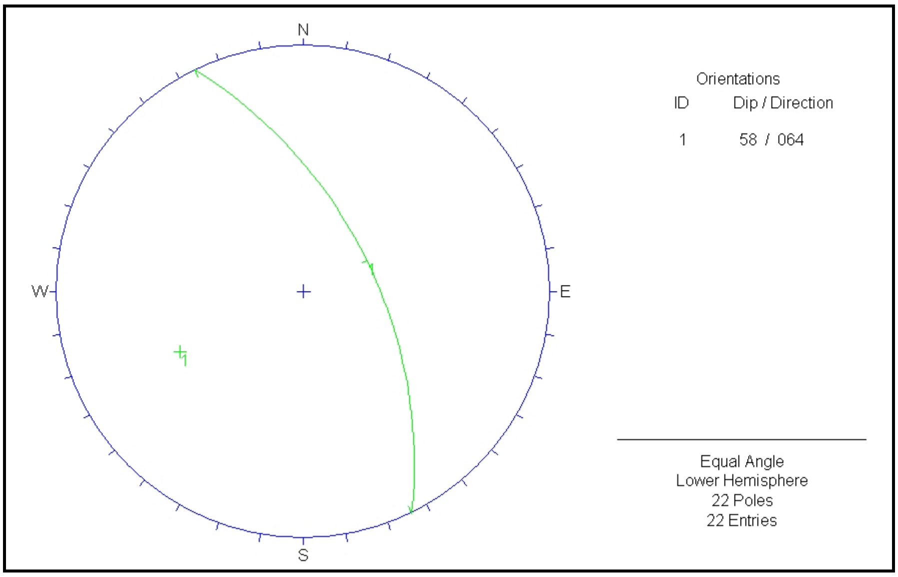


Figure 3.3. The major discontinuity plane in the study area

3.2. Laboratory Tests

3.2.1. Soil Laboratory Tests

In order to determine the physical and index properties of the soil and to understand the characteristics of the lithology; natural unit weight, moisture content, specific gravity, sieve and Atterberg tests have been conducted on the disturbed (SPT) samples. A summary of the laboratory test results as well as of the soil classifications are presented in Appendix D.

3.2.2. Rock Laboratory Test Results

Schist and graphite-schist levels containing metasandstone – limestone blocks were observed in the study area from which core samples could be retrieved. Uniaxial compression tests have been conducted on the core samples in the Rock Mechanics Laboratory of Yüksel Proje Uluslararası A.Ş. and the results are given in Table 3.3 below.

Table 3.3. Results of Rock Mechanics Tests

Borehole ID	Depth (m)	Natural Unit Weight γ_n (kN/m^3)	Uniaxial Compression Strength q_u (MPa)
IBH 72-3i	9.25-9.45	27.5	48.3
IBH 72-3i	15.00-15.35	24.9	31.2
IBH 72-3i	19.00-19.25	25.0	8.40
IBH 72-5	13.95-14.20	26.8	9.30
IBH 72-5	15.05-15.25	26.8	16.2
IBH 72-5	16.83-16.95	27.1	19.7
IBH 72-13	22.90-23.30	27.2	24.8
IBH 72-13	24.70-25.00	27.7	22.6

3.3. Assessment of Site Investigation and Laboratory Test Results

Boring logs summarizing soil profiles are presented in Appendix B. Based on these boreholes, three distinct layers were identified: i) landslide material, ii) parts of the Pazarcık mélange that weathered into soil, and iii) the Pazarcık mélange (schist and graphite-schist levels containing metasandstone – limestone blocks). The Pazarcık mélange forms the basement rock of the landslide. The geological and geotechnical properties of this and the other relevant units are given below:

i) *Landslide Material:*

This unit is composed of weathered schist – graphite-schist types of rocks of the Pazarcık mélange that are locally weathered into soil and mobilized by the landslide. According to the borehole logs, these units are found out to be composed of brown – yellowish brown, greenish gray colored, gravelly, silty sand, clayey sand and sandy silt, and also schist – graphite-schist type of rocks. The thickness of the unit is found out to be 3.00 – 29.0 m from the borehole logs and it was determined that the slip surface formed at the schist – graphite-schist contact. The range of the laboratory test results of the samples obtained from the SPT conducted at the landslide material is given below:

SPT (N)	3 ≤ SPT (N) ≤ 50+
Water content (W_n)	5% ≤ Wn ≤ 32%
Liquid limit (LL)	NP ≤ LL ≤ 53%
Plasticity Index (PI)	NP ≤ PI ≤ 25
Retained at number 4 sieve (+4)	1% ≤+ 4 ≤ 86%
Passing number 200 sieve (-200)	1% ≤ -200 ≤ 80%
Soil class (USCS)	SM, SC, CL, GP to GM, ML, GM, MH

A summary of the SPT N values vs. depth for the landslide material is shown in Figure 3.4.

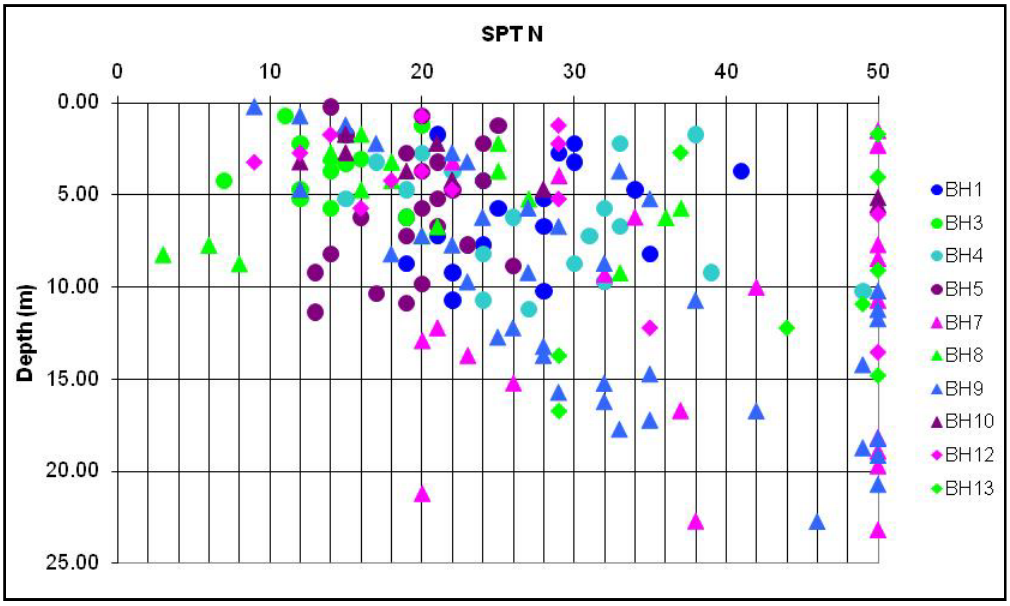


Figure 3.4. SPT $N_{1,60}$ values vs. depth for the landslide material

A summary of the LL values vs. depth is shown in Figure 3.5.

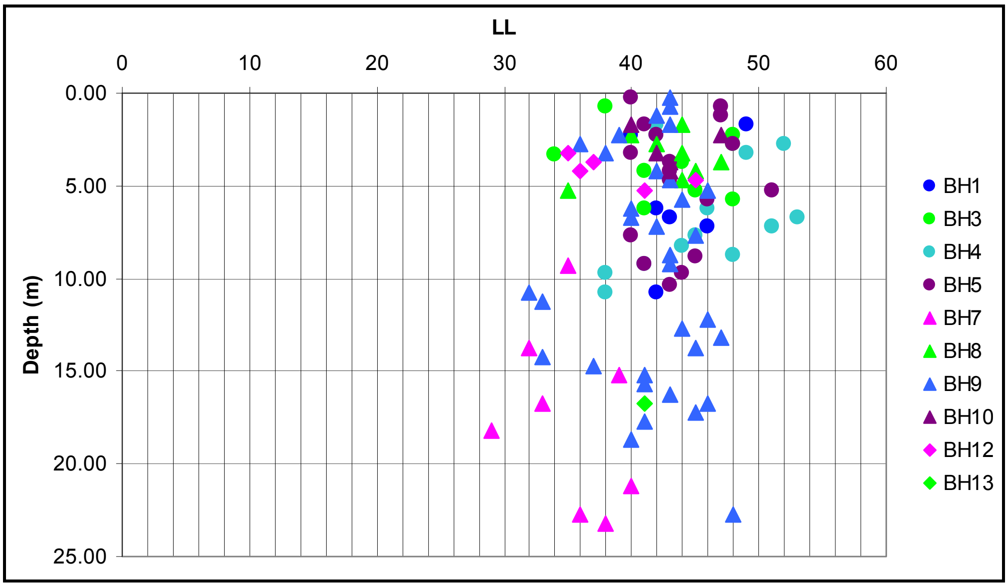


Figure 3.5. LL values vs. depth for the landslide material

A summary of the PI values vs. depth is shown in Figure 3.6.

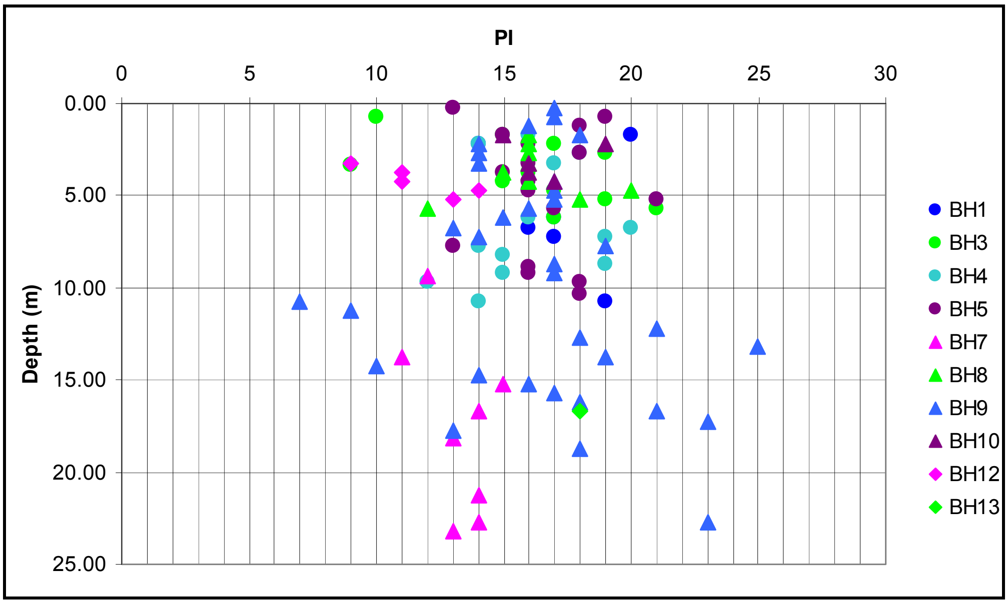


Figure 3.6. PI values vs. depth for the landslide material

The schist type of rocks that are included within the landslide mass are brown to yellowish light brown, greenish gray colored, disintegrable, weak to very weak in strength, very to completely weathered, occasionally moderately weathered and occasionally fragmented. On the other hand, the graphite-schist type rocks are dark gray to black colored, disintegrable, very weak in strength, generally completely weathered and occasionally decomposed into clay at some locations.

ii) <u>Parts of the Pazarcık Mélange that Weathered into Soil</u>

This unit represents the upper part of the schist – graphite-schist type of rocks that are included in the Pazarcık mélange that have weathered into soil. The thickness of this unit changes approximately from 1.00 to 11.0 m in the borehole logs. The unit is generally composed of brown – yellowish brown – greenish gray – brownish gray color, medium to very dense, sandy gravel/gravelly silty sand and medium to hard sandy silt. The gravel is generally moderately angular – round and is of schist – quartzite origin. The range of laboratory test results on the samples obtained from SPT testing is given below:

SPT (N)	7 ≤ SPT (N) ≤ 50+
Water content (W_n)	13% ≤ Wn ≤ 33%
Liquid limit (LL)	NP ≤ LL ≤ 47%
Plasticity Index (PI)	NP ≤ PI ≤ 23
Retained at number 4 sieve (+4)	3% ≤ +4 ≤ 61%
Passing number 200 sieve (-200)	11% ≤ -200 ≤ 72%
Soil class(USCS)	SM, SC, ML, GP to GM, GM

A summary of the SPT N values vs. depth is shown in Figure 3.7.

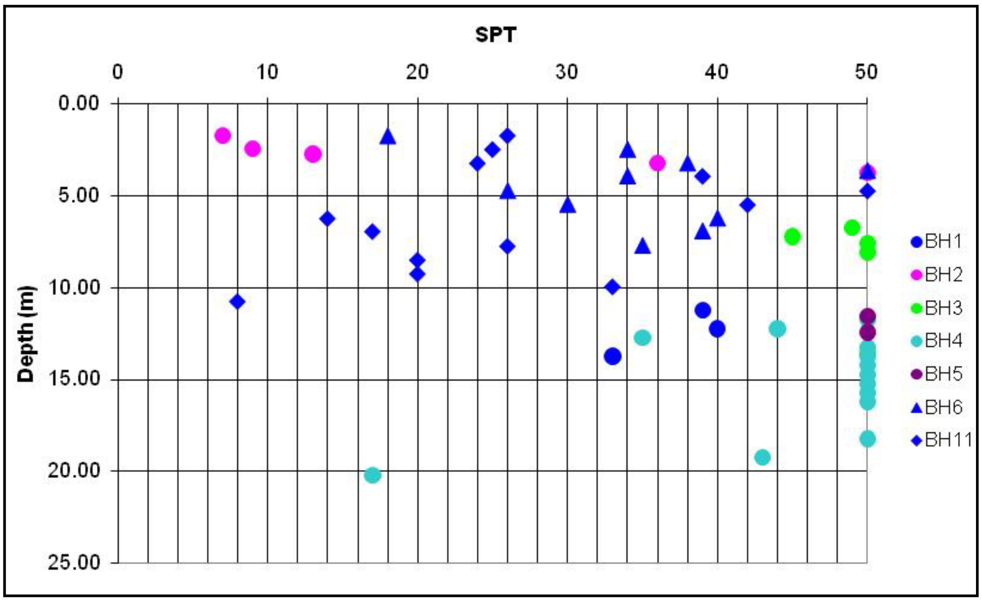


Figure 3.7. SPT $N_{1,60}$ values vs. depth for parts of the Pazarcık mélange that weathered into soil

A summary of the LL values vs. depth is shown in Figure 3.8.

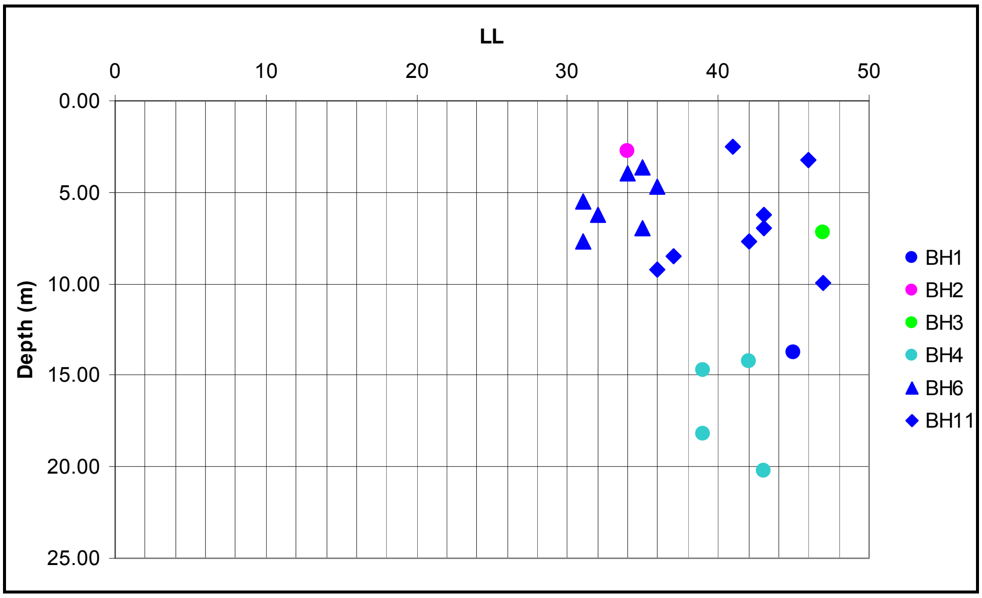


Figure 3.8. LL values vs. depth for parts of the Pazarcık mélange that weathered into soil

A summary of the PI values vs. depth is shown in Figure 3.8.

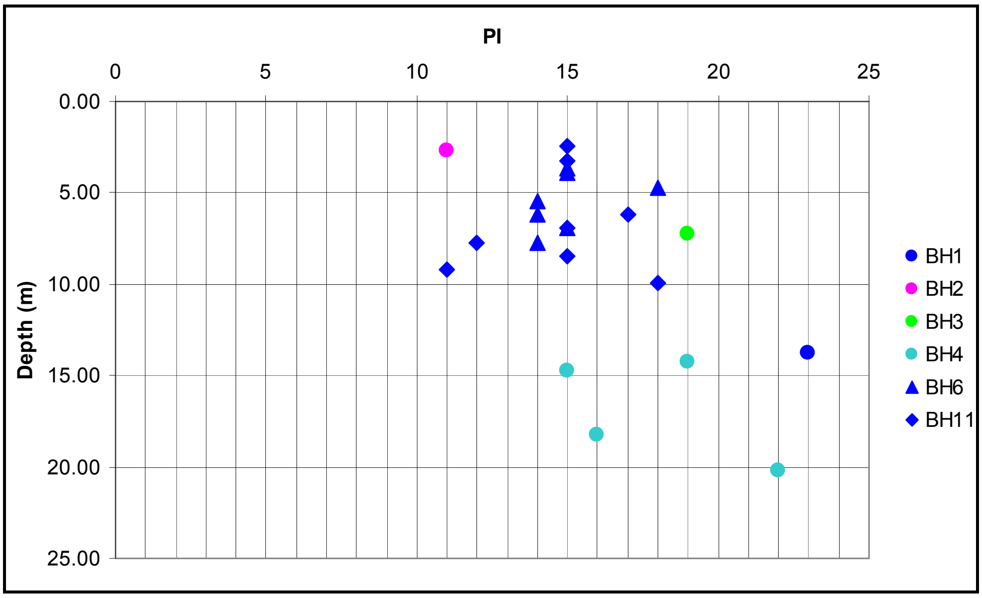


Figure 3.9. PI values vs. depth for parts of the Pazarcık mélange that weathered into soil

iii) ***<u>Pazarcık Melange (Pzp)</u>***

The Pazarcık mélange, which has basement unit characteristics is represented by schist and graphite-schist type of rocks that contain limestone blocks. These rock groups show lateral and vertical transitions in very close distances which is a general structural characteristic of the unit. The geotechnical properties of these rock groups are presented below.

In the light of data gathered from the geological field studies and the boreholes, the schist type of rocks are generally green – greenish light gray – yellowish brown – violet – purple color, disintegrable, low to moderately hard, generally of low to very low strength, occasionally of moderate strength, highly to completely weathered, occasionally slightly to moderately weathered, occasionally fragmented. The discontinuities were observed to have dips ranging from 0° to 90°, open apertures, polished, rough, undulated and dense clay infillings. In this unit, the graphite-schist bands and quartzite veins were occasionally observed. The total core recovery (TCR), rock quality designation (RQD) and laboratory and pressuremeter test result ranges of schist type rocks are summarized below:

Total Core Recovery (TCR)	0% ≤ TCR ≤ 100%
Rock Quality Designation (RQD)	0% ≤ RQD ≤ 100%
Uniaxial Compressive Strength (q_u)	8.40 MPa ≤ q_u ≤ 48.3 MPa
Natural unit weight (γ_n)	24.9 kN/m^3 ≤ γ_n ≤ 27.7 kN/m^3
Pressuremeter limit pressure (Pln)	6.76 kgf/cm^2 ≤ Pln ≤ 41.5 kgf/cm^2
Pressuremeter module (Ep)	66 kgf/cm^2 ≤ Ep ≤ 4,552 kgf/cm^2

The graphite-schist type rocks that are present in this unit are generally; dark gray – black – grayish dark gray colored, disintegrable, occasionally of low hardness, weak to very weak strength, highly to completely weathered and possess limestone and quartzite veins. The total core recovery (TCR), rock quality designation (RQD), laboratory and pressuremeter test results of the graphite-schist type of rocks are summarized below.

Total Core Recovery (TCR)	0% ≤ TCR ≤ 98%
Rock Quality Designation (RQD)	0% ≤ RQD ≤ 66%
Natural unit weight (γ_n)	27.2 kN/m^3
Uniaxial Compressive Strength (q_u)	24.8 MPa
Pressuremeter limit pressure (Pln)	5.66 kgf/cm^2
Pressuremeter module (Ep)	47 kgf/cm^2

The results of the laboratory tests that have been conducted on the samples gathered from SPT testing in highly to completely weathered levels of the graphite-schist unit is given below:

SPT (N)	17 ≤ SPT (N) ≤ 50+
Water content (Wn)	6% ≤ Wn ≤ 30%
Liquid limit (LL)	NP ≤ LL ≤ 47%
Plasticity Index (PI)	NP ≤ PI ≤ 15
Retained at number 4 sieve (+4)	8% ≤ +4 ≤ 52%
Passing number 200 sieve (-200)	6% ≤ -200 ≤ 44%
Soil class (USCS)	SM, SC, GP to GM

The schist type of rocks are generally regarded as impervious, occasionally of low permeability. The graphite-schist type rocks, on the other hand, are regarded as impervious. However, since this unit possesses a discontinuity set, it may be expected to allow groundwater circulation.

A summary of the SPT N values vs. depth is shown in Figure 3.10.

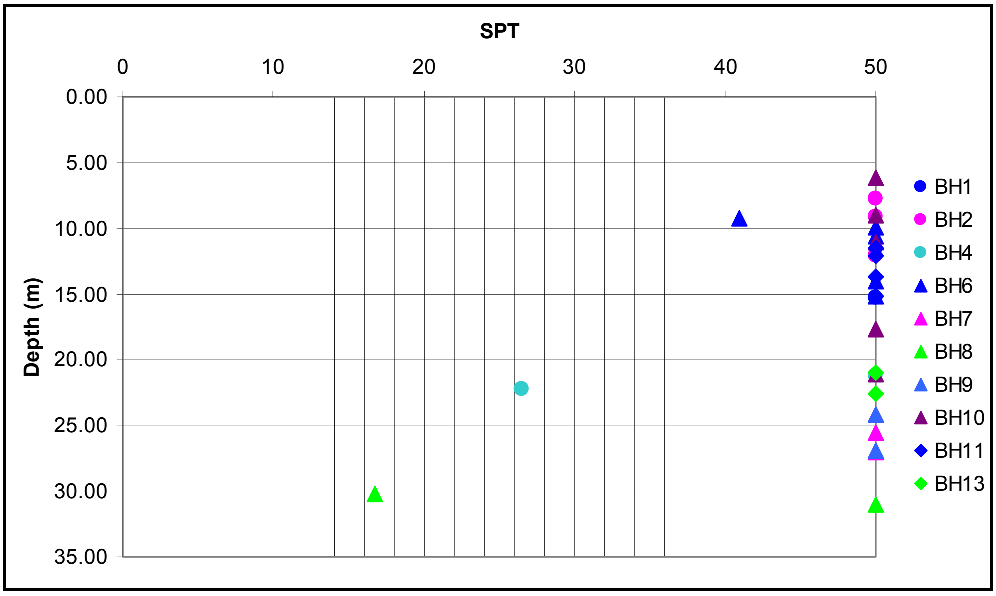


Figure 3.10. SPT $N_{1,60}$ values vs. depth for the Pazarcık mélange

A summary of the LL values vs. depth is shown in Figure 3.11.

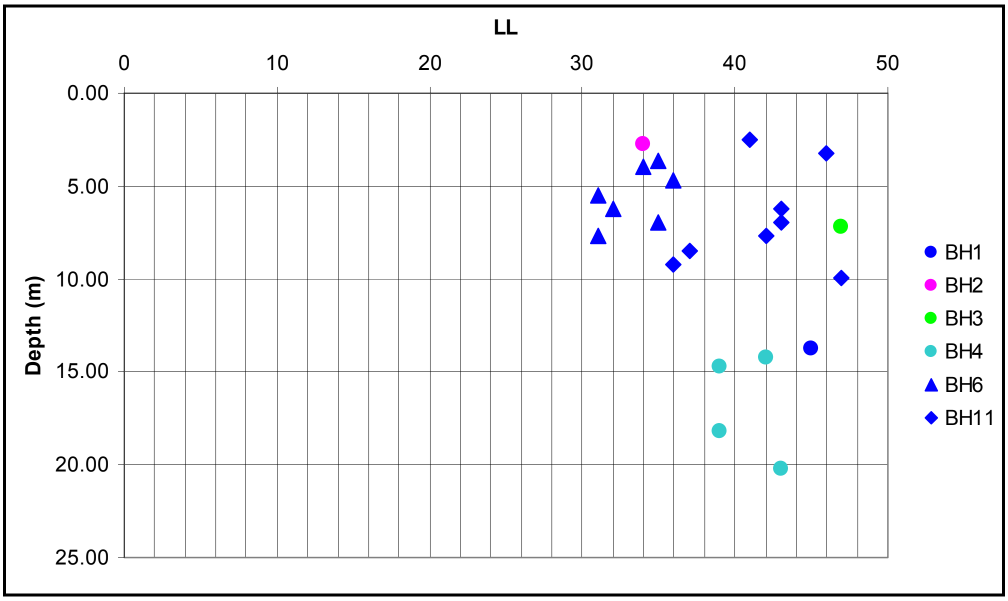


Figure 3.11. LL values vs. depth for the Pazarcık mélange

A summary of the PI values vs. depth is shown in Figure 3.12.

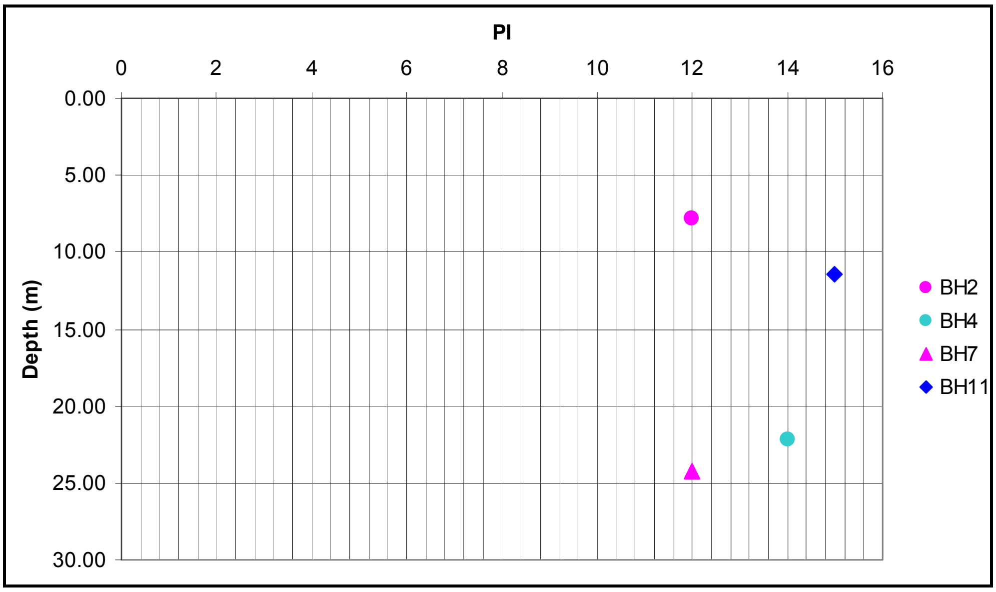


Figure 3.12. PI values vs. depth for the Pazarcık mélange

Rock mass classification systems are very useful tools for the preliminary design stage of a project, when very little detailed information on the rock mass is available. On the other hand, utilization of several rock mass classification systems is recommended to build up a picture of composition and characteristics of the rock mass to provide initial estimates of the shear strength and the deformational properties of the rock mass (Hoek et al., 1995). Rock mass strength parameters can be obtained by means of Rock Mass Rating (RMR), Q-system, Geological Strength Index (GSI) and Rock Mass Index (RMi) systems. In this study the RMR classification, for characterizing the overall properties of the rock mass quality was used. The RMR uses six parameters that are readily determined in the field: uniaxial compressive strength of the intact rock, rock quality designation (RQD), spacing of discontinuities, condition of discontinuities, groundwater conditions, and orientation of discontinuities (Bieniawski, 1989). The Rock Mass Rating system is presented in Table 3.4, giving the ratings for each of the six parameters. These ratings are summed to give a value of RMR and the rock mass is classified according to the RMR value.

Table 3.4. The Rock Mass Rating (RMR) System (after Bieniawski,1989)

A. CLASSIFICATION PARAMETERS AND THEIR RATINGS

	Parameter		Range of values						
1	Strength of intact rock material	Point-load strength index	>10 MPa	4 - 10 MPa	2 - 4 MPa	1 - 2 MPa	For this low range - uniaxial compressive test is preferred		
		Uniaxial comp. strength	>250 MPa	100 - 250 MPa	50 - 100 MPa	25 - 50 MPa	5 - 25 MPa	1 - 5 MPa	< 1 MPa
	Rating		15	12	7	4	2	1	0
2	Drill core Quality *RQD*		90% - 100%	75% - 90%	50% - 75%	25% - 50%	< 25%		
	Rating		20	17	13	8	3		
3	Spacing of discontinuities		> 2 m	0.6 - 2 . m	200 - 600 mm	60 - 200 mm	< 60 mm		
	Rating		20	15	10	8	5		
4	Condition of discontinuities (See E)		Very rough surfaces Not continuous No separation Unweathered wall rock	Slightly rough surfaces Separation < 1 mm Slightly weathered walls	Slightly rough surfaces Separation < 1 mm Highly weathered walls	Slickensided surfaces or Gouge < 5 mm thick or Separation 1-5 mm Continuous	Soft gouge >5 mm thick or Separation > 5 mm Continuous		
	Rating		30	25	20	10	0		
5	Groundwater	Inflow per 10 m tunnel length (l/m)	None	< 10	10 - 25	25 - 125	> 125		
		(Joint water press)/ (Major principal σ)	0	< 0.1	0.1, - 0.2	0.2 - 0.5	> 0.5		
		General conditions	Completely dry	Damp	Wet	Dripping	Flowing		
	Rating		15	10	7	4	0		

B. RATING ADJUSTMENT FOR DISCONTINUITY ORIENTATIONS (See F)

Strike and dip orientations		Very favourable	Favourable	Fair	Unfavourable	Very Unfavourable
Ratings	Tunnels & mines	0	-2	-5	-10	-12
	Foundations	0	-2	-7	-15	-25
	Slopes	0	-5	-25	-50	

C. ROCK MASS CLASSES DETERMINED FROM TOTAL RATINGS

Rating	100 ← 81	80 ← 61	60 ← 41	40 ← 21	< 21
Class number	I	II	III	IV	V
Description	Very good rock	Good rock	Fair rock	Poor rock	Very poor rock

D. MEANING OF ROCK CLASSES

Class number	I	II	III	IV	V
Average stand-up time	20 yrs for 15 m span	1 year for 10 m span	1 week for 5 m span	10 hrs for 2.5 m span	30 min for 1 m span
Cohesion of rock mass (kPa)	> 400	300 - 400	200 - 300	100 - 200	< 100
Friction angle of rock mass (deg)	> 45	35 - 45	25 - 35	15 - 25	< 15

E. GUIDELINES FOR CLASSIFICATION OF DISCONTINUITY conditions

Discontinuity length (persistence)	< 1 m	1 - 3 m	3 - 10 m	10 - 20 m	> 20 m
Rating	6	4	2	1	0
Separation (aperture)	None	< 0.1 mm	0.1 - 1.0 mm	1 - 5 mm	> 5 mm
Rating	6	5	4	1	0
Roughness	Very rough	Rough	Slightly rough	Smooth	Slickensided
Rating	6	5	3	1	0
Infilling (gouge)	None	Hard filling < 5 mm	Hard filling > 5 mm	Soft filling < 5 mm	Soft filling > 5 mm
Rating	6	4	2	2	0
Weathering	Unweathered	Slightly weathered	Moderately weathered	Highly weathered	Decomposed
Ratings	6	5	3	1	0

F. EFFECT OF DISCONTINUITY STRIKE AND DIP ORIENTATION IN TUNNELLING**

Strike perpendicular to tunnel axis		Strike parallel to tunnel axis	
Drive with dip - Dip 45 - 90°	Drive with dip - Dip 20 - 45°	Dip 45 - 90°	Dip 20 - 45°
Very favourable	Favourable	Very unfavourable	Fair
Drive against dip - Dip 45-90°	Drive against dip - Dip 20-45°	Dip 0-20 - Irrespective of strike°	
Fair	Unfavourable	Fair	

* Some conditions are mutually exclusive . For example, if infilling is present, the roughness of the surface will be overshadowed by the influence of the gouge. In such cases use A.4 directly.

** Modified after Wickham et al (1972).

As a result of the scanline survey, the RMR classification rating value and the rock mass classification of the Pazarcık mélange schist block are given in Table 3.5 (Section 3.1.4 gives more details on the schist block).

Table 3.5. RMR classification of the Pazarcık mélange schist block

Parameter	**Ranging Value**		**Rating Value**
Strength of Intact Rock	5-25 MPa		2
RQD	<25%		3
Spacing of Discontinuity	<60 mm		5
Condition of Discontinuity	Persistence	1-3 m	4
	Aperture	>5 mm	0
	Roughness	Slightly rough	3
	Infilling	Soft filling <5 mm	2
	Weathering	Highly weathering	1
Groundwater	Completely dry		15
RMR			**35**
Rock Mass Class			**(IV) Poor Rock**

CHAPTER 4

SLOPE STABILITY ANALYSIS

4.1. Introduction

The scope of the stability analysis of an existing slope is to verify its safety condition and whether or not to carry out preventive or corrective measures. In the case where a slope is to be designed, stability analyses enables the engineer to assess a suitable geometry to ensure a minimum factor of safety (FS) under environmental conditions such as rainfall and vegetation, as well as anthropic action such as: excavations, loadings and drainage. There are two types of stability analyses: total stress and effective stress analyses. The first case corresponds to short term situations, saturated soils and impeded drainage conditions, such as end-of-construction cases. The second case, effective stress analyses, can be used for long term stability analyses in which drained conditions prevail, or even short term cases, when pore pressures are known accurately. It is suggested that most natural slopes and also slopes in residual soils should be analyzed through the effective stress method, considering the maximum water level that can be reached under severe rainstorms (Sayao, 2004).

The analysis of slopes takes into account a variety of factors relating to topography, geology, and material properties, often relating to whether the slope was naturally formed or engineered (Abramson et al., 2002).

4.2. Methods of Slope Stability Analysis

A quantitative assessment of the stability of a slope is clearly important when judgement is needed about whether the slope is stable or not, and decisions are to be made as a consequence. There are a number of different methods of stability analysis available, but the procedures are broadly similar in concept (Nash, 1992).

4.2.1. Limit Equilibrium Method

The limit equilibrium method is commonly used in slope stability analysis since it is relatively simple when compared with the finite element analysis.

Firstly, the slope under consideration and the soil forming it are modeled theoretically, including the loadings on the slope and a failure criterion for the soil is introduced. The analysis then indicates whether the failure criterion is reached, and a comparison may then be made between these conditions and those under which the modeled slope just fail. It is important to realize that the results of such an analysis are of limited value themselves, as they are dependent on the theoretical models adopted for the slope and the soil. However, when combined with experience of their application in similar conditions, the results are a useful input to the decision-making process (Nash, 1992).

In the limit equilibrium method a failure surface of simple shape is assumed and the material above this surface is considered as a free body. Then the sliding mass is divided into a number of slices. The disturbing and resisting forces above the assumed failure surface are estimated enabling the formulation of equations concerning force equilibrium or moment equilibrium (or both) of the potential sliding surface. The solution of these equations provides quantitative information, called "Factor of Safety (FS)", concerning the stability of the slope. Table 4.1 lists the common methods of analysis and the conditions of static equilibrium that are satisfied in determining the FS (Abramson et al., 2002).

Table 4.1. Static Equilibrium Conditions Satisfied by Limit Equilibrium Methods (Abramson et al., 2002)

Method	Force Equilibrium		Moment Equilibrium
	x	y	
Ordinary method of slices (OMS)	No	No	Yes
Bishop's simplified	Yes	No	Yes
Janbu's simplified	Yes	Yes	No
Lowe and Karafiath	Yes	Yes	No
Corps of Engineers	Yes	Yes	No
Spencer's	Yes	Yes	Yes
Bishop's rigorous	Yes	Yes	Yes
Janbu's generalized	Yes	Yes	No
Sarma's	Yes	Yes	Yes
Morgenstern-Price	Yes	Yes	Yes

The next step is repeating the calculations for a number of sliding surfaces and finding a factor of safety for each. The sliding surface with a minimum factor of safety is marked as the critical surface along which failure is most probable. In the limit equilibrium method, in addition to the internal friction angle, factors such as the weight of sliding mass, cohesion, pore pressure, geometry of the slope, seismic acceleration, tension crack position and external loads are all taken into account (Bromhead, 1992).

All limit equilibrium methods for slope stability analysis divide a slide-mass into "n" smaller slices (Figure 4.1) and each slice is affected by a general system of forces; as shown in Figure 4.2 (Abramson et al., 2002).

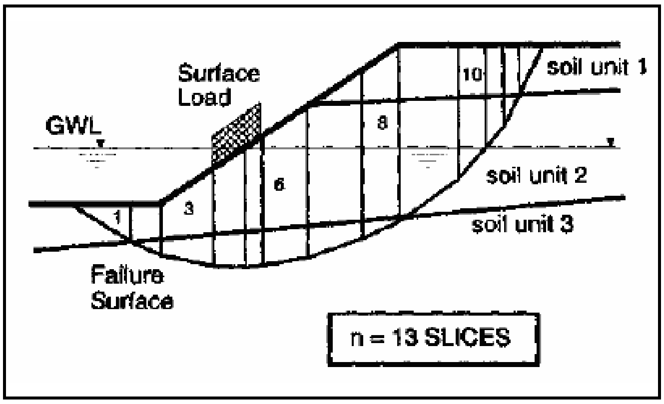
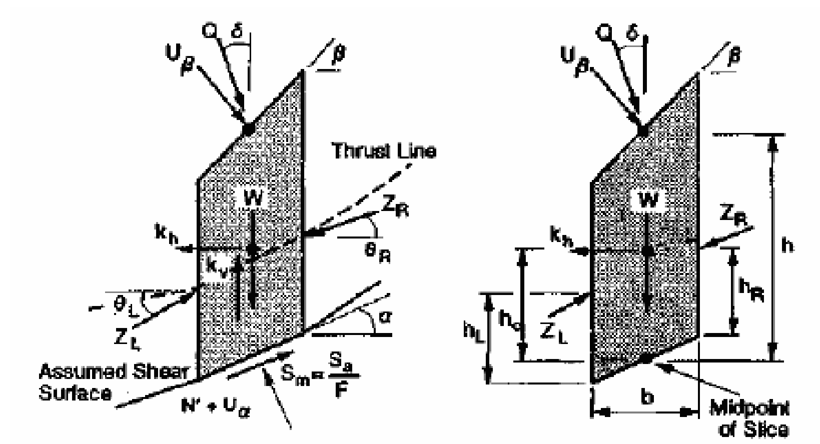


Figure 4.1. Division of sliding mass into slices (Abramson et al., 2002)



F = factor of safety
= c + N ' tan<t>

U_α = pore water force

W = weight of slice

Q = external surcharge

k_h = horizontal seismic coefficient

Z_R = right interslice force

θ_R = right interslice force angle

h_R = height to force ZR

β = inclination of slice top

b = width of slice

S_a = available strength
S_m = mobilized strength

U_β = surface water force

N' = effective normal force

k_v = vertical seismic coefficient

Z_L = left interslice force

θ_L = left interslice force angle

h_L = height to force ZL

α = inclination of slice base

δ = inclination of surcharge

h = average height of slice

h_c = height to centroid of slice

Figure 4.2. Forces acting on a typical slice (Abramson et al., 2002)

The thrust line indicated in Figure 4.2 connects the points of application of the interslice forces, Z_i. The location of this thrust line may be assumed, as in the rigorous Janbu method, or its location may be determined using a rigorous method of analysis that satisfies complete equilibrium. The popular simplified methods of analysis neglect the location of the interslice force because complete equilibrium is not satisfied for the failure mass (Abramson et al., 2002).

For this system there are (6n-2) unknowns, as listed in Table 4.2. In addition, since only four equations can be written for the limit equilibrium of the system, the solution is statically indeterminate. However, a solution is possible provided that the number of unknowns can be reduced by making some simplifying assumptions. One of the common assumptions is that the normal force on the base of the slice acts at the midpoint thus reducing the number of unknowns to (5n -2). This then requires an additional (n-2) assumption to make the problem determinate. It is these assumptions that generally categorize the available methods of analysis (Abramson et al., 2002).

Table 4.2 Equations and unknowns associated with the method of slices (Abramson et al., 2002)

Equations	Condition	Unknown	Variable
n	Moment equilibrium for each slice	1	Factor of safety
		n	Normal force at base of each slice, *N′*
2n	Force equilibrium in two directions (for each slice)	n	Location of normal force, *N′*
		n	Shear force at base of each slice, Sm
n	Mohr-Coulomb relationship between shear strength and normal effective stress	n-1	Interslice force, *Z*
		n-1	Inclination of interslice force, θ
		n-1	Location of interslice force (line of thrust)
4n	**Total number of equations**	**6n-2**	**Total number of unknowns**

The assumptions made by each of these methods, to render the problem determinate, are summarized below (Abramson et al., 2002).

Ordinary Method of Slices (OMS): This is the simplest of the method of slices and allows hand calculation. In this method, interslice forces are assumed to be parallel to the base of the slice and it fails to satisfy force equilibrium. Bishop's Simplified Method: Bishop assumes that all interslice shear forces are zero, reducing the number of unknowns by (n-1). This leaves (4n-1) unknowns, leaving the solution overdetermined as horizontal force equilibrium will not be satisfied for one slice.

Janbu's Simplified Method: Interslice shear forces are assumed to be zero, reducing the number of unknowns to (4n -1). This leads to an over determined solution that will not completely satisfy moment equilibrium conditions. However, Janbu presented a correction factor, f_o, to account for this inadequacy.

Bishop's Rigorous Method: Bishop assumes (n -1) interslice shear forces to calculate an FS. Since this assumption leaves (4n -1) unknowns, moment equilibrium cannot be directly satisfied for all slices. However, Bishop introduces an additional unknown by suggesting that there exists a unique distribution of the interslice resultant force, out of a possible infinite number, that will rigorously satisfy the equilibrium equations.

Janbu's Generalized Method: Janbu assumes a location of the thrust line, thereby reducing the number of unknowns to (4n -1). Similar to the rigorous Bishop method, Janbu's generalized method also suggests that the actual location of the thrust line is an additional unknown, and thus equilibrium can be satisfied rigorously if the assumption selects the correct thrust line.

Spencer's Method: In the Spencer method, it is assumed that the resultant interslice force has a constant, but an unknown inclination (Spencer, 1967). These (n-1) assumptions again reduce the number of unknowns to (4n-1), but the unknown inclination is an additional component that subsequently increases the number of unknowns to match the required 4n equations.

Morgenstern-Price Method: Morgenstern and Price method is similar to Spencer's method, except that the inclination of the interslice resultant force is assumed to vary according to a "portion" of an arbitrary function. This additional "portion" of a selected function introduces an additional unknown, leaving 4n unknowns and 4n equations (Morgenstern and Price, 1965).

A summary of the common limit equilibrium methods and their conditions are given in Table 4.3.

Table 4.3. Common limit equilibrium methods and their conditions (Nash, 1992)

Method	**Shape of failure surface**	**Assumptions about interslice forces**	**Calculated practically by**	
			Hand	**Computer**
Ordinary method of slices (OMS)	Circular	Resultant parallel to base	Yes	Yes
Bishop's simplified	Circular	Horizontal	Yes	Yes
Janbu's simplified	Circular, Noncircular	Horizontal correction factor	Yes	Yes
Spencer's	Circular, Noncircular	Constant inclination	No	Yes
Bishop's rigorous	Circular, Noncircular	Assume distribution	Yes	Yes
Janbu's generalized	Circular, Noncircular	Define trust line	Yes	Yes
Morgenstern-Price	Circular, Noncircular	$X/E=\lambda f(x)$	No	Yes

4.2.2. Finite Element Method

The finite element method (FEM) can be effectively used for stability evaluations utilizing the c-ϕ reduction procedure (Brinkgreve and Bakker 1991, Vermeer and van Langen, 1989). A suitable alternative to the traditional limit equilibrium approaches is the finite element method in that, it is more versatile and requires fewer a priory assumptions, especially regarding the failure mechanism. Evolution of the failure zone is gradually dependent on the deformation behavior of soils described by a suitable constitutive model (Potts and Zdravkovic, 1999). Thus no assumption needs to be made in advance about the shape or location of the failure surface that arises naturally in the zones where the shear strength of soils is insufficient to resist the shear load. In modeling failure processes attention is usually limited to elastic-perfect plastic behavior so that the hardening or the softening behavior of real soils confirmed by a number of experimental observations is excluded from the analysis. An extensive numerical experimentation on stability of slopes under these assumptions is reported by Griffith (2001). The use of finite elements in geotechnical engineering, however, is much more versatile and by no means limited to stability analysis of earth slopes. The stresses within the slopes are strongly influenced by K_o, the ratio of lateral to vertical normal effective stresses, but conventional limit equilibrium procedures ignore this important feature (Chowdhury, 1981). In reality, the stress distributions within the slopes would be different and hence, would significantly influence their stability.

The finite element method (FEM) bypasses many of the deficiencies that are inherent with the limit equilibrium methods. It was first introduced to geotechnical engineering by Clough and Woodward (1967), but its use has been limited to the analysis of complex earth structures. For typical cases, the FEM can incorporate incremental construction for embankments and excavations in an attempt to simulate the stress history of the soil within the slope. However, the quality of the FEM is directly dependent on the ability of the selected constitutive model to realistically simulate the nonlinear behavior of the soil within the slope. For new embankment designs, the data may be collected from laboratory tests. For excavations and natural slopes, the constitutive model can only really be developed on the basis of high quality field tests that are further supported by field observations (Abramson et al., 2002).

The FEM essentially divides the soil continuum into discrete units, that is, finite elements (Figure 4.3). These elements are interconnected at their nodes and at predefined boundaries of the continuum. The displacement method formulation of the FEM is typically used for geotechnical applications and presents results in the form of displacements, stresses, and strains at the nodal points. There are many two and three dimensional computer programs available for finite element analyses of slopes and embankments.

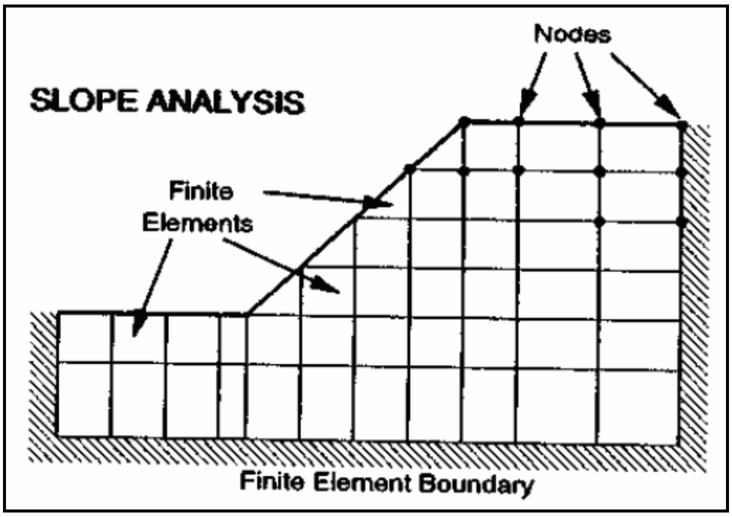


Figure 4.3. Definitions of terms used for FEM (Abramson et al., 2002)

4.3. Seismic Slope Stability Analysis

Earthquake ground motions are capable of inducing large destabilizing inertial forces of a cyclic nature, in slopes and embankments. Also, the shear strength of the soil may be reduced due to transient loads (i.e., cyclic strains) or due to the generation of excess pore water pressures. The combined effect of the seismic loads and the changes in shear strength will result in an overall decrease in the stability of the affected slope (Abramson et al., 2002).

Typically, cyclic loads will generate excess pore water pressures in loose, saturated cohesionless material (gravels, sands and nonplastic silts), which may liquefy with a considerable loss of pre-earthquake strength. However, cohesive soils and dry cohesionless materials are not generally affected by cyclic loads to the same extent. If the cohesive soil is not sensitive, in most cases it appears that at least 80 percent of the static shear strength will be retained during and after the cyclic loading (Makdisi and Seed, 1978). In general, four methods of analysis have been proposed for the evaluation of the stability of slopes during earthquakes. With an increasing order of the complexity and expense, these are the pseudo-static method, Newmark's displacement method, post-earthquake stability, and dynamic finite element analysis.

4.3.1. Pseudo-Static Method

The pseudo-static method offers the simplest approach for evaluating the stability of a slope in an earthquake prone region. In its implementation, the limit equilibrium method is modified to include horizontal and vertical static seismic forces that are used to simulate the potential inertial forces due to ground accelerations in an earthquake. These seismic forces are assumed to be proportional to the weight of the potential sliding mass times seismic coefficients, k_h and k_v, expressed in terms of the acceleration of the underlying earth (in units of g). It is recommended that only the most critical surface, as identified by a static analysis, should be reanalyzed using pseudo-static seismic coefficients, as it will be the most stressed region within the slope (Abramson, et al., 2002).

Typically, the seismic force is presumed to act in the horizontal direction only, that is, k_v=0, inducing inertial force, k_hW, in the slope, where W is the weight of the potential sliding mass. A FS is then calculated using conventional methods. The greatest difficulty with this procedure involves the selection of an appropriate seismic coefficient and the value of an acceptable FS (Abramson, et al., 2002).

The magnitude of the seismic coefficient should effectively simulate the nature of the expected earthquake forces, which will depend on earthquake intensity, for example, peak ground acceleration (PGA), duration of shaking and frequency content. Of course as a very conservative assumption, one can select a seismic coefficient that is equal to the PGA expected at the slope. However, this conservatism will lead to a very uneconomic evaluation. The selection of such coefficients, therefore, must be rationalized if slopes are to be designed economically (Abramson et al., 2002). Some typical seismic coefficients that have been used for evaluating the seismic stability of slopes are given in Table 4.4.

Table 4.4. Typical seismic coefficients and FS in practices (Abramson et al., 2002)

Seismic Coefficient	Remarks
0.10	Major earthquake, FS>1.0 (Corps of Engineers,1982)
0.15	Great Earthquake, FS>1.0 (Corps of Engineers,1982)
0.15-0.25	Japan, FS>1.0
0.05-0.15	State of California
0.15	Seed (1979), with FS>1.15 and a 20 percent strength reduction
(1/3)PGA - (1/2)PGA*	Marcuson and Franklin (1983), FS>1.0
(1/2)PGA*	Hynes-Graffin and Franklin (1984), FS>1.0 and a 20 percent strength reduction

*PGA in g

4.3.2. Newmark's Displacement Method

The procedure proposed by Newmark (1965) extends the simple pseudo-static approach by directly considering the acceleration time history (accelerogram) of the slide mass within the slope. This accelerogram, selected to represent a realistic model of the ground motions expected at the site, is then compared with the yield acceleration to determine permanent displacements (Abramson et al., 2002).

Newmark's method assumes existence of a well-defined slip surface, a rigid, perfectly plastic slide material, a negligible loss of shear strength during shaking, and occurrence of permanent strains only if the dynamic stress exceeds the shear resistance. Also, the slope is only presumed to deform in the downslope direction, thus implying infinite dynamic shear resistance in the upslope direction. The procedure requires that the value of a yield acceleration or critical seismic coefficient, k_y, be determined for the potential failure surface using conventional limit equilibrium methods. The main difficulty associated with this method is related to the selection of an appropriate accelerogram that simulates the motions of the slide mass. However, once this has been selected, the permanent displacements are calculated by double integration of the portions of the accelerogram that exceed the yield acceleration for the critical failure surface (Abramson et al., 2002).

The reported permanent displacements represent the motion of the center of gravity of the slide mass. For a planar slip-surface, the direction of this permanent displacement will be parallel to the slip surface. For the typical nonplanar failure surface, the direction of the permanent displacements is not immediately obvious. In such cases, the initial direction of the block's motion may be determined by considering the free-body forces that exist along the boundary of the slide mass. This direction may be calculated first by the resultant of all the shear forces and all the normal forces acting along the failure surface boundary. This essentially amounts to a vertical summation of the shear and normal forces at the base of all slices, as determined in a limit equilibrium analysis. The permanent displacements are then assumed to act along the direction of the resultant of the cumulative shear and normal forces (Bromhead, 1992).

A typical ground response analysis consists of selecting an accelerogram to represent excepted motions on bedrock, which should effectively simulate the intensity, duration and frequency content of the shaking motions. Then by using a numerical model, these bedrock motions are propagated through the overlying soil layers. Results from such an analysis can provide acceleration, stress and strain time histories within the geometric model of the slope (Abramson et al., 2002).

4.3.3. Postearthquake Stability

Postearthquake stability is calculated using laboratory undrained strengths, determined on representative soil samples that have been subjected to the cyclic loads comparable to the anticipated earthquake (Abramson et al., 2002).

4.3.4. Dynamic Finite Element Analysis

In dynamic finite element analysis, a coupled two- (or three-) dimensional analysis using an appropriate constitutive soil model will provide details concerning stresses, strains, and permanent displacements (Abramson et al., 2002).

CHAPTER 5

ASSESSMENT OF SLOPE INSTABILITY

5.1. Introduction

Within the scope of “the Bursa – İnegöl – Bozüyük Highway (Section II) Construction Job between KM: 69+400 – 81+700” a considerable amount of mass movement occurred during the construction work of the left cutting slope in between KM: 72+000 and 72+200 in May, 2006. 40 to 60 cm wide tension cracks formed approximately 110 m behind the cutting slope; and throughout the terrain, surface deformations occurred due to mass movement. As a solution to this problem, the left cutting slope was inclined with a ratio of 3/2 (h/V). However, despite all the preventive measures taken, the mass movement continued and the width of the tension crack at the crown area of the mass movement was measured in terms of meters. After the movement, the cutting slope was observed to be displaced about 1.0 – 1.5 m within the road cut.

5.2. Mechanism of the Landslide

The landslide has occurred inside the Pazarcık mélange (Pzp). The rocks in the mélange are very weak and completely decomposed. According to Abramson et al. (2002), mélanges are difficult geotechnical materials to deal in analyzing slope stability because of their heterogeneity and complex nature. In light of the conducted studies, the landslide in general is controlled by fault lines and advanced joint systems but also exhibits circular slip properties in the toe region. According to the data provided by the geological – geotechnical investigations, the landslide has a length of approximately 200 m, a width of approximately 130 m and an elevation difference between the landslides’ crown and toe is approximately 48 m. The mass thickness of the current landslide according to the inclinometer measurements was found to vary between approximately 3 – 29 m along the slip surface and the current mean speed of the movement along the most critical slip surface was measured to range from 2.05 to 7.60 mm/day. The digital elevation model of the study area and its close vicinity is given in Figure 5.1.

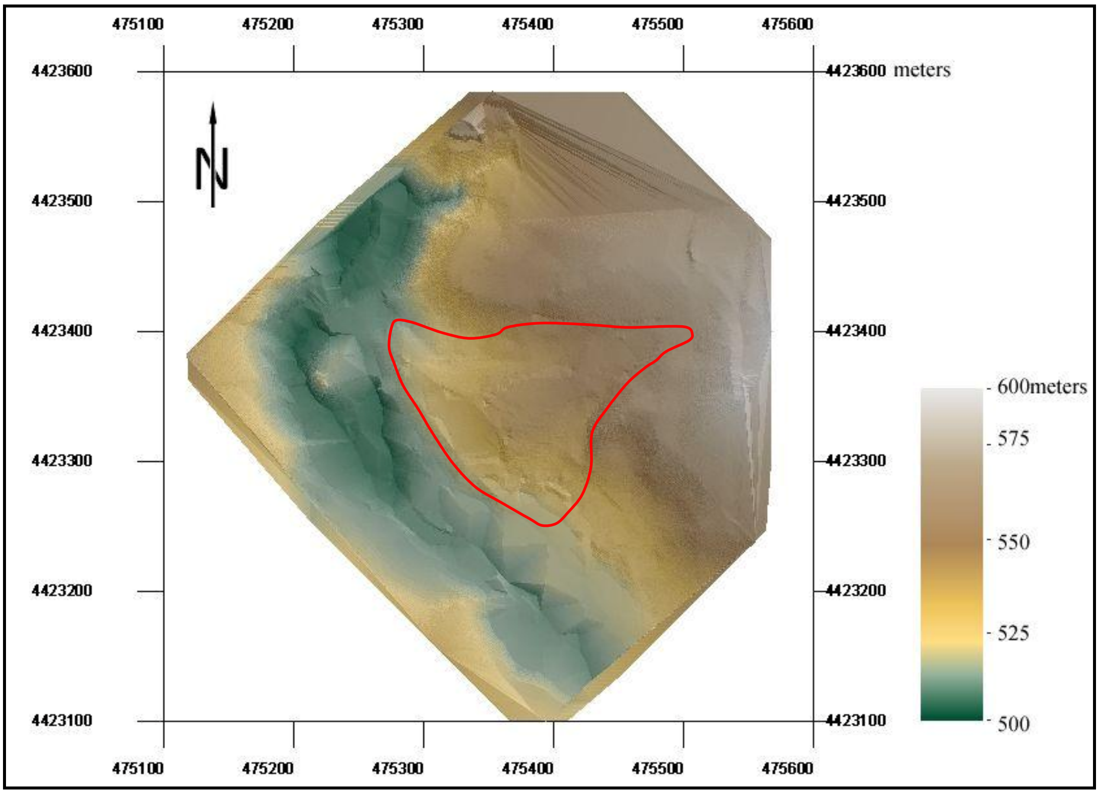


Figure 5.1. Digital elevation model of the study area (the boundary of the landslide is denoted with the solid red line)

According to the Varnes (1978), if the ratio of the depth (D) to the length (L) of a landslide is greater than 0.15, the landslide can be categorized as a “rotational slide”. If the ratio is less than 0.10, it is a “translational slide”. The landslide, with an average D/L ratio of about 0.08 appears to be a translational slide.

In addition to the excavation at the toe of slope, the most important factors triggering the landslide are the active surface water and groundwater flow.

5.3. Determination of the Shear Strength Parameters

Following the geotechnical site investigation, a back analysis has been carried out using the limit equilibrium stability software Slope/W to determine the mobilized shear strength of the slope.

5.3.1. Back Analysis

Back analysis is probably the most valuable tool available for the slope stability problems. With the aid of the back analysis methods, relevant shear strength parameters can be obtained that otherwise would not be obtained through conventional laboratory testing (Abramson et al., 2002).

According to Filz et al. (1992), an analytic model of a failed or failing slope developed by back analysis consists of five components:

(1) Landslide geometry including the ground surface, slip surface, and material boundary locations

(2) Pore water pressures on the sliding surface at the time of failure. These are necessary for effective stress analysis

(3) External loads acting on the slope at the time of failure

(4) Unit weights of the materials involved in the landslide

(5) Strength of materials along the failure surface.

Often the first four components of the model can be evaluated with reasonable accuracy based on field and laboratory investigations. Back analysis is often used to establish the fifth component of the model, that is, the soil strengths, on the assumption that the factor of safety is equal to 1.0 at the time of failure. Because of large deformations, residual strengths are often in effect along the existing failure surfaces, and the material strengths can be characterized by values of effective stress, residual friction angle and the effective cohesion intercept (Abramson et al., 2002).

5.3.2. Determination of the Shear Strength Parameters of the Failure Surface by Back Analysis

Back analyses were carried out using conventional limit equilibrium method to establish the mobilized shear strength parameters of the slope. The back analyses were performed on four cross sections, which are nearly parallel to the direction of movement, using the slice method of Morgenstern and Price with the help of Slope/W. The location and direction of the cross sections used in the analysis are given in Appendix A, Figure A1 and the cross sections are given in Appendix A, Figures A2 through A5.

During the back analysis well defined slip surfaces and groundwater tables were adopted in the models. The positions of the failure surface for all four cross sections were obtained from the results of the inclinometer readings.

The slope consisted of three lithologies from bottom to the top, namely the Pazarcık mélange, parts of the Pazarcık mélange that weathered into soil, and the landslide material which were defined in the back analyses. The strength parameters of parts of the Pazarcık mélange that weathered into soil that will be used in the stability analyses were determined by Yüksel Proje Uluslararası A.Ş. (2007) from the field investigations and correlations of soil properties as follows:

The cohesion was determined using approximate correlation between undrained shear strength and SPT(N) values (Sowers, 1979) and the lower bound of the correlation, c' = 5 kPa, was taken into account in order to be on the safe side. The internal friction angle was determined using the relationship between SPT (N) and internal friction angle (Peck et al., 1974) and the lower value of the internal friction angle (ϕ’) of 30° was chosen.

The rock mass strength parameters of the Pazarcık mélange were determined by using the RocLab 1.0 computer software which is based on the generalized Hoek-Brown failure criterion. In addition to the Hoek-Brown failure criterion using the other parameters (mb, s and a), RocLab always calculates equivalent Mohr-Coulomb parameters (cohesion and friction angle) for the rock mass (Rocscience, 2002). Figure 5.2 shows the graphical relationship between the normal and shear stresses of Pazarcık mélange as calculated by RocLab.

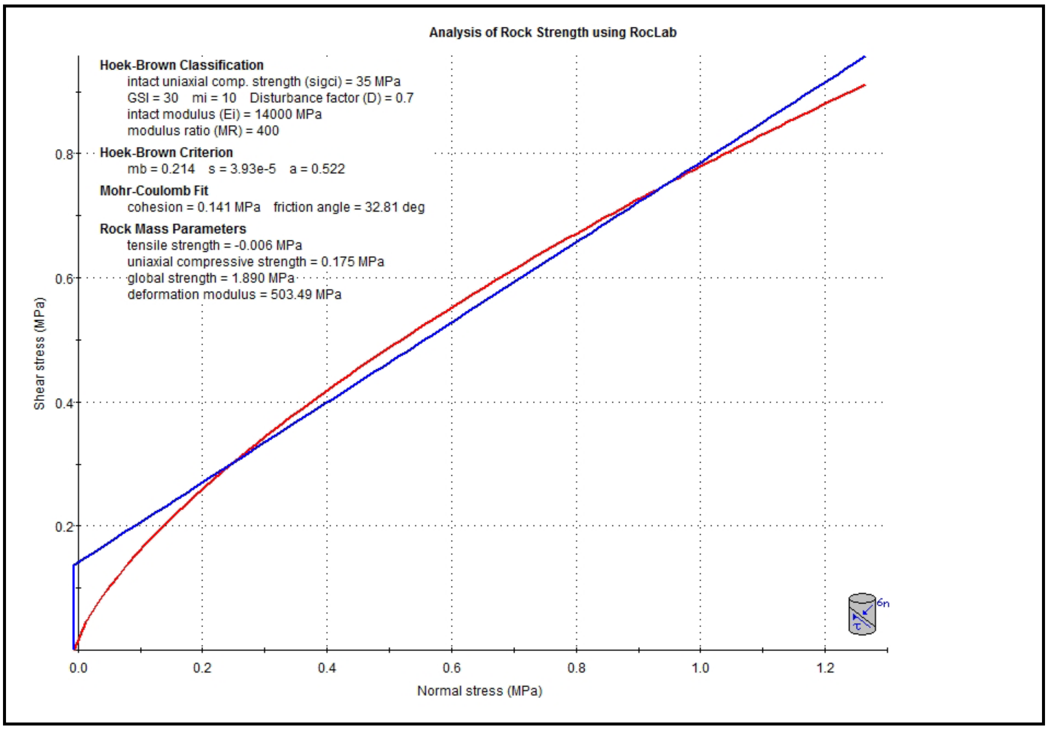


Figure 5.2. Normal stress vs. shear stress as calculated by RocLab 1.0

The strength parameters of the Pazarcık mélange were determined according to RocLab as follows:

c = 141 kPa

ϕ = 33°

After the determination of the strength parameters for the parts of the Pazarcık mélange that weathered into soil and for the Pazarcık mélange, the strength parameters of the landslide material were obtained from back analysis by adjusting c’ and ϕ’ parameters until the factor of safety is unity (FS=1.0) which is regarded as a prerequisite for failure in a limit equilibrium analytical model. Back analyses results showing the c’- ϕ’ pairs of limit equilibrium condition in the form of c’- ϕ’ curves are given in Figure 5.3.

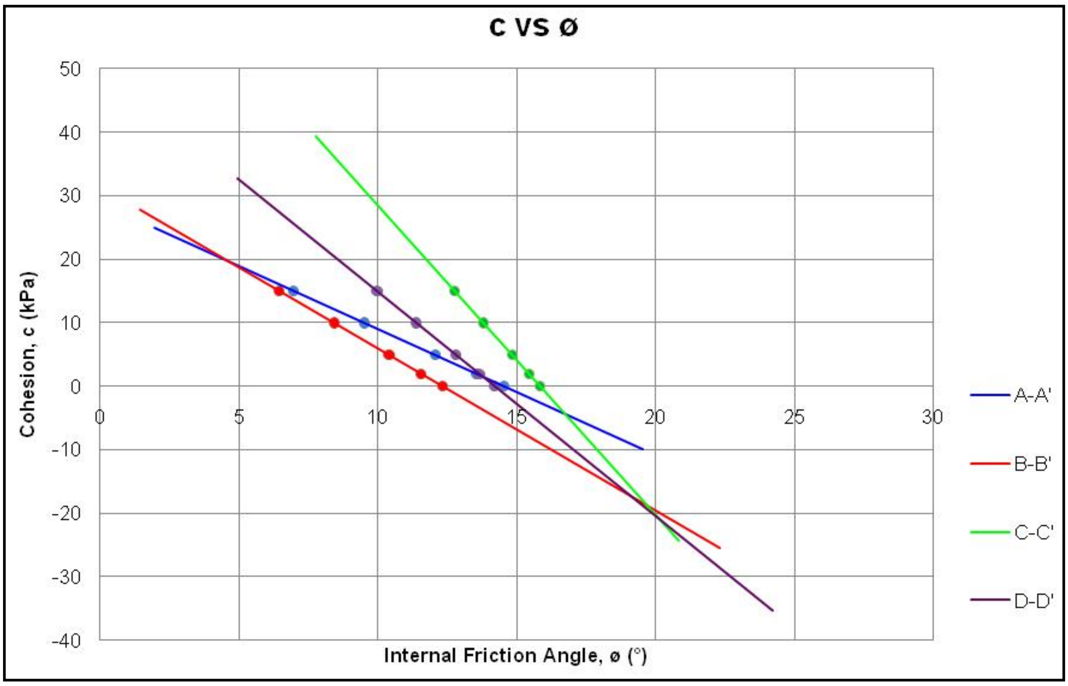


Figure 5.3. Back analyses results showing the c’-ϕ’ pairs for FS=1.0 for the various cross sections

As it can be seen from Figure 5.3, all four curves c’-ϕ’ curves intersect at six points. According to Craig (1992), the residual cohesion for many soils is very low and can be taken as zero. In addition to Craig’s statement, since four of the six intersections intersections fall in the region where c’ has a negative value and since c’ cannot take a value smaller than “0°”, it is taken as zero. For the c’=0 condition ϕ’ ranges between 12° and 16°. Due to the cohesionless nature of the landslide material and the statement of Craig (1992), the pairs of c’ = 0 kPa and ϕ’ = 15.7° have been considered as representative mean values for the landslide material and will be used for slope design.

5.4. Modeling of the Landslide

After the determination of the shear strength parameters for all three materials, the most suitable cross section that represents the landslide area was chosen in order to model the landslide and to find the most appropriate remediation technique.

Since the deepest landslide mass, the longest slip surface and the highest number of inclinometer measurements (4) were present in cross section C-C’, this cross section was selected for slope design. The landslide was modeled through utilizing both limit equilibrium analysis and finite element method.

5.4.1. Limit Equilibrium Modeling of the Landslide

A coupled hydrogeological-slope stability analysis was used to assess the stability of the landslide. Since rainfall can be defined as a parameter decreasing the shear strength (due to an increase in pore water pressure on the failure surface), the landslide was modeled using the approach of a general infiltration analysis combined with a hydrogeological-slope stability analysis performed with the computer softwares SEEP/W and SLOPE/W. There are two fundamental types of the finite element seepage analyses, which are the steady-state and the transient analyses, respectively.

Steady state describes a situation where the state of the model is time independent. This type of analysis does not consider how long it takes to achieve a steady condition. The model will reach a solved set of pressure and flow conditions for the given set of unique boundary conditions applied to it and that is the extent of the analysis. A transient analysis by definition means one that is always changing. It is changing because it considers how long the soil takes to respond to the user boundary conditions. For a transient analysis, it is essential to define the initial (starting) total head at all the nodes. It is important to recognize that the initial conditions for a transient analysis can have a significant effect on the solution (Geo-Slope, 2008).

5.4.1.1. Steady State Model

Water contributes greatly to many landslides. Careful examination of existing drainage lines and potential change of drainage routes to the spot under scrutiny should be made. Such drainage may appear on the surface or may go underground and reappear as seepage water that may cause damage to slopes (Abramson et al., 2002). Therefore the boundary conditions of the model should be determined carefully while constructing the model.

In the steady state seepage analysis three boundary conditions, which are infiltration, potential seepage face and zero pressure head were adopted to the model in order to represent a realistic case of the landslide (Figure 5.4).

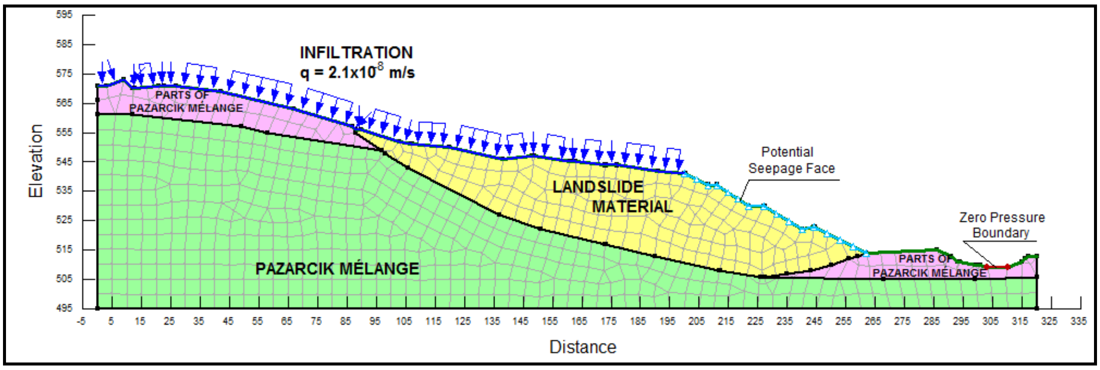


Figure 5.4. Input model for steady state seepage analysis

While assigning the infiltration rate, an annual mean precipitation of 673.5 mm, in accordance with the Turkish State Meteorological Service between the years 1960 and 2000 in the region was considered which led to an infiltration rate from precipitation of 2.1 x10^{-8} m/s in modeling the study area. According to Freeze and

Cherry (1979), the hydraulic conductivity of fractured metamorphic rocks varies between 10^{-8} m/s and 10^{-4} m/s. By considering these numbers, the hydraulic conductivity values that were used in the steady state analysis are given in Table 5.1. The result of the steady state seepage analysis is given in Figure 5.5.

Table 5.1. Parameters used in the steady state seepage analysis for Seep/W

Material	Hydraulic Conductivity, k (m/s)
Landslide Material	1.0×10^{-6}
Parts of Pazarcık Mélange	2.0×10^{-6}
Pazarcık Mélange	5.0×10^{-7}

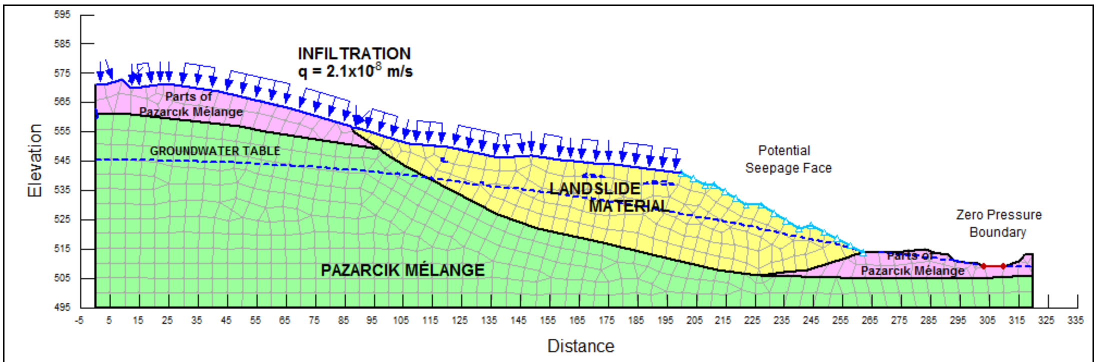


Figure 5.5. Result of the steady state seepage analysis

As it can be seen from Figure 5.5, the position of the groundwater table is almost identical to the actual case, as given in the cross section C-C’ in Appendix A, Figure A4. The resulting pore water pressure distribution (Figure 5.6) was directly linked into the slope stability analysis in order to perform a coupled slope stability analysis. The geotechnical material parameters used in the slope stability analysis are given in Table 5.2.

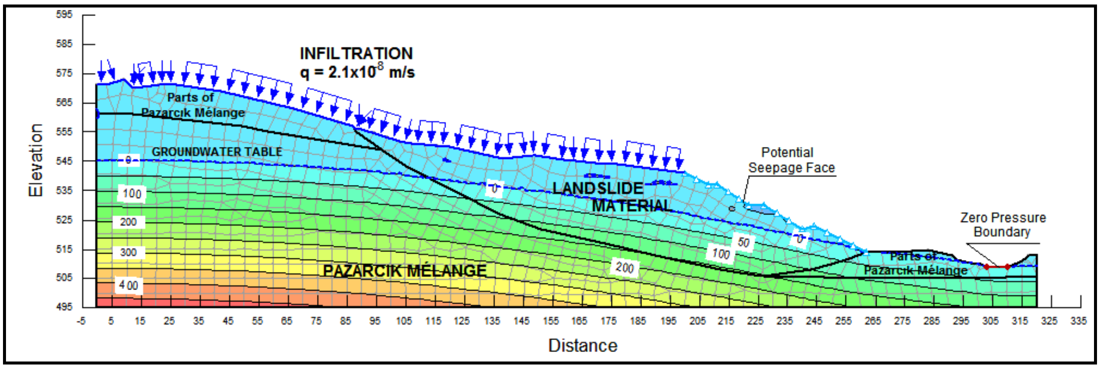


Figure 5.6. Pore water pressure distribution as a result of the steady state seepage analysis

Table 5.2. Geotechnical parameters used in the steady state analysis for Slope/W

Material	Material Model	Unit Weight (kN/m^3)	Cohesion, c' (kPa)	Internal Friction Angle, ϕ' (°)
Landslide Material	Mohr-Coulomb	20	0	15.7
Parts of Pazarcık Mélange	Mohr-Coulomb	20	5	30
Pazarcık Mélange	Mohr-Coulomb	26	141	33

The slope stability analysis uses, as input data, for each time step positive and negative pore water distributions obtained from the seepage analysis. The Morgenstern and Price method and half-sine function were selected to compute the factor of safety. The results of the seepage and slope stability analyses leading to FS=1.001 is given by Figure 5.7.

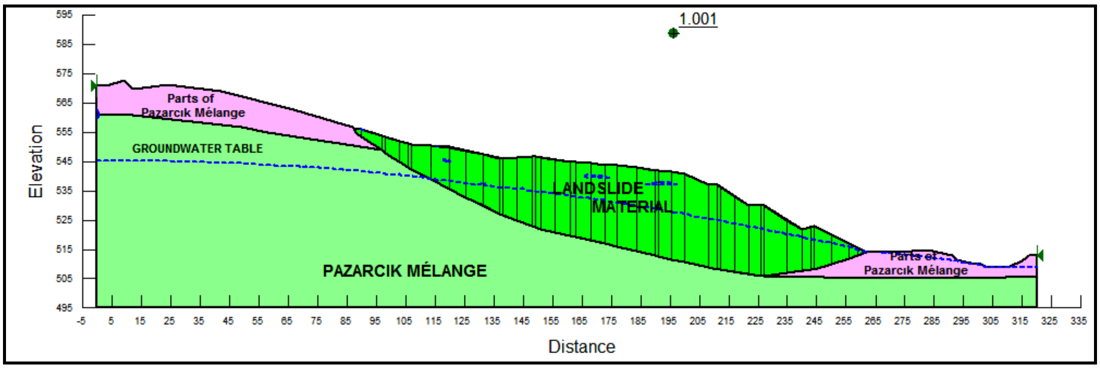


Figure 5.7. The result of the slope stability model for steady state condition

5.4.1.2. Transient Model

The transient analysis can be performed in two ways: by either reading the data from an initial condition file created in a separate analysis or by drawing the initial water table position (Casagli et al., 2005). In the first way, initial conditions are introduced from the file created by a steady-state seepage analysis. The parameters used in the transient model analysis are the same as that used in the steady state analysis. The result of a transient state seepage analysis model from the steady state analysis is given in Figure 5.8.

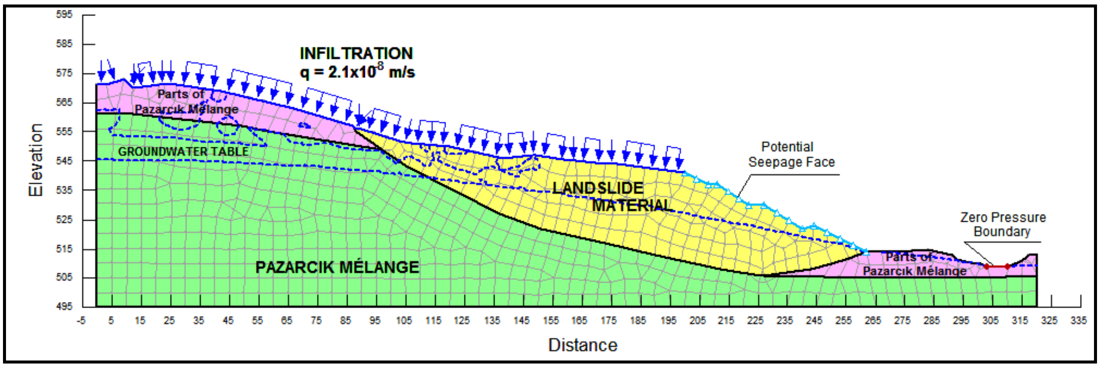


Figure 5.8. Transient seepage analysis having initial condition from steady state analysis

The slope stability analysis for each time step uses positive and negative pore water distributions obtained from the transient seepage analysis. The Morgenstern and Price method and the half-sine function were selected to compute the factor of safety. The result of a transient seepage slope stability analyses with a FS=0.996 is given in Figure 5.9.

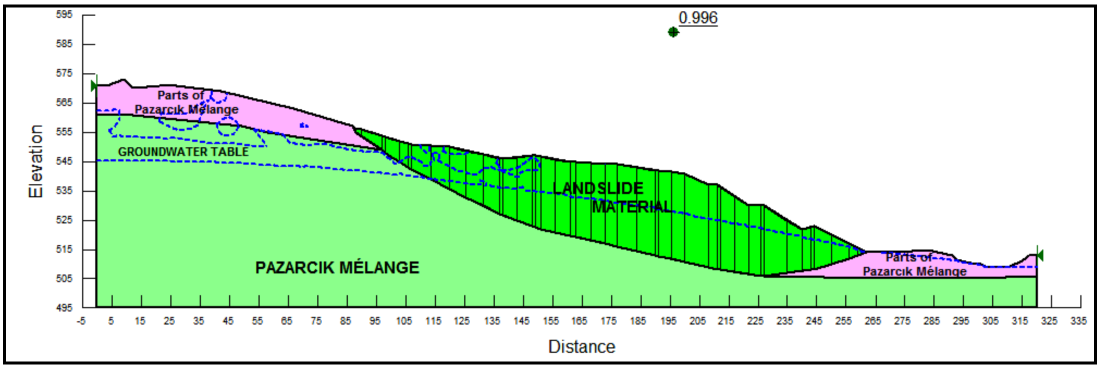


Figure 5.9. The result of a slope stability model for transient condition

The input model for the transient analysis through drawing the initial groundwater position is given in Figure 5.10. The result of the transient seepage slope stability analyses through drawing the initial groundwater level led to a FS of 0.990, which was about 4% lower than that of the steady state slope stability analysis (Figure 5.11).

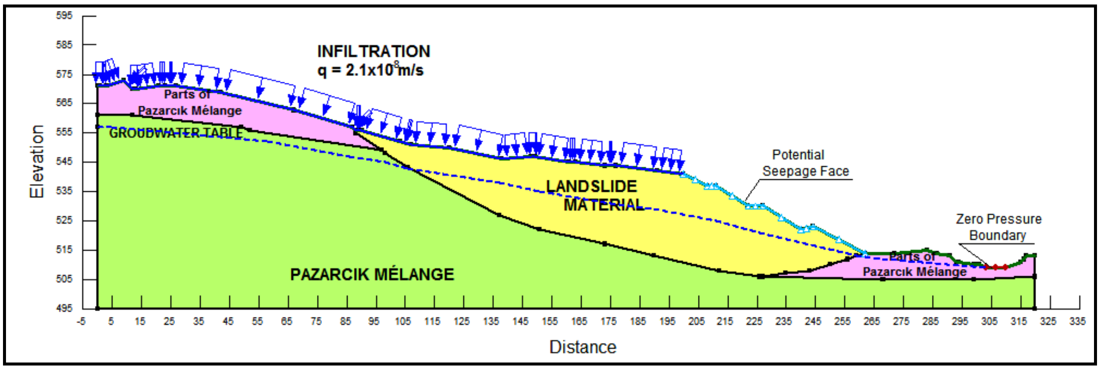


Figure 5.10. Input model for the transient seepage analysis by drawing initial groundwater level

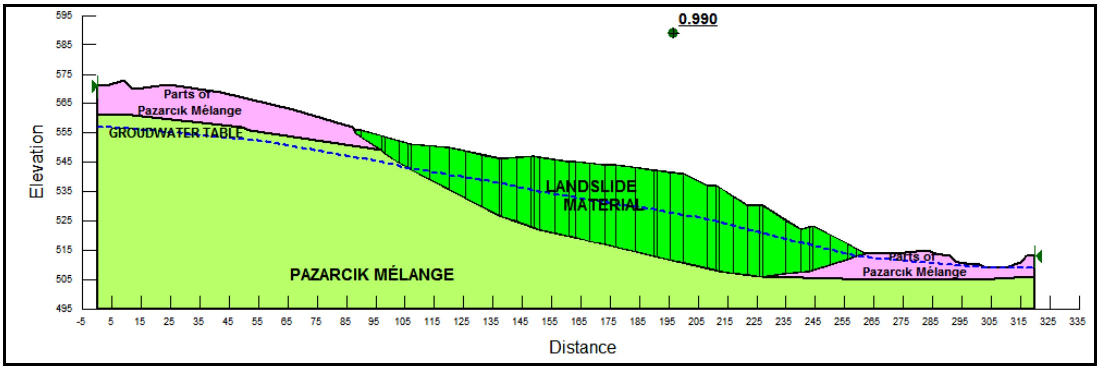


Figure 5.11. The result of the slope stability model for transient condition through drawing the initial groundwater position

5.4.2. Finite Element Modeling of the Landslide

For the numerical analysis of the slope a 2D plane strain finite element model with simple Mohr-Coulomb model was constructed in PLAXIS v.8.2 (PLAXIS, 2006). The PLAXIS model was constructed in two stages. First, the original slope before the road construction (i.e. excavation) was modeled. After that, the failure condition which is the case of excavation at the toe was modeled. In these two models the predetermined shear strength parameters in the limit equilibrium method were used. Since in PLAXIS the slip surface cannot be defined and the most critical slip surface was somehow determined to be shallower than the one determined by the inclinometer measurements, there was a need to insert a relatively weak layer, which can be referred to as a discrete shear zone along the identified slip surface to initiate the most critical slip surface.

Calibrations were performed using the shear wave velocities to fit the horizontal displacements obtained from the numerical model to the ones measured in the site by inclinometers. The parameters used in PLAXIS are given in Table 5.3. The generated and deformed mesh of the model is given in Figure 5.12 and the total displacements are shown in Figure 5.13.

Table 5.3. Parameters used in PLAXIS

Material	**Cohesion, c' (kPa)**	**Internal Friction Angle, ϕ' (°)**	**Poisson's Ratio, ν**	**Shear Wave Velocity, V_s (m/s)**
Landslide Material	0	15.7	0.33	110
Parts of Pazarcık Mélange	5	30	0.33	260
Pazarcık Mélange	141	33	0.25	350

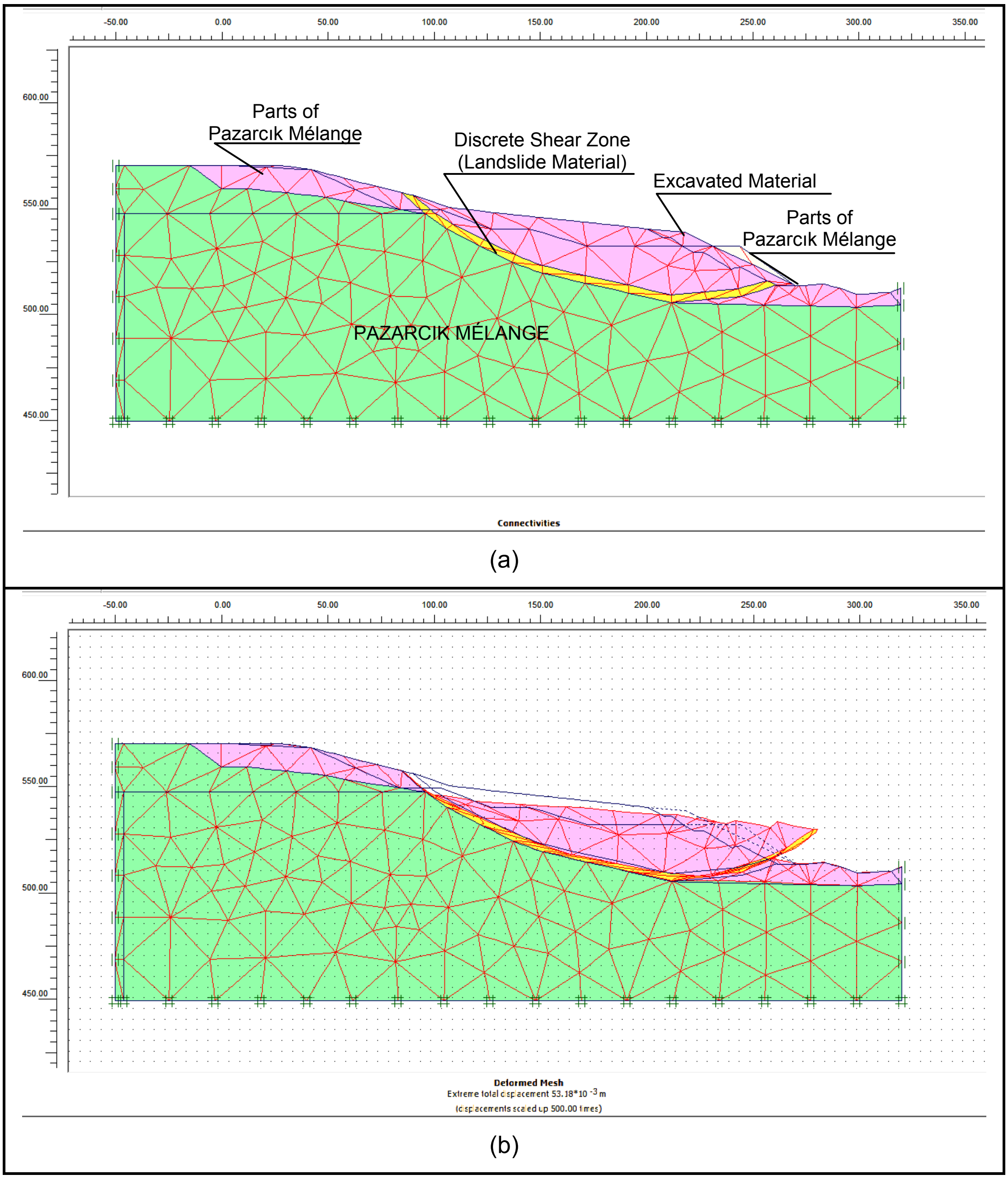


Figure 5.12.a. Generated mesh, b. deformed mesh of the landslide model

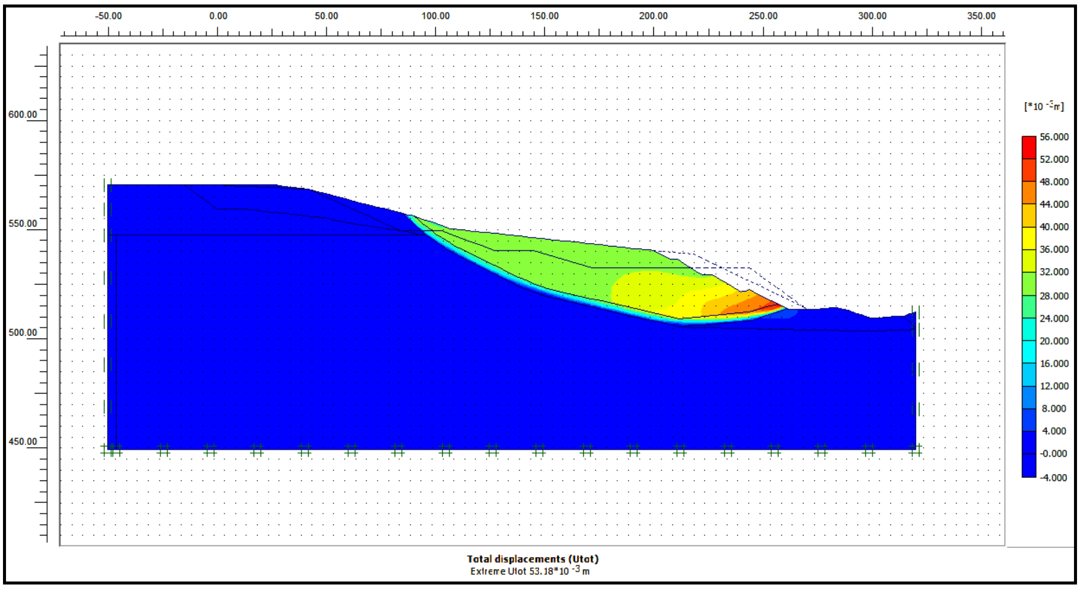


Figure 5.13. Total displacements obtained by PLAXIS v.8.2.

The measured and computed values are given in Table 5.4. Comparison of the inclinometer readings of IBH-7i with the total displacement obtained with PLAXIS is shown in Figure 5.14. As it can be seen from Table 5.4, the displacements computed by PLAXIS are in good agreement with the readings obtained from the inclinometer measurements.

Table 5.4. Total displacements

Borehole ID	Inclinometer Test Result	PLAXIS Result
IBH-7i	41 mm	41 mm
IBH-8i	38 mm	34 mm
IBH-9i	34 mm	30 mm
IBH-10i	26 mm	29 mm

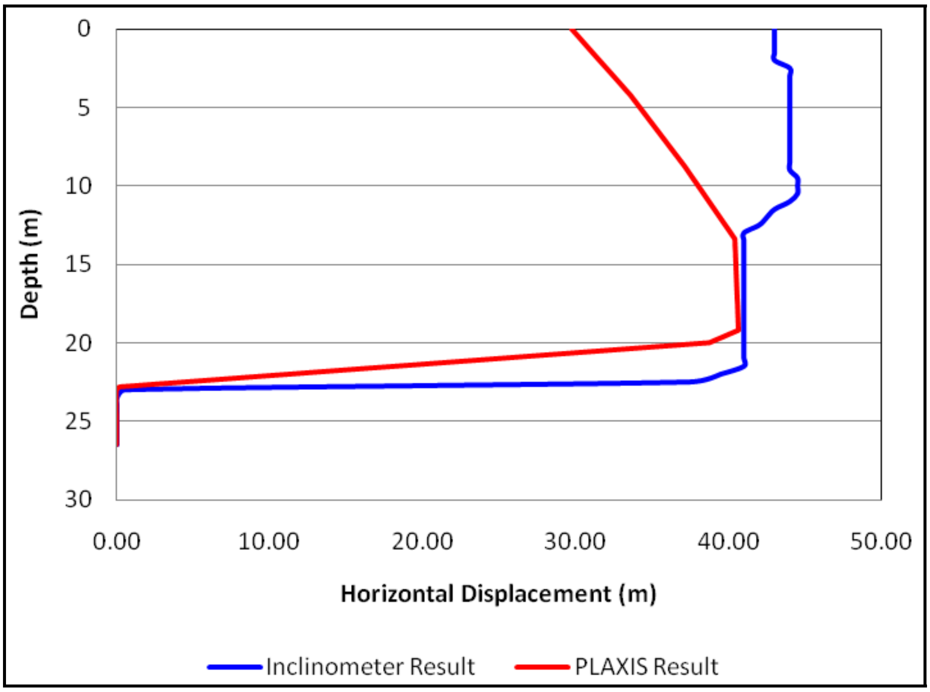


Figure 5.14. Comparison of the horizontal displacements for IBH-7i

Inspection of Figure 5.14 indicates that PLAXIS was particularly successful in predicting the horizontal displacements at the toe of the slope which is almost always considered as the most critical location of the entire slope.

The stability analysis was performed using the c-phi reduction method to calculate the global safety factor. The factor of safety values obtained before and after the excavation were determined to be 1.18 and 0.969, respectively. The factor of safety obtained from the limit equilibrium analyses before and after the excavation were calculated as 1.17 and 0.990, respectively. A comparison of the factor of safety values before and after excavation obtained with the limit equilibrium analysis and the finite element method indicates that the results are in good agreement (i.e., within 0.60% to 2.1%; Figure 5.15).

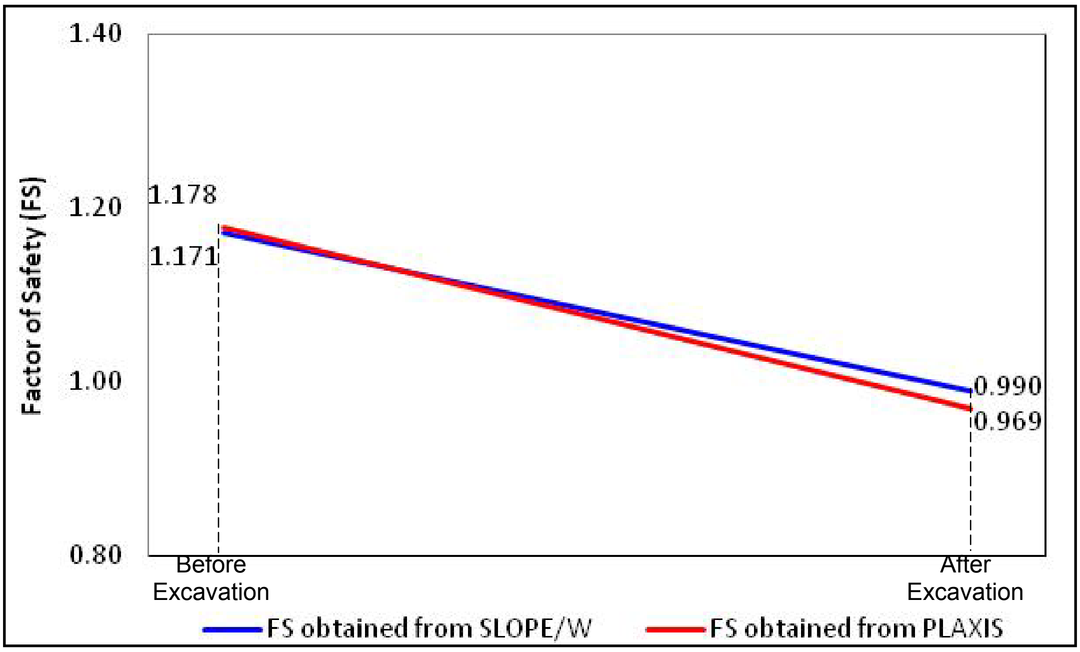


Figure 5.15. Comparison of the FS values obtained with the limit equilibrium analysis and the finite element method

It must be noted that the FS value obtained from PLAXIS is very close to the FS value calculated by Slope/W using Morgenstern-Price method for the case of before excavation. In the case of after excavation the FS value obtained from PLAXIS is about 2.1% lower than that of given by Slope/W. Although there is a slight difference in the FS, it can be concluded that for the static condition the finite element methods and the limit equilibrium analysis give similar results in terms of assessing the stability of the slopes.

5.4.3. Seismic Slope Stability of the Landslide

Earthquake motions can induce significant horizontal and vertical dynamic stresses in slopes. These stresses produce dynamic normal and shear stresses along the potential failure surfaces within the slope. When superimposed upon the previously existing static shear stresses, the dynamic shear stresses may exceed the available shear strength of the soil and produce instability of the slope. Therefore, in seismically active regions, earthquakes are a major trigger for the instability of natural and man-made slopes and seismic effects pose essential design considerations for slope stability (Kramer, 1996 and Li et al., 2009).

5.4.3.1. Pseudo-Static Analysis of the Landslide

Beginning in the 1920s, the seismic stability of earth structures has been analyzed by pseudo-static approach in which the effects of an earthquake are represented by constant horizontal and/or vertical accelerations (Kramer, 1996). In the pseudo-static analysis the earthquake effects are simplified as dimensionless horizontal and vertical seismic coefficients (k_h and k_v). However, it should be noted that pseudo static analysis is often based on a horizontal seismic coefficient. The magnitude of the coefficient is expressed in terms of a percentage of gravity acceleration (Li et al., 2009). Seed (1979) recommend the use a horizontal coefficient of 0.10 for earthquakes of Richter's magnitude 6.5 and 0.15 for earthquakes of Richter's magnitude 8.5. For both cases, a FS≥1.15 is required for slope design.

Depending on the seismicity of the study area, which is given in Section 1.4 in detail, the horizontal coefficient of 0.10 may be used for the pseudo-static seismic slope stability analysis. However, for a conservative approach a horizontal coefficient of 0.15 was also utilized in Slope/W. The FS values as a function of seismic horizontal coefficients are given in Table 5.5.

Table 5.5. FS values corresponding to seismic horizontal coefficients of 0.10g and 0.15g

k_h (g)	**FS**
0.10	0.675
0.15	0.579

CHAPTER 6

SLOPE STABILIZATION AND DYNAMIC ANALYSIS OF THE LANDSLIDE

6.1. Slope Stabilization Methods

Slope stabilization methods generally reduce driving forces, increase resisting forces, or both. Driving forces can be reduced by excavation of material from the appropriate part of the unstable ground and drainage of water to reduce the hydrostatic pressures acting on the unstable zone. Resisting forces can be increased by:

1. Drainage that increases the shear strength of the ground

2. Elimination of weak strata or other potential failure zones

3. Building of retaining structures or other supports

4. Provision of in-situ reinforcement of the ground

5. Chemical treatment (hardening of soils) to increase the shear strength of the ground (Abramson et al., 2002).

6.1.1 Drainage

Drainage is by far the most frequently used means of stabilizing slopes. Slope failures are very often precipitated by a rise in the groundwater level and increased pore pressures. Therefore, lowering groundwater levels and reducing pore pressures is a logical means of improving stability. In addition, improving drainage is often less expensive than other methods of stabilization, and a large volume of ground can frequently be stabilized at a relatively low cost. As a result, drainage is an often-used method, either alone or in conjunction with other methods. Drainage improves slope stability in two important ways:

1. It reduces pore pressures within the soil, thereby increasing the effective stress and the shear strength; and

2. it reduces the driving forces of water pressures in cracks, thereby reducing the shear stress required for equilibrium.

Once a system of drainage has been established, it must be maintained to keep it functional. Erosion may disrupt surface drains and ditches, and underground drains may become clogged by siltation or bacterial growth. Siltation can be minimized by constructing drains of materials that satisfy filter criteria, and bacterial clogging can be removed by flushing with chemical agents, such as bleach (Duncan et al., 2005).

6.1.1.1. Surface Water Drainage

Surface water is controlled to eliminate or reduce infiltration and to provide erosion protection. Cut slopes should be protected with interceptor drains installed along the crest of the cut, along benches and along the toe (Figure 6.1.a). On the long cuts the interceptors are connected to downslope collectors (Figure 6.1.b). All drains should be lined with nonerodable materials, free of cracks or other openings and designed to direct all concentrated runoff to discharge offslope. With failing slopes, installation of an interceptor along the crest beyond the head of the landslide area will reduce runoff into the landslide. Roadway storm water drains should be located so as to not discharge on steep slopes immediately adjacent to the roadway.

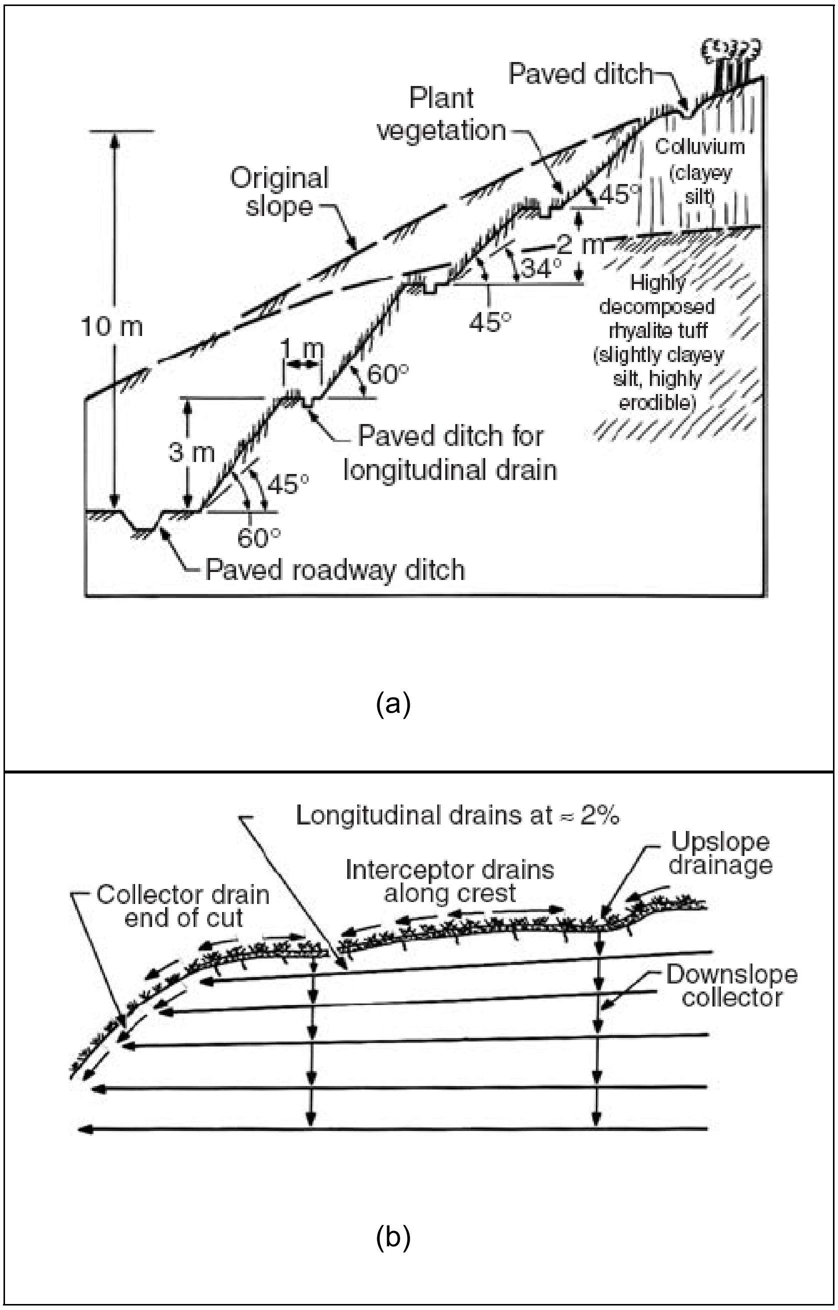


Figure 6.1.a. Benching scheme for cut (low benches permit maximum inclination to reduce the effect of runoff erosion), b. Longitudinal and downslope drains (Hunt, 2005)

6.1.1.2. Subsurface Water Drainage

Subsurface drainage systems are installed to lower the piezometric level below the potential or existing sliding surface. Selection of the drainage method is based on the consideration of the slope materials, structure and groundwater conditions (static, perched, or artesian) and the location of the phreatic surface. As the drains are installed, the piezometric head is monitored by piezometers and the efficiency of the drains is evaluated. The season of the year and the potential for increased flow during wet seasons must be considered, and if piezometric levels are observed to rise to dangerous values (as determined by stability analysis or from monitoring slope movements), the installation of additional drains is required (Hunt, 2005).

6.1.1.2.1. Methods of Subsurface Water Drainage

Deep wells have been used to stabilize many deep-seated slide masses, but they are costly since continuous or frequent pumping is required. Check valves normally are installed so that when the water level rises, pumping begins. Deep wells are most effective if installed in relatively free draining material below the failing mass.

Vertical, cylindrical gravity drains are useful in perched water table conditions, where an impervious stratum overlies an open, free draining stratum with a lower piezometric level. The drains permit seepage by gravity through the confining stratum and thus relieve hydrostatic pressures. Clay strata over granular soils, or clays or shales over open-jointed rock, offer favorable conditions for gravity drains where a perched water table exists.

Sub horizontal drain is one of the most effective methods to improve stability of a cut slope or to stabilize a failing slope. Installed at a slight angle upslope to penetrate the phreatic zone and permit gravity flow, they usually consist of a perforated pipe, of 50.8 mm (2 in) diameter or larger, forced into a predrilled hole of slightly larger diameter than the pipe. Sub horizontal drains have been installed to lengths of more than 100 m. Spacing depends on the type of material being drained; fine-grained soils may require spacing as close as 3 to 8 m, whereas, for more permeable materials, 8 to 15 m may be sufficient. Santi et al. (2003) report on recent installations of sub horizontal wick drains to stabilize slopes. Composed of geotextiles (i.e., polypropylene) they have the important advantages of stretching and not rupturing during deformation, and are resistant to clogging. Installation proceeds with a disposal plate attached to the end of a length of wick drain that is inserted into a drive pipe. The pipe, which can be a wire line drill rod, is pushed into the slope with a bulldozer or backhoe. Additional lengths of wicks and pipe are attached and driven into the slope. When the final length is installed, the drive pipe is extracted.

Drainage galleries are very effective for draining large movement masses but their installation is difficult and costly. They are used mostly in rock masses where roof support is less of a problem than in soils. Installed below the failure zone to be effective, they are often backfilled with stone. Vertical holes drilled into the galleries from the above provide for drainage from the failure zone into the galleries.

Interceptor trench drains or slots are installed along a slope to intercept seepage in a cut or sliding mass, but they must be sufficiently deep. The slotted pipe is laid in the trench bottom, embedded in sand, and covered with free-draining material, then sealed at the surface (Figure 6.2). The drain bottom should be sloped to provide for gravity drainage to a discharge point. Interceptor trench drains are generally not practical on steep, heavily vegetated slopes because installation of drains and access roads requires stripping the vegetation, which will further decrease stability.

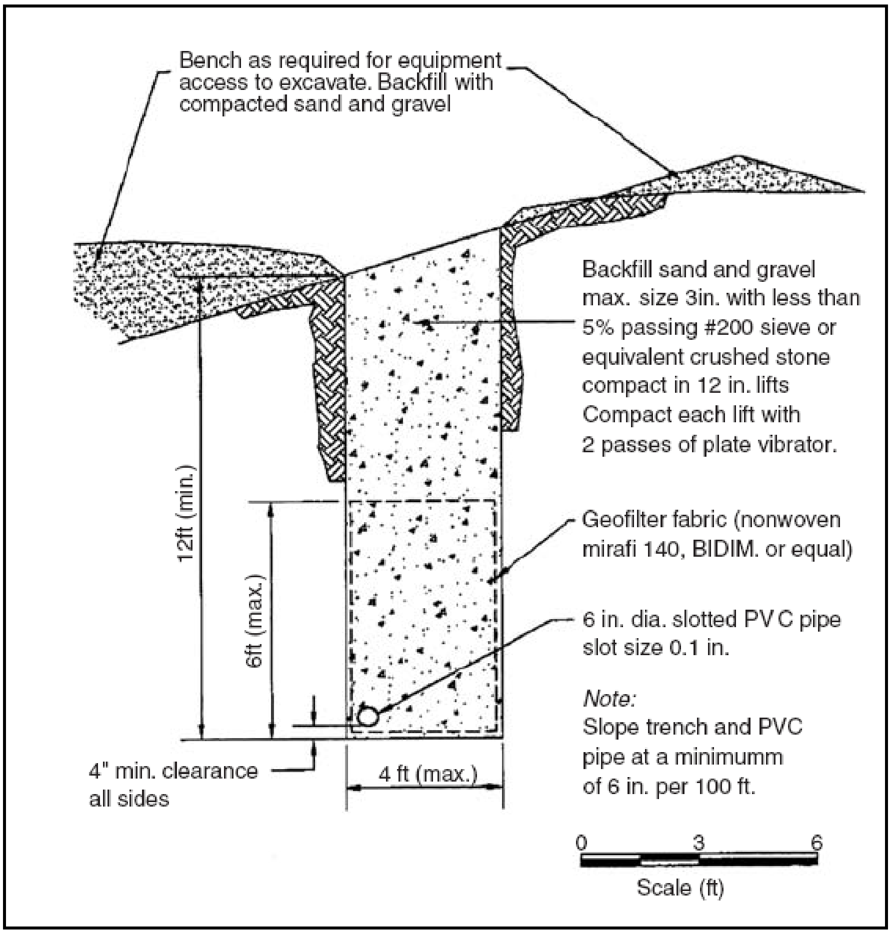


Figure 6.2. Typical slope trench drain (Hunt, 2005)

Relief trenches or slots relieve pore pressures at the slope toe. They are relatively simple to install. Excavation should performed in sections and quickly backfilled with stone so as not to reduce the slope stability and possibly cause a total failure. Generally, relief trenches are most effective for slump slides where high toe seepage forces are the major cause of instability.

Electro-osmosis has been used occasionally to stabilize silts and clayey silts, but the method is relatively costly and not a permanent solution unless operation is maintained (Hunt, 2005).

6.1.2. Unloading and Rock Buttresses

A slope can be made more stable by excavation to reduce its height or make it less steep. Flattening a slope or reducing its height as shown in Figure 6.3 reduces the shear stresses along potential sliding surfaces and increases the factor of safety. As shown in Figure 6.3, any type of excavation results in a reduction of the useful area at the crest of the slope. Improving stability by excavation requires (1) that an area at the top of the slope can be sacrificed to improve stability, (2) that the site is accessible to construction equipment, and (3) that an area is available for disposal of the excavated material (Duncan et al., 2005).

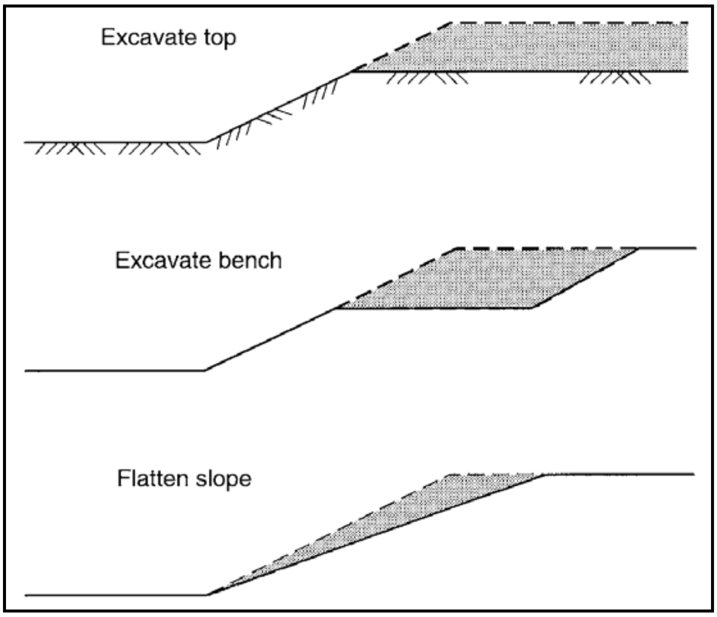


Figure 6.3. Slope stabilization by excavation (Duncan et al., 2005)

Buttress fills are of two types. A buttress of high strength well-compacted material (Figure 6.4) provides strength and weight, both of which improve stability. A berm of uncompacted material at the bottom of a slope, sometimes called a gravity berm, provides weight and reduces the shear stresses in the slope, even if it consists of weak and compressible soil. The effectiveness of either type of berm is improved if it is placed on a layer of free-draining material that allows drainage of water from the soil beneath. An example involving both excavation and buttressing is shown in Figure 6.5. Balancing the volume of cut and fill makes it unnecessary to dispose of material off-site or to import soil for buttress construction. Even soil that has been involved in sliding can be improved and made suitable for berm construction by compaction to high density near optimum water content (Duncan et al., 2005).

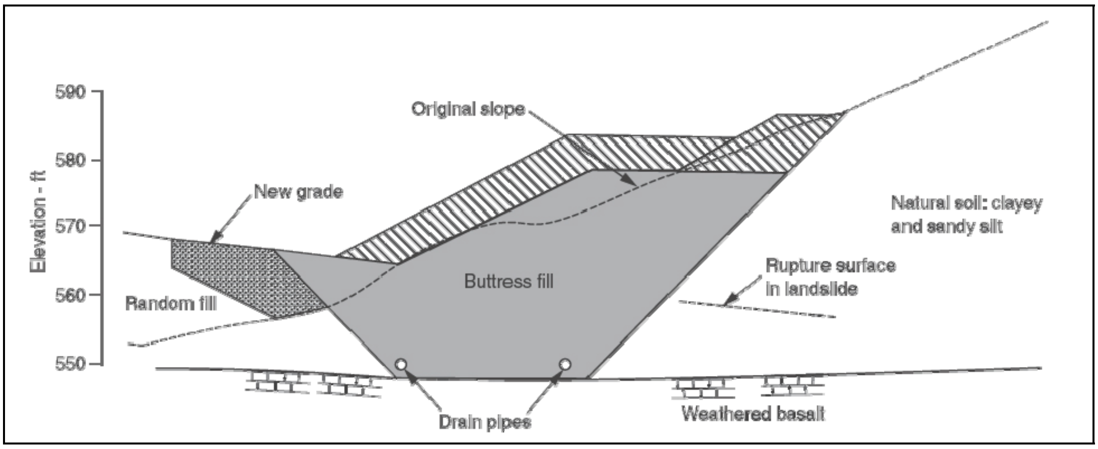


Figure 6.4. Structural buttress (Duncan et al., 2005)

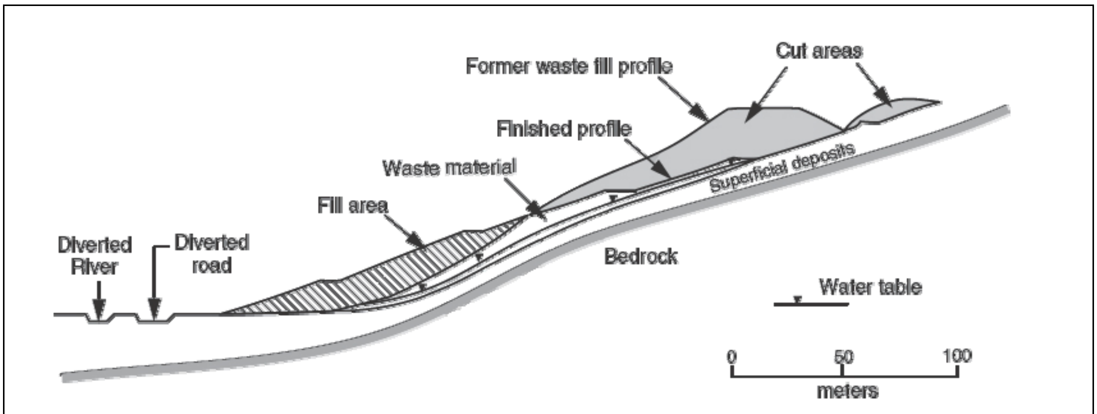


Figure 6.5 Slope stabilization by cut and fill (Duncan et al., 2005)

6.2. Slope Stabilization Methods of the Landslide

According to the Technical Specification of General Directorate of Highways, FS≥1.3 is required for the static design of residual material and FS≥1.1 is required for the design of residual soil in earthquake condition (General Directorate of Highways, 2008). However, Seed (1979) recommended that FS≥1.15 is required in the earthquake condition. To be on the safe side FS≥1.15 was taken into consideration while designing the slope under earthquake condition.

As a remediation alternative, dewatering by subsurface and surface drainage, application of a rock buttress at the toe, and unloading of the landslide material is recommended in both static and pseudo-static conditions (with a seismic coefficient is 0.15). The subsurface drainage system is provided by sub horizontal drain which is one of the most effective and cheapest methods to improve stability of a cut slope. Sub horizontal drains have been installed to lengths ranging from 20 to 80 m with a spacing of 10 m. A schematic view of subsurface and surface drainage system is given in Figures 6.6 and 6.7, respectively.

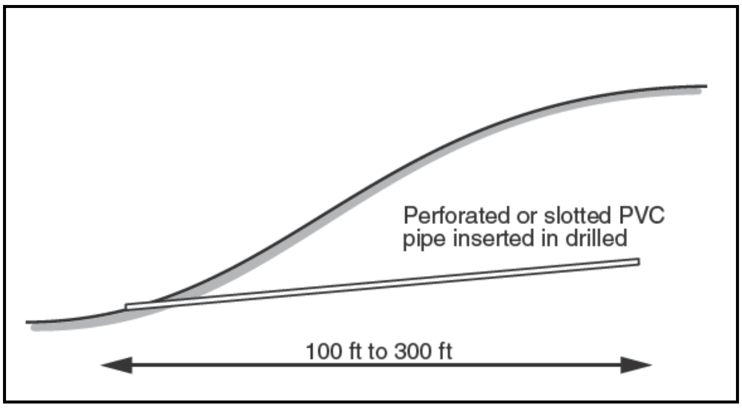


Figure 6.6. A schematic view of subsurface drainage system (Hunt, 2005)

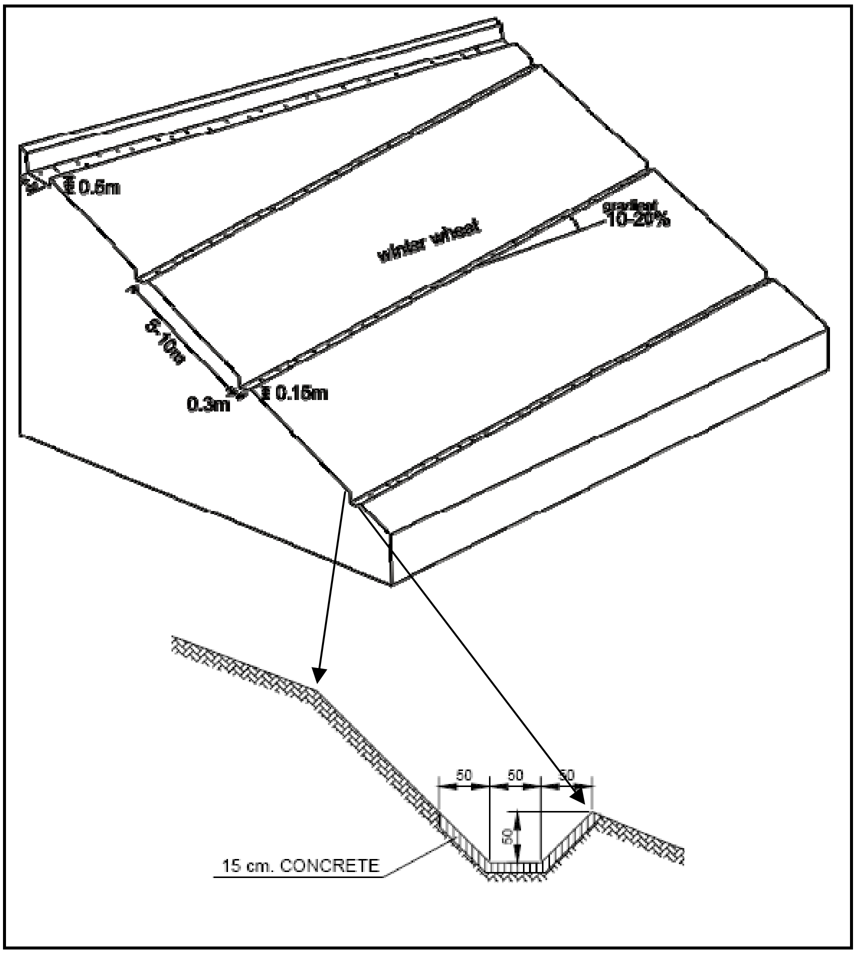


Figure 6.7. A schematic view of surface drainage system

The results of the model for static and pseudo-static conditions are given in Figure 6.8 (with FS=1.34) and in Figure 6.9 (with FS=1.21), respectively. The remediation methods are given step by step in these figures.

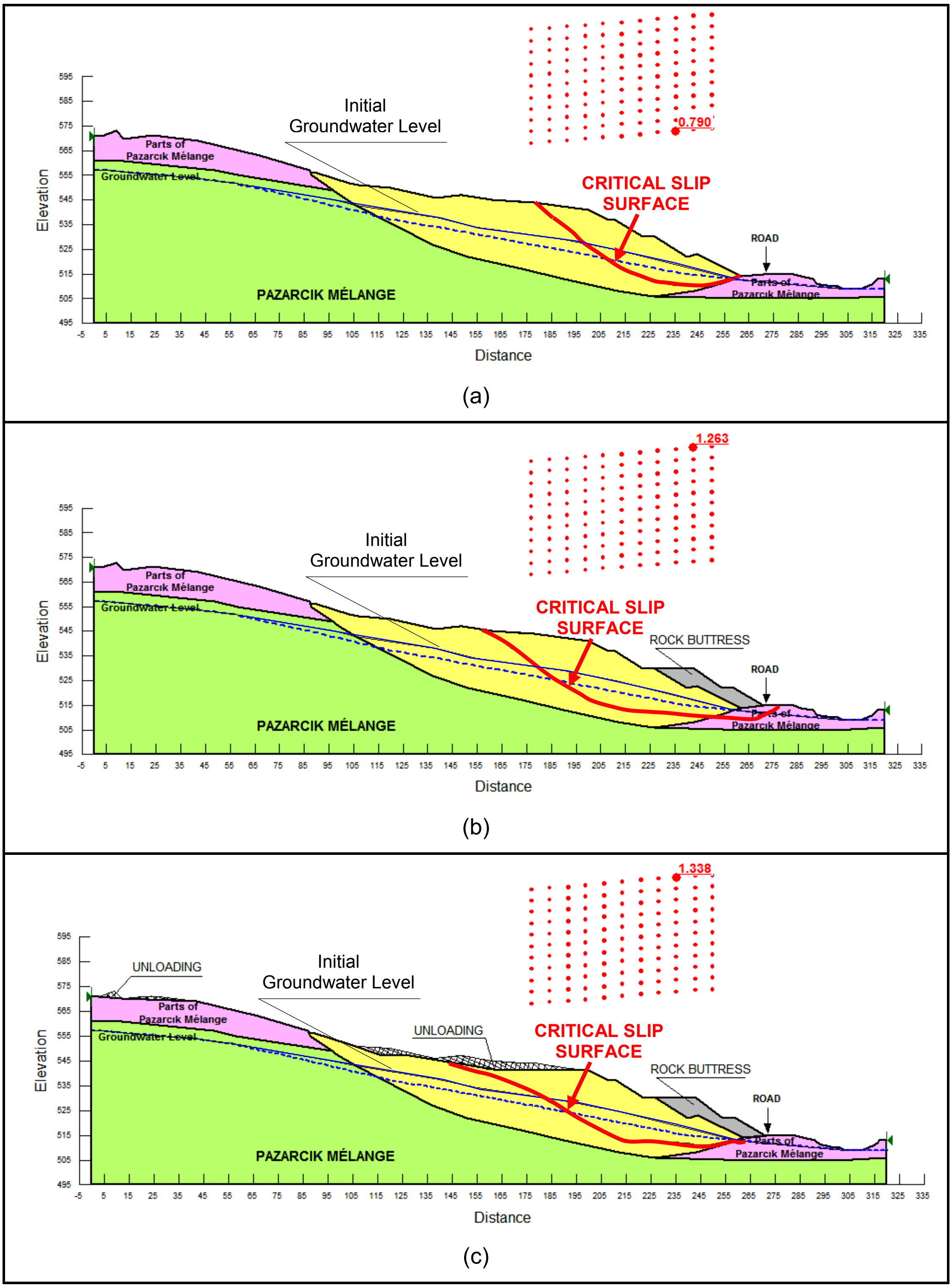


Figure 6.8. Landslide remediation steps presented as a function of FS under static conditions. a. Dewatering by subsurface and surface drainage resulting in a FS=0.79, b. Application of rock buttress resulting in a FS=1.26, c. Unloading the landslide material resulting in a FS=1.34

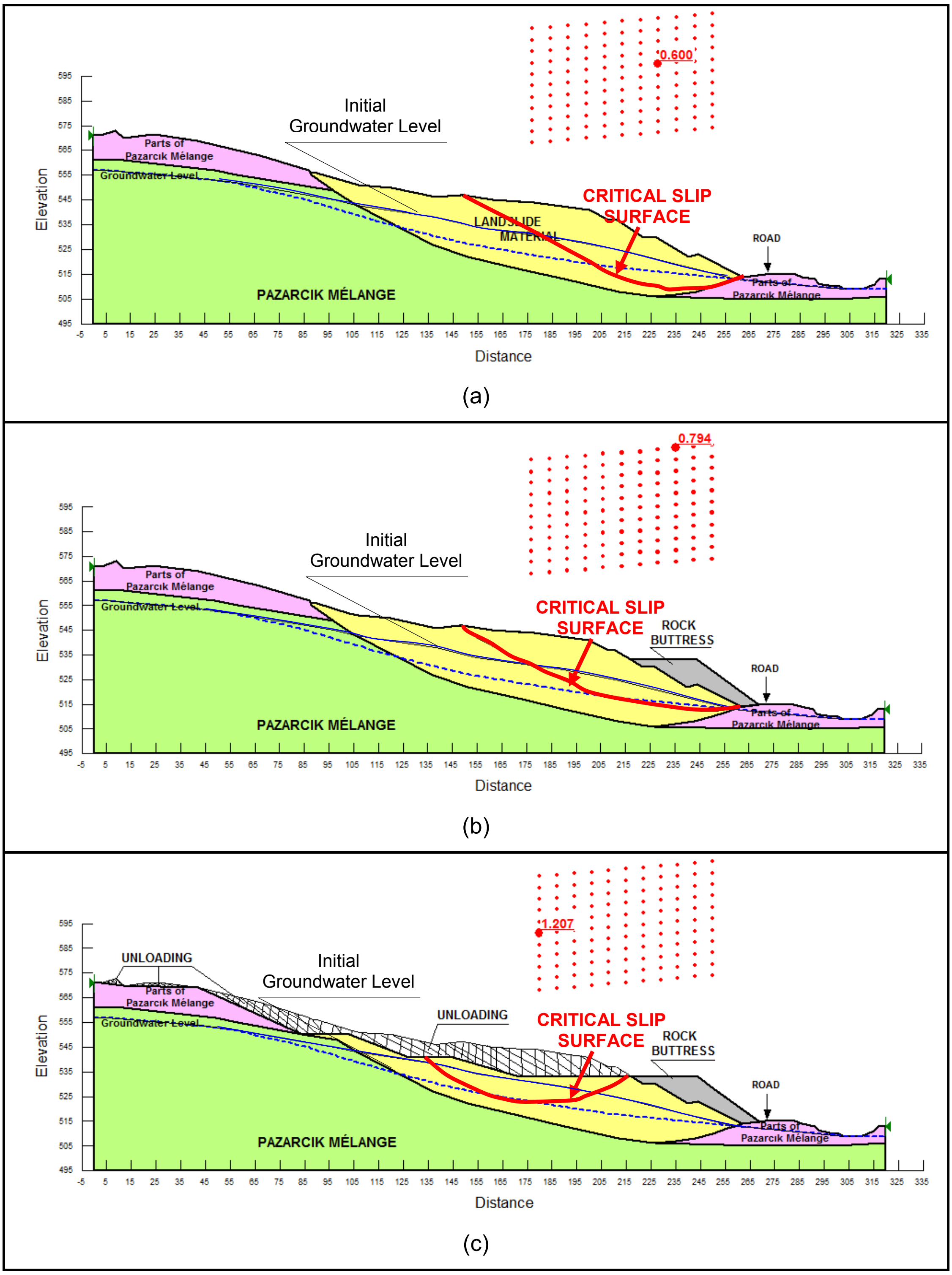


Figure 6.9. Landslide remediation steps presented as a function of FS under pseudo-static conditions. a. Dewatering by subsurface and surface drainage resulting in a FS=0.60, b. Application of rock buttress resulting in a FS=0.79, c. Unloading the landslide material resulting in a FS=1.21

The slope remediation algorithm for the static analysis presented in Figure 6.8 which encompasses dewatering by subsurface and surface drainage, application of a rock buttress at the toe and unloading of the landslide material leads to a FS of 1.34 which is sufficient for the stability of the slope according to the Technical Specification of General Directorate of Highways (2006). The remediation model for the pseudo-static analysis given in Figure 6.9 by which dewatering by subsurface and surface drainage, application of a rock buttress at the toe and unloading of the landslide material for a seismic coefficient of 0.15 g leads to a FS of 1.21 which is also sufficient for the stability of the slope according to the Technical Specification of General Directorate of Highways (2006).

6.3. Dynamic Analysis of the Landslide

Since dynamic response analysis may lead to a more precise seismic evaluation of slopes, the remedied slope was analyzed with PLAXIS. Four different earthquake records which possess seismic characteristics comparable to the seismicity of the study area as explained below were utilized in the dynamic slope stability analysis.

The study area is located in the Eskişehir Fault Zone, which is defined as a right-lateral strike-slip fault. The faults that form the Eskişehir fault zone are mostly active and have the capacity of producing small to medium-sized earthquakes (Koçyiğit, 2003). The largest event recorded along the Eskişehir Fault Zone is the 20 February 1956 Eskişehir (Çukurhisar) earthquake with a moment magnitude of 6.4. Therefore, for an assessment of design motion parameters, an earthquake with a moment magnitude of 6.4 was considered. The distance to the causative fault was assumed to be 4 km. The fault mechanism, magnitude, distance to the fault rupture and PGA were the main criteria in selecting these design scenario earthquakes.

Attenuation relations were used for the estimation of the ground motion accelerations by the use of determined parameters. Boore et al. (1997) mostly use near-mid field records (<80km) while deriving the attenuation relationships whereas Abrahamson and Silva (1997) make use of far field records for the derivation of the attenuation relationships (Douglas, 2001). Since a distance of 4 km is considered as a near field, attenuation relationships proposed by Boore et al. (1997) were used in this study.

According to Boore et al. (1997), peak acceleration is determined by utilizing Eq. (6.1):

$$\log(Y) = b_1 + b_{1SS} G_{SS} + b_{1RS} G_{RS} + b_2(M-6) + b_3(M-6)^2 + b_4 r + b_5 \log r + b_6 G_B + b_7 G_C \pm \varepsilon \quad (6.1)$$

where

Y: ground motion parameter (in cm/s for response spectra and g for peak acceleration)

M: moment magnitude

$r = \left(d^2 + h^2\right)^{1/2}$

d: closest distance to the vertical projection of the fault plane to the ground surface in km

G_{SS} = 1.0 for strike-slip faulting and 0.0 otherwise

G_{RS} = 1.0 for reverse-slip faulting and 0.0 otherwise

G_B = 1.0 for stiff soil site and 0.0 otherwise

G_C = 1.0 for soft soil site and 0.0 otherwise

b_1 = 0.0 for strike-or reverse-slip faulting

The fault type is left lateral strike-slip, therefore noting that G_{SS} = 1.0, G_{RS} = 0.0, and b_1 = 0.0, Eqn. (6.1) may be expressed as:

$$\log(Y) = b_{1SS} + b_2(M-6) + b_3(M-6)^2 + b_4 r + b_5 \log r + b_6 G_B + b_7 G_C \quad (6.2)$$

All coefficients (for the larger horizontal component) used for the attenuation relations and the calculated PGA for study area are given in Table 6.1. below.

Table 6.1. Data utilized for the attenuation relationships (from Boore et al., 1997)

b_{1SS}	b_2	b_3	b_4	b_5	b_6	b_7	h	r	G_B	G_C	log(Y)	Y
-0.068	0.216	0	0	-0.777	0.158	0.254	5.48	8.13	0	0	-0.470	0.34

Utilizing the Boore et al. (1997) attenuation relationship, the expected PGA is determined to be 0.34 g. Since there is no earthquake recorded at or near the vicinity of the study area, the four earthquake records are selected as scenario events for the dynamic analysis as explained above. The earthquake database of PEER (2009) Strong Motion online catalog was searched and the records presented by Table 6.2. were obtained. As explained above, the fault mechanism, magnitude, distance to fault rupture and PGA are the main criteria in selecting these design scenario earthquakes.

Table 6.2. Scenario earthquakes used in the dynamic slope stability analyses (PEER, 2009)

Fault mechanism	Name	Magnitude	Distance (km)	PGA (g)
Strike-slip	Düzce	7.1	8.2	0.348
Strike-slip	Imperial Valley	6.5	4.2	0.360
Strike-slip	Parkfield	6.1	5.3	0.367
Strike-slip	Supersitition Hills	6.7	12.4	0.300

In the dynamic analyses, dynamic excitation was applied from the base of the model as acceleration time histories. The potential permanent displacements computed by PLAXIS are given in the following figures for the four selected earthquake records separately (Figures 6.10-6.13).

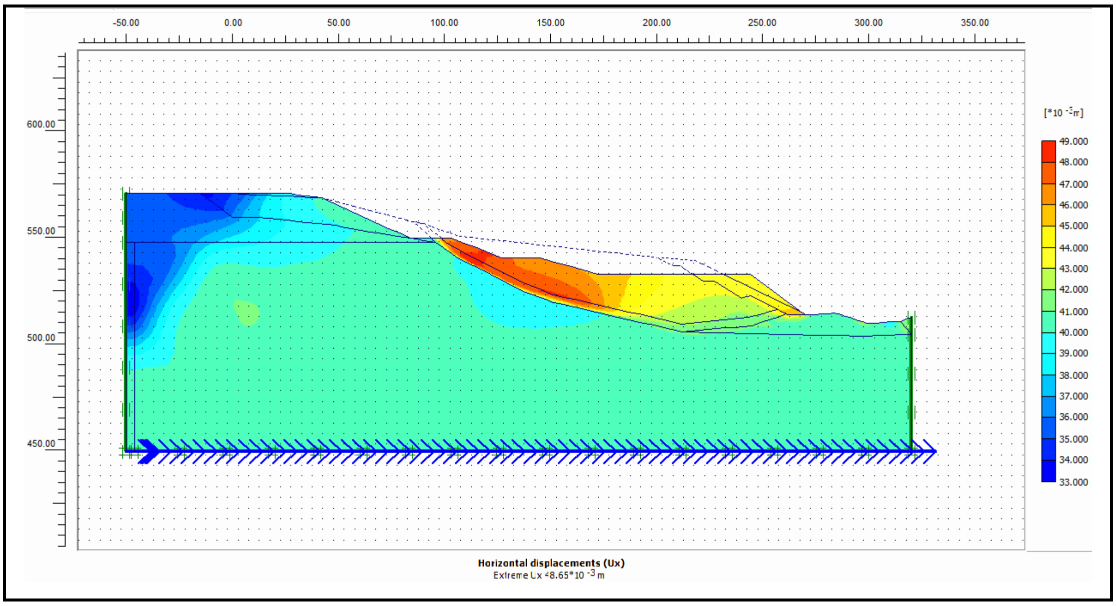


Figure 6.10. Potential horizontal displacement utilizing the Düzce earthquake record

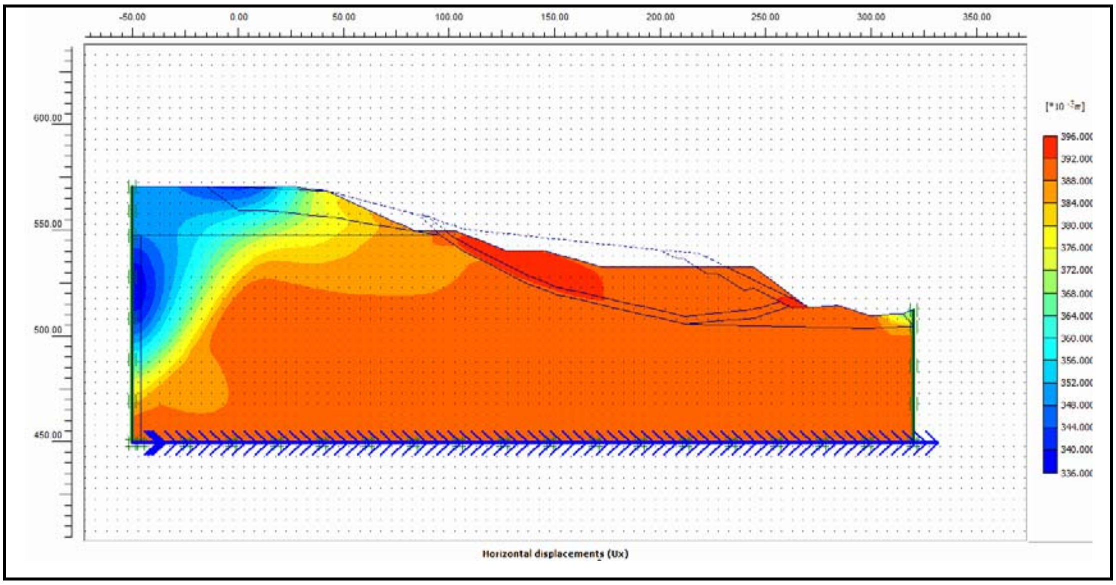


Figure 6.11. Potential horizontal displacement utilizing the Imperial Valley earthquake record

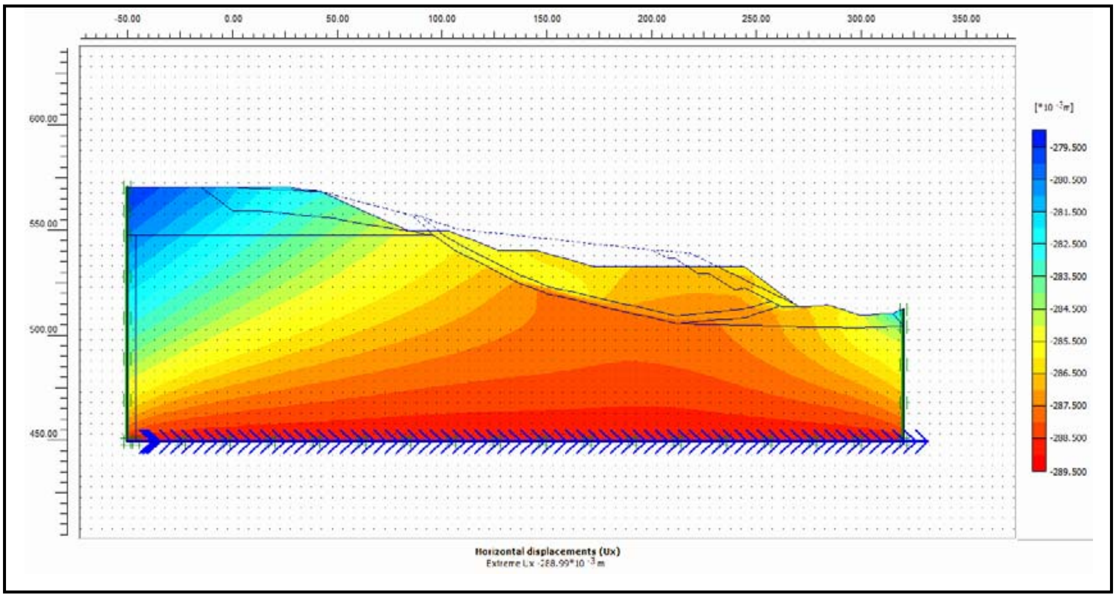


Figure 6.12. Potential horizontal displacement utilizing the Parkfield earthquake record

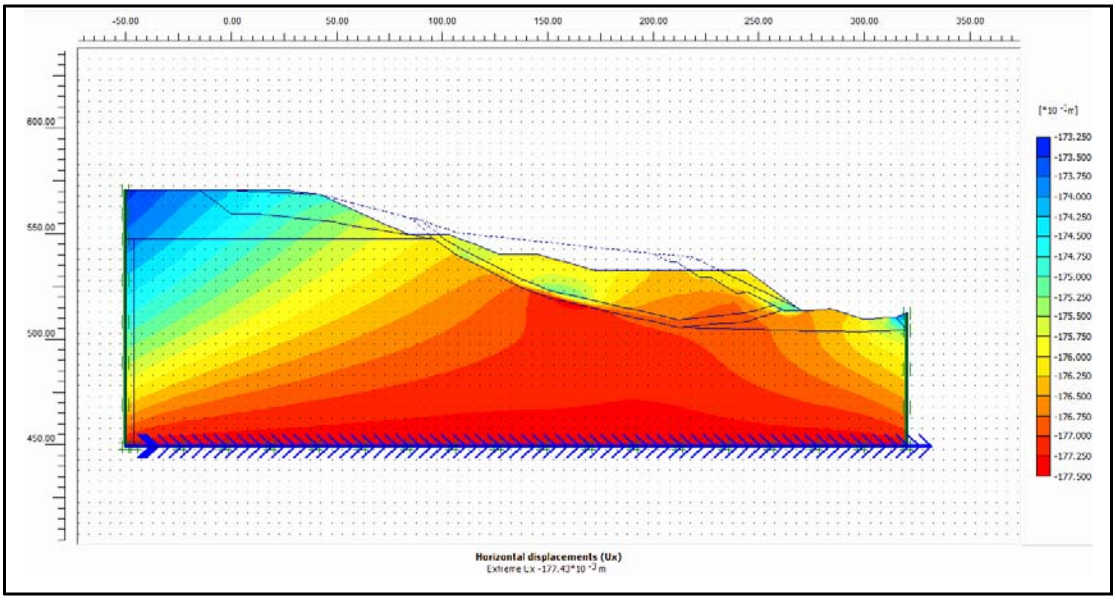


Figure 6.13. Potential horizontal displacement utilizing the Supersitition Hills earthquake record

The potential displacements were calculated as 7.0 mm, 8.0 mm, 5.0 mm and 2.5 mm for the Düzce, Imperial Valley, Parkfield and Supersitition Hills earthquake records, respectively.

Table 6.3. Potential displacements for dynamic slope stability analyses

Name	Magnitude	Distance (km)	PGA (g)	Potential Displacement (mm)
Düzce	7.1	8.2	0.348	7.0
Imperial Valley	6.5	4.2	0.360	8.0
Parkfield	6.1	5.3	0.367	5.0
Supersitition Hills	6.7	12.4	0.300	2.5

Inspection of the results presented by Table 6.3 indicates that as far as the potential permanent displacements are concerned, the slope may be expected to experience displacements of up to 8.0 mm during an earthquake occurring in the region.

CHAPTER 7

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

During the “Bursa – İnegöl – Bozüyük Road (Section II) Construction (between KM: 69+400 – 81+700)” a considerable amount of mass movement occurred in May, 2006 in between the KM: 72+000 and 72+200 during the construction work of the left cutting slope. 40 to 60 cm wide tension cracks formed approximately 110 m behind the cutting slope, and deformations have occurred throughout the terrain surface due to the mass movement. As a solution to this problem, the left cutting slope has been inclined with a ratio of 3/2 (h/V). However, despite all the preventive measures taken, the mass movement continued and the width of the tension crack at the crown area of the mass movement could be expressed in terms of meters. After the movement, the cutting slope displaced about 1.0 – 1.5 m within the road cut.

Initially, parameters of the mobilized soil along the slide surface was determined by back analyses of the landslide geometry along four profiles by using the Slope/W software. According to the back analyses results, shear strength parameters were determined as c = 0 kPa and ϕ = 15.7° for the landslide material. Then, the study area was modeled using coupled analyses (with the computer programs of Seep/W and Slope/W) along the most representative profile of the study area and the most suitable remediation technique was determined by considering the landslide mechanism, parameters determined from the geotechnical investigations, the size of the landslide and location of the slip circle. Furthermore, since the study area is located in a second degree earthquake hazard region, pseudo-static stability analyses using the Slope/W software was performed for the earthquake potential and the most suitable remediation technique was determined. For both analyses the most appropriate stabilization techniques are surface and subsurface drainage, application of rock buttress at the toe of the slope and unloading the landslide material.

Static and pseudo-static slope stability analyses were performed using Morgenstern-Price Method by Slope /W software. The factor of safety for the static analyses was found as 1.34, which is sufficient for the residual material. The factor of safety computed by the pseudo-static approach is 1.21 with the horizontal seismic coefficient of 0.15. The stability of the landslide was checked under selected earthquake records considering the seismicity of the region. Potential permanent displacements were estimated by using the finite element software PLAXIS using four different earthquake records representing the seismic characteristics of the region. The potential displacements computed with PLAXIS ranged between 2.5 and 8.0 mm, with a mean value of 5.6 mm. Thus, considering the potential permanent displacements, the slope may be expected to experience displacements of up to 10 mm during an earthquake occurring in the region.

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APPENDIX A

GEOLOGICAL MAP AND CROSS SECTIONS

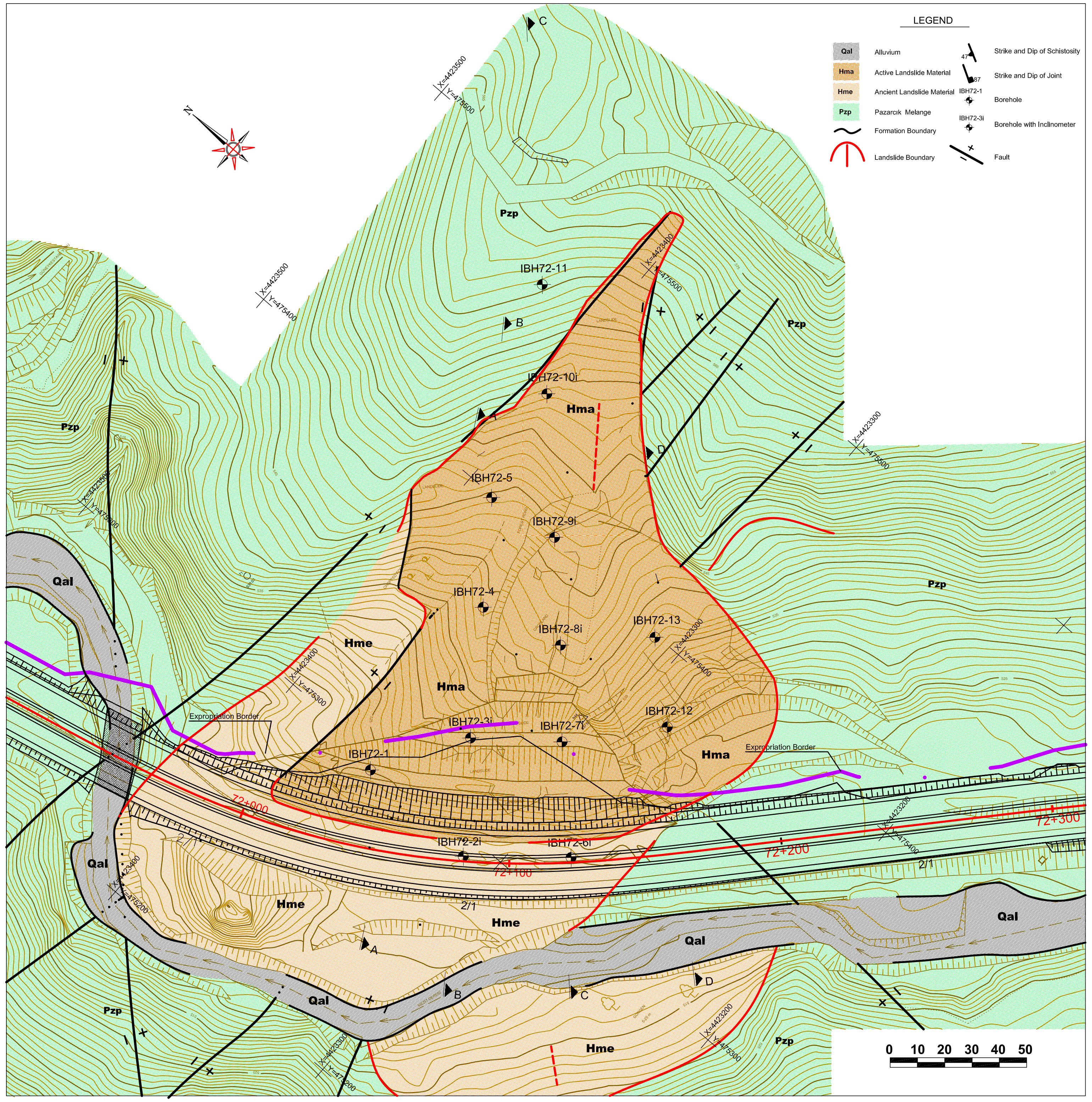


Figure A.1. Geological map of the study area (After Yüksel Proje, 2006)

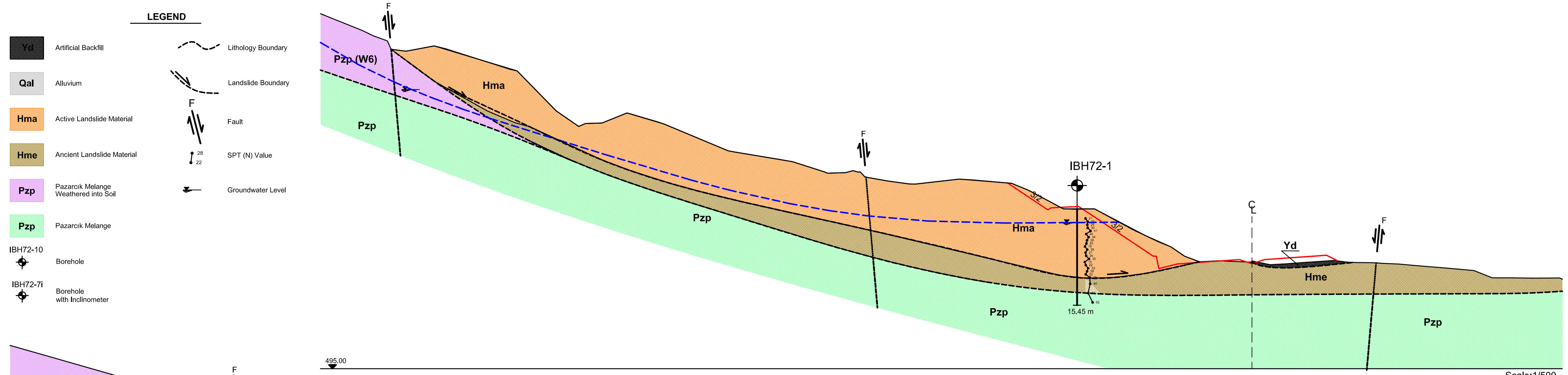


Figure A.2. Geological cross-section A-A' (After Yüksel Proje, 2006)

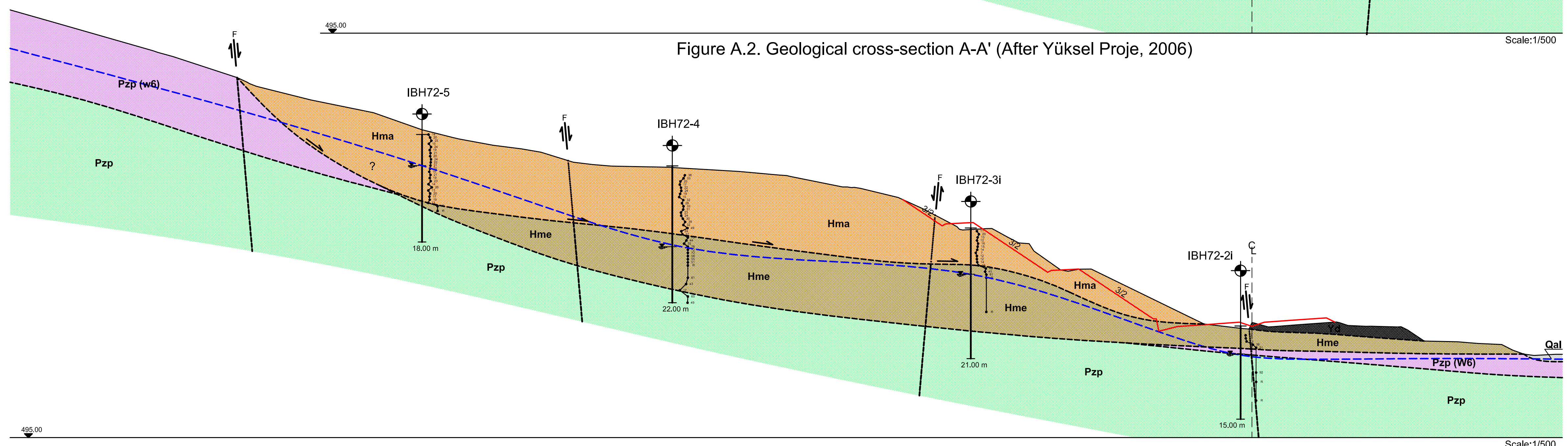


Figure A.3. Geological cross-section B-B' (After Yüksel Proje, 2006)

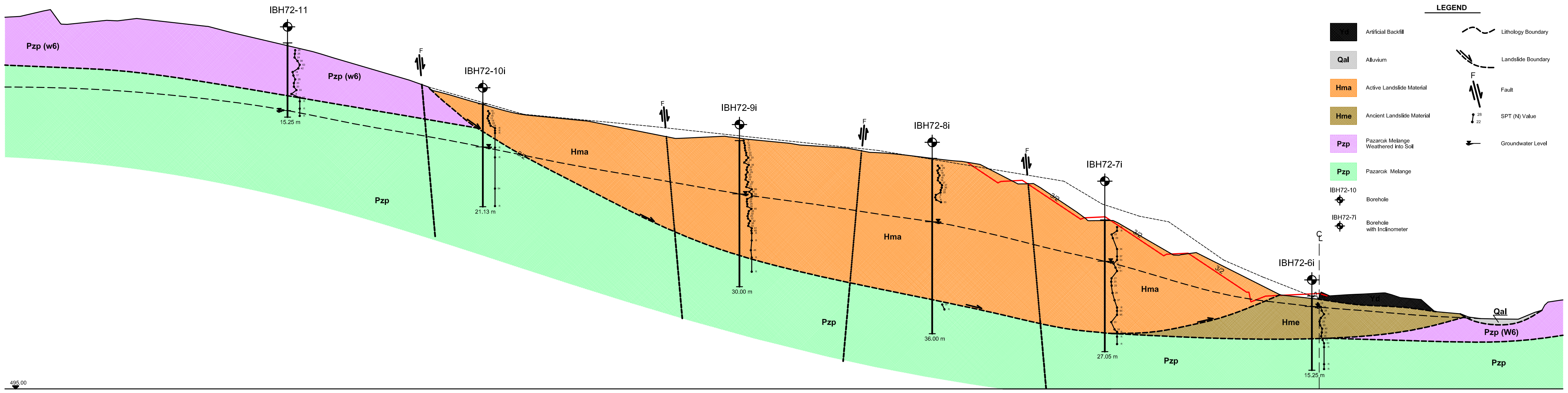


Figure A.4. Geological cross-section C-C' (After Yüksel Proje, 2006)

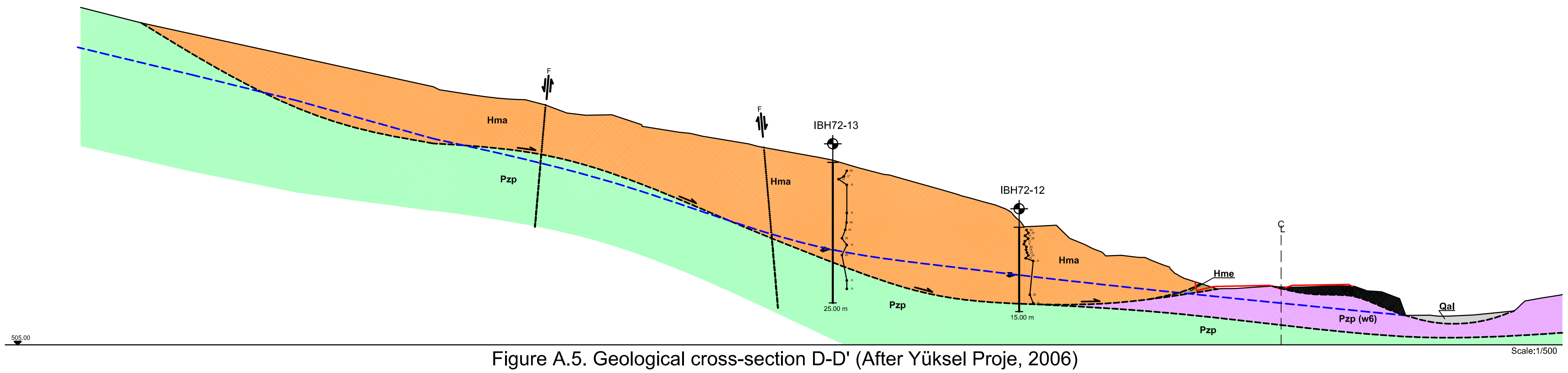


Figure A.5. Geological cross-section D-D' (After Yüksel Proje, 2006)

APPENDIX B

BOREHOLE LOGS

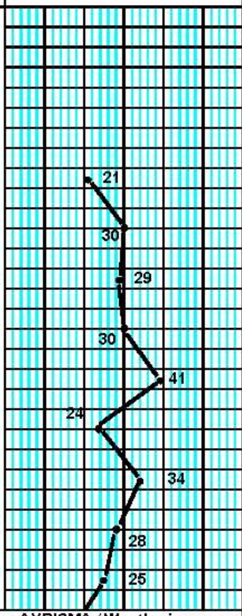
YÜKSEL PROJE

YÜKSEL PROJE ULUSLARARASI A.Ş.
Birlik Mahallesi 9. Cadde No:41
06610 ÇANKAYA-ANKARA
TEL: (312) 495 70 00 FAX: (312) 495 70 24
www.yukselproje.com.tr

SONDAJ LOGU / BORING LOG

SONDAJ Borehole	No :	İBH72-1
SAYFA Page	No :	1/2

PROJE ADI / Project Name	: İNEGÖL-BOZÜYÜK YOLU	DELİK ÇAPI / Hole Diameter	:
SONDAJ YERİ / Boring Location	: Heyelan / Landslide	YERALTI SUYU / Groundwater	: 2,05 m
KİLOMETRE / Chainage	: 72+040, 28,15 m sol / left	MUH.BOR.DER. / Casing Depth	: 15,00 m NW
SONDAJ DER. / Boring Depth	: 15,45 m	BAŞ.BİT.TAR. / Start Finish Date	: 10.12.2006 - 11.12.2006
SONDAJ KOTU / Elevation	: 520,65 m	KOORDİNAT / Coordinate (E-W) Y	: 475 294,60
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Foremost B-53 / Rotary	KOORDİNAT / Coordinate (N-S) X	: 4 423 358,15

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Sample Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test — DARBE SAYISI Numb. of Blows: 0 - 15 cm	15-30 cm	30-45 cm	N	GRAFİK Graph (10 20 30 40 50 60)	JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
0 – 6	SPT-1	1.50 – 1.95	10	10	11	21		Brown- yellow.sh brown- greenish grey-purple colored, medium dense - dense, clayey, silty gravelly **SAND** / sandy **GRAVEL** Moist, fine -coarse grained, brittle-strong, schist-quartzite originated, angular, 25-35 % fine-coarse grained, angular sub-angular, brittle-little strong- strong, schist, quartzite originated pebbles, 15-25 % low plasticity and fine grained material							
	SPT-2	2.00 – 2.45	9	14	16	30									
	SPT-3	2.50 – 2.95	10	12	17	29									
	SPT-4	3.00 – 3.45	12	14	16	30									
	SPT-5	3.50 – 3.95	13	20	21	41									
	SPT-6	4.00 – 4.45	10	11	13	24									
	SPT-7	4.50 – 4.95	11	15	19	34									
	SPT-8	5.00 – 5.45	16	13	15	28									
	SPT-9	5.50 – 5.95	11	12	13	25									

DAYANIMLILIK / Strength			AYRIŞMA / Weathering			İNCE DANELİ / Fine Grained			İRİ DANELİ/Coarse Grained		
I	DAYANIMLI	Strong	I	TAZE	Fresh	N : 0-2	ÇOK YUMUŞAK	V.Soft	N : 0-4	ÇOK GEVŞEK	V.Loose
II	ORTA DAYANIMLI	M.Strong	II	AZ AYRIŞMIŞ	Slightly W.	N : 3-4	YUMUŞAK	Soft	N : 5-10	GEVŞEK	Loose
III	ORTA ZAYIF	M.Weak	III	ORTA D. AYR.	Mod. Weath.	N : 5-8	ORTA KATI	M.Stiff	N : 11-30	ORTA SIKI	M.Dense
IV	ZAYIF	Weak	IV	ÇOK AYR.	Slightly W.	N : 9-15	KATI	Stiff	N : 31-50	SIKI	Dense
V	ÇOK ZAYIF	V.Weak	V	TÜMÜYLE A.	Comp.Weat.	N : 16-30	ÇOK KATI	V.Stiff	N : >50	ÇOK SIKI	V.Dense
						N : >30	SERT	Hard			

KAYA KALİTESİ TANIMI - RQD			KIRIKLAR - 30 cm / Fractures			ORANLAR - Proportions					
% 0-25	ÇOK ZAYIF	V.Poor	1	SEYREK	Wide (W)	% 5	PEK AZ	Slightly	% 5	PEK AZ	Slightly
% 25-50	ZAYIF	Poor	1-2	ORTA	Moderate (M)	% 5-15	AZ	Little	% 5-20	AZ	Little
% 50-75	ORTA	Fair	2-10	SIK	Close (Cl)	% 15-35	ÇOK	Very	% 20-50	ÇOK	Very
% 75-90	İYİ	Good	10-20	ÇOK SIKI	Intense (I)	% 35	VE	And			
% 90-100	ÇOK İYİ	Excellent	>20	PARÇALI	Crushed (Cr)						

SPT	Standart Penetrasyon Testi / Standart Penetration Test	K	Karot Numunesi / Core Sample		LOGU YAPAN / Logged By	KONTROL / Checked
D	Örselenmiş Numune / Disturbed sample	P	Pressiyometre Deneyi / Pressuremeter Test	ISIM Name	Talip ERBAY Jeoloji Mühendisi	
UD	Örselenmemiş Numune / Undisturbed Sample	k	Permeabilite Deneyi / Permeability Test	IMZA Sign		

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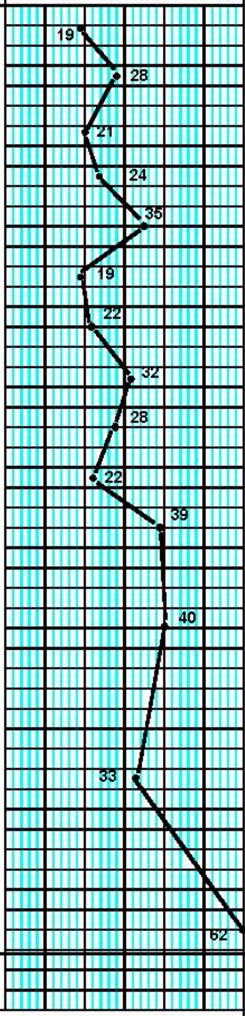
SONDAJ LOGU / BORING LOG

SONDAJ / Borehole No : **İBH72-1**
SAYFA / Page No : **2/2**

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test – DARBE SAYISI Numb. of Blows: 0 - 15 cm	15-30 cm	30-45 cm	N
6	SPT-10	6.00 – 6.45	14	9	10	19
	SPT-11	6.50 – 6.95	8	12	16	28
7	SPT-12	7.00 – 7.45	8	10	11	21
	SPT-13	7.50 – 7.95	9	12	12	24
8	SPT-14	8.00 – 8.45	13	16	19	35
	SPT-15	8.50 – 8.95	10	9	10	19
9	SPT-16	9.00 – 9.45	8	10	12	22
	SPT-17	9.50 – 9.95	14	15	17	32
10	SPT-18	10.00 – 10.45	10	12	16	28
	SPT-19	10.50 – 10.95	11	10	12	22
11	SPT-20 / P1	11.00 – 11.40 – 11.45	25	19	20	39
12	SPT-21	12.00 – 12.45	26	22	18	40
13						
	SPT-22	13.50 – 13.95	12	15	18	33
14						
15	SPT-23	15.00	15	28	34	62
16						

GRAFİK / Graph



JEOTEKNİK TANIMLAMA / Geotechnical Description

(Other columns: PROFİL / Profile, DAYANIMLILIK/Strength, AYRIŞMA / Weathering, KIRIK / Fracture (30cm), KAROT%(TCR)/T.CoreR., RQD %, LUGEON)

Brown- yellow.sh brown- greenish grey-purple colored, medium dense-dense, clayey, silty gravelly **SAND** / sandy **GRAVEL**. Moist, fine -coarse grained, brittle-strong, schist-quartzite originated, angular, 25-35 % fine-coarse grained, angular sub-angular, brittle-little strong-strong, schist, quartzite originated pebbles, 15-25 % low plasticity and fine grained material

9.00 m

Dark grey-black-green-greenish grey-light brown, medium dense-dense, clayey, silty, gravelly **SAND.** Moist, fine-coarse grained, angular, 20-30 % fine-coarse grained, angular pebbles, %15-25 low plasticity, fine material

10.85 m

GRAPHITE SCHIST
Dark-grey-black, soft, weak, completely weathered.

14.50 m

SCHIST
Green-greenish light grey-pink colored, soft, weak, completely weathered.

End of Boring: 15,45 m.

Not: Kuyuya yeraltısuyu gözlemleri için 15,00 m, Ø50 mm. perfore PVC boru indirilip, kuyu ağzı betonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked
İSİM Name	Talip ERBAY Jeoloji Mühendisi	
İMZA Sign		

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SONDAJ LOGU / BORING LOG

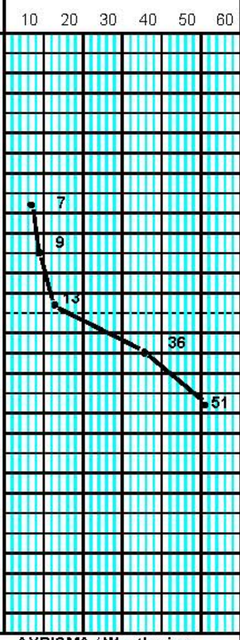
SONDAJ Borehole	No :	**İBH72-2i**
SAYFA Page	No :	**1/2**

PROJE ADI / Project Name	: İNEGÖL-BOZÜYÜK YOLU	DELİK ÇAPI / Hole Diameter	:
SONDAJ YERİ / Boring Location	: Heyelan / Landslide	YERALTI SUYU / Groundwater	: 1.70 m
KİLOMETRE / Chainage	: 72+080, 1,83 m sol / left	MUH.BOR.DER. / Casing Depth	: 4,50 m HW, 15,00 m NW
SONDAJ DER. / Boring Depth	: 15,00 m	BAŞ.BİT.TAR. / Start Finish Date	: 10.12.2006 - 12.12.2006
SONDAJ KOTU / Elevation	: 512,95 m	KOORDİNAT / Coordinate (E-W) Y	: 475 292,73
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Foremost B-53 / Rotary	KOORDİNAT / Coordinate (N-S) X	: 4 423 311,77

STANDART PENETRASYON DENEYİ / Standart Penetration Test

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Sample Type	MANEVRA BOYU/Run	DARBE SAYISI 0 - 15 cm	15-30 cm	30-45 cm	N	JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
0							Brown, loose, clayey, sandy, **GRAVEL** / gravelly **SAND.** Moist, fine-coarse grained, brittle-strong; 30-40% fine-coarse grained, gravelly.							
1														
	SPT-1	1.50 - 1.95	4	3	4	**7**								
2	SPT-2	2.00 - 2.45	2	5	4	**9**	2.40 m							
	SPT-3	2.50 - 2.95	8	6	7	**13**	Brown, medium dense-dense, gravelly, silty **SAND**. Moist-wet, fine-coarse grained, sub-angular, sub-rounded, brittle-strong; 15-25% fie grained; 10-15 % brittle-strong fine coarse gravelly							
3	SPT-4	3.00 - 3.45	7	12	24	**36**	3.50 m							
	SPT-5	3.50 - 3.95	24	28	23	**51**	Brown- grayish brown, very dense, sandy **GRAVEL.** Wet, fine-coarse grained, subrounded-rounded, little strong-strong, schist-quartzite-limestone originated; 10-15% fine-coarse grained, strong sandy, minor; 5% fine material. (LANDSLIDE MATERIAL)							
4		4.50					4.50 m							
5	K-1						**SCHIST** Brown-yellowish brown-grey, brittle-little strong, weak-very weak, moderately-slightly weathered. lower levels completely weathered.		III IV	III IV	I	80	17	
	P1	5.40												
6		6.00												

GRAFİK / Graph



DAYANIMLILIK / Strength			AYRIŞMA / Weathering			İNCE DANELİ / Fine Grained			İRİ DANELİ/Coarse Grained		
I	DAYANIMLI	Strong	I	TAZE	Fresh	N : 0-2	ÇOK YUMUŞAK	V.Soft	N : 0-4	ÇOK GEVŞEK	V.Loose
II	ORTA DAYANIMLI	M.Strong	II	AZ AYRIŞMIŞ	Slightly W.	N : 3-4	YUMUŞAK	Soft	N : 5-10	GEVŞEK	Loose
III	ORTA ZAYIF	M.Weak	III	ORTA D. AYR.	Mod. Weath.	N : 5-8	ORTA KATI	M.Stiff	N : 11-30	ORTA SIKI	M.Dense
IV	ZAYIF	Weak	IV	ÇOK AYR.	Slightly W.	N : 9-15	KATI	Stiff	N : 31-50	SIKI	Dense
V	ÇOK ZAYIF	V.Weak	V	TÜMÜYLE A.	Comp.Weat.	N : 16-30	ÇOK KATI	V.Stiff	N : >50	ÇOK SIKI	V.Dense
						N : >30	SERT	Hard			

KAYA KALİTESİ TANIMI - RQD			KIRIKLAR - 30 cm / Fractures			ORANLAR - Proportions					
% 0-25	ÇOK ZAYIF	V.Poor	1	SEYREK	Wide (W)	% 5	PEK AZ	Slightly	% 5	PEK AZ	Slightly
% 25-50	ZAYIF	Poor	1-2	ORTA	Moderate (M)	% 5-15	AZ	Little	% 5-20	AZ	Little
% 50-75	ORTA	Fair	2-10	SIK	Close (Cl)	% 15-35	ÇOK	Very	% 20-50	ÇOK	Very
% 75-90	İYİ	Good	10-20	ÇOK SIKI	Intense (I)	% 35	VE	And			
% 90-100	ÇOK İYİ	Excellent	>20	PARÇALI	Crushed (Cr)						

SPT	Standart Penetrasyon Testi Standart Penetration Test	K	Karot Numunesi Core Sample		LOGU YAPAN Logged By	KONTROL Checked
D	Örselenmiş Numune Disturbed sample	P	Pressiyometre Deneyi Pressuremeter Test	İSİM Name	Talip ERBAY Jeoloji Mühendisi	
UD	Örselenmemiş Numune Undisturbed Sample	k	Permeabilite Deneyi Permeability Test	İMZA Sign		

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SONDAJ LOGU / BORING LOG

SONDAJ / Borehole No: **İBH72-2i**
SAYFA / Page No: **2/2**

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	0 - 15 cm	15-30 cm	30-45 cm	N	GRAFİK Graph	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
6.00–7.00	K-2	6.00									50	0	
7.00–7.50	K-3	7.00									19	0	
7.50–7.95	SPT-6	7.50	21	46	46	**92**	92						
7.95–9.00	K-4	7.95									23	0	
9.00–9.14	SPT-7	9.00	50/14	-	-	**R**	R	IV	IV				
9.14–10.50	K-5	9.14						V	V	Cr	40	0	
10.50–11.50	K-6	10.50									26	0	
11.50–12.00	K-7	11.50									0	0	
12.00–12.08	SPT-8	12.00	50/8	-	-	**R**	R	V	V				
12.08–12.50	K-8	12.08									0	0	
12.50–13.30	K-9	12.50						IV	IV		39	0	
13.30–14.00	K-10	13.30						III IV	III IV	Cl	66	43	
14.00–15.00	K-11	14.00						IV V / II III	IV V / II III	Cr / W	100	46	

Depth (m)	JEOTEKNİK TANIMLAMA / Geotechnical Description
6.00–7.65	**SCHIST** Brown-yellowish brown-grey, brittle-little strong, weak-very weak, moderately-slightly weathered, lower levels completely weathered.
7.65–9.00	**GRAPHITE SCHIST** Dark grey-black, soft-brittle, weak-very weak, slightly-completely weathered.
9.00–10.30	**SCHIST** Grey-light brown, brittle-little strong, weak-very weak, slightly-completely weathered.
10.30–11.50	**SCHIST** Green, brittle-friable, very weak, completely weathered.
11.50–12.50	**SCHIST** Green, pinkish-grey, brittle-soft, very weak, completely weathered.
12.50–14.40	**SCHIST** Green, brittle-little strong, weak-moderately weak,sligtly-completely weathered.
14.40–15.00	**SCHIST** Purple, hard-moderately hard, weak-moderately weak, slightly-completely weathered.

End of Boring: 15,00 m.

Not : Kuyuya 15,00 m inklinometre borusu indirilip, enjeksiyonu yapılmıştır.

LOGU YAPAN / Logged By — İSİM / Name: Talip ERBAY, Jeoloji Mühendisi; İMZA / Sign:
KONTROL / Checked

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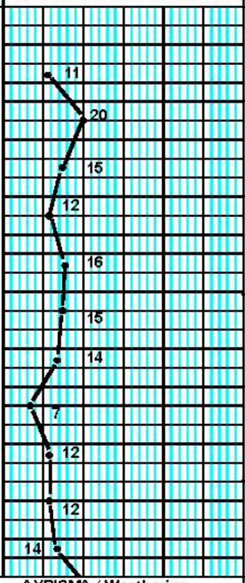
SONDAJ LOGU / BORING LOG

SONDAJ / Borehole No : İBH72-3i
SAYFA / Page No : 1/3

PROJE ADI / Project Name	: İNEGÖL-BOZÜYÜK YOLU		DELİK ÇAPI / Hole Diameter	:
SONDAJ YERİ / Boring Location	: Heyelan / Landslide		YERALTI SUYU / Groundwater	: 7.40 m
KİLOMETRE / Chainage	: 72+079, 45,27 m sol / left		MUH.BOR.DER. / Casing Depth	: 15,00 m HW, 13,50 m NW
SONDAJ DER. / Boring Depth	: 21,00 m		BAŞ.BİT.TAR. / Start Finish Date	: 07.12.2006-10.12.2006
SONDAJ KOTU / Elevation	: 528,70 m		KOORDİNAT / Coordinate (E-W) Y	: 475 327,38
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Mobile Drill B-53 / Rotary		KOORDİNAT / Coordinate (N-S) X	: 4 423 337,98

STANDART PENETRASYON DENEYİ / Standart Penetration Test — DARBE SAYISI / Numb. of Blows; GRAFİK (10 20 30 40 50 60)

SONDAJ DERİNLİĞİ / Boring Depth (m)	NUMUNE CİNSİ / Sample Type	MANEVRA BOYU/Run	0-15 cm	15-30 cm	30-45 cm	N	JEOTEKNİK TANIMLAMA / Geotechnical Description
0							Yellowish brown-light brown, silty **SAND.** Moist, fine coarse grained; 25-30% silt.
	SPT-1	0.50–0.95	5	5	6	**11**	
1	SPT-2	1.00–1.45	6	10	10	**20**	1.00 m — **SCHIST** Brown-greenish grey, soft-friable, very weak, completely weathered.
	SPT-3	1.50–1.95	7	8	7	**15**	
2	SPT-4	2.00–2.45	4	5	7	**12**	2.00 m — **SCHIST** Green, friable, very weak, completely weathered.
	SPT-5	2.50–2.95	4	8	8	**16**	
3	SPT-6	3.00–3.45	3	7	8	**15**	3.05 m — **SCHIST** Brown, friable, very weak, completely weathered.
	SPT-7	3.50–3.95	5	7	7	**14**	
4	SPT-8	4.00–4.45	3	3	4	**7**	4.00 m — **SCHIST** Brown-greenish grey, purple, soft, very weak, Completely weathered clayey **(Potential slip surface)**.
	SPT-9	4.50–4.95	5	5	7	**12**	
5	SPT-10	5.00–5.45	4	5	7	**12**	5.00 m — **GRAPHITE SCHIST** Dark grey-black, soft, very weak, completely weathered.
6	SPT-11	5.50–5.95	3	5	9	**14**	



PROFİL / Profile | DAYANIMLILIK/Strength | AYRIŞMA / Weathering | KIRIK / Fracture (30cm) | KAROT%(TCR)/T.CoreR. | RQD % | LUGEON

DAYANIMLILIK / Strength			AYRIŞMA / Weathering			İNCE DANELİ / Fine Grained			İRİ DANELİ/Coarse Grained		
I	DAYANIMLI	Strong	I	TAZE	Fresh	N : 0-2	ÇOK YUMUŞAK	V.Soft	N : 0-4	ÇOK GEVŞEK	V.Loose
II	ORTA DAYANIMLI	M.Strong	II	AZ AYRIŞMIŞ	Slightly W.	N : 3-4	YUMUŞAK	Soft	N : 5-10	GEVŞEK	Loose
III	ORTA ZAYIF	M.Weak	III	ORTA D. AYR.	Mod. Weath.	N : 5-8	ORTA KATI	M.Stiff	N : 11-30	ORTA SIKI	M.Dense
IV	ZAYIF	Weak	IV	ÇOK AYR.	Highly W.	N : 9-15	KATI	Stiff	N : 31-50	SIKI	Dense
V	ÇOK ZAYIF	V.Weak	V	TÜMÜYLE A.	Comp.Weat.	N : 16-30	ÇOK KATI	V.Stiff	N : >50	ÇOK SIKI	V.Dense
						N : >30	SERT	Hard			

KAYA KALİTESİ TANIMI - RQD			KIRIKLAR - 30 cm / Fractures			ORANLAR - Proportions					
% 0-25	ÇOK ZAYIF	V.Poor	1	SEYREK	Wide (W)	% 5	PEK AZ	Slightly	% 5	PEK AZ	Slightly
% 25-50	ZAYIF	Poor	1-2	ORTA	Moderate (M)	% 5-15	AZ	Little	% 5-20	AZ	Little
% 50-75	ORTA	Fair	2-10	SIK	Close (Cl)	% 15-35	ÇOK	Very	% 20-50	ÇOK	Very
% 75-90	İYİ	Good	10-20	ÇOK SIKI	Intense (I)	% 35	VE	And			
% 90-100	ÇOK İYİ	Excellent	>20	PARÇALI	Crushed (Cr)						

SPT	Standart Penetrasyon Testi / Standart Penetration Test	K	Karot Numunesi / Core Sample	LOGU YAPAN / Logged By	KONTROL / Checked
D	Örselenmiş Numune / Disturbed sample	P	Pressiyometre Deneyi / Pressuremeter Test	İSİM / Name: Talip ERBAY, Jeoloji Mühendisi	
UD	Örselenmemiş Numune / Undisturbed Sample	k	Permeabilite Deneyi / Permeability Test	İMZA / Sign	

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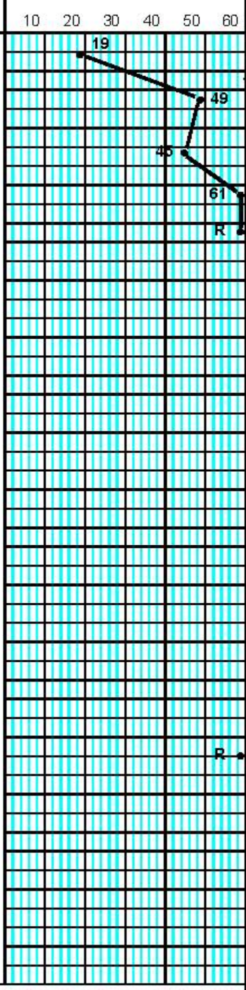
SONDAJ LOGU / BORING LOG

SONDAJ Borehole No: İBH72-3i
SAYFA Page No: 2/3

STANDART PENETRASYON DENEYİ / Standart Penetration Test

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	DARBE SAYISI 0 - 15 cm	15-30 cm	30-45 cm	N
6	SPT-12	6.00 – 6.45	8	9	10	**19**
	SPT-13	6.50 – 6.95	23	29	20	**49**
6.90	P1					
7	SPT-14	7.00 – 7.45	19	24	21	**45**
	SPT-15	7.50 – 7.95	9	21	40	**61**
8	SPT-16	8.00 – 8.13	50/13	-	-	**R**
	K-1	8.13 – 9.00				
9	K-2	9.00 – 10.50				
10	P2	9.90				
	K-3	10.50 – 11.20				
11	K-4	11.20 – 12.00				
12	K-5	12.00 – 13.50				
13	SPT-17	13.50 – 13.62	50/12	-	-	**R**
14	K-6	13.62 – 15.00				
	P3	14.40				
15	K-7	15.00 –				
16						

GRAFİK Graph



JEOTEKNİK TANIMLAMA / Geotechnical Description

GRAPHITE SCHIST
Definiton on page 1/3

— 6.50 m —

SCIST
Brown, soft-friabe, very weak, highly-completely weathered.

— 8.20 m —

SCHIST
Brown-yellowish brown, little-moderately hard, weak-moderately weak, moderately-highly weathered, brittle in some parts, weak-very weak, completely weathered, dense quatrz veins.

discontinuities; 0°,45°,70°,90°, light, matte, irregular, dense clay filling.

Run	PROFIL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
K-1 (8.20 – 9.00)		III	III IV	Cl	46	25	
K-2 (9.00 – 10.50)		I	II III	W	87	49	
		III IV	III IV	Cr			
K-3 (10.50 – 11.20)					79	14	
K-4 (11.20 – 12.00)		V	IV V	Cr	62	12	
K-5 (12.00 – 13.50)					37	6	
K-6 (13.62 – 15.00)		III IV	IV	Cl	65	9	
K-7 (15.00 –)		II III	III IV	M	100	60	

LOGU YAPAN Logged By	KONTROL Checked
İSİM Name: Talip ERBAY, Jeoloji Mühendisi	
İMZA Sign	

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SONDAJ LOGU / BORING LOG

SONDAJ Borehole No: İBH72-3i
SAYFA Page No: 3/3

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	SPT 0-15 cm	SPT 15-30 cm	SPT 30-45 cm	N	GRAFİK Graph (10 20 30 40 50 60)	JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
16	K-7	16.50						**SCHIST** Brown-yellowish brown, little-moderately hard, weak-moderately weak, moderately-highly weathered, brittle in some parts, weak-very weak, completely weathered, dense quatrz veins. discontinuities; 0°,45°,70°,90°, light, matte, irregular, dense clay filling.		III IV	IV	Cr	100	60	
17	K-8														
	P4	17.40										Cl	100	60	
18		18.00													
19	K-9											Cr	100	55	
												M			
		19.50													
20	P5	19.90										Cl	100	47	
	K-10											Cr			
21								**End of Boring: 21,00 m.**							
22															
23															
24															
25															
26															

STANDART PENETRASYON DENEYİ / Standart Penetration Test — DARBE SAYISI / Numb. of Blows

Not : Kuyuya 21,00 m inklinometre borusu indirilip, enjeksiyonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked
İSİM Name	Talip ERBAY Jeoloji Mühendisi	
İMZA Sign		

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SONDAJ LOGU / BORING LOG

SONDAJ Borehole	No :	İBH72-4
SAYFA Page	No :	1/3

PROJE ADI / Project Name	: İNEGÖL-BOZÜYÜK YOLU	DELİK ÇAPI / Hole Diameter	:
SONDAJ YERİ / Boring Location	: Heyelan / Landslide	YERALTI SUYU / Groundwater	: 13.45 m
KİLOMETRE / Chainage	: 72+079, 45,27 m sol / left	MUH.BOR.DER. / Casing Depth	: 1,50 m HW, 22,00 m NW
SONDAJ DER. / Boring Depth	: 22,45 m	BAŞ.BİT.TAR. / Start Finish Date	: 07.12.2006-10.12.2006
SONDAJ KOTU / Elevation	: 538,69 m	KOORDİNAT / Coordinate (E-W) Y	: 475 366,73
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Foremost B-53 / Rotary	KOORDİNAT / Coordinate (N-S) X	: 4 423 365,60

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Sample Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test — DARBE SAYISI Numb. of Blows 0-15 cm	15-30 cm	30-45 cm	N	GRAFİK Graph (10 20 30 40 50 60)	JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
0															
1															
	SPT-1	1.50–1.95	15	19	19	**38**	38								
2	SPT-2	2.00–2.45	12	15	18	**33**	33								
	SPT-3	2.50–2.95	10	9	11	**20**	20	**SCHIST** Yellow-yellowish brown, soft-friable, very weak, completely weathered-clayey		V	V				
3	SPT-4	3.00–3.45	9	8	9	**17**	17								
	SPT-5	3.50–3.95	9	12	10	**22**	22								
4	SPT-6	4.00–4.45	8	9	15	**24**	24								
	SPT-7	4.50–4.95	9	8	11	**19**	19								
5	SPT-8	5.00–5.45	6	7	8	**15**	15								
6	SPT-9	5.50–5.95	16	14	18	**32**	32								

DAYANIMLILIK / Strength			AYRIŞMA / Weathering			İNCE DANELİ / Fine Grained				İRİ DANELİ/Coarse Grained			
I	DAYANIMLI	Strong	I	TAZE	Fresh	N :	0-2	ÇOK YUMUŞAK	V.Soft	N : 0-4	ÇOK GEVŞEK	V.Loose	
II	ORTA DAYANIMLI	M.Strong	II	AZ AYRIŞMIŞ	Slightly W.	N :	3-4	YUMUŞAK	Soft	N : 5-10	GEVŞEK	Loose	
III	ORTA ZAYIF	M.Weak	III	ORTA D. AYR.	Mod. Weath.	N :	5-8	ORTA KATI	M.Stiff	N : 11-30	ORTA SIKI	M.Dense	
IV	ZAYIF	Weak	IV	ÇOK AYR.	Slightly W.	N :	9-15	KATI	Stiff	N : 31-50	SIKI	Dense	
V	ÇOK ZAYIF	V.Weak	V	TÜMÜYLE A.	Comp.Weat.	N :	16-30	ÇOK KATI	V.Stiff	N : >50	ÇOK SIKI	V.Dense	
						N :	>30	SERT	Hard				

KAYA KALİTESİ TANIMI - RQD			KIRIKLAR - 30 cm / Fractures			ORANLAR - Proportions					
% 0-25	ÇOK ZAYIF	V.Poor	1	SEYREK	Wide (W)	% 5	PEK AZ	Slightly	% 5	PEK AZ	Slightly
% 25-50	ZAYIF	Poor	1-2	ORTA	Moderate (M)	% 5-15	AZ	Little	% 5-20	AZ	Little
% 50-75	ORTA	Fair	2-10	SIK	Close (Cl)	% 15-35	ÇOK	Very	% 20-50	ÇOK	Very
% 75-90	İYİ	Good	10-20	ÇOK SIKI	Intense (I)	% 35	VE	And			
% 90-100	ÇOK İYİ	Excellent	>20	PARÇALI	Crushed (Cr)						

SPT	Standart Penetrasyon Testi / Standart Penetration Test	K	Karot Numunesi / Core Sample	LOGU YAPAN / Logged By	KONTROL / Checked
D	Orselenmiş Numune / Disturbed sample	P	Pressiyometre Deneyi / Pressuremeter Test	İSİM / Name: Talip ERBAY, Jeoloji Mühendisi	
UD	Örselenmemiş Numune / Undisturbed Sample	k	Permeabilite Deneyi / Permeability Test	İMZA / Sign	

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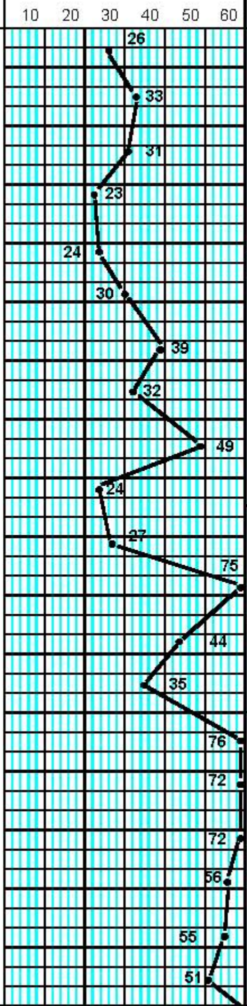
SONDAJ LOGU / BORING LOG

SONDAJ Borehole No: **İBH72-4**
SAYFA Page No: **2/3**

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test – DARBE SAYISI 0 - 15 cm	15-30 cm	30-45 cm	N
6	SPT-10	6.00 – 6.45	10	11	15	**26**
	SPT-11	6.50 – 6.95	8	14	19	**33**
7	SPT-12	7.00 – 7.45	10	13	18	**31**
	SPT-13	7.50 – 7.95	8	10	13	**23**
8	SPT-14	8.00 – 8.45	9	11	13	**24**
	SPT-15	8.50 – 8.95	9	14	16	**30**
9	SPT-16	9.00 – 9.45	8	18	21	**39**
	SPT-17	9.50 – 9.95	17	15	17	**32**
10	SPT-18	10.00 – 10.45	11	14	35	**49**
	SPT-19	10.50 – 10.95	10	11	13	**24**
11	SPT-20	11.00 – 11.45	10	13	14	**27**
	SPT-21	11.50 – 11.95	9	32	43	**75**
12	SPT-22	12.00 – 12.45	19	25	19	**44**
	SPT-23	12.50 – 12.95	12	14	21	**35**
13	SPT-24	13.00 – 13.45	27	41	35	**76**
	SPT-25	13.50 – 13.95	21	33	39	**72**
14	SPT-26	14.00 – 14.45	20	30	42	**72**
	SPT-27	14.50 – 14.95	20	25	31	**56**
15	SPT-28	15.00 – 15.45	19	26	29	**55**
16	SPT-29	15.50 – 15.95	11	24	27	**51**

GRAFİK Graph



JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
SCHIST Yellow-yellowish brown, soft-friable, very weak, completely weathered-clayey							
10.90 m							
GRAPHITE SCHIST Greenis grey-grey-black, soft, very weak, completely weathered.		V	V				
13.00 m							
SCHIST Green-greenish grey-purple, soft-friable, very weak, completely weathered, clayey.							

LOGU YAPAN Logged By	KONTROL Checked
İSİM Name: Talip ERBAY Jeoloji Mühendisi	
İMZA Sign	

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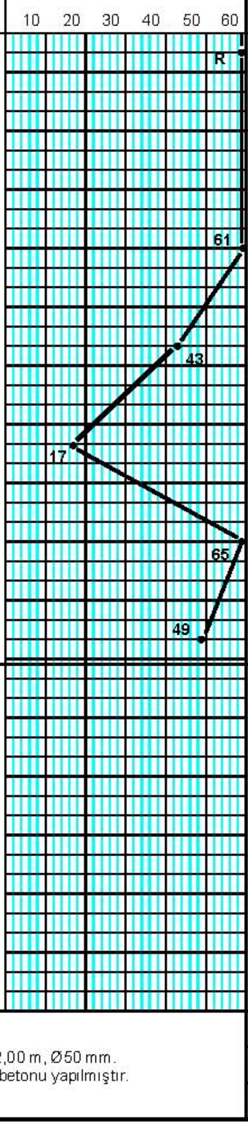
SONDAJ LOGU / BORING LOG

SONDAJ Borehole No : İBH72-4
SAYFA Page No : 3/3

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test – DARBE SAYISI Numb. of Blows: 0 - 15 cm	15-30 cm	30-45 cm	N	JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
16	SPT-30	16.00–16.43	27	40	50/13	R	**SCHIST** Definiton on page 2/3			V				
17							17.00 m							
18	SPT-31	18.00–18.45	26	27	34	**61**								
19	SPT-32	19.00–19.45	24	17	26	**43**	**GRAPHITE SCHIST** Dark grey-black, soft-friable, very weak, slightly-completely weathered.		V	IV V				
20	SPT-33	20.00–20.45	12	6	11	**17**								
21	SPT-34	21.00–21.45	18	24	41	**65**								
22	SPT-35	22.00	15	19	30	**49**								
23–26							**End of Boring : 22,45 m.**							

GRAFİK Graph



Not : Kuyuya yeraltısuyu gözlemleri için 22,00 m, Ø50 mm. perfore PVC boru indirilip, kuyu ağzı betonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked
İSİM Name	Talip ERBAY Jeoloji Mühendisi	
İMZA Sign		

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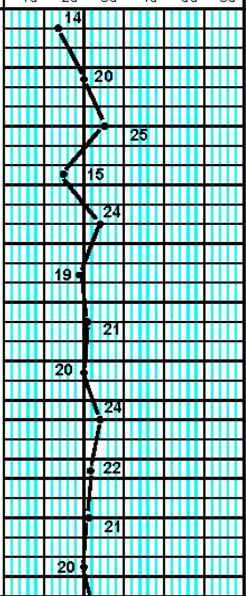
SONDAJ LOGU / BORING LOG

SONDAJ Borehole No : İBH72-5
SAYFA Page No : 1/3

PROJE ADI / Project Name	: İNEGÖL-BOZÜYÜK YOLU	DELİK ÇAPI / Hole Diameter	:
SONDAJ YERİ / Boring Location	: Heyalan / Landslide	YERALTI SUYU / Groundwater	: 4.60 m
KİLOMETRE / Chainage	: 72+081, 133,65 m sol / left	MUH.BOR.DER. / Casing Depth	: 4,50 m HW, 13,50 m NW
SONDAJ DER. / Boring Depth	: 17,30 m	BAŞ.BİT.TAR. / Start Finish Date	: 11.12.2006-13.12.2006
SONDAJ KOTU / Elevation	: 543,75 m	KOORDİNAT / Coordinate (E-W) Y	: 475 399,26
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Craelius D-500 / Rotary	KOORDİNAT / Coordinate (N-S) X	: 4 423 389,41

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Sample Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test — DARBE SAYISI Numb. of Blows: 0 - 15 cm	15-30 cm	30-45 cm	N	GRAFİK Graph	JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
0	SPT-1	0.00 - 0.45	8	6	8	14		Brown-yellowish brown-greenish grey-green colored, medium dense, greavelly, silty **SAND** / sandy **SILT.** Moist, fine-coarse grained, brittle-little hard-medium hard; 30-40% low plasticity, fine material; 20-30% fine-coarse grained, brittle-hard, angular, schist-quartzite originated gravel, gravel amount reduces at lower leves and fine material increases							
	SPT-2	0.50 - 0.95	7	9	1	20									
1	SPT-3	1.00 - 1.45	9	1	1	25									
	SPT-4	1.50 - 1.95	8	7	8	15									
2	SPT-5	2.00 - 2.45	6	9	1	24									
	SPT-6	2.50 - 2.95	8	8	1	19									
3	SPT-7	3.00 - 3.45	6	1	1	21									
	SPT-8	3.50 - 3.95	7	9	1	20									
4	SPT-9	4.00 - 4.45	8	1	1	24									
	SPT-10	4.50 - 4.95	6	1	1	22									
5	SPT-11	5.00 - 5.45	7	1	1	21									
6	SPT-12	5.50 - 5.95	7	1	9	20									

DAYANIMLILIK / Strength			AYRIŞMA / Weathering			İNCE DANELİ / Fine Grained			İRİ DANELİ/Coarse Grained		
I	DAYANIMLI	Strong	I	TAZE	Fresh	N : 0-2	ÇOK YUMUŞAK	V.Soft	N : 0-4	ÇOK GEVŞEK	V.Loose
II	ORTA DAYANIMLI	M.Strong	II	AZ AYRIŞMIŞ	Slightly W.	N : 3-4	YUMUŞAK	Soft	N : 5-10	GEVŞEK	Loose
III	ORTA ZAYIF	M.Weak	III	ORTA D. AYR.	Mod. Weath.	N : 5-8	ORTA KATI	M.Stiff	N : 11-30	ORTA SIKI	M.Dense
IV	ZAYIF	Weak	IV	ÇOK AYR.	Slightly W.	N : 9-15	KATI	Stiff	N : 31-50	SIKI	Dense
V	ÇOK ZAYIF	V.Weak	V	TÜMÜYLE A.	Comp.Weat.	N : 16-30	ÇOK KATI	V.Stiff	N : >50	ÇOK SIKI	V.Dense
						N : >30	SERT	Hard			

KAYA KALİTESİ TANIMI - RQD			KIRIKLAR - 30 cm / Fractures			ORANLAR - Proportions					
% 0-25	ÇOK ZAYIF	V.Poor	1	SEYREK	Wide (W)	% 5	PEK AZ	Slightly	% 5	PEK AZ	Slightly
% 25-50	ZAYIF	Poor	1-2	ORTA	Moderate (M)	% 5-15	AZ	Little	% 5-20	AZ	Little
% 50-75	ORTA	Fair	2-10	SIK	Close (Cl)	% 15-35	ÇOK	Very	% 20-50	ÇOK	Very
% 75-90	İYİ	Good	10-20	ÇOK SIKI	Intense (I)	% 35	VE	And			
% 90-100	ÇOK İYİ	Excellent	>20	PARÇALI	Crushed (Cr)						

SPT	Standart Penetrasyon Testi / Standart Penetration Test	K	Karot Numunesi / Core Sample	LOGU YAPAN / Logged By	KONTROL / Checked
D	Orselenmiş Numune / Disturbed sample	P	Pressiyometre Deneyi / Pressuremeter Test	İSİM / Name: Talip ERBAY, Jeoloji Mühendisi	
UD	Örselenmemiş Numune / Undisturbed Sample	k	Permeabilite Deneyi / Permeability Test	İMZA / Sign	

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SONDAJ LOGU / BORING LOG

SONDAJ Borehole No : İBH72-5
SAYFA Page No : 2/3

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test – DARBE SAYISI Numb. of Blows: 0 - 15 cm	15-30 cm	30-45 cm	N	JEOTEKNİK TANIMLAMA Geotechnical Description	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
6	SPT-13	6.00–6.45	7	7	9	16	Brown-yellowish brown-greenish grey-green colored, medium dense, greavelly, silty **SAND** / sandy **SILT** (Descrpition on page 1/3)						
	SPT-14	6.50–6.95	6	8	1	21							
7	SPT-15	7.00–7.45	6	8	1	19							
	SPT-16	7.50–7.95	7	1	1	23							
8							8.00 m						
	SPT-17	8.00–8.45	4	6	8	14	Grrenish dark grey-green-black, medium dense, silty gravelly **SAND.** Moist, fine-coarse grained, brittle-hard, angular, schist, graphite-schist, quartzite originated; 30-40%, brittle-little hard, angular, schist, graphite-schits originated gravelly; 20-30% low plasticity, fine material.						
	SPT-18	8.50–8.95	8	1	1	26							
9	SPT-19	9.00–9.45	6	5	8	13							
	SPT-20	9.50–9.95	6	9	1	20							
10	SPT-21	10.00–10.45	5	6	1	17							
	SPT-22	10.50–10.95	5	8	1	19							
11	SPT-23	11.00–11.45	3	8	5	13							
							11.50 m						
	SPT-24	11.50–11.60	5/1	-	-	R	**GRAPHITE SCHIST** Dark grey-black, soft-brittle, very weak, completely weathered.	V	V				
12	SPT-25	12.30–12.54	4	5/9	-	R							
13	K-1	12.60–13.50					13.10 m	V	V		55	33	
14	K-2	13.50–14.60					**SCHIST** Light green, medium hard, weak-moderately weak, slightly weathered-fresh, very dense quartzite veins. (14.80-15.90 gprahite schist bands) Discontinuities; 30°,70°,90° light, shiny, slick, ondulating.	II III	I II	C	100	100	
15	K-3	14.60–15.80									100	100	
16	K-4	15.80									97	90	

	LOGU YAPAN Logged By	KONTROL Checked
İSİM Name	Talip ERBAY Jeoloji Mühendisi	
İMZA Sign		

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SONDAJ LOGU / BORING LOG

SONDAJ Borehole No : İBH72-5
SAYFA Page No : 3/3

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	SPT 0 - 15 cm	SPT 15-30 cm	SPT 30-45 cm	N	GRAFİK Graph (10 20 30 40 50 60)	JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
16–17	K-4							**SCHIST** Light Green, medium hard, medium strong - medium weaki slightly weathered, fresh, very dense quartz veins. (Definition on page 2/3)		II III	I II	C	97	90	
17–26								**End of Boring: 17,30 m.**							

STANDART PENETRASYON DENEYİ / Standart Penetration Test; DARBE SAYISI / Numb. of Blows

Not : Kuyuya yeraltısuyu gözlemleri için 17,00 m, Ø50 mm. perfore PVC boru indirilip, kuyu ağzı betonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked
İSİM Name	Talip ERBAY Jeoloji Mühendisi	
İMZA Sign		

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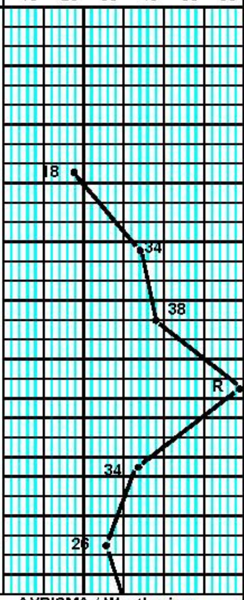
SONDAJ LOGU / BORING LOG

SONDAJ Borehole	No :	İBH72-6i
SAYFA Page	No :	1/2

PROJE ADI / Project Name	: İNEGÖL-BOZÜYÜK YOLU	DELİK ÇAPI / Hole Diameter	:
SONDAJ YERİ / Boring Location	: Heyelan / Landslide	YERALTI SUYU / Groundwater	: 2.15 m
KİLOMETRE / Chainage	: 72+119, 1,50 m sol / left	MUH.BOR.DER. / Casing Depth	: 15,00 m HW
SONDAJ DER. / Boring Depth	: 15,25 m	BAŞ.BİT.TAR. / Start Finish Date	: 06.12.2006-07.12.2006
SONDAJ KOTU / Elevation	: 514,07 m	KOORDİNAT / Coordinate (E-W) Y	: 475 318,08
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Craelius D-750 / Rotary	KOORDİNAT / Coordinate (N-S) X	: 4 423 281,52

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Sample Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test — DARBE SAYISI Numb. of Blows: 0-15 cm	15-30 cm	30-45 cm	N	GRAFİK Graph (10 20 30 40 50 60)	JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
0 – 3.50								Dark grey-black, medium dense-dense, clayey gravelly **SAND.** Moist, fine-coarse grained, brittle-hard, schist originated; 15-25% fine-coarse grained, brittle-hard, angular gravel; 20-30% fine material.							
	SPT-1	1.50 – 1.95	6	8	10	**18**	18								
	SPT-2	2.25 – 2.70	10	14	20	**34**	34								
	SPT-3	3.00 – 3.45	12	16	22	**38**	38								
3.50 – 4.30								Brown, very dense, gravelly, clayey, silty **SAND.** Moist, fine-coarse grained, brittle-hard, 15-20% fine-coarse grained, gravelly; 15-20% fine material.							
	SPT-4	3.75 – 4.10	11	14	50/5	**R**	R								
4.30 –								**GRAPHITE SCHIST** (Definiton on page 2/2).		V	V				
	SPT-5	4.50 – 4.95	10	14	20	**34**	34								
5.40	P1														
	SPT-6	5.25 – 5.70	10	12	14	**26**	26								



DAYANIMLILIK / Strength			AYRIŞMA / Weathering			İNCE DANELİ / Fine Grained			İRİ DANELİ/Coarse Grained		
I	DAYANIMLI	Strong	I	TAZE	Fresh	N : 0-2	ÇOK YUMUŞAK	V.Soft	N : 0-4	ÇOK GEVŞEK	V.Loose
II	ORTA DAYANIMLI	M.Strong	II	AZ AYRIŞMIŞ	Slightly W.	N : 3-4	YUMUŞAK	Soft	N : 5-10	GEVŞEK	Loose
III	ORTA ZAYIF	M.Weak	III	ORTA D. AYR.	Mod. Weath.	N : 5-8	ORTA KATI	M.Stiff	N : 11-30	ORTA SIKI	M.Dense
IV	ZAYIF	Weak	IV	ÇOK AYR.	Slightly W.	N : 9-15	KATI	Stiff	N : 31-50	SIKI	Dense
V	ÇOK ZAYIF	V.Weak	V	TÜMÜYLE A.	Comp.Weat.	N : 16-30	ÇOK KATI	V.Stiff	N : >50	ÇOK SIKI	V.Dense
						N : >30	SERT	Hard			

KAYA KALİTESİ TANIMI - RQD			KIRIKLAR - 30 cm / Fractures			ORANLAR - Proportions					
% 0-25	ÇOK ZAYIF	V.Poor	1	SEYREK	Wide (W)	% 5	PEK AZ	Slightly	% 5	PEK AZ	Slightly
% 25-50	ZAYIF	Poor	1-2	ORTA	Moderate (M)	% 5-15	AZ	Little	% 5-20	AZ	Little
% 50-75	ORTA	Fair	2-10	SIK	Close (Cl)	% 15-35	ÇOK	Very	% 20-50	ÇOK	Very
% 75-90	İYİ	Good	10-20	ÇOK SIKI	Intense (I)	% 35	VE	And			
% 90-100	ÇOK İYİ	Excellent	>20	PARÇALI	Crushed (Cr)						

SPT	Standart Penetrasyon Testi / Standart Penetration Test	K	Karot Numunesi / Core Sample	LOGU YAPAN / Logged By	KONTROL / Checked
D	Orselenmiş Numune / Disturbed sample	P	Pressiyometre Deneyi / Pressuremeter Test	İSİM / Name: Talip ERBAY, Jeoloji Mühendisi	
UD	Örselenmemiş Numune / Undisturbed Sample	k	Permeabilite Deneyi / Permeability Test	İMZA / Sign	

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SONDAJ LOGU / BORING LOG

SONDAJ Borehole No : **İBH72-6i**

SAYFA Page No : **2/2**

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	0 - 15 cm	15-30 cm	30-45 cm	N	JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
6	SPT-7	6.00	9	14	16	**30**								
		6.45												
		6.70												
7	SPT-8		16	18	22	**40**								
		7.15					**GRAPHITE SCHIST**							
		7.50												
	SPT-9		15	17	22	**39**	Dark grey-black colored, soft-friable, very weak, completely weathered.							
8		7.95							IV V	IV V				
		8.25												
	P2	8.40												
	SPT-10		18	22	13	**35**								
		8.70												
9		9.00												
	SPT-11		17	18	25	**43**								
		9.45												
		9.70												
10	SPT-12		11	20	40	**60**								
		10.15					10.40 m							
	SPT-13	10.50 / 10.62	50/12	-	-	**R**	**SCHIST**							
11	K-1						Greenish grey- green colored, brittle- little hard, weak- very weak, heaviliy-completely weathered.					27	0	
	P3	11.40												
12		12.00					Lower levels (13.50m-15.25m) soft,very weak, completely weathered.		IV V	IV V				
	K-2											41	0	
13														
		13.50									Cr			
	K-3											0	0	
14	SPT-14	14.00 / 14.14	50/14	-	-	**R**								
	K-4								V	V		12	0	
15	SPT-15	15.00	48	50/10	-	**R**								
16							**End of Borehole: 15,25 m.**							

Not : Kuyuya 15,00 m inklinometre borusu indirilip, enjeksiyonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked
İSİM Name	Talip ERBAY Jeoloji Mühendisi	
İMZA Sign		

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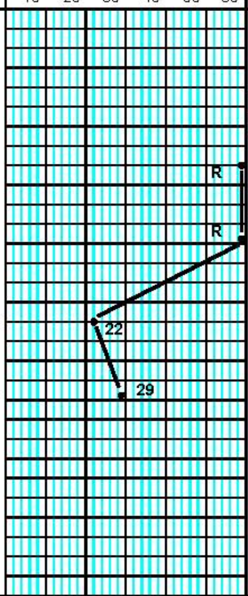
SONDAJ LOGU / BORING LOG

SONDAJ Borehole	No :	İBH72-7i
SAYFA Page	No :	1/4

PROJE ADI / Project Name	: İNEGÖL-BOZÜYÜK YOLU	DELİK ÇAPI / Hole Diameter	:
SONDAJ YERİ / Boring Location	: Heyelan / Landslide	YERALTI SUYU / Groundwater	: 8.50 m
KİLOMETRE / Chainage	: 72+118, 43,97 m sol / left	MUH.BOR.DER. / Casing Depth	: 25.10 m HW, 21,00 m NW
SONDAJ DER. / Boring Depth	: 27,05 m	BAŞ.BİT.TAR. / Start Finish Date	: 22.11.2006-26.11.2006
SONDAJ KOTU / Elevation	: 529,70 m	KOORDİNAT / Coordinate (E-W) Y	: 475 348,09
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Craelius D 750 / Rotary	KOORDİNAT / Coordinate (N-S) X	: 4 423 311,61

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Sample Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test — DARBE SAYISI Numb. of Blows 0 - 15 cm	15-30 cm	30-45 cm	N	GRAFİK	JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
0–6	SPT-1	1.50–1.55	50/5	-	-	R	R	**SCHIST** yellow, yellowish ligt brown, pinkish-purple colored, brittle-little hard to medium hard in some parts, weak-medium weak to very weak in some parts, heavily-completely weathered, quartzite veins. Note: 9.2-9.5m graphite schist bands.		IV V	IV V				
	K-1	1.55–2.25											44	0	
	SPT-2	2.25–2.39	50/14	-	-	R	R								
	K-2	2.39–3.00								V	V		0	0	
	SPT-3	3.00–3.45	17	10	12	22	22								
	K-3	3.45–3.75										Cr	100	0	
	SPT-4	3.75–4.20	10	17	12	29	29								
	K-4	4.20–6.00								IV V	IV V		52	10	



DAYANIMLILIK / Strength			AYRIŞMA / Weathering			İNCE DANELİ / Fine Grained				İRİ DANELİ/Coarse Grained			
I	DAYANIMLI	Strong	I	TAZE	Fresh	N : 0-2	ÇOK YUMUŞAK	V.Soft		N : 0-4	ÇOK GEVŞEK	V.Loose	
II	ORTA DAYANIMLI	M.Strong	II	AZ AYRIŞMIŞ	Slightly W.	N : 3-4	YUMUŞAK	Soft		N : 5-10	GEVŞEK	Loose	
III	ORTA ZAYIF	M.Weak	III	ORTA D. AYR.	Mod. Weath.	N : 5-8	ORTA KATI	M.Stiff		N : 11-30	ORTA SIKI	M.Dense	
IV	ZAYIF	Weak	IV	ÇOK AYR.	Slightly W.	N : 9-15	KATI	Stiff		N : 31-50	SIKI	Dense	
V	ÇOK ZAYIF	V.Weak	V	TÜMÜYLE A.	Comp.Weat.	N : 16-30	ÇOK KATI	V.Stiff		N : >50	ÇOK SIKI	V.Dense	
						N : >30	SERT	Hard					

KAYA KALİTESİ TANIMI - RQD			KIRIKLAR - 30 cm / Fractures			ORANLAR - Proportions					
% 0-25	ÇOK ZAYIF	V.Poor	1	SEYREK	Wide (W)	% 5	PEK AZ	Slightly	% 5	PEK AZ	Slightly
% 25-50	ZAYIF	Poor	1-2	ORTA	Moderate (M)	% 5-15	AZ	Little	% 5-20	AZ	Little
% 50-75	ORTA	Fair	2-10	SIK	Close (Cl)	% 15-35	ÇOK	Very	% 20-50	ÇOK	Very
% 75-90	İYİ	Good	10-20	ÇOK SIKI	Intense (I)	% 35	VE	And			
% 90-100	ÇOK İYİ	Excellent	>20	PARÇALI	Crushed (Cr)						

SPT	Standart Penetrasyon Testi Standart Penetration Test	K	Karot Numunesi Core Sample	LOGU YAPAN Logged By	KONTROL Checked
D	Orselenmiş Numune Disturbed sample	P	Pressiyometre Deneyi Pressuremeter Test	İSİM Name: Talip ERBAY Jeoloji Mühendisi	
UD	Örselenmemiş Numune Undisturbed Sample	k	Permeabilite Deneyi Permeability Test	İMZA Sign	

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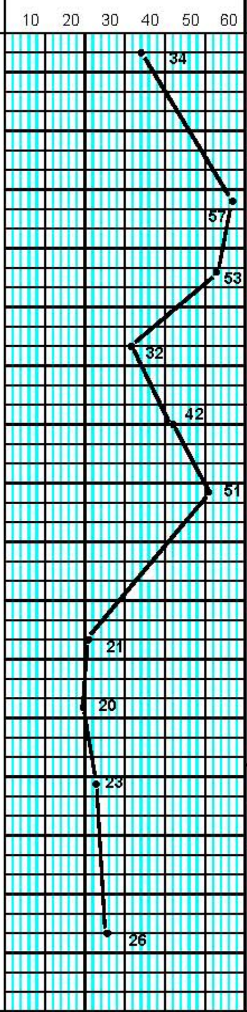
SONDAJ LOGU / BORING LOG

SONDAJ / Borehole No : İBH72-7i
SAYFA / Page No : 2/4

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test — DARBE SAYISI 0 - 15 cm	15-30 cm	30-45 cm	N	JEOTEKNİK TANIMLAMA Geotechnical Description	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
6	SPT-5	6.00	10	14	20	34	**SCHIST** Yellow, yellowish-light brown, pinkish-purple colored, brittle-little hard to medium hard in some parts. weak-medium weak to very weak in some parts, heavily-completely weathered, quartzite veins. Note: 9.20m-9.50m Graphite schist bands.	IV V	IV V	Cr			
7	K-5	6.45									19	0	
	SPT-6	7.50	24	27	30	57							
8	K-6	7.95									60	0	
	SPT-7	8.25	22	25	28	53							
	K-7	8.70									0	0	
9	SPT-8	9.00	10	12	20	32							
	K-8	9.45									46	0	
9.90	P1	9.80					9.80 m						
10	SPT-9	9.80	13	18	24	42	**SCHISt** Greenish grey, soft-brittle, very weak, heavily-completely weathered, contains	V	IV V	Cr			
	K-9	10.25									0	0	
	SPT-10	10.50	15	20	31	51							
11	K-10	10.95									13	0	
12	SPT-11	12.00	8	10	11	21							
	K-11	12.45									60	0	
13	SPT-12	12.70	9	8	12	20							
	K-12	13.15									0	0	
	SPT-13	13.50	8	10	13	23	13.50 m **GRAPHITE SCHIST** (Definition on page 3/4)						
14	K-13	13.95									0	0	
15	SPT-14	15.00	7	10	16	26							
16	K-14	15.45									0	0	

GRAFİK



LOGU YAPAN Logged By	KONTROL Checked
İSİM Name: Talip ERBAY Jeoloji Mühendisi	
İMZA Sign	

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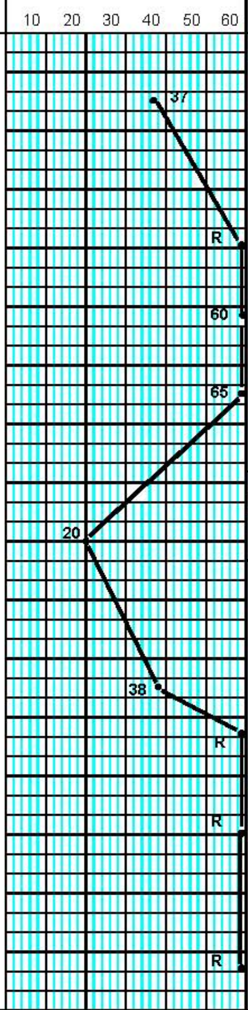
SONDAJ LOGU / BORING LOG

SONDAJ / Borehole No: **İBH72-7i**
SAYFA / Page No: **3/4**

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	0 - 15 cm	15-30 cm	30-45 cm	N	JEOTEKNİK TANIMLAMA Geotechnical Description	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
16	K-14	16.50					**GRAPHITE SCHIST**				0	0	
	SPT-15	16.95	13	15	22	37	Dark grey-black colroed, soft-friable, very weak, heavily-completely weathered, partly clayey						
17	P2 / K-15	17.40 / 18.00									26	0	
18	SPT-16	18.37	38	47	50/7	R							
	K-16	18.70									0	0	
19	SPT-17	19.15	15	25	35	60							
	K-17	19.50									0	0	
20	SPT-18	19.95	14	27	38	65							
	K-18	21.00					20.50 m **SCHIST** green, soft, very weak, completely weathered.	V	IV V	Cr	0	0	
21	SPT-19	21.45	9	9	11	20	21.40 m						
22	K-19	22.50									0	0	
	SPT-20	22.95	18	18	20	38							
23	SPT-21	23.00 / 23.40	22	29	50/10	R							
	K-20	24.00					**SCHIST**				0	0	
24	SPT-22	24.43	26	46	50/13	R	greenish grey, pinkish-purple colored, soft, very weak, completely weathered.						
25	K-21	25.50									20	0	
	SPT-23	25.60	50/10	-	-	R							
26	K-22										16	0	

STANDART PENETRASYON DENEYİ / Standart Penetration Test — GRAFİK / Graph



PROFİL / Profile

LOGU YAPAN / Logged By	KONTROL / Checked
İSİM / Name: Talip ERBAY, Jeoloji Mühendisi	
İMZA / Sign	

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SONDAJ LOGU / BORING LOG

SONDAJ Borehole No: **İBH72-7i**

SAYFA Page No: **4/4**

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test — DARBE SAYISI Numb. of Blows: 0 - 15 cm	15-30 cm	30-45 cm	N	GRAFİK Graph (10 20 30 40 50 60)	JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
26	K-23	26.00 – 27.00						**SCHIST** (Definition on page 3/4)					16	0	
27	SPT-24	27.00 – 27.05	50/5	-	-	**R**	R								
28–36								**End of Boring: 27,05 m.**							

Not : Kuyuya 27,00 m inklinometre borusu indirilip, çimento enjeksiyonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked
İSİM Name	Talip ERBAY Jeoloji Mühendisi	
İMZA Sign		

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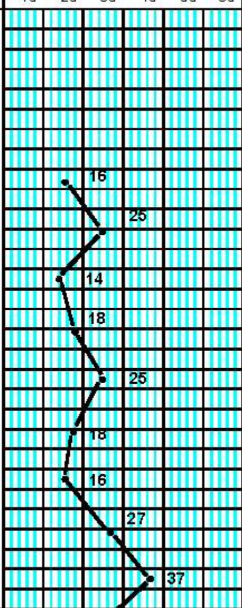
SONDAJ LOGU / BORING LOG

SONDAJ Borehole	No :	İBH72-8i
SAYFA Page	No :	1/4

PROJE ADI / Project Name	: İNEGÖL-BOZÜYÜK YOLU	DELİK ÇAPI / Hole Diameter	:
SONDAJ YERİ / Boring Location	: Heyelan / Landslide	YERALTI SUYU / Groundwater	: 13.00 m
KİLOMETRE / Chainage	: 72+119, 79,38 m sol /sol	MUH.BOR.DER. / Casing Depth	: 3.00 m HW, 36.00 m NW
SONDAJ DER. / Boring Depth	: 36,00 m	BAŞ.BİT.TAR. / Start Finish Date	: 30.11.2006-06.12.2006
SONDAJ KOTU / Elevation	: 542,32 m	KOORDİNAT / Coordinate (E-W) Y	: 475 374,62
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Craelius D 500 / Rotary	KOORDİNAT / Coordinate (N-S) X	: 4 423 335,09

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Sample Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test — DARBE SAYISI Numb. of Blows: 0 - 15 cm	15-30 cm	30-45 cm	N	JEOTEKNİK TANIMLAMA Geotechnical Description
0							
1							
	SPT-1	1.50 – 1.95	5	7	9	16	Brown-yellowish brown-grey-greenish grey colored, medium dense, silty, gravelly **SAND**. Moist, fine-coarse grained, brittle-hard, 25-30% fine-coarse grained, brittle-hard, schist-quartzite originated gravel, 15-25% low plasticity, fine material.
2	SPT-2	2.00 – 2.45	7	10	15	25	
	SPT-3	2.50 – 2.95	5	6	8	14	
3	SPT-4	3.00 – 3.45	6	8	10	18	
	SPT-5	3.50 – 3.95	8	11	14	25	
4	SPT-6	4.00 – 4.45	6	8	10	18	
	SPT-7	4.50 – 4.95	9	7	9	16	5.00 m
5	SPT-8	5.00 – 5.45	8	12	15	27	Silty, sandy **GRAVEL** (Description on page 2/4).
6	SPT-9	5.50 – 5.95	18	16	21	37	

GRAFİK Graph



PROFİL Profile | DAYANIMLILIK/Strength | AYRIŞMA / Weathering | KIRIK / Fracture (30cm) | KAROT%(TCR)/T.CoreR. | RQD % | LUGEON

DAYANIMLILIK / Strength			AYRIŞMA / Weathering			İNCE DANELİ / Fine Grained			IRI DANELİ/Coarse Grained		
I	DAYANIMLI	Strong	I	TAZE	Fresh	N : 0-2	ÇOK YUMUŞAK	V.Soft	N : 0-4	ÇOK GEVŞEK	V.Loose
II	ORTA DAYANIMLI	M.Strong	II	AZ AYRIŞMIŞ	Slightly W.	N : 3-4	YUMUŞAK	Soft	N : 5-10	GEVŞEK	Loose
III	ORTA ZAYIF	M.Weak	III	ORTA D. AYR.	Mod. Weath.	N : 5-8	ORTA KATI	M.Stiff	N : 11-30	ORTA SIKI	M.Dense
IV	ZAYIF	Weak	IV	ÇOK AYR.	Slightly W.	N : 9-15	KATI	Stiff	N : 31-50	SIKI	Dense
V	ÇOK ZAYIF	V.Weak	V	TÜMÜYLE A.	Comp.Weat.	N : 16-30	ÇOK KATI	V.Stiff	N : >50	ÇOK SIKI	V.Dense
						N : >30	SERT	Hard			

KAYA KALİTESİ TANIMI - RQD			KIRIKLAR - 30 cm / Fractures			ORANLAR - Proportions					
% 0-25	ÇOK ZAYIF	V.Poor	1	SEYREK	Wide (W)	% 5	PEK AZ	Slightly	% 5	PEK AZ	Slightly
% 25-50	ZAYIF	Poor	1-2	ORTA	Moderate (M)	% 5-15	AZ	Little	% 5-20	AZ	Little
% 50-75	ORTA	Fair	2-10	SIK	Close (Cl)	% 15-35	ÇOK	Very	% 20-50	ÇOK	Very
% 75-90	İYİ	Good	10-20	ÇOK SIKI	Intense (I)	% 35	VE	And			
% 90-100	ÇOK İYİ	Excellent	>20	PARÇALI	Crushed (Cr)						

				LOGU YAPAN Logged By	KONTROL Checked
SPT	Standart Penetrasyon Testi Standart Penetration Test	K	Karot Numunesi Core Sample		
D	Örselenmiş Numune Disturbed sample	P	Pressiyometre Deneyi Pressuremeter Test	İSİM Name: Talip ERBAY Jeoloji Mühendisi	
UD	Örselenmemiş Numune Undisturbed Sample	k	Permeabilite Deneyi Permeability Test	İMZA Sign	

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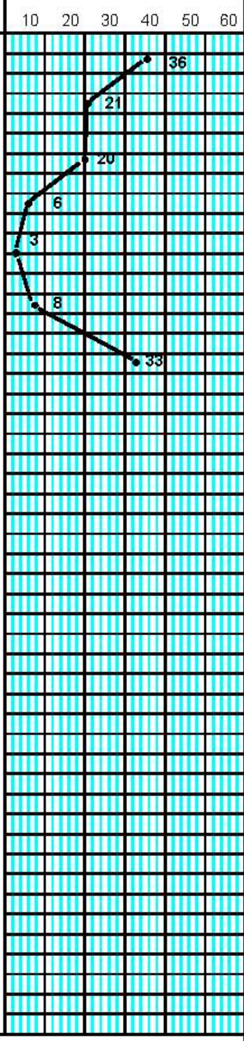
SONDAJ LOGU / BORING LOG

SONDAJ Borehole	No :	İBH72-8i
SAYFA Page	No :	2/4

STANDART PENETRASYON DENEYİ / Standart Penetration Test

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	DARBE SAYISI Numb. of Blows 0 - 15 cm	15-30 cm	30-45 cm	N	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30 cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
6	SPT-10	6.00 – 6.45	12	18	18	36						
7	SPT-11	6.50 – 6.95	13	12	9	21						
	SPT-12	7.00 – 7.45	7	10	10	20						
	SPT-13	7.50 – 7.95	5	3	3	6						
8	SPT-14	8.00 – 8.45	2	1	2	3						
	SPT-15	8.50 – 8.95	15	5	3	8						
9	SPT-16	9.00 – 9.45	7	21	12	33	V	V				
	K-1	9.50 – 10.00					IV V	IV V	Cr	6	0	
10	K-2	10.00 – 10.50								27	25	
11	K-3	10.50 – 11.80					III IV	III IV	Cl / Cr	94	39	
12, 13	K-4	11.80 – 13.60					IV V	IV V	Cl / Cr	95	34	
14	K-5	13.60 – 14.50					III IV / V	III IV / IV V	Cl / Cr	100	0	
15, 16	K-6	14.50 – 16.00					III IV	III IV	Cl / Cr	100	39	

GRAFİK / Graph



JEOTEKNİK TANIMLAMA / Geotechnical Description

6.00 – 8.75 m: Yellowish brown, silty, sandy **GRAVEL**. Most, fine-coarse grained, little hard-medium hard, schist originated; 15-25% sand; 5-10% fine material. **(Talus / Landslide material)**

8.75 m

8.75 – 9.50 m: **SCHIST** Greenish-brownish grey colored, soft-friable, very weak, completely weathered.

9.50 m

9.50 – 16.00 m: **SCHIST**
Brown-yellowish brown, brittle-little hard to medium hard in some parts, moderately to highly weathered. dense quartzite veins

Discontinuities; 0°,30°,45°,90° open, irregular, slippery in some parts, calcite-clay filling, FeO-MnO covered.

LOGU YAPAN Logged By	KONTROL Checked
İSİM Name: Talip ERBAY, Jeoloji Mühendisi	
İMZA Sign	

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SONDAJ LOGU / BORING LOG

SONDAJ / Borehole No: **İBH72-8i**
SAYFA / Page No: **3/4**

STANDART PENETRASYON DENEYİ / Standart Penetration Test — DARBE SAYISI / Numb. of Blows (0-15 cm, 15-30 cm, 30-45 cm, N); GRAFİK / Graph (10, 20, 30, 40, 50, 60)

SONDAJ DERİNLİĞİ / Boring Depth (m)	NUMUNE CİNSİ / Samp. Type	MANEVRA BOYU/Run	JEOTEKNİK TANIMLAMA / Geotechnical Description	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30 cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
16–17.50	K-7	16.00–17.50	**SCHIST** Brown-yellowish brown, brittle-little hard to medium hard in some parts, weak-medium weak to very weak in some parts, moderately-highly weathered, dense quartzite veins. Discontinuities; 0°,30°,45°,90° open, irregular, slippery in some parts, calcite-clay filling, FeO-MnO covered.	III IV	III IV	Cr / I	100	24	
17.50–18.10	K-8	17.50–18.10				I / Cr	97	32	
18.10–19.00	K-9	18.10–19.00				Cr / Cl	100	0	
19.00–19.80	K-10	19.00–19.80				Cl	68	44	
19.80–21.00	K-11	19.80–21.00	20.50 m			Cr	48	0	
21.00–22.50	K-12	21.00–22.50	**SCHIST** Purple-greenish grey colored, soft-friable, little hard, weak-very weak, highly-completely weathered.	IV V	IV V	Cr	65	15	
22.50–23.50	K-13	22.50–23.50				Cr	51	0	
23.50–24.60	K-14	23.50–24.60		III IV	III IV	Cr	60	9	
24.60–25.10	K-15	24.60–25.10		IV V	IV V	Cr	0	0	
25.10–26.00	K-16	25.10–26.00	26.00 m			Cr	99	0	

LOGU YAPAN / Logged By — İSİM / Name: Talip ERBAY, Jeoloji Mühendisi; İMZA / Sign:

KONTROL / Checked

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SONDAJ LOGU / BORING LOG

SONDAJ Borehole	No :	İBH72-8i
SAYFA Page	No :	4/4

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	0 - 15 cm	15-30 cm	30-45 cm	N	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30 cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
26	K-16	26.10								99	0	
27	K-17									71	0	
	K-18	27.50								18	0	
28	K-19	28.00					IV V	IV V		19	0	
29	K-20	29.00							Cr	0	0	
30	SPT-17	30.00	15	17	22	**39**						
	K-21	30.45								0	0	
31	SPT-18	31.00	50/10	-	-	**R**						
	K-22	31.10								48	0	
	K-23	31.50					III IV	III IV		64	0	
32	K-24	32.00							I	66	20	
33	K-25	33.00								97	12	
34	K-26	34.00					IV V	IV V	Cr	45	0	
35	K-27	35.00								52	12	
36		36.00										

STANDART PENETRASYON DENEYİ / Standart Penetration Test — DARBE SAYISI / Numb. of Blows; GRAFİK / Graph (10 20 30 40 50 60): 39, R

JEOTEKNİK TANIMLAMA / Geotechnical Description (PROFİL / Profile)

26.00 m

SCHIST
Brown, brittle-little hard, weak-very weak, heavily-completely weathered.

27.40 m

SCHIST
Purple-grennish grey, soft-friable, very weak, completely weathered.

29.00 m

GRAPHITE SCHIST
Dark grey-black colored, soft-friable, very weak, heavilt-completely weathered.

31.10 m

SCHIST
Greenish-greenish light grey, brittle-little hard to medium hard in some parts, weak-very weak, medium-heavily weathered, lower levels completely weathered.

35.30 m

GPRAHITE SCHIST
Dark grey-black, soft-friable, very weak, heavily-completely weathered.

END OF BORING : 36,00 m.

Not : Kuyuya 36,00 m inklinometre borusu indirilip, enjeksiyonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked
İSİM Name	Talip ERBAY Jeoloji Mühendisi	
İMZA Sign		

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SONDAJ LOGU / BORING LOG

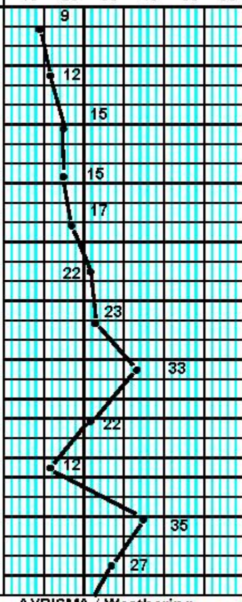
SONDAJ / Borehole No : **İBH72-9i**
SAYFA / Page No : **1/4**

PROJE ADI / Project Name	: İNEGÖL-BOZÜYÜK YOLU	DELİK ÇAPI / Hole Diameter	:
SONDAJ YERİ / Boring Location	: Heyelan / Landslide	YERALTI SUYU / Groundwater	: 11.00 m
KİLOMETRE / Chainage	: 72+119, 118,92 m sol / left	MUH.BOR.DER. / Casing Depth	: 6.00 m HW, 30.00 m NW
SONDAJ DER. / Boring Depth	: 30,00 m	BAŞ.BİT.TAR. / Start Finish Date	: 03.12.2006-07.12.2006
SONDAJ KOTU / Elevation	: 545,97 m	KOORDİNAT / Coordinate (E-W) Y	: 475 403,16
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Foremost B-53 / Rotary	KOORDİNAT / Coordinate (N-S) X	: 4 423 362,45

STANDART PENETRASYON DENEYİ / Standart Penetration Test

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Sample Type	MANEVRA BOYU/Run	DARBE SAYISI Numb. of Blows 0 - 15 cm	15-30 cm	30-45 cm	N
0	SPT-1	0.00 - 0.45	5	4	5	9
	SPT-2	0.50 - 0.95	4	5	7	12
1	SPT-3	1.00 - 1.45	5	7	8	15
	SPT-4	1.50 - 1.95	7	7	8	15
2	SPT-5	2.00 - 2.45	5	7	10	17
	SPT-6	2.50 - 2.95	6	10	12	22
3	SPT-7	3.00 - 3.45	7	10	13	23
	SPT-8	3.50 - 3.95	10	15	18	33
4	SPT-9	4.00 - 4.45	9	12	10	22
	SPT-10	4.50 - 4.95	5	5	7	12
5	SPT-11	5.00 - 5.45	9	15	20	35
6	SPT-12	5.50 - 5.95	8	13	14	27

GRAFİK



JEOTEKNİK TANIMLAMA / Geotechnical Description

Brown-yellowish light brown-yellow colored, medium dense-dense, gravelly, silty **SAND** / sandy **SILT** / silty, gravelly **SAND.** Moist fine-coarse grained, brittle-hard; 30-40% low plasticity, fine material; 10-20% fine-medium grained, angular, quartzite-schist originated gravel.

Gravel ratio increases (25-35%) towards lower levels (after 5.00 meters)

PROFİL / Profile | DAYANIMLILIK/Strength | AYRIŞMA / Weathering | KIRIK / Fracture (30cm) | KAROT%(TCR)/T.CoreR. | RQD % | LUGEON

DAYANIMLILIK / Strength			AYRIŞMA / Weathering		
I	DAYANIMLI	Strong	I	TAZE	Fresh
II	ORTA DAYANIMLI	M.Strong	II	AZ AYRIŞMIŞ	Slightly W.
III	ORTA ZAYIF	M.Weak	III	ORTA D. AYR.	Mod. Weath.
IV	ZAYIF	Weak	IV	ÇOK AYR.	Slightly W.
V	ÇOK ZAYIF	V.Weak	V	TÜMÜYLE A.	Comp.Weat.

İNCE DANELİ / Fine Grained			İRİ DANELİ/Coarse Grained		
N : 0-2	ÇOK YUMUŞAK	V.Soft	N : 0-4	ÇOK GEVŞEK	V.Loose
N : 3-4	YUMUŞAK	Soft	N : 5-10	GEVŞEK	Loose
N : 5-8	ORTA KATI	M.Stiff	N : 11-30	ORTA SIKI	M.Dense
N : 9-15	KATI	Stiff	N : 31-50	SIKI	Dense
N : 16-30	ÇOK KATI	V.Stiff	N : >50	ÇOK SIKI	V.Dense
N : >30	SERT	Hard			

KAYA KALİTESİ TANIMI - RQD			KIRIKLAR - 30 cm / Fractures		
% 0-25	ÇOK ZAYIF	V.Poor	1	SEYREK	Wide (W)
% 25-50	ZAYIF	Poor	1-2	ORTA	Moderate (M)
% 50-75	ORTA	Fair	2-10	SIK	Close (Cl)
% 75-90	İYİ	Good	10-20	ÇOK SIKI	Intense (I)
% 90-100	ÇOK İYİ	Excellent	>20	PARÇALI	Crushed (Cr)

ORANLAR - Proportions					
% 5	PEK AZ	Slightly	% 5	PEK AZ	Slightly
% 5-15	AZ	Little	% 5-20	AZ	Little
% 15-35	ÇOK	Very	% 20-50	ÇOK	Very
% 35	VE	And			

SPT	Standart Penetrasyon Testi / Standart Penetration Test	K	Karot Numunesi / Core Sample
D	Orselenmiş Numune / Disturbed sample	P	Pressiyometre Deneyi / Pressuremeter Test
UD	Örselenmemiş Numune / Undisturbed Sample	k	Permeabilite Deneyi / Permeability Test

	LOGU YAPAN / Logged By	KONTROL / Checked
İSİM / Name	Talip ERBAY Jeoloji Mühendisi	
İMZA / Sign		

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SONDAJ LOGU / BORING LOG

SONDAJ / Borehole No: **İBH72-9i**
SAYFA / Page No: **2/4**

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	0 - 15 cm	15-30 cm	30-45 cm	N
6	SPT-13	6.00 - 6.45	10	10	14	**24**
	SPT-14	6.50 - 6.95	8	12	17	**29**
7	SPT-15	7.00 - 7.45	8	9	11	**20**
	SPT-16	7.50 - 7.95	9	11	11	**22**
8	SPT-17	8.00 - 8.45	7	7	11	**18**
	SPT-18	8.50 - 8.95	11	13	19	**32**
9	SPT-19	9.00 - 9.45	6	8	19	**27**
	SPT-20	9.50 - 9.95	6	10	13	**23**
10	SPT-21	10.00 - 10.45	10	21	35	**56**
	SPT-22	10.50 - 10.95	18	21	17	**38**
11	SPT-23	11.00 - 11.45	18	26	27	**53**
	SPT-24	11.50 - 11.95	28	32	22	**54**
12	SPT-25	12.00 - 12.45	13	12	14	**26**
	SPT-26	12.50 - 12.95	7	11	14	**25**
13	SPT-27	13.00 - 13.45	12	14	14	**28**
	SPT-28	13.50 - 13.95	10	9	19	**28**
14	SPT-29	14.00 - 14.45	24	28	21	**49**
	SPT-30	14.50 - 14.95	9	17	18	**35**
15	SPT-31	15.00 - 15.45	8	15	17	**32**
16	SPT-32	15.50 - 15.95	7	12	17	**29**

STANDART PENETRASYON DENEYİ / Standart Penetration Test — DARBE SAYISI / Numb. of Blows — GRAFİK / Graph (10 20 30 40 50 60)

JEOTEKNİK TANIMLAMA / Geotechnical Description

Brown-yellowish light brown-yellow colored, medium dense-dense, gravelly, silty **SAND** / sandy **SILT** / silty, gravelly **SAND.** Moist fine-coarse grained, brittle-hard; 30-40% low plasticity, fine material; 10-20% fine-medium grained, angular, quartzite-schist originated gravel.

Gravel ratio increases (25-35%) towards lower levels (after 5.00 meters)

—— 10.00 m ——

Brown, hard, siltyi gravelly **SAND** / sandy **GRAVEL**. Moist, fine-coarse grained, brittle-hard, angular-quartzite-schist originated gravel; 10-20% fine material.

Uppoer levels dominated with sandy silt.
(Talus / Landslide material)

16.00 m

PROFİL / Profile | DAYANIMLILIK/Strength | AYRIŞMA / Weathering | KIRIK / Fracture (30cm) | KAROT%(TCR)/T.CoreR. | RQD % | LUGEON

LOGU YAPAN / Logged By	KONTROL / Checked
İSİM / Name: Talip ERBAY, Jeoloji Mühendisi	
İMZA / Sign:	

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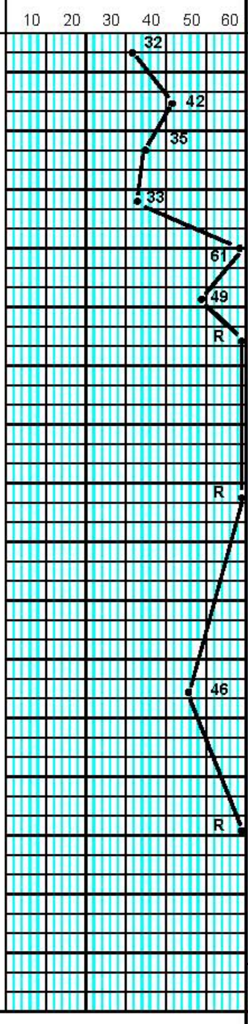
SONDAJ LOGU / BORING LOG

SONDAJ Borehole No :	İBH72-9i
SAYFA Page No :	3/4

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	0 - 15 cm	15-30 cm	30-45 cm	N	JEOTEKNİK TANIMLAMA Geotechnical Description	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
16	SPT-33	16.00 – 16.45	12	15	17	**32**	**GRAPHITE SCHIST** Dark grey-black, soft-friable, weak-very weak, heavily-completely weathered. Discontinuities cannot be observed due to weathering.	V	V				
	SPT-34	16.50 – 16.95	11	16	26	**42**							
17	SPT-35	17.00 – 17.45	9	15	20	**35**							
	SPT-36	17.50 – 17.95	12	15	18	**33**							
18	SPT-37	18.00 – 18.45	11	30	31	**61**							
	SPT-38	18.50 – 18.95	13	18	31	**49**							
19	SPT-39	19.00 – 19.28	20	50/13	-	**R**							
	K-1	19.50 – 20.00						IV-V	IV-V	Cr	38	0	
20	K-2	20.00 – 20.50									24	0	
	SPT-40	20.50 – 20.93	26	49	50/13	**R**							
21	K-3	20.93 – 22.00									21	0	
22	K-4	22.00 – 22.50									0	0	
	SPT-41	22.50 – 22.95	22	21	25	**46**							
23	K-5	22.95 – 23.50									42	0	
	K-6	23.50 – 24.00									24	0	
24	SPT-42	24.00 – 24.29	25	50/14	-	**R**							
	K-7	24.29 – 25.00									0	0	
25	K-8	25.00 – 25.50					25.50 m				40	0	
26	K-9	25.50 – 25.90					(Definiition on page 4/4)				75	25	

STANDART PENETRASYON DENEYİ / Standart Penetration Test — GRAFİK / Graph



LOGU YAPAN Logged By	KONTROL Checked
İSİM Name: Talip ERBAY, Jeoloji Mühendisi	
İMZA Sign	

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SONDAJ LOGU / BORING LOG

SONDAJ Borehole No : **İBH72-9i**

SAYFA Page No : **4/4**

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test — DARBE SAYISI Numb. of Blows: 0 - 15 cm	15-30 cm	30-45 cm	N	GRAFİK Graph (10 20 30 40 50 60)	JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
26	K-10	26.00						**GRAPHITE SCHIST** Dark grey-black, soft-friable, little hard, very weak, heavily-completely weathered, dense quartzite veins, piecewise.		IV V	IV V	Cr	17	0	
27	SPT-43	26.90 / 27.00	50/10	-	-	R	R								
	K-11												41	21	
28	K-12	27.80											53	21	
29	K-13	28.50											36	0	
	K-14	29.30								III IV	III IV		80	56	
30		30.00						30.00 m							
31								**END OF BORING : 30,00 m.**							
32															
33															
34															
35															
36															

Not : Kuyuya 29,50 m inklinometre borusu indirilip, enjeksiyonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked
İSİM Name	Talip ERBAY Jeoloji Mühendisi	
İMZA Sign		

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SONDAJ LOGU / BORING LOG

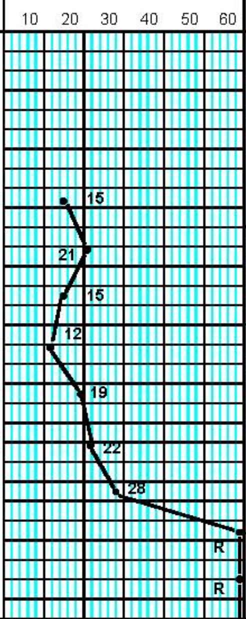
SONDAJ Borehole	No :	İBH72-10i
SAYFA Page	No :	1/3

PROJE ADI / Project Name	: İNEGÖL-BOZÜYÜK YOLU	DELİK ÇAPI / Hole Diameter	:
SONDAJ YERİ / Boring Location	: Heyelan / Landslide	YERALTI SUYU / Groundwater	: 8.90 m
KİLOMETRE / Chainage	: 72+119, 171,58 m sol / left	MUH.BOR.DER. / Casing Depth	: 12.30 m HW, 21.00 m NW
SONDAJ DER. / Boring Depth	: 21,13 m	BAŞ.BİT.TAR. / Start Finish Date	: 04.12.2006-07.12.2006
SONDAJ KOTU / Elevation	: 553,53 m	KOORDİNAT / Coordinate (E-W) Y	: 475 441,25
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Mobile Drill B-53 / Rotary	KOORDİNAT / Coordinate (N-S) X	: 4 423 398,81

STANDART PENETRASYON DENEYİ / Standart Penetration Test

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Sample Type	MANEVRA BOYU/Run	DARBE SAYISI Numb. of Blows 0-15 cm	15-30 cm	30-45 cm	N	JEOTEKNİK TANIMLAMA Geotechnical Description	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
0–2.00							Brown, medium dense, clayey, silty **SAND.** Moist, fine-coarse grained, brittle-little hard,angular, schist-quartzite originated ; 5-10% brittle-little hard gravelly, 30-40% fine material.						
	SPT-1	1.50–1.95	5	7	8	15							
2.00 m	SPT-2	2.00–2.45	9	10	11	21	Brown, very dense, gravelly, sandy, clayey **SILT**. Moist, low-medium plasticity; 5-10% brittle-hard gravelly, 20-30% fine coarse sandy.						
	SPT-3	2.50–2.95	7	7	8	15							
3.00 m	SPT-4	3.00–3.45	3	5	7	12	Greenish grey-brown-green, medium dense, clayey, siltyi gravelly **SAND** / sandy **GRAVEL.** Moist, fine-coarse grained, brittle-little hard, 20-30% fine-coarse grained, brittle-little hard,angular, schist quartzite originated gravel; 10-20% fine material.						
	SPT-5	3.50–3.95	7	8	11	19							
	SPT-6	4.00–4.45	5	9	13	22							
	SPT-7	4.50–4.95	8	13	15	28							
5.15 m	SPT-8	5.00–5.34	11	40	50/4	R	**SCHIST** Green-greenish grey, soft-friable, very weak, completely weathered.	V	V	Cr			
	SPT-9	5.50–5.61	50/11	-	-	R							

GRAFİK / Graph



DAYANIMLILIK / Strength			AYRIŞMA / Weathering			İNCE DANELİ / Fine Grained			İRİ DANELİ/Coarse Grained		
I	DAYANIMLI	Strong	I	TAZE	Fresh	N : 0-2	ÇOK YUMUŞAK	V.Soft	N : 0-4	ÇOK GEVŞEK	V.Loose
II	ORTA DAYANIMLI	M.Strong	II	AZ AYRIŞMIŞ	Slightly W.	N : 3-4	YUMUŞAK	Soft	N : 5-10	GEVŞEK	Loose
III	ORTA ZAYIF	M.Weak	III	ORTA D. AYR.	Mod. Weath.	N : 5-8	ORTA KATI	M.Stiff	N : 11-30	ORTA SIKI	M.Dense
IV	ZAYIF	Weak	IV	ÇOK AYR.	Slightly W.	N : 9-15	KATI	Stiff	N : 31-50	SIKI	Dense
V	ÇOK ZAYIF	V.Weak	V	TÜMÜYLE A.	Comp.Weat.	N : 16-30	ÇOK KATI	V.Stiff	N : >50	ÇOK SIKI	V.Dense
						N : >30	SERT	Hard			

KAYA KALİTESİ TANIMI - RQD			KIRIKLAR - 30 cm / Fractures			ORANLAR - Proportions					
% 0-25	ÇOK ZAYIF	V.Poor	1	SEYREK	Wide (W)	% 5	PEK AZ	Slightly	% 5	PEK AZ	Slightly
% 25-50	ZAYIF	Poor	1-2	ORTA	Moderate (M)	% 5-15	AZ	Little	% 5-20	AZ	Little
% 50-75	ORTA	Fair	2-10	SIK	Close (Cl)	% 15-35	ÇOK	Very	% 20-50	ÇOK	Very
% 75-90	İYİ	Good	10-20	ÇOK SIKI	Intense (I)	% 35	VE	And			
% 90-100	ÇOK İYİ	Excellent	>20	PARÇALI	Crushed (Cr)						

				LOGU YAPAN Logged By	KONTROL Checked
SPT	Standart Penetrasyon Testi / Standart Penetration Test	K	Karot Numunesi / Core Sample		
D	Örselenmiş Numune / Disturbed sample	P	Pressiyometre Deneyi / Pressuremeter Test	İSİM Name: Talip ERBAY, Jeoloji Mühendisi	
UD	Örselenmemiş Numune / Undisturbed Sample	k	Permeabilite Deneyi / Permeability Test	İMZA Sign	

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SONDAJ LOGU / BORING LOG

SONDAJ Borehole	No :	İBH72-10i
SAYFA Page	No :	2/3

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test – DARBE SAYISI 0 - 15 cm	15-30 cm	30-45 cm	N	GRAFİK Graph (10 20 30 40 50 60)	JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
6	SPT-10	6.00 6.25	45	50/10	-	R	R	(Definition on page 1/3) 6.25 m		V	V	Cr			
7	K-1	7.50						**CHLORITE SCHIST** Green, brittle-little hard, weak-very weak, medium-heavily weathered, Discontinuities; 45°-70°-90°, open, irregular, slippery, clay. 45°,90° closed, calcite filling (1.00-5.00 mm thickness). 7.50 m			III IV		100	19	
8	K-2	8.20						**SCHIST** Grey-greenish grey- brownish light grey, brittle-little hard, weak-very weak, heavily-completely weathered. Upper levels (7.50-8.20 m), soft, very weak, kompletely weathered, clayey. Dense quartzide veins (10.00-12.40m)		IV V	IV V	Cr	57	0	
	K-3												51	0	
9	SPT-11	9.00 9.07	50/7	-	-	R	R								
	K-4	10.00											60	0	
10	K-5												30	0	
11	SPT-12	11.00 11.21	47	50/6	-	R	R								
	K-6	12.00						12.40 m					18	0	
12 13	K-7	13.50						**LIMESTONE** Light grey colored, hard, strong, slightly weathered. Discontinuities; 30°,70°,90°, open, mattei ondulating, rough, calcite filling. Closed fractures (1.00-2.00 mm thick) filled with calcite. Schist bands in some parts.		I	II	W	75	57	
14	K-8	15.00						14.85 m					92	83	
15 16	K-9							**GRAPHITE SCHIST** Dark grey-black, little-medium hard, medium weak, mediumweathered, dense limestone and quartzie veins.		III	III	M	69	49	

	LOGU YAPAN Logged By	KONTROL Checked
ISIM Name	Talip ERBAY Jeoloji Mühendisi	
IMZA Sign		

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SONDAJ LOGU / BORING LOG

SONDAJ Borehole	No :	İBH72-10i
SAYFA Page	No :	3/3

STANDART PENETRASYON DENEYİ / Standart Penetration Test

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	DARBE SAYISI Numb. of Blows 0-15 cm	15-30 cm	30-45 cm	N	GRAFİK Graph (10 20 30 40 50 60)	JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA/Weathering	KIRIK/Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
16		16.10						(Definition on page 2/3) 16.10 m							
		16.50													
17	K-10												22	0	
		17.40													
	SPT-13		12	19	35	54	54								
		17.85													
18	K-11							**GRAPHITE SCHIST** Dark-grey-black colored, soft-friable, hard in some parts, weak-very weak, heavily-completely weathered, clayey, very dense quartzite veins.		IV V	IV V	CI	55	0	
		18.70													
19	K-12												38	0	
		19.50													
20	K-13												22	0	
21	SPT-14	21.00	50/13	-	-	R	R								
								END OF BORING: 21.13 m.							
22															
23															
24															
25															
26															

Not : Kuyuya 21,00 m inklinometre borusu indirilip, enjeksiyonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked
İSİM Name	Talip ERBAY Jeoloji Mühendisi	
İMZA Sign		

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SONDAJ LOGU / BORING LOG

SONDAJ Borehole	No :	İBH72-11
SAYFA Page	No :	1/2

PROJE ADI / Project Name	: İNEGÖL-BOZÜYÜK YOLU	DELİK ÇAPI / Hole Diameter	:
SONDAJ YERİ / Boring Location	: Heyelan / Landslide	YERALTI SUYU / Groundwater	: 13,90 m
KİLOMETRE / Chainage	: 72+119, 211,63 m sol / left	MUH.BOR.DER. / Casing Depth	: 12,50 m NW
SONDAJ DER. / Boring Depth	: 15,25 m	BAŞ.BİT.TAR. / Start Finish Date	: 08.12.2006-09.12.2006
SONDAJ KOTU / Elevation	: 566,04 m	KOORDİNAT / Coordinate (E-W) Y	: 475 470,53
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Craelius D-750 / Rotary	KOORDİNAT / Coordinate (N-S) X	: 4 423 426,14

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Sample Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test — DARBE SAYISI Numb. of Blows: 0 - 15 cm	15-30 cm	30-45 cm	N	GRAFİK Graph (10 20 30 40 50 60)	JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
0 – 1.50		1.50						Brown-yellowish brown, very hard, gravelly, clayey, silty **SAND**. Moist, fine-coarse grained; 30-40% fine material, 5-10% fine-medium grained, brittle-hard, angular schist-qartzite originated gravel.							
1.50 – 1.95	SPT-1	1.95	10	13	13	**26**	26								
1.95 – 2.25		2.25													
2.25 – 2.70	SPT-2	2.70	10	11	14	**25**	25								
2.70 – 3.00		3.00													
3.00 – 3.45	SPT-3	3.45	8	9	15	**24**	24								
3.45 – 3.70		3.70													
3.70 – 4.15	SPT-4	4.15	14	15	24	**39**	39	4.30 m							
4.15 – 4.50		4.50													
4.50 – 4.95	SPT-5	4.95	19	33	30	**63**	63	Greenish grey- brownish grey, hard, gravelly, silty **SAND.** Moist, fine-coarse grained, brittle, 20-30% fine-coarse grained, brittle -hard, schist originated gravel; 15-25% fine							
4.95 – 5.25		5.25													
5.25 – 5.70 (5.40)	SPT-6	5.70	11	17	25	**42**	42								
6															

DAYANIMLILIK / Strength			AYRIŞMA / Weathering			İNCE DANELİ / Fine Grained			İRİ DANELİ/Coarse Grained		
I	DAYANIMLI	Strong	I	TAZE	Fresh	N : 0-2	ÇOK YUMUŞAK	V.Soft	N : 0-4	ÇOK GEVŞEK	V.Loose
II	ORTA DAYANIMLI	M.Strong	II	AZ AYRIŞMIŞ	Slightly W.	N : 3-4	YUMUŞAK	Soft	N : 5-10	GEVŞEK	Loose
III	ORTA ZAYIF	M.Weak	III	ORTA D. AYR.	Mod. Weath.	N : 5-8	ORTA KATI	M.Stiff	N : 11-30	ORTA SIKI	M.Dense
IV	ZAYIF	Weak	IV	ÇOK AYR.	Slightly W.	N : 9-15	KATI	Stiff	N : 31-50	SIKI	Dense
V	ÇOK ZAYIF	V.Weak	V	TÜMÜYLE A.	Comp.Weat.	N : 16-30	ÇOK KATI	V.Stiff	N : >50	ÇOK SIKI	V.Dense
						N : >30	SERT	Hard			

KAYA KALİTESİ TANIMI - RQD			KIRIKLAR - 30 cm / Fractures			ORANLAR - Proportions					
% 0-25	ÇOK ZAYIF	V.Poor	1	SEYREK	Wide (W)	% 5	PEK AZ	Slightly	% 5	PEK AZ	Slightly
% 25-50	ZAYIF	Poor	1-2	ORTA	Moderate (M)	% 5-15	AZ	Little	% 5-20	AZ	Little
% 50-75	ORTA	Fair	2-10	SIK	Close (Cl)	% 15-35	ÇOK	Very	% 20-50	ÇOK	Very
% 75-90	İYİ	Good	10-20	ÇOK SIKI	Intense (I)	% 35	VE	And			
% 90-100	ÇOK İYİ	Excellent	>20	PARÇALI	Crushed (Cr)						

SPT	Standart Penetrasyon Testi / Standart Penetration Test	K	Karot Numunesi / Core Sample	LOGU YAPAN / Logged By	KONTROL / Checked
D	Orselenmiş Numune / Disturbed sample	P	Pressiyometre Deneyi / Pressuremeter Test	İSİM / Name: Talip ERBAY, Jeoloji Mühendisi	
UD	Örselenmemiş Numune / Undisturbed Sample	k	Permeabilite Deneyi / Permeability Test	İMZA / Sign	

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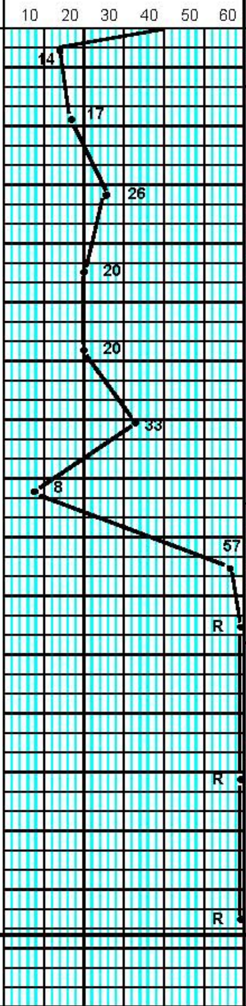
SONDAJ LOGU / BORING LOG

SONDAJ / Borehole No : İBH72-11
SAYFA / Page No : 2/2

STANDART PENETRASYON DENEYİ / Standart Penetration Test

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	DARBE SAYISI Numb. of Blows 0 - 15 cm	15-30 cm	30-45 cm	N	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
6	SPT-7	6.00 – 6.45	11	8	6	14						
7	SPT-8	6.70 – 7.15	11	8	9	17						
8	SPT-9	7.50 – 7.95	9	10	16	26						
	SPT-10	8.25 – 8.70	11	9	11	20						
9	SPT-11	9.00 – 9.45	7	9	11	20						
10	SPT-12	9.70 – 10.15	12	15	18	33						
	SPT-13	10.50 – 10.95	4	4	4	8						
11	SPT-14	11.25 – 11.70	17	28	29	57						
12	SPT-15	12.00 – 12.27	28	50/12	-	R						
13	K-1	12.60 – 13.50					V	IV-V	Cr	61	0	
	SPT-16	13.50 – 13.90	20	32	50/10	R						
14	K-2	13.90 – 15.00								23	0	
15	SPT-17	15.00	44	50/10	-	R						
16												

GRAFİK / Graph



Depth	JEOTEKNİK TANIMLAMA / Geotechnical Description
6.00 – 6.60 m	Gravellyi silty **SAND** (Secription on page 1/2)
6.60 – 10.85 m	Brown-yellowish brown, towards lower leves, brownish grey-greenish grey colored, very hard, gravelly, silty, **SAND** / sandy **SILT.** Moist, fine-coarse grained, brittle; 5-15% fine-medium grained, brittle, schist originated gravel; %35-45 low-medium plasticity, fine material.
10.85 – 12.27 m	Brown-greyish brown-dark grey colored, vert stiff, siltyi gravelly **SAND** / sadny **GRAVEL.** Moist, fine-coarse grained, brittle-little hard; 35-45%, brittle-little hard, angular, schist originated gravel; 5-15% fine material.
12.27 m –	**GRAPHITE SCHIST** Dark grey-grey-black colored, soft-friable, very weak, heavily-completely weathered.

END OF BORING: 15,25 m.

Not : Kuyuya yeraltısuyu gözlemleri için 15,00 m, Ø50 mm. perfore PVC boru indirilip, 40x40x15 cm. kuyu ağzı betonu yapılmıştır.

	LOGU YAPAN / Logged By	KONTROL / Checked
İSİM / Name	Talip ERBAY Jeoloji Mühendisi	
İMZA / Sign		

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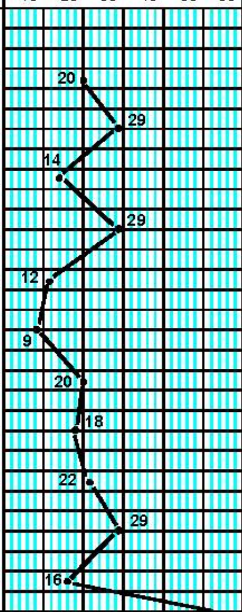
SONDAJ LOGU / BORING LOG

SONDAJ Borehole	No :	İBH72-12
SAYFA Page	No :	1/2

PROJE ADI / Project Name	: İNEGÖL-BOZÜYÜK YOLU	DELİK ÇAPI / Hole Diameter	:
SONDAJ YERİ / Boring Location	: Heyelan / Landslide	YERALTI SUYU / Groundwater	: 8.75 m
KİLOMETRE / Chainage	: 72+159, 46,59 m sol / left	MUH.BOR.DER. / Casing Depth	: 4,50 m HW, 15,00 m NW
SONDAJ DER. / Boring Depth	: 15,00 m	BAŞ.BİT.TAR. / Start Finish Date	: 10.12.2006 - 12.12.2006
SONDAJ KOTU / Elevation	: 525,90 m	KOORDİNAT / Coordinate (E-W) Y	: 475 377,29
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Mobile Drill B-53 / Rotary	KOORDİNAT / Coordinate (N-S) X	: 4 423 285,90

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Sample Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test – DARBE SAYISI Numb. of Blows 0-15 cm	15-30 cm	30-45 cm	N	GRAFİK Graph (10 20 30 40 50 60)	JEOTEKNİK TANIMLAMA Geotechnical Description	PROFIL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
0															
	SPT-1	0.50 – 0.95	9	10	10	20									
1	SPT-2	1.00 – 1.45	6	13	16	29									
	SPT-3	1.50 – 1.95	11	6	8	14									
2	SPT-4	2.00 – 2.45	9	13	16	29									
	SPT-5	2.50 – 2.95	10	7	5	12		**SCHIST** Brown-yellowish light brown, brittle-friable, little hard-hard, very weak to weak in some parts, completely weathered.							
3	SPT-6	3.00 – 3.45	3	3	6	9				V	V				
	SPT-7	3.50 – 3.95	9	9	11	20									
4	SPT-8	4.00 – 4.45	8	9	9	18									
	SPT-9	4.50 – 4.95	6	9	13	22									
5	SPT-10	5.00 – 5.45	10	11	18	29									
6	SPT-11	5.50 – 5.95	4	5	11	16									



DAYANIMLILIK / Strength			AYRIŞMA / Weathering			INCE DANELİ / Fine Grained			IRI DANELİ/Coarse Grained		
I	DAYANIMLI	Strong	I	TAZE	Fresh	N : 0-2	ÇOK YUMUŞAK	V.Soft	N : 0-4	ÇOK GEVŞEK	V.Loose
II	ORTA DAYANIMLI	M.Strong	II	AZ AYRIŞMIŞ	Slightly W.	N : 3-4	YUMUŞAK	Soft	N : 5-10	GEVŞEK	Loose
III	ORTA ZAYIF	M.Weak	III	ORTA D. AYR.	Mod. Weath.	N : 5-8	ORTA KATI	M.Stiff	N : 11-30	ORTA SIKI	M.Dense
IV	ZAYIF	Weak	IV	ÇOK AYR.	Slightly W.	N : 9-15	KATI	Stiff	N : 31-50	SIKI	Dense
V	ÇOK ZAYIF	V.Weak	V	TÜMÜYLE A.	Comp.Weat.	N : 16-30	ÇOK KATI	V.Stiff	N : >50	ÇOK SIKI	V.Dense
						N : >30	SERT	Hard			

KAYA KALİTESİ TANIMI - RQD			KIRIKLAR - 30 cm / Fractures			ORANLAR - Proportions					
% 0-25	ÇOK ZAYIF	V.Poor	1	SEYREK	Wide (W)	% 5	PEK AZ	Slightly	% 5	PEK AZ	Slightly
% 25-50	ZAYIF	Poor	1-2	ORTA	Moderate (M)	% 5-15	AZ	Little	% 5-20	AZ	Little
% 50-75	ORTA	Fair	2-10	SIK	Close (Cl)	% 15-35	ÇOK	Very	% 20-50	ÇOK	Very
% 75-90	İYİ	Good	10-20	ÇOK SIKI	Intense (I)	% 35	VE	And			
% 90-100	ÇOK İYİ	Excellent	>20	PARÇALI	Crushed (Cr)						

					LOGU YAPAN Logged By	KONTROL Checked
SPT	Standart Penetrasyon Testi Standart Penetration Test	K	Karot Numunesi Core Sample			
D	Örselenmiş Numune Disturbed sample	P	Pressiyometre Deneyi Pressuremeter Test	İSİM Name	Talip ERBAY Jeoloji Mühendisi	
UD	Örselenmemiş Numune Undisturbed Sample	k	Permeabilite Deneyi Permeability Test	İMZA Sign		

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SONDAJ LOGU / BORING LOG

SONDAJ / Borehole No : IBH72-12
SAYFA / Page No : 2/2

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	0 - 15 cm	15-30 cm	30-45 cm	N	GRAFİK Graph	JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
6	SPT-12	6.00 6.10 6.20	50/10	-	-	R	R	Tanımı sayfa 1/2'dedir. 6.10 m							
7	K-1							**SCHIST** Brown-yellowish brown, brittle-little hard, weak-very weak, moderately weak in some parts, heavily weathered, completeley weatehred in some parts, piecewise in general. Discontinuities; 10°, 70°, 90°, open, matte, rough, ondulating, dense clay filling, FeO covered, quartz veins in some parts. Closed fractures; 10^0, 70^0, 90^0, calcite-silisium filled.		IV V	IV V	Cr	100	9	
	P1	7.40 7.50													
8	K-2	9.00											91	30	
9	K-3	10.20										Cl	89	43	
10	P2	10.40													
11	K-4	11.30						11.50 m				I	84	28	
	K-5	12.00						**GRAPHITE SCHIST** Dark grey-black, soft-brittle, weak-very weak, heavily-completely weathered.				Cr	8	0	
12	SPT-13	12.45	24	18	17	35	35								
13	K-6	13.50						13.60 m					9	0	
	SPT-14	13.61	50/11	-	-	R	R								
14	K-7							**SCHIST** Purple, brittle-hard, weak-moderately weak, very weak in some parts, moderately-highly weathered, dense quartz veins.		III IV	III IV		34	14	
15								**END OF BORING: 15,00 m.**							
16															

Not : Kuyuya yeraltısuyu ölçümleri için 15,00 m Ø50 mm'lik perfore PVC boru indirilip, kuyubaşı betonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked
İSİM Name	Talip ERBAY Jeoloji Mühendisi	
İMZA Sign		

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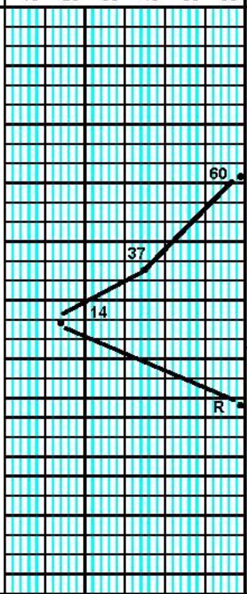
SONDAJ LOGU / BORING LOG

SONDAJ Borehole No: **İBH72-13**
SAYFA Page No: **1/3**

PROJE ADI / Project Name	: İNEGÖL-BOZÜYÜK YOLU	DELİK ÇAPI / Hole Diameter	:
SONDAJ YERİ / Boring Location	: Heyelan / Landslide	YERALTI SUYU / Groundwater	: 16.00 m
KİLOMETRE / Chainage	: 72+158, 79,74 m sol / left	MUH.BOR.DER. / Casing Depth	: 24.00 m HW, 4.50 m NW
SONDAJ DER. / Boring Depth	: 25,00 m	BAŞ.BİT.TAR. / Start Finish Date	: 07.12.2006-11.12.2006
SONDAJ KOTU / Elevation	: 537,45 m	KOORDİNAT / Coordinate (E-W) Y	: 475 399,30
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Craelius D 500 / Rotary	KOORDİNAT / Coordinate (N-S) X	: 4 423 310,72

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Sample Type	MANEVRA BOYU/Run	0-15 cm	15-30 cm	30-45 cm	N	JEOTEKNİK TANIMLAMA Geotechnical Description	DAYANIMLILIK/Strength	AYRIŞMA/Weathering	KIRIK/Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
0–1.50							Brown-green-greenish grey colored, dense-very dense, silty, sandy **GRAVEL.** Fine-coarse grained, brittle-hard, angular.						
1.50–1.95	SPT-1	1.50 / 1.95	12	21	39	**60**							
2.00–2.50	K-1	2.00									36	0	
2.50–2.95	SPT-2	2.50 / 2.95	6	12	25	**37**							
3.00–3.45	SPT-3	3.00 / 3.45	4	3	11	**14**	3.50 m						
3.50–4.00	K-2	3.50					**SCHIST** Green, brittle-little hard, medium hard in some parts, weak-very weak, medium weak in some parts, moderately-highly weathered, completely weathered in some parts, piecewise. Fracture; 0°,90° open, rough, clay filling.				20	0	
4.00–4.10	SPT-4	4.00 / 4.10	50/10	-	-	**R**							
4.10–5.20	K-3							III IV	III IV		52	9	
5.20–6.00	K-4	5.20									28	0	

STANDART PENETRASYON DENEYİ / Standart Penetration Test — DARBE SAYISI / Numb. of Blows — GRAFİK (10 20 30 40 50 60)



PROFİL / Profile

DAYANIMLILIK / Strength			AYRIŞMA / Weathering			İNCE DANELİ / Fine Grained				İRİ DANELİ/Coarse Grained			
I	DAYANIMLI	Strong	I	TAZE	Fresh	N : 0-2	ÇOK YUMUŞAK	V.Soft		N : 0-4	ÇOK GEVŞEK	V.Loose	
II	ORTA DAYANIMLI	M.Strong	II	AZ AYRIŞMIŞ	Slightly W.	N : 3-4	YUMUŞAK	Soft		N : 5-10	GEVŞEK	Loose	
III	ORTA ZAYIF	M.Weak	III	ORTA D. AYR.	Mod. Weath.	N : 5-8	ORTA KATI	M.Stiff		N : 11-30	ORTA SIKI	M.Dense	
IV	ZAYIF	Weak	IV	ÇOK AYR.	Slightly W.	N : 9-15	KATI	Stiff		N : 31-50	SIKI	Dense	
V	ÇOK ZAYIF	V.Weak	V	TÜMÜYLE A.	Comp.Weat.	N : 16-30	ÇOK KATI	V.Stiff		N : >50	ÇOK SIKI	V.Dense	
						N : >30	SERT	Hard					

KAYA KALİTESİ TANIMI - RQD			KIRIKLAR - 30 cm / Fractures			ORANLAR - Proportions					
% 0-25	ÇOK ZAYIF	V.Poor	1	SEYREK	Wide (W)	% 5	PEK AZ	Slightly	% 5	PEK AZ	Slightly
% 25-50	ZAYIF	Poor	1-2	ORTA	Moderate (M)	% 5-15	AZ	Little	% 5-20	AZ	Little
% 50-75	ORTA	Fair	2-10	SIK	Close (Cl)	% 15-35	ÇOK	Very	% 20-50	ÇOK	Very
% 75-90	İYİ	Good	10-20	ÇOK SIKI	Intense (I)	% 35	VE	And			
% 90-100	ÇOK İYİ	Excellent	>20	PARÇALI	Crushed (Cr)						

SPT	Standart Penetrasyon Testi / Standart Penetration Test	K	Karot Numunesi / Core Sample	LOGU YAPAN / Logged By	KONTROL / Checked
D	Örselenmiş Numune / Disturbed sample	P	Pressiyometre Deneyi / Pressuremeter Test	İSİM / Name: Talip ERBAY, Jeoloji Mühendisi	
UD	Örselenmemiş Numune / Undisturbed Sample	k	Permeabilite Deneyi / Permeability Test	İMZA / Sign	

YÜKSEL PROJE

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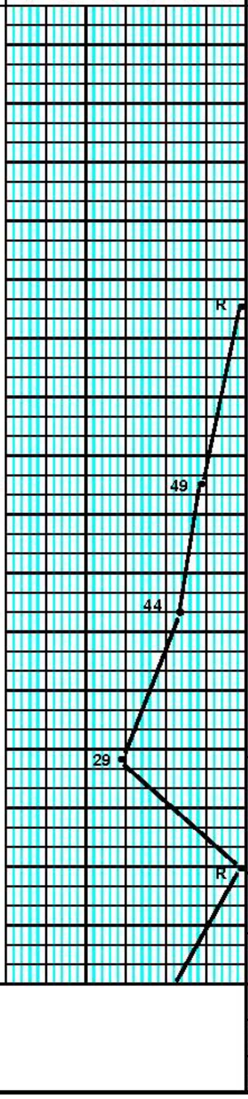
SONDAJ LOGU / BORING LOG

SONDAJ / Borehole No: **İBH72-13**

SAYFA / Page No: **2/3**

SONDAJ DERİNLİĞİ / Boring Depth (m)	NUMUNE CİNSİ / Samp. Type	MANEVRA BOYU/Run	0-15 cm	15-30 cm	30-45 cm	N	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
6	K-5	6.00 – 6.50					IV-V	IV-V		60	0	
7	K-6	6.50 – 7.20								89	14	
8	K-7	7.20 – 8.30					III / IV	III / IV		51	0	
	K-8	8.30 – 9.00								36	0	
9	SPT-5	9.00 – 9.20	27	50/5	-	R						
	K-9	9.20 – 10.00								75	0	
10	K-10	10.00 – 10.70								49	0	
11	SPT-6	10.70 – 11.15	14	21	28	49						
	K-11	11.15 – 12.00					IV-V	IV-V		41	0	
12	SPT-7	12.00 – 12.45	17	21	23	44						
	K-12	12.45 – 13.00								100	0	
13	K-13	13.00 – 13.50								0	0	
	SPT-8	13.50 – 13.95	14	14	15	29						
14	K-14	13.95 – 14.70					V	V		0	0	
	SPT-9	14.70 – 14.90	16	50/5	-	R						
15	K-15	14.90 – 15.80					I-II	I-II		72	31	
16												

STANDART PENETRASYON DENEYİ / Standart Penetration Test – GRAFİK / Graph



JEOTEKNİK TANIMLAMA / Geotechnical Description

SCHIST
Green, brittle-little hard, medium hard in some parts, weak-very weak, moderately weak in some parts, medium-highly weathered, completely weathered in some parts, piecewise.

Fracture: 0°,90° open, rough, clay filled

13.75 m

SCHIST
Brown-green-greenish grey, soft, very weak, completely weathered

14.90 m

SCHIST
Purple, grey, hard-medium hard, strong- medium strong, slightly weathered.

15.50 m

Clayey,gravelly **SAND**
(Description on page 3/3.)

	LOGU YAPAN / Logged By	KONTROL / Checked
İSİM / Name	Talip ERBAY, Jeoloji Mühendisi	
İMZA / Sign		

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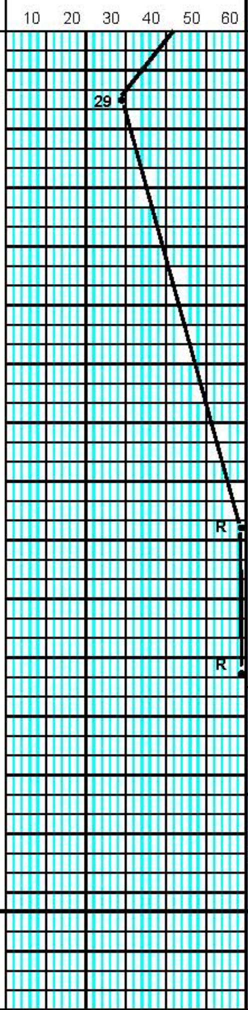
SONDAJ LOGU / BORING LOG

SONDAJ / Borehole No : **İBH72-13**

SAYFA / Page No : **3/3**

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	0 - 15 cm	15-30 cm	30-45 cm	N	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
16.50–16.95	SPT-10	16.50 / 16.95	8	14	15	**29**						
16.95–18.00	K-16	18.00								27	0	
18.00–19.50	K-17	19.50								45	0	
19.50–20.00	K-18	20.00					IV V	IV V		27	0	
20.00–21.00	K-19	21.00								35	0	
21.00–21.05	SPT-11	21.00 / 21.05	50/5	-	-	**R**						
21.05–22.50	K-20	22.50								18	0	
22.50–22.73	SPT-12	22.50 / 22.73	45	50/8	-	**R**						
22.73–24.00	K-21	24.00					II III	II III		96	66	
24.00–25.00	K-22									98	40	

STANDART PENETRASYON DENEYİ / Standart Penetration Test — GRAFİK / Graph



JEOTEKNİK TANIMLAMA / Geotechnical Description (PROFİL / Profile)

Brown-greyish brown, medium dense, clayey, gravelly **SAND.** Moist, fine-coarse grained, brittle-little hard; 10-20% fine coarse grained, angular gravel; 25-35 fine material.

(Potential Slip Surface)

— 17.80 m —

SCHIST
Grey-greenish grey-purple, brittle little hard, weak-very weak, moderately-heavily weathered, lower levels completeley weathered, piecewise.

— 22.70 m —

GRAPHITE SCHIST
Dark grey-black, medium hard, medium strong-medium weak, slightly-moderately weathered, quartzite veins.

— 23.80 m —

SCHIST
Green-purple-greenish grey, moderately hard, moderately strong, slightly weathered,

END OF BORING : 25.00 m.

Not : Kuyuya yeraltısuyu gözlemleri için 25,00 m, Ø50 mm. perfore PVC boru indirilip, kuyu ağzı betonu yapılmıştır.

	LOGU YAPAN / Logged By	KONTROL / Checked
İSİM / Name	Talip ERBAY Jeoloji Mühendisi	
İMZA / Sign		

APPENDIX C

CORE BOX PHOTOS

BOREHOLE NO : IBH72-2i
CORE BOX NO : 1/1

BOREHOLE NO : IBH72-3i
CORE BOX NO : 1/2

BOREHOLE NO : IBH72-3i

CORE BOX NO : 2/2

BOREHOLE NO : IBH72-5

CORE BOX NO : 1/1

BOREHOLE NO : IBH72-6i

CORE BOX NO : 1/1

BOREHOLE NO : IBH72-7i

CORE BOX NO : 1/1

BOREHOLE NO : IBH72-8i

CORE BOX NO : 1/3

BOREHOLE NO : IBH72-8i

CORE BOX NO : 2/3

BOREHOLE NO : IBH72-8i

CORE BOX NO : 3/3

BOREHOLE NO : IBH72-9i

CORE BOX NO : 1/1

BOREHOLE NO : IBH72-10İ

CORE BOX NO : 1/2

BOREHOLE NO : IBH72-10İ

CORE BOX NO : 2/2

BOREHOLE NO : IBH72-11

CORE BOX NO : 1/1

BOREHOLE NO : IBH72-12

CORE BOX NO : 1/1

BOREHOLE NO : IBH72-13i

CORE BOX NO : 1/2

BOREHOLE NO : IBH72-13i

CORE BOX NO : 2/2

APPENDIX D

SOIL LABORATORY TEST RESULTS

YÜKSEL PROJE

SOIL-ROCK MECHANICS LABORATORY

ZEML-Fr-23

Form of Test Results

PROJECT NAME: BURSA - İNEGÖL - BOZÜYÜK ROAD

SAMPLE			Wn	en	γ_n	γ_s	ATTERBERG LIMITS			SIEVE ANALYSIS		SOIL	UNCONFINED COMPRESSION TEST	TRIAXIAL COMPRESSION TEST	
BOREHOLE ID	ID	DEPTH (m)	%		kN/m^3		LL %	PL %	PI	+4 %	-200 %	CLASS. (USCS)	qu kPa	C kPa	Ø degree
İBH72-1	SPT-1	1,50-1,95	25				49	29	20	4	65	ML			
	SPT-2	2,00-2,45	24				40	26	14	15	42	SC			
	SPT-3	2,50-2,95	14				-	NP	-	25	25	SM			
	SPT-4	3,00-3,45	14				-	NP	-	22	22	SM			
	SPT-5	3,50-3,95	15				-	NP	-	19	29	SM			
	SPT-6	4,00-4,45	14				-	NP	-	12	26	SM			
	SPT-*7	4,50-4,95	18				-	NP	-	52	18	GM			
	SPT-8	5,00-5,45	21				-	NP	-	31	26	SM			
	SPT-9	5,50-5,95	14				-	NP	-	45	21	GM			
	SPT-10	6,00-6,45	22				42	25	17	16	37	SC			
	SPT-11	6,50-6,95	23				43	27	16	13	44	SM			
	SPT-12	7,00-7,45	24				46	29	17	16	44	SM			
	SPT-13	7,50-7,95	18				-	NP	-	17	39	SM			
	SPT-14	8,00-8,45	17				-	NP	-	28	33	SM			
	SPT-16	9,00-9,45	15				-	NP	-	27	30	SM			
	SPT-17	9,50-9,95	15				-	NP	-	24	29	SM			
	SPT-18	10,00-10,45	17				-	NP	-	26	31	SM			

YÜKSEL PROJE

SOIL-ROCK MECHANICS LABORATORY

ZEML-Fr-23

Form of Test Results

PROJECT NAME: BURSA - İNEGÖL - BOZÜYÜK ROAD

SAMPLE			Wn	en	γ_n	γ_s	ATTERBERG LIMITS			SIEVE ANALYSIS		SOIL	UNCONFINED COMPRESSION TEST	TRIAXIAL COMPRESSION TEST	
BOREHOLE ID	ID	DEPTH (m)	%		kN/m^3		LL %	PL %	PI	+4 %	-200 %	CLASS. (USCS)	qu kPa	C kPa	Ø degree
İBH72-1	SPT-19	10,50-10,95	18				42	23	19	15	35	SC			
	SPT-20	11,00-11,45	12				-	NP	-	21	25	SM			
	SPT-21	12,00-12,45	15				-	NP	-	23	22	SM			
	SPT-22	13,50-13,95	17				45	22	23	5	53	CL			
	SPT-23	15,00-15,45	11				-	NP	-	41	13	SM			
İBH72-2i	SPT-1	1,50-1,95	20				-	NP	-	19	39	SM			
	SPT-2/A	2,00-2,40	5				-	NP	-	64	1	GW			
	SPT-2/B	2,40-2,45	20				-	NP	-	13	24	SM			
	SPT-3	2,50-2,95	9				34	23	11	5	13	SM			
	SPT-4	3,00-3,45	6				-	NP	-	54	17	GM			
	SPT-5	3,50-3,95	13				-	NP	-	61	11	GP-GM			
	SPT-6/A	7,50-7,65	10				-	NP	-	37	22	SM			
	SPT-6/B	7,65-7,95	10				31	19	12	31	20	SC			
	SPT-7	9,00-9,14	11				-	NP	-	41	16	SM			
	SPT-8	12,00-12,08	13				-	NP	-	62	12	GM			

YÜKSEL PROJE

SOIL-ROCK MECHANICS LABORATORY

ZEML-Fr-23

Form of Test Results

PROJECT NAME: BURSA - İNEGÖL - BOZÜYÜK ROAD

SAMPLE			Wn	en	γ_n	γ_s	ATTERBERG LIMITS			SIEVE ANALYSIS		SOIL	UNCONFINED COMPRESSION TEST	TRIAXIAL COMPRESSION TEST	
BOREHOLE ID	ID	DEPTH (m)	%		kN/m^3		LL %	PL %	PI	+4 %	-200 %	CLASS. (USCS)	qu kPa	C kPa	Ø degree
İBH72-3i	SPT-1	0,50-0,95	17				38	28	10	26	30	SM			
	SPT-2	1,00-1,45	13				-	NP	-	55	7	GP-GM			
	SPT-3	1,50-1,95	17				42	27	15	17	36	SM			
	SPT-4	2,00-2,45	16				48	31	17	37	31	GM			
	SPT-5	2,50-2,95	18				48	29	19	6	46	SM			
	SPT-6/A	3,00-3,15	24				-	NP	-	13	43	SM			
	SPT-6/B	3,15-3,45	22				34	25	9	10	46	SM			
	SPT-7	3,50-3,95	24				44	28	16	8	54	ML			
	SPT-8	4,00-4,45	23				41	26	15	9	56	ML			
	SPT-9	4,50-4,95	8				43	26	17	14	38	SC			
	SPT-10	5,00-5,45	19				45	26	19	7	44	SC			
	SPT-11	5,50-5,95	27				48	27	21	2	60	CL			
	SPT-12	6,00-6,45	16				41	24	17	10	35	SC			
	SPT-13/A	6,50-6,65	20				-	NP	-	12	37	SM			
	SPT-13/B	6,65-6,95	31				-	NP	-	9	48	SM			
	SPT-14	7,00-7,45	23				47	28	19	7	44	SC			
	SPT-15/A	7,50-7,95	24				-	NP	-	9	45	SM			

YÜKSEL PROJE

SOIL-ROCK MECHANICS LABORATORY

ZEML-Fr-23

Form of Test Results

PROJECT NAME: BURSA - İNEGÖL - BOZÜYÜK ROAD

SAMPLE			Wn	en	γ_n	γ_s	ATTERBERG LIMITS			SIEVE ANALYSIS		SOIL	UNCONFINED COMPRESSION TEST	TRIAXIAL COMPRESSION TEST	
BOREHOLE ID	ID	DEPTH (m)	%		kN/m^3		LL %	PL %	PI	+4 %	-200 %	CLASS. (USCS)	qu kPa	C kPa	Ø degree
İBH72-3i	SPT-15/B	7,65-7,95	17				-	NP	-	27	23	SM			
	SPT-16	8,00-8,13	13				-	NP	-	65	6	GW-GM			
	SPT-17	13,50-13,62	22				-	NP	-	5	43	SM			
İBH72-4	SPT-1	1,50-1,95	21				42	26	16	19	32	SM			
	SPT-2	2,00-2,45	21				42	28	14	26	30	SM			
	SPT-3	2,50-2,95	31				52	34	18	13	54	MH			
	SPT-4	3,00-3,45	31				49	32	17	12	34	SM			
	SPT-5	3,50-3,95	24				-	NP	-	30	22	SM			
	SPT-6	4,00-4,45	28				-	NP	-	30	24	SM			
	SPT-7	4,50-4,95	29				-	NP	-	23	30	SM			
	SPT-8	5,00-5,45	27				-	NP	-	39	18	SM			
	SPT-9	5,50-5,95	25				-	NP	-	37	20	SM			
	SPT-10	6,00-6,45	26				46	30	16	21	33	SM			
	SPT-11	6,50-6,95	31				53	33	20	1	74	MH			
	SPT-12	7,00-7,45	32				51	32	19	3	66	MH			
	SPT-13	7,50-7,95	29				45	31	14	1	57	ML			

YÜKSEL PROJE

SOIL-ROCK MECHANICS LABORATORY

Form of Test Results

ZEML-Fr-23

PROJECT NAME: BURSA - İNEGÖL - BOZÜYÜK ROAD

SAMPLE			Wn	en	γ_n	γ_s	ATTERBERG LIMITS			SIEVE ANALYSIS		SOIL CLASS. (USCS)	UNCONFINED COMPRESSION TEST	TRIAXIAL COMPRESSION TEST	
BOREHOLE ID	ID	DEPTH (m)	%		kN/m^3		LL %	PL %	PI	+4 %	-200 %		qu kPa	C kPa	Ø degree
İBH72-4	SPT-14	8,00-8,45	25				44	29	15	10	45	SM			
	SPT-15	8,50-8,95	30				48	29	19	7	60	ML			
	SPT-16	9,00-9,45	23				41	26	15	16	32	SC			
	SPT-17	9,50-9,95	27				38	26	12	9	58	ML			
	SPT-18	10,00-10,45	14				-	NP	-	40	19	SM			
	SPT-19	10,50-10,95	18				38	24	14	29	34	SC			
	SPT-20/A	11,00-11,25	19				-	NP	-	20	25	SM			
	SPT-20/B	11,25-11,45	15				-	NP	-	21	34	SM			
	SPT-21	11,50-11,95	11				-	NP	-	28	23	SM			
	SPT-22	12,00-12,45	10				-	NP	-	39	18	SM			
	SPT-23	12,50-12,95	10				-	NP	-	37	21	SM			
	SPT-24	13,00-13,45	10				-	NP	-	37	22	SM			
	SPT-25	13,50-13,95	10				-	NP	-	36	20	SM			
	SPT-26	14,00-14,45	13				42	23	19	20	41	SC			
	SPT-27	14,50-14,95	17				39	24	15	6	44	SC			
	SPT-28	15,00-15,45	15				-	NP	-	17	34	SM			
	SPT-29	15,50-15,95	16				-	NP	-	10	42	SM			

YÜKSEL PROJE

SOIL-ROCK MECHANICS LABORATORY

Form of Test Results

ZEML-Fr-23

PROJECT NAME: BURSA - İNEGÖL - BOZÜYÜK ROAD

SAMPLE			Wn	en	γ_n	γ_s	ATTERBERG LIMITS			SIEVE ANALYSIS		SOIL CLASS. (USCS)	UNCONFINED COMPRESSION TEST	TRIAXIAL COMPRESSION TEST	
BOREHOLE ID	ID	DEPTH (m)	%		kN/m^3		LL %	PL %	PI	+4 %	-200 %		qu kPa	C kPa	Ø degree
İBH72-4	SPT-30	16,00-16,43	14				-	NP	-	28	22	SM			
	SPT-31	18,00-18,45	10				39	23	16	15	25	SC			
	SPT-32	19,00-19,45	9				-	NP	-	36	19	SM			
	SPT-33	20,00-20,45	13				43	21	22	23	39	SC			
	SPT-34	21,00-21,45	6				-	NP	-	48	13	SM			
	SPT-35	22,00-22,45	10				32	18	14	19	27	SC			
İBH72-5	SPT-1	0,00-0,45	22				40	27	13	9	48	SM			
	SPT-2	0,50-0,95	17				47	28	19	22	38	SC			
	SPT-3	1,00-1,45	17				47	29	18	6	53	CL			
	SPT-4	1,50-1,95	19				41	26	15	8	49	SC			
	SPT-5	2,00-2,45	21				42	26	16	4	60	ML			
	SPT-6	2,50-2,95	21				48	30	18	7	57	ML			
	SPT-7	3,00-3,45	18				40	24	16	45	21	GC			
	SPT-8	3,50-3,95	14				43	28	15	28	21	SM			
	SPT-9	4,00-4,45	23				43	27	16	10	45	SM			
	SPT-10	4,50-4,95	24				43	27	16	3	49	SM			

YÜKSEL PROJE

SOIL-ROCK MECHANICS LABORATORY

ZEML-Fr-23

Form of Test Results

PROJECT NAME: BURSA - İNEGÖL - BOZÜYÜK ROAD

SAMPLE			Wn	en	γ_n	γ_s	ATTERBERG LIMITS			SIEVE ANALYSIS		SOIL CLASS.	UNCONFINED COMPRESSION TEST	TRIAXIAL COMPRESSION TEST	
BOREHOLE ID	ID	DEPTH (m)	%		kN/m^3		LL %	PL %	PI	+4 %	-200 %	(USCS)	qu kPa	C kPa	Ø degree
İBH72-5	SPT-11	5,00-5,45	30				51	30	21	7	55	MH			
	SPT-12	5,50-5,95	19				46	29	17	29	28	SM			
	SPT-13	6,00-6,45	22				-	NP	-	11	39	SM			
	SPT-14	6,50-6,94	26				Inadequate Sample			5	54	MH			
	SPT-15	7,00-7,45	20				Inadequate Sample			6	53	MH			
	SPT-16	7,50-7,95	18				40	27	13	28	19	SM			
	SPT-17	8,00-8,45	23				-	NP	-	11	43	SM			
	SPT-18/A	8,50-8,75	23				-	NP	-	10	45	SM			
	SPT-18/B	8,75-8,95	23				45	29	16	20	38	SM			
	SPT-19	9,00-9,45	17				41	25	16	9	38	SC			
	SPT-20/A	9,50-9,65	19				Inadequate Sample			3	52	CL			
	SPT-20/B	9,65-9,80	28				44	27	18	4	49	SM/SC			
	SPT-20/C	9,80-9,85	15				-	NP	-	21	36	SM			
	SPT-21/A	10,00-10,30	14				-	NP	-	10	37	SM			
	SPT-21/B	10,30-10,45	27				43	25	18	7	46	SC			
	SPT-22/A	10,50-10,65	9				-	NP	-	31	20	SM			
	SPT-22/B	10,65-10,80	23				-	NP	-	6	47	SM			

YÜKSEL PROJE

SOIL-ROCK MECHANICS LABORATORY

ZEML-Fr-23

Form of Test Results

PROJECT NAME: BURSA - İNEGÖL - BOZÜYÜK ROAD

SAMPLE			Wn	en	γ_n	γ_s	ATTERBERG LIMITS			SIEVE ANALYSIS		SOIL CLASS.	UNCONFINED COMPRESSION TEST	TRIAXIAL COMPRESSION TEST	
BOREHOLE ID	ID	DEPTH (m)	%		kN/m^3		LL %	PL %	PI	+4 %	-200 %	(USCS)	qu kPa	C kPa	Ø degree
İBH72-5	SPT-22/C	10,80-10,95	18				Inadequate Sample			8	50	CL			
	SPT-23/A	11,00-11,30	12				-	NP	-	20	22	SM			
	SPT-23/B	11,30-11,45	22				-	NP	-	6	44	SM			
	SPT-24	11,50-11,60	11				-	NP	-	35	21	SM			
	SPT-25	12,30-12,54	14				-	NP	-	12	28	SM			
İBH72-6i	SPT-1	1,50-1,95	18				-	NP	-	16	35	SM			
	SPT-2	2,25-2,70	14				-	NP	-	16	39	SM			
	SPT-3	3,00-3,45	12				-	NP	-	15	28	SM			
	SPT-4/A	3,50-3,75	15				35	20	15	23	36	SC			
	SPT-4/B	3,75-4,10	13				34	19	15	35	24	SC			
	SPT-5	4,50-4,95	12				36	18	18	6	36	SC			
	SPT-6	5,25-5,70	10				31	17	14	14	27	SC			
	SPT-7	6,00-6,45	11				32	18	14	17	23	SC			
	SPT-8	6,70-7,15	13				35	20	15	13	26	SC			
	SPT-9	7,50-7,95	12				31	17	14	12	25	SC			
	SPT-10	8,25-8,70	11				-	NP	-	36	18	SM			

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SOIL-ROCK MECHANICS LABORATORY

Form of Test Results

PROJECT NAME: BURSA - İNEGÖL - BOZÜYÜK ROAD

SAMPLE			Wn %	en	γ_n kN/m^3	γ_s	ATTERBERG LIMITS			SIEVE ANALYSIS		SOIL CLASS. (USCS)	UNCONFINED COMPRESSION TEST	TRIAXIAL COMPRESSION TEST	
BOREHOLE ID	ID	DEPTH (m)					LL %	PL %	PI	+4 %	-200 %		qu kPa	C kPa	Ø degree
İBH72-6i	SPT-11	9,00-9,45	13				-	NP	-	8	32	SM			
	SPT-12	9,70-10,15	14				-	NP	-	16	32	SM			
	SPT-13	10,50-10,62	9				-	NP	-	23	23	SM			
	SPT-14	14,00-14,14	8				-	NP	-	25	21	SM			
	SPT-15	15,00-15,25	15				-	NP	-	7	32	SM			
İBH72-7i	SPT-1	1,50-1,55	7				-	NP	-	78	7	GP-GM			
	SPT-2	2,25-2,39	8				-	NP	-	83	3	GP			
	SPT-3	3,00-3,45	12				-	NP	-	69	10	GP-GM			
	SPT-4	3,75-4,20	14				-	NP	-	55	14	GM			
	SPT-5	6,00-6,45	10				-	NP	-	73	4	GP			
	SPT-6	7,50-7,95	5				-	NP	-	74	3	GP			
	SPT-7	8,25-8,70	13				-	NP	-	62	7	GP-GM			
	SPT-8/A	9,00-9,20	14				-	NP	-	46	20	GM			
	SPT-8/B	9,20-9,45	9				35	23	12	37	18	SC			
	SPT-9	9,80-10,25	15				-	NP	-	16	30	SM			
	SPT-10	10,50-10,95	16				-	NP	-	30	19	SM			

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SOIL-ROCK MECHANICS LABORATORY

Form of Test Results

PROJECT NAME: BURSA - İNEGÖL - BOZÜYÜK ROAD

SAMPLE			Wn %	en	γ_n kN/m^3	γ_s	ATTERBERG LIMITS			SIEVE ANALYSIS		SOIL CLASS. (USCS)	UNCONFINED COMPRESSION TEST	TRIAXIAL COMPRESSION TEST	
BOREHOLE ID	ID	DEPTH (m)					LL %	PL %	PI	+4 %	-200 %		qu kPa	C kPa	Ø degree
İBH72-7i	SPT-11	12,00-12,45	22				-	NP	-	9	42	SM			
	SPT-12	12,70-13,15	11				-	NP	-	58	5	GW			
	SPT-13	13,50-13,95	14				32	21	11	14	26	SC			
	SPT-14	15,00-15,45	14				39	24	15	17	33	SC			
	SPT-15	16,50-16,95	14				33	19	14	11	30	SC			
	SPT-16	18,00-18,37	7				29	16	13	13	21	SC			
	SPT-17	18,70-19,15	10				-	NP	-	55	8	GW-GM			
	SPT-18	19,50-19,95	11				-	NP	-	33	16	SM			
	SPT-19	21,00-21,45	16				40	26	14	24	28	SM/SC			
	SPT-20	22,50-22,95	14				36	22	14	14	29	SC			
	SPT-21	23,00-23,45	14				38	25	13	15	40	SM			
	SPT-22	24,00-24,43	11				32	20	12	18	27	SC			
	SPT-23	25,50-25,60	3				-	NP	-	87	1	GW			
	SPT-24	27,00-27,05	7				-	NP	-	80	1	GW			
İBH72-8i	SPT-1	1,50-1,95	18				44	28	16	8	46	SM			
	SPT-2	2,00-2,45	22				40	24	16	6	53	CL			

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SOIL-ROCK MECHANICS LABORATORY

Form of Test Results

PROJECT NAME: BURSA - İNEGÖL - BOZÜYÜK ROAD

SAMPLE			Wn	en	γ_n	γ_s	ATTERBERG LIMITS			SIEVE ANALYSIS		SOIL	UNCONFINED COMPRESSION TEST	TRIAXIAL COMPRESSION TEST	
BOREHOLE ID	ID	DEPTH (m)	%		kN/m³		LL %	PL %	PI	+4 %	-200 %	CLASS. (USCS)	qu kPa	C kPa	Ø degree
İBH72-8i	SPT-3	2,50-2,95	12				42	27	16	37	24	SM			
	SPT-4	3,00-3,45	16				44	28	16	9	58	ML			
	SPT-5	3,50-3,95	19				47	27	15	2	66	CL			
	SPT-6	4,00-4,45	18				45	27	16	8	62	CL/ML			
	SPT-7	4,50-4,95	16				44	28	20	12	53	ML			
	SPT-8	5,00-5,45	12				35	23	18	59	11	GP-GM			
	SPT-9	5,50-5,95	14				-	NP	12	65	10	GP-GM			
	SPT-10	6,00-6,45	10				-	NP	-	72	7	GP-GM			
	SPT-11	6,50-6,95	14				-	NP	-	66	8	GP-GM			
	SPT-12	7,00-7,45	13				-	NP	-	67	7	GP-GM			
	SPT-13	7,50-7,95	18				-	NP	-	50	10	GP-GM			
	SPT-14	8,00-8,45	18				-	NP	-	45	11	GP-GM			
	SPT-15/A	8,50-8,75	12				-	NP	-	72	4	GW			
	SPT-15/B	8,75-9,00	16				-	NP	-	28	19	SM			
	SPT-16	9,00-9,45	12				-	NP	-	45	15	GM			
	SPT-17	30,00-30,45	20				-	NP	-	9	44	SM			
	SPT-18	31,00-31,10	10				-	NP	-	12	19	SM			

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SOIL-ROCK MECHANICS LABORATORY

Form of Test Results

PROJECT NAME: BURSA - İNEGÖL - BOZÜYÜK ROAD

SAMPLE			Wn	en	γ_n	γ_s	ATTERBERG LIMITS			SIEVE ANALYSIS		SOIL	UNCONFINED COMPRESSION TEST	TRIAXIAL COMPRESSION TEST	
BOREHOLE ID	ID	DEPTH (m)	%		kN/m³		LL %	PL %	PI	+4 %	-200 %	CLASS. (USCS)	qu kPa	C kPa	Ø degree
İBH72-9i	SPT-1	0,00-0,45	17				43	26	17	6	48	SC			
	SPT-2	0,50-0,95	20				43	26	17	6	46	SC			
	SPT-3	1,00-1,45	20				42	26	16	8	49	SM			
	SPT-4	1,50-1,95	18				43	25	18	11	40	SC			
	SPT-5	2,00-2,45	16				39	25	14	10	42	SC			
	SPT-6	2,50-2,95	18				36	22	14	6	47	SC			
	SPT-7	3,00-3,45	17				38	24	14	9	45	SC			
	SPT-8	3,50-3,95	16				Inadequate Sample			9	58	CL			
	SPT-9	4,00-4,45	17				42	25	17	21	29	SC			
	SPT-10	4,50-4,95	23				43	26	17	6	52	CL			
	SPT-11	5,00-5,45	27				46	29	17	2	77	ML			
	SPT-12	5,50-5,95	27				44	28	16	2	74	ML			
	SPT-13	6,00-6,45	22				40	25	15	11	35	SC			
	SPT-14	6,50-6,95	23				40	27	13	8	43	SM			
	SPT-15	7,00-7,45	32				42	28	14	5	61	ML			
	SPT-16	7,50-7,95	24				45	26	19	2	61	CL			
	SPT-17	8,00-8,45	23				-	NP	-	28	29	SM			

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SOIL-ROCK MECHANICS LABORATORY

Form of Test Results

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PROJECT NAME: BURSA - İNEGÖL - BOZÜYÜK ROAD

SAMPLE			Wn	en	γ_n	γ_s	ATTERBERG LIMITS			SIEVE ANALYSIS		SOIL CLASS.	UNCONFINED COMPRESSION TEST	TRIAXIAL COMPRESSION TEST	
BOREHOLE ID	ID	DEPTH (m)	%		kN/m³		LL %	PL %	PI	+4 %	-200 %	(USCS)	qu kPa	C kPa	Ø degree
İBH72-9i	SPT-18	8,50-8,95	21				43	26	17	7	55	CL			
	SPT-19	9,00-9,45	26				43	26	17	6	56	CL			
	SPT-20	9,50-9,95	19				-	NP	-	12	43	SM			
	SPT-21/A	10,00-10,25	12				-	NP	-	27	27	SM			
	SPT-21/B	10,25-10,45	21				-	NP	-	14	49	SM			
	SPT-22	10,50-10,95	16				32	25	7	20	27	SM			
	SPT-23	11,00-11,45	13				33	24	9	29	19	SC			
	SPT-24	11,50-11,95	11				-	NP	-	49	15	GM			
	SPT-25	12,00-12,45	22				46	25	21	10	58	CL			
	SPT-26	12,50-12,95	24				44	26	18	11	48	SC			
	SPT-27	13,00-13,45	22				47	22	25	12	42	SC			
	SPT-28	13,50-13,95	18				45	26	19	12	39	SC			
	SPT-29	14,00-14,45	15				33	23	10	34	25	GC			
	SPT-30	14,50-14,95	21				37	23	14	4	54	CL			
	SPT-31	15,00-15,45	21				41	25	16	3	54	CL			
	SPT-32	15,50-15,95	17				41	24	17	6	53	CL			
	SPT-33	16,00-16,45	20				43	25	18	8	49	SC			

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SOIL-ROCK MECHANICS LABORATORY

Form of Test Results

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PROJECT NAME: BURSA - İNEGÖL - BOZÜYÜK ROAD

SAMPLE			Wn	en	γ_n	γ_s	ATTERBERG LIMITS			SIEVE ANALYSIS		SOIL CLASS.	UNCONFINED COMPRESSION TEST	TRIAXIAL COMPRESSION TEST	
BOREHOLE ID	ID	DEPTH (m)	%		kN/m³		LL %	PL %	PI	+4 %	-200 %	(USCS)	qu kPa	C kPa	Ø degree
İBH72-9i	SPT-34	16,50-16,95	17				46	25	21	6	48	SC			
	SPT-35	17,00-17,45	17				45	22	23	12	43	SC			
	SPT-36	17,50-17,95	15				41	28	13	13	39	SM			
	SPT-37	18,00-18,45	12				-	NP	-	27	32	SM			
	SPT-38	18,50-18,95	12				40	22	18	11	33	SC			
	SPT-39/A	19,00-19,15	13				-	NP	-	11	38	SM			
	SPT-39/B	19,15-19,28	12				-	NP	-	11	43	SM			
	SPT-40	20,50-20,93	8				-	NP	-	52	11	GP-GM			
	SPT-41	22,50-22,95	14				48	25	23	7	56	CL			
	SPT-42	24,00-24,29	9				-	NP	-	35	29	SM			
	SPT-43	26,90-27,00	11				-	NP	-	19	30	SM			
İBH72-10i	SPT-1	1,50-1,95	18				40	25	15	6	50	CL			
	SPT-2	2,00-2,45	16				47	28	19	22	42	SM			
	SPT-3/A	2,50-2,85	21				Inadequate Sample			6	51	CL			
	SPT-3/B	2,85-2,95	20				Inadequate Sample			13	53	CL			
	SPT-4	3,00-3,45	19				42	26	16	10	46	SM			

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SOIL-ROCK MECHANICS LABORATORY

Form of Test Results

ZEML-Fr-23

PROJECT NAME: BURSA - İNEGÖL - BOZÜYÜK ROAD

SAMPLE			Wn	en	γ_n	γ_s	ATTERBERG LIMITS			SIEVE ANALYSIS		SOIL CLASS. (USCS)	UNCONFINED COMPRESSION TEST	TRIAXIAL COMPRESSION TEST	
BOREHOLE ID	ID	DEPTH (m)	%		kN/m^3		LL %	PL %	PI	+4 %	-200 %		qu kPa	C kPa	Ø degree
İBH72-10i	SPT-5	3,50-3,95	20				43	27	16	11	40	SM			
	SPT-6	4,00-4,45	16				43	26	17	21	28	SM			
	SPT-7	4,50-4,95	17				-	NP	-	25	27	SM			
	SPT-8	5,00-5,34	16				-	NP	-	19	38	SM			
	SPT-9	5,50-5,61	13				-	NP	-	10	42	SM			
	SPT-10	6,00-6,25	11				Inadequate Sample			8	51	CL			
	SPT-11	9,00-9,07	8				-	NP	-	69	8	GP-GM			
	SPT-12	11,00-11,21	8				-	NP	-	38	19	SM			
	SPT-13	17,40-17,65	12				-	NP	-	8	29	SM			
	SPT-14	21,00-21,13	10				-	NP	-	30	15	SM			
İBH72-11	SPT-1	1,50-1,95	24				-	NP	-	12	40	SM			
	SPT-2	2,50-2,70	25				41	26	15	4	51	CL/ML			
	SPT-3	3,00-3,45	26				46	31	15	3	53	ML			
	SPT-4	3,70-4,15	21				-	NP	-	30	26	SM			
	SPT-5	4,50-4,95	16				-	NP	-	21	25	SM			
	SPT-6	5,25-5,70	13				-	NP	-	50	16	GM			

YÜKSEL PROJE

SOIL-ROCK MECHANICS LABORATORY

Form of Test Results

ZEML-Fr-23

PROJECT NAME: BURSA - İNEGÖL - BOZÜYÜK ROAD

SAMPLE			Wn	en	γ_n	γ_s	ATTERBERG LIMITS			SIEVE ANALYSIS		SOIL CLASS. (USCS)	UNCONFINED COMPRESSION TEST	TRIAXIAL COMPRESSION TEST	
BOREHOLE ID	ID	DEPTH (m)	%		kN/m^3		LL %	PL %	PI	+4 %	-200 %		qu kPa	C kPa	Ø degree
İBH72-11	SPT-7	6,00-6,45	19				43	26	17	28	29	SC			
	SPT-8	6,70-7,15	33				43	28	15	3	72	ML			
	SPT-9	7,50-7,95	25				42	30	12	8	38	SM			
	SPT-10	8,25-8,70	23				37	22	15	15	33	SC			
	SPT-11	9,00-9,45	22				36	25	11	7	35	SM			
	SPT-12	9,70-10,15	24				47	29	18	17	43	SM			
	SPT-13/A	10,50-10,95	22				-	NP	-	23	27	SM			
	SPT-13/B	10,50-10,95	21				-	NP	-	10	44	SM			
	SPT-14	11,25-11,70	16				39	24	15	24	33	SC			
	SPT-15	12,00-12,27	30				-	NP	-	11	37	SM			
	SPT-16	13,50-13,90	12				-	NP	-	24	28	SM			
	SPT-17	15,00-15,25	8				-	NP	-	52	6	GP-GM			
İBH72-12	SPT-1	0,50-0,95	11				-	NP	-	57	16	GM			
	SPT-2	1,00-1,45	8				-	NP	-	61	14	GM			
	SPT-3	1,50-1,95	17				-	NP	-	48	17	GM			
	SPT-4/A	2,00-2,30	14				-	NP	-	34	27	SM			

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SOIL-ROCK MECHANICS LABORATORY

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Form of Test Results

PROJECT NAME: BURSA - İNEGÖL - BOZÜYÜK ROAD

SAMPLE			Wn	en	γ_n	γ_s	ATTERBERG LIMITS			SIEVE ANALYSIS		SOIL CLASS. (USCS)	UNCONFINED COMPRESSION TEST	TRIAXIAL COMPRESSION TEST	
BOREHOLE ID	ID	DEPTH (m)	%		kN/m³		LL %	PL %	PI	+4 %	-200 %		qu kPa	C kPa	Ø degree
İBH72-12	SPT-4/B	2,30-2,45	7				-	NP	-	41	15	SM			
	SPT-5	2,50-2,95	11				-	NP	-	56	15	GM			
	SPT-6	3,00-3,45	17				35	26	9	38	24	GM			
	SPT-7	3,50-3,95	14				37	26	11	52	20	GM			
	SPT-8	4,00-4,45	16				36	25	11	29	28	SM			
	SPT-9	4,50-4,95	19				45	31	14	23	51	ML			
	SPT-10	5,00-5,45	17				41	28	13	25	43	SM			
	SPT-11	5,50-5,95	24				-	NP	-	28	18	SM			
	SPT-12	6,00-6,10	6				-	NP	-	86	2	GP			
	SPT-13/A	12,00-12,20	10				-	NP	-	51	18	GM			
	SPT-13/B	12,20-12,45	10				-	NP	-	47	18	GM			
	SPT-14	13,50-13,95	11				-	NP	-	4	45	SM			
İBH72-13	SPT-1	1,50-1,95	6				-	NP	-	76	6	GP-GM			
	SPT-2	2,50-3,00	7				-	NP	-	83	6	GP-GM			
	SPT-3	3,00-3,45	5				-	NP	-	85	3	GP			
	SPT-4	4,00-4,10	8				-	NP	-	39	7	SP-SM			

YÜKSEL PROJE

SOIL-ROCK MECHANICS LABORATORY

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Form of Test Results

PROJECT NAME: BURSA - İNEGÖL - BOZÜYÜK ROAD

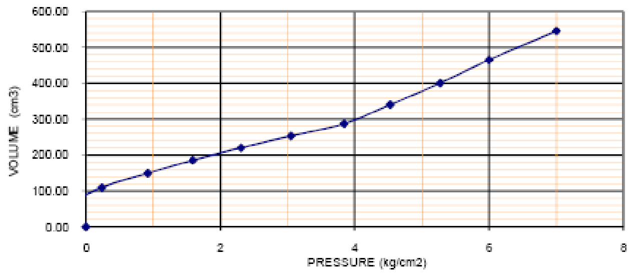
SAMPLE			Wn	en	γ_n	γ_s	ATTERBERG LIMITS			SIEVE ANALYSIS		SOIL CLASS. (USCS)	UNCONFINED COMPRESSION TEST	TRIAXIAL COMPRESSION TEST	
BOREHOLE ID	ID	DEPTH (m)	%		kN/m³		LL %	PL %	PI	+4 %	-200 %		qu kPa	C kPa	Ø degree
İBH72-13	SPT-5	9,00-9,20	9				-	NP	-	60	8	GP-GM			
	SPT-6	10,70-11,15	8				-	NP	-	63	9	GP-GM			
	SPT-7	12,00-12,45	15				-	NP	-	37	18	SM			
	SPT-8/A	13,50-13,75	16				-	NP	-	27	28	SM			
	SPT-8/B	13,75-13,95	24				Inadequate Sample			28	80	ML			
	SPT-9	14,70-14,90	22				-	NP	-	21	32	SM			
	SPT-10	16,50-16,95	16				41	23	18	32	20	SC			
	SPT-11	21,00-21,05	5				-	NP	-	57	7	GW-GM			
	SPT-12	22,50-22,73	9				-	NP	-	49	7	GW-GM			

APPENDIX E

PRESSUREMETER TEST RESULTS

BURSA-İNEGÖL-BOZÜYÜK ROAD (SECTION II)

PRESSUREMETER TEST
IBH72-1 P-1



Date	11.12.2006	Po (γ z) (kg/cm2)	1.35	Probe dia.	60	mm
Borehole ID	IBH72-1	P1 (kg/cm2)	1.59			
Test No	P-1	V1 (cm3)	185.00	K	2,209	cm3
Depth	11.40	P2 (kg/cm2)	3.05	PI	7.00	kg/cm2
GWT	2.05	V2 (cm3)	253.00	Pln	5.66	kg/cm2
Person	N.MENGILER	Vo (cm3)	535.00	E	47	kg/cm2

YÜKSEL PROJE

YÜKSEL PROJE ULUSLARARASI A.Ş.
Birlik Mahallesi 9. Cadde No:41
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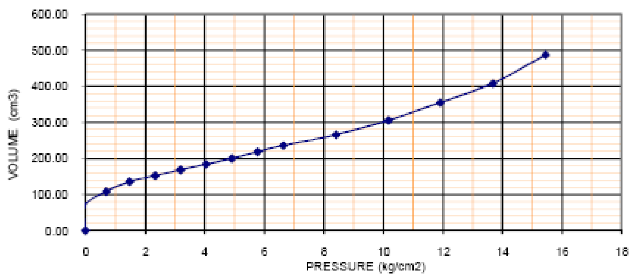
BURSA-İNEGÖL-BOZÜYÜK ROAD (SECTION II)

PRESSUREMETER TEST
IBH72-2i P-1



Date	11.12.2006	Po (γ z) (kg/cm2)	0.71	Probe dia	60	mm
Borehole ID	IBH72-2i	P1 (kg/cm2)	4.05			
Test No	P-1	V1 (cm3)	184.00	K	2,084	cm3
Depth	5.40	P2 (kg/cm2)	6.63	PI	15.45	kg/cm2
GWT	1.70	V2 (cm3)	236.00	Pln	14.74	kg/cm2
Person	N.MENGILER	Vo (cm3)	535.00	E	103	kg/cm2

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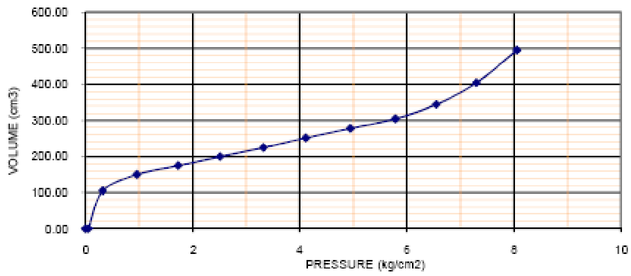
BURSA-İNEGÖL-BOZÜYÜK ROAD (SECTION II)

PRESSUREMETER TEST
IBH72-3i P-1



Date	08.12.2006	Po (γ z) (kg/cm2)	1.38	Probe dia.	60	mm
Borehole ID	IBH72-3i	P1 (kg/cm2)	2.51			
Test No	P-1	V1 (cm3)	200.00	K	2,133	cm3
Depth	6.90	P2 (kg/cm2)	4.11	PI	8.05	kg/cm2
GWT	7.40	V2 (cm3)	252.00	Pln	6.67	kg/cm2
Person	N.MENGILER	Vo (cm3)	535.00	E	66	kg/cm2

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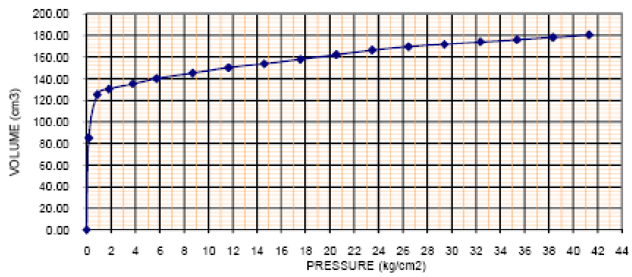
BURSA-İNEGÖL-BOZÜYÜK ROAD (SECTION II)

PRESSUREMETER TEST
IBH72-3i P-2



Date	08.12.2006	Po (γ z) (kg/cm2)	1.73	Probe dia.	60	mm
Borehole ID	IBH72-3i	P1 (kg/cm2)	17.57			
Test No	P-2	V1 (cm3)	157.81	K	1,849	cm3
Depth	9.90	P2 (kg/cm2)	26.44	PI	41.30	kg/cm2
GWT	7.40	V2 (cm3)	169.38	Pln	39.57	kg/cm2
Person	N.MENGILER	Vo (cm3)	535.00	E	1,418	kg/cm2

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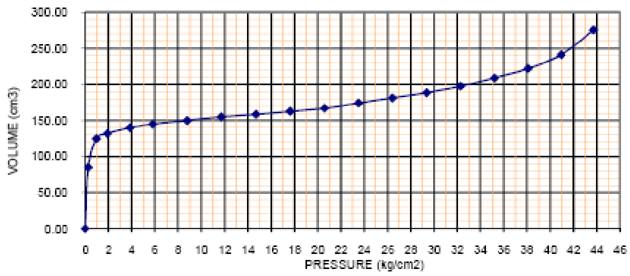
BURSA-İNEGÖL-BOZÜYÜK ROAD (SECTION II)

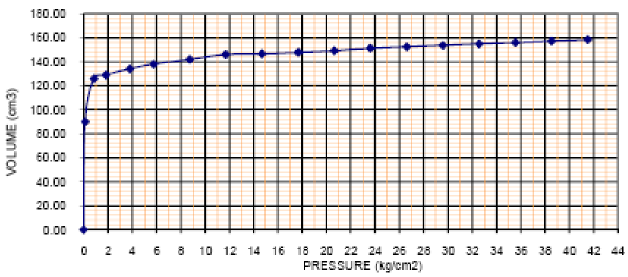
PRESSUREMETER TEST
IBH72-3i P-3



Date	09.12.2006	Po (γ z) (kg/cm2)	2.18	Probe dia	60	mm	**YÜKSEL PROJE**
Borehole ID	IBH72-3i	P1 (kg/cm2)	11.71				YÜKSEL PROJE ULUSLARARASI A.Ş.
Test No	P-3	V1 (cm3)	155.00	K	1,906	cm3	Birlik Mahallesi 9. Cadde No:41
Depth	14.40	P2 (kg/cm2)	20.58	Pl	43.70	kg/cm2	06610 ÇANKAYA-ANKARA
GWT	7.40	V2 (cm3)	167.00	Pln	41.52	kg/cm2	TEL: (312) 495 70 00 FAX: (312) 495 70 24
Person	N.MENGILER	Vo (cm3)	535.00	E	1,409	kg/cm2	www.yukselproje.com.tr

BURSA-İNEGÖL-BOZÜYÜK ROAD (SECTION II)

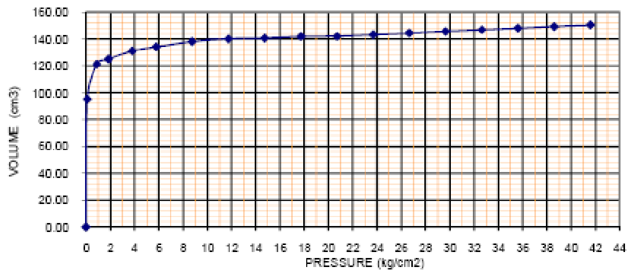
PRESSUREMETER TEST
IBH72-3i P-4



Date	09.12.2006	Po (γ z) (kg/cm2)	2.48	Probe dia.	60	mm	**YÜKSEL PROJE**
Borehole ID	IBH72-3i	P1 (kg/cm2)	23.61				YÜKSEL PROJE ULUSLARARASI A.Ş.
Test No	P-4	V1 (cm3)	151.19	K	1,821	cm3	Birlik Mahallesi 9. Cadde No:41
Depth	17.40	P2 (kg/cm2)	32.56	Pl	41.50	kg/cm2	06610 ÇANKAYA-ANKARA
GWT	7.40	V2 (cm3)	154.77	Pln	39.02	kg/cm2	TEL: (312) 495 70 00 FAX: (312) 495 70 24
Person	N.MENGILER	Vo (cm3)	535.00	E	4,552	kg/cm2	www.yukselproje.com.tr

BURSA-İNEGÖL-BOZÜYÜK ROAD (SECTION II)

PRESSUREMETER TEST
IBH72-3i P-5



Date	09.12.2006	Po (γ z) (kg/cm2)	2.73	Probe dia.	60	mm
Borehole ID	IBH72-3i	P1 (kg/cm2)	26.67			
Test No	P-5	V1 (cm3)	144.38	K	1,804	cm3
Depth	19.90	P2 (kg/cm2)	29.65	Pl	41.58	kg/cm2
GWT	7.40	V2 (cm3)	145.58	Pln	38.85	kg/cm2
Person	N.MENGILER	Vo (cm3)	535.00	E	4,480	kg/cm2

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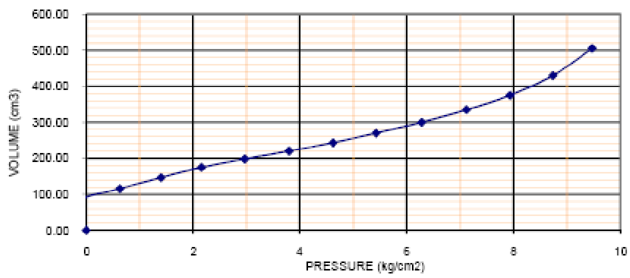
BURSA-İNEGÖL-BOZÜYÜK ROAD (SECTION II)

PRESSUREMETER TEST
IBH72-6i P-1



Date	06.12.2006	Po (γ z) (kg/cm2)	0.76	Probe dia.	60	mm
Borehole ID	IBH72-6i	P1 (kg/cm2)	3.8			
Test No	P-1	V1 (cm3)	220.00	K	2,157	cm3
Depth	5.40	P2 (kg/cm2)	5.43	Pl	9.47	kg/cm2
GWT	2.15	V2 (cm3)	270.00	Pln	8.71	kg/cm2
Person	N.MENGILER	Vo (cm3)	535.00	E	70	kg/cm2

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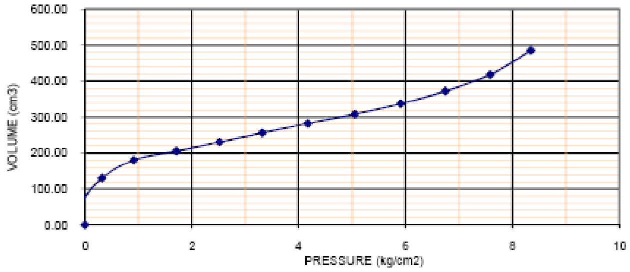
BURSA-İNEGÖL-BOZÜYÜK ROAD (SECTION II)

PRESSUREMETER TEST
IBH72-6i P-2



Date	07.12.2006	Po (γ z) (kg/cm2)	1.06	Probe dia.	60	mm
Borehole ID	IBH72-6i	P1 (kg/cm2)	3.32			
Test No	P-2	V1 (cm3)	256.00	K	2,198	cm3
Depth	8.40	P2 (kg/cm2)	5.05	Pl	8.34	kg/cm2
GWT	2.15	V2 (cm3)	308.00	Pln	7.28	kg/cm2
Person	N.MENGILER	Vo (cm3)	535.00	E	73	kg/cm2

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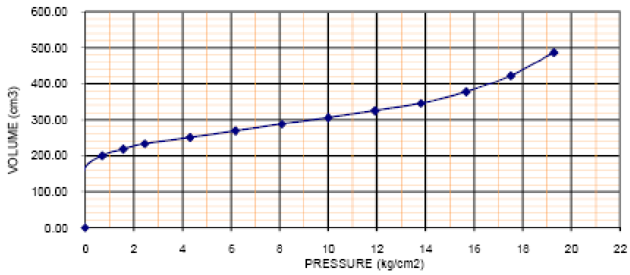
BURSA-İNEGÖL-BOZÜYÜK ROAD (SECTION II)

PRESSUREMETER TEST
IBH72-6i P-3



Date	07.12.2006	Po (γ z) (kg/cm2)	1.36	Probe dia.	60	mm
Borehole ID	IBH72-6i	P1 (kg/cm2)	6.18			
Test No	P-3	V1 (cm3)	269.00	K	2,220	cm3
Depth	11.40	P2 (kg/cm2)	10.00	Pl	19.27	kg/cm2
GWT	2.15	V2 (cm3)	306.00	Pln	17.92	kg/cm2
Person	N.MENGILER	Vo (cm3)	535.00	E	229	kg/cm2

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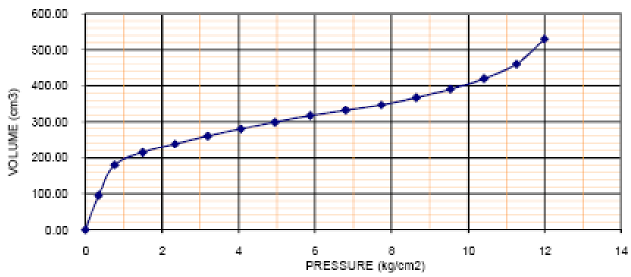
BURSA-İNEGÖL-BOZÜYÜK ROAD (SECTION II)

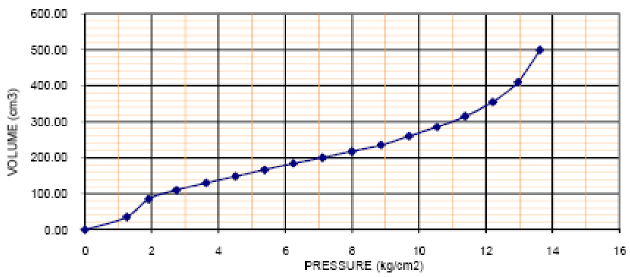
PRESSUREMETER TEST
IBH72-7i P-1



Date	23.11.2006	Po (γ z) (kg/cm2)	1.84	Probe dia.	60	mm	**YÜKSEL PROJE**
Borehole ID	IBH72-7i	P1 (kg/cm2)	3.19				YÜKSEL PROJE ULUSLARARASI A.Ş.
Test No	P-1	V1 (cm3)	260.00	K	2,304	cm3	Birlik Mahallesi 9. Cadde No:41
Depth	9.90	P2 (kg/cm2)	5.87	Pl	11.99	kg/cm2	06610 ÇANKAYA-ANKARA
GWT	8.50	V2 (cm3)	317.00	Pln	10.15	kg/cm2	TEL: (312) 495 70 00 FAX: (312) 495 70 24
Person	N.MENGILER	Vo (cm3)	535.00	E	108	kg/cm2	www.yukselproje.com.tr

BURSA-İNEGÖL-BOZÜYÜK ROAD (SECTION II)

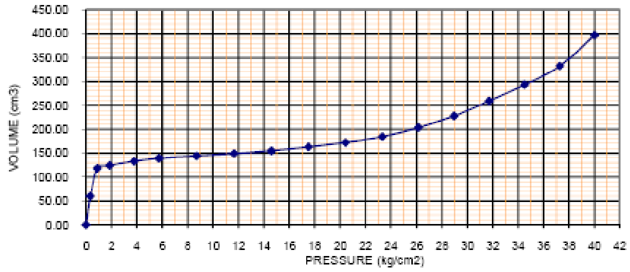
PRESSUREMETER TEST
IBH72-7i P-2



Date	24.11.2006	Po (γ z) (kg/cm2)	2.59	Probe dia.	60	mm	**YÜKSEL PROJE**
Borehole ID	IBH72-7i	P1 (kg/cm2)	5.38				YÜKSEL PROJE ULUSLARARASI A.Ş.
Test No	P-2	V1 (cm3)	166.00	K	2,062	cm3	Birlik Mahallesi 9. Cadde No:41
Depth	17.40	P2 (kg/cm2)	7.99	Pl	13.62	kg/cm2	06610 ÇANKAYA-ANKARA
GWT	8.50	V2 (cm3)	217.00	Pln	11.03	kg/cm2	TEL: (312) 495 70 00 FAX: (312) 495 70 24
Person	N.MENGILER	Vo (cm3)	535.00	E	106	kg/cm2	www.yukselproje.com.tr

BURSA-İNEGÖL-BOZÜYÜK ROAD (SECTION II)

PRESSUREMETER TEST
IBH72-12 P-1



Date	11.12.2006	Po (γ z) (kg/cm2)	1.48	Probe dia.	60	mm
Borehole ID	IBH72-12	P1 (kg/cm2)	5.75			
Test No	P-1	V1 (cm3)	139.00	K	1,962	cm3
Depth	7.40	P2 (kg/cm2)	11.66	PI	39.99	kg/cm2
GWT	8.75	V2 (cm3)	149.00	Pln	38.51	kg/cm2
Person	N.MENGILER	Vo (cm3)	535.00	E	1,160	kg/cm2

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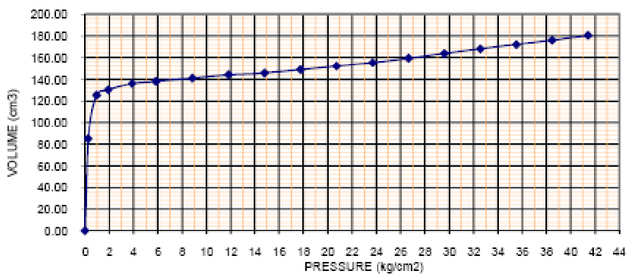
BURSA-İNEGÖL-BOZÜYÜK ROAD (SECTION II)

PRESSUREMETER TEST
IBH72-12 P-2



Date	12.12.2006	Po (γ z) (kg/cm2)	1.92	Probe dia.	60	mm
Borehole ID	IBH72-12	P1 (kg/cm2)	11.81			
Test No	P-2	V1 (cm3)	144.00	K	1,836	cm3
Depth	10.40	P2 (kg/cm2)	20.71	PI	41.40	kg/cm2
GWT	8.75	V2 (cm3)	152.00	Pln	39.49	kg/cm2
Person	N.MENGILER	Vo (cm3)	535.00	E	2,043	kg/cm2

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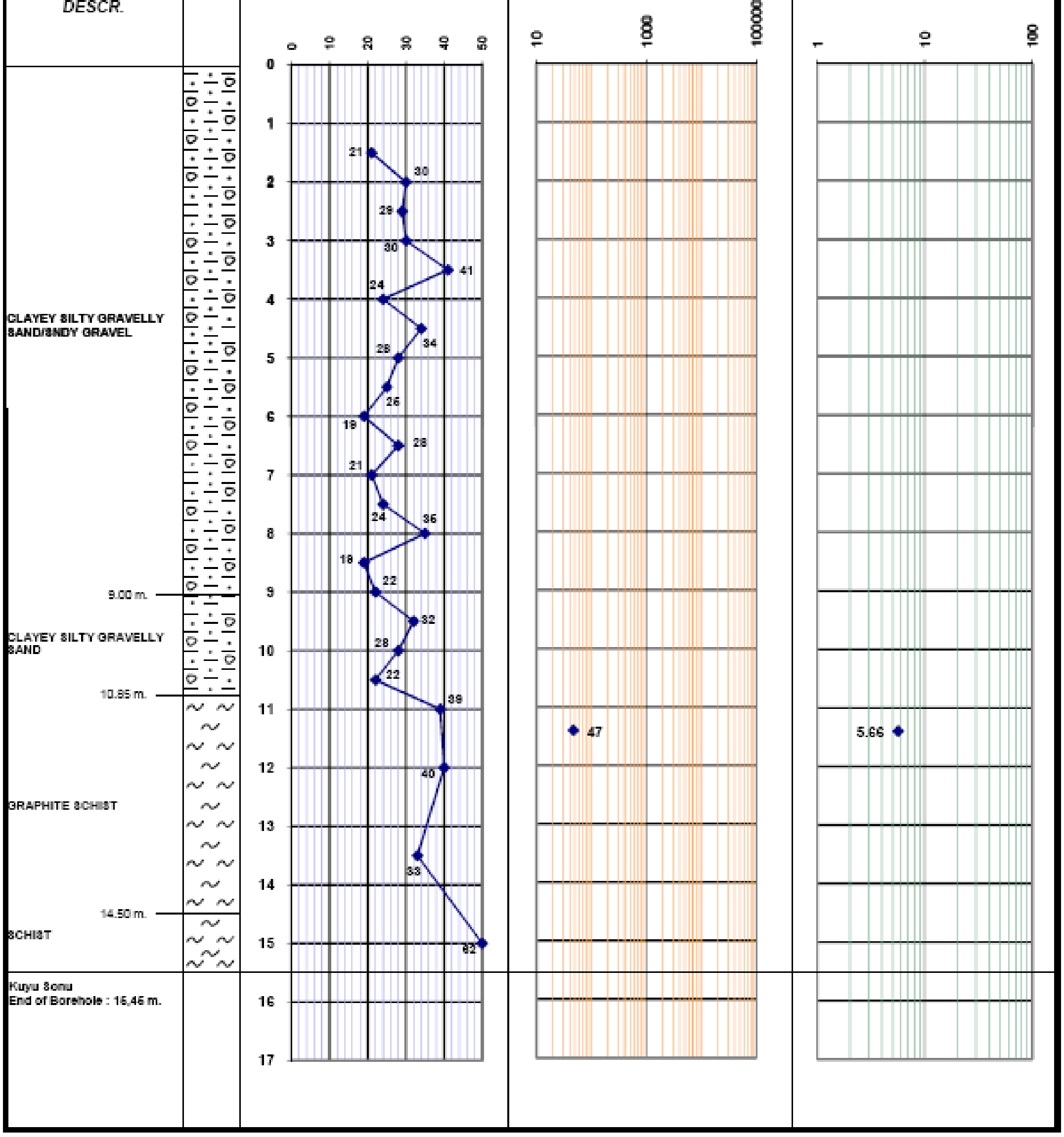
BURSA-İNEGÖL-BOZÜYÜK ROAD (SECTION II)
72+000 LANDSLIDE

SONDAJ NO / *BOREHOLE NO*	IBH72-1
YASS / *GWL*	2.05 m

ZEMİN TANIMI *SOIL DESCR.*	ZEMİN PROFİLİ *SOIL PROFILE*	STANDART PENETRASYON DENEYİ *STANDART PENETRATION TEST* N / 30 cm	PRESİYOMETRE DENEYİ *PRESSUREMETER TEST* DEFORMASYON MODÜLÜ *MODULUS OF DEFORMATION* (kg/cm²)	NET LİMİT BASINÇ *NET LİMİT PRESSURE* (kg/cm²)



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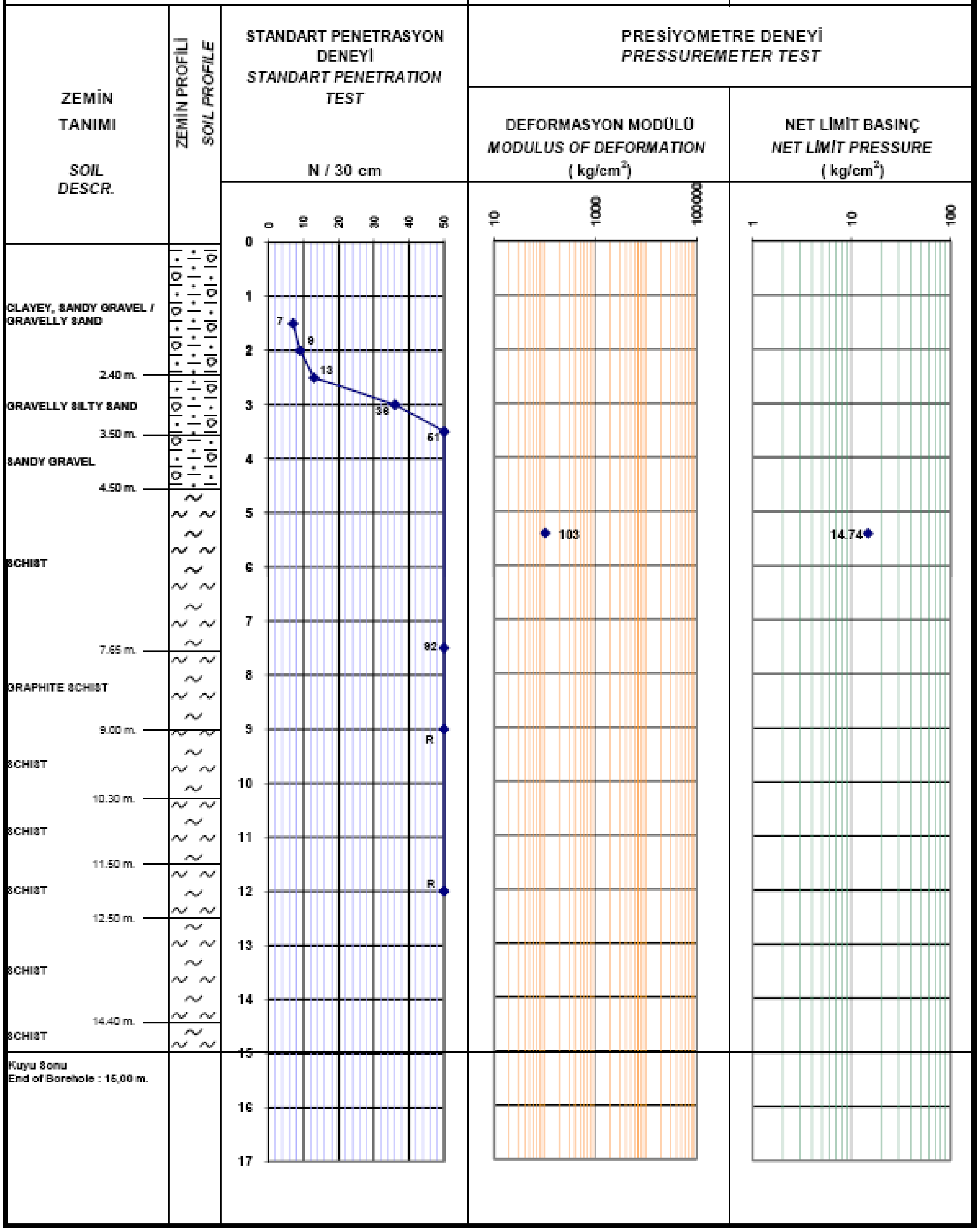
BURSA-İNEGÖL-BOZÜYÜK ROAD (SECTION II)
72+000 LANDSLIDE

SONDAJ NO / *BOREHOLE NO*	IBH72-2İ
YASS / *GWL*	1.70 m



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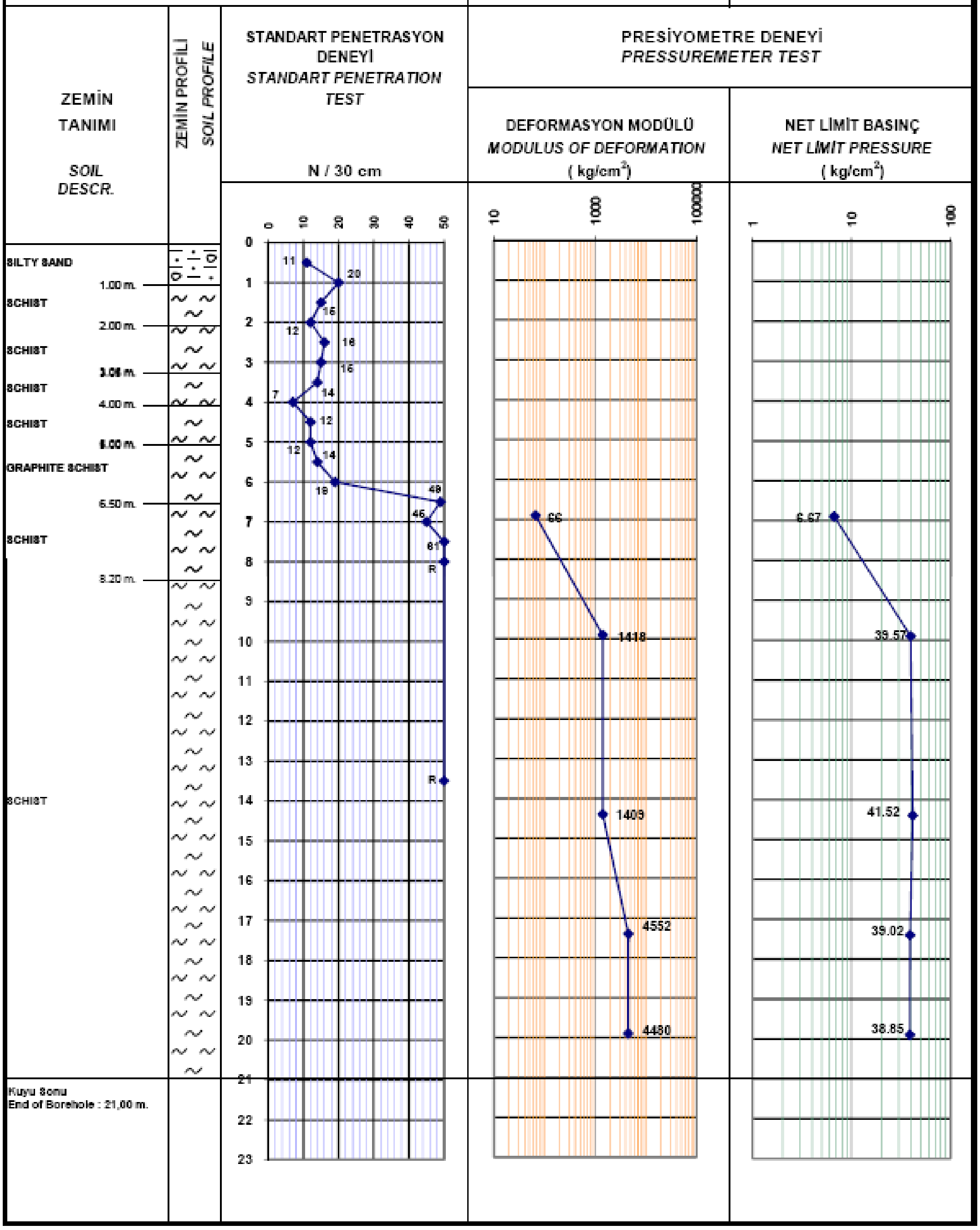
BURSA-İNEGÖL-BOZÜYÜK ROAD (SECTION II)
72+000 LANDSLIDE

SONDAJ NO / *BOREHOLE NO*	IBH72-3İ
YASS / *GWL*	7.40 m



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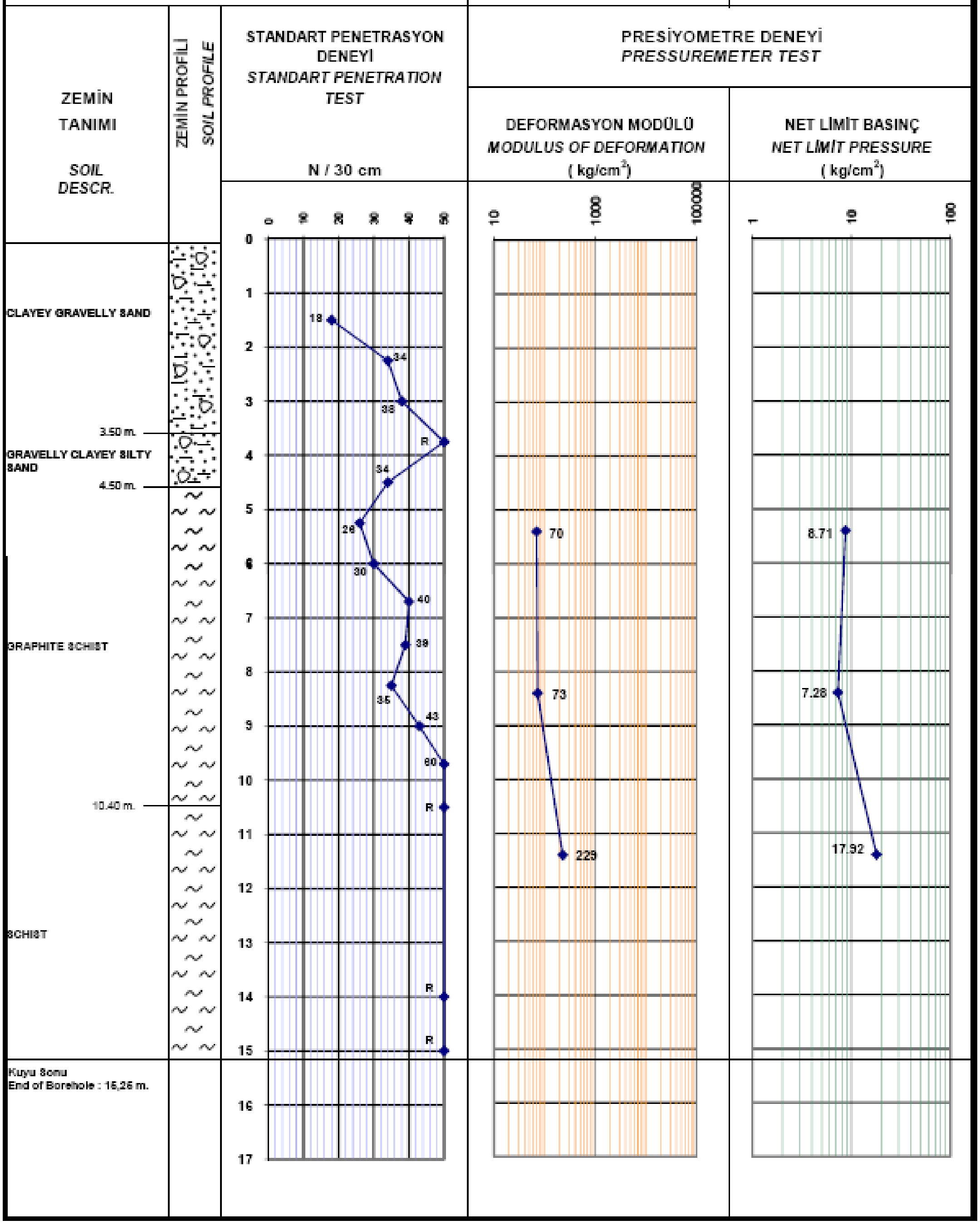
BURSA-İNEGÖL-BOZÜYÜK ROAD (SECTION II)
72+000 LANDSLIDE

SONDAJ NO / *BOREHOLE NO*	IBH72-6İ
YASS / *GWL*	2.15 m



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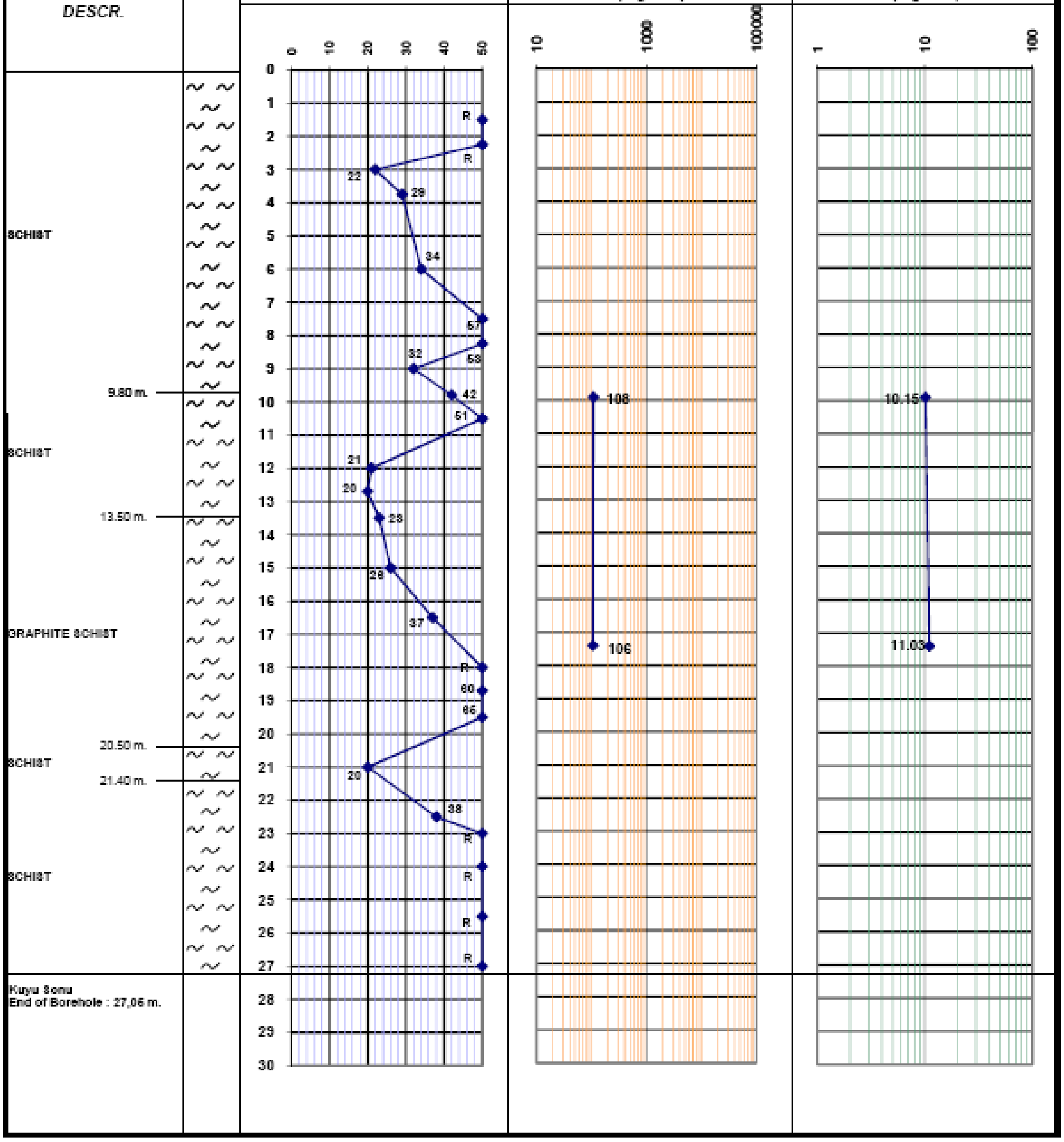
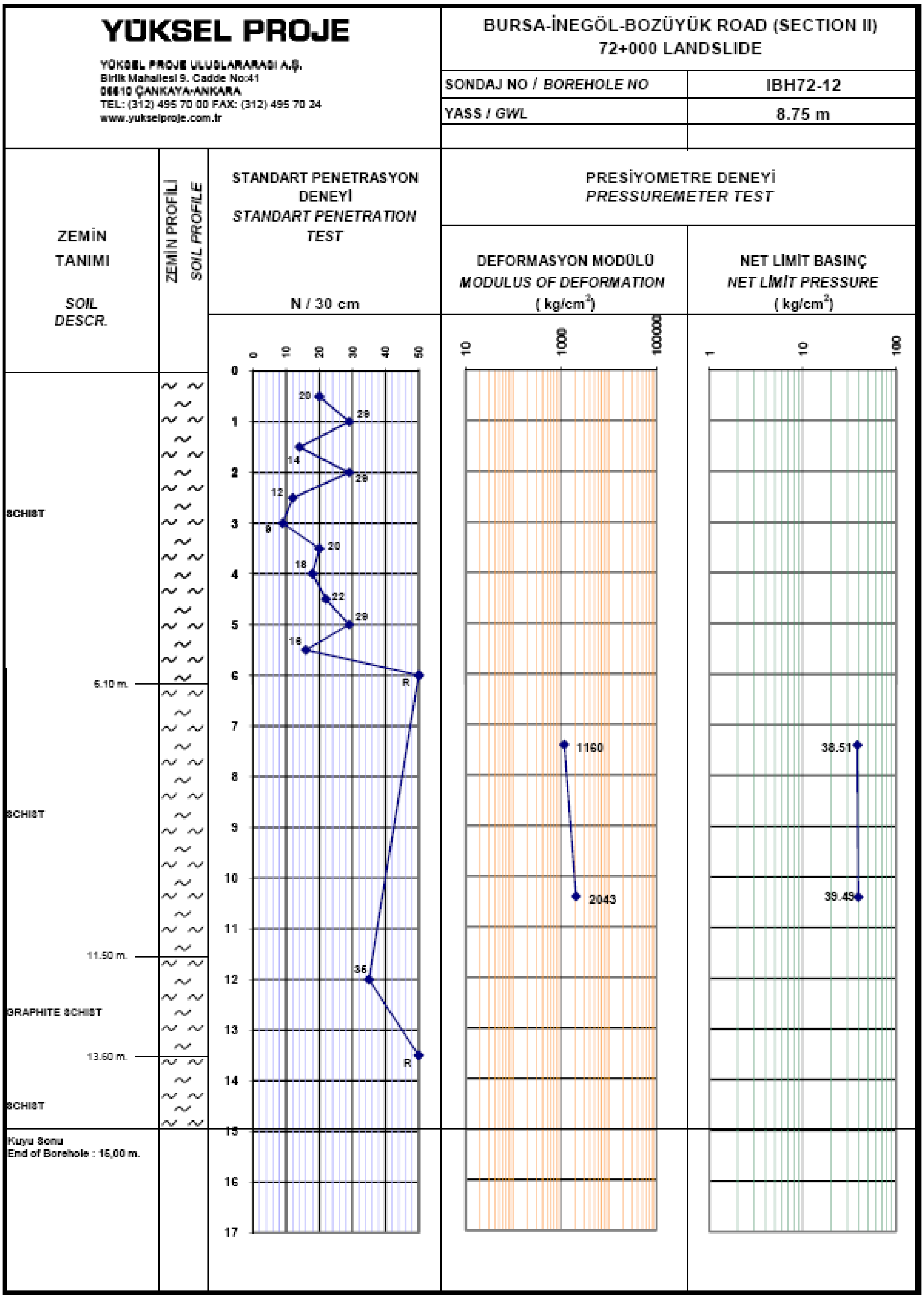
	SONDAJ NO / *BOREHOLE NO*	IBH72-7İ
	YASS / *GWL*	8.50 m

ZEMİN TANIMI *SOIL DESCR.*	ZEMİN PROFİLİ *SOIL PROFILE*	STANDART PENETRASYON DENEYİ *STANDART PENETRATION TEST* N / 30 cm	PRESİYOMETRE DENEYİ / *PRESSUREMETER TEST* DEFORMASYON MODÜLÜ *MODULUS OF DEFORMATION* (kg/cm^2)	NET LİMİT BASINÇ *NET LİMİT PRESSURE* (kg/cm^2)

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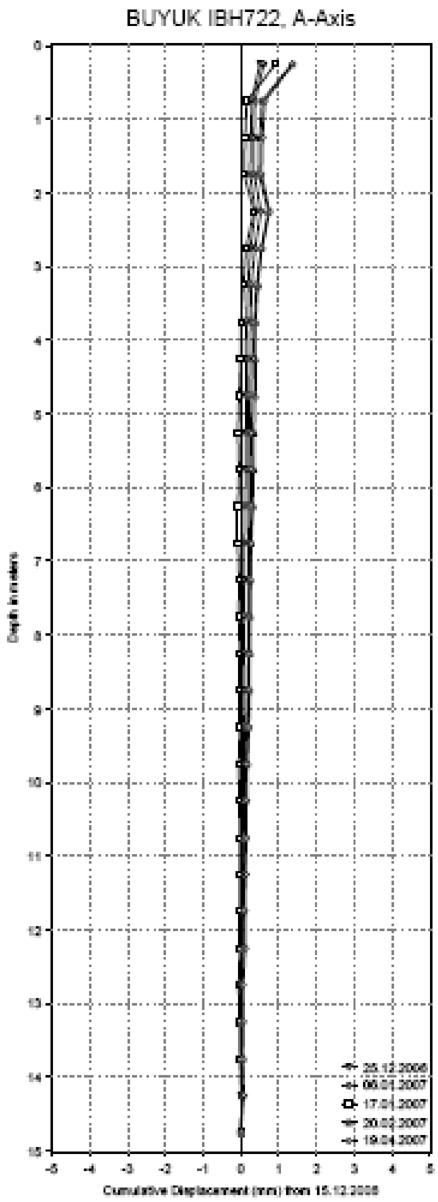
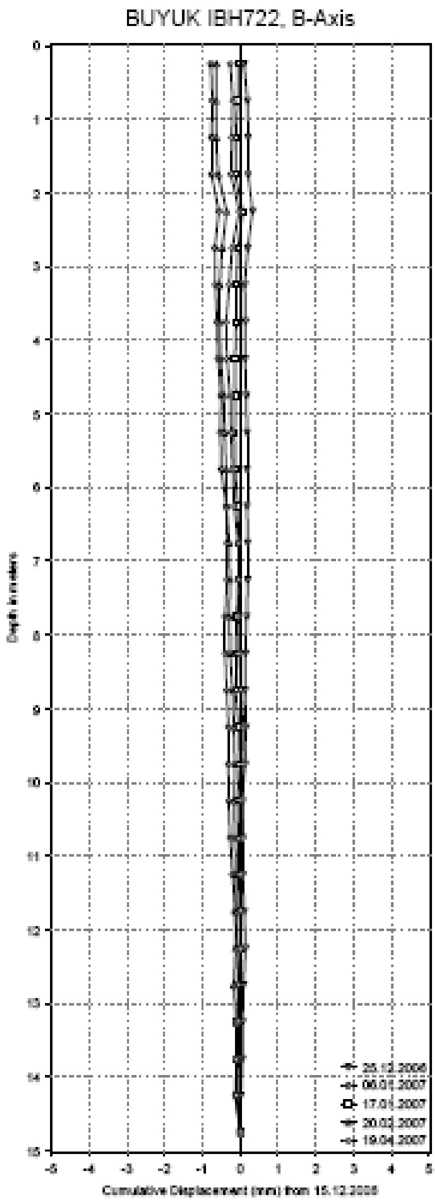
BURSA-İNEGÖL-BOZÜYÜK ROAD (SECTION II)
72+000 LANDSLIDE
SONDAJ NO / BOREHOLE NO
IBH72-12
YASS / GWL
8.75 m
ZEMİN TANIMI
SOIL DESCR.
ZEMİN PROFİLİ
SOIL PROFILE
STANDART PENETRASYON DENEYİ
STANDART PENETRATION TEST
N / 30 cm
PRESİYOMETRE DENEYİ
PRESSUREMETER TEST
DEFORMASYON MODÜLÜ
MODULUS OF DEFORMATION
(kg/cm2)
NET LİMİT BASINÇ
NET LİMİT PRESSURE
(kg/cm2)
SCHIST
6.10 m.
SCHIST
11.50 m.
GRAPHITE SCHIST
13.60 m.
SCHIST
Kuyu Sonu
End of Borehole : 15,00 m.
20
29
14
29
12
9
20
18
22
29
16
R
36
R
1160
2043
38.51
39.45

APPENDIX F

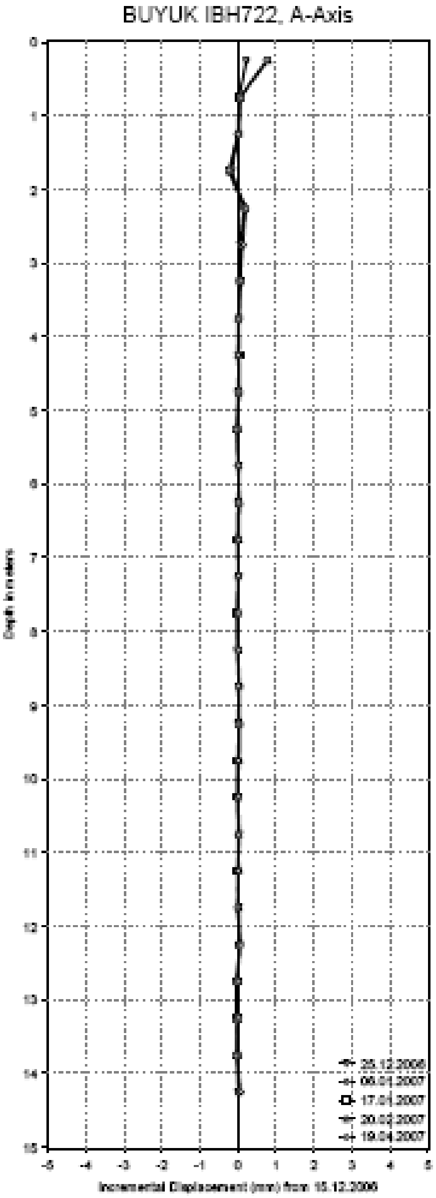
INCLINOMETER RESULTS

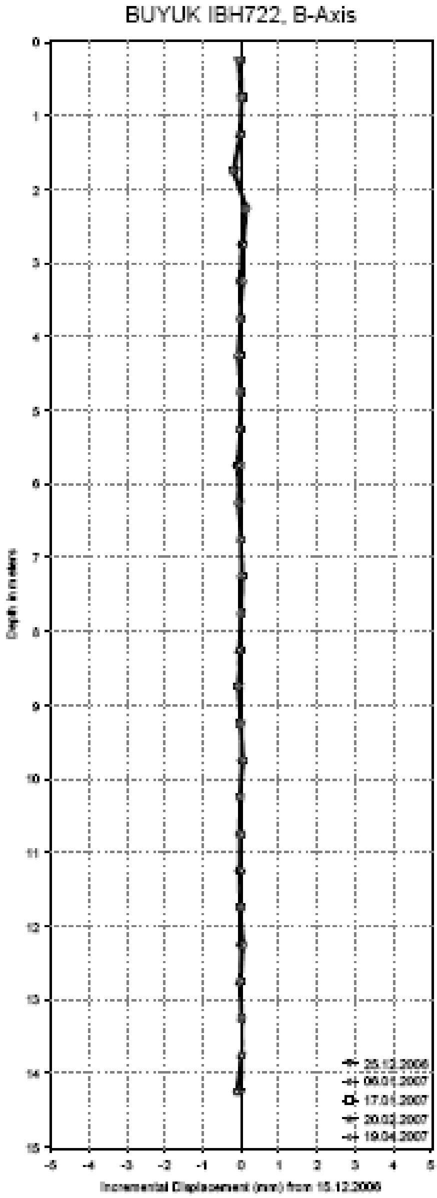




YÜKSEL PROJE

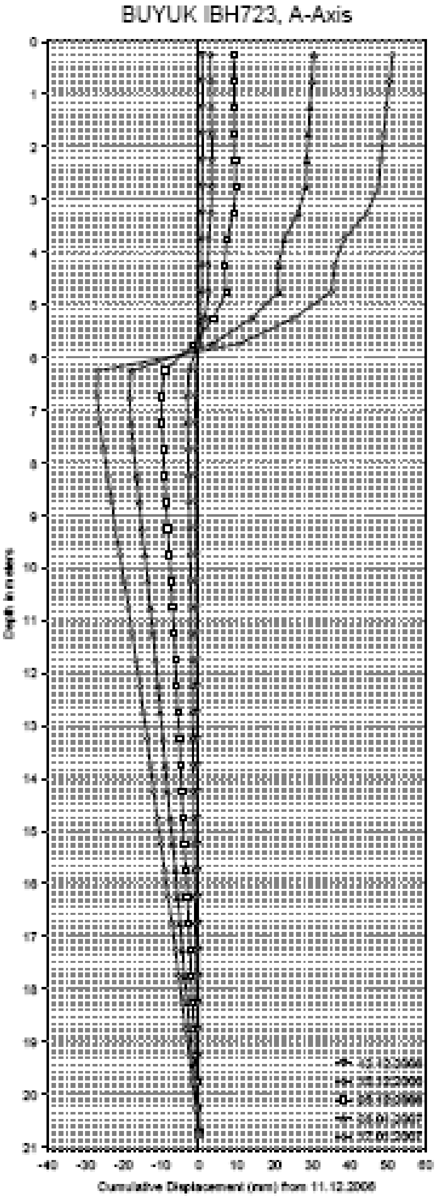
İNEGÖL - BOZÜYÜK YOLU (2.KISIM)
KM: 72+000-72+200 HEYELANI

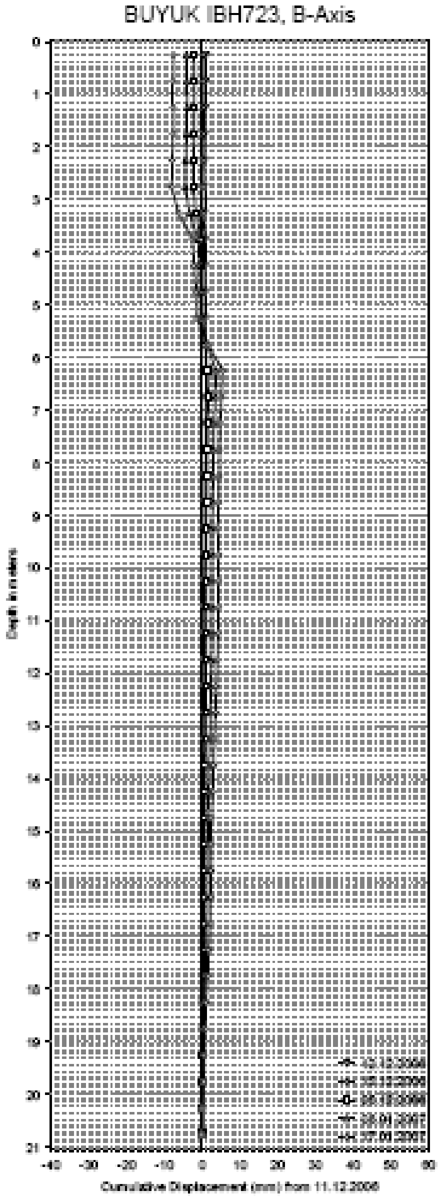




YÜKSEL PROJE

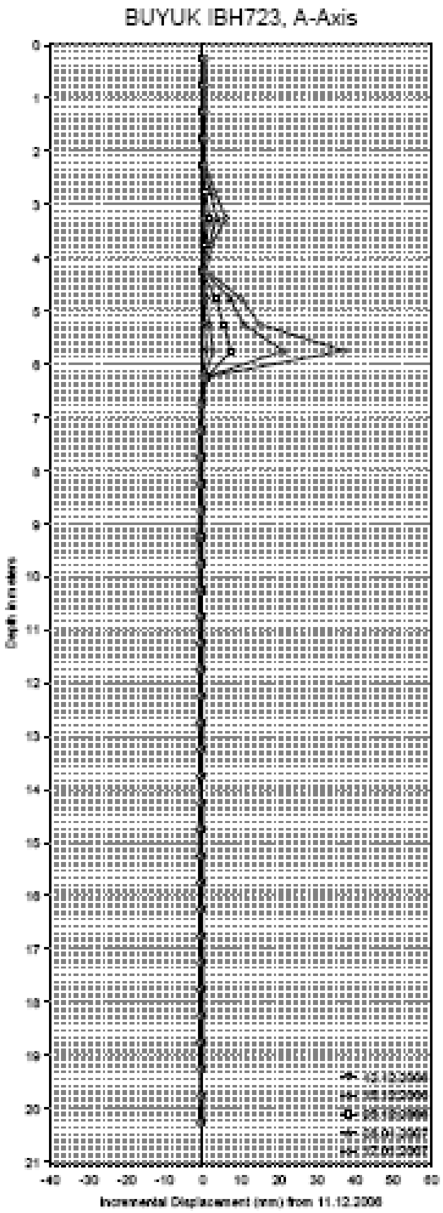
İNEGÖL - BOZÜYÜK YOLU (2.KISIM)
KM: 72+000-72+200 HEYELANI

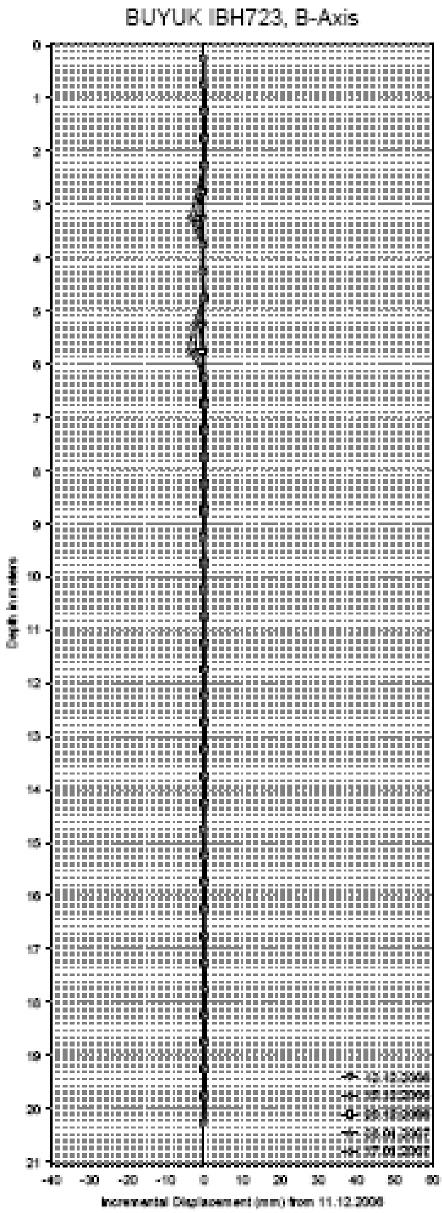




YÜKSEL PROJE

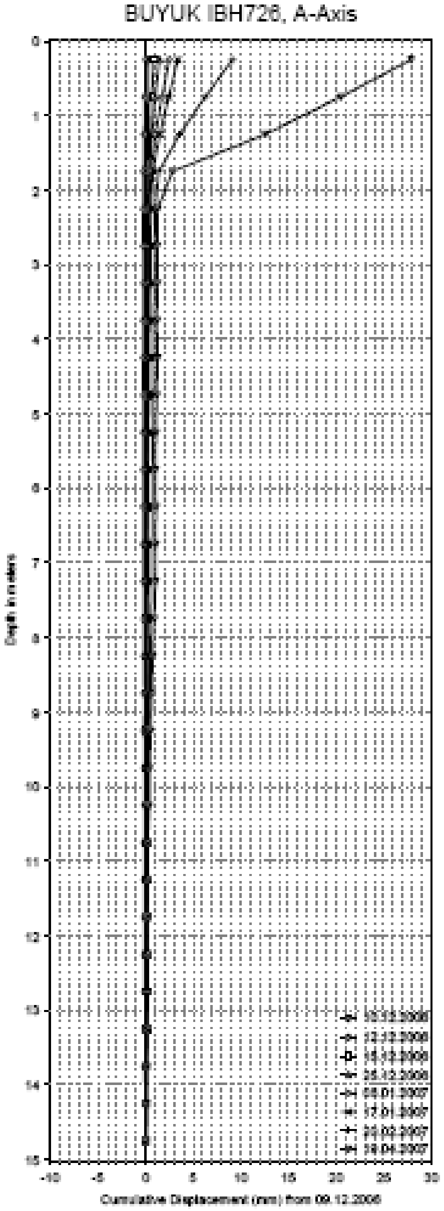
İNEGÖL - BOZÜYÜK YOLU (2.KISIM)
KM: 72+000-72+200 HEYELANI

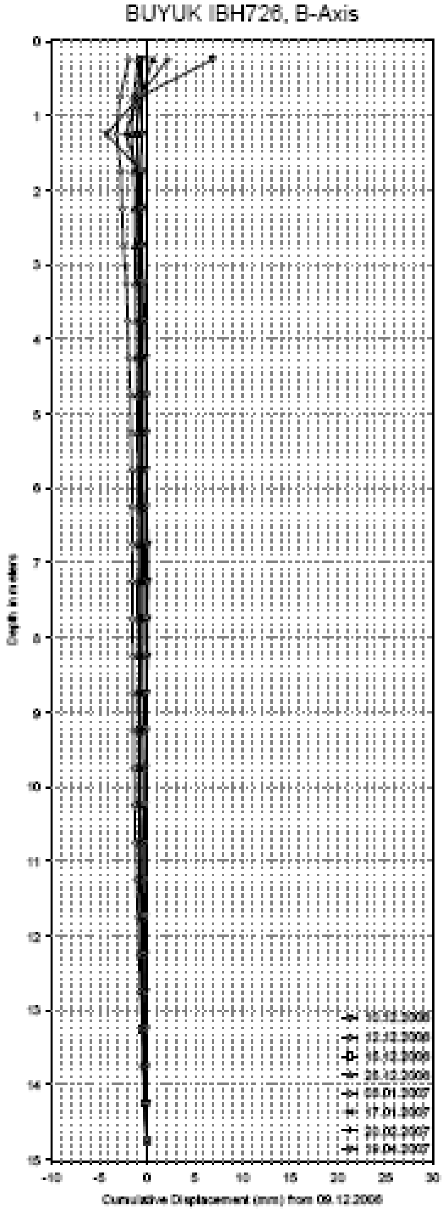




YÜKSEL PROJE

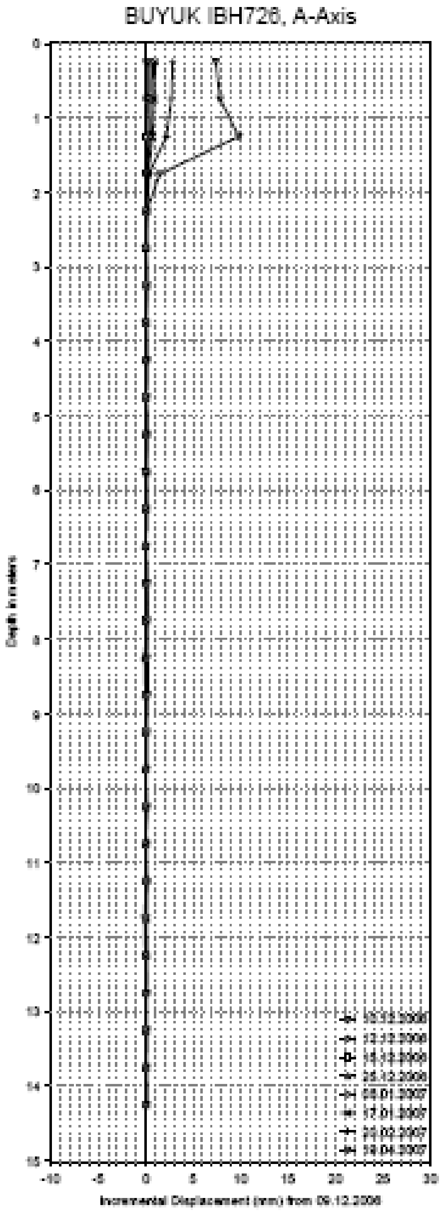
İNEGÖL - BOZÜYÜK YOLU (2.KISIM)
KM: 72+000-72+200 HEYELANI

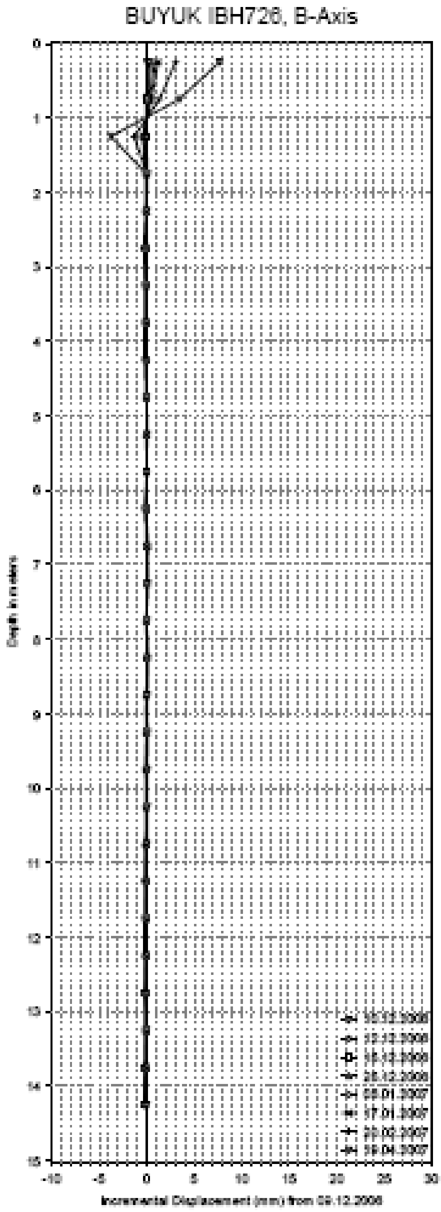




YÜKSEL PROJE

İNEGÖL - BOZÜYÜK YOLU (2.KISIM)
KM: 72+000-72+200 HEYELANI





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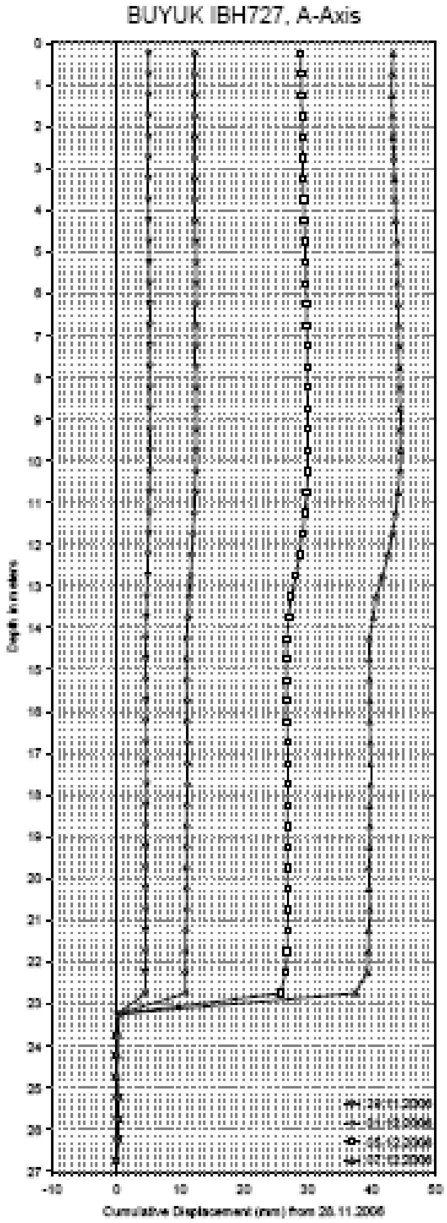
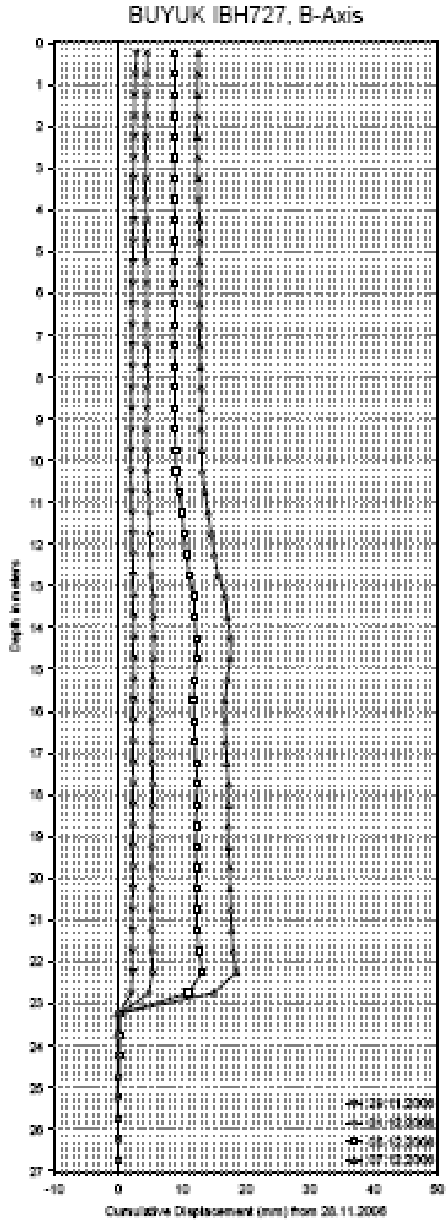
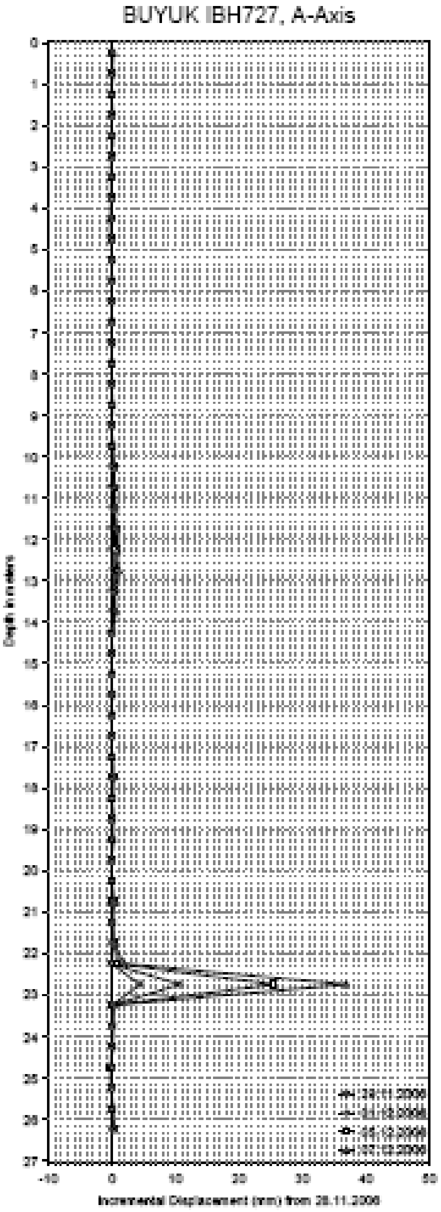
İNEGÖL - BOZÜYÜK YOLU (2.KISIM)
KM: 72+000-72+200 HEYELANI

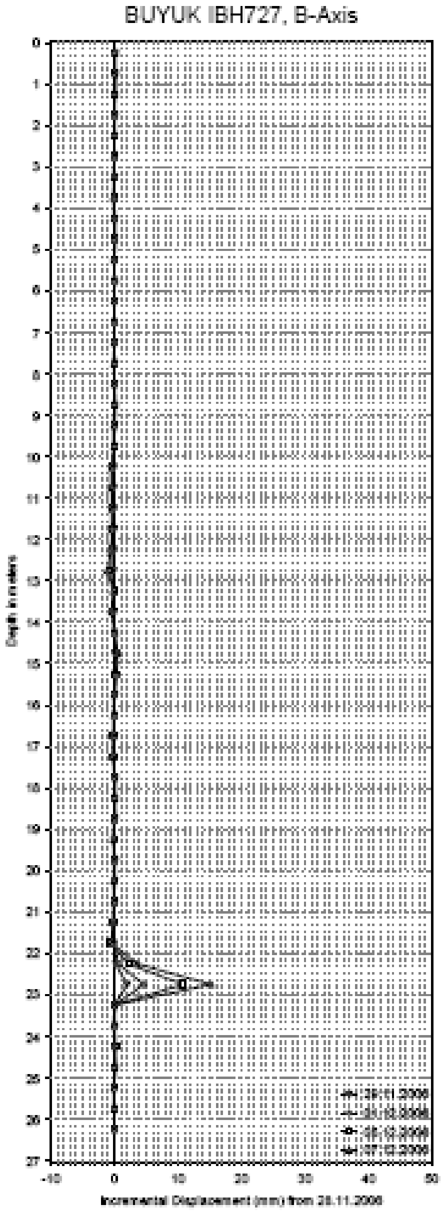




YÜKSEL PROJE

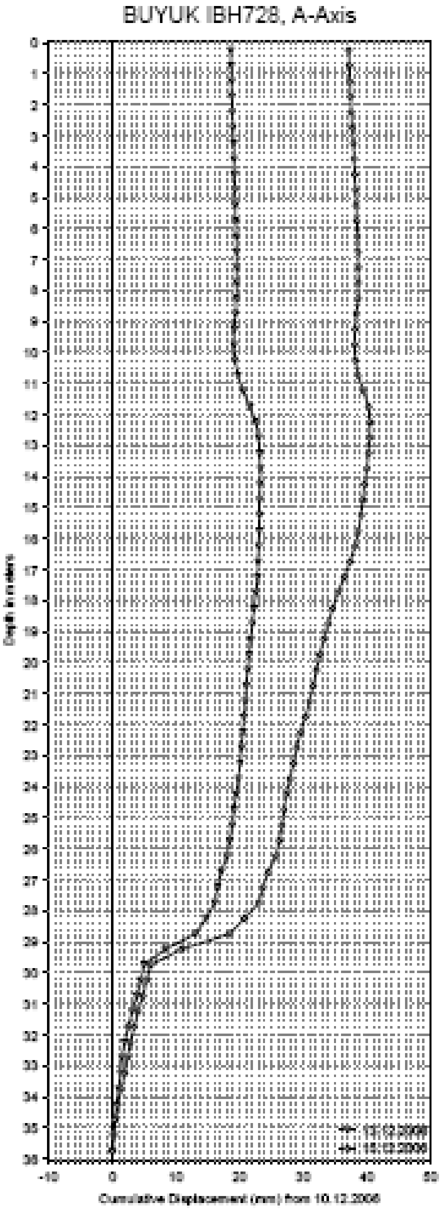
İNEGÖL - BOZÜYÜK YOLU (2.KISIM)
KM: 72+000-72+200 HEYELANI

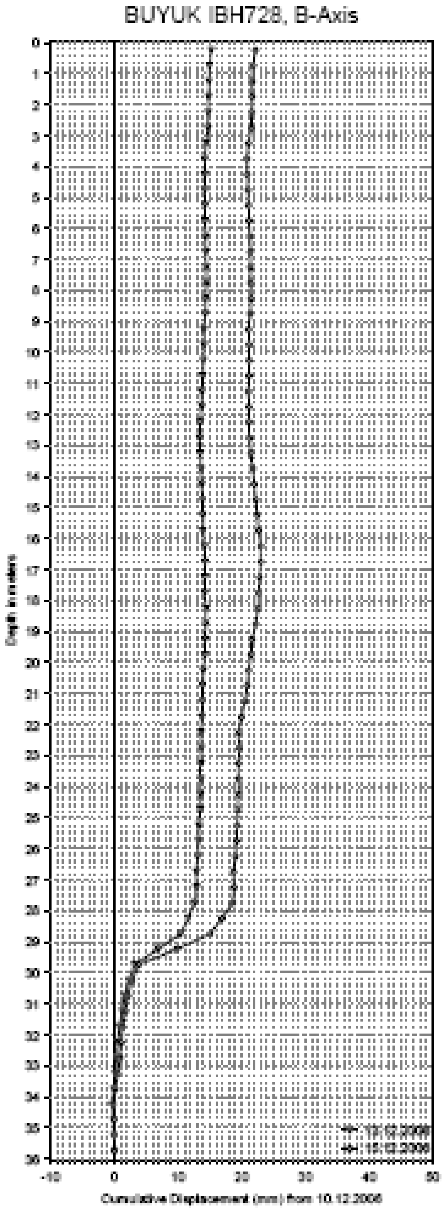




YÜKSEL PROJE

İNEGÖL - BOZÜYÜK YOLU (2.KISIM)
KM: 72+000-72+200 HEYELANI

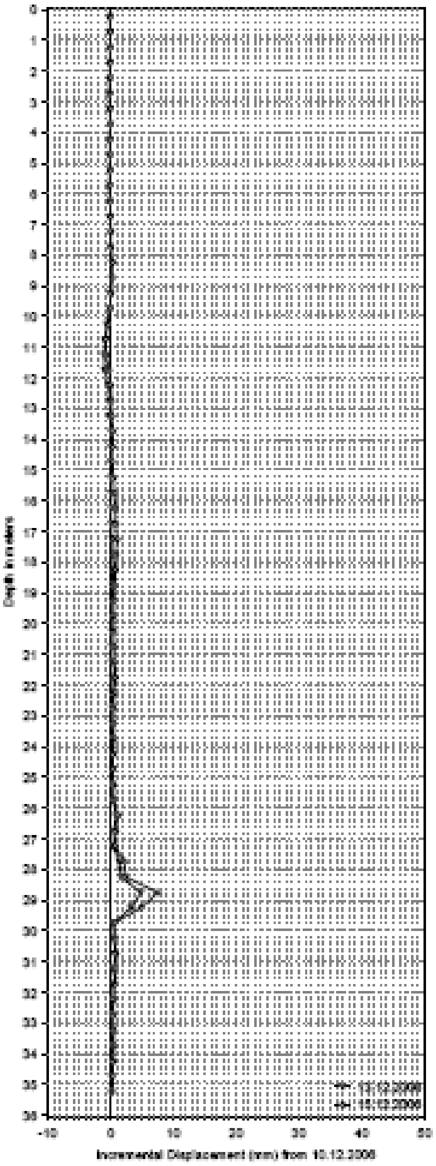




YÜKSEL PROJE

İNEGÖL - BOZÜYÜK YOLU (2.KISIM)
KM: 72+000-72+200 HEYELANI

BUYUK IBH728, A-Axis



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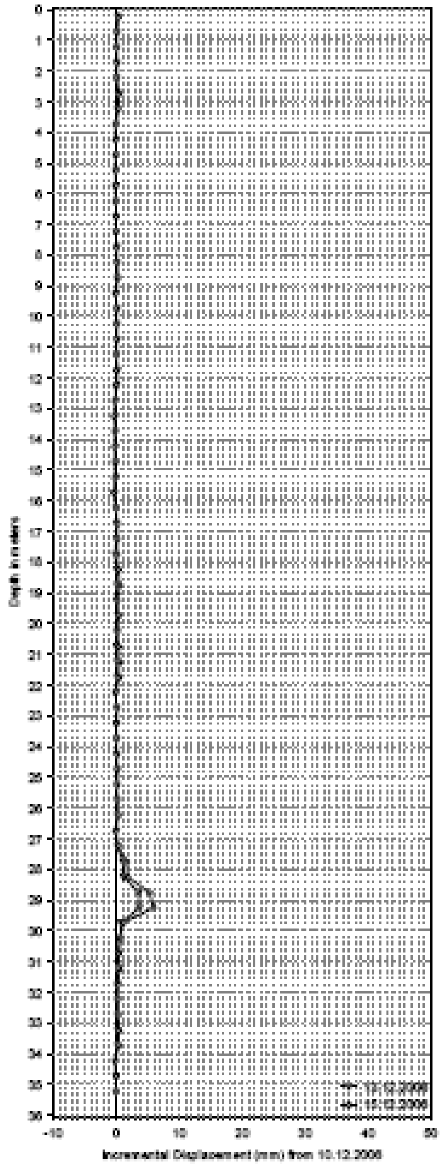
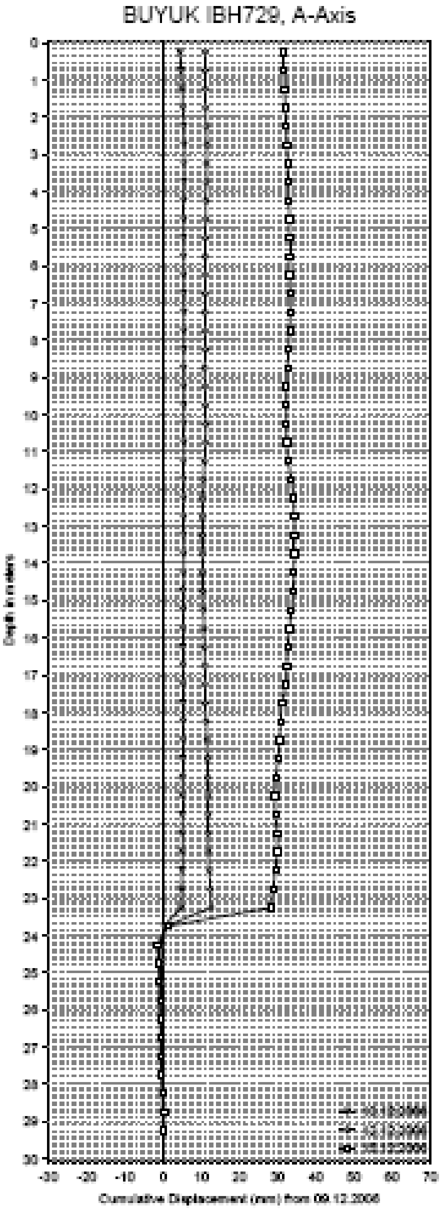
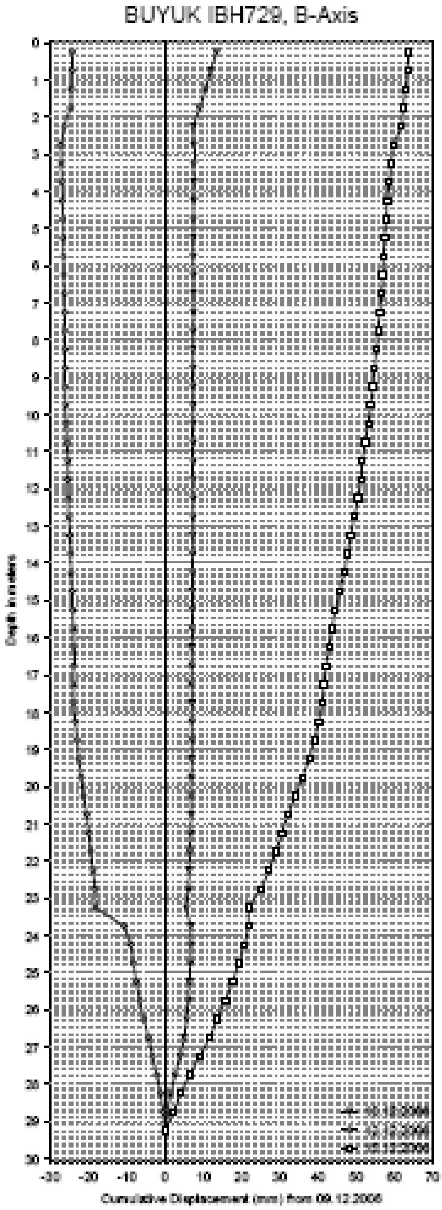


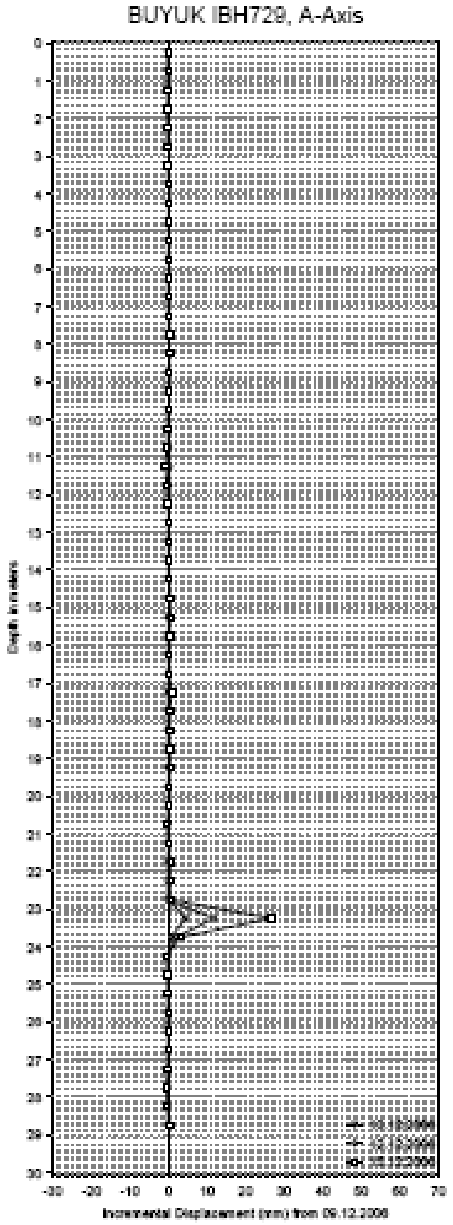
YÜKSEL PROJE

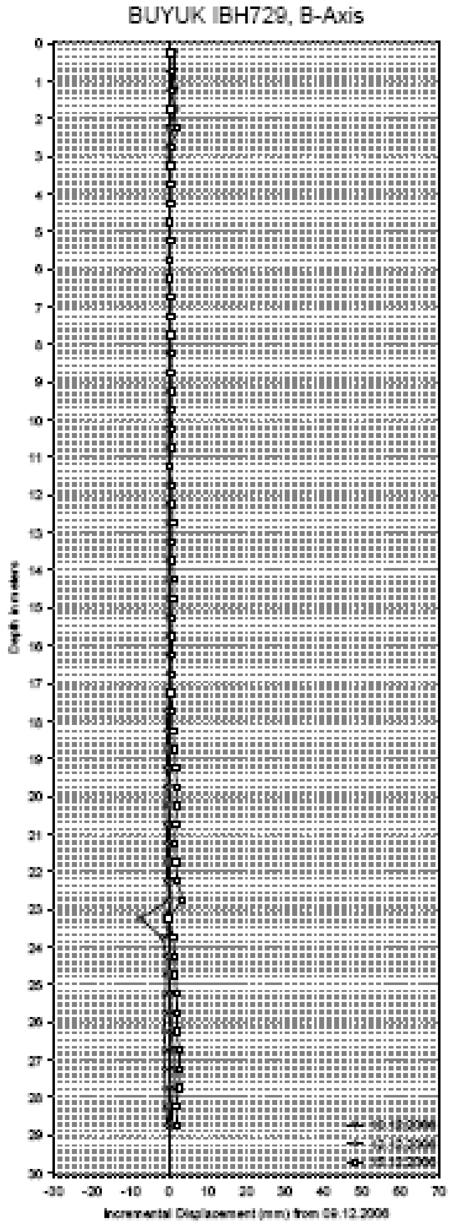
İNEGÖL - BOZÜYÜK YOLU (2.KISIM)
KM: 72+000-72+200 HEYELANI





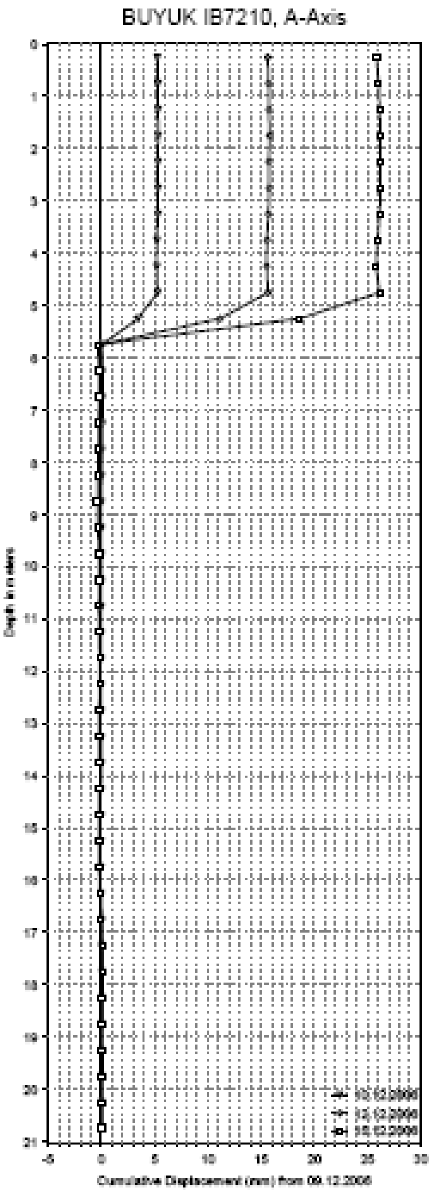
YÜKSEL PROJE	**İNEGÖL - BOZÜYÜK YOLU (2.KISIM)** **KM: 72+000-72+200 HEYELANI**

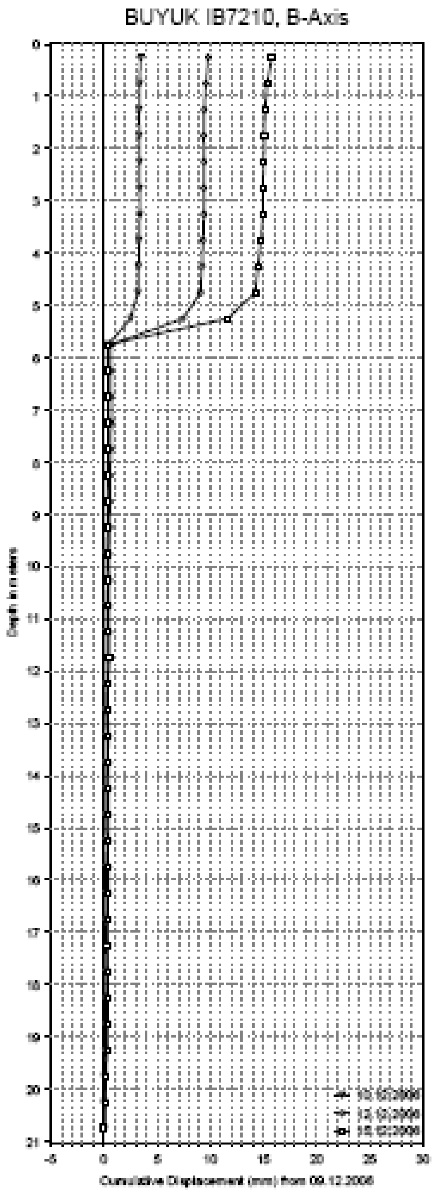




YÜKSEL PROJE

İNEGÖL - BOZÜYÜK YOLU (2.KISIM)
KM: 72+000-72+200 HEYELANI

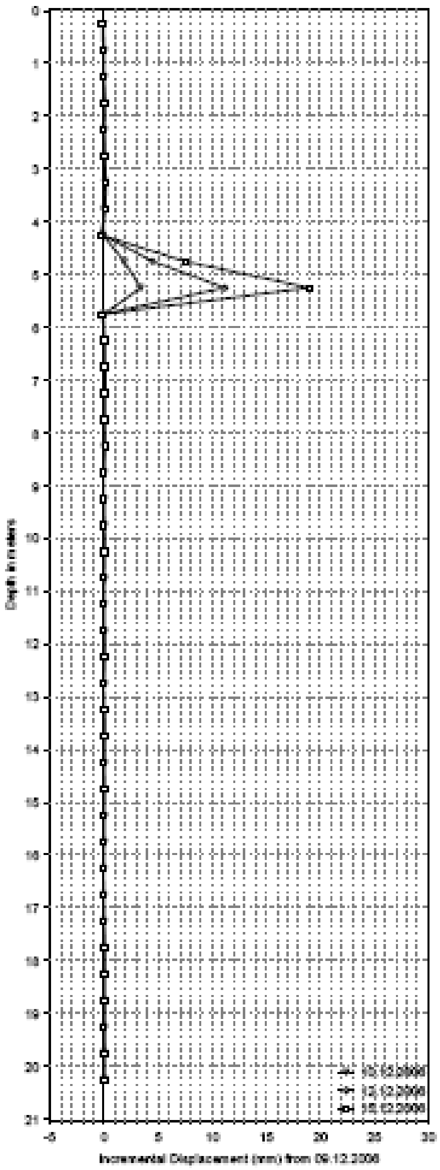




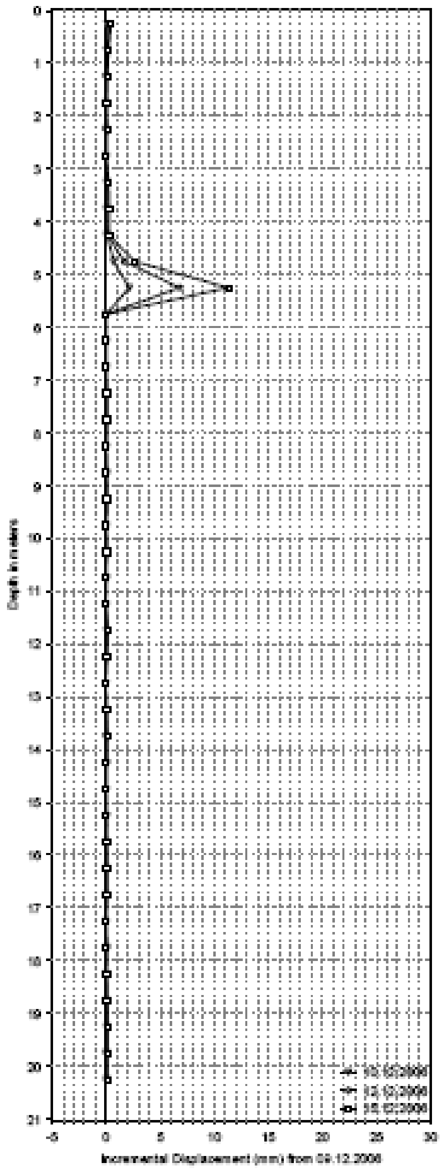
YÜKSEL PROJE

İNEGÖL - BOZÜYÜK YOLU (2.KISIM)
KM: 72+000-72+200 HEYELANI

BUYUK IB7210, A-Axis



BUYUK IB7210, B-Axis



YÜKSEL PROJE

İNEGÖL - BOZÜYÜK YOLU (2.KISIM)
KM: 72+000-72+200 HEYELANI