ESTIMATION OF CONSOLIDATION SETTLEMENTS CAUSED BY GROUNDWATER DRAINAGE AT ULUS-KEÇİÖREN SUBWAY PROJECT

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

M. ERDEM ALTINBİLEK

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
GEOLOGICAL ENGINEERING

APRIL 2006

Approval of the Graduate School of Natural and Applied Sciences.

Prof. Dr. Canan Özgen
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

Prof. Dr. Vedat Doyuran
Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

Prof. Dr. Vedat Doyuran
Supervisor

Examining Committee Members

Prof. Dr. Nurkan Karahanoğlu	(METU, GEOE)	______________________
Prof. Dr. Vedat Doyuran	(METU, GEOE)	______________________
Prof. Dr. Reşat Ulusay	(HU, GEOE)	______________________
Doç. Dr. Tamer Topal	(METU, GEOE)	______________________
Doç. Dr. K. Önder Çetin	(METU, CE)	______________________

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Lastname : M. Erdem ALTINBİLEK

Signature :

ABSTRACT

ESTIMATION OF CONSOLIDATION SETTLEMENTS CAUSED BY GROUNDWATER DRAINAGE AT ULUS-KEÇİÖREN SUBWAY PROJECT

ALTINBİLEK, M. Erdem
M.Sc., Department of Geological Engineering
Supervisor: Prof. Dr. Vedat DOYURAN

April 2006, 189 pages

Prediction of ground settlements have always been a big challenge for the engineers that are responsible for the design of subway tunnel projects. Since ground settlement is a crucial concept directly affecting the successfulness of a project, it must be taken seriously and should be accurately estimated. Consolidation settlements in the close proximity of Ulus-Keçiören Subway project due to groundwater drainage is the focus of this study. In this sense, the necessary data about the project characteristics and the site conditions were collected thru project descriptions and the geotechnical investigations conducted at the project site. Utilizing the generated database analytical calculations were carried out to predict the settlements. Upon completion of this stage of analysis several of the locations were numerically modeled for further investigation. Numerical analysis was conducted at four sections by using Plaxis, to determine the amount of expected displacements and the resulting groundwater situation. Despite of the differences between these two methods the resulting settlement estimations displayed consistency.

Keywords: consolidation settlement, subway tunnel, groundwater drainage

ÖZ

ULUS-KEÇİÖREN METRO GÜZERGAHINDA YERALTISUYU DRENAJI NEDENİYLE OLUŞAN KONSOLİDASYON OTURMALARININ BELİRLENMESİ

ALTINBİLEK, M.Erdem
Yüksek Lisans, Jeoloji Mühendisliği Bölümü
Tez Yöneticisi: Prof. Dr. Vedat DOYURAN

Nisan 2006, 189 sayfa

Metro tünel projelerinden sorumlu mühendisler için yüzey oturmaları her zaman önemli bir sorun teşkil etmektedir. Bu sorun, projenin başarısını doğrudan etkilemesi nedeniyle, ciddi olarak ele alınmalı ve hassas bir şekilde hesaplanmalıdır. Ulus-Keçiören Metro projesinde yeraltısuyu drenajı nedeniyle meydana gelebilecek konsolidasyon oturmaları bu çalışmanın odak noktasıdır. Bu amaçla, proje tanımlamaları ve jeoteknik araştırmalar dikkate alınarak proje özellikleri ve arazi koşulları hakkında gerekli bilgiler elde edilmiştir. Oluşturulan veritabanı yardımıyla olası oturma miktarları analitik olarak hesaplanmıştır. Analizin bu aşaması tamamlandıktan sonra belirlenen kesimler sayısal analizlerle ayrıntılı olarak incelenmiştir. Seçilen dört adet kesitte Plaxis programı ile olası deplasman değerleri ve yeraltısuyu son durumu belirlenmiştir. Bu iki yöntem arasındaki farklılıklara rağmen bulunan tahmini oturma miktarlarında tutarlılık gözlenmiştir.

Anahtar Kelimeler: konsolidasyon oturmaları, metro tüneli, yeraltısuyu drenajı

In loving memory of my dear Grandmother,
Gönül Çağlayaner

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to Prof. Dr. Vedat Doyuran for his valuable and encouraging guidance. He is the person that introduced me to geology a very long time ago and it has been a great experience to work with him ever since.

Special thanks to Dr. Nihat Işık that has provided valuable support on the numerical aspects of this dissertation. Thanks are also due to Yüksel Proje for providing the data that this study is based on.

I am very grateful to my beloved friends, Günseli – Deniz Akınç and Musa Yılmaz for standing beside me. Their great help and caring motivation made it a lot easier to complete this challenging work. I am also very thankful to Dr. Şahnaz Tiğrek for the useful academic advice she passed on.

Most importantly, I would like to thank my wonderful family that has always been there for me. I will always feel indebted for the unlimited love and constant support they have provided.

TABLE OF CONTENTS

LIST OF TABLES

Table

LIST OF FIGURES

Figure

CHAPTER 1

INTRODUCTION

1.1. Purpose and Scope

The focus of this study is to estimate the consolidation settlements taking place at the Ulus-Keçiören Subway Project. By calculating the settlements using different approaches, this study aims to investigate the efficiency of a variety of methods for calculating consolidation caused by groundwater drainage. During the course of the study a feedback of related theoretical information will also be provided.

Different approaches to be used for the estimation of consolidation settlements include both analytical and numerical methods. In this sense a range of information about the concept of consolidation and methods of settlement calculation are given as well as a detailed overview of the Ulus-Keçiören Subway project. The calculations were carried out by the help of both theoretical information such as commonly used concepts, equations determined by well known previous studies, textbook materials and data retrieved from the site such as the borehole logs, groundwater records, related laboratory test results and monitoring data.

Even though tunneling projects may cause many short and long term disturbances, this study specifically emphasizes the settlements due to the drawdown of groundwater table. This thesis discusses consolidation settlement calculations under the influence of Ulus-Keçiören project and suggests ways to improve the performance of these calculations where possible.

The settlement calculation process is the usual work to be done in every subway tunneling project and it is done in an intensive manner for the sake of the project. Every factor is carefully taken into consideration in detail within the project works to ensure an engineering accomplishment that will be satisfactory for its lifetime. Meanwhile the outcome of this study will represent an alternative point of view regarding the calculation methods and will be crucially important depending on the density of the population and constructions at the project area.

1.2. Location of the Study Area

The study area is the Ulus-Keçiören subway route which is 9685 meters long and stretched between two of Ankara’s most densely populated and intensely constructed neighborhoods. As seen in Figure 1.1 the subway route initiates from Gençlik Parkı and intersects Istanbul Road reaching Kazım Karabekir Avenue. Following this avenue it then passes through Fatih and Kızlar Pınarı Boulevards. After Gökçek Park it reaches the Dutluk Crossroad. From there the route leads to Gazino Crossroad through Nuri Pamir Boulevard and ends at Aksaray Avenue. There are 9 subway stations that will be built along this route. Most of these stations are named after the areas which they will be built in and they are: Ulus, ASKİ, Dışkapı, Meteroloji, Belediye, Mecidiye, Kuyubaşı, Dutluk and Gazino stations.

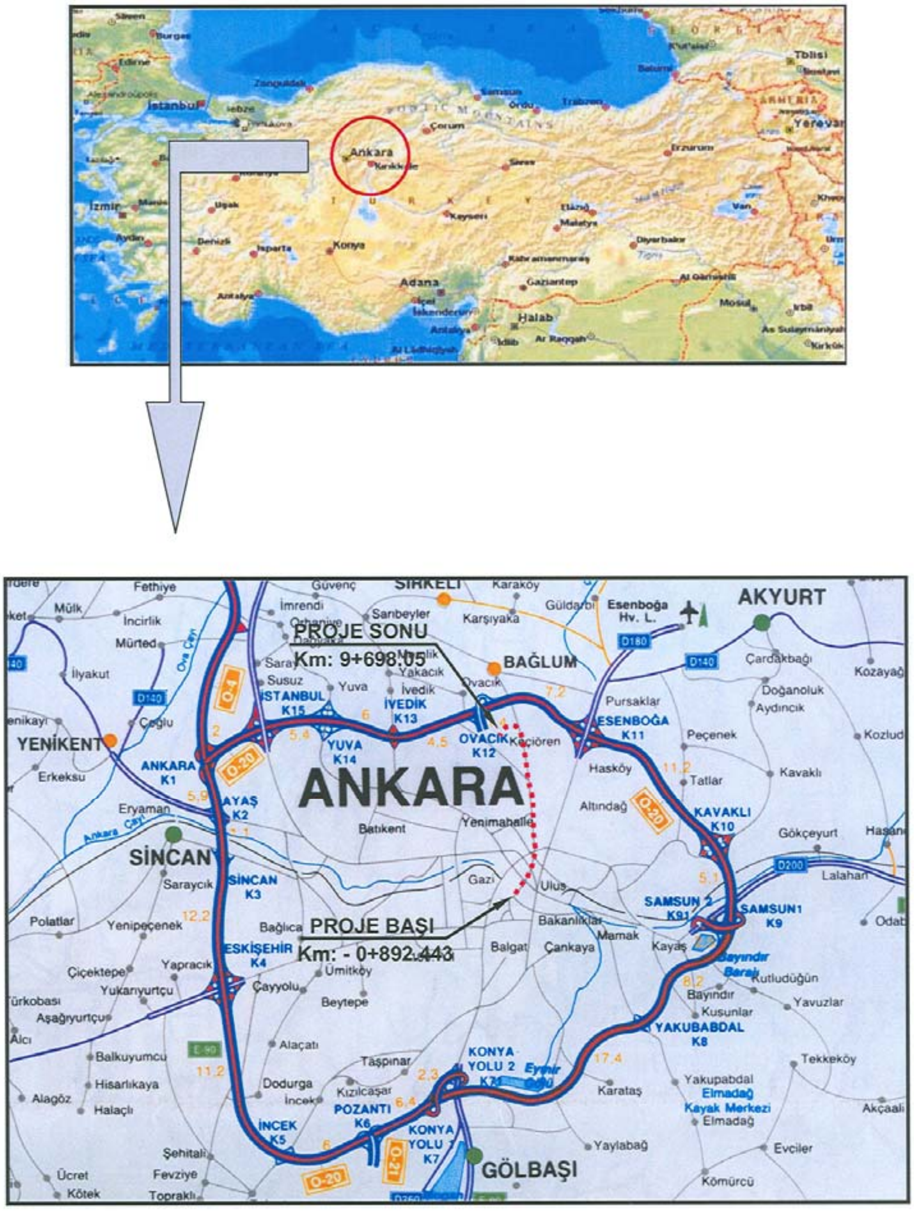


Figure 1.1 Location of the study area (Yüksel Proje, 2003)

Starting from Ulus the topography of the area is mostly flat (approximately at 850 meters of elevation) or slightly undulated. Towards the end where the project approaches the Keçiören area, topography starts rising steeply to higher elevation.

Since the project is located at where could be referred to as the heart of the city of Ankara, the construction stage is undergoing major challenges. The project works have to be performed under extreme care in order not to damage any of the surrounding structures above ground or service infrastructure founded below the ground as well as not to interfere with daily lives of the population within the vicinity of the neighborhood. Passing by many important residential and commercial areas the project will have a major affect on the city of Ankara. Even though the project is designed to make this a positive one, a minor mistake in the engineering applications can cause a mess in this critical area. Upon completion the project will provide a huge percentage of population the practicality of public mass transit which is not as well developed as it is supposed to be.

1.3. Previous Studies

Construction of urban tunnels in soft soil or weak rocks requires meticulous considerations in terms of geotechnical site investigations, construction methods, types of tunnel boring machines, tunnel support systems, groundwater control measures, instrumentation and monitoring of surface subsidence and the subsequent impact on nearby buildings and services. Among the considerations, the most important aspect is the control of surface subsidence and types of ground deformation to minimize any damage to surrounding constructions and disturbance to the population in the environment.

As infrastructure, buildings and services stretch through the densely populated and scarcely limited land space, the engineering projects that are to be designed at these areas should yield minimum disturbance to the routine daily lives of the city both while under construction and when providing service. In order to fully understand the extent of disturbance due to tunneling in such tight conditions, a comprehensive knowledge of the deformation caused by tunneling is essential. For settlement prediction purposes many empirical methods have been developed over the years through various field studies and experiences to predict the settlement caused by tunneling in soft ground by Peck (1969), Attewell *et al.* (1986), New and O'Reilly (1991) and semi-empirical methods were also developed by Lo *et al.* (1984). Some important considerations for the prediction of settlement are presented in their solutions but may not provide assistance in obtaining the ultimate result. Analytical methods could also be utilized, however, the characteristics of the soil profile and the site conditions regarding that specific design have to be acknowledged. Continuous research and advancement in technology towards tunneling works will inevitably lead to safer and both economically and environmentally efficient construction process (Tan and Ranjith, 2003).

There exist several approaches that are readily used in prediction of ground deformations associated with tunneling. Namely, analytical methods and numerical methods are commonly used in practice and the selection of the appropriate method depends on the complexity of the problem (Loganathan and Poulos, 1998).

Among many factors creating ground subsidence, one of the main causes is the consolidation process due to reduction of groundwater level. Even relatively small groundwater drainage will very rapidly reduce the pore pressure within a medium of soft clay deposits. This will then initiate a consolidation process gradually progressing upwards through the deposit. Such a consolidation process can lead to large ground deformations severely damaging any structure above this deposit. Even a tunnel project of average size may produce settlements up to 30-40 cm along the tunnel and settlements could be observed as far as 500 m from the tunnel alignment (Karlsrud, 2001).

Limiting of the surface settlement caused by tunneling in shallow and soft ground is of utmost importance for any tunnel engineer. While creating a solution for this great challenge one must not overlook the complexities of tunneling. Many problems can arise if settlements caused by tunneling are considered to be only vertically troubling. Studies and field works have shown numerous times that tunneling also causes lateral deformation and the longitudinal movement of the ground at the sides and ahead of the tunnel face, respectively. As a result of scarcity of research conducted to understand the longitudinal behavior of the ground along tunnel axis, very limited information is acknowledged to grasp longitudinal settlement. Attewell and Woodman (1982) overcame the difficulties of field studies, equipment installation and intensive monitoring by the help of an assumption which later on led to a model. Studies involving the lateral movement of the ground due to tunneling were comparatively more extensive. An empirical equation by Norgrove *et al.* (1979) is an aid to relate the subsurface settlement to the lateral deformations (Tan and Ranjith, 2003).

Proper drainage of groundwater during tunnel construction is essential because of three main reasons. First is to prevent an adverse internal environment. Tunnels and underground openings are subject to strict requirements to obtain a safe and dry internal environment for various reasons. In most of the cases such requirements do not allow presence of water on internal walls, the roof or on the ground of the tunnel. Only by controlled drainage of the excess groundwater, the effective work medium and the safety of both the equipment and the personnel inside the confined tunnel space can be assured. Another necessity is to prevent unacceptable impact on the external environment.

Tunneling introduces the risk of imposing adverse impacts to the surrounding environment by lowering the groundwater table, which may cause settlements of buildings and other surface structures in urban areas and disturb the balance of the natural lakes, ponds and recreational areas in the neighborhood. Findings by Kveldsvik *et al.* (2001) deeply emphasize the vulnerability of such natural areas and address the potential ecological consequences. Keeping the tunnel or underground opening dry should also be expected when hydrodynamic containment must be maintained. Of course such watertight tunneling is needed in particular cases of storage and disposal for leakage prevention (Grøv, 2001).

Throughout the world, land subsidence due to large amounts of fluid withdrawal has occurred in numerous regions and has been extensively investigated both quantitatively and qualitatively by many researchers. Such subsidence is explained by the consolidation of sedimentary deposits as the result of increasing effective stress (Bell *et al.,* 1986). Pratt and Johnson (1926) demonstrated that land subsidence resulted directly from lowering of the piezometric surface due to fluid extraction. Poland and Davis (1969) showed that the centers of subsidence in the Santa Clara valley, California, coincided with the centers of major pumping and development of subsidence increasingly occurred with the continuing groundwater utilization. In addition, Abidin *et al.* (2001) have proven that excessive groundwater extraction in Jakarta caused a serious land subsidence incident. Karlsrud (2001) included a valuable study to the literature by emphasizing that the water leakage that takes place during tunneling under urban areas of the Oslo region possessed a great subsidence threat. Furthermore, Chen *et al.* (2003) have shown that land subsidence in Suzhou City was strongly related with groundwater exploitation through a complex aquifer system.

All these researches have enlightened the future of tunnel engineering clearing the obstacles of ground settlement. Many studies are being carried out to have an advanced understanding about this subject and overwhelming discoveries takes place. Prior to conducting this study, a broad vision is gained through a detailed review of this source.

CHAPTER 2

ULUS – KEÇİÖREN SUBWAY PROJECT

2.1. Project Characteristics

Other than being a very vital public mass transport project for the city of Ankara, the construction of Ulus – Keçiören Subway project also inherits properties that are strikingly unique. A total of approximately 10 kilometers of excavation is being made where a maximum inclination of 3.5% is reached. Five kilometers of this excavation, which is within a volcanic series, is done by explosives using New Australian Tunneling Method (NATM). As of January 2006 excavation within the volcanic series neared completion and another 4 kilometers of the project will be excavated mostly in Ankara Clay and alluvial deposits through cut-and-cover and tunneling. In the original project, construction of 900 meters of the alignment is planned as using cut-and-cover technique at three different locations. The rest of excavation will be completed in the form of tunnel with nine subway stations that were mentioned earlier. All these different construction methods are selected through careful evaluation of site conditions, construction effectiveness, cost estimations, environmental impact and other important engineering concerns.

2.1.1. New Austrian Tunneling Method (NATM)

2.1.1.1. Historical Perspective

NATM is evolved as a result of experiences gained in Austrian Alpine tunneling conditions as the name implies. It was developed extensively between the years of 1957 – 1965 by the contribution of many tunneling pioneers. In 1958 Brunner patented “Shotcrete Method”-Runserau H.E.P Project-Squeezing ground, shotcrete application. After this, Mueller developed systematic deformation measuring system in 1960. The year of 1962 marks the time when Rabcewicz first used the term “NATM”. Two years later in 1964 NATM achieved worldwide recognition. A number of events which are important in the development of NATM are summarized chronologically in Table 2.1.

2.1.1.2. Definition

NATM aims stable and economic tunnel support systems where the main idea is to utilize the geological stress of the surrounding mass (soil or rock) to stabilize the tunnel itself. The NATM has been particularly successful in conditions where complex geological features are anticipated or indeed encountered and which cause uncertainties in the prognosis of the rock mass behavior. Success in improving tunnel stability is achieved by shortening the length of the round which in fact reduces rate of advance, but improves tunnel stability extremely. The definition made by the Austrian Society of Engineers and Architects states that, the NATM “…constitutes a method where the surrounding rock or soil formations of a tunnel are integrated into an overall ring-like support structure. Thus the supporting formations will themselves be part

Table 2.1 Series of events that lead to NATM in chronological order (Karakuş and Fowell, 2004)

Year	Development
1811	Invention of circular shield by Brunel
1848	First attempt to use fast-setting mortar by Wejwanow
1872	Replacement of timber by steel support by Rziha
1908	Invention of revolver shotcrete machine by Akeley
1914	First application of shotcrete in coal mines, Denver
1948	Introduction of dual-lining system by Rabcewicz
1954	Use of shotcrete to stabilize squeezing ground in tunneling by Brunner
1955	Development of ground anchoring by Rabcewicz
1960	Recognition of the importance of a systematic measuring system by Mueller
1962	Rabcewicz introduced the New Austrian Tunneling Method in a lecture to the XIII Geomechanics Colloquium in Salzburg
1964	English form of the term NATM first appeared in literature produced by Rabcewicz
1969	First urban NATM application in soft ground (Frankfurt am Main subway)
1980	Redefinition of NATM due to conflict existing in the literature by the Austrian National Committee on Underground Construction of the International Tunneling Association (ITA)

of this supporting structure.” A more recent definition is given by Sauer (1988) claiming that NATM is: “…A method of producing underground space by using all available means to develop the maximum self-supporting capacity of the rock or soil itself to provide the stability of the underground opening.” The NATM is actually an approach of philosopy, rather than a set of excavation and support techniques, integrating the principles of the behaviour of rock masses under load and monitoring the performance of underground construction during construction.

2.1.1.3. General Concepts of NATM

There exist twenty two principles of NATM in total. Among these principles seven important features play a major role in NATM:

1. Mobilization of rock mass strength
2. Shotcrete protection
3. Rock mass deformation and load measurements
4. Flexible supports
5. Invert closing
6. Tunneling contract agreements
7. Rock mass classification: Determining support measures

<u>Example:</u>

A1 – No support required (may be random local supports); fullface or top heading and bench in large excavation profiles; drill and blast

A2 – Shotcrete and random rockbolts; top heading (2.5-3.5m) and bench (4.00m); drill and blast

B1 – Shotcrete and systematic bolting; top heading (2.0-3.0m) and bench (4.00m); drill and blast

B2 – Shotcrete, systematic bolting, forepoling; top heading (1.5-2.5m), bench (3.5m); smooth blasting, roadheaders if rock masses are sensitive to vibrations

C1 – Shotcrete, systematic bolting, forepoling, steel ribs; top heading (1.0-1.5m), bench (2.0m), invert arch (100-150m); smooth blasting or rockheader or tunnel excavator

C2 – Shotcrete, systematic bolting, forepoling, steel ribs; top heading (1.2m), side galleries may be required, bench (2.0m), invert arch (25-50m); smooth blasting or rockheader or tunnel excavator

L1 – Shotcrete, forepoling or lagging ribs; top heading (1.5m), bench (3.0m), invert arch (100-150m); tunnel excavator

L2 – Shotcrete, forepoling or lagging ribs; top heading (1.5m), bench (2.0m), invert arch (24-50m); tunnel excavator

Figure 2.1 Photo image showing shotcrete application

Table 2.2 Rock classification system for NATM

Rock Class Description	Austrian Standard ÖNORM B2203	Classification after Rabcewicz-Parcher
A1 Stable	1 Stable	
A2 Slightly overbreaking	2 Afterbreaking	
B1 Friable	3 Slightly friable	II Friable
B2 Heavily friable	4 Friable or slightly pressure exerting	III Heavily friable
C1 Pressure exerting	5 Heavily friable or pressure exerting	IV Pressure exerting
C2 Heavily pressure exerting	6 Heavily pressure exerting	V Heavily pressure exerting or flowing
L1 Loose ground, highly cohesive		
L2 Loose ground, low cohesive		

The NATM is a widely used method that avoids an extensive supporting system by making effective use of the inherent ground strength and the strengthening of existing ground by shotcrete and rock bolts.

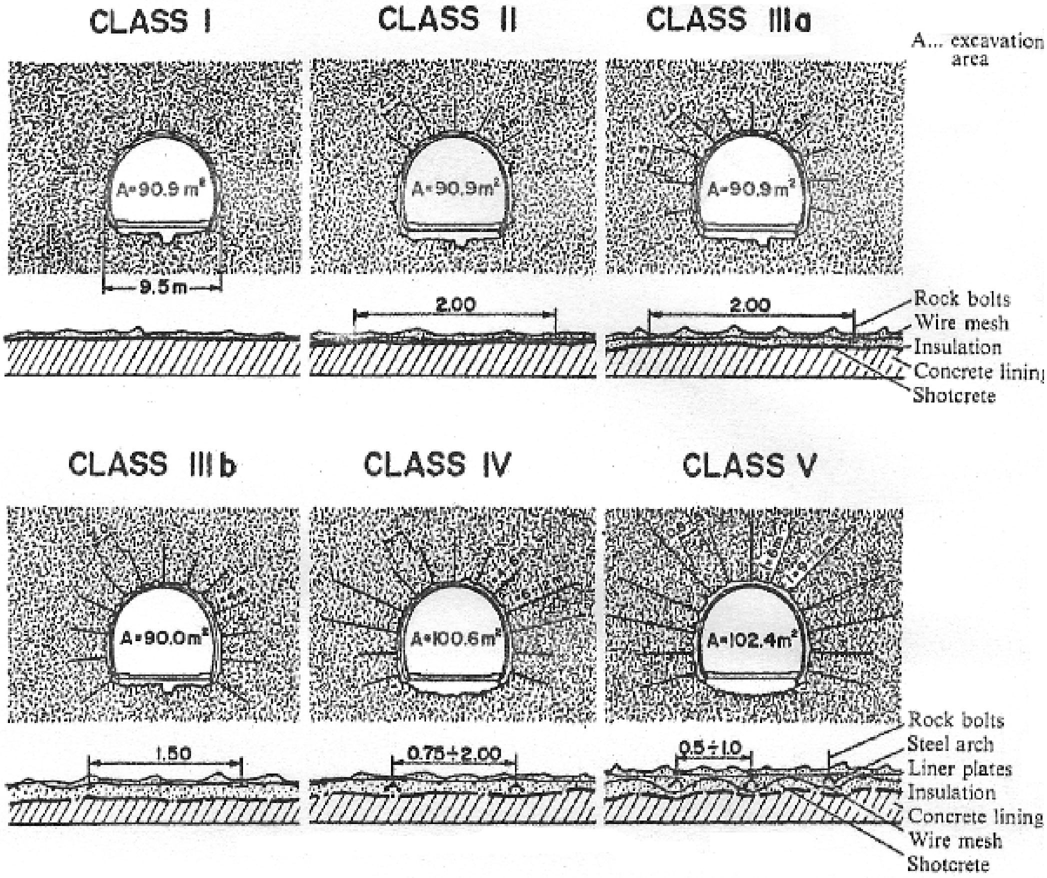


Figure 2.2 Support measures according to rock mass classification (Doyuran, 2000)

2.1.2. Types of Tunnel Cross-sections

Ahead of construction phase of such a remarkable project the information from geological and geotechnical investigations must be fully acknowledged. Geological and geotechnical reports should be reviewed and the geotechnical profile of the tunnel should be studied well. The sections with different rock classes, the critical zones (pressured, weak or fractured rock mass, thin overburden, groundwater problem, fault, etc.) should be determined and corresponding excavation method and support measures should be defined. This is a vital work when it comes to make comparisons between the evaluations made in the reports and the observations (geological mapping and geotechnical measurements) made at the tunnel face as the excavation proceeds.

Along the tunnel alignment there are six different types of tunnel cross-sections designed according to the project requirements, site conditions and the criteria above. They all serve different sorts of purposes and possess unique systems of support measures (Figure 2.3) with changing intensities.

Figure 2.3 Support measures: steel ribs, shotcrete, wire mesh, and concrete lining

2.1.2.1. Approach Tunnel

The subway excavation is carried out at approximately 20-35 meters of depth from the ground surface. In this case an approach tunnel is required to transport machinery and workers to the tunnel face. Excavation is done by blasting and progress length is around 2 meters in average. Support measures to be installed are steel ribs, wire mesh, shotcrete (20-25 cm in thickness) and rock bolts depending on the rock class in which tunnel is excavated. Besides of the approach tunnels there are two shaft accesses (Dutluk and Gazino shafts) connected to the main-line tunnel (Figure 2.4).

Figure 2.4 A view of the shaft access

2.1.2.2. Main-line (Base) Tunnel

As the name implies, this type of tunnel cross-section is the one that subway line and necessary appliances are situated in. The excavation is done in two stages during which the top and bottom halves of the tunnel face are blasted consequently. The diameter is 6.10 meters.

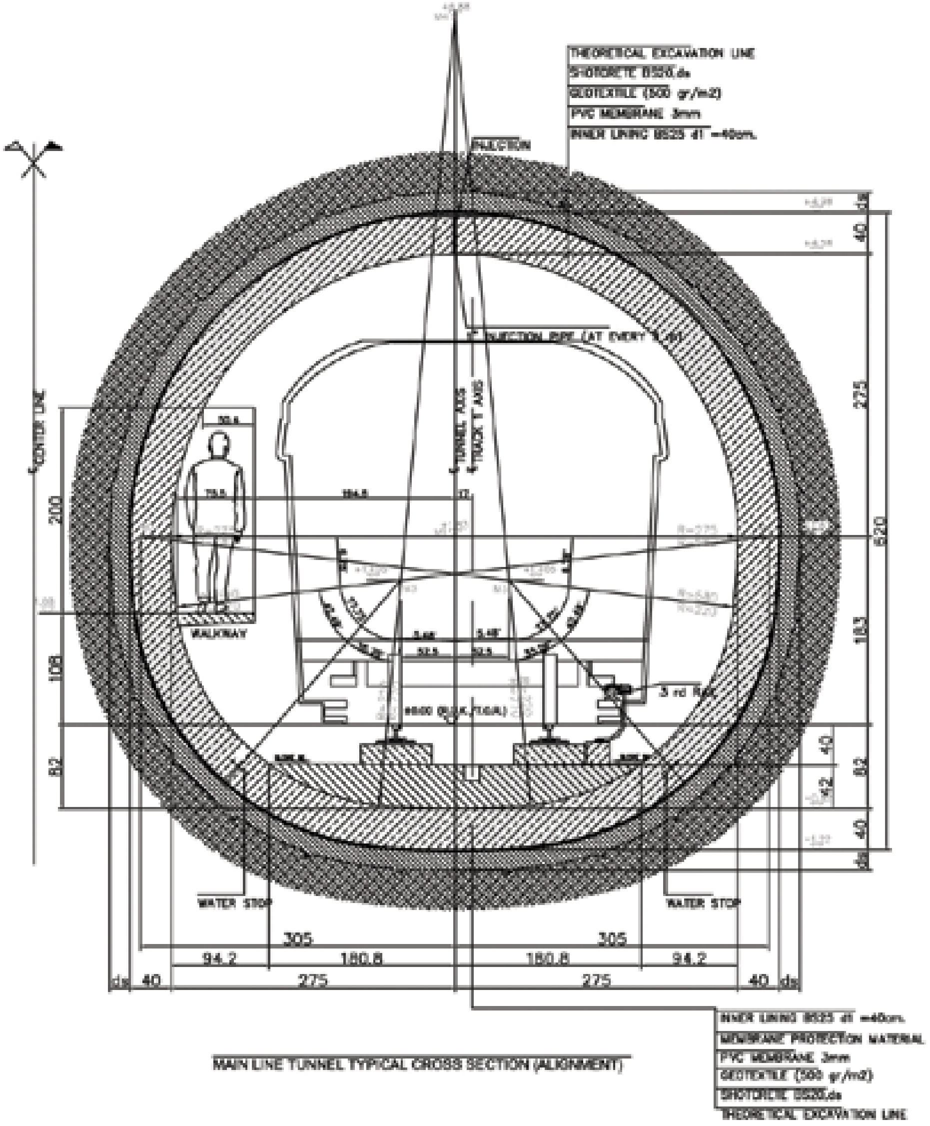


Figure 2.5 Main-line (Base) tunnel cross-section (Türkerler-Limak, 2004)

Steel ribs, two layers of wire mesh, systematic rock bolting and 20-25 cm thick reinforced shotcrete are designed as immediate support completed with a finishing concrete lining of 40 cm of thickness (Figure 2.5). Intensity of support application is determined according to the conditions of the excavated material and the frequency of structures on the ground surface.

2.1.2.3. Turnout Tunnel

It is the most critical kind of tunnel cross-section since the two tubes containing their own subway lines are combined together within the same single cross-section. It is the biggest cross-section designed in the project with 15 meters of diameter (Figure 2.6). Since a huge portion of material is excavated, the support installation is upgraded and improved. Same types of support measures with the main-line tunnel are applied more intensively including 25 cm of reinforced shotcrete and 50 cm of concrete lining.

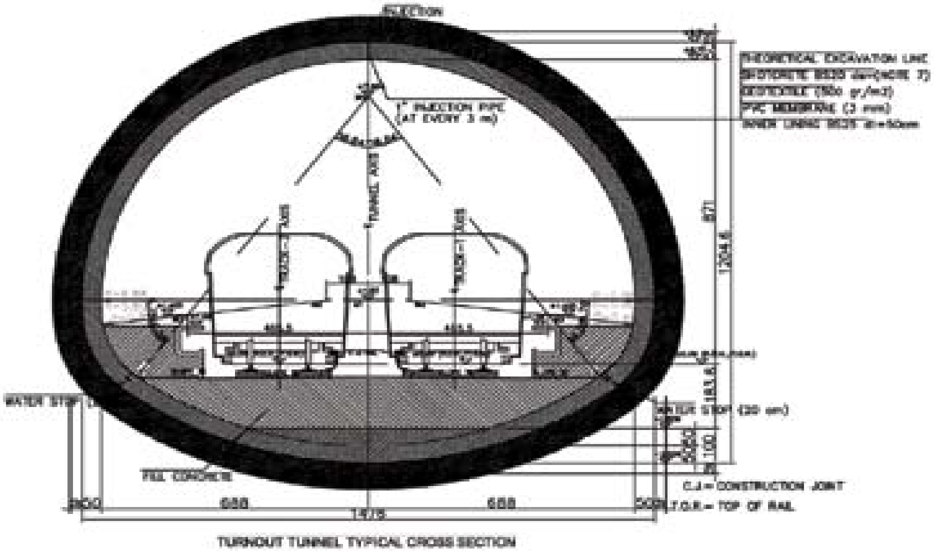


Figure 2.6 Turnout tunnel cross-section (Türkerler-Limak, 2004)

There are various excavation methods in NATM according to the split of excavation face such as full face, bench cut, top/bottom drift and sectional excavation. Since this tunnel profile requires excavation of a sizable tunnel face and plays an important role in the project its excavation is planned in six phases (Figure 2.7).

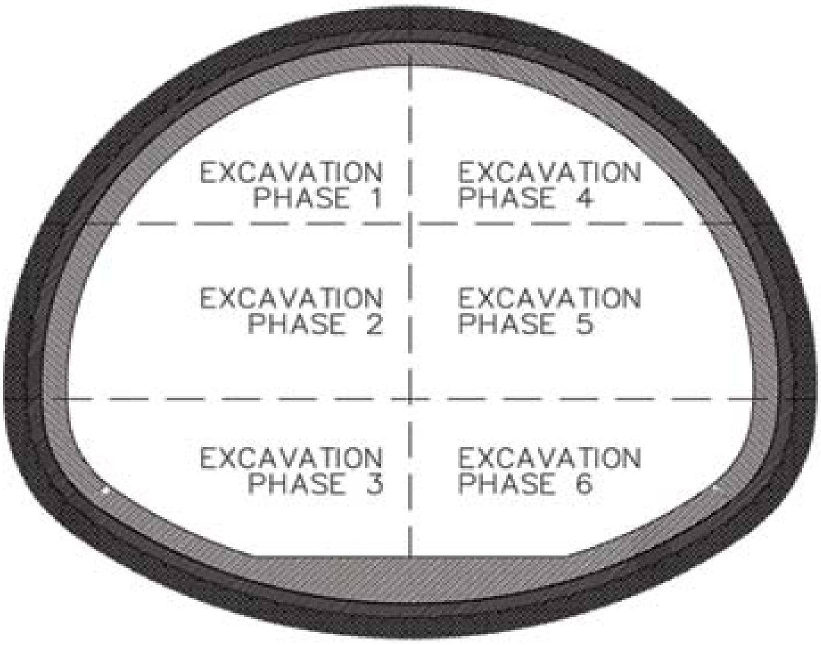


Figure 2.7 Six phase excavation method

Excavation Phase 1 progresses further than all the other phases having the most distant excavation face. Excavation faces 2, 3, 4 and 5 reach a closer distance. Phase 6 is the excavation with least progress (Figure 2.8). This method of excavation enhances the security measures for tunnel construction as well as the long-term safety factor of the project.

Figure 2.8 Photo images illustrating six phase excavation: close and far

2.1.2.4. Station Platform Tunnel

This tunnel profile is the one that encapsulates the subway line together with a platform area that provides space for passengers of the mass transit unit (Figures 2.9 and 2.10). In order to fit all of these, a large excavation area of 9 meters of diameter is designed and the excavation is planned as two stages.

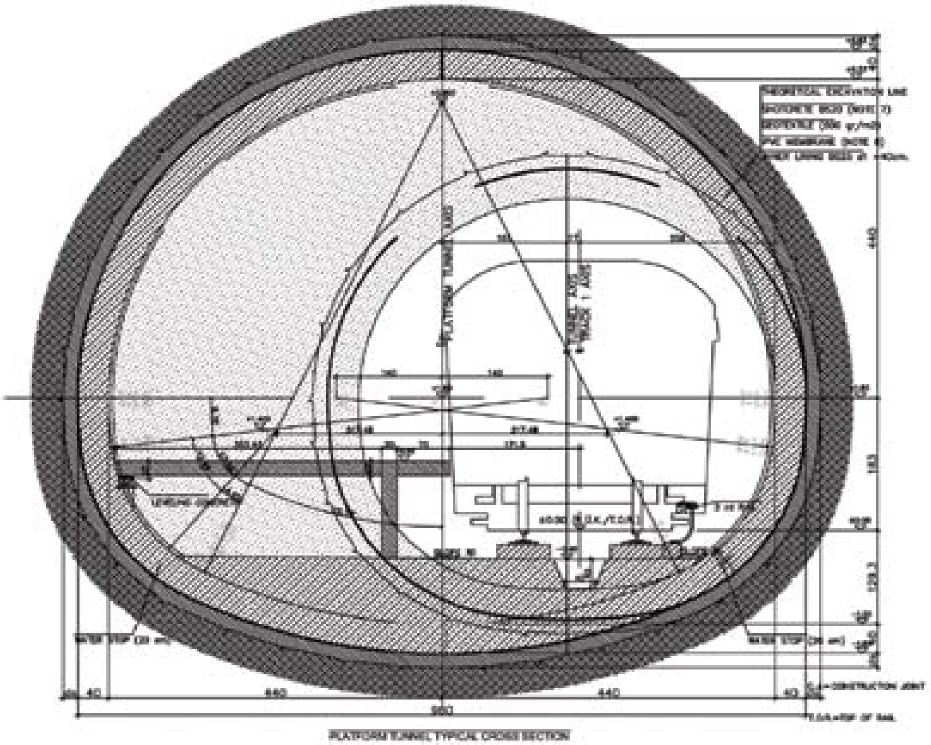


Figure 2.9 Platform tunnel cross-section (Türkerler-Limak, 2004)

Figure 2.10 A view from the platform tunnel cross-section

2.1.2.5. Connection Tunnel

They are the tunnels that provide a link between the two separate subway lines. It is a smaller elliptical tunnel profile that is planned to offer opportunities for maintenance and emergency cases (Figure 2.11). The excavation of this type of cross-section should be done only after the bigger tunnel profiles fulfill their deformation limit. Support systems include use of wire mesh, shotcrete of 20 cm thickness and 50 cm of concrete lining.

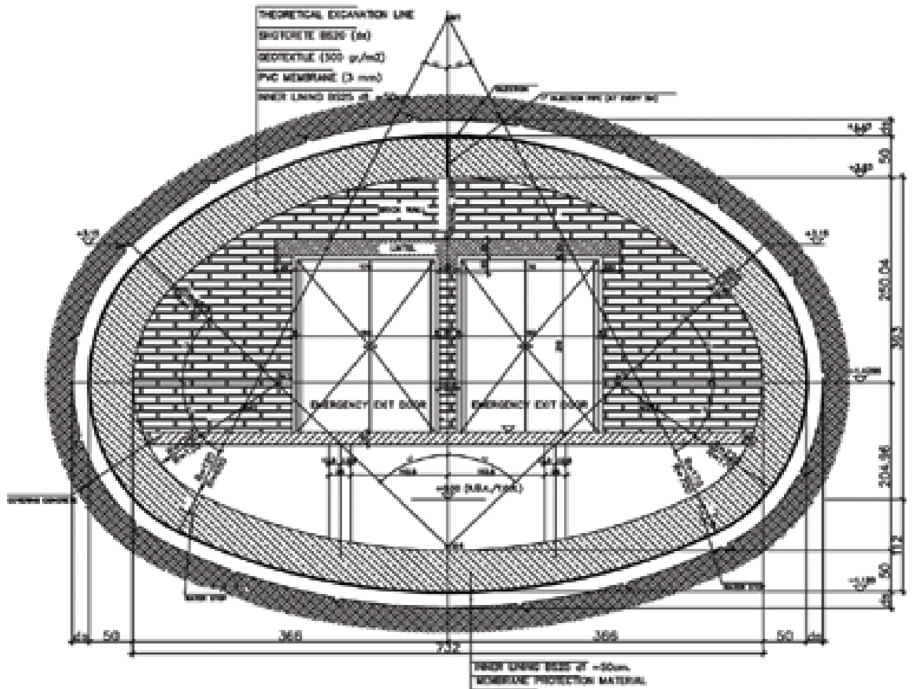


Figure 2.11 Connection tunnel cross-section (Türkerler-Limak, 2004)

Figure 2.12 Photo image showing connection tunnel

2.1.2.6. Staircase Inclined Tunnel

These profiles are used for the excavations that create direct access from ground surface to the tunnel level. They obviously require shallow overburden thickness to enable the public reaching the subway system with less effort. Among the variety of support measures are wire mesh, shotcrete and concrete lining applications.

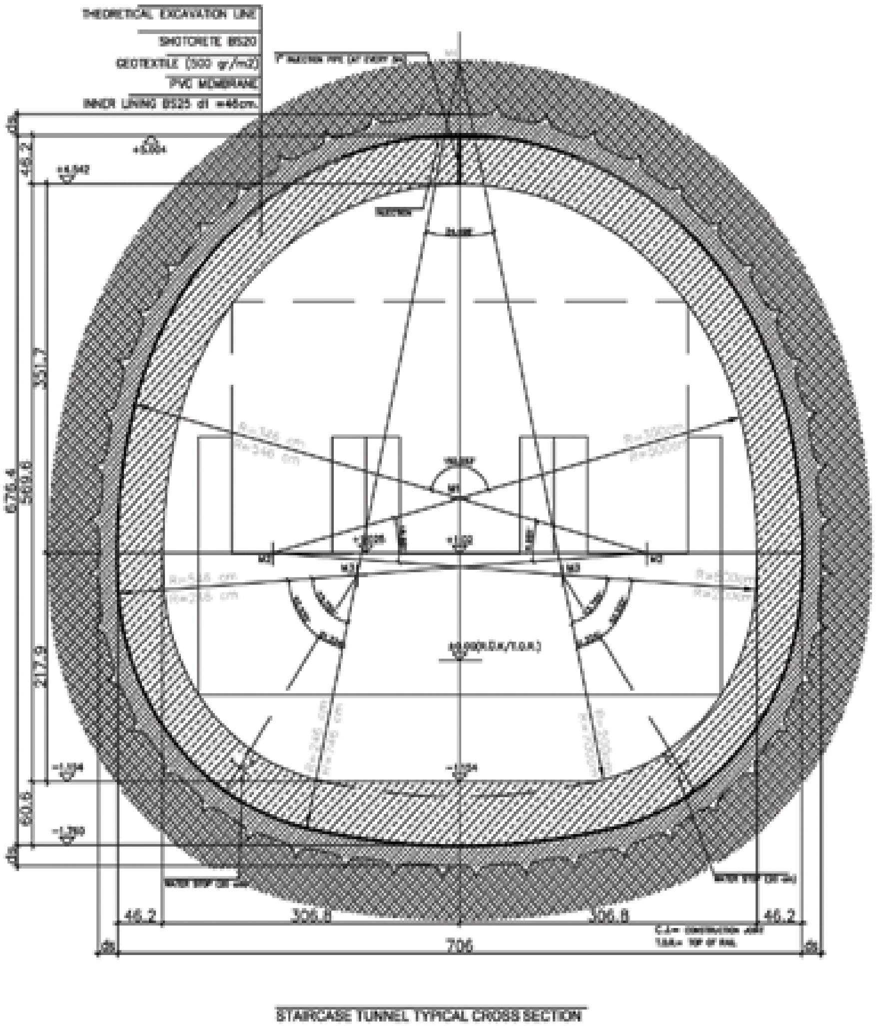


Figure 2.13 Staircase inclined tunnel cross-section (Türkerler-Limak, 2004)

2.1.3. Investigation Works

2.1.3.1. Geological Mapping

A geological map of 1/5000 scale was prepared by Yüksel Proje (2003) for the region where Ulus – Keçiören Subway is located. Utilizing the input from boreholes drilled, a geological profile is also prepared (Appendix A).

2.1.3.2. Borehole Investigations

Due to dense settlement only limited rock outcrops could be observed along the subway alignment. Thus, in order to reveal the geology along the route a number of boreholes were planned. A total of 1938.35 meters of drilling was made by Yüksel Proje (2005) in 67 boreholes to figure out the type, thickness, contact relationships, geological and geotechnical properties of lithological units present along the Ulus – Keçiören Subway route. Details regarding these boreholes are given in Appendix B.

Figure 2.14 Photo image showing borehole drill

In order to define the soil profile along the subway route, disturbed (SPT) and undisturbed samples were collected. In every borehole Standard Penetration Tests (SPT) and Pressuremeter tests were conducted at every 1.5 meters of depth in soil units. To determine the permeability of soil and rock units Constant Head Permeability and Water Pressure tests were conducted. SPT samples that are retrieved were prevented from exposure by plastic bags and undisturbed (UD) samples were sealed off by paraffin. Rock core samples were stored, with regard to the order, in wooden core boxes. All the samples were investigated further in soil mechanics laboratory of Yüksel Proje.

YÜKSEL PROJE
Birlik Mahallesi 9. Cadde No: 41 Çankaya 06610 - ANKARA
Tel: (0.312) 495 70 00 (pbx) Fax: (0.312) 495 70 24

PROJECT : Proje : ULUS KEÇİÖREN METROSU
BH. No. : (Sondaj No:) UK.16/B
Date (Tarih) 19-10-04
Sample No. : (Örnek No.) 10
Sample Depth: (Örnek Derinliği) 15.00,15.45
Type of Sample : (Örnek Türü) SPT
Soil Description (Zemin Tanımı)
SPT No. Of Blows (SPT Darbe Sayısı) 7-9-9

Figure 2.15 SPT Sampler, sample bag and pressuremeter device

For groundwater level monitoring, a perforated PVC pipes were installed into the boreholes. Groundwater level measurements are taken regularly on a monthly and for some periods, on a biweekly basis.

2.2. Geology

2.2.1. General Geology

Main geological units exposed in and at close vicinity of Ankara are: Dikmen Formation, Alacaatli Formation, Hançili Formation, volcanic series, Akhöyük Formation, Etimesgut Formation and alluvial deposits.

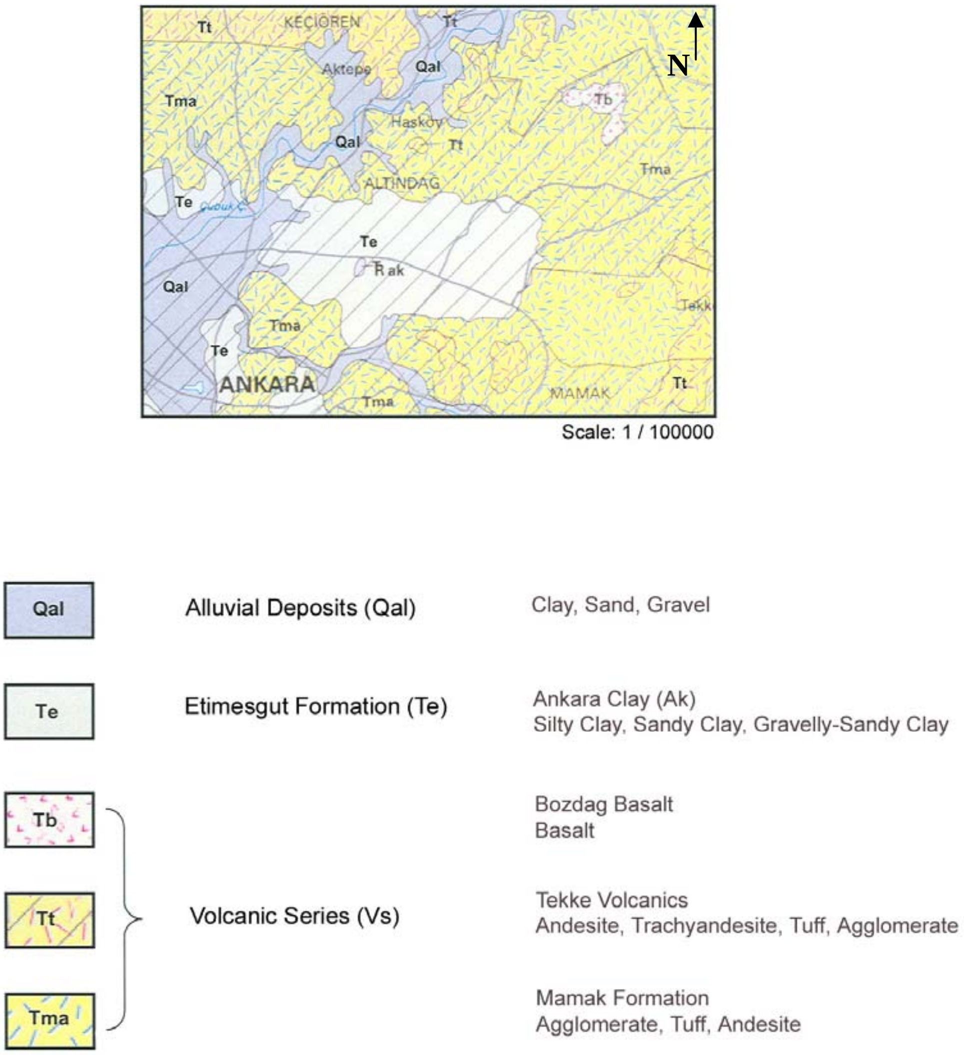


Figure 2.16 Geological map of Ankara (Akyürek *et al.*, 1997)

Primary rock unit in the area is the Dikmen Formation of Paleozoic – Triassic age which lithologically consists of schist and greywacke with occasional limestone blocks. Alacaatlı Formation is mostly represented by limestones which crop out at Alacaatlı, Balıkuyumcu, Dereköy and Deveci villages. It also contains marl, claystone, sandstone and occasional sand – gravel layers. Along the subway route, Hançili Formation is represented by sandstone, siltstone and tuff alternations. This formation is closely associated with the volcanites of the same age. Inside the city, near Ankara Citadel, Keçiören, Mamak and north of Yenimahalle a volcanic series of Miocene age is observed. This volcanic series contains andesite, dacite, basalt, tuff and agglomerate. The Akhöyük Formation consists of an alternation of claystone, marl and clay. Etimesgut Formation of Pliocene age is a clay based combination of lacustrine deposits and river deposits. It consists of silty clay and gravelly, sandy clay. It is also referred to as "Ankara Clay". Alluvial deposits are seen along the major stream valleys.

2.2.2. Geology of the Study Area

The units exposing along Ulus – Keçiören Subway route include Hançili Formation, Volcanic Series, Ankara Clay and alluvial deposits. In urban environment most of these units are concealed with artificial fill, asphalt paved roads and buildings. Within the total length of subway route the sedimentary units cover 5650 meters (approximately 58%) and volcanic series cover the remaining 4035 meters (approximately 42%).

2.2.2.1. Hançili Formation

Hançili Formation is deposited in streams and lakes in a terrestrial environment (lake being the dominant environment of deposition) in which alluvial fans are developed at the margins. It is formed by the alternation of clayey limestone, marl, siltstone, sandstone, conglomerate and tuff of Miocene age. At parts it may contain bituminous shale and gypsum. During this alternation, dominant rock type changes locally. Andesite sills have been observed. Clay-limestone and marl are white to yellowish-white, thin-to-medium bedded and alternates with siltstone and sandstone. Siltstone is grey, weakly cemented, thinly layered and shows lamination. Conglomerate and sandstone are yellowish-grey, weakly cemented and do not show obvious layering. This formation was first named by Akyürek *et al.* (1980). Along the subway route it is encountered in few boreholes and constitutes about 2% of the subway route.

2.2.2.2. Volcanic Series

The volcanic series is dominantly composed of andesite, basalt, tuff and agglomerate. The agglomerate is white, grey and red colored and it contains andesite, dacite, and basalt fragments of different sizes within a tuffaceous matrix. Layering is barely observed. Andesite is usually red, pink, grey and black. Basalt is black and dark brown. It is vesicular and shows flow structure. These volcanic units show a chaotic mixture causing sudden changes in lithology as the excavation proceeds through the tunnel.

2.2.2.3. Ankara Clay

It is dominantly composed of silty and/or sandy clays with occasional sand and gravel lenses. They are deposited within the floodplains of ancient streams. Even though fine-grained deposits are dominant the sand and gravel lenses represent ancient river channels. Outcropping between Etlik Avenue and Turgut Özal Boulevard, the Ankara Clay is of Pliocene age. It is basically silty clay and gravelly, sandy clay that is red, brown and beige, fissured, contains carbonate concretions, partly has layers of sand and gravel, either low or high in plasticity, very stiff and over-consolidated. Its mineralogical composition is directly controlled by the bedrock from which they are derived. For instance, montmorillonite originates from volcanic rocks; whereas chlorite is a weathering by-product of schist and greywacke. The sand and gravel lenses within the unit range between sandy gravel, clayey sand or clayey, sandy gravel. The Ankara Clay could be found at a 20% portion of the subway route.

2.2.2.4. Alluvial Deposits

They are observed within the Ankara Creek and its tributaries. The deposits are composed of sandy-silty clay, clayey sand, clayey-sandy gravel. The clayey fractions possess medium to high plasticity. The color of the alluvial deposits is grayish-brown.

The clayey portion of these deposits possesses a great potential of causing consolidation settlement. Presence of clay is surely the main reason of consideration but high plasticity, water content, permeability to allow drainage and other properties put this unit forward more than Ankara Clay. Hence this unit stands at the focal point of this study in terms of consolidation settlements. It is the main sedimentary unit representing the 36% of the subway route.

2.2.2.5. Artificial Fill

Covers the project area almost completely. It is originated by the excavations made for the constructions of neighboring structures and other dumped material. It occurs mostly as a thin layer and its engineering aspects are at an unsatisfactory level.

2.3. Hydrogeology

The groundwater conditions of Ulus – Keçiören Subway Project are very closely related with the hydrogeological properties of the existing geological units that were mentioned earlier.

Within the volcanic series, the agglomerate unit has low permeability. Andesite and dacite units allow groundwater movement depending on the fractures they bear. Tuff that is found in lenses within these rocks is usually not permeable at all. Ankara Clay, which is an impermeable unit, possesses some residual groundwater at the sand-gravel lenses it contains. Depending on size of these lenses and place where they are situated, groundwater could be found at different levels of depth even though a groundwater table is not established generally throughout this unit. Since these sand-gravel lenses are separate from each other, during excavation of Ankara Clay it could be either completely dry or groundwater could be encountered at some parts. The river channels and their branches that intersect the tunnel route have accumulated alluvial deposits represented by sandy clay, clayey sand and clayey-sandy gravel. These units contain groundwater, are highly permeable and because of these reasons they are expected to have a negative effect on the excavation process.

Figure 2.17 Groundwater drainage

As an underground excavation is under operation it is quite difficult to predict the amount of groundwater draining from fractured rocks. This difficulty could be explained by three main aspects. Firstly, it is quite a challenge to determine the hydrogeological aspects of rocks that are to be passed on tunnel route. Even though geological mapping studies, investigational borehole drillings, permeability and water pressure tests reveal some information about subsurface geology and the hydraulic properties of the rocks, the distance between boreholes cause lack of data that is critical for investigation. This lack of data is a result of the heterogeneity of the soil profile. Besides the subway route passes through a residential area covering a great portion of the project area which makes examination of surface geology impossible. A second factor is the difficulty of modeling groundwater drainage due to specific soil conditions at the site. The complexities are much more at a medium of fractured rocks than a porous medium of soil. The last aspect is the inadequacy of field works. The number of field tests conducted to define hydraulic properties of rocks is not enough and the medium made up of rocks is way too heterogeneous. Therefore, the input from these field tests will not go further than giving a general idea because it cannot provide the numerical support that is sufficient for any kind of model. For example, it is even not possible to pick an average value of hydraulic conductivity in a case when different permeability levels are read from two different depths of the same borehole. In a medium of alluvial soil the hydraulic properties are relatively more homogeneous even if it is known to be a mix of clay, silt, sand and gravel showing lateral and vertical transitions.

Uncontrolled groundwater flow is one of the worst geotechnical problems the tunneling operation may cause. Sudden discharge of groundwater through a tunnel face inside a medium of saturated, highly jointed and fractured rock is a critical problem. Hence the potential groundwater discharges that may occur should be elaborated at the design stage. If predicted early, certain drainage precautions can be taken for such groundwater discharges. Depending on the inclination of the excavation base the drainage could happen by gravity otherwise pumping will be necessary. In any case prior acknowledgement of the amount of groundwater to be drained is needed. Amount of discharge could usually be decreased by the use of impervious barriers or injection applications. But these measures may not provide any guarantee for stopping leakage through tunnel face or the invert.

2.3.1. Distribution of Hydraulic Conductivity Values

A total of 73 constant head permeability tests and 41 water pressure tests were conducted inside the boreholes drilled during the investigation works. Water pressure tests were done in the volcanic series and the Hançili formation, whereas in the alluvial deposits and Ankara clay constant head permeability tests were performed.

The alluvial deposits consist of clay, silty clay, clayey silt, gravelly clay, clayey silty sand, sandy gravel, gravelly sand. They are observed in the form of layers and lenses having lateral and vertical transitions. The hydraulic conductivity values range between 1.5*10^{-7} m/sec and 6.4*10^{-4} m/sec. In Figure 2.18, the distribution of hydraulic conductivity values derived from the permeability tests is displayed (Doyuran, 2005). The value of 10^{-8} m/sec indicates impervious unit. It can be observed from the normal distribution of the values that the average hydraulic conductivity concentrates around 10^{-6} m/sec. The average is assumed to be 3.3*10^{-6} m/sec.

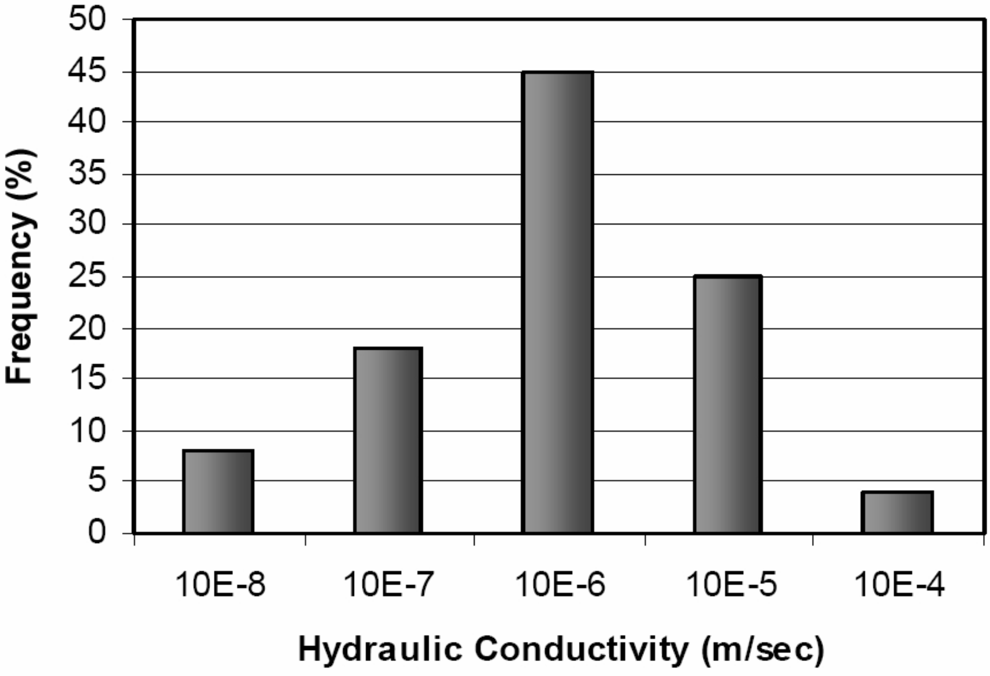


Figure 2.18 Distribution of hydraulic conductivity in alluvial deposits (Doyuran, 2005)

For Ankara clay 17 out of 22 permeability tests yielded no seepage and hence they are regarded as impervious. In three of these tests the hydraulic conductivity is estimated as 10^{-7}m/sec, in one of them $6.7x10^{-6}$ m/sec and in another one $1.17x10^{-5}$ m/sec were found. Ankara clay could be considered to be impervious depending on these values. Other construction projects carried out in Ankara clay yielded insignificant amount of groundwater drainage.

A total of 39 water pressure tests were conducted in andesite, dacite, agglomerate and tuff units, also called volcanic series. Tests results suggested that the permeability ranges between 1.17 and 25 Lugeon. As it is proved in Figure 2.19, there is no correlation between Lugeon and RQD values. This is a result of anisotropic - heterogeneous medium fractured rocks create and the limitations of water pressure test.

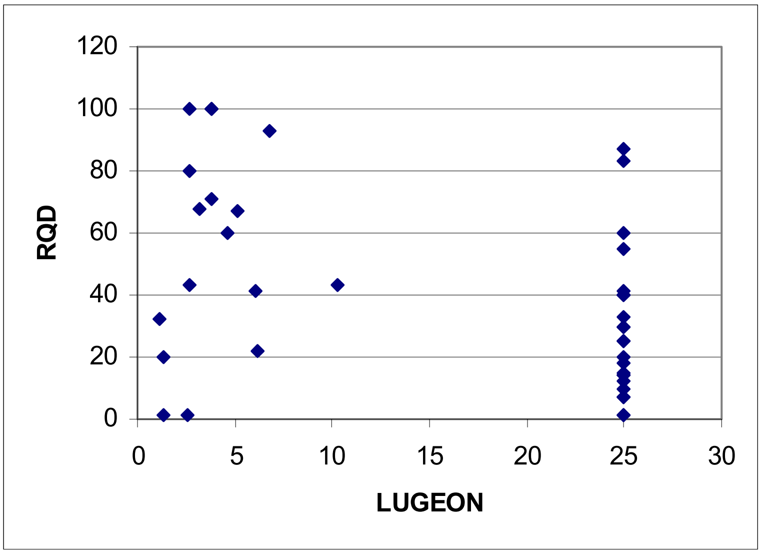


Figure 2.19 Comparison of water pressure test results and RQD values (Doyuran, 2005)

The results of the water pressure tests depend on the aperture size of discontinuities as well as their orientation. RQD being related with frequency of fractures does not suggest that it is directly related to permeability. A rock mass that bears many narrow aperture discontinuities has a low permeability as well as RQD. Therefore the aperture of discontinuities is more important rather than frequency. As seen in Figure 2.19, the 24 out of 25 test results are over 25 Lugeons indicating that the discontinuities from the rocks forming the volcanic series happen to have wide apertures. Hence occasional high discharge of groundwater is to be expected when excavating the tunnel in this zone. The hydraulic conductivity in volcanic series is around $4*10^{-7}$ m/sec (Doyuran, 2005).

2.3.2. Groundwater Levels

Starting from 01.10.2003, groundwater level at every drilled borehole on the subway route was measured on a monthly basis. The measurements revealed that groundwater table is positioned at a depth usually shallower than 10 meters. The hydrostatic pressure on the crown of tunnel is less than 3 atm., at some parts as low as 1-1.5 atm. The initiation of tunnel excavation works triggered groundwater drainage either as leakage or low-medium discharge drainage causing significant drop of groundwater table in boreholes near the tunnel face.

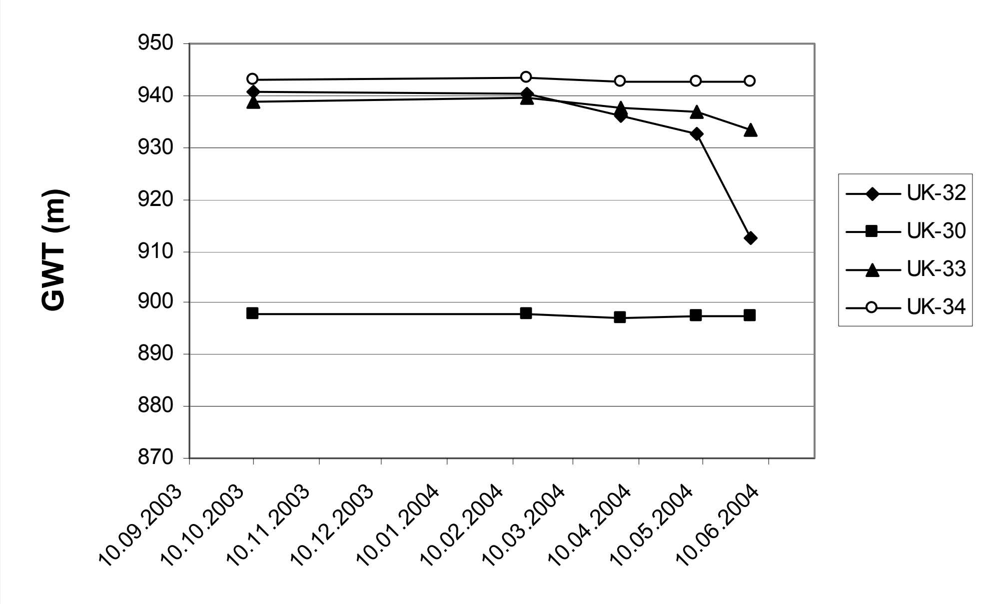


Figure 2.20 Changes in groundwater level in the boreholes due to drainage during tunnel construction (Doyuran, 2005)

2.3.3. Groundwater Drainage in Tunnel

The region where subway route passes through alluvial deposits of Ankara Stream the hydraulic conductivity is $3.3*10^{-6}$ m/sec and the hydraulic burden (depth from groundwater table to the invert of tunnel) changes between 20 and 2 meters. The excavation works have not yet started at this region so groundwater drainage did not occur. Possible groundwater drainage per unit length of the tunnel is calculated by using static levels and the results are displayed in Figure 2.21. This figure also shows that in worst case the expected level of drainage is 350 m^3/day (~4lt/sec) for one meter of excavated portion (Doyuran, 2005). This amount will surely go down as the hydraulic burden decreases with time. Of course such a furious drainage will not be achieved since the excavation can not be completed in a single day. The drainage situation for the worst case is shown in Figure 2.22. In this case the drainage will start around 350 m^3/day, descending rapidly by time and reaching a stable flow regime with low discharge (Doyuran, 2005). Both Figures 2.21 and 2.22 prove that groundwater drainage will be in controllable limit even when no precautions are taken. On the other hand, the sand-gravel lenses existing in alluvial deposits may cause remarkable discharge occasionally.

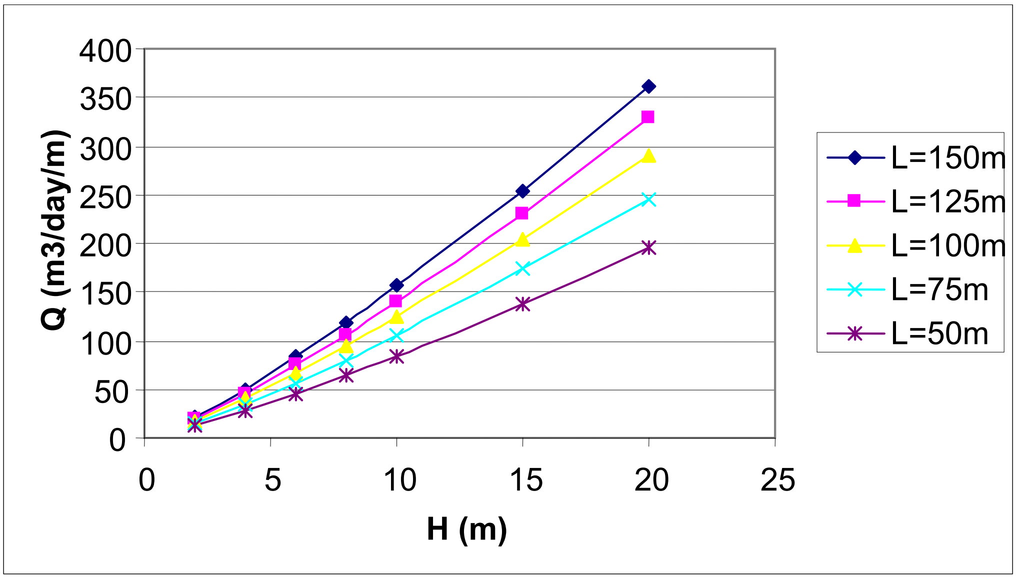


Figure 2.21 Groundwater drainage with respect to hydraulic head and the radius of influence (Doyuran, 2005)

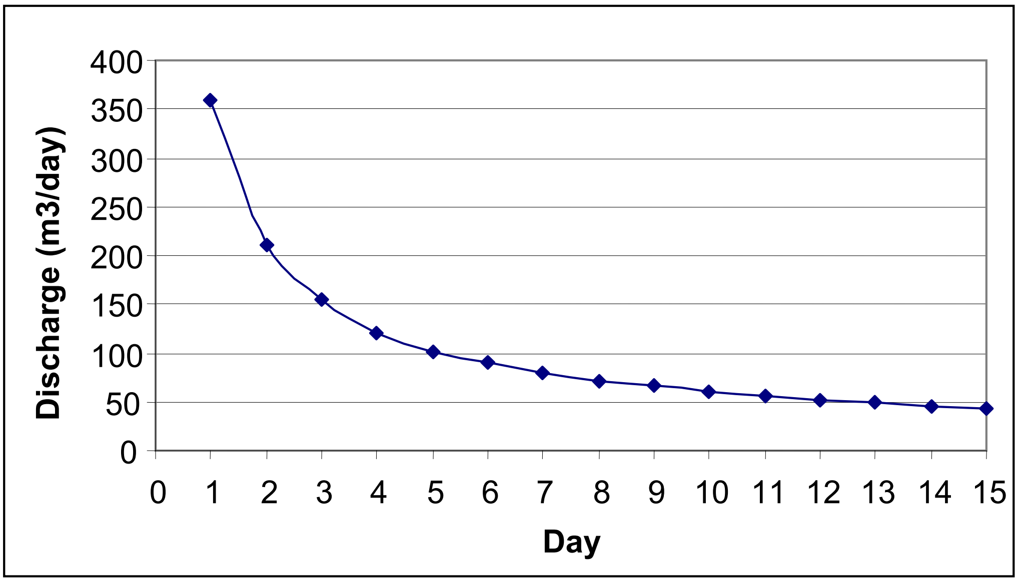


Figure 2.22 Change of groundwater drainage with time (Doyuran, 2005)

As mentioned earlier in regions where tunnel excavations will be carried out in Ankara clay, no critical groundwater drainage is expected given that the unit is impermeable.

Figure 2.23 Groundwater inflow to the tunnel

2.3.4. General Evaluation

Among the geological units that form a foundation to the subway tunnel construction, the alluvial deposits and the volcanic series show aquifer properties, therefore, having a great hydrogeological importance. Through these units leakage and low-discharge draining is expected. However, this can be controlled by necessary precautions and will diminish to an insignificantly low level with time.

The problems that may occur in alluvial deposits might be sand boils, caused by loss of groundwater equilibrium in presence of cohesionless soil at the excavation base. The other one is consolidation settlement due to drainage which reduces the pore water pressure within a soft clay deposit. The buildings that are located on top of this bed of clay deposit may have serious settlement damage in the long term. Groundwater drainage when excavating the volcanic series will cause a decrease in the pore water pressure at the clay/rock interface. This will trigger the consolidation process to take action starting from this interface and progressing up through the clay bed. These occurrences should be carefully monitored since they may result in cracks on the buildings of the surrounding area. In addition, the flushing of fine particle deposits during groundwater drainage should be prevented. The drainage should be kept at a low and stable level if possible.

From the tunneling point of view, it is well known that the presence of groundwater has a negative effect on rock mass properties and behavior. Hence this fact shouldn't be ignored when rock mass classes are being assigned and when temporary support measures are being designed.

2.4. Geotechnical Investigations

To acquire detailed information about the site conditions, geotechnical investigations of wide coverage are used. These investigations are divided as field studies and laboratory tests. All these investigations helped to distinguish the units that need concentrating on from a geotechnical point of view. They also aided the analysis process which will be explained later on.

2.4.1. In-situ Investigations

Best way to gather important information about a project is to get observations out in the field where project is located. It involves all the techniques and inquiries that can be used to gain knowledge on a particular location. It proves even better results once ground investigation starts, during when in depth investigation of subsurface material is done.

For this purpose, a total of 67 boreholes were drilled through almost 2 kilometers of soil by Yüksel Proje. Observations made by supervising engineers were recorded on logs producing a detailed lithological profile. Sampling allowed further research about the material and in-situ testing helped with useful and highly precise data from the actual site in its natural state. A variety of in-situ tests provide feedback at the same time as drilling continues. These tests include standard penetration tests and pressuremeter tests. Both of these tests clearly present compressibility, resistivity and deformation behaviors by determining corresponding properties of the soil material.

The investigations in the field showed that artificial fill should be disregarded. It has also proven that deeply seated Ankara Clay is highly resistant for consolidation. The alluvial layer that was found at around the mid-borehole depth displayed high-sustainability of settlement. The risk imposing zones in the project area were also noticed during the course of these studies.

2.4.2. Laboratory Investigations

The soil mechanics laboratory of Yüksel Proje put a great effort in determining important material parameters from the project area. The samples received were carefully investigated by reliable methods. Main investigations carried out were:

- Sieve analyses
- Determination of Atterberg limits
- Uniaxial compression tests
- Triaxial compression tests
- Consolidation tests

Data provided by these studies were collected within a database created especially for the purpose of consolidation analysis. Evidently, instead of Ankara Clay, the alluvial deposits were once again proven to bear a potential of consolidation.

2.5. Recent Developments

Despite the fact that the construction phase already began, some major changes were applied to the original project. As much as it was surprising to come across such execution, the modifications were improving and necessary for the current situation.

The most important change made was about the tunnel alignment. The original project suggested that the subway line would extend from Keçiören to Ulus. However, the tunnel route was then re-directed in the direction of Tandoğan starting from Mecidiye subway station. Therefore, the new alignment connects Keçiören – Tandoğan to each other even though the name of the project remains as Ulus – Keçiören Subway Project.

Due to this remarkable deviation from the initial state of the project, almost all aspects of the design needed an up-to-date evaluation. This re-evaluation process included the method of tunneling as well. According to the latest investigation works, newly designated project area was assessed and tunneling by TBM (Tunnel Boring Machine) was selected as a suitable conduct rather than cut-and-cover method. The TBM for soft ground tunneling would especially be active at the newly added portion of the alignment where alluvial deposits are abundant. This way the groundwater drainage that was expected to take place on an extensive scale is avoided even before it began because of the fact that support measures are applied right after excavation when tunneling with TBM.

Figure 2.24 Open excavation for tunnel portal approach at Dışkapı.

Figure 2.25 Assemblage of TBM at Dışkapı station

Figure 2.26 TBM and segment installation

Even though these series of changes were appropriate for the sake of the project, modifications of such proportions must be completed before project initiation and during the planning stage when the project is being designed. The change of plans also took its tool on the scope of this dissertation by costing much more time and effort. The findings of this thesis study would be relevant and useful in the case when a tunneling methodology that allows groundwater drainage (such as cut-and-cover method) is adopted.

CHAPTER 3

THEORETICAL BACKGROUND ON CONSOLIDATION

3.1. General Definition

It is a well-known fact that any material tends to reform and change its shape due to application of load. A steel rod will extend under the influence of tensile stress whereas a cement block will shorten as a result of compressive pressure. Stress changes have a similar effect upon soil. When this behavior is investigated it is understood that some deformations are reversible with the removal of load whereas others show a permanent effect on the material under influence. It is called an elastic deformation if recovery is observed. Plastic deformation, on the other hand, is the type which strain lasts. Only a small portion of ground deformation inhabits elastic behavior. In addition to this, the historical record of the soil is a factor when deformation behavior is to be estimated, meaning that a previously applied stress somehow leaves a trace property on the soil. All these characteristics make investigation of ground deformation an extremely complicated problem which can not be always expressed by mathematical equations (Özaydın, 1997).

The process of consolidation is the gradual reduction in volume of a saturated low permeability soil due to drainage of pore water. It continues until the excess pore water pressure is completely dissipated. Consolidation settlement is the vertical displacement of the ground surface corresponding to the volume change at any stage of the consolidation process (Craig, 2004). There are three main reasons for consolidation:

- compaction of soil particles
- compaction of air/water in the pores
- extrusion of air/water in the pores

Soil particles are usually composed of solid minerals which resist to yield a noticeable amount of compaction. Since the compressibility of water is also negligible, the compaction of pore water within a fully saturated soil will not be able to contribute to the consolidation either. All is left for consolidation to occur is the last option (pore water extrusion) which brings soil particles closer and decreases the overall volume of the soil. Hence the main reason for consolidation (especially in saturated soil) is the dissipation of pore water. Consolidation is the process of soil mechanics in which reduction of volume occurs and varying levels of permeability within a soil profile brings in the time factor. In order to investigate the consolidation of soil, stress-deformation-time relationships must be elaborated (Özaydın, 1997).

The process of swelling, on the other hand, is the gradual increase in the volume of a soil under negative excess pore water pressure proving that it is the reverse of consolidation. Consolidation settlement may occur due to a structure built over a layer of saturated clay or by lowering of groundwater table whereas excavation of saturated clay may result in heaving (reverse of settlement) which will cause swelling of clay at the bottom of the excavation (Craig, 2004).

3.2. Consolidation (Oedometer) Test

The properties of a soil during one-dimensional consolidation or swelling can be determined by means of the consolidation test carried out by oedometer device (Figure 3.1).

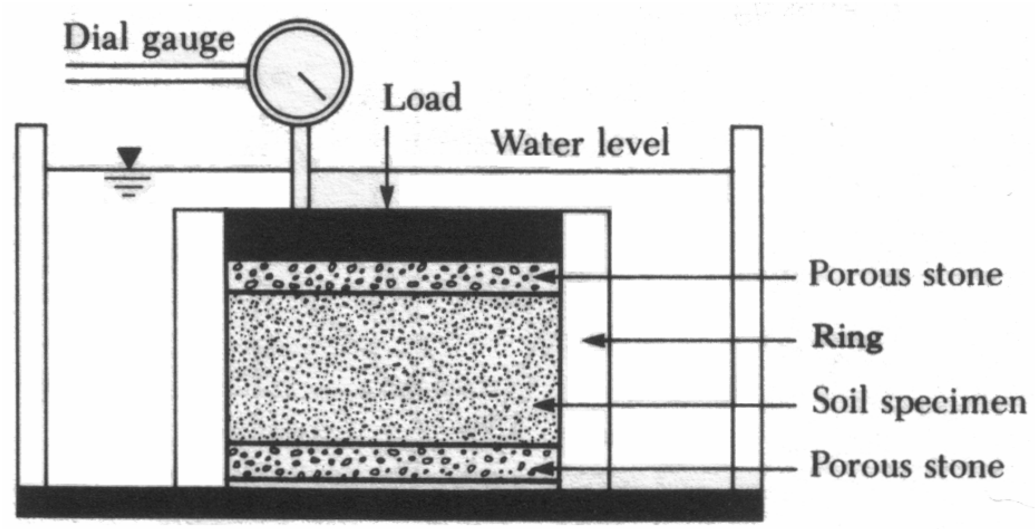


Figure 3.1 Schematic diagram of consolidation test apparatus (Das, 2002)

The test specimen is disc-shaped (6.35 cm. in diameter and 2.54 cm. in height) and placed inside a metal ring and lying between two porous stones. The porous stone on top is fixed below a loading cap through which pressure can be applied to the specimen. The whole assembly is situated in an open cell filled with water to which the pore water in the specimen has free access. The confining ring imposes a condition of zero lateral strain on the specimen. The ring must have a smooth and polished surface at the inner face for reduced side friction. The compression level of the specimen under pressure is measured by use of a dial gauge. According to the standardized test procedure load on the specimen is applied (initial pressure depending on the type of soil) followed by a sequence of pressures each being double the previous value. Each pressure is maintained for a 24 hour period during which compression readings are taken at suitable intervals. These are usually ¼, ½, 1, 2, 5, 10, 30 min.; 1, 2, 4, 8, 24 hr. intervals (Figure 3.2). At the end of the increment period the excess pore water pressure has completely dissipated and the applied pressure is equal to the vertical effective stress within the specimen. This way it is possible to determine the consolidation settlement caused by various incremental loadings (Cernica, 1995).

Figure 3.2 Photo image of oedometer device in soil mechanics laboratory of Yüksel Proje

Based on laboratory tests, a graph can be plotted showing the variation of the void ratio e at the end of consolidation against the corresponding stress p. The nature of change in void ratio (e) to stress (log p) is displayed in Figure 3.3.

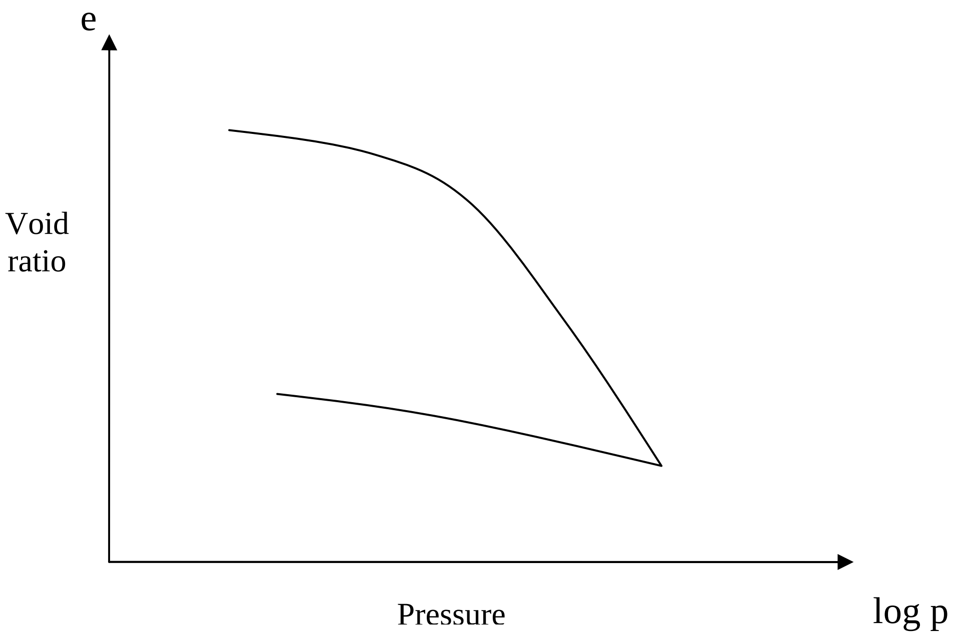


Figure 3.3 An example of e – log p curve for soft clay

After the desired consolidation pressure is reached, the specimen is gradually unloaded allowing it to swell. The variation of e against log p during this unloading period is also plotted in Figure 3.3.

From the e-log p graph, three parameters can be derived that will be essential in calculation of settlement. These are:

a. Pre-consolidation pressure, p_c: It is the maximum past effective overburden pressure to which the soil has been subjected. A simple graphical procedure was proposed by Casagrande (1936) to obtain this value from e-log p curve. Comparing this value to the applied pressure will reveal the level of consolidation (overconsolidation ratio, OCR). Soil deposits are found in either normally consolidated or overconsolidated state in the nature. The soil is normally consolidated if the present effective overburden pressure p_0 is equal to pre-consolidation pressure (p_0=p_c) and overconsolidated if present effective overburden pressure is less than pre-consolidation pressure (p_0<p_c).

b. Compression index, C_c: It is the slope of linear portion of the loading curve. The value determined from curve may be somewhat different from that encountered in the field primarily due to the remolding of soil. It can vary widely based on soil type and there are some empirical correlations that have been suggested.
c. Swelling Index, C_s: It is important in the consolidation settlement estimation for overconsolidated clays. It is about 1/4 to 1/5 of the compression index in most cases.

At the time of compression, soil structure goes through continuous changes and the clay does not bounce back to the original structure after the expansion. Studies have shown that overconsolidated clay will be much less compressible than normally consolidated form. There are two parameters that represent the compressibility of the clay, one of which is the compression index that is described above. The other is the coefficient of volume compressibility, m_v, which is defined as the change in volume per unit volume per unit increase in effective stress. It is not a constant value for particular soil but instead it depends on the stress range over which it is calculated (Das, 2002).

3.3. The Principle of Effective Stress

The best way to visualize the structure of the soil is as a skeleton of solid particles enclosing continuous voids that contain either water or air. The volume of soil skeleton can change due to rearrangement of soil particles. In fully saturated soil a reduction of volume is only possible by escape of water (which is incompressible) from the voids. The concept of effective stress is introduced when this water extrusion occurs.

In 1923, Terzaghi presented the principle of effective stress and the importance of the forces transmitted through the soil skeleton was recognized. The principle is a relationship based on experimental data, applies only to fully saturated soils and involves following three stresses:

a. the total normal stress, σ : the force per unit area on a plane within the soil mass
b. the pore water pressure, u : the pressure of water in voids
c. the effective normal stress, $\sigma^{'}$: the stress transmitted through the soil skeleton only.

The relationship is: $\sigma = \sigma^{'} + u$ (3.1)

An increase in pore water pressure results in transient flow of pore water towards free-draining zone. This drainage continues until steady-state pore water pressure is reached. The increase in pore water pressure above this value is referred to as excess pore water pressure. Dissipation is the reduction of the excess pore water pressure back to steady-state value and the soil is considered to be in drained condition. As pore water drainage takes place (for reasons such as, external loading, tunnel excavation, groundwater pumping, etc.), the reducing space can not be replaced by air and particles of soil are taking up new positions. With the dissipating excess pore water pressure, loading will be entirely carried by the soil skeleton increasing the vertical effective stress, making the soil particles become more condensed and therefore creating a reduction in volume. This is the process of consolidation settlement and the time taken to complete this process depends on the permeability of the soil. Since this behavior usually occurs in cohesive soil such as clay which has low permeability and slow drain ability, consolidation could become a long-term process with more than one phase.

The mechanics of consolidation could be explained by the aid of a basic analogy. Figure 3.4 displays a spring inside a water-filled cylinder with a valve fitted piston on top. Spring represents the compressible soil skeleton, water in the cylinder is the pore water and the valve deploys the permeability of soil. With the valve closed (Figure 3.4 a - b), a load placed on top will not move the piston because the water is incompressible. This situation corresponds to the undrained condition in the soil. However, with the valve opened (Figure 3.4 c - d), the water will be forced out allowing the piston to move and squeeze the spring to which the load is transmitted to. Increase in the load on spring will represent the decrease in pore water pressure. Load will be totally lifted by the piston and the spring, resembling the drained condition in the soil. Load carried by the spring is assumed to be the effective normal stress in the soil and the movement of the piston is the change in volume of the soil (Craig, 2004).

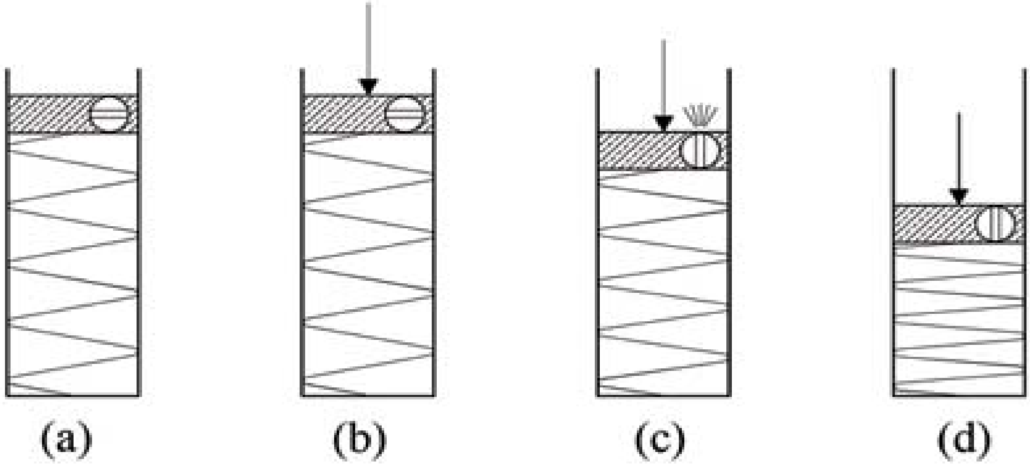


Figure 3.4 Consolidation analogy

3.4. Terzaghi's Theory of One-Dimensional Consolidation

This theory relates three main quantities:

a. excess pore water pressure (u)
b. depth (z)
c. time (t)

It is based on following assumptions:

1. The soil is homogeneous
2. The soil is fully saturated
3. The solid particles and water are incompressible
4. Compression and flow are one-dimensional (vertical)
5. Strains are small
6. Darcy's Law is valid at all hydraulic gradients
7. Both the coefficient of permeability and the coefficient of volume compressibility remain constant throughout the process
8. There is a unique relationship between void ratio and effective stress that is independent of time.

When these assumptions are investigated carefully some shortcomings of the theory become evident. From studies made it is known that a deviation from Darcy' Law exists at low hydraulic gradients. Considering assumption 7, the coefficient of permeability and the coefficient of volume compressibility both decrease during consolidation since the void ratio and effective stress have a non-linear relationship. On the other hand, it is a reasonable assumption for the case of small stress increments. The most important limitations of Terzaghi's theory arise from the eighth assumption. There is evidence from the experimental results that the void ratio-effective stress relationship is dependent of time.

3.5. Calculation of Consolidation Settlement

3.5.1. One Dimensional Method

The value of either the coefficient of volume compressibility or the compression index is required for the estimation of consolidation settlement. Assuming that the settlement is one-dimensional, the condition of zero lateral strain applies within the clay layer. The decrease in volume per unit volume of clay is expressed as below in terms of void ratio:

$$\frac{\Delta V}{V_0} = \frac{e_0 - e}{1 + e_0} \qquad (3.2)$$

Considering that in the absence of lateral strain, decrease in volume is equal to reduction in thickness per unit thickness. The settlement of a layer with thickness H is given by:

$$S_c = m_v \Delta \sigma^{'} H \qquad (3.3)$$

Here, $\Delta\sigma^{'}$ (stands for the change in effective stress) and m_v are assumed to be constant with depth (Craig, 2004).

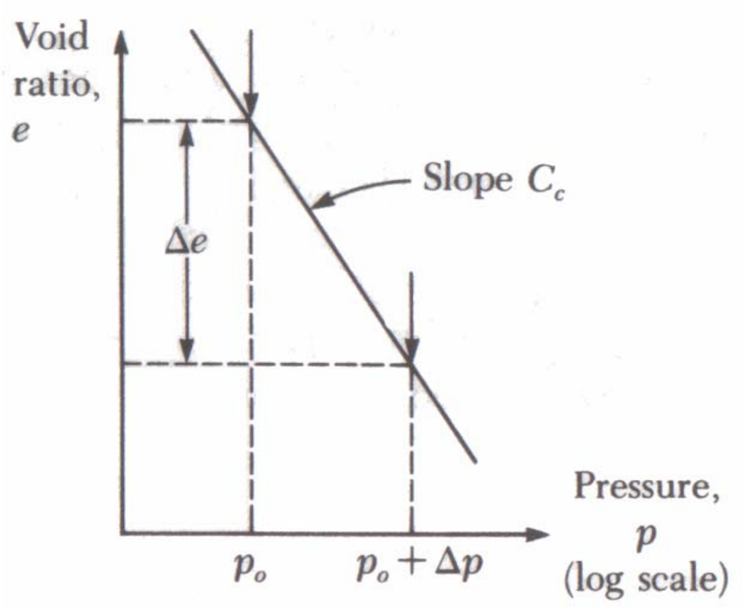


Figure 3.5 e – log p curve for normally consolidated clay (Das, 2002)

For normally consolidated clay the e-log p curve will be like in Figure 3.5, therefore, the equation for calculating consolidation settlement is:

$$S = \frac{C_c H}{1 + e_0} \log \frac{p_0 + \Delta p}{p_0} \qquad (3.4)$$

For overconsolidated clay, however, the e-log p curve has two different sections as shown in Figure 3.6 and the settlement calculation depends on Δp value (Das, 2002). In the case where the summation of initial effective overburden pressure and average pressure increase on the clay layer (which reveals the pressure in final condition) is less than pre-consolidation pressure ($p_o + \Delta p < p_c$), the settlement is calculated by:

$$S = \frac{C_s H}{1 + e_0} \log \frac{p_0 + \Delta p}{p_0} \quad \text{(Case 1)} \qquad (3.5)$$

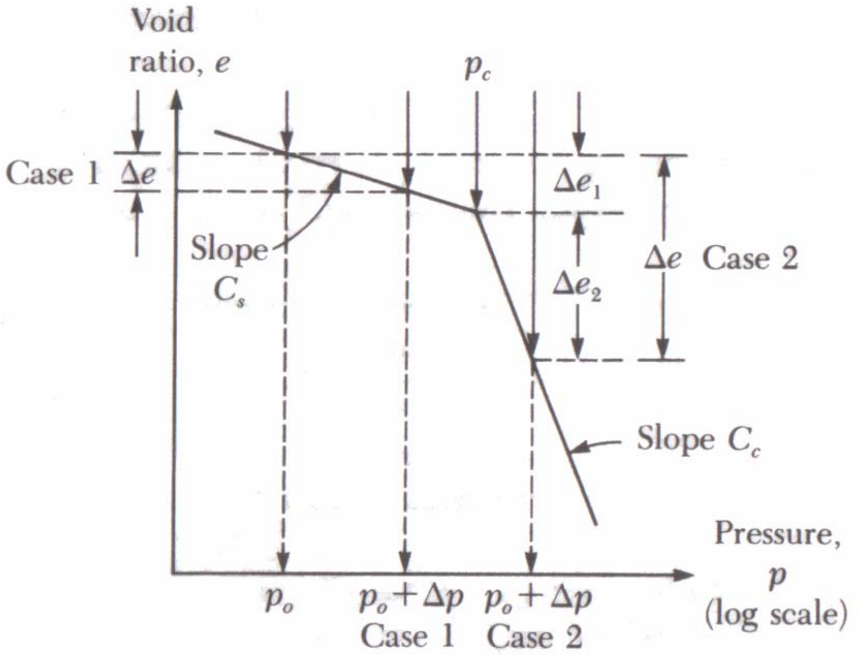


Figure 3.6 e – log p curve for overconsolidated clay (Das, 2002)

The other case suggests that if $p_o < p_c < p_o + \Delta p$, then:

$$S = \frac{C_c H}{1+e_0}\log\frac{p_c}{p_0} + \frac{C_c H}{1+e_0}\log\frac{p_0 + \Delta p}{p_c} \quad \text{(Case 2)} \qquad (3.6)$$

3.5.2. Skempton-Bjerrum Method

The equation from the preceding section are based on one-dimensional laboratory consolidation tests using representative samples of the clay and the underlying assumption is that the increase of pore water pressure is equal to the increase of stress at any given depth. In the field, however, this assumption will fail to comply. In practice significant lateral strain will occur and the initial excess pore water pressure will depend on the in-situ stress conditions. In such cases where lateral strain exists, there will be an immediate settlement in addition to the consolidation settlement. Skempton-Bjerrum modification for consolidation settlement calculation takes this into account by the aid of a pore water pressure parameter and settlement ratio (Craig, 2004).

3.5.3. Stress Path Method

As the name implies this is a method which recognizes the stress path followed up to the final state of stress as a factor that affects the resulting soil deformation. The method relies on the correct selection of typical soil elements and on the test specimens capable of truly representing the in-situ material regardless of having a sound principle. It is considered complex and time consuming due to the triaxial techniques involved in running the correct stress paths (Craig, 2004).

3.6. Average Degree of Consolidation

As explained earlier, gradual dissipation of the excess pore water pressure causes an increase in effective stress which induces settlement. To be able to estimate the degree of consolidation of a clay layer at some time t after the consolidation process initiated, the rate of dissipation of the excess pore water pressure should be known (Das, 2002).

The average degree of consolidation of clay layer is defined by:

$$U = \frac{S_t}{S_{\max}} \tag{3.7}$$

where S_t : settlement of a clay layer at time t

S_{max} : maximum consolidation settlement that the clay will undergo

3.7. Consolidation Behavior in Natural Soil Deposits

Different types of soil display consolidation behaviors totally unique to themselves. Even though the general form of strain-stress curves derived from oedometer tests are similar, the rate and amount of consolidation show variations depending on soil types. Furthermore, this process is under the effect of stress history, degree of compaction and internal structure of soil together with the errors that happen during retrieval of test specimen and its preparations for laboratory test. All these factors should be taken into account when investigating the consolidation behavior of natural soil deposits.

3.7.1. Compaction of Sand

Sandy soil performs a sudden reaction to consolidation and immediate compaction occurs. In the field, the compaction and corresponding settlements happen and are completed in the construction phase. Most important factor that affects consolidation of sand is the degree of compaction. The difficulty of undisturbed sample retrieval enforces the necessity of artificial specimen (prepared with the same sand in field) production to be used in oedometer test. The results should be satisfactory, but it should not be forgotten that the sand layers in the field may hold differences. Especially in the situations which involve cemented or collapsible sandy soil the test would create misleading results. Silty soil usually has a similar behavior to that of fine sand as well. It is more suitable to take undisturbed samples from silty soil making it available for laboratory investigation.

3.7.2. Consolidation of Clay

Consolidation is a slow process depending on time when it comes to clay. In order to get the exact field behavior, the experiments should be carefully conducted on undisturbed samples. Compaction of clay is highly affected by its loading history. It just so happens that in some cases the present effective vertical stress (weight of the overlying layers) turns out to be less than a stress applied in the past. In such cases the clay layer has been consolidated beforehand but then the additional stress is diminished. As mentioned before, this type of soil is called pre-consolidated or overconsolidated clay. If the present overburden pressure is actually the biggest consolidation pressure experienced then the clay layer is said to be normally consolidated. The e – log p curve gives a better idea about the consolidation behavior of this type of soil.

CHAPTER 4

ANALYSIS

In this section the consolidation settlement due to groundwater drainage at the alluvial sections of the Ulus-Keçiören subway project is predicted. Before beginning the whole process, detailed information regarding the site and the project were gathered to establish an understanding of the whole situation. Furthermore, certain assumptions were made to provide the analysis with the ability to closely represent the actual site parameters and project characteristics. The calculations were carried out according to the analytical equations and basic principles suggested by widely accepted conventional methods that are in existence for quite a long time. These calculated values of settlement are then verified by the aid of a numerical model constructed in the Plaxis program.

4.1. Database Generation

In order to initiate the analysis, the cases that match the conditions of this study were picked and the required data were gathered through the results of a variety of tests. The following steps point out to the creation of a data source that aided the settlement calculations.

4.1.1. Borehole Selection

As mentioned previously, the sedimentary strata for which consolidation settlement is expected are the layers of alluvial deposits. These alluvial materials contain gravel, sand and silt deposits, which are intercalated with the soft clay deposits and/or embedded within a clayey matrix. This geological unit is more vulnerable to settlements than the Ankara clay which is a hard, stiff, relatively impervious silty clay which occasional contains gravelly and sandy lenses. Moreover, the investigation is based on settlement solely caused by the groundwater withdrawal from the clayey relatively permeable units. In order to be able to assess the settlement process in the alluvial deposits, related data should be gathered from in-situ and laboratory tests which will provide detailed information about the characteristics of the layer that is expected to experience consolidation settlement. Sometimes it is not possible to conduct such detailed investigation at the preliminary stages of a project and so, the in-situ tests and samples may not be available from the corresponding material. Throughout subsurface exploration works that were conducted in the project area it has been a challenge to find the ones fitting the above conditions. This difficulty was due to unavailability of the undisturbed samples, presence of alluvial deposits at only certain parts of the project and the fact that project works are still under way during the preparation of this study. Therefore, only some of the boreholes drilled on the route in between Tandoğan and Mecidiye stations suited the case above. These boreholes are: TA-1, TA-2, TA-3, TA-4, TA-5, TA-6, TA-7, TA-8, TA-9, TA-21, TA-23, TA-24, TA-25, UK-7, UK-8, UK-12A and UK-18A1 (Yüksel Proje, 2003). A total of 17 boreholes (Appendix C) which are unique according to following criteria:

- located at certain topographical elevations
- variable depths to groundwater table

- variable thickness of the compressible layers
- variable composition of the alluvial deposits
- uneven lowering of the groundwater table
- variable overburden thickness above the tunnel
- availability and/or lack of in-situ tests and samples for laboratory analysis

All of these criteria mentioned above provided the study with the versatility of input data. This way, the method of settlement estimation had to be defined and adjusted separately for every other case which, obviously, proposed a fine challenge to incorporate accurate results.

4.1.2. Measuring the Depth to Groundwater Table

As mentioned earlier, monitoring of the depth to groundwater is a routine check within the coverage of project works. The PVC pipes installed upon the completion of boreholes make it possible to keep track of groundwater level fluctuations on a regular basis. Depth to groundwater table is measured within every geotechnical borehole.

4.1.3. Defining the Tunnel Depth

The thickness of overburden changes at every other location depending on topography, project requirements (gradient of the tunnel) and the type of tunnel cross-section. The geological cross-section (Appendix A) that is prepared together with the compiled project report (Yüksel Proje, 2003) presents the topographical elevation at the surface and the elevation of top of rail that is to be installed inside the tunnel. The depth of the tunnel is revealed by simply the subtraction of these two values from one another. The groundwater table depth will be assumed to drop down to invert level as the drainage process continues.

4.1.4. Determining Unit Weight Values of Soil

Natural unit weight and specific gravity values were available in the geotechnical reports (Yüksel Proje, 2005). In addition to the natural unit weight, the value of saturated unit weight is also necessary during the course of analysis. Saturated unit weight can be calculated effortlessly if initial void ratio (e_o) and specific gravity (G_s) values of the material are known:

$$\gamma_{sat} = \left(\frac{G_s + e_0}{1 + e_0} \right) \gamma_{water} \tag{4.1}$$

With the saturated and natural unit weight values for every undisturbed sample it is possible to perform effective stress analysis.

4.1.5. Calculation of Pre-consolidation Pressure

Pre-consolidation pressure can be obtained from e – log p curve by use of a simple graphical procedure (Casagrande, 1936). Firstly, the point of inflection where the sharpest curvature is achieved on e – log p curve is found. This point is shown on Figure 4.1 as point O. Next, two lines passing through this point are plotted, one being a tangent to e – log p curve (line OB in Figure 4.1) and the other being a horizontal line (line OA in Figure 4.1). Then, the straight line portion of the e – log p curve is produced. The point where these two lines intersect with the bisector of the two lines on point O shows the value of pre-consolidation pressure. This point is displayed as point D on Figure 4.1.

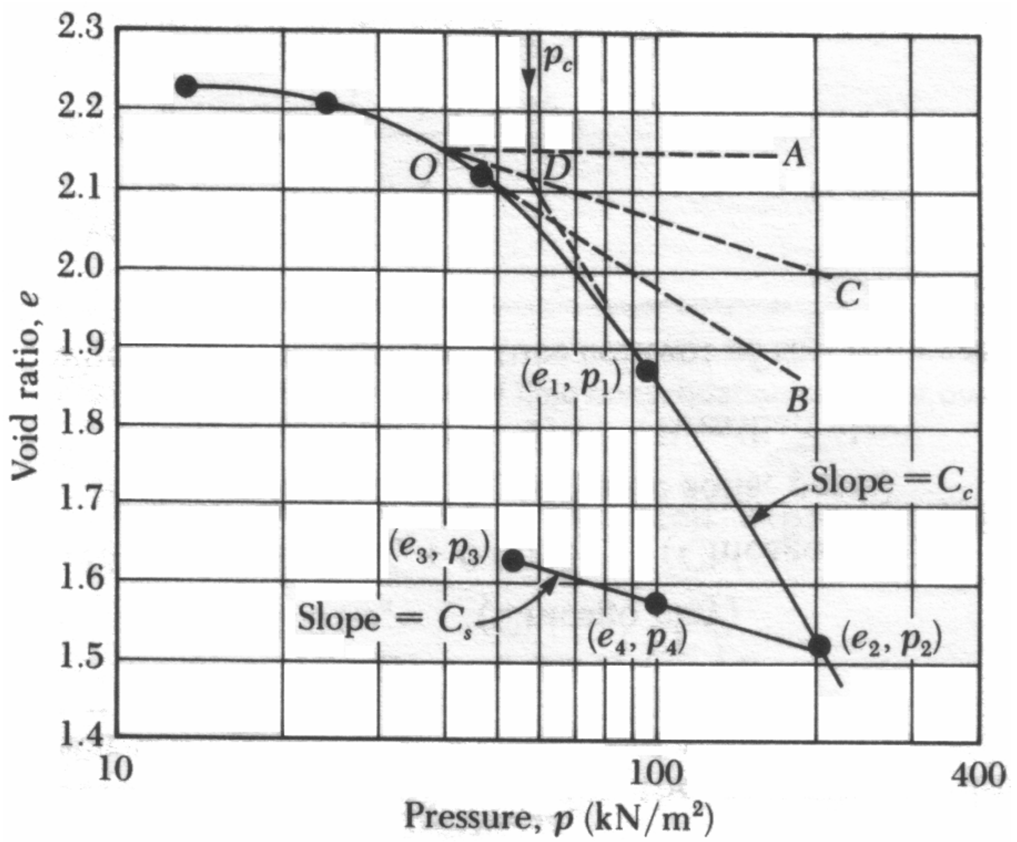


Figure 4.1 Calculation of pre-consolidation pressure from e – log p curve (Das, 2002)

This procedure was applied to the entire consolidation test results received from the 17 boreholes that are used in the analysis. The values of pre-consolidation pressure created an opinion whether the soil at respective boreholes is normally consolidated or overconsolidated.

4.1.6. Calculating the Compression Index

Another important value derived from the e – log p curve is the compression index (C_c). It is the slope of the linear portion of the loading curve on e – log p plot. Therefore, according to Figure 4.1 the following expression is obtained.

$$C_c = \frac{e_1 - e_2}{\log p_2 - \log p_1} = \frac{e_1 - e_2}{\log\left(\frac{p_2}{p_1}\right)} \tag{4.2}$$

4.1.7. Calculating the Swelling Index

Similar to that of compression index, the swelling index (c_S) is also found using e – log p plot. The attention this time is diverted to the unloading part of the e – log p curve (Figure 4.1) and it is again the slope that gives the value of swelling index:

$$C_s = \frac{e_3 - e_4}{\log p_4 - \log p_3} = \frac{e_3 - e_4}{\log\left(\frac{p_4}{p_3}\right)} \tag{4.3}$$

The final overall form of the database that is created to be used in settlement calculations is tabulated below.

Table 4.1 Database generated for settlement calculation

	Po	eo	γ_n	γ_s	Cc	Cs	OCR
TA-1 UD-1	115	1.24	16.60	17.08	0.270	0.0660	1.00
TA-1 UD-2	110	0.95	17.50	17.76	0.200	0.0500	1.00
TA-2 UD-1	110	0,87	18.30	18.78	0.200	0.0330	1.00
TA-3 UD-1	110	0.94	18.10	18.51	0.200	0.0170	1.00
TA-4 UD-1	120	1.51	15.60	16.18	0.400	0.0830	1.33
TA-4 UD-2	100	1.01	17.10	17.57	0.270	0.0330	1.00
TA-4 UD-3	150	0.82	18.10	18.60	0.166	0.0330	1.00
TA-5 UD-1	110	1.37	16.20	16.89	0.370	0.0660	1.22
TA-5 UD-2	120	0.90	18.00	18.43	0.200	0.0330	1.10
TA-6 UD-1	170	0.97	17.60	18.13	0.230	0.0500	1.79
TA-6 UD-2	160	1.01	17.70	18.11	0.230	0.0500	1.14
TA-7 UD-1	110	0.92	17.90	18.50	0.133	0.0330	1.16
TA-7 UD-2	100	0.99	17.70	18.24	0.166	0.0330	1.00
TA-8 UD-1	120	1.15	16.80	17.48	0.200	0.0500	1.71
TA-9 UD-1	190	1.27	15.90	16.64	0.166	0.0330	1.90
TA-21 UD-1	200	0.76	18.10	18.67	0.133	0.0330	1.18
TA-21 UD-2	125	1.07	17.30	17.82	0.166	0.0330	1.00
TA-23 UD-1	90	1.32	16.20	16.79	0.330	0.0660	1.00
TA-23 UD-2	125	0.99	17.38	17.99	0.200	0.0500	1.00
TA-24 UD-1	95	1.51	15.70	16.34	0.430	0.0660	1.06
TA-24 UD-2	160	1.17	17.40	18.22	0.166	0.0660	1.28
TA-24 UD-3	145	0.90	17.60	18.12	0.133	0.0330	1.00
TA-25 UD-1	105	1.34	16.50	17.06	0.330	0.0660	1.00
TA-25 UD-2	160	1.15	17.30	17.70	0.200	0.0660	1.30
UK-7 UD-1	200	0.96	18.10	18.17	0.270	0.0330	1.05
UK-8 UD-1	140	0.85	18.60	18.45	0.166	0.0660	1.00
UK-12A UD-1	200	0.82	17.80	18.27	0.100	0.0166	2.67
UK-18A1 UD-1	155	1.05	17.20	17.71	0.200	0.0500	1.00

4.2. Calculation of Consolidation Settlement

Following the tabulation of the source data the situation is now available for the calculation of consolidation settlements. However, a few more adjustments in relation to the systematic of calculations are essential for the benefit of the case. Utilizing the compressible layer for calculations, considering the context of the material, adapting the input from in-situ and laboratory tests, choosing the correct analytical approach and integrating the necessary parameters are parts of the problem which are dealt with as explained in this section.

4.2.1. Division of Compressible Layer into Sub-layers

First of all, borehole logs were elaborated and prepared for the analysis. Due to the requirements and the sake of the study, the compressible layer is the portion of the alluvial deposits submerged in groundwater. Therefore, it extends from the top level of the saturated alluvial deposits, to until either the bottom of the tunnel cross-section or the bottom level of the alluvial deposits whichever is reached first. This complete layer will not be available for the analysis as a whole and must be divided into sub-layers. The reason is that, at greater depths through the alluvial clay layer the tendency to induce settlement increases rapidly in a logarithmic fashion. Increasing stress conditions have an important role in this together with groundwater conditions and characteristics of the soil. The layer itself may also go through some structural changes that will provoke (collapsibility, high plasticity, fissures, etc.) or inhibit (cementation, carbonated zones, high stiffness, etc.) occurrence of settlement. Hence the layer that is expected to be under the influence of consolidation is divided into sub-layers of approximately 1.5-2.0 meter thickness. This way the layer in consideration will be represented more precisely by means of corresponding geological properties and stress conditions attained separately to each sub-layer. The parameters recovered from in-situ and laboratory tests are also assigned to the sub-layers at those borehole depths where the test was conducted or the sample was taken.

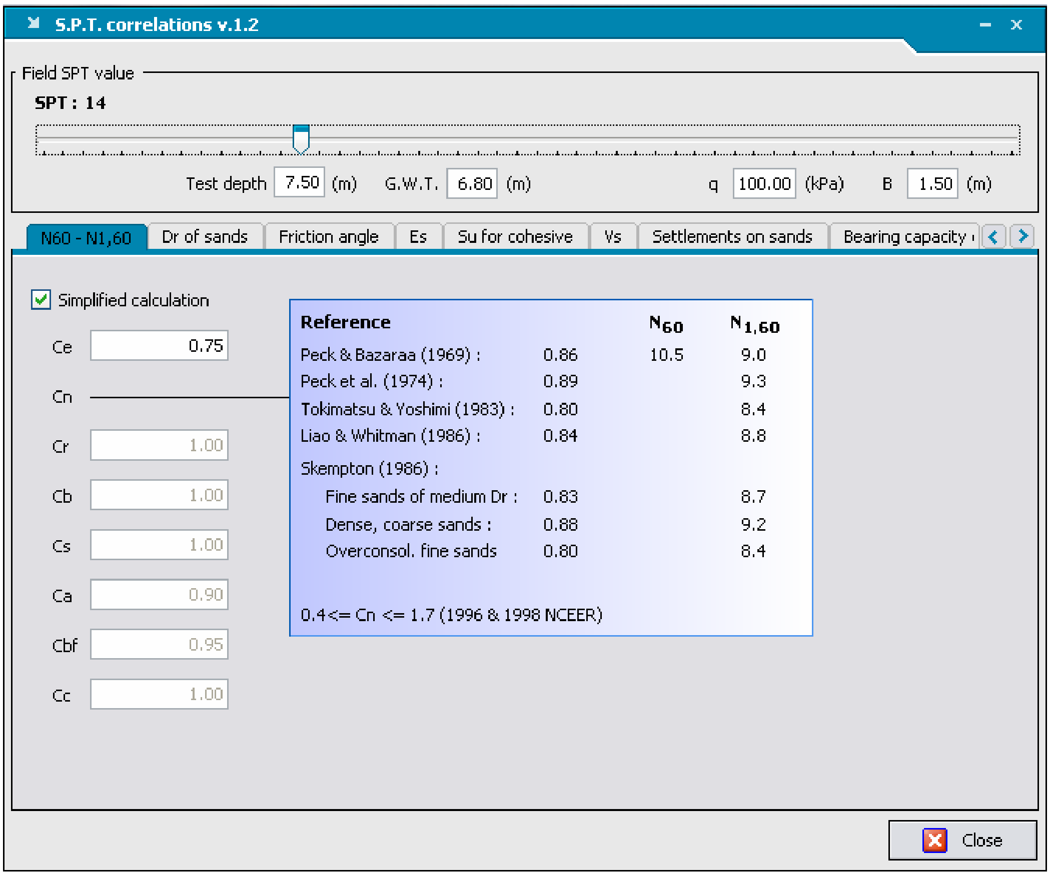
4.2.2. Settlement Calculations at Sand-Gravel Deposits

Alluvial deposits found at the project area often contain cohesionless material that shows only a small amount of long-term settlement. Although clay deposits dominate the unit in general, it would be unwise to exclude levels of sand and gravel from the settlement calculation process.

The performance of such deposits in the consolidation test cannot be trusted and using results from such applications will cause a serious flaw affecting the reliability of the study. Instead the in-situ tests are quite valuable to provide the data needed for analysis.

In this study, the layers of alluvial deposits that contain sand and gravel were included in the analysis stage by use of the Standard Penetration Test (SPT) results. This type of in-situ testing is a practical, economical and a very common technique of sub-surface exploration that has been applied in the project whenever possible. The N values resulted from SPT tests give idea about other properties of the soil as well.

Since these sorts of deposits are not practical for an attempt to produce a decent e – log p curve, the values for C_c and C_s are not available. In this case the settlement equations based on these two coefficients are not suitable. Instead, the utilized equation is the one that links settlement to the coefficient of volume compressibility which could be defined by using SPT values. For this purpose, a computer program converting SPT values into many other soil parameters was used. The program is called S.P.T. correlations v.1.2, a simple application to use (Figure 4.2).



Field SPT value

SPT : 14

Test depth 7.50 (m) G.W.T. 6.80 (m) q 100.00 (kPa) B 1.50 (m)

☑ Simplified calculation

Ce 0.75

Cn

Cr 1.00

Cb 1.00

Cs 1.00

Ca 0.90

Cbf 0.95

Cc 1.00

Reference		N_{60}	$N_{1,60}$
Peck & Bazaraa (1969) :	0.86	10.5	9.0
Peck et al. (1974) :	0.89		9.3
Tokimatsu & Yoshimi (1983) :	0.80		8.4
Liao & Whitman (1986) :	0.84		8.8
Skempton (1986) :			
Fine sands of medium Dr :	0.83		8.7
Dense, coarse sands :	0.88		9.2
Overconsol. fine sands	0.80		8.4

0.4<= Cn <= 1.7 (1996 & 1998 NCEER)

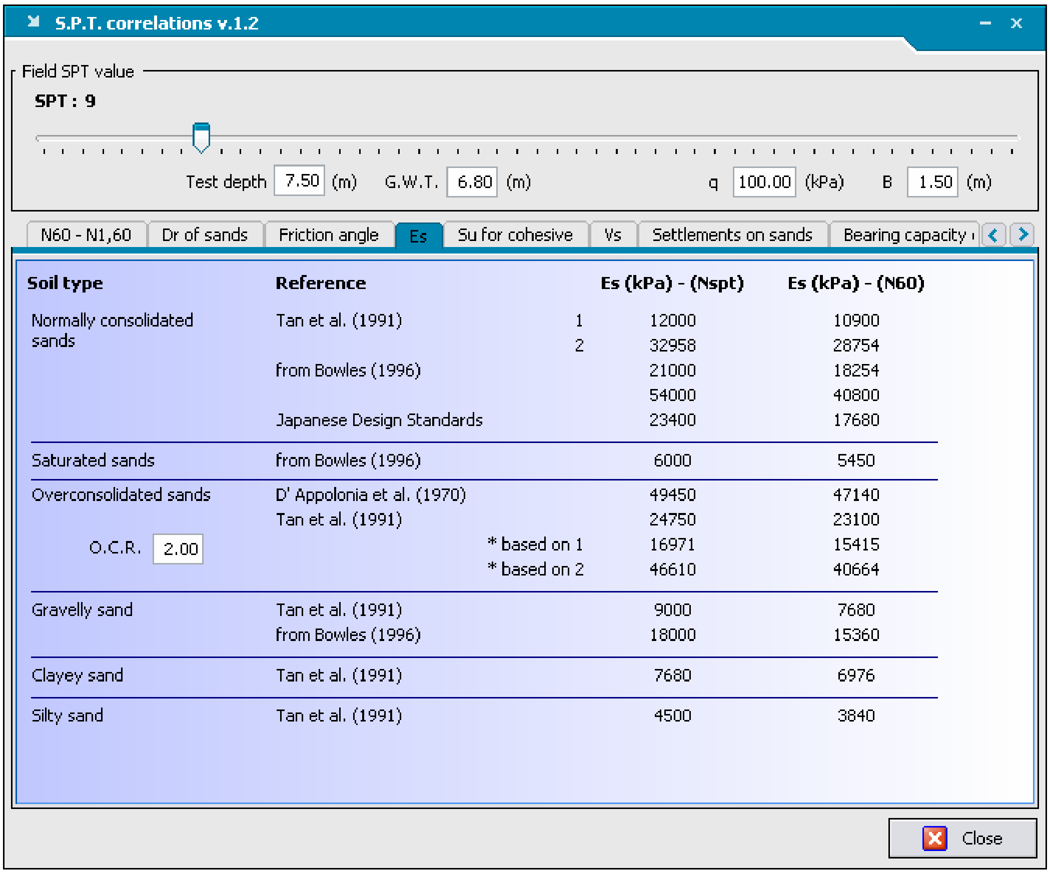
Figure 4.2 S.P.T. correlations program

During the course of the analysis as the sand-gravel layers are encountered, raw N values observed at the field are corrected into $N_{1,60}$. Three types of corrections are applied to these N values. The first one is the energy correction, C_e. Since it is a procedure applied worldwide, this correction is needed to standardize every different application. In Turkey a donut hammer released by a pulley mechanism of two turns on cathead is usually used and therefore the hammer efficiency (E_m) value is equal to 0.45. To get the corrected value of $N_{1,60}$:

$$N_{1,60} = N_{field} \frac{E_m}{0.6} \tag{4.4}$$

All that is needed in the program is to input the energy correction value which is the ratio of hammer efficiency to 0.6 and that is 0.75 in this case (Figure 4.2). The other correction which is the overburden correction (Liao and Whitman, 1986) is automatically applied by the program when testing depth and depth to groundwater table is entered. Further corrections could be manually inserted such as rod length factor C_R, borehole diameter factor C_B, sampling method factor C_S and others. After all of these corrections are executed, $N_{1,60}$ value is available depending on the preferred method.

Every N_{field} values found in the alluvial sand-gravel layers are converted into $N_{1,60}$ values as explained above and the value proposed according to appropriate methodology is taken into account. Then, the average of these $N_{1,60}$ values are re-entered into the program to get the corresponding value of deformation modulus, E_s. It is critical to pick the correct methodology that will propose a more reasonable value with respect to the material composition. In the course of the analysis, deformation modulus of artificial fill was found by the method of Bowles (1996) for gravelly sand. For sandy soil preferred method for determining E_s value was Tan *et al.* (1991) for clayey sand (Figure 4.3).



Field SPT value

SPT : 9

Test depth 7.50 (m) G.W.T. 6.80 (m) q 100.00 (kPa) B 1.50 (m)

Soil type	Reference		Es (kPa) - (Nspt)	Es (kPa) - (N60)
Normally consolidated sands	Tan et al. (1991)	1	12000	10900
		2	32958	28754
	from Bowles (1996)		21000	18254
			54000	40800
	Japanese Design Standards		23400	17680
Saturated sands	from Bowles (1996)		6000	5450
Overconsolidated sands	D' Appolonia et al. (1970)		49450	47140
	Tan et al. (1991)		24750	23100
O.C.R. 2.00		* based on 1	16971	15415
		* based on 2	46610	40664
Gravelly sand	Tan et al. (1991)		9000	7680
	from Bowles (1996)		18000	15360
Clayey sand	Tan et al. (1991)		7680	6976
Silty sand	Tan et al. (1991)		4500	3840

Figure 4.3 Determining E_s value by S.P.T. correlations program

The deformation modulus is an important parameter because when inverted, it provides the coefficient of volume compressibility ($m_v = 1 / E_s$) which is a direct component of the settlement equation (3.3) mentioned earlier. Deformation modulus retrieved from the program (E_s) is assumed to be equal to E_{oed}, the modulus of deformation derived from oedometer test. Multiplying $1/E_s$ with layer thickness H and change in effective stress between initial and final conditions $\Delta\sigma'$ will give the amount of settlement that will be experienced in that particular layer.

4.2.3. Settlement Calculations at Silt-Clay Deposits

Alluvial deposits found at the project area are mostly composed of cohesive silty-clay matrix. Undisturbed sampling in this type of soil is a very convenient method of getting useful and uncorrupt information about the compressibility of the material. Further investigation carried out at soil mechanics laboratories often provide vital information like Atterberg limits, swelling potential, cohesion level and much more.

In this case the attention is on e – log p graphs which are plotted according to the results of oedometer tests conducted on undisturbed samples. As stated before, the e – log p graphs hold very important information about settlement process. The indices of compression and swelling summarize the consolidation behavior of the soil under investigation. In the analysis, these indices are utilized together with pre-consolidation pressure and settlement calculation is completed by the designated equation that is appropriate for the conditions.

For such deposits the first step is to determine the properties of soil. Natural and saturated unit weight values ($\gamma_{n,}$ γ_s), pre-consolidation pressure (p_c), initial void ratio (e_0) and indices of compression and swelling (C_c, C_s) are all noted in the database. These values are assigned to each sub-layer and are driven from the tests on closest undisturbed sample within the borehole. First step was to determine the initial stress condition at the midpoint of each sub-layer. Comparing this to pre-consolidation pressure revealed the ratio of consolidation. There were cases where initial effective stress was greater than pre-consolidation pressure but since this is not possible these two values were assumed to be equal and the layer was assumed to be normally consolidated. This situation will be emphasized on upcoming discussions section. The next step is to calculate the effective stress (using γ_n) after groundwater is drained completely to the tunnel level. Considering these two effective stress values one of the three equations is picked and the amount of settlement is estimated by the help of either C_c, C_s or both.

4.3. Assumptions

A number of assumptions were adopted for improving the analysis by means of practicality, flexibility and precision. These are listed below:

- Settlements that occur due to ground loss are not included in the analysis. Any other reason than groundwater drainage is excluded while calculating settlement.
- The change in effective stress during the process of consolidation and its effects are ignored. Only initial and final effective stresses were taken into consideration.
- In accordance with the initial project the tunnel construction method is assumed to be cut-and-cover. Tunneling methods that inhibit water drainage into the tunnel excavation (such as TBM) are not considered even if they are to be selected with a modification in the project.
- The groundwater drainage is predefined as a sudden incident. The study is completely independent of time since the main objective is to find the ultimate amount of settlements that the project area is potentially exposed to under special circumstances. Therefore, permeability and time parameters are not applied in this study.
- The relationship between the groundwater drainage and the consolidation process is ignored. In reality the consolidation occurs during the groundwater drainage but in this study the drainage is assumed to occur first and only then, the

consolidation is to take place with new conditions under affect.

- The drop in groundwater table is assumed to fall down to the invert level. In actual case, this drop may be interrupted due to some lithological occurrences or decrease in rate of groundwater drainage.
- The groundwater table is considered to stay horizontal during the lowering and even after the drainage is complete. It is an assumption made for not complicating the analysis.
- The settlements were estimated with respect to the tunnel axis only. Settlements away from the axis were not taken into account.
- Possible deformations on the tunnel surface and uneven settlements are assumed not to happen.
- Once the sub-layers are defined, they are all considered to be homogeneous elements on their own.
- Very low values of pre-consolidation pressure are ignored and the corresponding material is assumed to be normally consolidated.
- Investigation works conducted in the field and the soil mechanics laboratory are assumed to be by the standards with minimum error possible.

4.4. Numerical Analysis

When analyzing the settlement due to groundwater drainage at the project area analytical concepts were primarily utilized. This process is possibly under the effect of numerous errors that started to accumulate from the time the project works began. The systematic of analysis brought the need for specific assumptions that also set some limitations on the concluding results. Even though the analytical approaches that were used in this study are trustworthy methods with long history of application, their results should be confirmed by another approach that will use different criteria and a different path to get the results out of the identical conditions simulated in a numerical medium.

For this purpose, numerical models of several sections located at the project area were constructed by Plaxis. In this section the operating principles, preparation of the model, considered facts and the calculation process will be explained.

4.4.1. General Definition for Plaxis Program

Development of PLAXIS began in 1987 at the Technical University of Delft as an initiative of the Dutch Department of Public Works and Water Management. The initial brief was to develop a simple finite element code for the analysis of river embankments on the soft soils of the lowlands of Holland. In subsequent year, Plaxis was extended to cover most other areas of geotechnical engineering. Because of continuously growing activities, a company named PLAXIS BV was formed in 1993.

PLAXIS v. 7.2 (1998) is a finite element program for plane strain and axisymmetric modeling of soil and rock behavior. Plaxis has a fully automatic mesh generation, allowing for a virtually infinite number of 6-node and 15-node elements, based on graphical input of soil layers. The models can contain both drained and undrained layers. For undrained layers, excess pore pressures are calculated and elasto-plastic consolidation analysis may be carried out. Large deformations may be analyzed by means of an updated mesh (Lagrangian) calculation. Using this option, the finite element mesh is continuously updated during the calculation. For some situations, a conventional small strain analysis may show a significant change of geometry. In these situations, it is advisable to perform a more accurate Updated Lagrangian calculation (PLAXIS, 1998).

Main goal of Plaxis is to fulfill its intention to provide a practical analysis tool for use by geotechnical engineers who are not necessarily numerical specialists. Most of the time practical engineers find non-linear finite element computations cumbersome and too time-consuming for regular analyses. This issue was addressed through intense research and development and theoretically sound computational procedures encapsulated in a logical and easy-to-use shell is designed. As a result, Plaxis came to use as a world-wide numerical code in practical applications.

Plaxis is the finite element package specifically intended for the analysis of deformation and stability in geotechnical engineering projects. Geotechnical applications require advanced constitutive models for the simulation of the non-linear and time-dependent behavior of soils. In addition, since soil is multi-phase material, special procedures are required to deal with numerous cases arise in the complicated nature of the soil.

Although the modeling of the soil itself is an important issue, many geotechnical engineering projects involve the modeling of structures and the interaction between the structures and the soil. Plaxis is equipped with exclusive features to deal with the numerous complexities of geotechnical structures. A brief summary of the important features of the program is given below.

4.4.1.1. Graphical Input of Geometry Models

The input of soil layers, structures, construction stages, loads and boundary conditions are based on convenient drawing procedures (CAD), which allows a detailed and accurate modeling of real situations to be achieved. From this geometry model a finite element mesh is automatically generated.

4.4.1.2. Automatic Mesh Generation

Plaxis allows for fully automated generation of unstructured finite element meshes with options for global and local mesh refinement. The mesh generator is a special version of the Triangle generator.

4.4.1.3. High-order Elements

High order elements are available to enable a smooth distribution of stresses in the soil and an accurate prediction of failure loads. In addition to the quadratic 6-node triangular elements 15-node cubic strain triangles are available (and preferred for this study) which perform extremely well in axisymmetric analyses.

4.4.1.4. Beams

Special beam elements are used to model the bending of retaining walls, tunnel linings and other slender structures. The behavior of these elements is defined using flexural rigidity, a normal stiffness and an ultimate bending moment. A plastic hinge may develop for elastoplastic beams, as soon as the ultimate moment is mobilized. Beams may be used together with interfaces to perform highly realistic analyses of a large range of geotechnical structures.

4.4.1.5. Interfaces

These joint elements are needed for calculations involving soil-structure interaction. They may be used to simulate the thin zone of intensely shearing material at the contact of footings, piles, geotextiles, retaining walls, etc. Values of interface friction angle and adhesion that are not necessarily the same as the friction angle and cohesion of the surrounding soil, may be assigned to these elements.

4.4.1.6. Tunnels

Plaxis offers a convenient option to create circular and non-circular tunnels composed of arcs. Beams and interfaces may be added to model the tunnel lining and the interaction with the surrounding soil. Fully isoparametric elements are used to model the curved boundaries within the mesh. Different practical methods are implemented to analyze the deformations that occur due to the construction of the tunnel.

4.4.1.7. Mohr-Coulomb Model

This robust and basic non-linear model is based on soil parameters that are known in most practical situations but not all non-linear features of soil behavior are included. The Mohr-Coulomb model may be used to compute realistic ultimate loads for circular footings, short piles, etc. It may also be used to calculate a safety factor using a “phi-c reduction” approach.

4.4.1.8. Advanced Soil Models

Plaxis offers a variety of soil models in addition to the Mohr-Coulomb model. To analyze accurately the logarithmic compression behavior of normally consolidated soft soils, a Cam-Clay type model is available. This is called the Soft Soil Model, the model which was utilized in this study. For stiffer soils, such as overconsolidated clays and sand, an elastoplastic type of hyperbolic model is available and it is the Hardening Soil Model.

4.4.1.9. Steady State Pore Pressure

Two alternative approaches exist for the generation of steady state pore pressures. Complex pore pressure distributions may be generated on the basis of a two-dimensional groundwater flow analysis. As an alternative for simpler situations, multi-linear pore pressure distributions can be directly generated on the basis of phreatic lines.

4.4.1.10. Excess Pore Pressures

Plaxis is equipped with the ability to distinguish between drained and undrained soils to model permeable sands as well as almost impermeable clays. Excess pore pressures are computed during plastic calculations when undrained soil layers are subjected to loads. Undrained loading situations are often decisive for the stability of geotechnical structures. In cases of insufficient stability, intermediate consolidation periods have to be introduced to reduce the excess pore pressures.

4.4.1.11. Automatic Load Stepping

Plaxis can be run in an automatic step-size and automatic time step selection mode. This avoids the need for users to select suitable load increments for plastic calculations by themselves and it guarantees an efficient calculation systems.

4.4.1.12. Staged Construction

It is possible to simulate construction and excavation processes by activating and deactivating clusters of elements. This procedure allows for a realistic assessment of stresses and displacements.

4.4.1.13. Updated Lagrangian Analysis

Using this option makes the finite element mesh to update continuously during the calculation. For some situations, a conventional small strain analysis may show a significant change of geometry. In these kinds of cases it is advised to perform more accurate Updated Lagrangian calculation, which is called an Updated Mesh analysis in Plaxis.

4.4.1.14. Consolidation

Although this feature was not accessed in the study, the decay of excess pore pressures with time can be computed in a consolidation analysis. A consolidation analysis requires the input of permeability coefficients in the various soil layers. Automatic time stepping procedures make the analysis precise and easy-to-use.

4.4.2. The Soft-Soil Model

The soil model is picked with respect to the geological aspects of the project section that is being concentrated on. In this study the soil model established is the soft-soil model. Some properties of Soft-Soil model are:

- Stress dependent stiffness (logarithmic compression behavior)
- Distinction between primary loading and unloading-reloading
- Memory for pre-consolidation stress
- Failure behavior according to the Mohr Coulomb criterion

In the Soft-Soil model, a logarithmic relation between the volumetric strain, ε_v, and the mean effective stress, $p^{'}$, is assumed. For failure behavior modeling purposes, a linearly elastic – perfectly plastic Mohr Coulomb type yield function is introduced.

4.4.2.1. Parameters in the Soft-Soil Model

A number of parameters are needed to be defined so that the process could be initiated. These are:

a. Modified compression index, λ^*, determines the compressibility of the material in primary loading. It is in relation with normalized parameters by parameters below:

$$\lambda^* = \frac{C_c}{2.3(1+e)} \tag{4.5}$$

b. Modified swelling index, κ^*, determines the compressibility of the material in unloading and subsequent reloading. Using Poisson's ratio for unloading / reloading, ν_{ur}, it can be defined by:

$$\kappa^* \approx 1.3 \frac{1-\nu_{ur}}{1+\nu_{ur}} \frac{C_s}{1+e} \tag{4.6}$$

Both of these two parameters can be obtained from an isotropic compression test with unloading. Slope of the primary loading line gives the modified compression index, whereas the slope of the unloading (or swelling) line gives the modified swelling index (Figure 4.4).

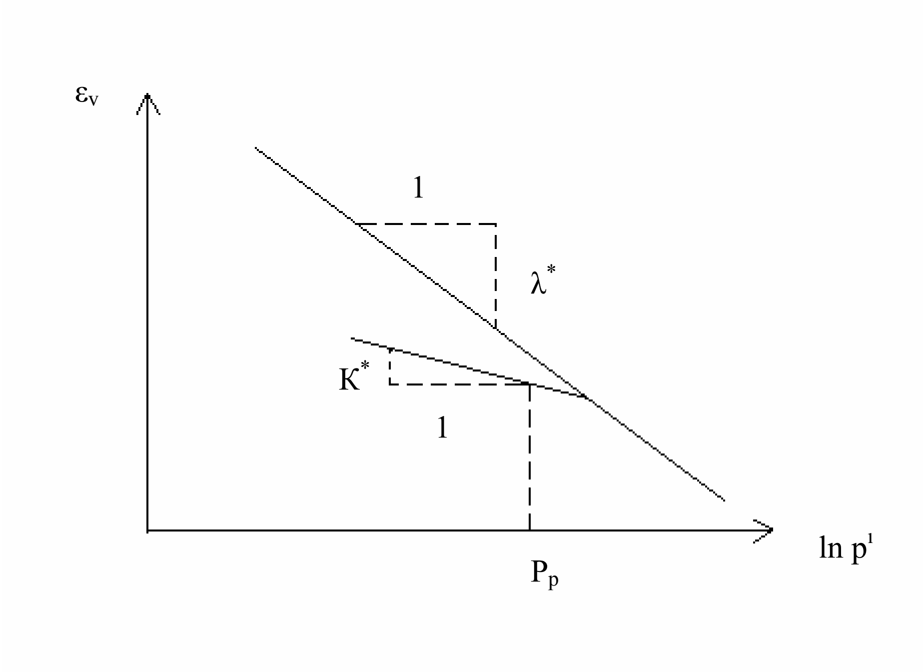


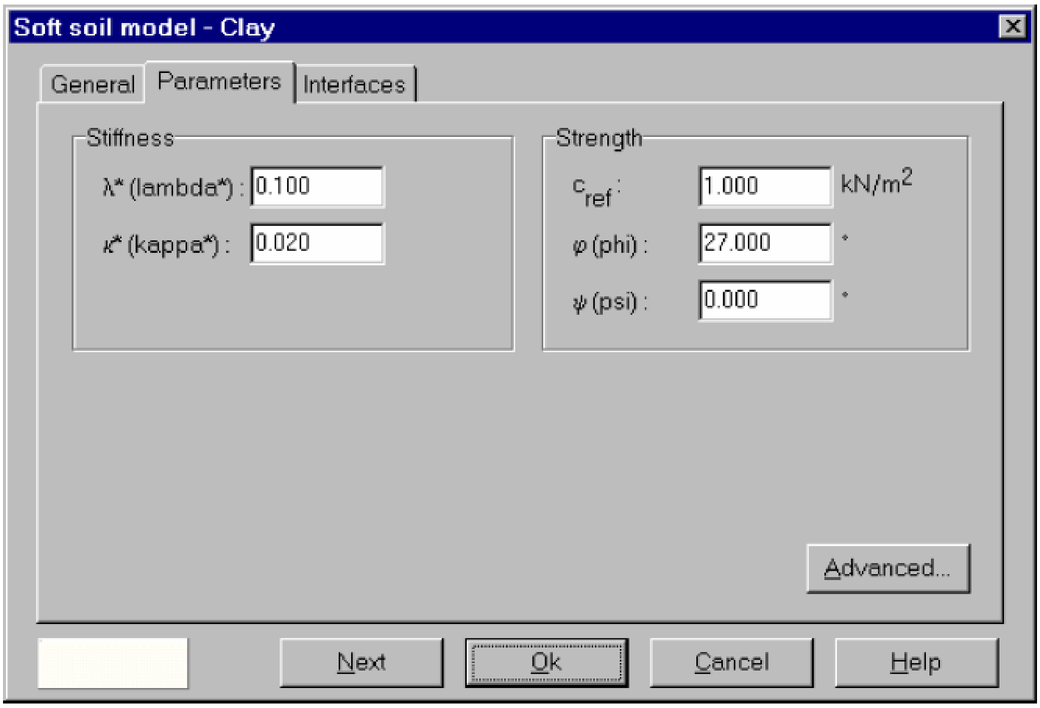
Figure 4.4 Logarithmic relation between volumetric strain-mean stress

c. Cohesion, c, it has the dimension of stress. Entering a cohesion value will result in an elastic region that is partly located in the ‘tension’ zone of the stress space. Input of large cohesion value will simulate state of overconsolidation

d. Friction angle, φ, specified in degrees and represents the increase of shear strength with effective stress level

e. Dilatancy angle, ψ, for the type of materials that are analyzed by Soft-Soil model, dilatancy can generally be neglected

All these parameters are registered in the Soft-Soil model to set up Plaxis for specified analysis (Figure 4.5).



λ* (lambda*) : 0.100

κ* (kappa*) : 0.020

c_{ref} : 1.000 kN/m^2

φ (phi) : 27.000 °

ψ (psi) : 0.000 °

Figure 4.5 Parameters tab for the Soft-Soil model

4.4.3. Selecting the Locations for Analyses

A total of four sections were selected to be analyzed in Plaxis. These sections were picked from locations where, depending on calculations discussed in previous chapter, maximum and minimum amount of consolidation settlements are expected and two other randomly selected locations. The locations chosen for section preparation are at boreholes TA-5 (for maximum estimated settlement), TA-9 (for minimum estimated settlement), TA-3 and TA-23 (both randomly selected). At these locations Plaxis is used to point out whether the calculations completed earlier are realistic enough.

4.4.4. Preparation of the Sections

Every section is geometrically identified to the program by a CAD. The geometry of mesh is defined in accordance with Mestat (1997), extending the lateral boundaries of each section six folds of the tunnel diameter and the bottom of the section as deep as five times the diameter of the tunnel.

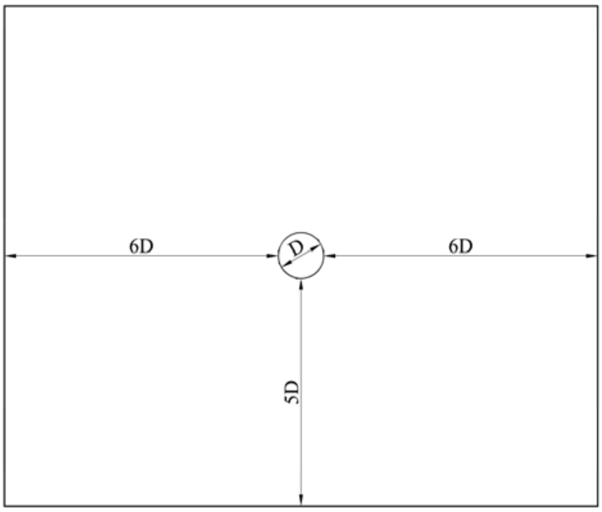


Figure 4.6 Sketch of the section geometry

Geological units are defined lithologically in the same sequence at the exact depths with the borehole log and corresponding soil properties are noted. The information includes cohesion, internal friction angle, deformation modulus, overconsolidation ratio, modified indices of compression and swelling. Any structures that are constructed on ground surface are means of surcharge load and should be found in the prepared section. In the case of four locations that were picked for analysis, such constructions do not exist. This can be observed from the plan view of the project area in Figure 4.7 or at the actual site.

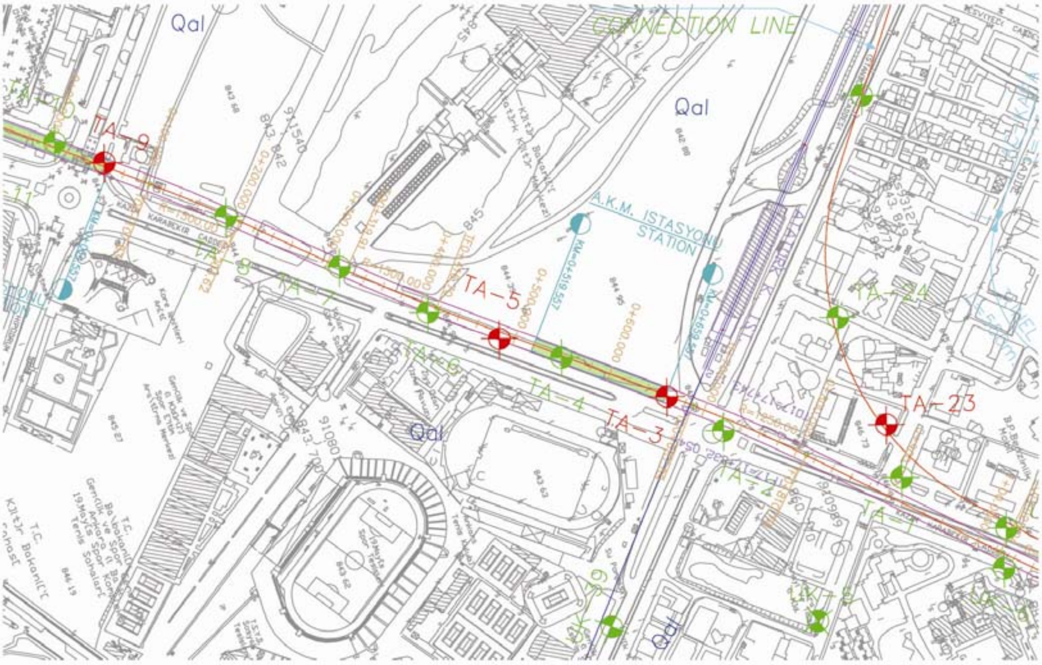


Figure 4.7 Plan view of section locations

The boundary conditions specified for these sections play an important role in the way the Plaxis processes. Nodes located at the bottom boundary of the section geometry are fixed in both x (horizontal) and y (vertical) directions. Nodes found at the side boundaries of the model sections are fixed in x direction and free in y direction to enable simulation of deformations. As far as the groundwater flow is concerned the nodes at the bottom border of geometry are closed to groundwater flow. Groundwater pressures due to total head are assigned to the nodes at the side boundaries of the model. This way, the position of the groundwater table is determined. Drain boundary condition is assigned to the nodes located at the tunnel opening. This allows the natural discharge of the groundwater into the tunnel excavation the same way as it happens in the actual case.

The selected borehole locations of TA-3, TA-23, TA-9 and TA-5 were represented by sections 1-to-4. All of the four sections prepared in Plaxis are displayed in Figures 4.8, 4.9, 4.10, and 4.11. The related properties mentioned before are also provided within the coverage of these sections. Table 4.2 shows number of elements and nodes for the numerical models of each section.

Table 4.2 Information regarding numerical models of each section

	Section-1 (TA-3)	**Section-2 (TA-23)**	**Section-3 (TA-9)**	**Section-4 (TA-5)**
Number of elements	1943	1814	2295	2413
Number of nodes	15791	21768	18727	19555

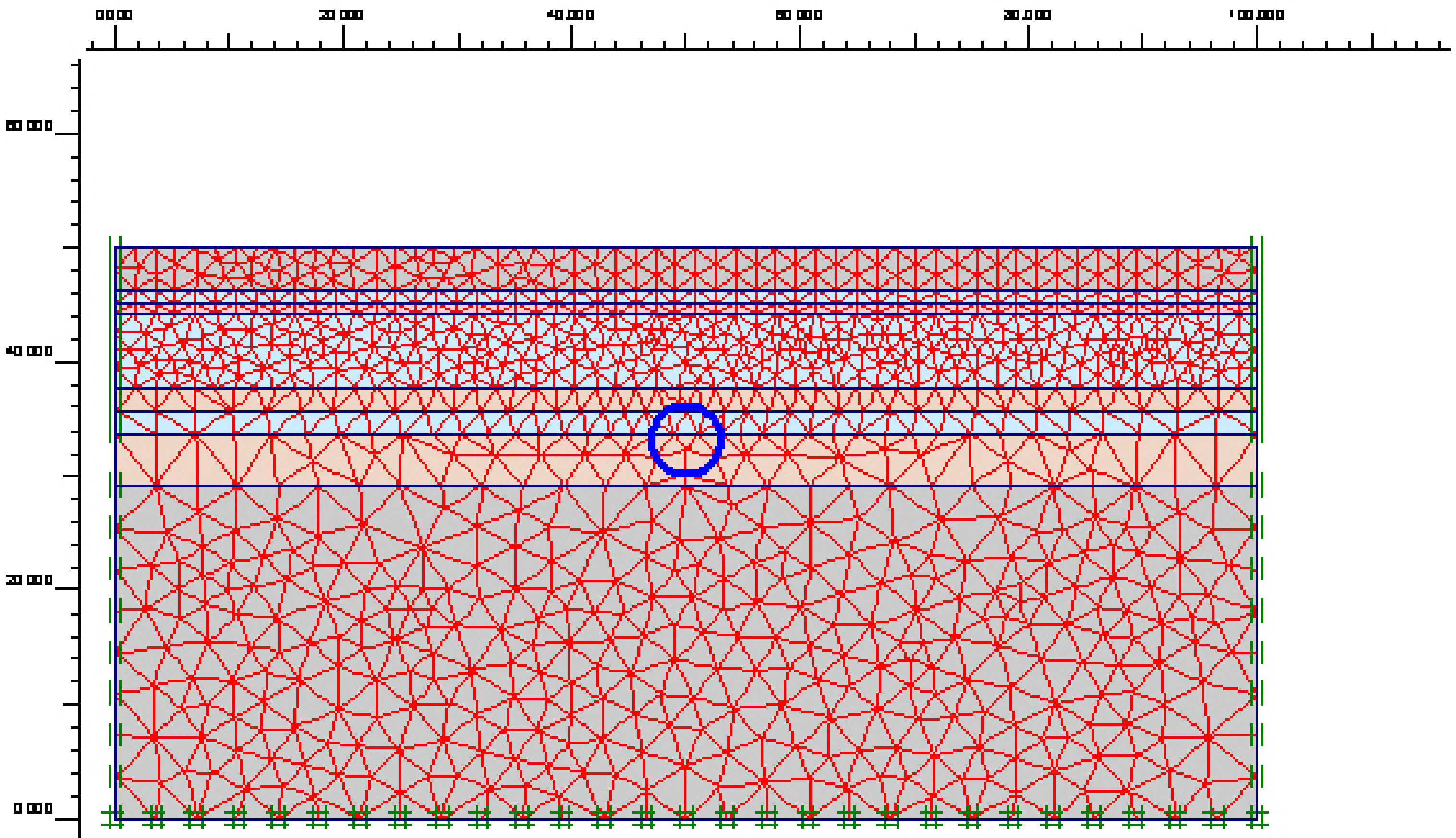


Figure 4.8 Mesh geometry and boundary conditions of Section-1

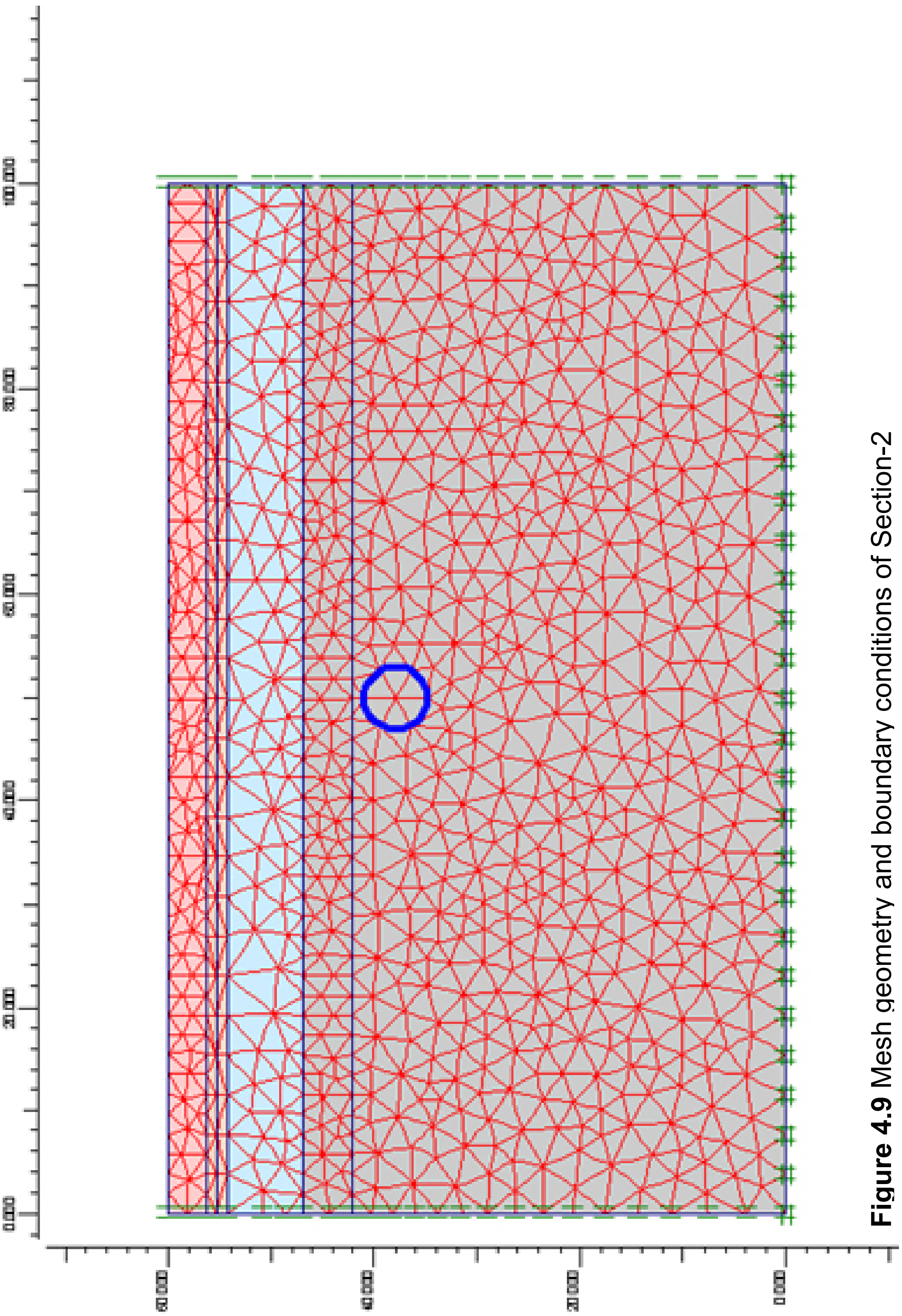


Figure 4.9 Mesh geometry and boundary conditions of Section-2

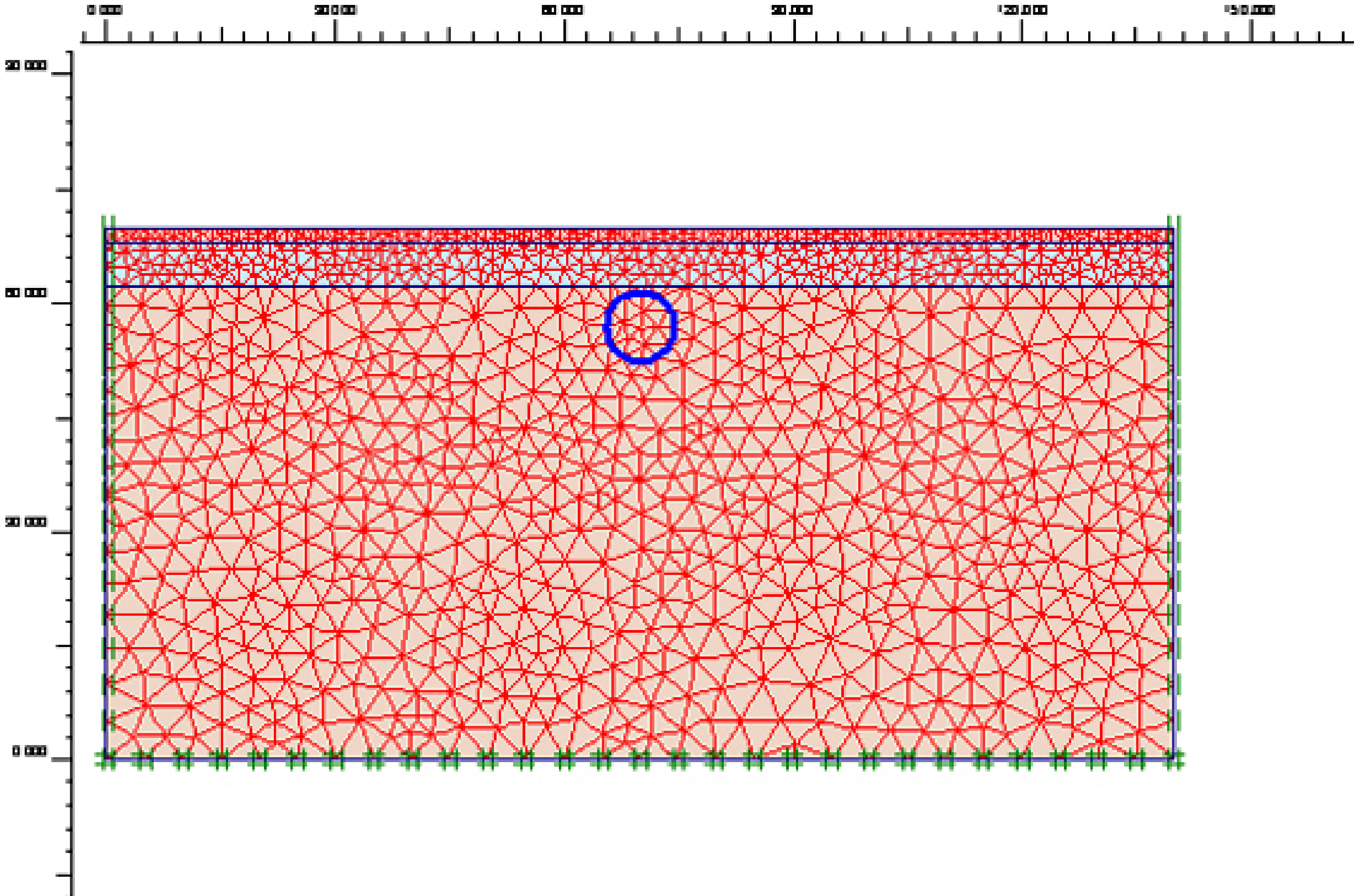


Figure 4.10 Mesh geometry and boundary conditions of Section-3

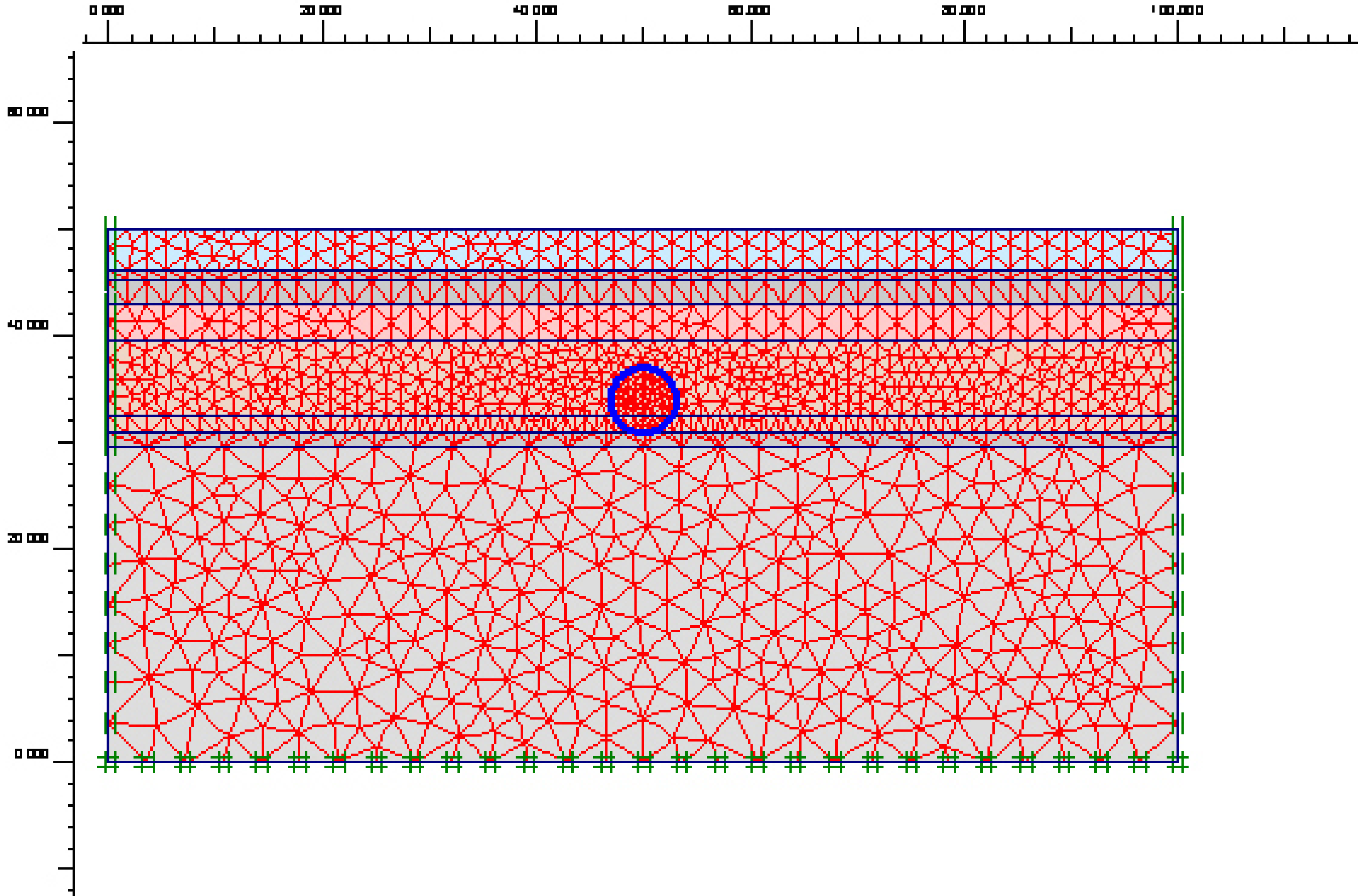


Figure 4.11 Mesh geometry and boundary conditions of Section-4

4.4.5. Defining Stages of Analysis

Sections that are identified into the system are ready for analysis that should be designed as separate stages for Plaxis to process. The analyses take place in four stages:

a. Stage-1: At this first stage in-situ effective stress generation takes place according to the initial site conditions and the parameters notified in the section.

b. Stage-2: Tunnel excavation is implemented with reduced overburden load. In order to simulate the effect of tunnel face on the deformations that occur at the unsupported section of the tunnel, ∑M-Stage parameter was selected as 0.5 in value. The displacements that take place until the installation of support measures are taken into consideration with this reduction in the overburden pressure. At this stage no support is yet applied at the tunnel cross-section.

c. Stage-3: The tunnel cross-section is integrated with the lining. Properties of the lining are stated in order to simulate the actual support systems. ∑M-Stage is set to 1 so that the overburden pressure is applied to its full extent. Regarding deformations are calculated. All of the displacements that are calculated until the end of this stage are the displacements that occurred due to tunneling.

d. Stage-4: Since the study aims to determine the amount of deformations due to only groundwater drainage, the displacements that were calculated at previous stages are ignored and set to zero at the beginning of this stage. In this stage the lining that is permeable allows groundwater to drain into the tunnel and the drained water is pumped out. From this point on, the stage mechanism works in two divisions, because Plaxis elaborates the consolidation and the drainage as independent (i.e. uncoupled) processes.

i. The position of the groundwater table is estimated by taking a constant level of permeability for all soil materials found within the section. An overall approximate phreatic line representing the steady state groundwater level is generated with respect to the groundwater calculations.

ii. Upon completion of drainage the increase in effective stress and the resulting settlements formed in the final case are calculated.

Plaxis goes through specified computations following each phase and the final situation is displayed on screen so that the unique effects of that stage are clearly visible. Mesh geometry, boundary conditions, settlement of the ground surface, deformations at tunnel surface, position of groundwater table and groundwater flow tendencies can be all observed by the illustrations of Plaxis. Such concluding displays for each section and the numerical results will be presented next chapter.

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1. Results of Analytical Approach

Consolidation settlement calculations done according to the analytical formulas suggested in the literature were quite straightforward once the site conditions were adapted to a basic systematic. The estimated settlements for every other borehole location are ranging from a few millimeters up to 20 centimeters. The arithmetical average of these estimations point out to 10 centimeters of average settlement. Amount of estimated settlements are available at Table 5.1. These values are also displayed in a histogram for better understanding of settlement distribution (Figure 5.1).

Table 5.1 Settlements estimated by analytical approach

Borehole	Settlement (cm)
TA-1	13,13
TA-2	7,68
TA-3	11,47
TA-4	17,62
TA-5	21,34
TA-6	13,61
TA-7	11,16
TA-8	0,71
TA-9	0,124
TA-21	5,53
TA-23	19,21
TA-24	12,26
TA-25	5,85
UK-7	8,01
UK-8	10,99
UK-12A	3,29
UK-18A1	6,37

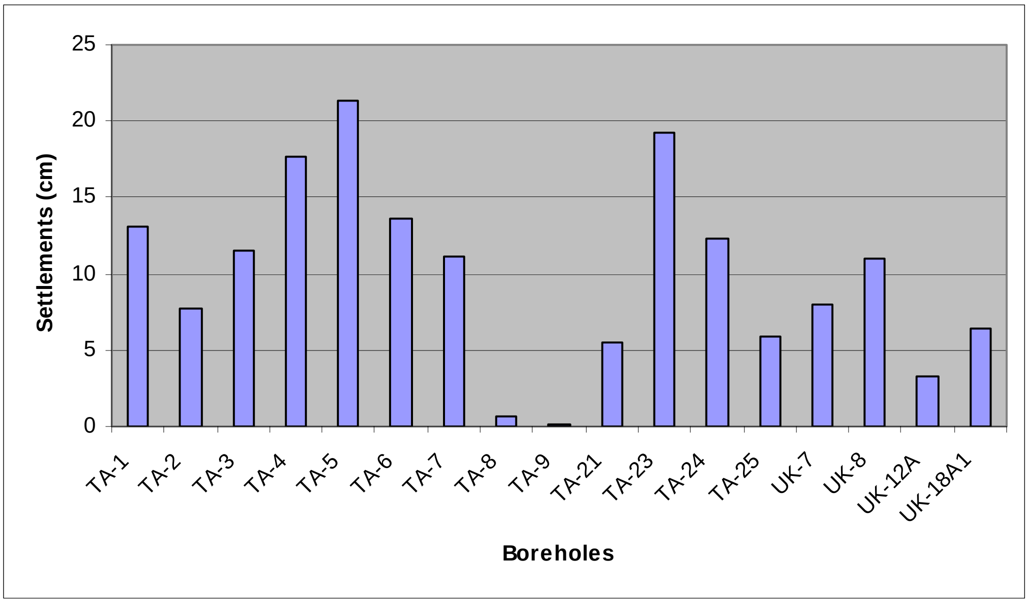


Figure 5.1 The histogram showing settlement estimations

5.2. Results of Numerical Analysis

Plaxis produces graphical display of the results on the model section that was setup for analysis. These graphs visualize the steady-state groundwater level with associated pore pressure contours after the drainage of groundwater into the tunnel as well as the total displacement contours due to the process of consolidation. Extreme active pore pressures are: -443 kN/m^2 for Section-1, -532 kN/m^2 for Section-2, -634 kN/m^2 for Section-3 and -451 kN/m^2 for Section-4. Negative values indicate pressure. The amounts of maximum settlement are: 9.46 cm for Section-1, 22.31 cm for Section-2, 1.63 cm for Section-3 and 20.96 cm for Section-4. The resulting illustrations of four separately prepared sections are given in Figures 5.2 to 5.9.

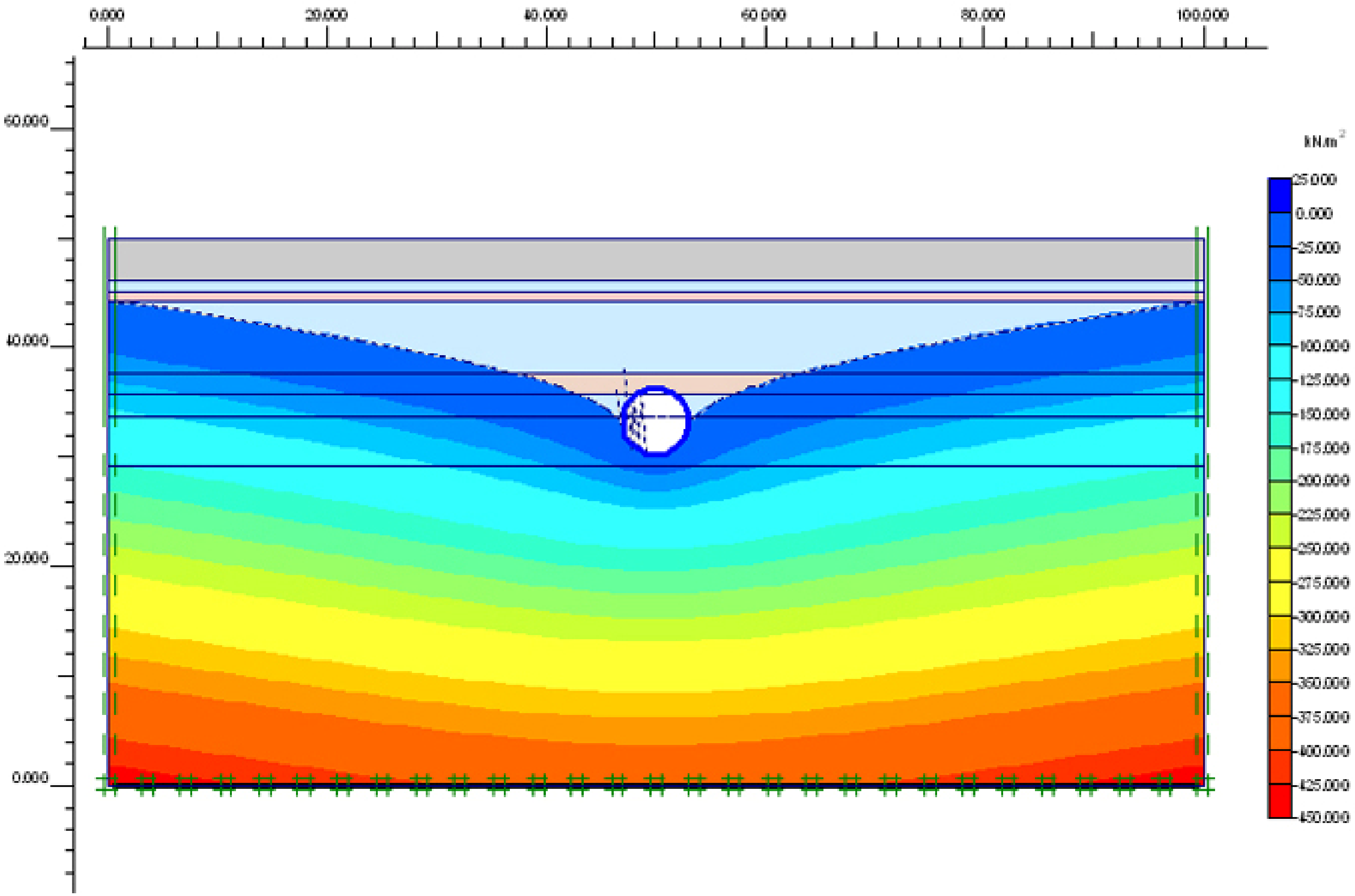


Figure 5.2 Final position of groundwater table and pore pressure levels for Section-1

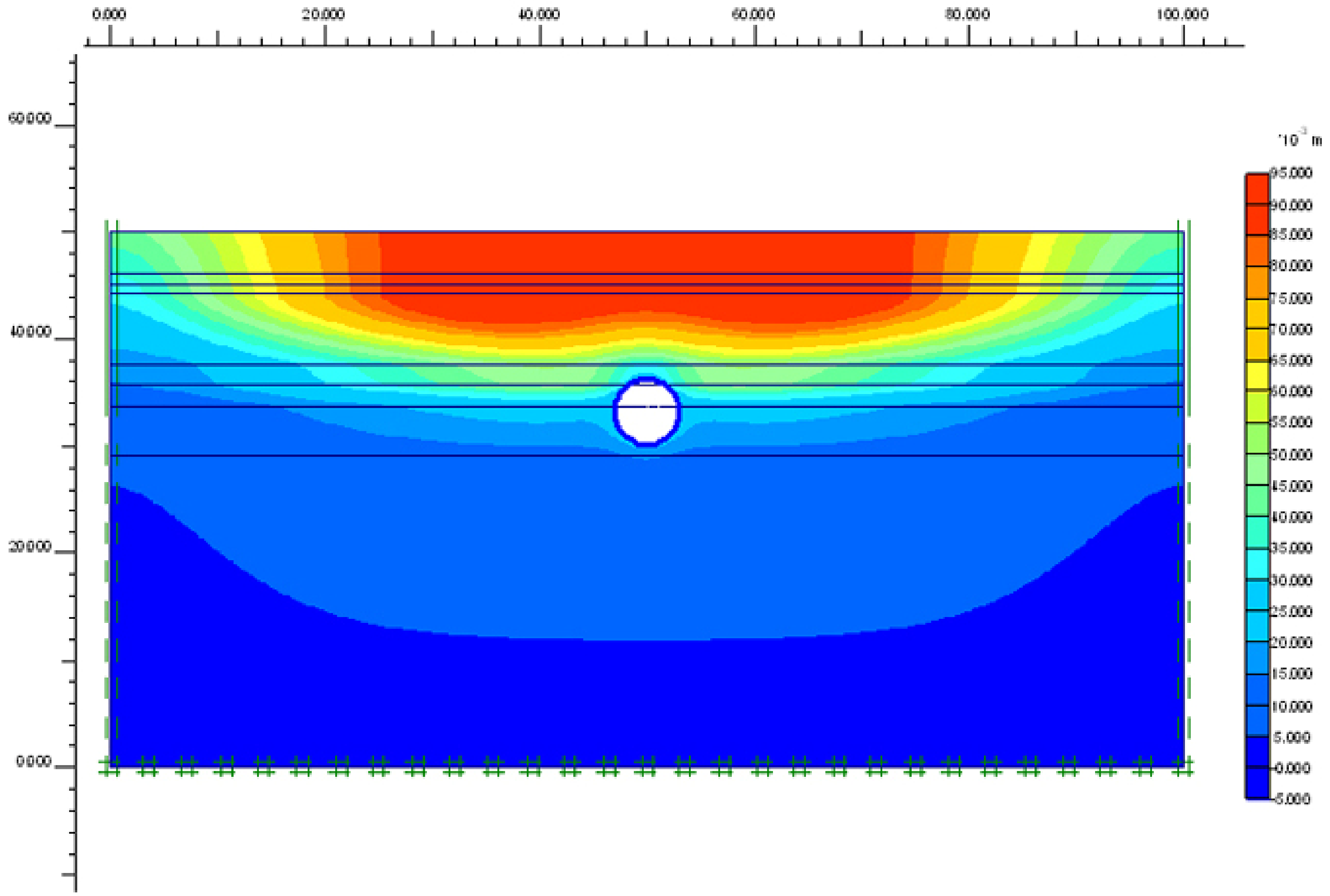


Figure 5.3 Contours of total displacement due to consolidation at Section-1

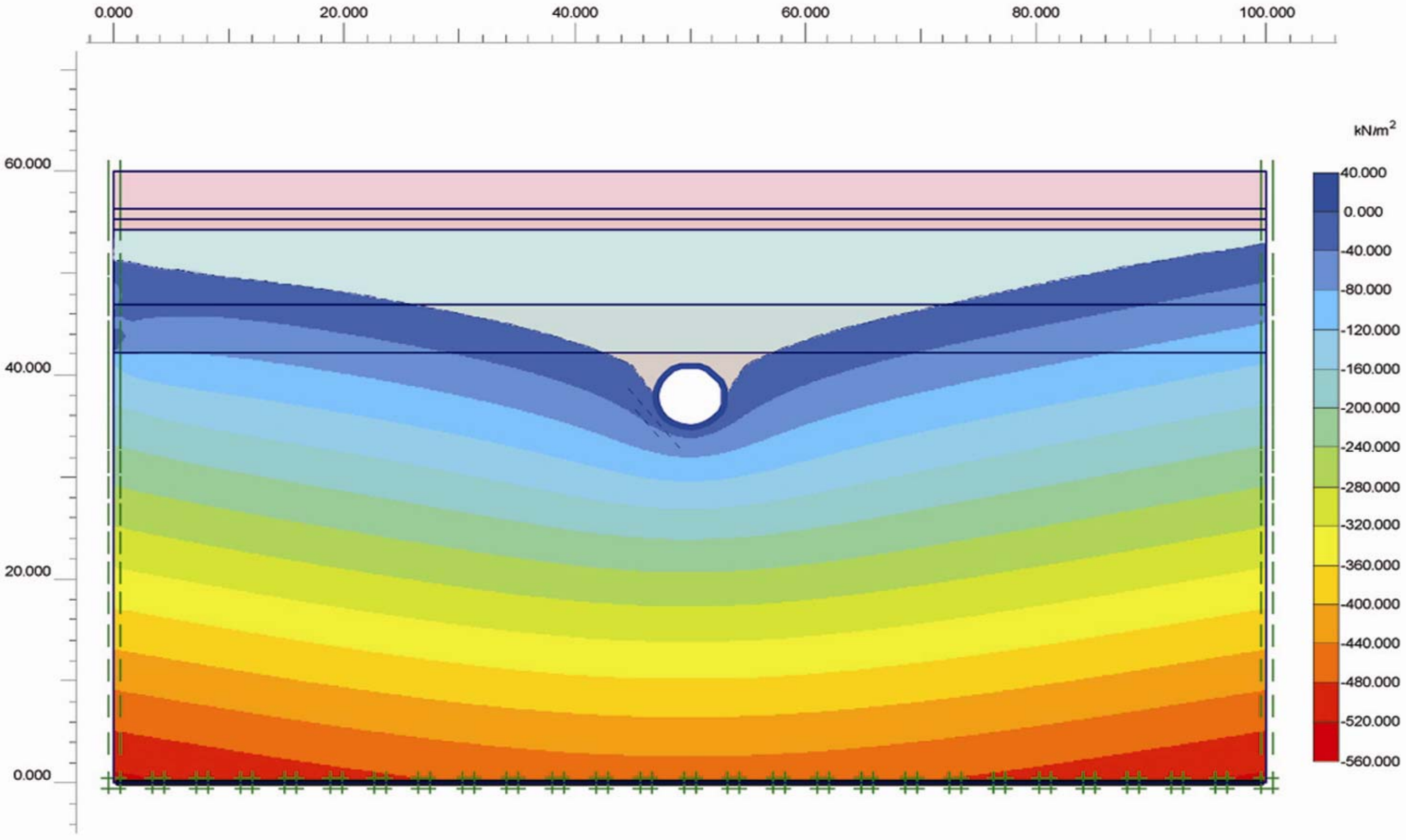


Figure 5.4 Final position of groundwater table and pore pressure levels for Section-2

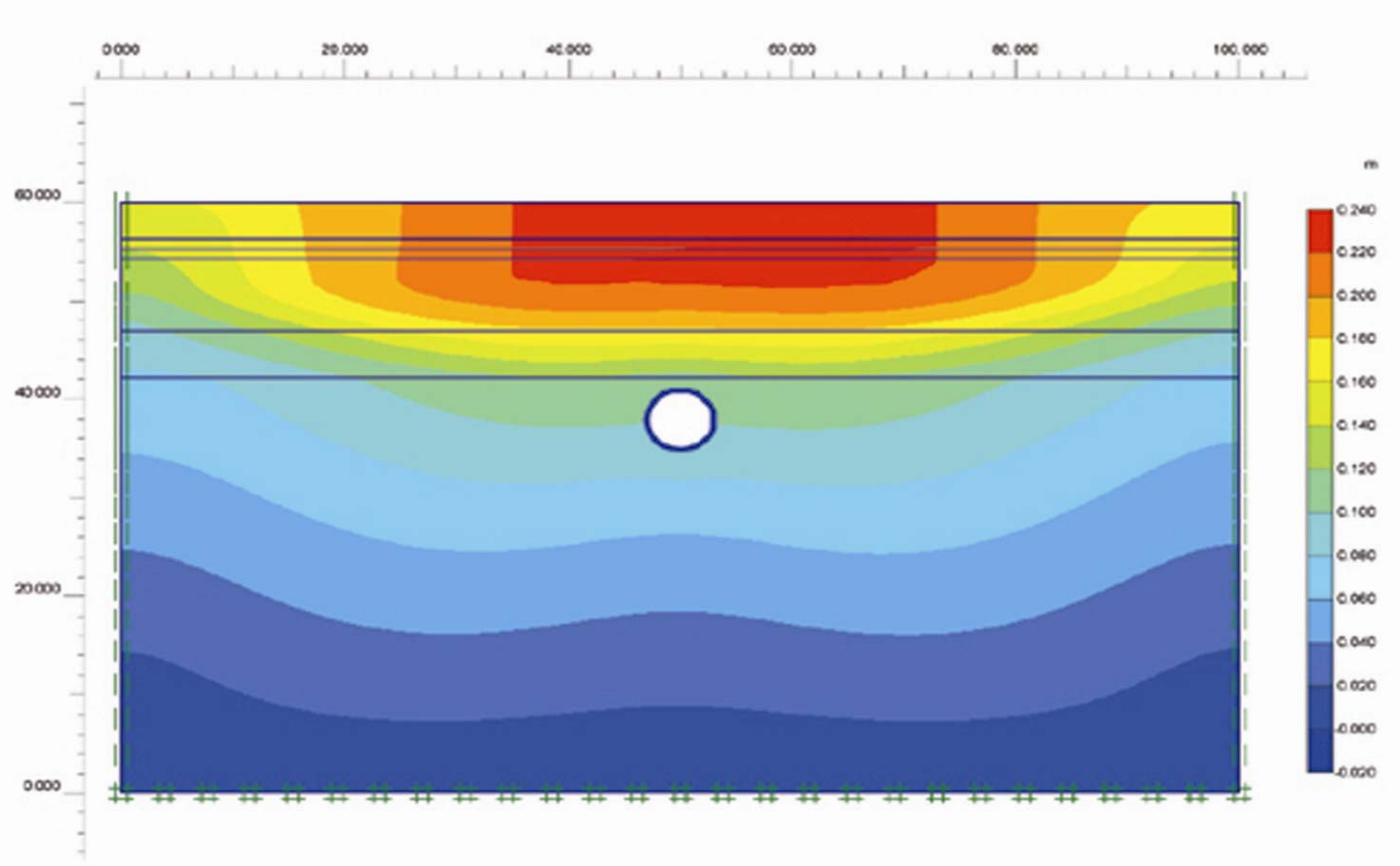


Figure 5.5 Contours of total displacement due to consolidation at Section-2

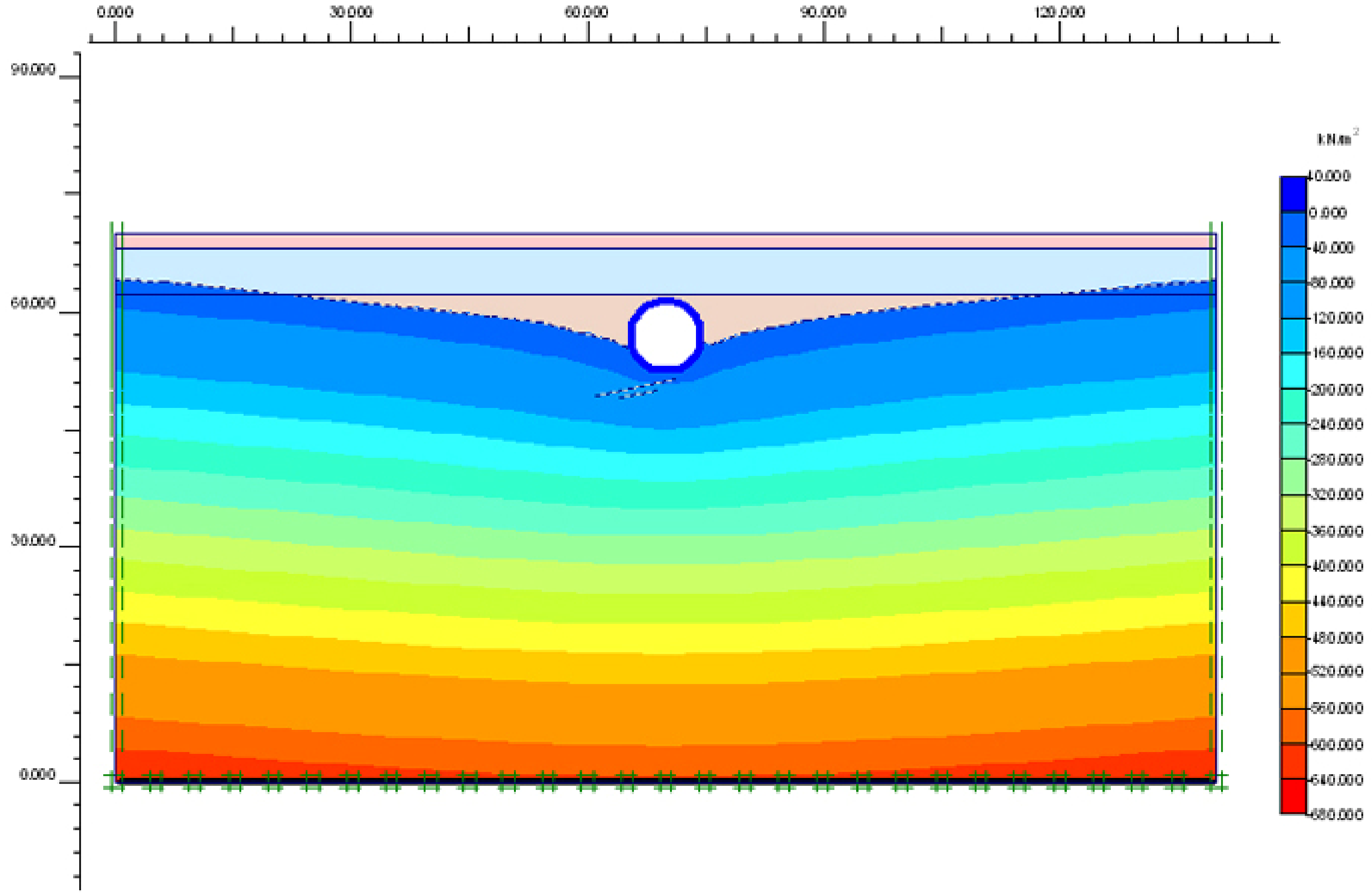


Figure 5.6 Final position of groundwater table and pore pressure levels for Section-3

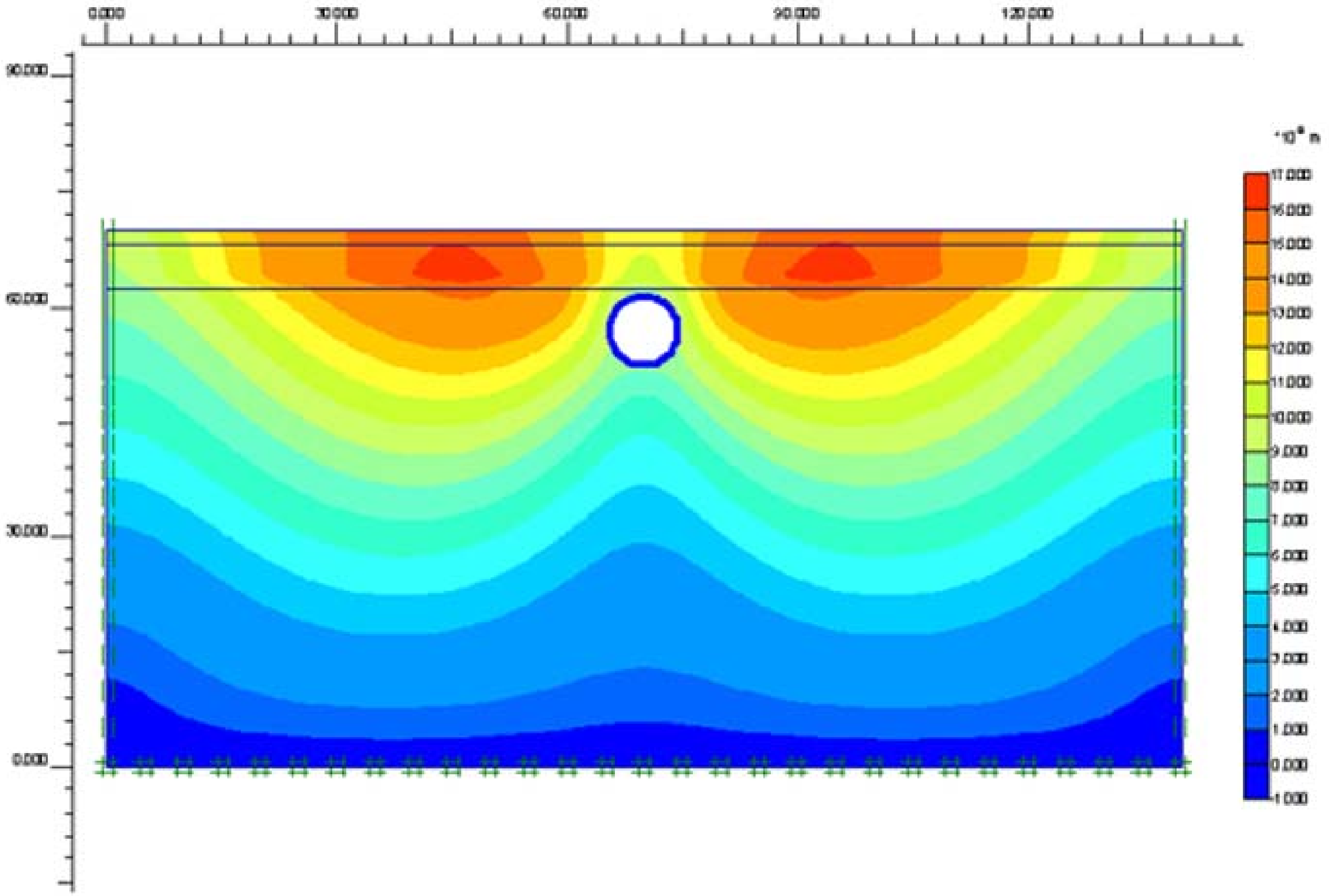


Figure 5.7 Contours of total displacement due to consolidation at Section-3

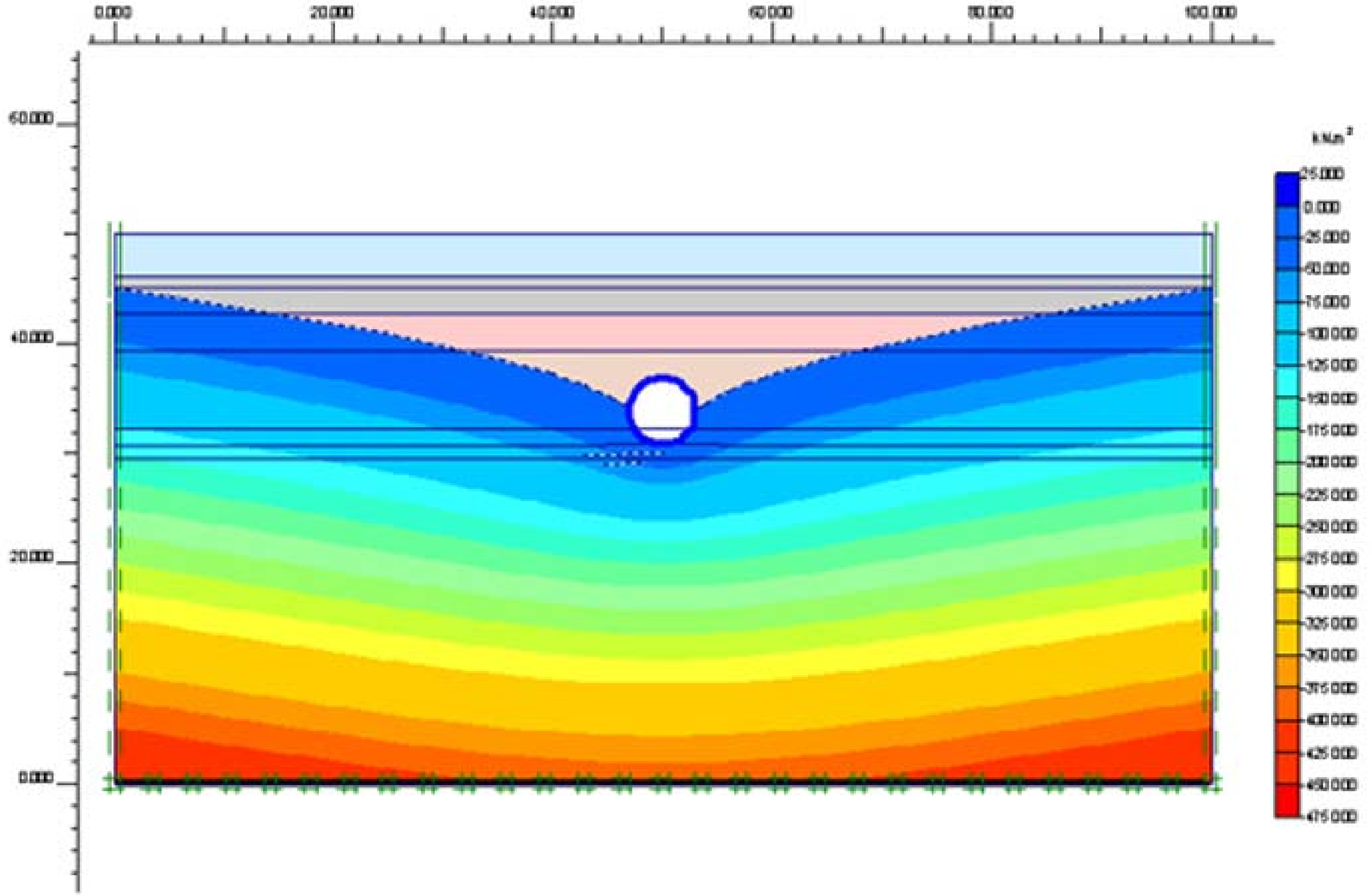


Figure 5.8 Final position of groundwater table and pore pressure levels for Section-4

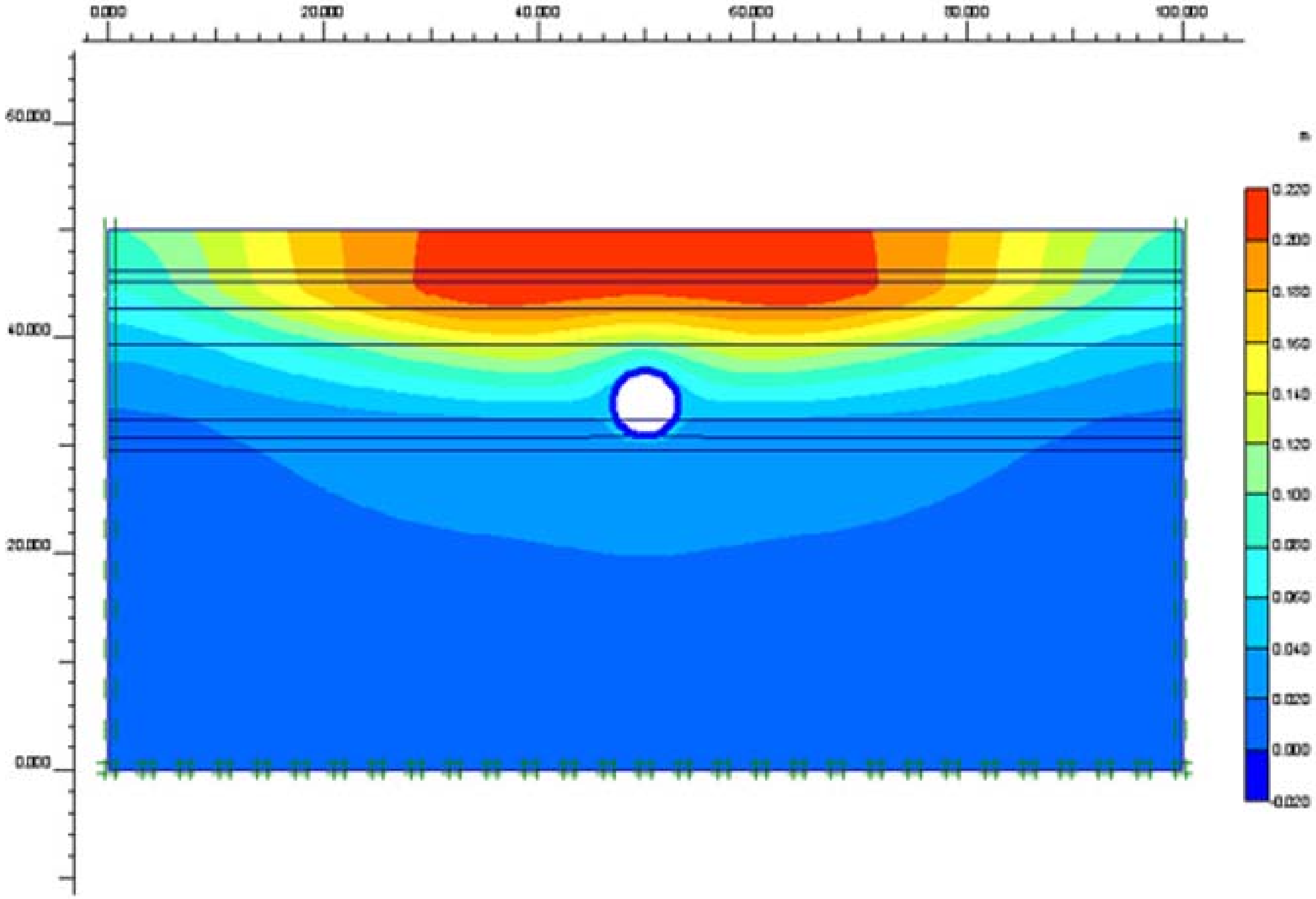


Figure 5.9 Contours of total displacement due to consolidation at Section-4

5.3. Discussions

The analysis portion of the study was under the effect of many complex factors. Defining the actual site conditions through limited quantity of investigation works was quite a challenge. To be able to run the analysis smoothly, one has to be greatly familiar with the related concepts.

In the analytical phase of the study too many restricting assumptions were adapted. The computations did not involve as many parameters as the numerical analysis where a lot more aspects of the consolidation process were considered. The results proposed by analytical methods show maximum settlement occurrence at the location of borehole TA-5. The numerical analysis, on the other hand, highlighted borehole TA-23 as the location with the settlement risk of highest magnitude.

As seen in Table 5.1, the settlement values predicted by analytical calculations vary from a few centimeters to more than 20 centimeters. Settlements of around 10-15 centimeters were observed at TA-1, TA-3, TA-6, TA-7, TA-24 and UK-8 locations mostly because the compressible layer is fairly thick and the groundwater table decline is allowed since the tunnel is constructed at a moderate depth. At TA-24, the layer which will settle is very thick but mostly composed of cohesionless soil with low settlement potential. At locations of TA-8 and TA-9 level of ground subsidence is almost zero because tunnel is at a shallower depth and hence the compressible layer is very thin. At TA-4, TA-5 and TA-23 settlements are over 15 centimeters because of the deeply seated tunnel and a thick, compressible layer consisting of soft clay soil. Approximately 5-to-10 centimeters of settlement is expected near UK-7, UK-12A, UK-18A1, TA-2, TA-21 and TA-25 locations because the layer which will experience compression is mostly made up of cohesionless soil material that is reluctant for consolidation settlements. Especially at TA-2 the artificial fill layer which is incapable of consolidation is very thick and therefore the settlements are low.

The only odd thing about the results from numerical model was seen at the settlement contours of Section-3. Despite the fact that literature of tunnel engineering suggests maximum amount of ground deformations at the axis of the tunnel, in Section-3 this is not the case. The contours in Figure 5.7 must have appeared similar to those settlement graphs of other sections. Only reasonable explanation for this is that the thickness of compressible layer that was drained is smaller at the axis of the tunnel than at the sides. Therefore, a different sort of resulting graph was produced as Plaxis processed the case with respect to groundwater drainage only. This difference could also be explained by the fact that the tunnel in this section is seated at a shallow depth and therefore, the structure itself, could have provided a certain support to the overlying soil material.

It should be noted that the analyses from both approaches were unique in their own and were not meant to yield exact matching results of consolidation settlements. In accordance, the estimated settlement results of the analyses from the numerical approach were consistent with those from the previous phase with just 2-to-3 centimeters of difference (Table 5.2). The similarity of these results could be explained by the certainty of field parameters and use of the same database for analyses.

Table 5.2 Comparison of analytical and numerical results

	Settlements	
	Analytical Calculations (cm)	Numerical Model (cm)
TA-3	11.47	9.46
TA-5	21.34	20.96
TA-9	0.12	1.63
TA-23	19.21	22.31

The analytical approach is concerned with the initial effective stress conditions and the increase in effective stress caused by groundwater drainage to determine the degree of volumetric compression. The changes in effective stress that happen during the consolidation process are not involved. On the other hand, the numerical method considers the stress changes caused by tunnel excavation together with the effective stress discrepancies due to groundwater extrusion in a realistic manner. The numerical model involves the shear deformations in the analyses as well as the volumetric strains.

The estimated amount of settlements in this study may not conform with those that are to be observed in the actual field. The suggested ground displacements are the ultimate values and to achieve these values all the assumptions of the study must take place in the real case. Since most of these assumptions, that were used to bring practicality into the study, have no chance of occurrence, the actual measurements are (most probably) going to be less than the estimated values. The recent modifications made in the project already took effect. Hence, the expected groundwater drainage and estimated settlements will not be permitted.

The types of tunnel cross-sections will also have an important effect on the intention and magnitude of the settlements. The turnout tunnel cross-section requires the biggest excavation area where two subway lines are intersected and therefore it is the most critical cross-section. Station platform tunnel cross-sections also carry a huge importance with second largest diameter. Main-line (base) tunnels have great potential of causing settlements at increasing depths. Connection tunnels are smaller but still critical because they create tunnel crossings. Staircase inclined tunnel and approach tunnel cross-sections are the sections where risk of settlements is least since they are located at fairly shallower depths. Settling will also have a great tendency to happen at regions where geological situation gets complicated.

This study is prepared in accordance with the original project. If any modifications are to be deployed in the initial project, than the study should be taken as an independent case of its own. Creating a false opinion about the project is not among the intentions of the study since any problem such project would possibly face could be handled with an effective engineering practice.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

Estimation of consolidation settlements is a crucial part of almost every subway project. The process involves many complexities such as achieving precision in representation of the site conditions and the difficulty in adapting a high-performance model for the analyses. In this particular study about the Ulus – Keçiören subway project the circumstances became especially challenging.

In the first phase of the study, main concepts of the consolidation settlement were covered by a thorough literature review. This survey study provided the vision and ability to evaluate the terms of the project and relate them to the widely recognized consolidation concept. Since the availability of noticeable levels of consolidation settlement was limited, the investigation works done at the project area had to be searched for locations with the potential to sustain settlement. The scarcity of such investigational works and the difficulty of acquiring them took a great deal of time and effort. After the determination of a region that possesses settlement treat, the area was assessed so that a specific system of analysis based on analytical methods could be carried out. These well-known methods were executed efficiently and settlement estimation was conducted. The results of estimated consolidation settlement due to groundwater drainage according to analytical calculations are: 13.13 cm for TA-1, 7.68 cm for TA-2, 11.47 cm for TA-3, 17.62 cm for TA-4, 21.34

cm for TA-5, 13.61 cm for TA-6, 11.16 cm for TA-7, 0.71 cm for TA-8, 0.12 cm for TA-9, 5.53 cm for TA-21, 19.21 cm for TA-23, 12.26 cm for TA-24, 5.85 cm for TA-25, 8.01 cm for UK-7, 10.99 cm for UK-8, 3.29 cm for UK-12A and 6.37 cm for UK-18A1. Consequently the results of these analytical methods suggested that the project area may confront remarkable amount of settlements due to groundwater drainage and precautions must be taken. The location where predicted settlements reached a serious level is near and around the Atatürk Cultural Center (A.K.M.) with almost 20 centimeters of ground subsidence.

Following the first phase of analyses a few locations (namely TA-3, TA-5, TA-9 and TA-23) from the same region were investigated once again with a detailed numerical model prepared by Plaxis. The settlement amounts predicted via the numerical model were: 9.46 cm for Section-1 (TA-3), 22.31 cm for Section-2 (TA-23), 1.63 cm for Section-3 (TA-9) and 20.96 cm for Section-4 (TA-5). Moreover, the results put forward by this approach once again suggested that the magnitude of settlements could endanger the course of the project if left unattended. Depending on all of the facts above, the project area must be carefully handled and the groundwater drainage must be controlled to prevent settlements.

The issue of ground deformations must be dealt with as the project works move on. Every section should be evaluated according to the tunnel cross-section to be excavated, the properties of soil material, the depth where excavation is done and the groundwater conditions. Extra care must be taken at places where a critical tunnel cross-section is to be excavated or the geological conditions get complicated.

The estimated values of consolidation settlements through analytical and numerical calculations need to be verified by careful monitoring of ground deformations during and after construction works. It must be emphasized that consolidation settlement is a very slow process and hence the monitoring period must be kept long. Even though the estimated values of settlement have low chance of occurrence, the project works must be carried out in caution.

Toward the end of this study some drastic changes have been made regarding the subway alignment as well as the method of excavation. The original alignment between Keçiören and Ulus has been changed as Keçiören –Tandoğan and the excavation is decided to be made by TBM. Along the new subway alignment Ankara Clay will be the dominant lithology. Adoption of TBM will also greatly eliminate the consolidation problems along the alluvial foundation crossings. This study, however, may be regarded as a case study for future subway tunnel constructions which may traverse through compressible and water saturated layers.

REFERENCES

AKYÜREK, B., Duru, M., Sütçü, Y., Papak, İ., Şaroğlu, F., Pehlivan, N., Gönenç, O., Granit, S., Yaşar, T., 1:100.000 ölçekli açınsama nitelikli Türkiye Jeoloji Haritaları No: 55, Ankara-F15 Paftası, Maden Tetkik ve Arama Genel Müdürlüğü Jeoloji Etütleri Dairesi, Ankara, 1997.

AL-HOMOUD, A.S., and Tanash, N., Monitoring and Analysis of Settlement and Stability of an Embankment Dam Constructed in Stages on Soft Ground, in *Bull. Eng. Geol. Env.*, No: 59, 2001, pp.259-284.

BOWLES, J.E., Foundation Analysis and Design, McGraw-Hill, USA, 1996.

BRINKGREVE, R.B.J., and Vermeer P.A. *(edited by)*, PLAXIS v7.2 Manual, A.A. Balkema, Rotterdam, Netherlands, 1998.

CASAGRANDE, A., the Determination of the Pre-consolidation Load and Its Practical Significance, 1st ICSMFE, Volume: 113, 1936, pp. 901-991.

CERNICA, J.N., Geotechnical Engineering: Soil Mechanics, John Wiley & Sons Inc., USA, 1995.

CHEN, C., Pei, S., and Jiao, J.J., Land Subsidence caused by Groundwater Exploitation in Suzhou City, China, in *Hydrogeology Journal*, No: 11, 2003, pp.275-287.

CHOU, W., and Bobet, A., Predictions of Ground Deformations in Shallow Tunnels in Clay, in *Tunnelling and Underground Space Technology*, No: 17, 2002, pp. 3-19.

CRAIG, R.F., Craig's Soil Mechanics, Spon Press, New York, 2004.

DALGIÇ, S., and Şimşek, O., Settlement Predictions in the Anatolian Motorway, Turkey, in *Engineering Geology*, No: 67, 2002, pp. 185-199.

DAS, B.M., Advanced Soil Mechanics, McGraw-Hill, New York, 1983.

DAS, B.M., Principles of Foundation Engineering, fourth ed., PWS-Kent Pub. Co., Boston, 1998.

DAS, B.M., Principles of Geotechnical Engineering, Brooks-Cole, Thompson Learning, Pacific Grove, CA, ch.2002.

DOYURAN, V., Assessment of Groundwater Inflow into a Metro Tunnel (Ankara), Geoline 2005, Lyon, France, May 2005.

DOYURAN, V., Engineering Geology Lecture Notes, Unpublished Material, METU, 2000.

GEOLOGISMIKI, S.P.T. Correlations v.1.2, http://www.geologismiki.gr/Freeware.html, April 2006.

GRØV, E., Introduction to Water Control in Norwegian Tunnelling: Norwegian Tunneling Society, Pub. 12, 2001, pp. 7-11.

KARAKUŞ, M., and Fowell, R.J., An Insight into the New Austrian Tunnelling Method (NATM), ROCKMEC'2004 – VIIth Regional Rock Mechanics Symposium, Sivas, Turkey, 2004.

KARLSRUD, K., Control of water leakage when tunnelling under urban areas in the Oslo Region: Norwegian Tunneling Society, Pub. 12, 2001, pp. 27-33.

KVELDSVIK, V., Holm, T., Erikstad, L., and Enander, L., Planning of a 25km Long Water Supply Tunnel in an Environmentally Sensitive Area: Norwegian Tunneling Society, Pub. 12, 2001, pp. 65-74.

LIAO, S., and Whitman, R.V., Overburden Correction Factors for Sand, in *JGED*, Vol: 112 No: 3, 1986, pp. 373-377.

LOGANATHAN, N., and Poulos, H.G., Analytical Prediction for Tunneling-Induced Ground Movements in Clays, in *Journal of Geotechnical and Geoenvironmental Engineering*, September 1998, pp. 846-856.

MESTAT, P., Maillage d'elements finis pour les ouvrages de geotechnique: conseils et recommandations, Bulletin-Laboratoires des Ponts et Chaussees, No: 213, 1997, pp. 39-64.

McGREGOR, J.A., and Duncan, J.M., Performance and Use of the Standard Penetration Test in Geotechnical Practice, Center for Geotechnical Practice and Research, Virginia Tech., 1998.

ÖZAYDIN, K., Zemin Mekaniği, Birsen Yayınevi, Istanbul, 1997.

ÖZBEK, A., Türkmen, S., and Gül, M., the Deformation Evaluation of Kızlaç T3A Tunnel (Osmaniye, Turkey), in *Engineering Geology*, No: 67, 2003, pp. 309-320.

TAN, T., Inoue, T., and Lee, S., Hyperbolic Method for Consolidation Analysis, in *Journal of Geotechnical Engineering*, Vol:117 No: 11, 1991, pp. 1723-1737.

TAN, W. L., and Ranjith, P.G., 2003, Parameters and considerations in soft ground tunneling: EJGE Paper, p. 1-19, www.ejge.com/2003/Ppr0344/Ppr0344.htm

TÜRKERLER-LİMAK Ortaklığı, Ankara Metrosu Ulus-Keçiören hattı inşaatı projesi: delme tünel yapım yöntemi (NATM ile): Döküman No: TY-YD05, Ankara, 2004.

Yüksel Proje, Ön jeolojik-jeoteknik raporu: Döküman No: LK-000-000-GE-16-001-PO, Yüksel Proje Uluslararası A.Ş., Ankara, 2003.

Yüksel Proje, Tandoğan-Mecidiye İstasyonları arası ön jeolojik-jeoteknik etüt raporu: Döküman No: LK-000-000-GE-16-004-PO, Yüksel Proje Uluslararası A.Ş., Ankara, 2005.

APPENDICES

APPENDIX A

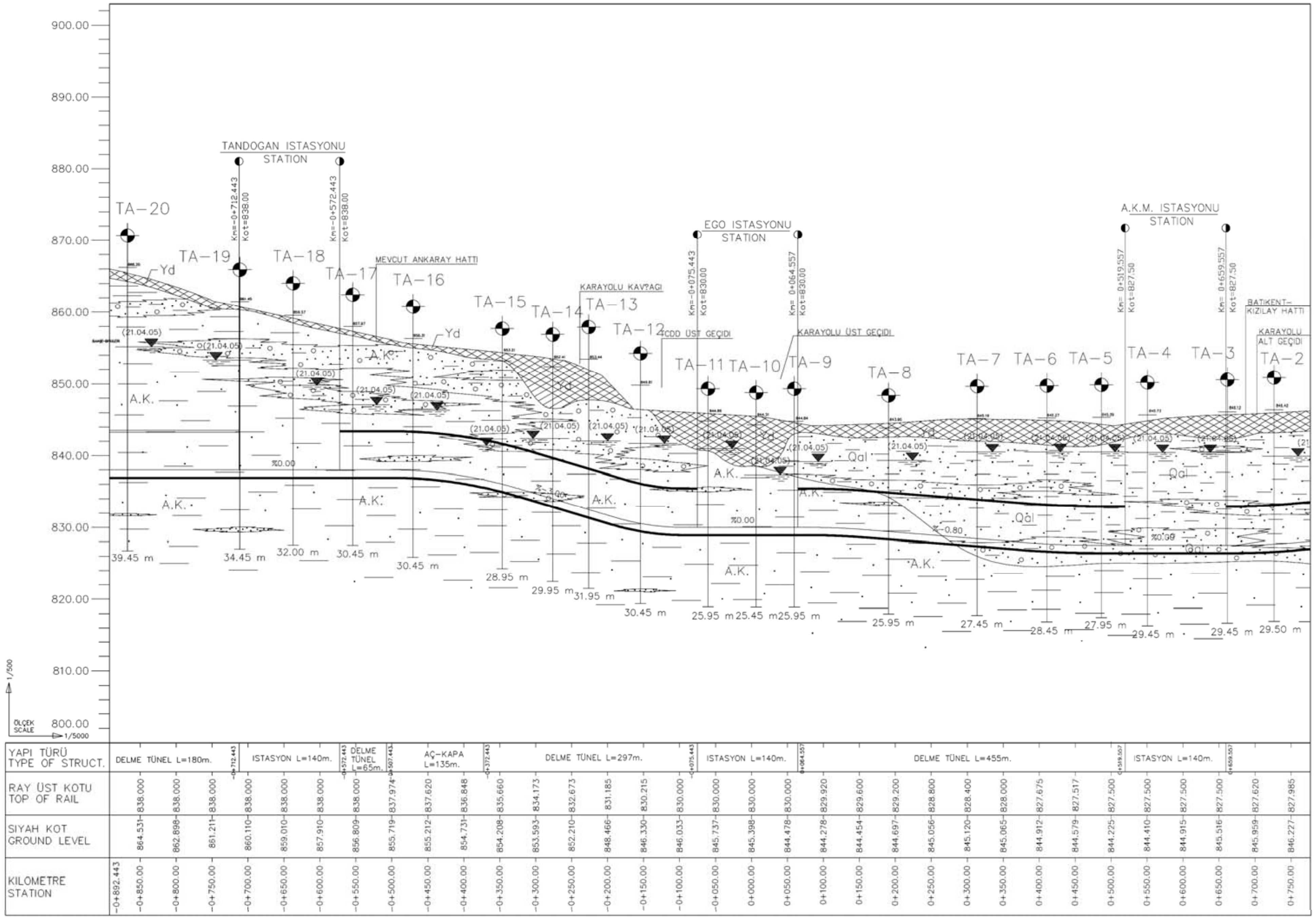


Figure A.1 Geological Cross-section of Subway Alignment

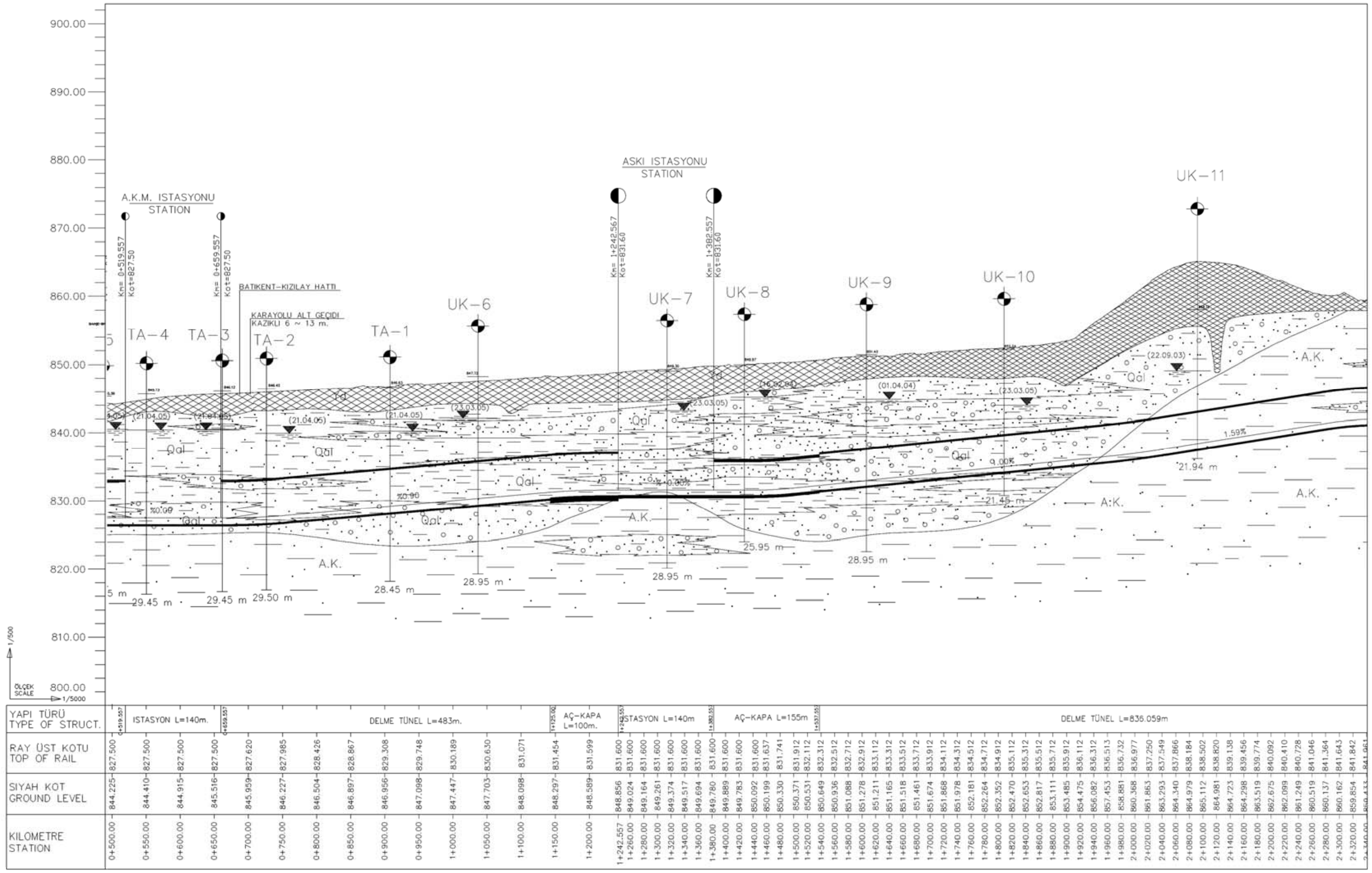


Figure A.1 Continuation of Geological Cross-section of Subway Alignment

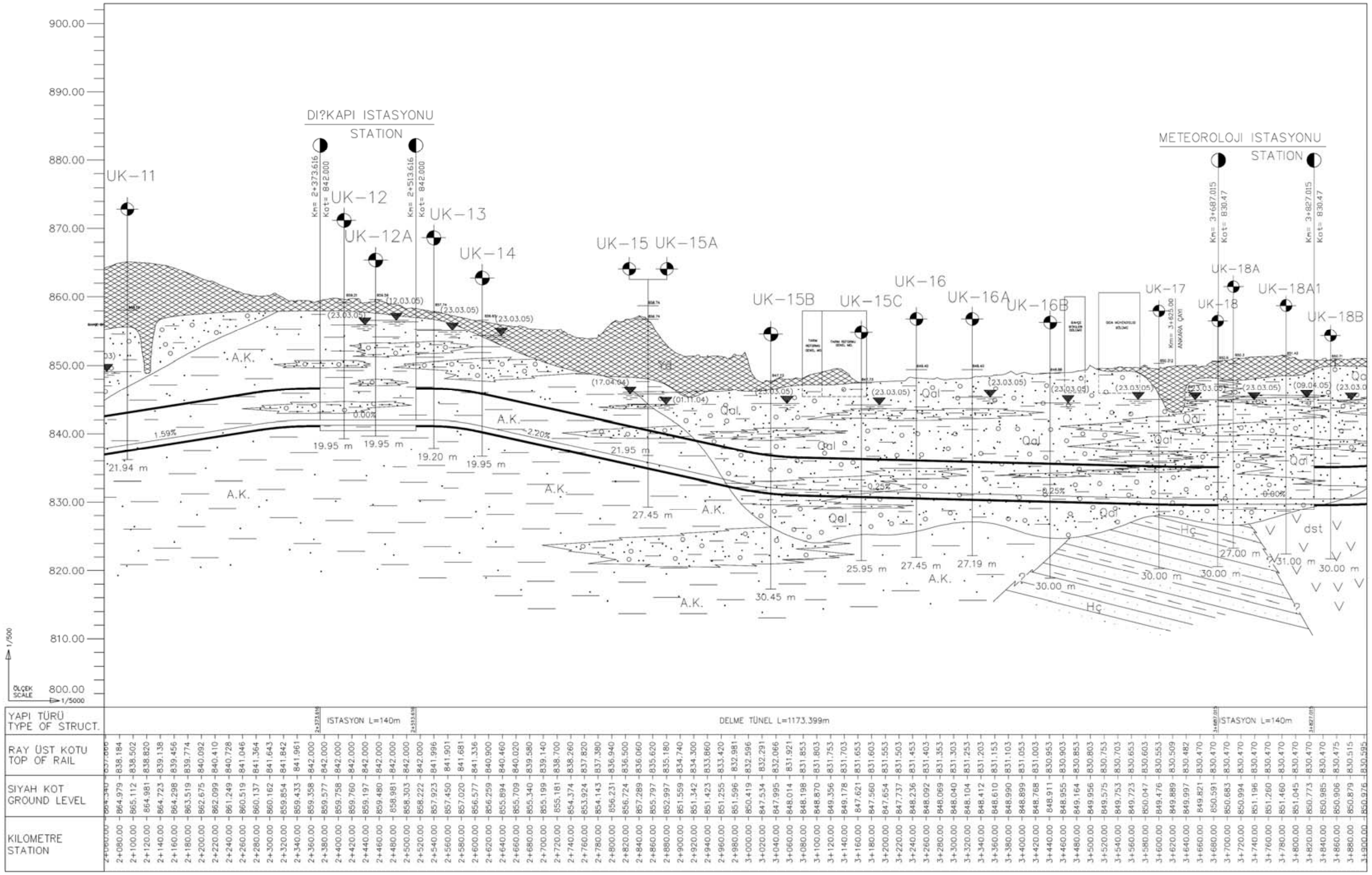


Figure A.1 Continuation of Geological Cross-section of Subway Alignment

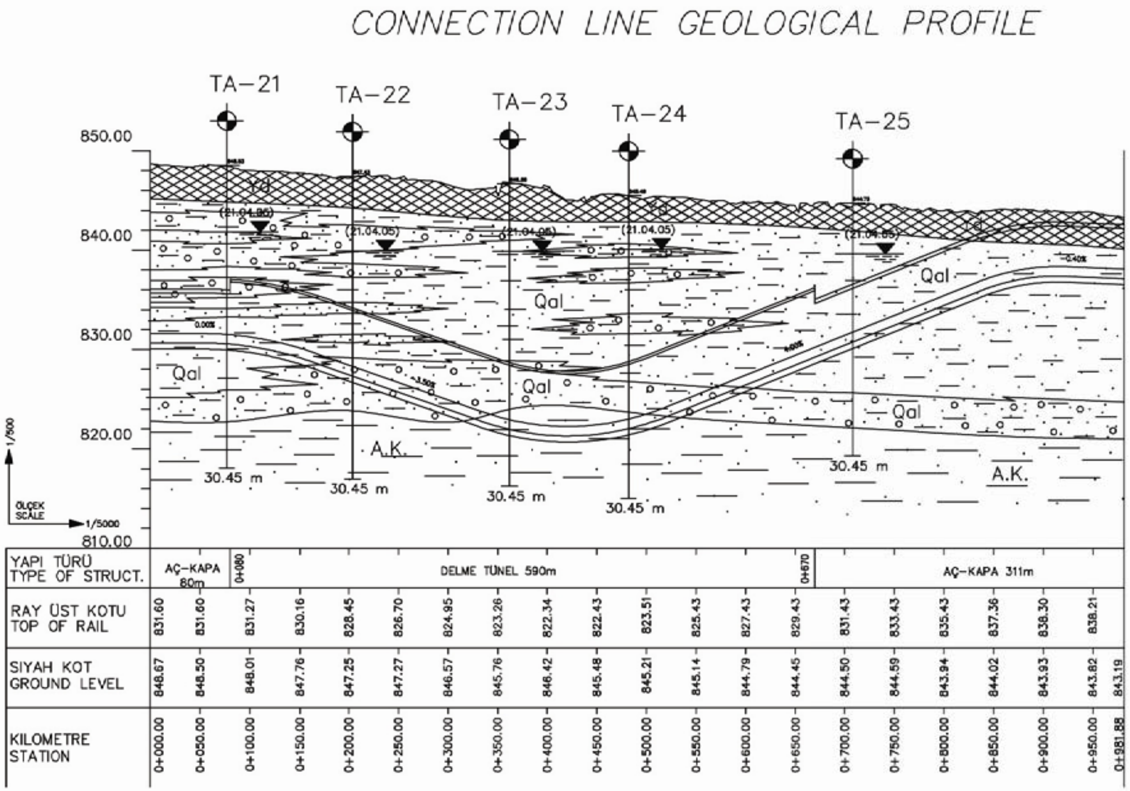


Figure A.2 Geological cross-section of connection line

APPENDIX B

Table B.1 Coordinates, Elevation and Depth of Boreholes

Borehole	Depth (m)	Y	X	Z
TA-1	28.45	486 946.64	4 423 615.32	846.63
TA-2	28.95	486 842.96	4 423 465.54	846.42
TA-3	29.45	486 792.19	4 423 424.50	846.12
TA-4	29.45	486 720.03	4 423 339.90	845.73
TA-5	27.95	486 681.71	4 423 288.36	845.39
TA-6	28.45	486 632.88	4 423 230.79	845.27
TA-7	27.45	486 560.86	4 423 163.91	845.19
TA-8	25.95	486 475.57	4 423 075.66	843.90
TA-9	25.95	486 384.68	4 422 980.59	844.84
TA-10	25.45	486 349.02	4 422 941.35	844.31
TA-11	25.95	486 324.94	4 422 873.95	844.86
TA-12	30.45	486 255.82	4 422 810.39	849.81
TA-13	31.95	486 203.94	4 422 759.80	853.44
TA-14	29.95	486 181.16	4 422 714.86	852.41
TA-15	28.95	486 166.51	4 422 646.03	853.21
TA-16	30.45	486 154.31	4 422 531.11	856.31
TA-17	30.45	486 150.38	4 422 447.27	857.97
TA-18	32.45	486 143.30	4 422 366.38	859.57
TA-19	34.45	486 132.36	4 422 293.46	861.45
TA-20	39.45	486 147.34	4 422 137.28	866.20
TA-21	30.45	487 121.48	4 423 783.03	848.53
TA-22	30.45	487 028.80	4 423 659.74	847.43
TA-23	30.45	486 892.21	4 423 619.04	846.68
TA-24	30.45	486 775.97	4 423 610.23	845.49
TA-25	25.45	486 577.77	4 423 707.25	844.73
UK-6	28.95	487 065.54	4 423 680.11	847.718
UK-7	28.95	487 225.14	4 423 908.30	849.298
UK-8	25.95	487 298.94	4 423 994.20	849.967
UK-9	28.95	487 417.13	4 424 132.08	851.435
UK-10	21.45	487 568.92	4 424 267.93	852.243
UK-11	21.94	487 731.81	4 424 500.52	858.119
UK-12	19.95	487 956.65	4 424 729.96	859.214
UK-12A	27.45	487 951.62	4 424 794.22	859.59
UK-13	19.92	488 022.82	4 424 845.69	857.741
UK-14	19.95	488 065.82	4 424 901.67	856.654
UK-15	21.95	488 135.00	4 425 125.50	858.744
UK-15A	27.45	488 168.20	4 425 117.19	856.74

Continuation of Table B.1

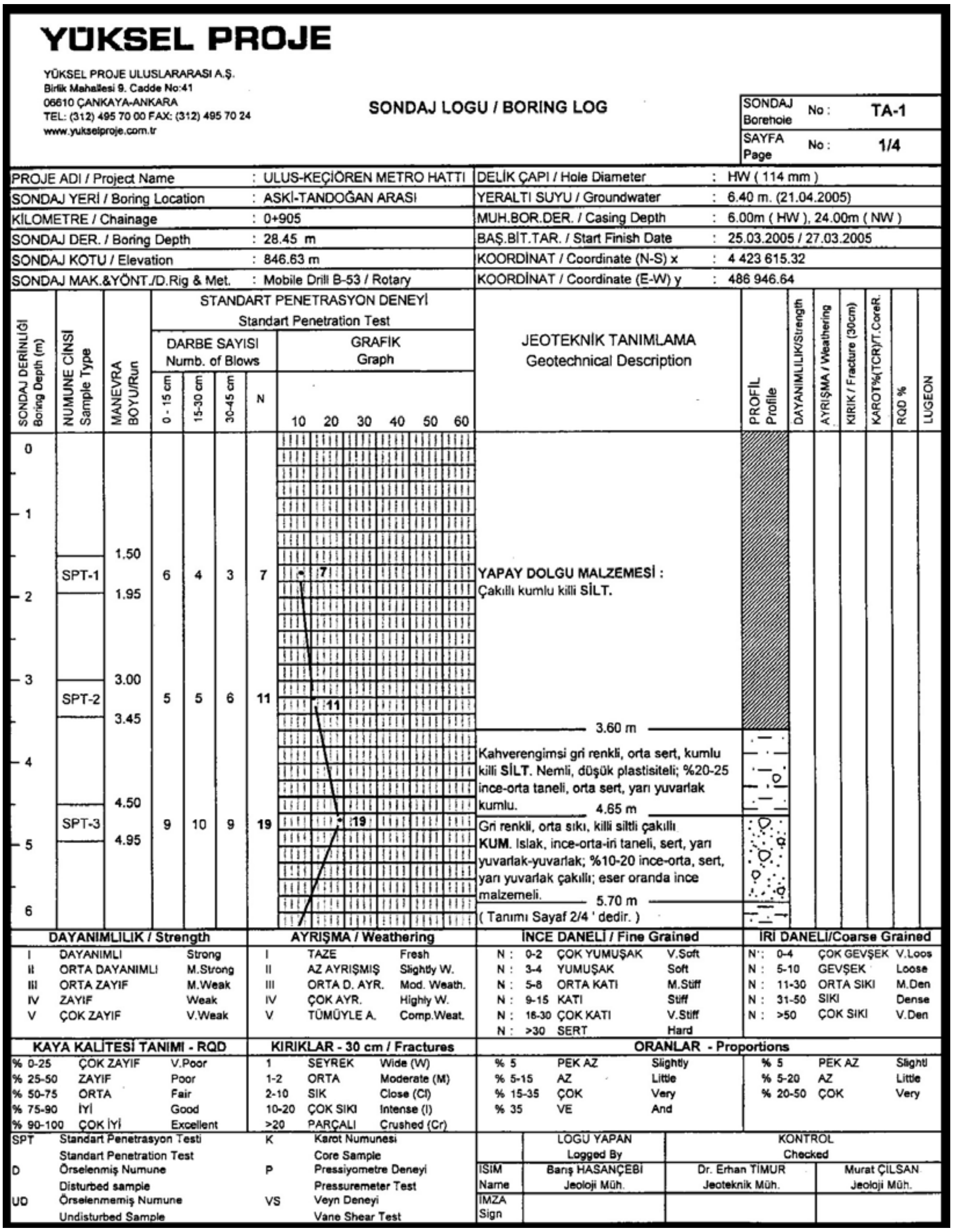
Borehole	**Depth (m)**	**Y**	**X**	**Z**
UK-15B	30.45	488 205.18	4 425 296.19	847.73
UK-15C	25.95	488 240.98	4 425 420.61	847.43
UK-16	27.45	488 226.17	4 425 508.53	849.4
UK-16A	27.19	488 285.36	4 425 576.53	848.4
UK-16B	30.00	488 316.10	4 425 686.24	848.88
UK-17	30.00	488 388.17	4 425 845.01	850.312
UK-18	30.00	488 363.53	4 425 927.76	850.6
UK-18A	27.00	488 392.85	4 425 943.52	850.3
UK-18A1	31.00	488 401.07	4 426 018.26	851.42
UK-18B	30.00	488 432.85	4 426 079.11	850.71
UK-18C	30.00	488 445.14	4 426 167.91	850.86
UK-19	25.50	488 461.12	4 426 235.52	851.593
UK-19A	32.20	488 444.36	4 426 321.41	852.56
UK-20	28.50	488 496.06	4 426 465.05	852.957
UK-20B	62.00	488 360.35	4 426 749.48	888.76
UK-21A	61.00	488 345.18	4 426 978.31	896.12
UK-21B	52.00	488 414.10	4 427 111.96	882.57
UK-22A	39.50	488 567.83	4 427 220.63	870.66
UK-22B	24.00	488 657.95	4 427 267.69	855.82
UK-22C	28.50	488 699.41	4 427 267.93	855.76
UK-22D	23.00	488 751.92	4 427 268.25	855.87
UK-22E	23.00	488 807.17	4 427 280.02	856.01
UK-23	19.50	488 854.51	4 427 315.19	856.2
UK-23A	27.00	488 934.88	4 427 336.52	85659
UK-24	21.00	489 035.09	4 427 357.74	857.847
UK-24A	12.00	489 098.70	4 429 396.73	858.78
UK-25	19.00	489 162.15	4 427 490.23	861.988
UK-25A	15.00	489 246.58	4 427 571.42	865.75
UK-26	17.00	489 381.78	4 427 814.10	877.186
UK-27	24.00	489 381.78	4 427 900.51	880.737

APPENDIX C

BOREHOLE LOGS

Source: Yüksel Proje Uluslararası A.Ş., Ankara (2005)

C.1. Borehole TA-1



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 :	TA-1
SAYFA Page	No :	1/4

PROJE ADI / Project Name	: ULUS-KEÇİÖREN METRO HATTI	DELİK ÇAPI / Hole Diameter	: HW (114 mm)
SONDAJ YERİ / Boring Location	: ASKİ-TANDOĞAN ARASI	YERALTI SUYU / Groundwater	: 6.40 m. (21.04.2005)
KİLOMETRE / Chainage	: 0+905	MUH.BOR.DER. / Casing Depth	: 6.00m (HW), 24.00m (NW)
SONDAJ DER. / Boring Depth	: 28.45 m	BAŞ.BİT.TAR. / Start Finish Date	: 25.03.2005 / 27.03.2005
SONDAJ KOTU / Elevation	: 846.63 m	KOORDİNAT / Coordinate (N-S) x	: 4 423 615.32
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Mobile Drill B-53 / Rotary	KOORDİNAT / Coordinate (E-W) y	: 486 946.64

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															
		1.50													
	SPT-1		6	4	3	7	7	**YAPAY DOLGU MALZEMESİ :** Çakıllı kumlu killi **SİLT.**							
2		1.95													
3		3.00													
	SPT-2		5	5	6	11	11								
		3.45						3.60 m							
4								Kahverengimsi gri renkli, orta sert, kumlu killi **SİLT**. Nemli, düşük plastisiteli; %20-25 ince-orta taneli, orta sert, yarı yuvarlak kumlu.							
		4.50						4.65 m							
	SPT-3		9	10	9	19	19	Gri renkli, orta sıkı, killi siltli çakıllı **KUM**. Islak, ince-orta-iri taneli, sert, yarı yuvarlak-yuvarlak; %10-20 ince-orta, sert, yarı yuvarlak çakıllı; eser oranda ince malzemeli.							
5		4.95													
								5.70 m							
6								(Tanımı Sayaf 2/4 ' dedir.)							

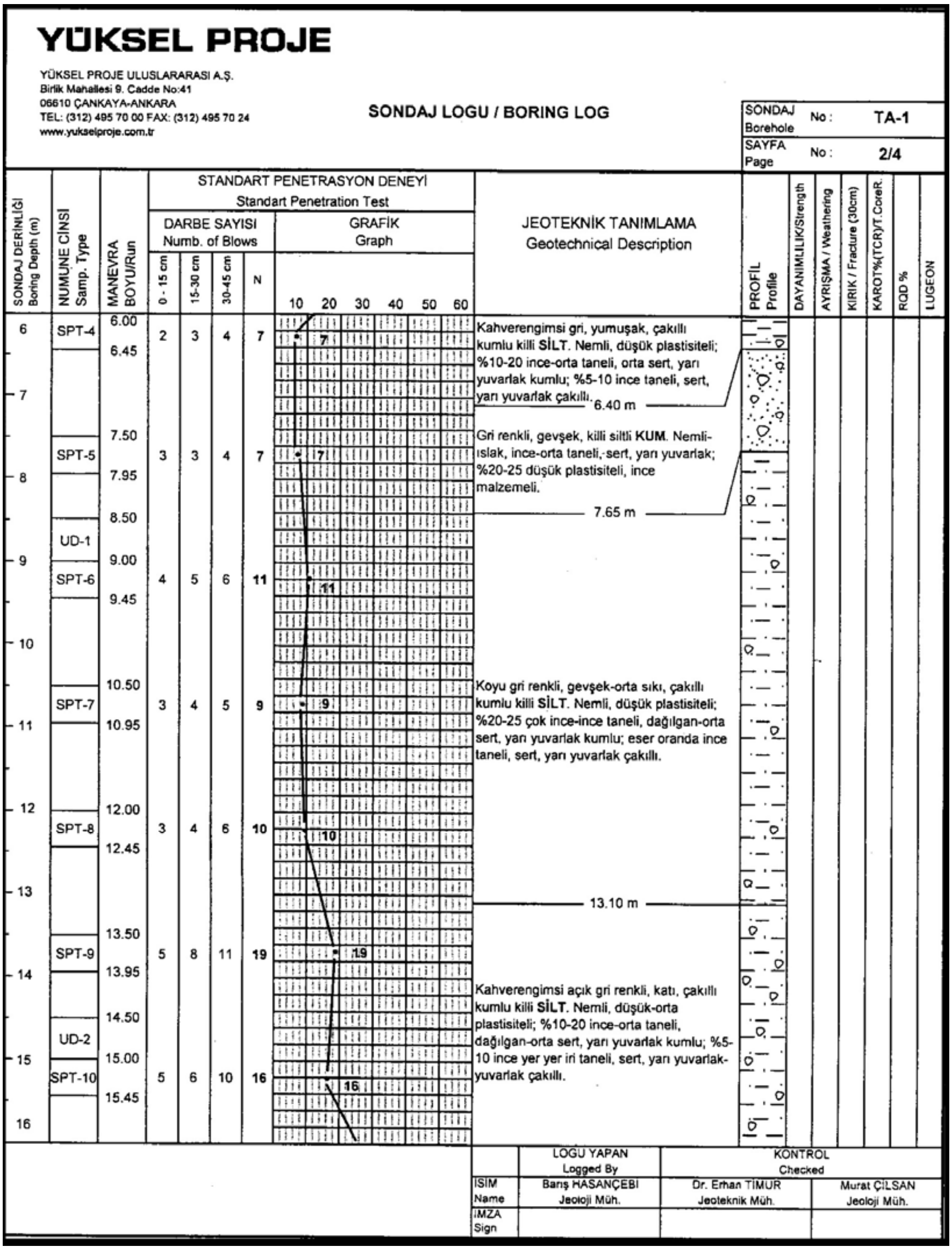
DAYANIMLILIK / Strength			AYRIŞMA / Weathering			İNCE DANELİ / Fine Grained			İRİ DANELİ/Coarse Grained		
I	DAYANIMLI	Strong	I	TAZE	Fresh	N : 0-2	ÇOK YUMUŞAK	V.Soft	N : 0-4	ÇOK GEVŞEK	V.Loos
II	ORTA DAYANIMLI	M.Strong	II	AZ AYRIŞMIŞ	Slightly W.	N : 3-4	YUMUŞAK	Soft	N : 5-10	GEVŞEK	Loose
III	ORTA ZAYIF	M.Weak	III	ORTA D. AYR.	Mod. Weath.	N : 5-8	ORTA KATI	M.Stiff	N : 11-30	ORTA SIKI	M.Den
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.Den
						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	Slightl
% 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
D	Örselenmiş Numune Disturbed sample	P	Pressiyometre Deneyi Pressuremeter Test
UD	Örselenmemiş Numune Undisturbed Sample	VS	Veyn Deneyi Vane Shear Test

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-1



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 : TA-1
SAYFA Page No : 2/4

STANDART PENETRASYON DENEYİ / Standart Penetration Test

NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	DARBE SAYISI Numb. of Blows 0 - 15 cm	15-30 cm	30-45 cm	N
SPT-4	6.00 6.45	2	3	4	7
SPT-5	7.50 7.95	3	3	4	7
UD-1	8.50 9.00				
SPT-6	9.00 9.45	4	5	6	11
SPT-7	10.50 10.95	3	4	5	9
SPT-8	12.00 12.45	3	4	6	10
SPT-9	13.50 13.95	5	8	11	19
UD-2	14.50 15.00				
SPT-10	15.00 15.45	5	6	10	16

JEOTEKNİK TANIMLAMA
Geotechnical Description

Kahverengimsi gri, yumuşak, çakıllı kumlu killi **SİLT**. Nemli, düşük plastisiteli; %10-20 ince-orta taneli, orta sert, yarı yuvarlak kumlu; %5-10 ince taneli, sert, yarı yuvarlak çakıllı.

6.40 m

Gri renkli, gevşek, killi siltli **KUM**. Nemli-ıslak, ince-orta taneli,-sert, yarı yuvarlak; %20-25 düşük plastisiteli, ince malzemeli.

7.65 m

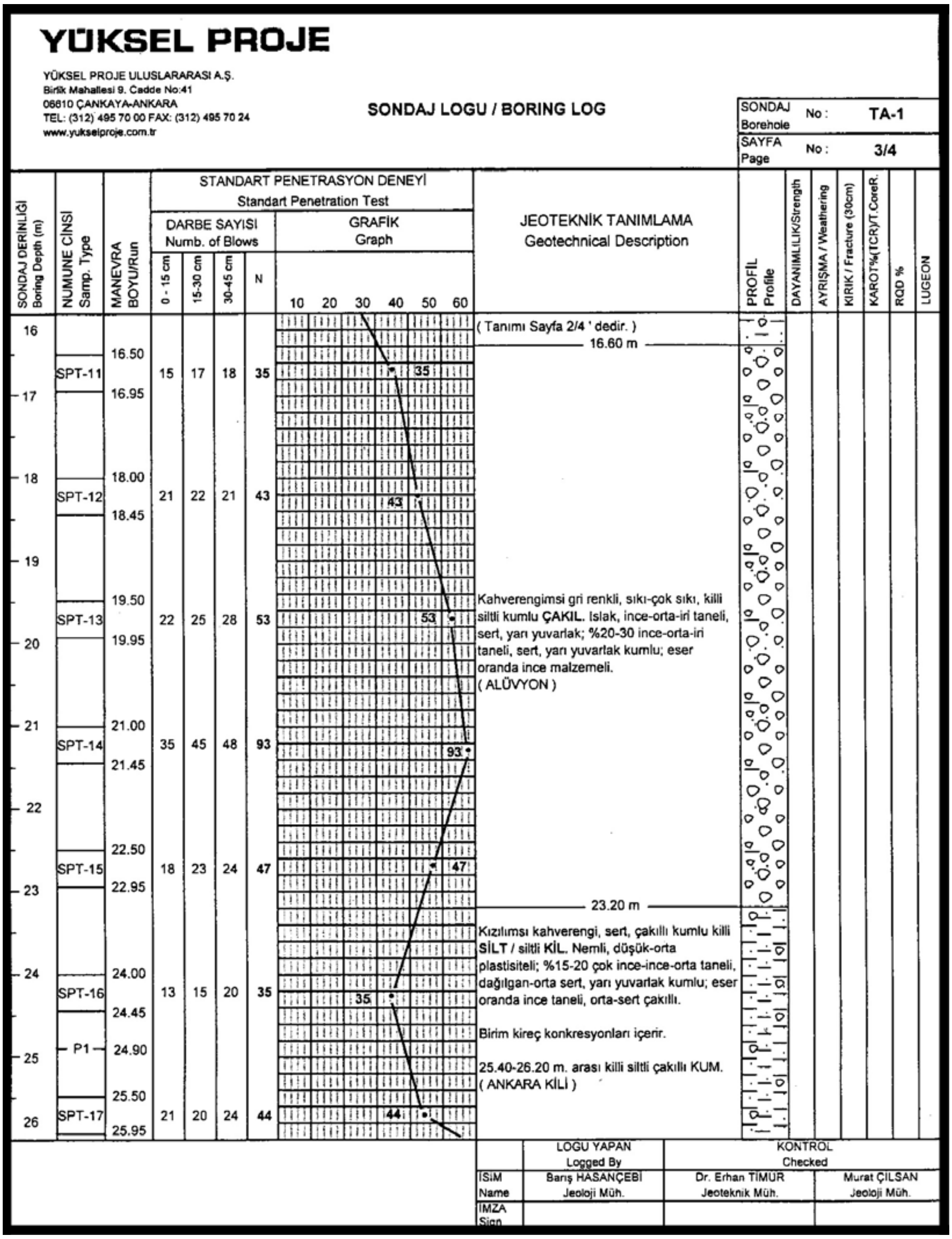
Koyu gri renkli, gevşek-orta sıkı, çakıllı kumlu killi **SİLT**. Nemli, düşük plastisiteli; %20-25 çok ince-ince taneli, dağılgan-orta sert, yarı yuvarlak kumlu; eser oranda ince taneli, sert, yarı yuvarlak çakıllı.

13.10 m

Kahverengimsi açık gri renkli, katı, çakıllı kumlu killi **SİLT**. Nemli, düşük-orta plastisiteli; %10-20 ince-orta taneli, dağılgan-orta sert, yarı yuvarlak kumlu; %5-10 ince yer yer iri taneli, sert, yarı yuvarlak-yuvarlak çakıllı.

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇİLSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-1



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 : **TA-1**
SAYFA Page No : **3/4**

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
16						
	SPT-11	16.50 16.95	15	17	18	**35**
17						
18	SPT-12	18.00 18.45	21	22	21	**43**
19						
	SPT-13	19.50 19.95	22	25	28	**53**
20						
21	SPT-14	21.00 21.45	35	45	48	**93**
22						
	SPT-15	22.50 22.95	18	23	24	**47**
23						
24	SPT-16	24.00 24.45	13	15	20	**35**
25	P1	24.90				
26	SPT-17	25.50 25.95	21	20	24	**44**

JEOTEKNİK TANIMLAMA
Geotechnical Description

(Tanımı Sayfa 2/4 ' dedir.)

16.60 m

Kahverengimsi gri renkli, sıkı-çok sıkı, killi siltli kumlu **ÇAKIL.** Islak, ince-orta-iri taneli, sert, yarı yuvarlak; %20-30 ince-orta-iri taneli, sert, yarı yuvarlak kumlu; eser oranda ince malzemeli.
(ALÜVYON)

23.20 m

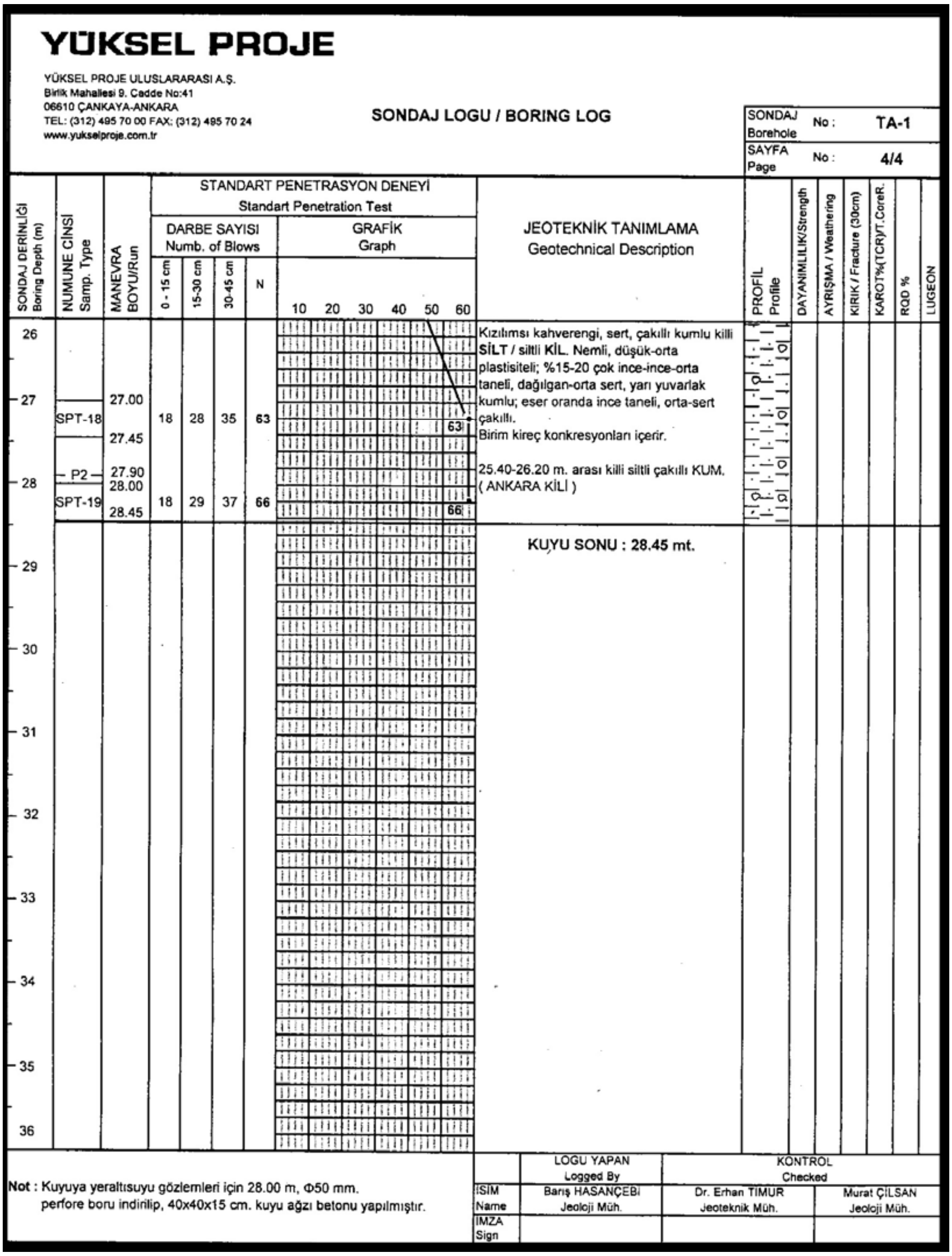
Kızılımsı kahverengi, sert, çakıllı kumlu killi **SİLT** / siltli **KİL.** Nemli, düşük-orta plastisiteli; %15-20 çok ince-ince-orta taneli, dağılgan-orta sert, yarı yuvarlak kumlu; eser oranda ince taneli, orta-sert çakıllı.

Birim kireç konkresyonları içerir.

25.40-26.20 m. arası killi siltli çakıllı KUM.
(ANKARA KİLİ)

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-1



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

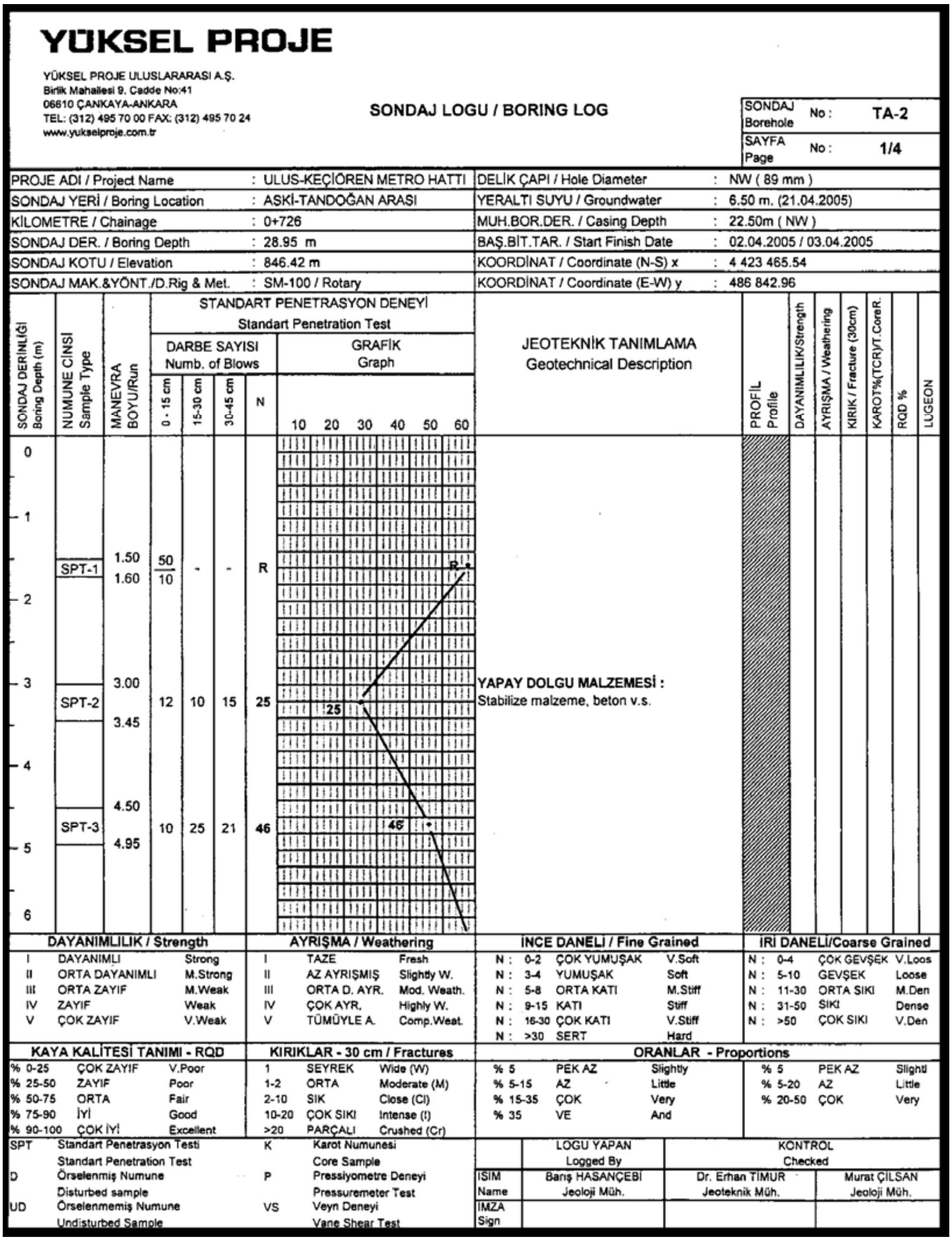
SONDAJ Borehole No : TA-1
SAYFA Page No : 4/4

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								Kızılımsı kahverengi, sert, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, düşük-orta plastisiteli; %15-20 çok ince-ince-orta taneli, dağılgan-orta sert, yarı yuvarlak kumlu; eser oranda ince taneli, orta-sert çakıllı. Birim kireç konkresyonları içerir. 25.40-26.20 m. arası killi siltli çakıllı KUM. (ANKARA KİLİ)							
27	SPT-18	27.00 27.45	18	28	35	63	63								
	P2	27.90													
28	SPT-19	28.00 28.45	18	29	37	66	66								
29								**KUYU SONU : 28.45 mt.**							
30															
31															
32															
33															
34															
35															
36															

Not : Kuyuya yeraltısuyu gözlemleri için 28.00 m, Φ50 mm. perfore boru indirilip, 40x40x15 cm. kuyu ağzı betonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TIMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
IMZA Sign			

C.2. Borehole TA-2



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 :	TA-2
SAYFA Page	No :	1/4

PROJE ADI / Project Name	: ULUS-KEÇİÖREN METRO HATTI	DELİK ÇAPI / Hole Diameter	: NW (89 mm)
SONDAJ YERİ / Boring Location	: ASKİ-TANDOĞAN ARASI	YERALTI SUYU / Groundwater	: 6.50 m. (21.04.2005)
KİLOMETRE / Chainage	: 0+726	MUH.BOR.DER. / Casing Depth	: 22.50m (NW)
SONDAJ DER. / Boring Depth	: 28.95 m	BAŞ.BİT.TAR. / Start Finish Date	: 02.04.2005 / 03.04.2005
SONDAJ KOTU / Elevation	: 846.42 m	KOORDİNAT / Coordinate (N-S) x	: 4 423 465.54
SONDAJ MAK.&YÖNT./D.Rig & Met.	: SM-100 / Rotary	KOORDİNAT / Coordinate (E-W) y	: 486 842.96

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Sample Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test					JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
			DARBE SAYISI Numb. of Blows				GRAFİK Graph								
			0 - 15 cm	15-30 cm	30-45 cm	N	10 20 30 40 50 60								
	SPT-1	1.50 1.60	50/10	-	-	R									
	SPT-2	3.00 3.45	12	10	15	25		**YAPAY DOLGU MALZEMESİ :** Stabilize malzeme, beton v.s.							
	SPT-3	4.50 4.95	10	25	21	46									

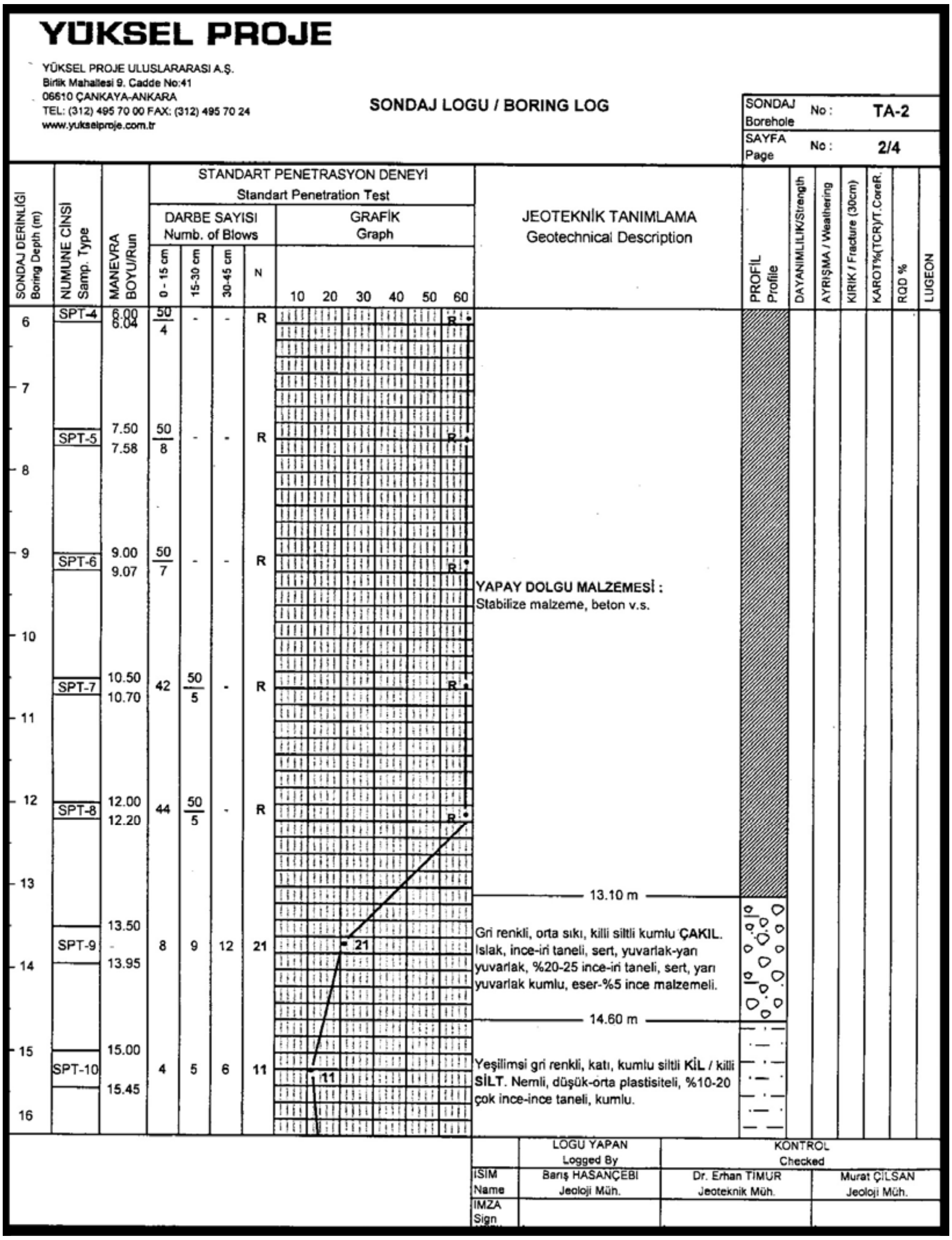
DAYANIMLILIK / Strength			AYRIŞMA / Weathering			İNCE DANELİ / Fine Grained			İRİ DANELİ/Coarse Grained		
I	DAYANIMLI	Strong	I	TAZE	Fresh	N : 0-2	ÇOK YUMUŞAK	V.Soft	N : 0-4	ÇOK GEVŞEK	V.Loos
II	ORTA DAYANIMLI	M.Strong	II	AZ AYRIŞMIŞ	Slightly W.	N : 3-4	YUMUŞAK	Soft	N : 5-10	GEVŞEK	Loose
III	ORTA ZAYIF	M.Weak	III	ORTA D. AYR.	Mod. Weath.	N : 5-8	ORTA KATI	M.Stiff	N : 11-30	ORTA SIKI	M.Den
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.Den
						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	Slightl
% 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
D	Örselenmiş Numune Disturbed sample	P	Pressiyometre Deneyi Pressuremeter Test
UD	Örselenmemiş Numune Undisturbed Sample	VS	Veyn Deneyi Vane Shear Test

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇİLSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-2



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 : TA-2
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 Numb. of Blows 0 - 15 cm	15-30 cm	30-45 cm	N
6	SPT-4	6.00 6.04	50/4	-	-	R
7						
	SPT-5	7.50 7.58	50/8	-	-	R
8						
9	SPT-6	9.00 9.07	50/7	-	-	R
10						
	SPT-7	10.50 10.70	42	50/5	-	R
11						
12	SPT-8	12.00 12.20	44	50/5	-	R
13						
	SPT-9	13.50 - 13.95	8	9	12	21
14						
15	SPT-10	15.00 15.45	4	5	6	11
16						

JEOTEKNİK TANIMLAMA
Geotechnical Description

YAPAY DOLGU MALZEMESİ :
Stabilize malzeme, beton v.s.

13.10 m

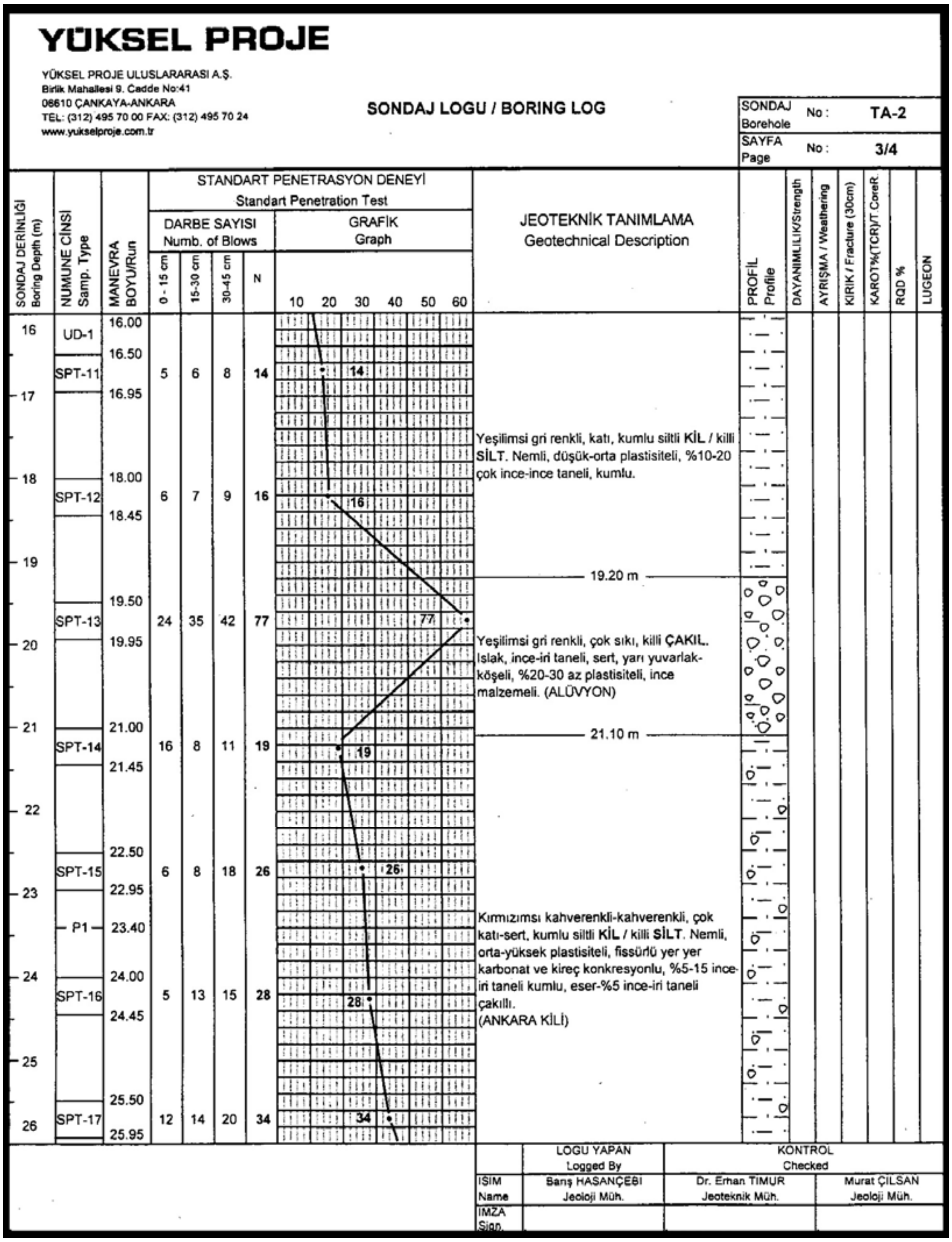
Gri renkli, orta sıkı, killi siltli kumlu **ÇAKIL**. Islak, ince-iri taneli, sert, yuvarlak-yarı yuvarlak, %20-25 ince-iri taneli, sert, yarı yuvarlak kumlu, eser-%5 ince malzemeli.

14.60 m

Yeşilimsi gri renkli, katı, kumlu siltli **KİL** / killi **SİLT**. Nemli, düşük-orta plastisiteli, %10-20 çok ince-ince taneli, kumlu.

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇİLSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-2



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 : TA-2
SAYFA Page No : 3/4

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
UD-1	16.00 16.50				
SPT-11	16.50 16.95	5	6	8	14
SPT-12	18.00 18.45	6	7	9	16
SPT-13	19.50 19.95	24	35	42	77
SPT-14	21.00 21.45	16	8	11	19
SPT-15	22.50 22.95	6	8	18	26
P1	23.40				
SPT-16	24.00 24.45	5	13	15	28
SPT-17	25.50 25.95	12	14	20	34

JEOTEKNİK TANIMLAMA
Geotechnical Description

Yeşilimsi gri renkli, katı, kumlu siltli **KİL** / killi **SİLT**. Nemli, düşük-orta plastisiteli, %10-20 çok ince-ince taneli, kumlu.

19.20 m

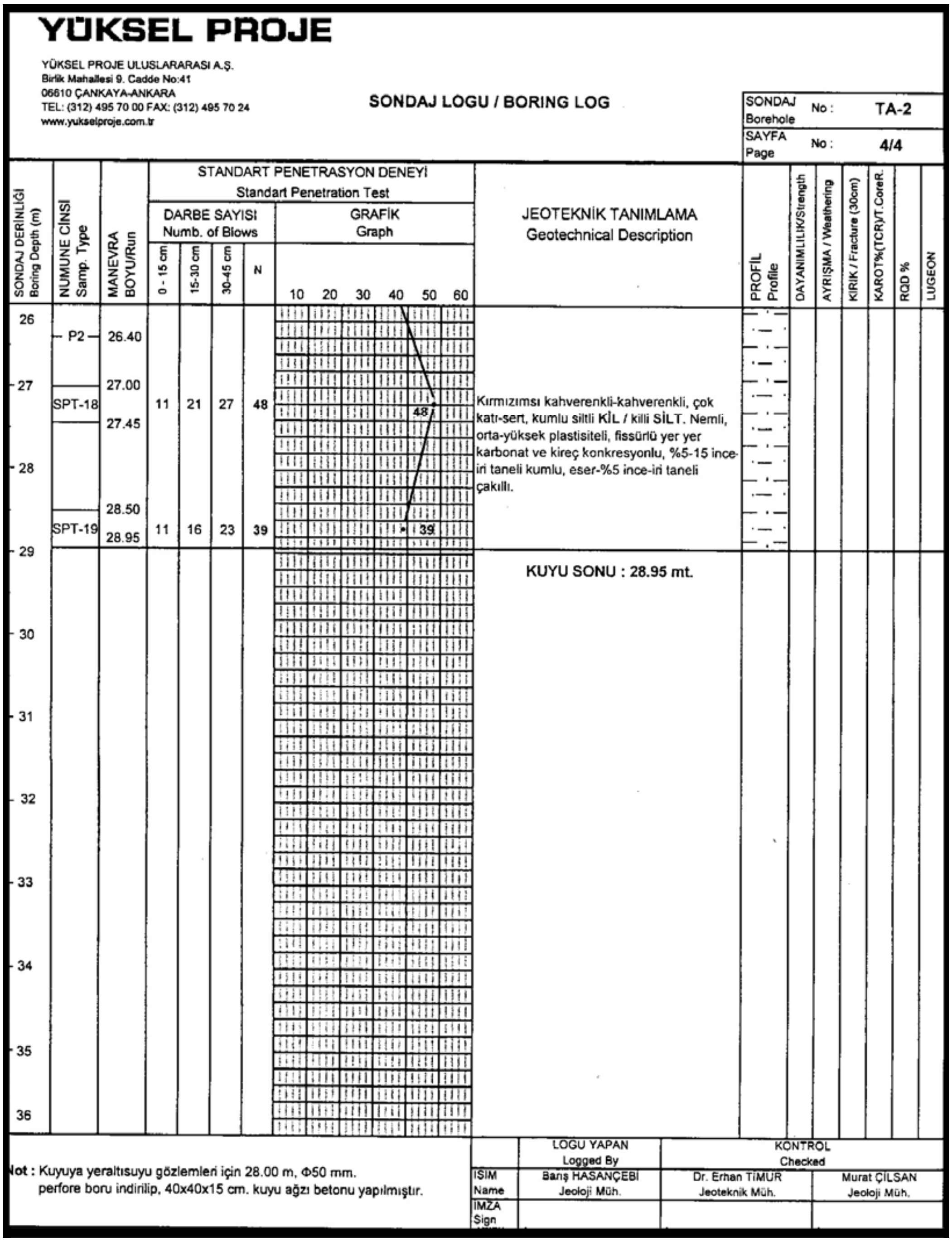
Yeşilimsi gri renkli, çok sıkı, killi **ÇAKIL**. Islak, ince-iri taneli, sert, yarı yuvarlak-köşeli, %20-30 az plastisiteli, ince malzemeli. (ALÜVYON)

21.10 m

Kırmızımsı kahverenkli-kahverenkli, çok katı-sert, kumlu siltli **KİL** / killi **SİLT**. Nemli, orta-yüksek plastisiteli, fissürlü yer yer karbonat ve kireç konkresyonlu, %5-15 ince-iri taneli kumlu, eser-%5 ince-iri taneli çakıllı.
(ANKARA KİLİ)

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TIMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign.			

Continuation of Borehole TA-2



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

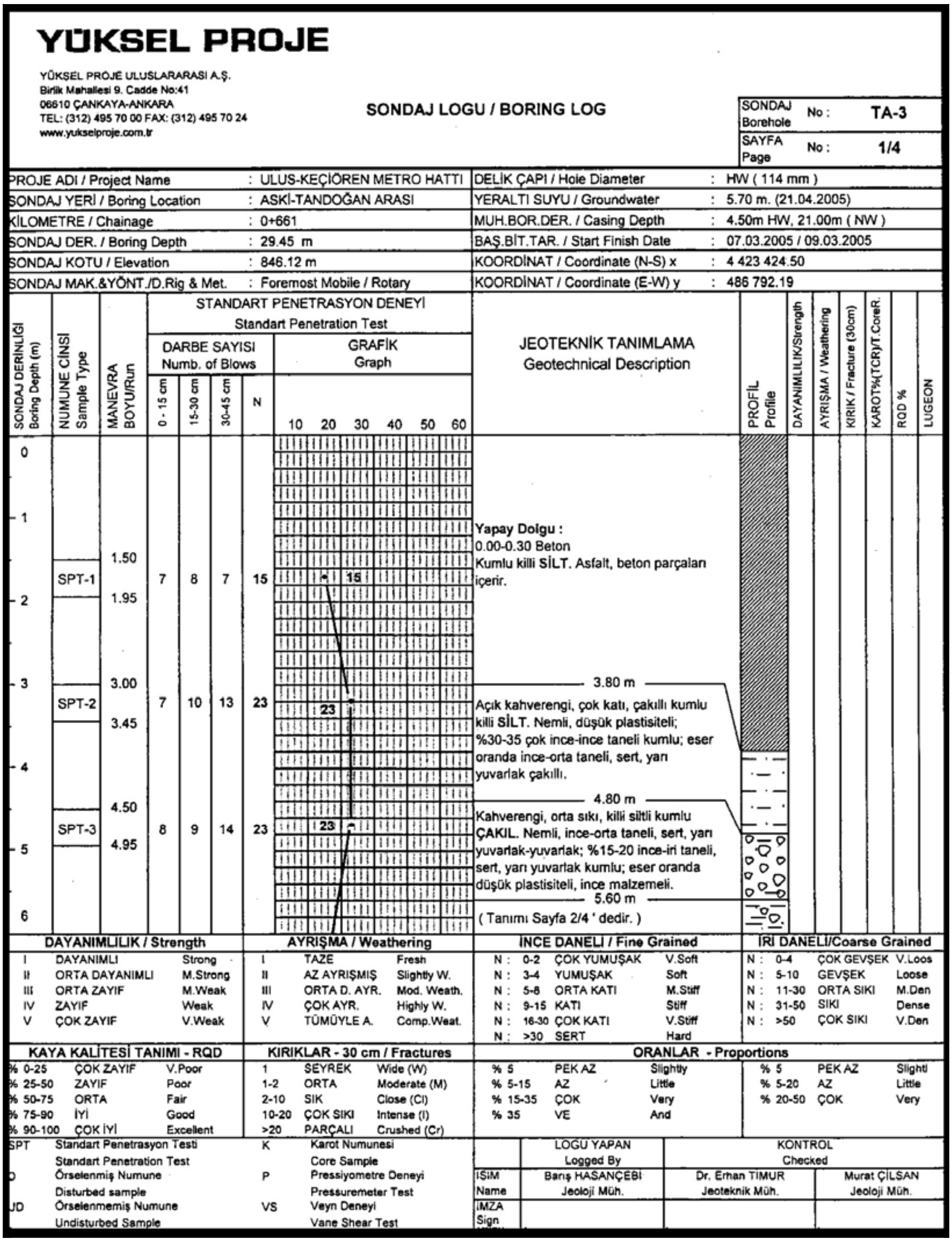
SONDAJ Borehole No : TA-2
SAYFA Page No : 4/4

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test					JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
			DARBE SAYISI Numb. of Blows				GRAFİK Graph								
			0 - 15 cm	15-30 cm	30-45 cm	N	10 20 30 40 50 60								
26															
	P2	26.40													
27		27.00													
	SPT-18		11	21	27	48	48	Kırmızımsı kahverenkli-kahverenkli, çok katı-sert, kumlu siltli **KİL / killi SİLT**. Nemli, orta-yüksek plastisiteli, fissürlü yer yer karbonat ve kireç konkresyonlu, %5-15 ince-iri taneli kumlu, eser-%5 ince-iri taneli çakıllı.							
		27.45													
28															
		28.50													
	SPT-19	28.95	11	16	23	39	39								
29								**KUYU SONU : 28.95 mt.**							
30															
31															
32															
33															
34															
35															
36															

Not : Kuyuya yeraltısuyu gözlemleri için 28.00 m, Φ50 mm. perfore boru indirilip, 40x40x15 cm. kuyu ağzı betonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked	
ISIM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇİLSAN Jeoloji Müh.
IMZA Sign			

C.3. Borehole TA-3



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 :	TA-3
SAYFA Page	No :	1/4

PROJE ADI / Project Name	: ULUS-KEÇİÖREN METRO HATTI	DELİK ÇAPI / Hole Diameter	: HW (114 mm)
SONDAJ YERİ / Boring Location	: ASKİ-TANDOĞAN ARASI	YERALTI SUYU / Groundwater	: 5.70 m. (21.04.2005)
KİLOMETRE / Chainage	: 0+661	MUH.BOR.DER. / Casing Depth	: 4.50m HW, 21.00m (NW)
SONDAJ DER. / Boring Depth	: 29.45 m	BAŞ.BİT.TAR. / Start Finish Date	: 07.03.2005 / 09.03.2005
SONDAJ KOTU / Elevation	: 846.12 m	KOORDİNAT / Coordinate (N-S) x	: 4 423 424.50
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Foremost Mobile / Rotary	KOORDİNAT / Coordinate (E-W) y	: 486 792.19

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Sample Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test					JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
			DARBE SAYISI Numb. of Blows				GRAFİK Graph								
			0 - 15 cm	15-30 cm	30-45 cm	N	10 20 30 40 50 60								
0									▨						
1								Yapay Dolgu : 0.00-0.30 Beton Kumlu killi SİLT. Asfalt, beton parçaları içerir.	▨						
	SPT-1	1.50 1.95	7	8	7	15	15		▨						
2									▨						
3	SPT-2	3.00 3.45	7	10	13	23	23	3.80 m Açık kahverengi, çok katı, çakıllı kumlu killi SİLT. Nemli, düşük plastisiteli; %30-35 çok ince-ince taneli kumlu; eser oranda ince-orta taneli, sert, yarı yuvarlak çakıllı.	▨						
4								4.80 m Kahverengi, orta sıkı, killi siltli kumlu ÇAKIL. Nemli, ince-orta taneli, sert, yarı yuvarlak-yuvarlak; %15-20 ince-iri taneli, sert, yarı yuvarlak kumlu; eser oranda düşük plastisiteli, ince malzemeli.							
	SPT-3	4.50 4.95	8	9	14	23	23								
5								5.60 m							
6								(Tanımı Sayfa 2/4 ' dedir.)							

DAYANIMLILIK / Strength

I	DAYANIMLI	Strong
II	ORTA DAYANIMLI	M.Strong
III	ORTA ZAYIF	M.Weak
IV	ZAYIF	Weak
V	ÇOK ZAYIF	V.Weak

AYRIŞMA / Weathering

I	TAZE	Fresh
II	AZ AYRIŞMIŞ	Slightly W.
III	ORTA D. AYR.	Mod. Weath.
IV	ÇOK AYR.	Highly W.
V	TÜMÜYLE A.	Comp.Weat.

İNCE DANELİ / Fine Grained

N :	0-2	ÇOK YUMUŞAK	V.Soft
N :	3-4	YUMUŞAK	Soft
N :	5-8	ORTA KATI	M.Stiff
N :	9-15	KATI	Stiff
N :	16-30	ÇOK KATI	V.Stiff
N :	>30	SERT	Hard

İRİ DANELİ/Coarse Grained

N :	0-4	ÇOK GEVŞEK	V.Loos
N :	5-10	GEVŞEK	Loose
N :	11-30	ORTA SIKI	M.Den
N :	31-50	SIKI	Dense
N :	>50	ÇOK SIKI	V.Den

KAYA KALİTESİ TANIMI - RQD

% 0-25	ÇOK ZAYIF	V.Poor
% 25-50	ZAYIF	Poor
% 50-75	ORTA	Fair
% 75-90	İYİ	Good
% 90-100	ÇOK İYİ	Excellent

KIRIKLAR - 30 cm / Fractures

1	SEYREK	Wide (W)
1-2	ORTA	Moderate (M)
2-10	SIK	Close (Cl)
10-20	ÇOK SIKI	Intense (I)
>20	PARÇALI	Crushed (Cr)

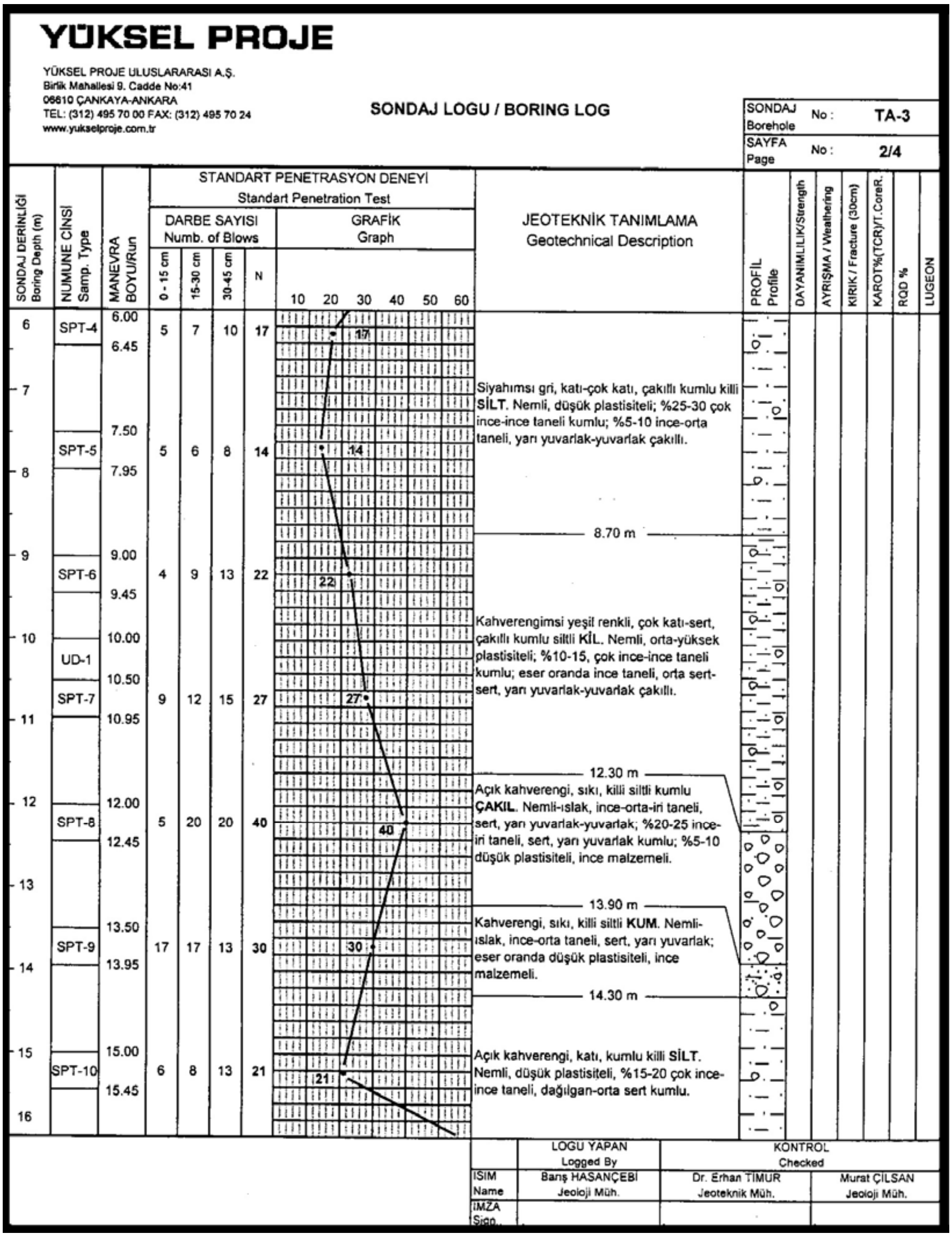
ORANLAR - Proportions

% 5	PEK AZ	Slightly	% 5	PEK AZ	Slightl
% 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	Örselenmiş Numune Disturbed sample	P	Pressiyometre Deneyi Pressuremeter Test
UD	Örselenmemiş Numune Undisturbed Sample	VS	Veyn Deneyi Vane Shear Test

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TIMUR Jeoteknik Müh.	Murat ÇİLSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-3



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 : TA-3
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
6	SPT-4	6.00 6.45	5	7	10	17
7						
	SPT-5	7.50 7.95	5	6	8	14
8						
9	SPT-6	9.00 9.45	4	9	13	22
10	UD-1	10.00				
	SPT-7	10.50 10.95	9	12	15	27
11						
12	SPT-8	12.00 12.45	5	20	20	40
13						
	SPT-9	13.50 13.95	17	17	13	30
14						
15	SPT-10	15.00 15.45	6	8	13	21
16						

GRAFİK Graph

JEOTEKNİK TANIMLAMA
Geotechnical Description

Siyahımsı gri, katı-çok katı, çakıllı kumlu killi **SİLT**. Nemli, düşük plastisiteli; %25-30 çok ince-ince taneli kumlu; %5-10 ince-orta taneli, yarı yuvarlak-yuvarlak çakıllı.

8.70 m

Kahverengimsi yeşil renkli, çok katı-sert, çakıllı kumlu siltli **KİL**. Nemli, orta-yüksek plastisiteli; %10-15, çok ince-ince taneli kumlu; eser oranda ince taneli, orta sert-sert, yarı yuvarlak-yuvarlak çakıllı.

12.30 m

Açık kahverengi, sıkı, killi siltli kumlu **ÇAKIL**. Nemli-ıslak, ince-orta-iri taneli, sert, yarı yuvarlak-yuvarlak; %20-25 ince-iri taneli, sert, yarı yuvarlak kumlu; %5-10 düşük plastisiteli, ince malzemeli.

13.90 m

Kahverengi, sıkı, killi siltli **KUM**. Nemli-ıslak, ince-orta taneli, sert, yarı yuvarlak; eser oranda düşük plastisiteli, ince malzemeli.

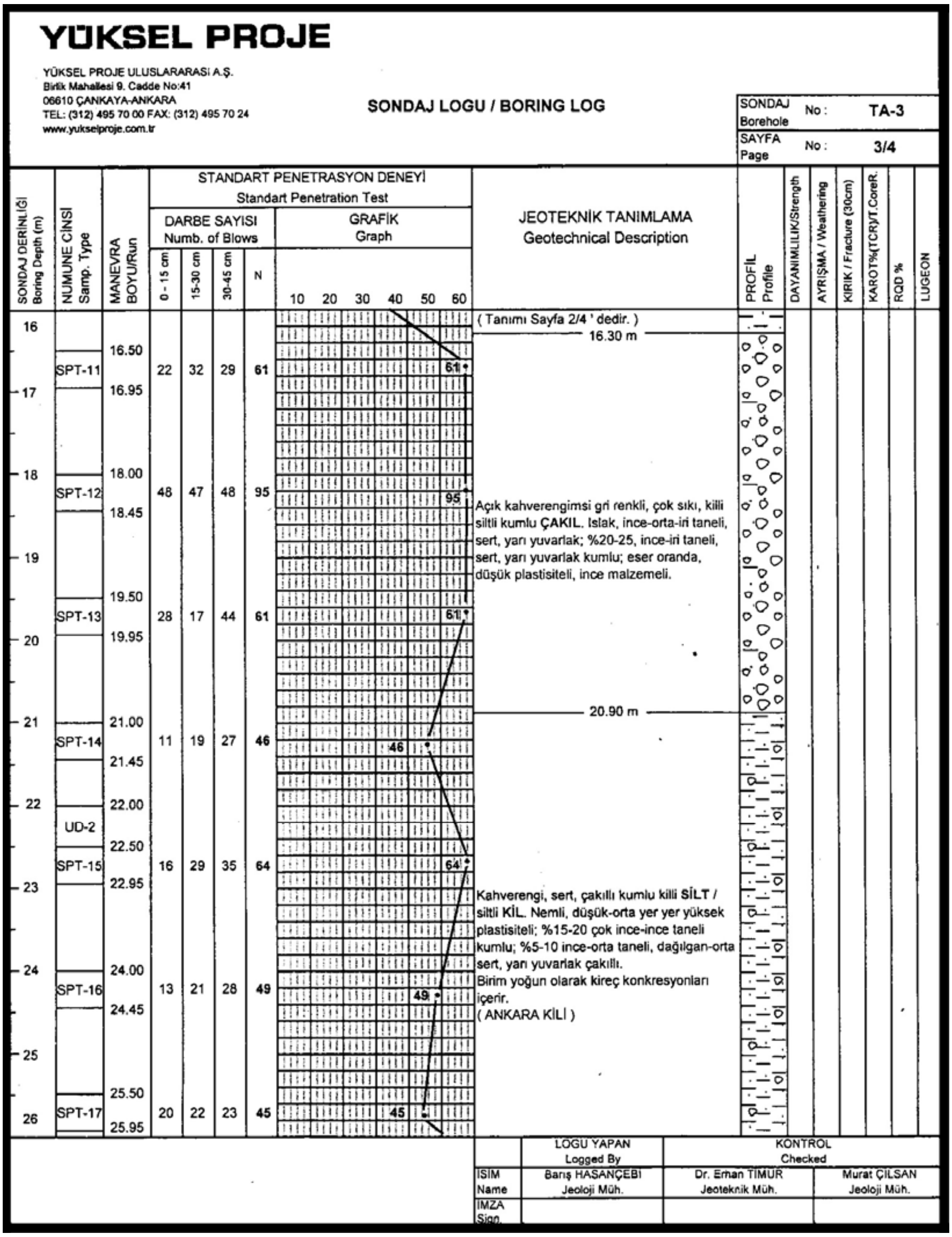
14.30 m

Açık kahverengi, katı, kumlu killi **SİLT**. Nemli, düşük plastisiteli, %15-20 çok ince-ince taneli, dağılgan-orta sert kumlu.

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

	LOGU YAPAN Logged By	KONTROL Checked	
ISIM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇİLSAN Jeoloji Müh.
IMZA Sign.			

Continuation of Borehole TA-3



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 :	TA-3
SAYFA Page	No :	3/4

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
16						
	SPT-11	16.50 16.95	22	32	29	61
17						
18	SPT-12	18.00 18.45	48	47	48	95
19						
	SPT-13	19.50 19.95	28	17	44	61
20						
21	SPT-14	21.00 21.45	11	19	27	46
22	UD-2	22.00 22.50				
	SPT-15	22.50 22.95	16	29	35	64
23						
24	SPT-16	24.00 24.45	13	21	28	49
25						
26	SPT-17	25.50 25.95	20	22	23	45

GRAFİK Graph

JEOTEKNİK TANIMLAMA Geotechnical Description

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

(Tanımı Sayfa 2/4 ' dedir.)

16.30 m

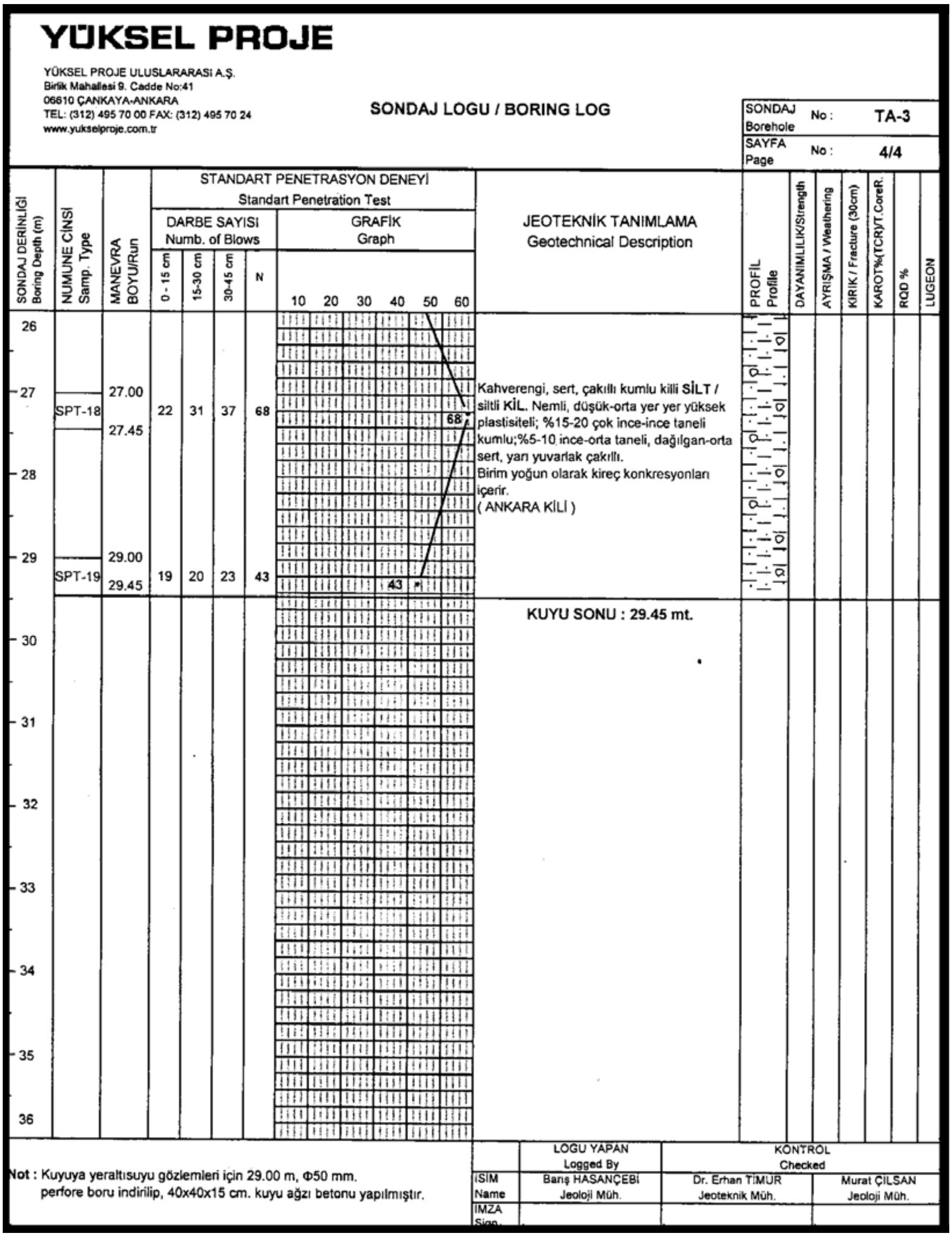
Açık kahverengimsi gri renkli, çok sıkı, killi siltli kumlu **ÇAKIL**. Islak, ince-orta-iri taneli, sert, yarı yuvarlak; %20-25, ince-iri taneli, sert, yarı yuvarlak kumlu; eser oranda, düşük plastisiteli, ince malzemeli.

20.90 m

Kahverengi, sert, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, düşük-orta yer yer yüksek plastisiteli; %15-20 çok ince-ince taneli kumlu; %5-10 ince-orta taneli, dağılgan-orta sert, yarı yuvarlak çakıllı.
Birim yoğun olarak kireç konkresyonları içerir.
(ANKARA KİLİ)

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign.			

Continuation of Borehole TA-3



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

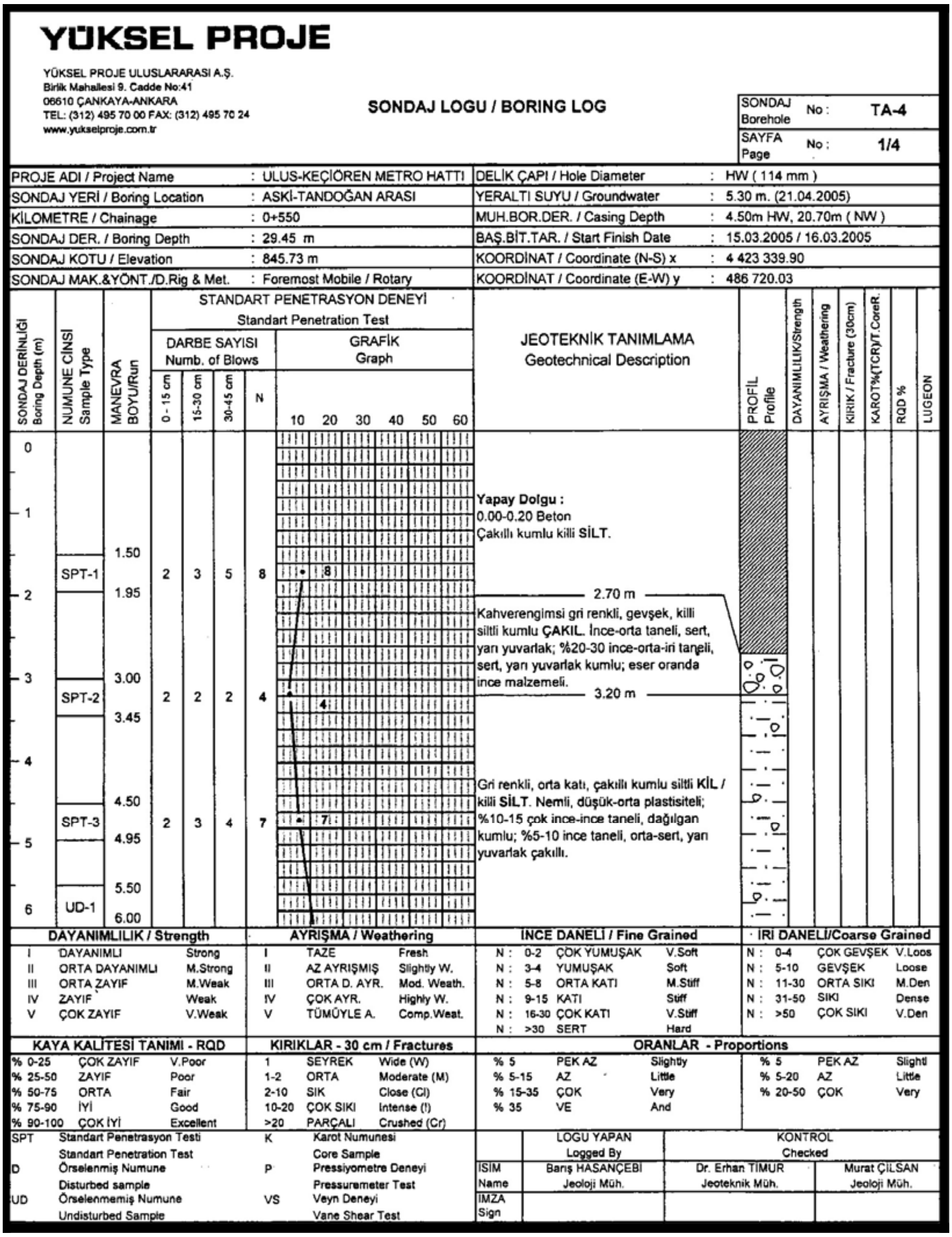
SONDAJ Borehole No : **TA-3**
SAYFA Page No : **4/4**

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	JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
27	SPT-18	27.00 27.45	22	31	37	68	68	Kahverengi, sert, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, düşük-orta yer yer yüksek plastisiteli; %15-20 çok ince-ince taneli kumlu;%5-10 ince-orta taneli, dağılgan-orta sert, yarı yuvarlak çakıllı. Birim yoğun olarak kireç konkresyonları içerir. (ANKARA KİLİ)							
29	SPT-19	29.00 29.45	19	20	23	43	43								
								KUYU SONU : 29.45 mt.							

Not : Kuyuya yeraltısuyu gözlemleri için 29.00 m, Φ50 mm. perfore boru indirilip, 40x40x15 cm. kuyu ağzı betonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign.			

C.4. Borehole TA-4



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 :	TA-4
SAYFA Page	No :	1/4

PROJE ADI / Project Name	: ULUS-KEÇİÖREN METRO HATTI	DELİK ÇAPI / Hole Diameter	: HW (114 mm)
SONDAJ YERİ / Boring Location	: ASKİ-TANDOĞAN ARASI	YERALTI SUYU / Groundwater	: 5.30 m. (21.04.2005)
KİLOMETRE / Chainage	: 0+550	MUH.BOR.DER. / Casing Depth	: 4.50m HW, 20.70m (NW)
SONDAJ DER. / Boring Depth	: 29.45 m	BAŞ.BİT.TAR. / Start Finish Date	: 15.03.2005 / 16.03.2005
SONDAJ KOTU / Elevation	: 845.73 m	KOORDİNAT / Coordinate (N-S) x	: 4 423 339.90
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Foremost Mobile / Rotary	KOORDİNAT / Coordinate (E-W) y	: 486 720.03

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Sample Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test					JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
			DARBE SAYISI Numb. of Blows				GRAFİK Graph								
			0 - 15 cm	15-30 cm	30-45 cm	N	10 20 30 40 50 60								
0 1								**Yapay Dolgu :** 0.00-0.20 Beton Çakıllı kumlu killi **SİLT**.							
2	SPT-1	1.50 1.95	2	3	5	8	8								
								2.70 m Kahverengimsi gri renkli, gevşek, killi siltli kumlu **ÇAKIL**. İnce-orta taneli, sert, yarı yuvarlak; %20-30 ince-orta-iri taneli, sert, yarı yuvarlak kumlu; eser oranda ince malzemeli.							
3	SPT-2	3.00 3.45	2	2	2	4	4	3.20 m							
4 5	SPT-3	4.50 4.95	2	3	4	7	7	Gri renkli, orta katı, çakıllı kumlu siltli **KİL** / killi **SİLT**. Nemli, düşük-orta plastisiteli; %10-15 çok ince-ince taneli, dağılgan kumlu; %5-10 ince taneli, orta-sert, yarı yuvarlak çakıllı.							
6	UD-1	5.50 6.00													

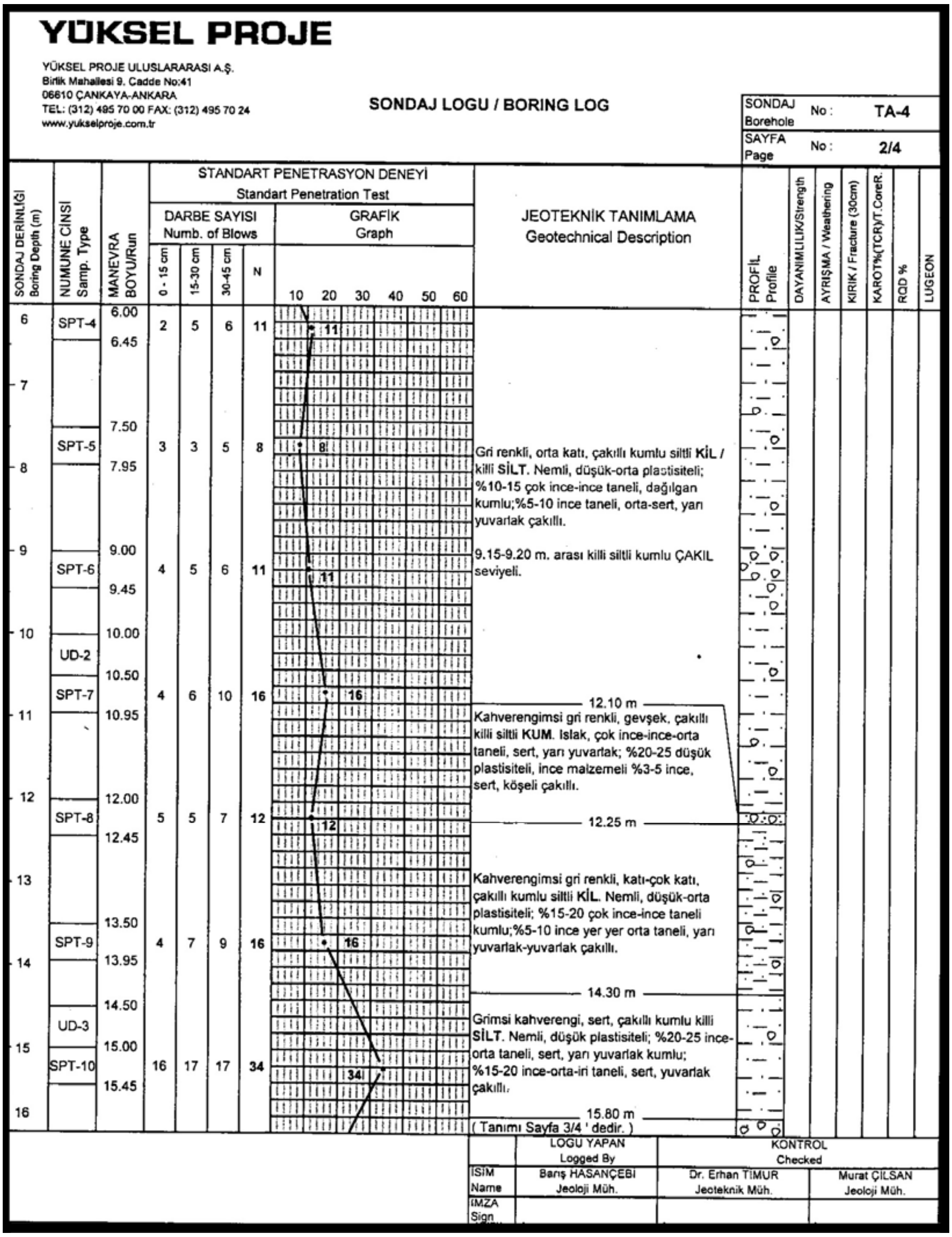
DAYANIMLILIK / Strength			AYRIŞMA / Weathering			İNCE DANELİ / Fine Grained			IRI DANELİ/Coarse Grained		
I	DAYANIMLI	Strong	I	TAZE	Fresh	N : 0-2	ÇOK YUMUŞAK	V.Soft	N : 0-4	ÇOK GEVŞEK	V.Loos
II	ORTA DAYANIMLI	M.Strong	II	AZ AYRIŞMIŞ	Slightly W.	N : 3-4	YUMUŞAK	Soft	N : 5-10	GEVŞEK	Loose
III	ORTA ZAYIF	M.Weak	III	ORTA D. AYR.	Mod. Weath.	N : 5-8	ORTA KATI	M.Stiff	N : 11-30	ORTA SIKI	M.Den
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.Den
						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	Slightl
% 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
D	Örselenmiş Numune Disturbed sample	P	Pressiyometre Deneyi Pressuremeter Test
UD	Örselenmemiş Numune Undisturbed Sample	VS	Veyn Deneyi Vane Shear Test

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇİLSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-4



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 : TA-4
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 Numb. of Blows 0 - 15 cm	15-30 cm	30-45 cm	N
6	SPT-4	6.00 6.45	2	5	6	11
7						
	SPT-5	7.50 7.95	3	3	5	8
8						
9	SPT-6	9.00 9.45	4	5	6	11
10	UD-2	10.00 10.50				
	SPT-7	10.95	4	6	10	16
11						
12	SPT-8	12.00 12.45	5	5	7	12
13						
	SPT-9	13.50 13.95	4	7	9	16
14						
	UD-3	14.50				
15	SPT-10	15.00 15.45	16	17	17	34
16						

JEOTEKNİK TANIMLAMA
Geotechnical Description

Gri renkli, orta katı, çakıllı kumlu siltli **KİL / killi SİLT**. Nemli, düşük-orta plastisiteli; %10-15 çok ince-ince taneli, dağılgan kumlu;%5-10 ince taneli, orta-sert, yarı yuvarlak çakıllı.

9.15-9.20 m. arası killi siltli kumlu ÇAKIL seviyeli.

12.10 m

Kahverengimsi gri renkli, gevşek, çakıllı killi siltli **KUM**. Islak, çok ince-ince-orta taneli, sert, yarı yuvarlak; %20-25 düşük plastisiteli, ince malzemeli %3-5 ince, sert, köşeli çakıllı.

12.25 m

Kahverengimsi gri renkli, katı-çok katı, çakıllı kumlu siltli **KİL**. Nemli, düşük-orta plastisiteli; %15-20 çok ince-ince taneli kumlu;%5-10 ince yer yer orta taneli, yarı yuvarlak-yuvarlak çakıllı.

14.30 m

Grimsi kahverengi, sert, çakıllı kumlu killi **SİLT**. Nemli, düşük plastisiteli; %20-25 ince-orta taneli, sert, yarı yuvarlak kumlu; %15-20 ince-orta-iri taneli, sert, yuvarlak çakıllı.

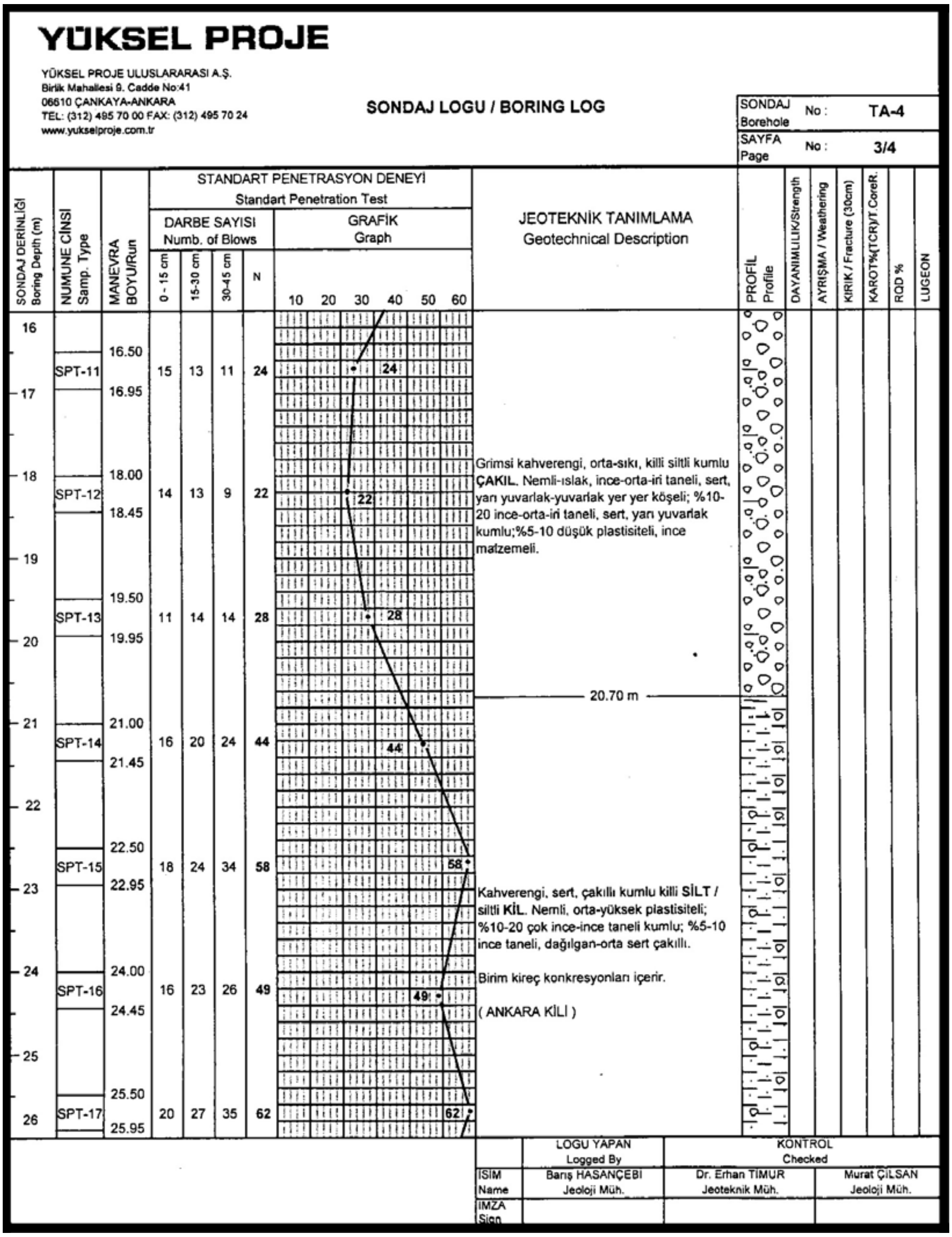
15.80 m

(Tanımı Sayfa 3/4 ' dedir.)

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

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-4



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 : TA-4
SAYFA Page No : 3/4

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
16						
	SPT-11	16.50 16.95	15	13	11	24
17						
18	SPT-12	18.00 18.45	14	13	9	22
19						
	SPT-13	19.50 19.95	11	14	14	28
20						
21	SPT-14	21.00 21.45	16	20	24	44
22						
	SPT-15	22.50 22.95	18	24	34	58
23						
24	SPT-16	24.00 24.45	16	23	26	49
25						
26	SPT-17	25.50 25.95	20	27	35	62

GRAFİK Graph: 10 20 30 40 50 60

JEOTEKNİK TANIMLAMA Geotechnical Description

Grimsi kahverengi, orta-sıkı, killi siltli kumlu **ÇAKIL**. Nemli-ıslak, ince-orta-iri taneli, sert, yarı yuvarlak-yuvarlak yer yer köşeli; %10-20 ince-orta-iri taneli, sert, yarı yuvarlak kumlu;%5-10 düşük plastisiteli, ince malzemeli.

20.70 m

Kahverengi, sert, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, orta-yüksek plastisiteli; %10-20 çok ince-ince taneli kumlu; %5-10 ince taneli, dağılgan-orta sert çakıllı.

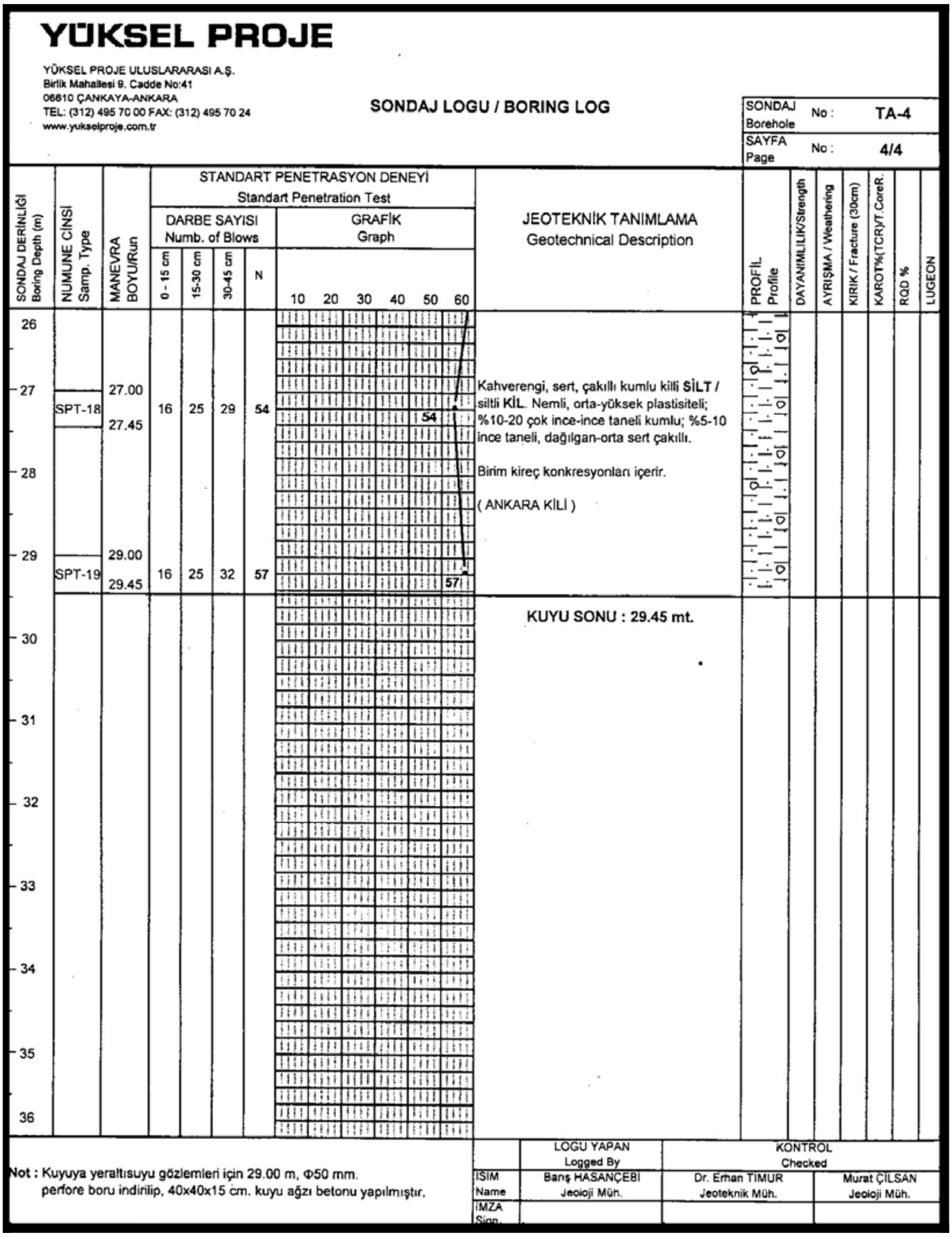
Birim kireç konkresyonları içerir.

(ANKARA KİLİ)

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

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇİLSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-4



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

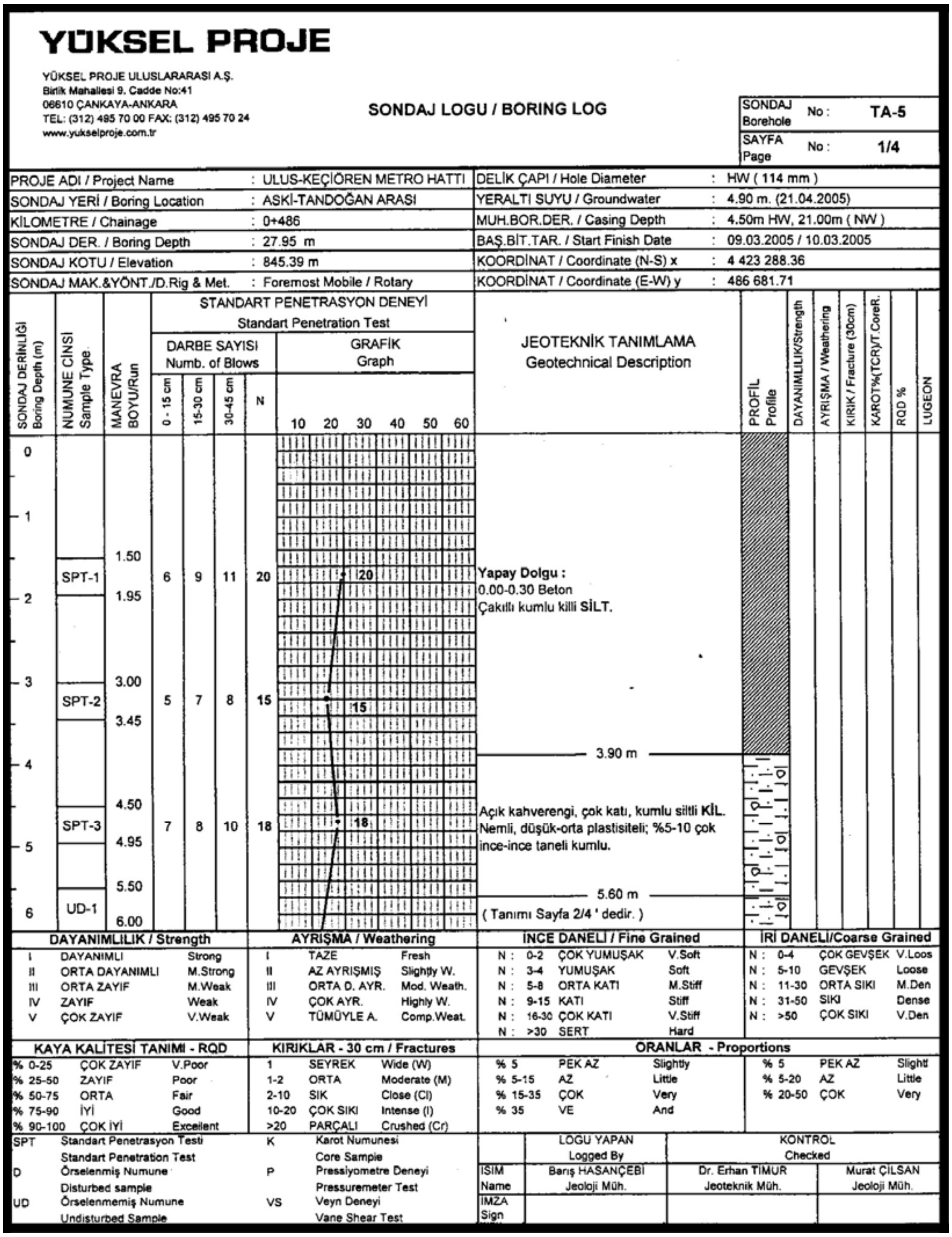
SONDAJ Borehole No : TA-4
SAYFA Page No : 4/4

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	JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
26															
27	SPT-18	27.00 27.45	16	25	29	54	54	Kahverengi, sert, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, orta-yüksek plastisiteli; %10-20 çok ince-ince taneli kumlu; %5-10 ince taneli, dağılgan-orta sert çakıllı. Birim kireç konkresyonları içerir. (ANKARA KİLİ)							
28															
29	SPT-19	29.00 29.45	16	25	32	57	57								
30								**KUYU SONU : 29.45 mt.**							
31															
32															
33															
34															
35															
36															

Not : Kuyuya yeraltısuyu gözlemleri için 29.00 m, Φ50 mm. perfore boru indirilip, 40x40x15 cm. kuyu ağzı betonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked	
İSIM Name	Banş HASANÇEBİ Jeoloji Müh.	Dr. Erhan TIMUR Jeoteknik Müh.	Murat ÇİLSAN Jeoloji Müh.
İMZA Sign.			

C.5. Borehole TA-5



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 :	TA-5
SAYFA Page	No :	1/4

PROJE ADI / Project Name	: ULUS-KEÇİÖREN METRO HATTI	DELİK ÇAPI / Hole Diameter	: HW (114 mm)
SONDAJ YERİ / Boring Location	: ASKİ-TANDOĞAN ARASI	YERALTI SUYU / Groundwater	: 4.90 m. (21.04.2005)
KİLOMETRE / Chainage	: 0+486	MUH.BOR.DER. / Casing Depth	: 4.50m HW, 21.00m (NW)
SONDAJ DER. / Boring Depth	: 27.95 m	BAŞ.BİT.TAR. / Start Finish Date	: 09.03.2005 / 10.03.2005
SONDAJ KOTU / Elevation	: 845.39 m	KOORDİNAT / Coordinate (N-S) x	: 4 423 288.36
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Foremost Mobile / Rotary	KOORDİNAT / Coordinate (E-W) y	: 486 681.71

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	6	9	11	20	20	**Yapay Dolgu :** 0.00-0.30 Beton Çakıllı kumlu killi **SİLT**.							
2															
3	SPT-2	3.00 3.45	5	7	8	15	15								
4								3.90 m							
	SPT-3	4.50 4.95	7	8	10	18	18	Açık kahverengi, çok katı, kumlu siltli **KİL**. Nemli, düşük-orta plastisiteli; %5-10 çok ince-ince taneli kumlu.							
5															
6	UD-1	5.50 6.00						5.60 m (Tanımı Sayfa 2/4 ' dedir.)							

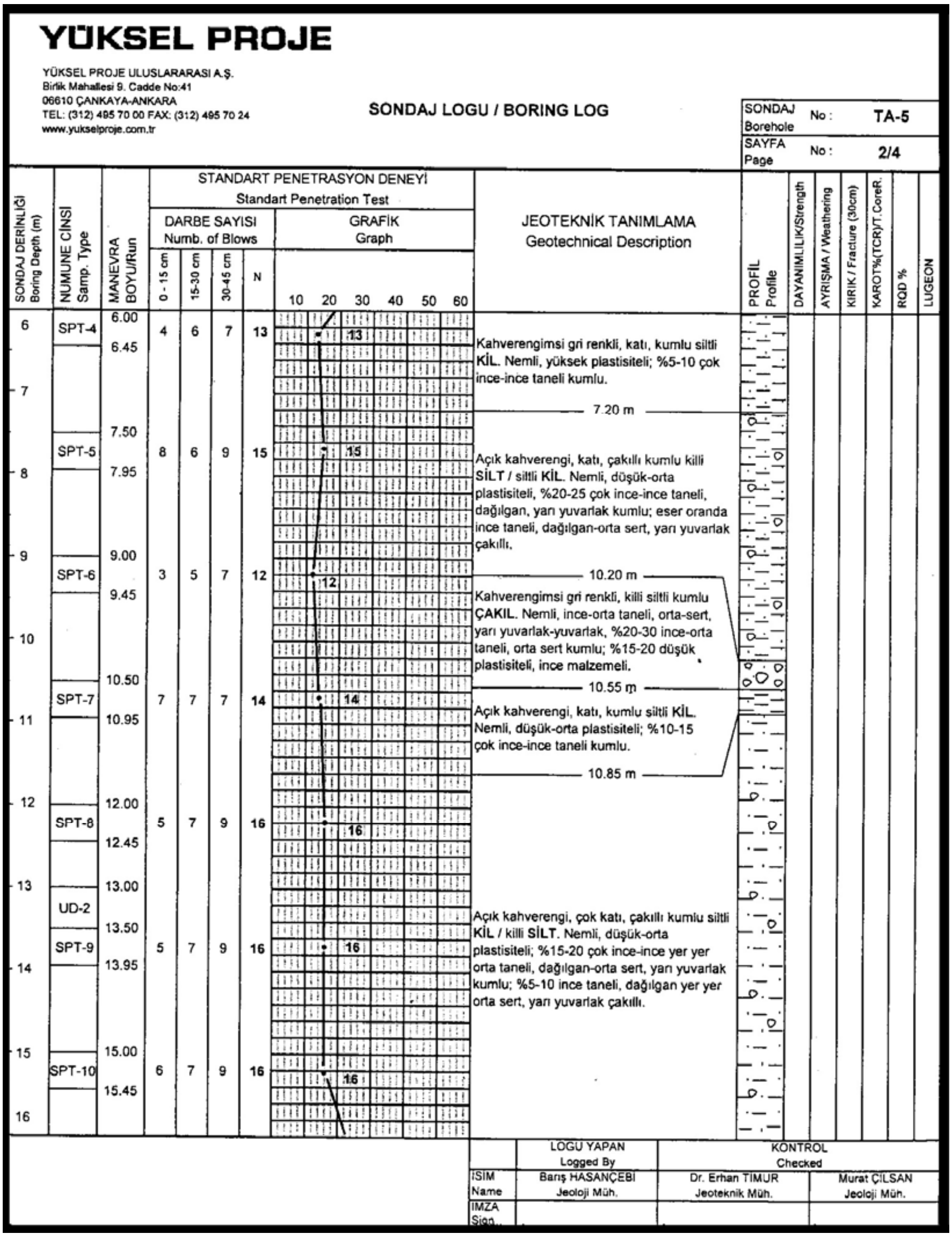
DAYANIMLILIK / Strength			AYRIŞMA / Weathering			İNCE DANELİ / Fine Grained			İRİ DANELİ/Coarse Grained		
I	DAYANIMLI	Strong	I	TAZE	Fresh	N : 0-2	ÇOK YUMUŞAK	V.Soft	N : 0-4	ÇOK GEVŞEK	V.Loos
II	ORTA DAYANIMLI	M.Strong	II	AZ AYRIŞMIŞ	Slightly W.	N : 3-4	YUMUŞAK	Soft	N : 5-10	GEVŞEK	Loose
III	ORTA ZAYIF	M.Weak	III	ORTA D. AYR.	Mod. Weath.	N : 5-8	ORTA KATI	M.Stiff	N : 11-30	ORTA SIKI	M.Den
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.Den
						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	Slightl
% 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
D	Örselenmiş Numune Disturbed sample	P	Pressiyometre Deneyi Pressuremeter Test
UD	Örselenmemiş Numune Undisturbed Sample	VS	Veyn Deneyi Vane Shear Test

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇİLSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-5



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 : **TA-5**
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-4	6.00 6.45	4	6	7	13
7						
	SPT-5	7.50 7.95	8	6	9	15
8						
9	SPT-6	9.00 9.45	3	5	7	12
10						
	SPT-7	10.50 10.95	7	7	7	14
11						
12	SPT-8	12.00 12.45	5	7	9	16
13	UD-2	13.00 13.50				
14	SPT-9	13.50 13.95	5	7	9	16
15	SPT-10	15.00 15.45	6	7	9	16
16						

JEOTEKNİK TANIMLAMA
Geotechnical Description

Kahverengimsi gri renkli, katı, kumlu siltli **KİL**. Nemli, yüksek plastisiteli; %5-10 çok ince-ince taneli kumlu.

7.20 m

Açık kahverengi, katı, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, düşük-orta plastisiteli, %20-25 çok ince-ince taneli, dağılgan, yarı yuvarlak kumlu; eser oranda ince taneli, dağılgan-orta sert, yarı yuvarlak çakıllı.

10.20 m

Kahverengimsi gri renkli, killi siltli kumlu **ÇAKIL**. Nemli, ince-orta taneli, orta-sert, yarı yuvarlak-yuvarlak, %20-30 ince-orta taneli, orta sert kumlu; %15-20 düşük plastisiteli, ince malzemeli.

10.55 m

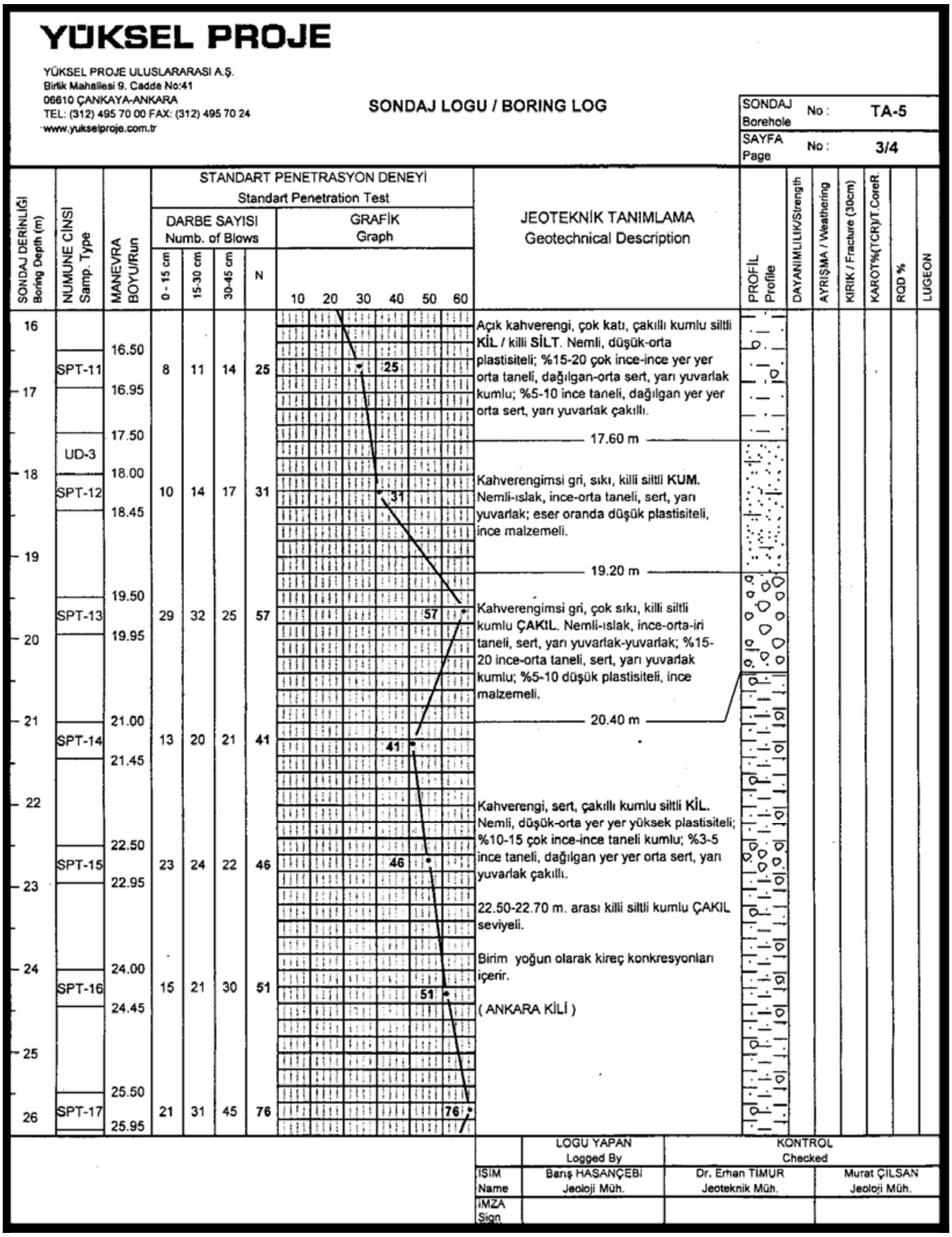
Açık kahverengi, katı, kumlu siltli **KİL**. Nemli, düşük-orta plastisiteli; %10-15 çok ince-ince taneli kumlu.

10.85 m

Açık kahverengi, çok katı, çakıllı kumlu siltli **KİL** / killi **SİLT**. Nemli, düşük-orta plastisiteli; %15-20 çok ince-ince yer yer orta taneli, dağılgan-orta sert, yarı yuvarlak kumlu; %5-10 ince taneli, dağılgan yer yer orta sert, yarı yuvarlak çakıllı.

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign.			

Continuation of Borehole TA-5



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 : TA-5
SAYFA Page No : 3/4

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
16		16.50				
17	SPT-11	16.95	8	11	14	25
	UD-3	17.50 18.00				
18	SPT-12	18.45	10	14	17	31
19		19.50				
20	SPT-13	19.95	29	32	25	57
21	SPT-14	21.00 21.45	13	20	21	41
22		22.50				
23	SPT-15	22.95	23	24	22	46
24	SPT-16	24.00 24.45	15	21	30	51
25		25.50				
26	SPT-17	25.95	21	31	45	76

JEOTEKNİK TANIMLAMA
Geotechnical Description

Açık kahverengi, çok katı, çakıllı kumlu siltli **KİL** / killi **SİLT**. Nemli, düşük-orta plastisiteli; %15-20 çok ince-ince yer yer orta taneli, dağılgan-orta sert, yarı yuvarlak kumlu; %5-10 ince taneli, dağılgan yer yer orta sert, yarı yuvarlak çakıllı.

17.60 m

Kahverengimsi gri, sıkı, killi siltli **KUM**. Nemli-ıslak, ince-orta taneli, sert, yarı yuvarlak; eser oranda düşük plastisiteli, ince malzemeli.

19.20 m

Kahverengimsi gri, çok sıkı, killi siltli kumlu **ÇAKIL**. Nemli-ıslak, ince-orta-iri taneli, sert, yarı yuvarlak-yuvarlak; %15-20 ince-orta taneli, sert, yarı yuvarlak kumlu; %5-10 düşük plastisiteli, ince malzemeli.

20.40 m

Kahverengi, sert, çakıllı kumlu siltli **KİL**. Nemli, düşük-orta yer yer yüksek plastisiteli; %10-15 çok ince-ince taneli kumlu; %3-5 ince taneli, dağılgan yer yer orta sert, yarı yuvarlak çakıllı.

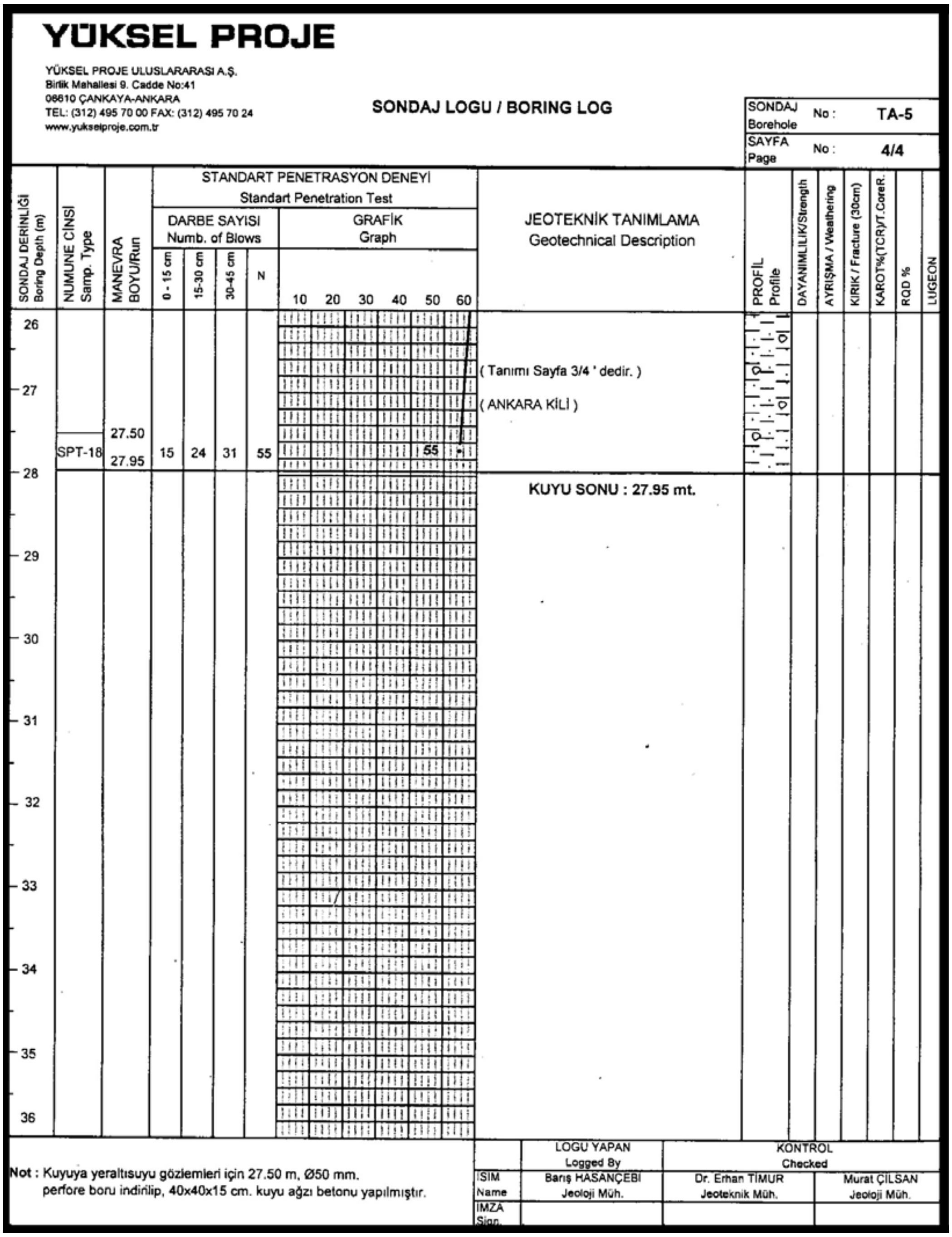
22.50-22.70 m. arası killi siltli kumlu ÇAKIL seviyeli.

Birim yoğun olarak kireç konkresyonları içerir.

(ANKARA KİLİ)

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-5



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

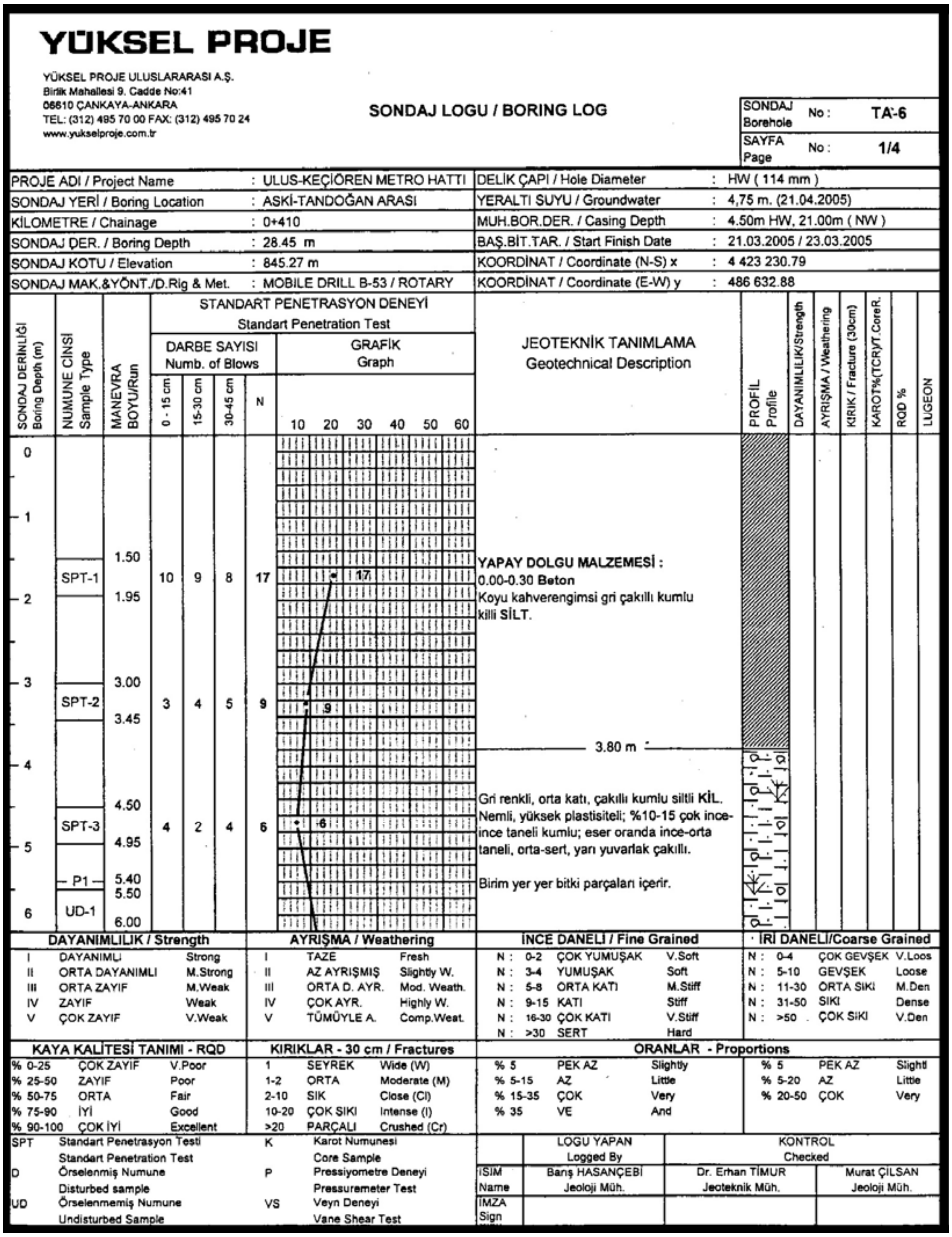
SONDAJ Borehole No : **TA-5**
SAYFA Page No : **4/4**

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								(Tanımı Sayfa 3/4 ' dedir.) (ANKARA KİLİ)							
27		27.50													
	SPT-18	27.95	15	24	31	55	55								
28								**KUYU SONU : 27.95 mt.**							
29															
30															
31															
32															
33															
34															
35															
36															

Not : Kuyuya yeraltısuyu gözlemleri için 27.50 m, Ø50 mm. perfore boru indirilip, 40x40x15 cm. kuyu ağzı betonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked	
İSIM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
IMZA Sign.			

C.6. Borehole TA-6



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 :	TA-6
SAYFA Page	No :	1/4

PROJE ADI / Project Name	: ULUS-KEÇİÖREN METRO HATTI	DELİK ÇAPI / Hole Diameter	: HW (114 mm)
SONDAJ YERİ / Boring Location	: ASKİ-TANDOĞAN ARASI	YERALTI SUYU / Groundwater	: 4,75 m. (21.04.2005)
KİLOMETRE / Chainage	: 0+410	MUH.BOR.DER. / Casing Depth	: 4.50m HW, 21.00m (NW)
SONDAJ DER. / Boring Depth	: 28.45 m	BAŞ.BİT.TAR. / Start Finish Date	: 21.03.2005 / 23.03.2005
SONDAJ KOTU / Elevation	: 845.27 m	KOORDİNAT / Coordinate (N-S) x	: 4 423 230.79
SONDAJ MAK.&YÖNT./D.Rig & Met.	: MOBILE DRILL B-53 / ROTARY	KOORDİNAT / Coordinate (E-W) y	: 486 632.88

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	10	9	8	17	17	**YAPAY DOLGU MALZEMESİ :** **0.00-0.30 Beton** Koyu kahverengimsi gri çakıllı kumlu killi **SİLT**.							
2															
3	SPT-2	3.00 3.45	3	4	5	9	9								
								3.80 m							
4								Gri renkli, orta katı, çakıllı kumlu siltli **KİL**. Nemli, yüksek plastisiteli; %10-15 çok ince-ince taneli kumlu; eser oranda ince-orta taneli, orta-sert, yarı yuvarlak çakıllı. Birim yer yer bitki parçaları içerir.							
	SPT-3	4.50 4.95	4	2	4	6	6								
5	P1	5.40													
6	UD-1	5.50 6.00													

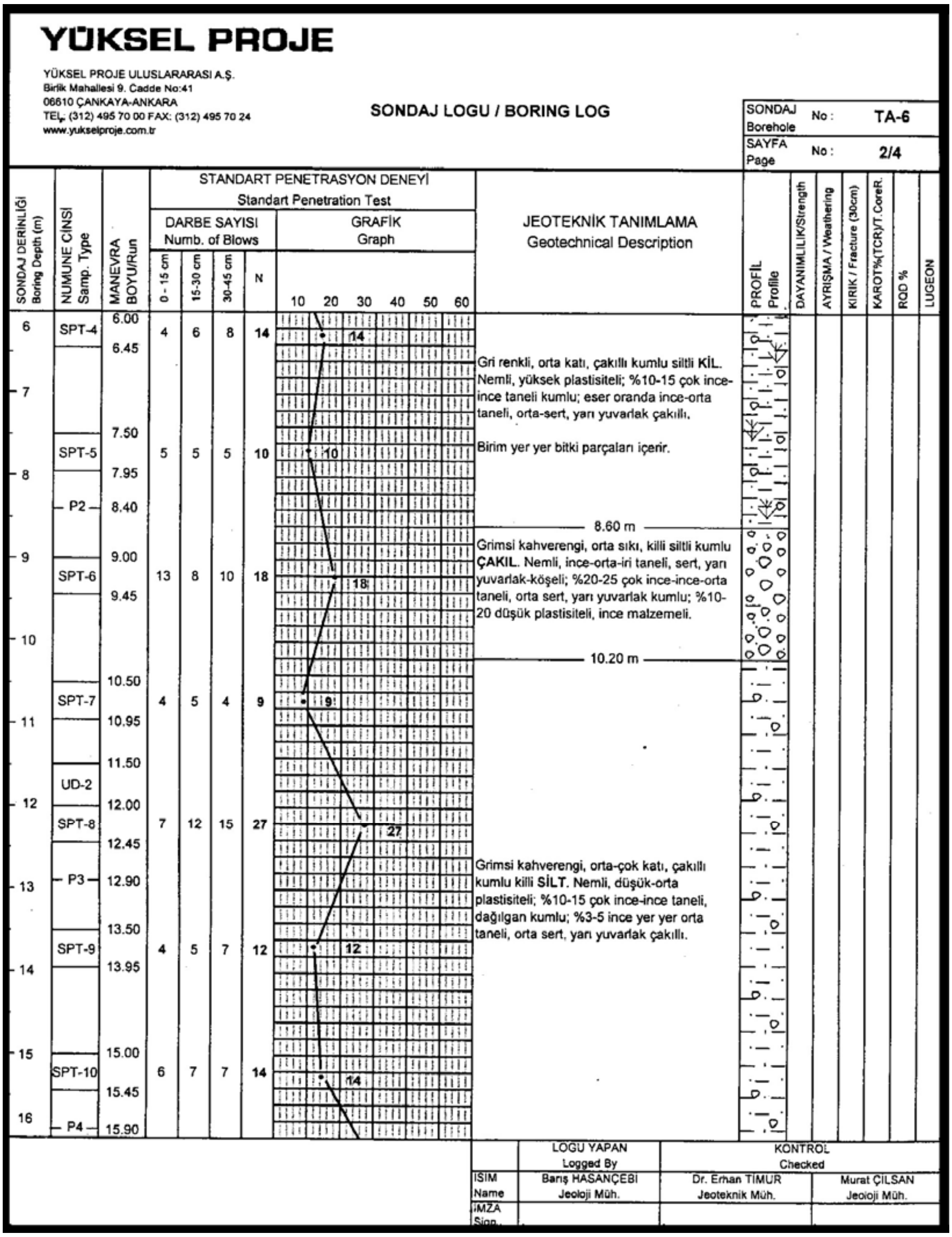
DAYANIMLILIK / Strength			AYRIŞMA / Weathering			İNCE DANELİ / Fine Grained			İRİ DANELİ/Coarse Grained		
I	DAYANIMLI	Strong	I	TAZE	Fresh	N : 0-2	ÇOK YUMUŞAK	V.Soft	N : 0-4	ÇOK GEVŞEK	V.Loos
II	ORTA DAYANIMLI	M.Strong	II	AZ AYRIŞMIŞ	Slightly W.	N : 3-4	YUMUŞAK	Soft	N : 5-10	GEVŞEK	Loose
III	ORTA ZAYIF	M.Weak	III	ORTA D. AYR.	Mod. Weath.	N : 5-8	ORTA KATI	M.Stiff	N : 11-30	ORTA SIKI	M.Den
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.Den
						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	Slightl
% 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
D	Örselenmiş Numune Disturbed sample	P	Pressiyometre Deneyi Pressuremeter Test
UD	Örselenmemiş Numune Undisturbed Sample	VS	Veyn Deneyi Vane Shear Test

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-6



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 : **TA-6**
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 Numb. of Blows 0 - 15 cm	15-30 cm	30-45 cm	N
6	SPT-4	6.00	4	6	8	14
		6.45				
7						
		7.50				
	SPT-5		5	5	5	10
8		7.95				
	P2	8.40				
9		9.00				
	SPT-6		13	8	10	18
		9.45				
10						
		10.50				
	SPT-7		4	5	4	9
11		10.95				
		11.50				
	UD-2					
12		12.00				
	SPT-8		7	12	15	27
		12.45				
13	P3	12.90				
		13.50				
	SPT-9		4	5	7	12
14		13.95				
15		15.00				
	SPT-10		6	7	7	14
		15.45				
16	P4	15.90				

JEOTEKNİK TANIMLAMA
Geotechnical Description

Gri renkli, orta katı, çakıllı kumlu siltli **KİL**. Nemli, yüksek plastisiteli; %10-15 çok ince-ince taneli kumlu; eser oranda ince-orta taneli, orta-sert, yarı yuvarlak çakıllı.

Birim yer yer bitki parçaları içerir.

8.60 m

Grimsi kahverengi, orta sıkı, killi siltli kumlu **ÇAKIL**. Nemli, ince-orta-iri taneli, sert, yarı yuvarlak-köşeli; %20-25 çok ince-ince-orta taneli, orta sert, yarı yuvarlak kumlu; %10-20 düşük plastisiteli, ince malzemeli.

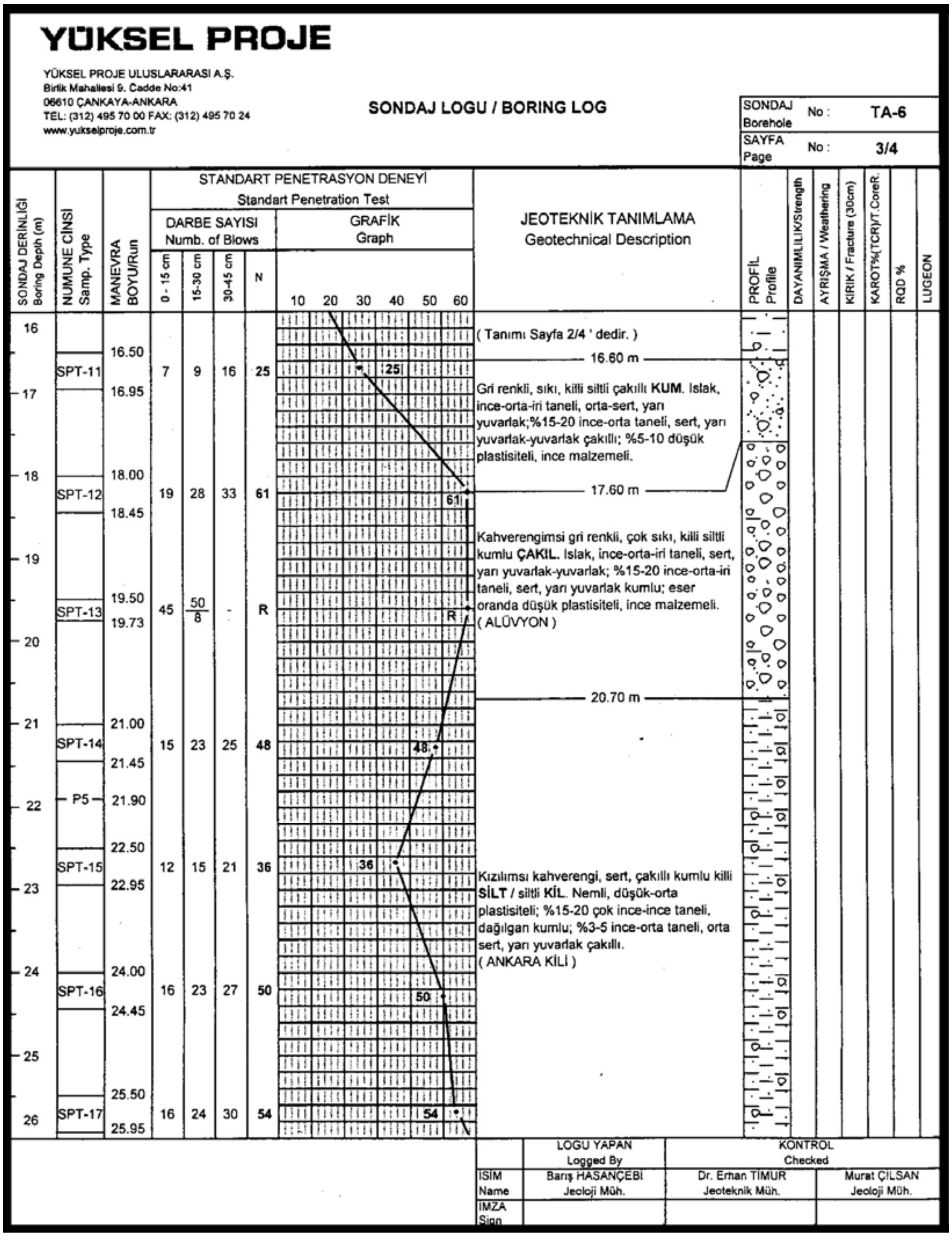
10.20 m

Grimsi kahverengi, orta-çok katı, çakıllı kumlu killi **SİLT**. Nemli, düşük-orta plastisiteli; %10-15 çok ince-ince taneli, dağılgan kumlu; %3-5 ince yer yer orta taneli, orta sert, yarı yuvarlak çakıllı.

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

	LOGU YAPAN Logged By	KONTROL Checked	
İSIM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign.			

Continuation of Borehole TA-6



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 : **TA-6**
SAYFA Page No : **3/4**

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
SPT-11	16.50 16.95	7	9	16	25
SPT-12	18.00 18.45	19	28	33	61
SPT-13	19.50 19.73	45	50/8	-	R
SPT-14	21.00 21.45	15	23	25	48
P5	21.90				
SPT-15	22.50 22.95	12	15	21	36
SPT-16	24.00 24.45	16	23	27	50
SPT-17	25.50 25.95	16	24	30	54

JEOTEKNİK TANIMLAMA
Geotechnical Description

(Tanımı Sayfa 2/4 ' dedir.)

16.60 m

Gri renkli, sıkı, killi siltli çakıllı **KUM**. Islak, ince-orta-iri taneli, orta-sert, yarı yuvarlak;%15-20 ince-orta taneli, sert, yarı yuvarlak-yuvarlak çakıllı; %5-10 düşük plastisiteli, ince malzemeli.

17.60 m

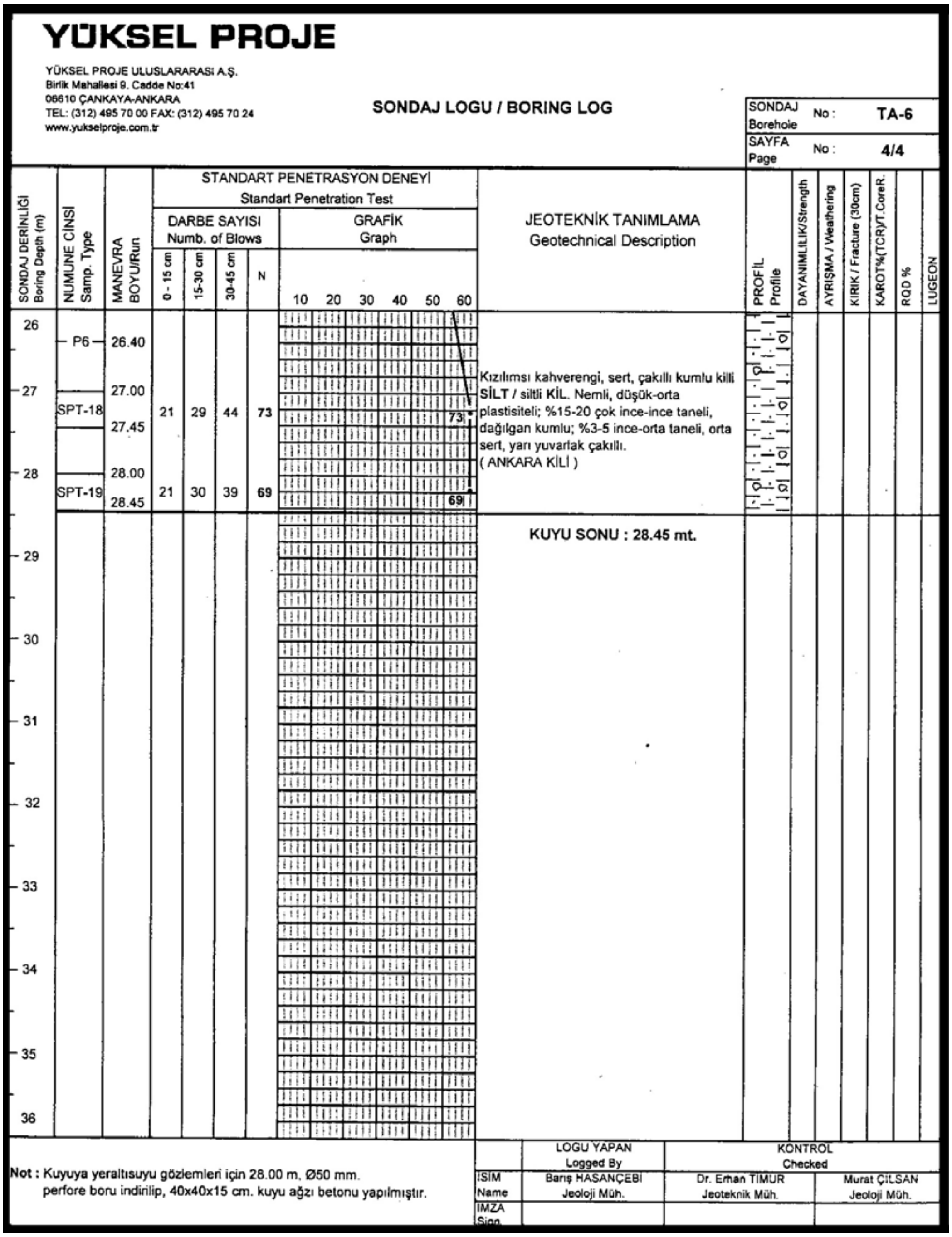
Kahverengimsi gri renkli, çok sıkı, killi siltli kumlu **ÇAKIL.** Islak, ince-orta-iri taneli, sert, yarı yuvarlak-yuvarlak; %15-20 ince-orta-iri taneli, sert, yarı yuvarlak kumlu; eser oranda düşük plastisiteli, ince malzemeli.
(ALÜVYON)

20.70 m

Kızılımsı kahverengi, sert, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, düşük-orta plastisiteli; %15-20 çok ince-ince taneli, dağılgan kumlu; %3-5 ince-orta taneli, orta sert, yarı yuvarlak çakıllı.
(ANKARA KİLİ)

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-6



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

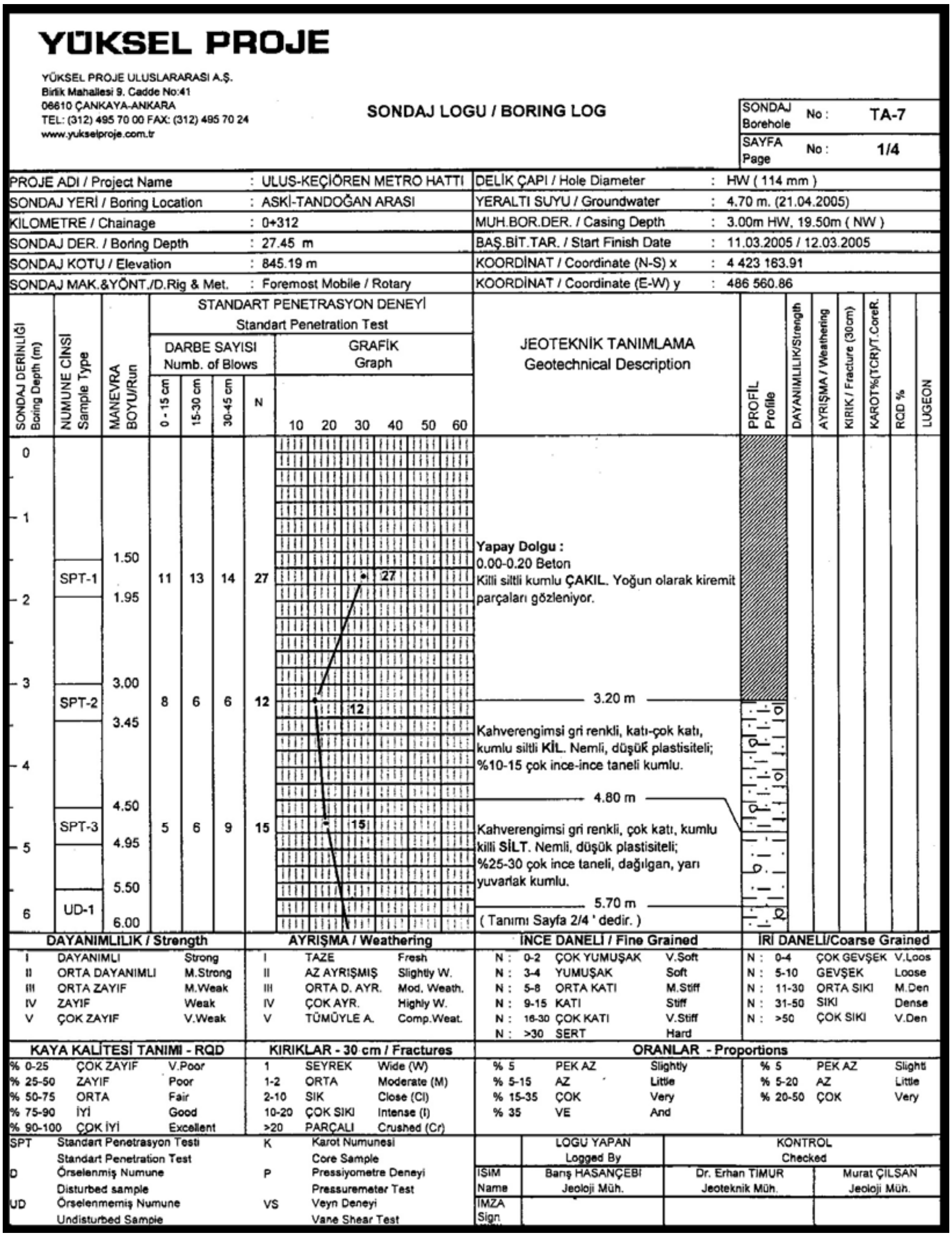
SONDAJ Borehole No : **TA-6**
SAYFA Page No : **4/4**

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	P6	26.40						Kızılımsı kahverengi, sert, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, düşük-orta plastisiteli; %15-20 çok ince-ince taneli, dağılgan kumlu; %3-5 ince-orta taneli, orta sert, yarı yuvarlak çakıllı. (ANKARA KİLİ)							
27	SPT-18	27.00 27.45	21	29	44	73	73								
28	SPT-19	28.00 28.45	21	30	39	69	69								
29								**KUYU SONU : 28.45 mt.**							
30															
31															
32															
33															
34															
35															
36															

Not : Kuyuya yeraltısuyu gözlemleri için 28.00 m. Ø50 mm. perfore boru indirilip, 40x40x15 cm. kuyu ağzı betonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign.			

C.7. Borehole TA-7



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 :	TA-7
SAYFA Page	No :	1/4

PROJE ADI / Project Name	: ULUS-KEÇİÖREN METRO HATTI	DELİK ÇAPI / Hole Diameter	: HW (114 mm)
SONDAJ YERİ / Boring Location	: ASKİ-TANDOĞAN ARASI	YERALTI SUYU / Groundwater	: 4.70 m. (21.04.2005)
KİLOMETRE / Chainage	: 0+312	MUH.BOR.DER. / Casing Depth	: 3.00m HW, 19.50m (NW)
SONDAJ DER. / Boring Depth	: 27.45 m	BAŞ.BİT.TAR. / Start Finish Date	: 11.03.2005 / 12.03.2005
SONDAJ KOTU / Elevation	: 845.19 m	KOORDİNAT / Coordinate (N-S) x	: 4 423 163.91
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Foremost Mobile / Rotary	KOORDİNAT / Coordinate (E-W) y	: 486 560.86

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Sample Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test					JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
			DARBE SAYISI Numb. of Blows				GRAFİK Graph								
			0 - 15 cm	15-30 cm	30-45 cm	N	10 20 30 40 50 60								
0															
1															
	SPT-1	1.50 1.95	11	13	14	27	27	**Yapay Dolgu :** 0.00-0.20 Beton Killi siltli kumlu **ÇAKIL**. Yoğun olarak kiremit parçaları gözleniyor.							
2															
3	SPT-2	3.00 3.45	8	6	6	12	12	3.20 m Kahverengimsi gri renkli, katı-çok katı, kumlu siltli **KİL**. Nemli, düşük plastisiteli; %10-15 çok ince-ince taneli kumlu.							
4								4.80 m							
5	SPT-3	4.50 4.95	5	6	9	15	15	Kahverengimsi gri renkli, çok katı, kumlu killi **SİLT**. Nemli, düşük plastisiteli; %25-30 çok ince taneli, dağılgan, yarı yuvarlak kumlu.							
6	UD-1	5.50 6.00						5.70 m (Tanımı Sayfa 2/4 ' dedir.)							

DAYANIMLILIK / Strength

I	DAYANIMLI	Strong
II	ORTA DAYANIMLI	M.Strong
III	ORTA ZAYIF	M.Weak
IV	ZAYIF	Weak
V	ÇOK ZAYIF	V.Weak

AYRIŞMA / Weathering

I	TAZE	Fresh
II	AZ AYRIŞMIŞ	Slightly W.
III	ORTA D. AYR.	Mod. Weath.
IV	ÇOK AYR.	Highly W.
V	TÜMÜYLE A.	Comp.Weat.

İNCE DANELİ / Fine Grained

N :	0-2	ÇOK YUMUŞAK	V.Soft
N :	3-4	YUMUŞAK	Soft
N :	5-8	ORTA KATI	M.Stiff
N :	9-15	KATI	Stiff
N :	16-30	ÇOK KATI	V.Stiff
N :	>30	SERT	Hard

İRİ DANELİ/Coarse Grained

N :	0-4	ÇOK GEVŞEK	V.Loos
N :	5-10	GEVŞEK	Loose
N :	11-30	ORTA SIKI	M.Den
N :	31-50	SIKI	Dense
N :	>50	ÇOK SIKI	V.Den

KAYA KALİTESİ TANIMI - RQD

% 0-25	ÇOK ZAYIF	V.Poor
% 25-50	ZAYIF	Poor
% 50-75	ORTA	Fair
% 75-90	İYİ	Good
% 90-100	ÇOK İYİ	Excellent

KIRIKLAR - 30 cm / Fractures

1	SEYREK	Wide (W)
1-2	ORTA	Moderate (M)
2-10	SIK	Close (Cl)
10-20	ÇOK SIKI	Intense (I)
>20	PARÇALI	Crushed (Cr)

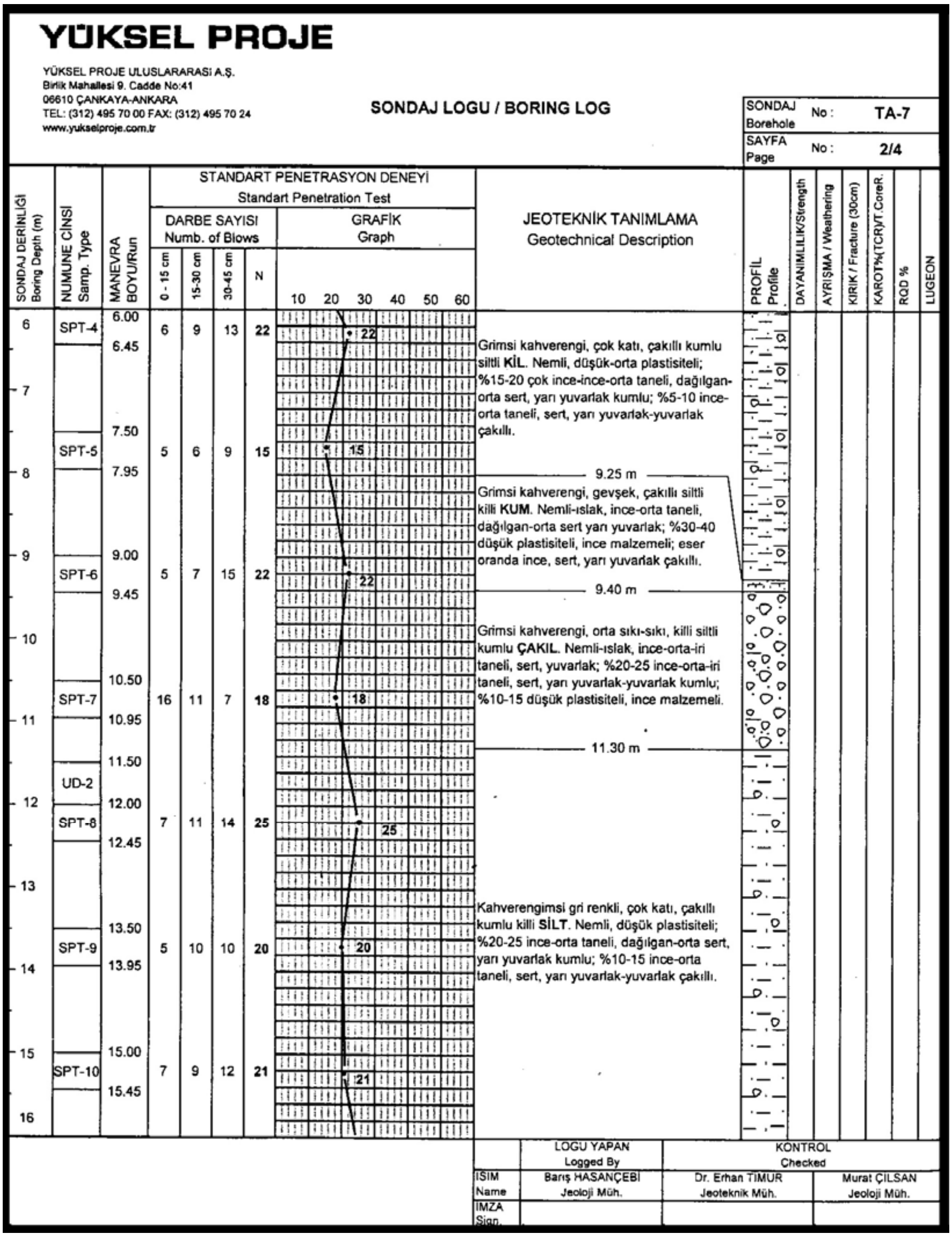
ORANLAR - Proportions

% 5	PEK AZ	Slightly	% 5	PEK AZ	Slight
% 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	Örselenmiş Numune Disturbed sample	P	Pressiyometre Deneyi Pressuremeter Test
UD	Örselenmemiş Numune Undisturbed Sample	VS	Veyn Deneyi Vane Shear Test

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TIMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-7



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 :	TA-7
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 Numb. of Blows: 0 - 15 cm	15-30 cm	30-45 cm	N
6	SPT-4	6.00 6.45	6	9	13	22
7						
	SPT-5	7.50 7.95	5	6	9	15
8						
9	SPT-6	9.00 9.45	5	7	15	22
10						
	SPT-7	10.50 10.95	16	11	7	18
11						
	UD-2	11.50 12.00				
12	SPT-8	12.00 12.45	7	11	14	25
13						
	SPT-9	13.50 13.95	5	10	10	20
14						
15	SPT-10	15.00 15.45	7	9	12	21
16						

JEOTEKNİK TANIMLAMA
Geotechnical Description

Grimsi kahverengi, çok katı, çakıllı kumlu siltli **KİL**. Nemli, düşük-orta plastisiteli; %15-20 çok ince-ince-orta taneli, dağılgan-orta sert, yarı yuvarlak kumlu; %5-10 ince-orta taneli, sert, yarı yuvarlak-yuvarlak çakıllı.

9.25 m

Grimsi kahverengi, gevşek, çakıllı siltli killi **KUM**. Nemli-ıslak, ince-orta taneli, dağılgan-orta sert yarı yuvarlak; %30-40 düşük plastisiteli, ince malzemeli; eser oranda ince, sert, yarı yuvarlak çakıllı.

9.40 m

Grimsi kahverengi, orta sıkı-sıkı, killi siltli kumlu **ÇAKIL**. Nemli-ıslak, ince-orta-iri taneli, sert, yuvarlak; %20-25 ince-orta-iri taneli, sert, yarı yuvarlak-yuvarlak kumlu; %10-15 düşük plastisiteli, ince malzemeli.

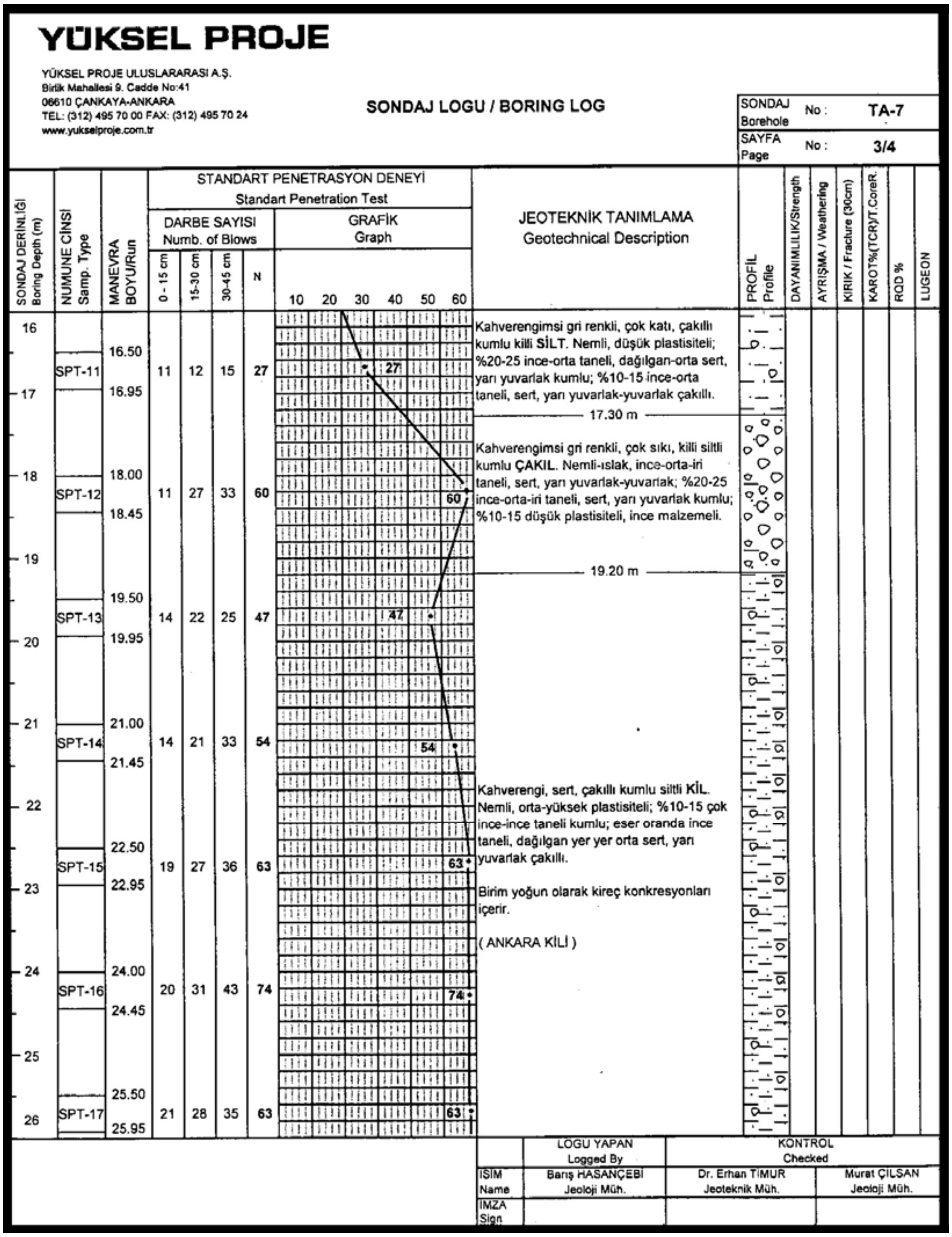
11.30 m

Kahverengimsi gri renkli, çok katı, çakıllı kumlu killi **SİLT**. Nemli, düşük plastisiteli; %20-25 ince-orta taneli, dağılgan-orta sert, yarı yuvarlak kumlu; %10-15 ince-orta taneli, sert, yarı yuvarlak-yuvarlak çakıllı.

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

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign.			

Continuation of Borehole TA-7



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 : TA-7
SAYFA Page No : 3/4

STANDART PENETRASYON DENEYİ / Standart Penetration Test

NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	DARBE SAYISI Numb. of Blows 0 - 15 cm	15-30 cm	30-45 cm	N
SPT-11	16.50 16.95	11	12	15	27
SPT-12	18.00 18.45	11	27	33	60
SPT-13	19.50 19.95	14	22	25	47
SPT-14	21.00 21.45	14	21	33	54
SPT-15	22.50 22.95	19	27	36	63
SPT-16	24.00 24.45	20	31	43	74
SPT-17	25.50 25.95	21	28	35	63

GRAFİK Graph

JEOTEKNİK TANIMLAMA / Geotechnical Description

Kahverengimsi gri renkli, çok katı, çakıllı kumlu killi **SİLT**. Nemli, düşük plastisiteli; %20-25 ince-orta taneli, dağılgan-orta sert, yarı yuvarlak kumlu; %10-15 ince-orta taneli, sert, yarı yuvarlak-yuvarlak çakıllı.

17.30 m

Kahverengimsi gri renkli, çok sıkı, killi siltli kumlu **ÇAKIL**. Nemli-ıslak, ince-orta-iri taneli, sert, yarı yuvarlak-yuvarlak; %20-25 ince-orta-iri taneli, sert, yarı yuvarlak kumlu; %10-15 düşük plastisiteli, ince malzemeli.

19.20 m

Kahverengi, sert, çakıllı kumlu siltli **KİL**. Nemli, orta-yüksek plastisiteli; %10-15 çok ince-ince taneli kumlu; eser oranda ince taneli, dağılgan yer yer orta sert, yarı yuvarlak çakıllı.

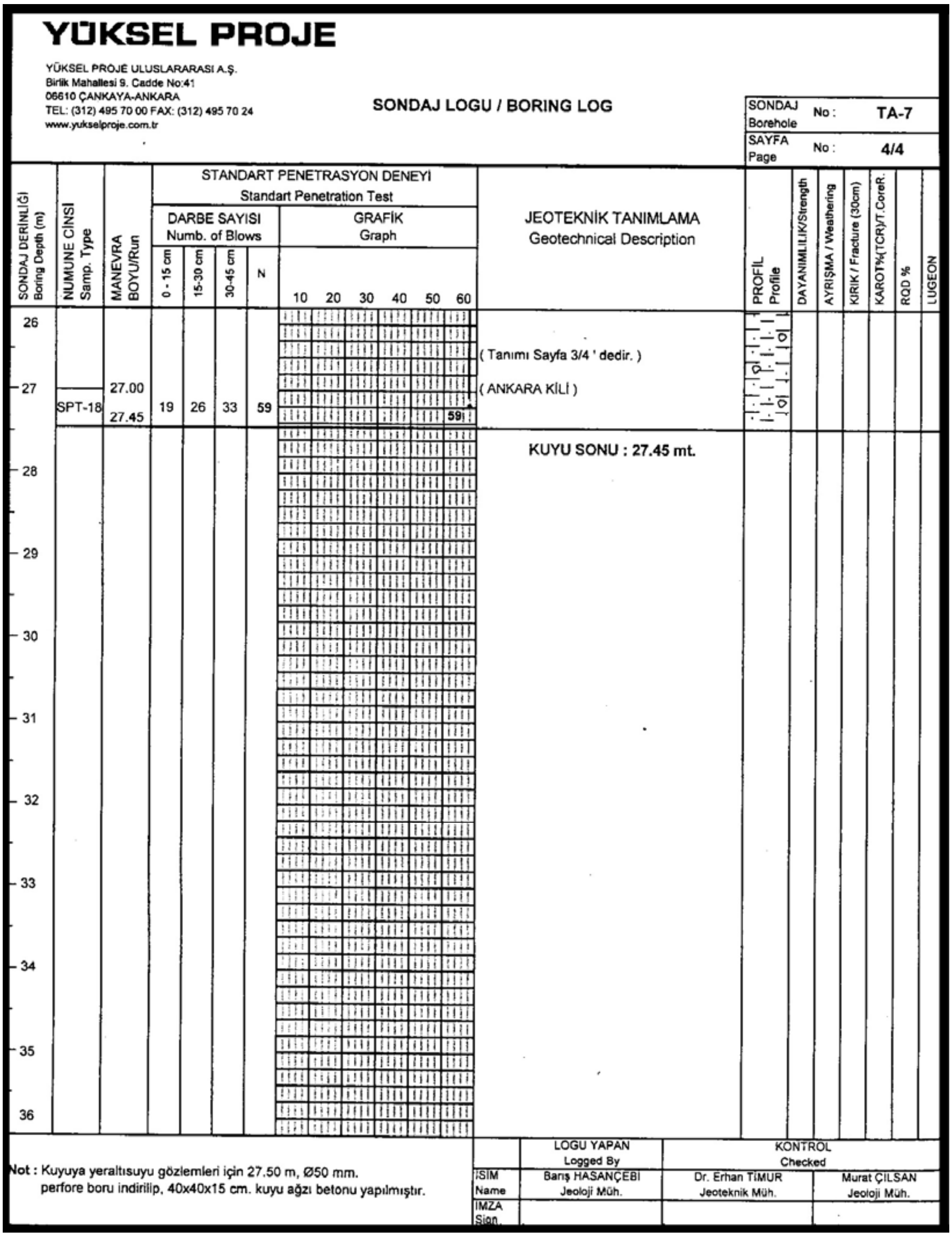
Birim yoğun olarak kireç konkresyonları içerir.

(ANKARA KİLİ)

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

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-7



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

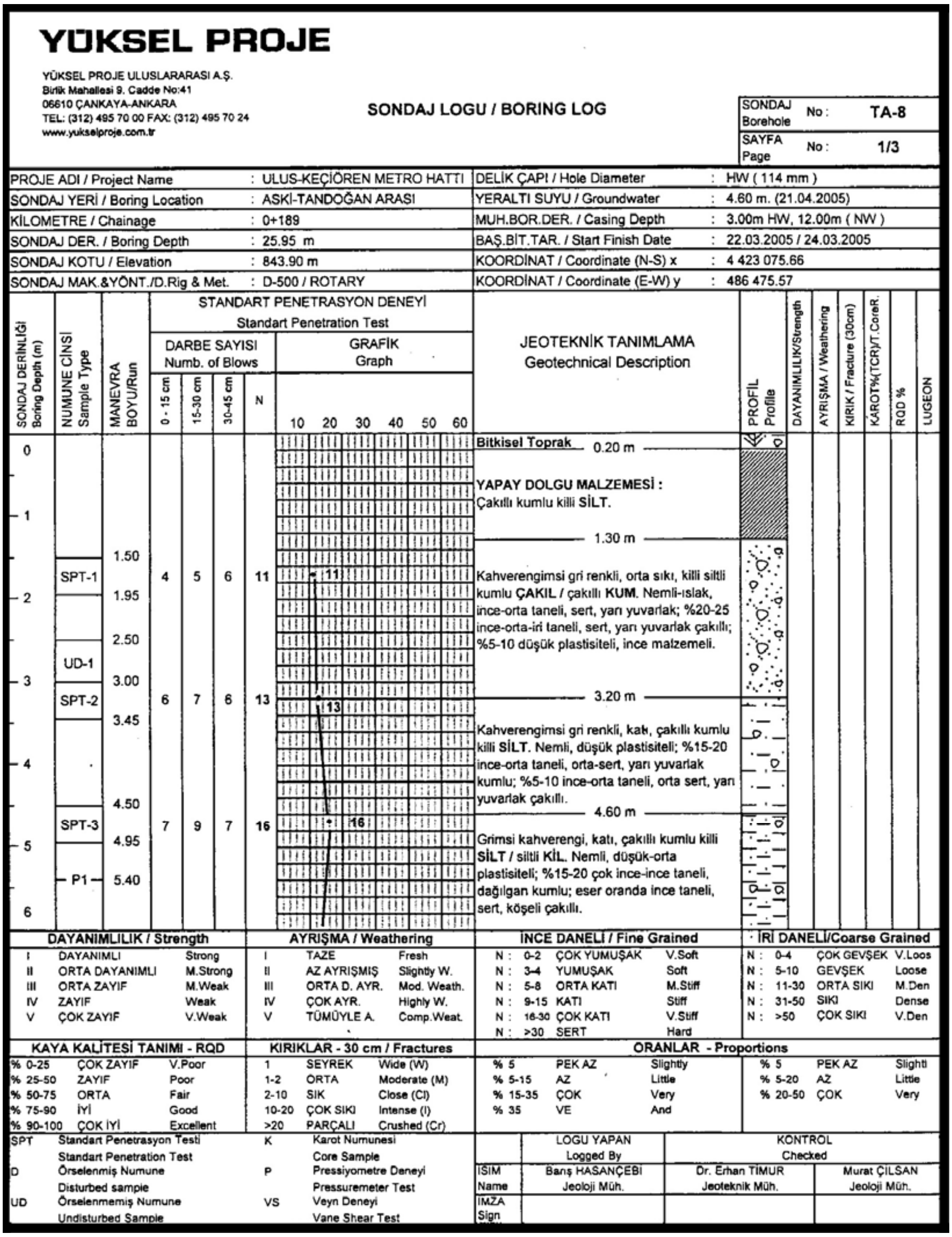
SONDAJ Borehole No : TA-7
SAYFA Page No : 4/4

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYI 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								(Tanımı Sayfa 3/4 ' dedir.)							
27	SPT-18	27.00 27.45	19	26	33	59	59	(ANKARA KİLİ)							
								KUYU SONU : 27.45 mt.							
28															
29															
30															
31															
32															
33															
34															
35															
36															

Not : Kuyuya yeraltısuyu gözlemleri için 27.50 m, Ø50 mm. perfore boru indirilip, 40x40x15 cm. kuyu ağzı betonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign.			

C.8. Borehole TA-8



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 :	TA-8
SAYFA Page	No :	1/3

PROJE ADI / Project Name	: ULUS-KEÇİÖREN METRO HATTI	DELİK ÇAPI / Hole Diameter	: HW (114 mm)
SONDAJ YERİ / Boring Location	: ASKİ-TANDOĞAN ARASI	YERALTI SUYU / Groundwater	: 4.60 m. (21.04.2005)
KİLOMETRE / Chainage	: 0+189	MUH.BOR.DER. / Casing Depth	: 3.00m HW, 12.00m (NW)
SONDAJ DER. / Boring Depth	: 25.95 m	BAŞ.BİT.TAR. / Start Finish Date	: 22.03.2005 / 24.03.2005
SONDAJ KOTU / Elevation	: 843.90 m	KOORDİNAT / Coordinate (N-S) x	: 4 423 075.66
SONDAJ MAK.&YÖNT./D.Rig & Met.	: D-500 / ROTARY	KOORDİNAT / Coordinate (E-W) y	: 486 475.57

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Sample Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test					JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
			DARBE SAYISI Numb. of Blows				GRAFİK Graph								
			0 - 15 cm	15-30 cm	30-45 cm	N	10 20 30 40 50 60								
0								**Bitkisel Toprak** 0.20 m							
								YAPAY DOLGU MALZEMESİ : Çakıllı kumlu killi **SİLT**.							
1								1.30 m							
		1.50													
	SPT-1		4	5	6	11	11	Kahverengimsi gri renkli, orta sıkı, killi siltli kumlu **ÇAKIL** / çakıllı **KUM**. Nemli-ıslak, ince-orta taneli, sert, yarı yuvarlak; %20-25 ince-orta-iri taneli, sert, yarı yuvarlak çakıllı; %5-10 düşük plastisiteli, ince malzemeli.							
2		1.95													
		2.50													
	UD-1														
3		3.00						3.20 m							
	SPT-2		6	7	6	13	13								
		3.45						Kahverengimsi gri renkli, katı, çakıllı kumlu killi **SİLT**. Nemli, düşük plastisiteli; %15-20 ince-orta taneli, orta-sert, yarı yuvarlak kumlu; %5-10 ince-orta taneli, orta sert, yarı yuvarlak çakıllı.							
4															
		4.50						4.60 m							
	SPT-3		7	9	7	16	16	Grimsi kahverengi, katı, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, düşük-orta plastisiteli; %15-20 çok ince-ince taneli, dağılgan kumlu; eser oranda ince taneli, sert, köşeli çakıllı.							
5		4.95													
	P1	5.40													
6															

DAYANIMLILIK / Strength		
I	DAYANIMLI	Strong
II	ORTA DAYANIMLI	M.Strong
III	ORTA ZAYIF	M.Weak
IV	ZAYIF	Weak
V	ÇOK ZAYIF	V.Weak

AYRIŞMA / Weathering		
I	TAZE	Fresh
II	AZ AYRIŞMIŞ	Slightly W.
III	ORTA D. AYR.	Mod. Weath.
IV	ÇOK AYR.	Highly W.
V	TÜMÜYLE A.	Comp.Weat.

İNCE DANELİ / Fine Grained			
N :	0-2	ÇOK YUMUŞAK	V.Soft
N :	3-4	YUMUŞAK	Soft
N :	5-8	ORTA KATI	M.Stiff
N :	9-15	KATI	Stiff
N :	16-30	ÇOK KATI	V.Stiff
N :	>30	SERT	Hard

İRİ DANELİ/Coarse Grained			
N :	0-4	ÇOK GEVŞEK	V.Loos
N :	5-10	GEVŞEK	Loose
N :	11-30	ORTA SIKI	M.Den
N :	31-50	SIKI	Dense
N :	>50	ÇOK SIKI	V.Den

KAYA KALİTESİ TANIMI - RQD		
% 0-25	ÇOK ZAYIF	V.Poor
% 25-50	ZAYIF	Poor
% 50-75	ORTA	Fair
% 75-90	İYİ	Good
% 90-100	ÇOK İYİ	Excellent

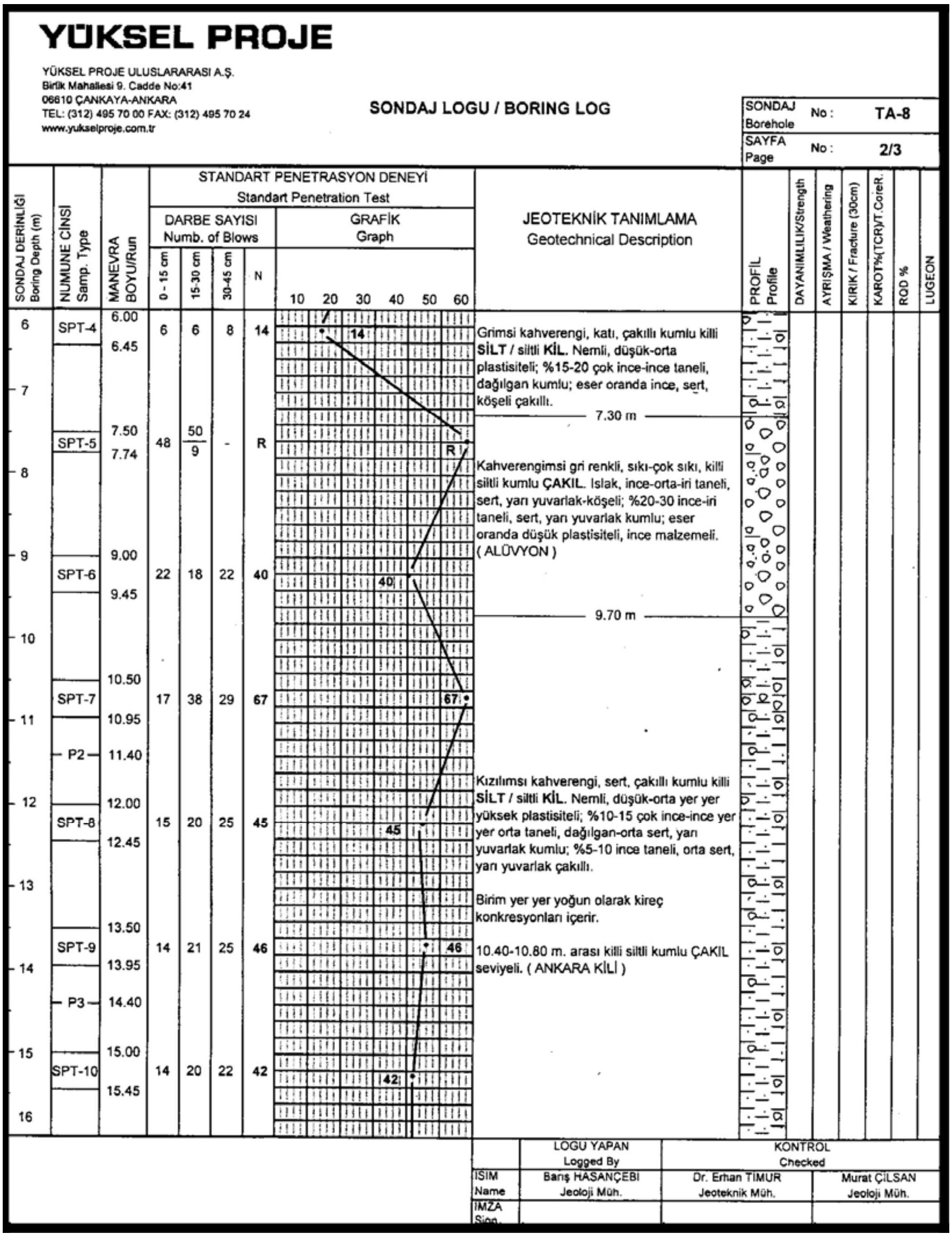
KIRIKLAR - 30 cm / Fractures		
1	SEYREK	Wide (W)
1-2	ORTA	Moderate (M)
2-10	SIK	Close (Cl)
10-20	ÇOK SIKI	Intense (I)
>20	PARÇALI	Crushed (Cr)

ORANLAR - Proportions					
% 5	PEK AZ	Slightly	% 5	PEK AZ	Slighti
% 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	Örselenmiş Numune Disturbed sample	P	Pressiyometre Deneyi Pressuremeter Test
UD	Örselenmemiş Numune Undisturbed Sample	VS	Veyn Deneyi Vane Shear Test

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇİLSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-8



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 : TA-8
SAYFA Page No : 2/3

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
SPT-4	6.00 6.45	6	6	8	14
SPT-5	7.50 7.74	48	50/9	-	R
SPT-6	9.00 9.45	22	18	22	40
SPT-7	10.50 10.95	17	38	29	67
P2	11.40				
SPT-8	12.00 12.45	15	20	25	45
SPT-9	13.50 13.95	14	21	25	46
P3	14.40				
SPT-10	15.00 15.45	14	20	22	42

JEOTEKNİK TANIMLAMA
Geotechnical Description

Grimsi kahverengi, katı, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, düşük-orta plastisiteli; %15-20 çok ince-ince taneli, dağılgan kumlu; eser oranda ince, sert, köşeli çakıllı.

7.30 m

Kahverengimsi gri renkli, sıkı-çok sıkı, killi siltli kumlu **ÇAKIL**. Islak, ince-orta-iri taneli, sert, yarı yuvarlak-köşeli; %20-30 ince-iri taneli, sert, yarı yuvarlak kumlu; eser oranda düşük plastisiteli, ince malzemeli. (ALÜVYON)

9.70 m

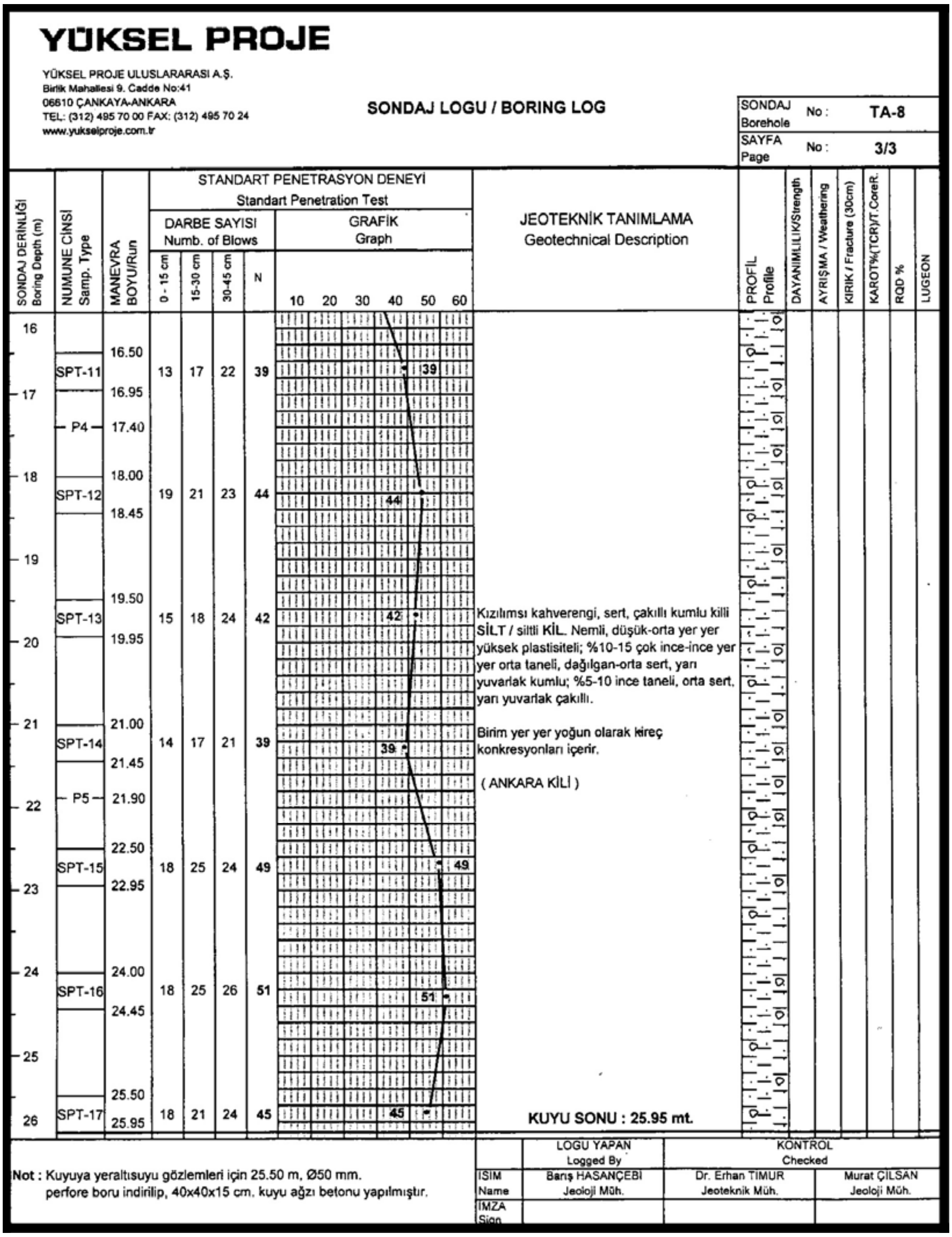
Kızılımsı kahverengi, sert, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, düşük-orta yer yer yüksek plastisiteli; %10-15 çok ince-ince yer yer orta taneli, dağılgan-orta sert, yarı yuvarlak kumlu; %5-10 ince taneli, orta sert, yarı yuvarlak çakıllı.

Birim yer yer yoğun olarak kireç konkresyonları içerir.

10.40-10.80 m. arası killi siltli kumlu ÇAKIL seviyeli. (ANKARA KİLİ)

	LOGU YAPAN Logged By	KONTROL Checked	
ISIM Name	Barış HASANÇEBI Jeoloji Müh.	Dr. Erhan TIMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
IMZA Sign.			

Continuation of Borehole TA-8



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 : **TA-8**
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
16						
17	SPT-11	16.50 16.95	13	17	22	39
	P4	17.40				
18	SPT-12	18.00 18.45	19	21	23	44
19						
20	SPT-13	19.50 19.95	15	18	24	42
21	SPT-14	21.00 21.45	14	17	21	39
22	P5	21.90				
23	SPT-15	22.50 22.95	18	25	24	49
24	SPT-16	24.00 24.45	18	25	26	51
25						
26	SPT-17	25.50 25.95	18	21	24	45

JEOTEKNİK TANIMLAMA
Geotechnical Description

Kızılımsı kahverengi, sert, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, düşük-orta yer yer yüksek plastisiteli; %10-15 çok ince-ince yer yer orta taneli, dağılgan-orta sert, yarı yuvarlak kumlu; %5-10 ince taneli, orta sert, yarı yuvarlak çakıllı.

Birim yer yer yoğun olarak kireç konkresyonları içerir.

(ANKARA KİLİ)

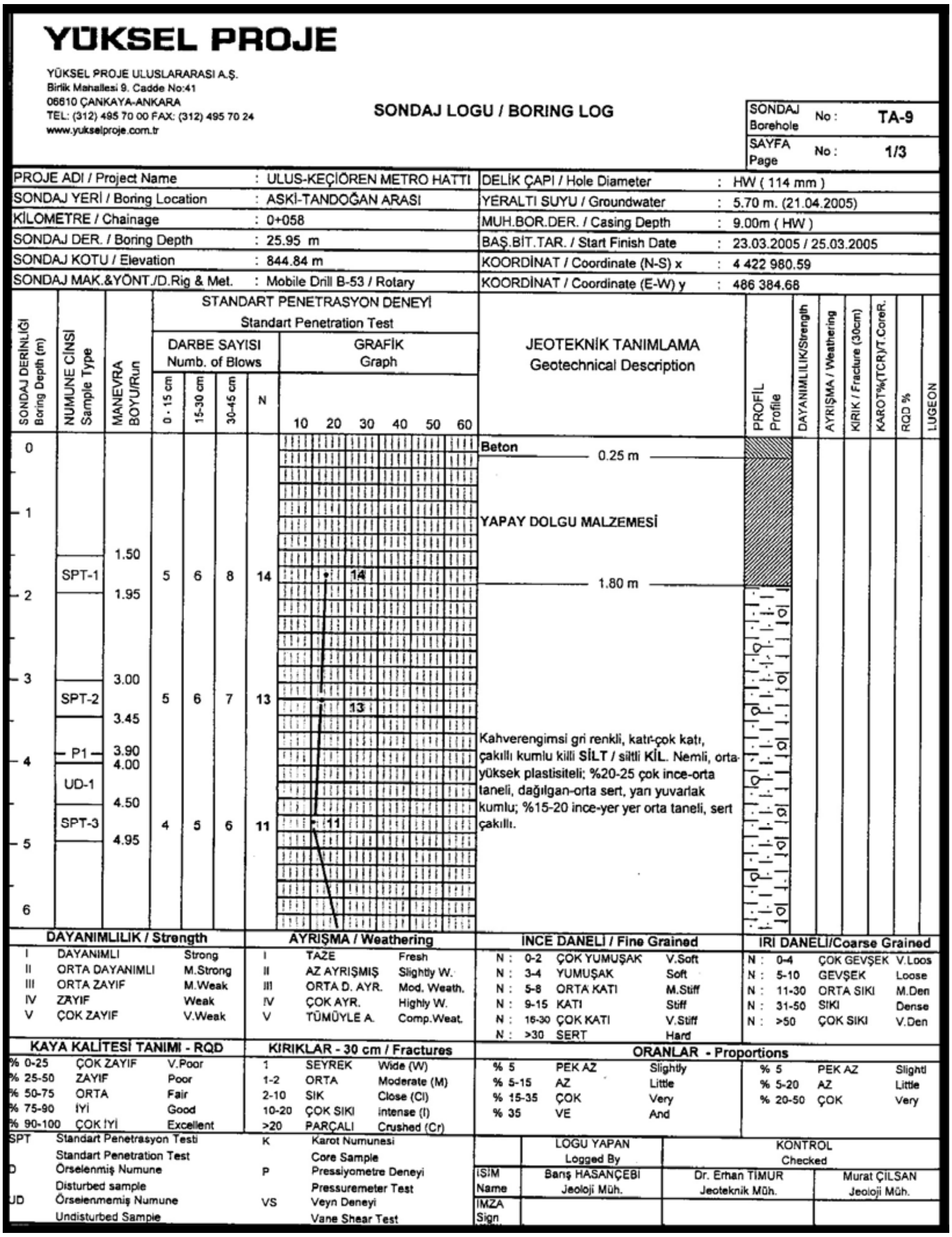
KUYU SONU : 25.95 mt.

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

Not : Kuyuya yeraltısuyu gözlemleri için 25.50 m, Ø50 mm. perfore boru indirilip, 40x40x15 cm. kuyu ağzı betonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TIMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign			

C.9. Borehole TA-9



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 :	TA-9
SAYFA Page	No :	1/3

PROJE ADI / Project Name	: ULUS-KEÇİÖREN METRO HATTI	DELİK ÇAPI / Hole Diameter	: HW (114 mm)
SONDAJ YERİ / Boring Location	: ASKİ-TANDOĞAN ARASI	YERALTI SUYU / Groundwater	: 5.70 m. (21.04.2005)
KİLOMETRE / Chainage	: 0+058	MUH.BOR.DER. / Casing Depth	: 9.00m (HW)
SONDAJ DER. / Boring Depth	: 25.95 m	BAŞ.BİT.TAR. / Start Finish Date	: 23.03.2005 / 25.03.2005
SONDAJ KOTU / Elevation	: 844.84 m	KOORDİNAT / Coordinate (N-S) x	: 4 422 980.59
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Mobile Drill B-53 / Rotary	KOORDİNAT / Coordinate (E-W) y	: 486 384.68

STANDART PENETRASYON DENEYİ / Standart Penetration Test

NUMUNE CİNSİ Sample Type	MANEVRA BOYU/Run	DARBE SAYISI Numb. of Blows 0 - 15 cm	15-30 cm	30-45 cm	N
	1.50				
SPT-1		5	6	8	14
	1.95				
	3.00				
SPT-2		5	6	7	13
	3.45				
P1	3.90				
	4.00				
UD-1					
	4.50				
SPT-3		4	5	6	11
	4.95				

SONDAJ DERİNLİĞİ Boring Depth (m): 0, 1, 2, 3, 4, 5, 6

GRAFİK Graph: 10 20 30 40 50 60

JEOTEKNİK TANIMLAMA / Geotechnical Description

Beton 0.25 m

YAPAY DOLGU MALZEMESİ

1.80 m

Kahverengimsi gri renkli, katı-çok katı, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, orta-yüksek plastisiteli; %20-25 çok ince-orta taneli, dağılgan-orta sert, yarı yuvarlak kumlu; %15-20 ince-yer yer orta taneli, sert çakıllı.

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

DAYANIMLILIK / Strength

I	DAYANIMLI	Strong
II	ORTA DAYANIMLI	M.Strong
III	ORTA ZAYIF	M.Weak
IV	ZAYIF	Weak
V	ÇOK ZAYIF	V.Weak

AYRIŞMA / Weathering

I	TAZE	Fresh
II	AZ AYRIŞMIŞ	Slightly W.
III	ORTA D. AYR.	Mod. Weath.
IV	ÇOK AYR.	Highly W.
V	TÜMÜYLE A.	Comp.Weat.

İNCE DANELİ / Fine Grained

N :	0-2	ÇOK YUMUŞAK	V.Soft
N :	3-4	YUMUŞAK	Soft
N :	5-8	ORTA KATI	M.Stiff
N :	9-15	KATI	Stiff
N :	16-30	ÇOK KATI	V.Stiff
N :	>30	SERT	Hard

IRI DANELİ/Coarse Grained

N :	0-4	ÇOK GEVŞEK	V.Loos
N :	5-10	GEVŞEK	Loose
N :	11-30	ORTA SIKI	M.Den
N :	31-50	SIKI	Dense
N :	>50	ÇOK SIKI	V.Den

KAYA KALİTESİ TANIMI - RQD

% 0-25	ÇOK ZAYIF	V.Poor
% 25-50	ZAYIF	Poor
% 50-75	ORTA	Fair
% 75-90	İYİ	Good
% 90-100	ÇOK İYİ	Excellent

KIRIKLAR - 30 cm / Fractures

1	SEYREK	Wide (W)
1-2	ORTA	Moderate (M)
2-10	SIK	Close (Cl)
10-20	ÇOK SIKI	intense (I)
>20	PARÇALI	Crushed (Cr)

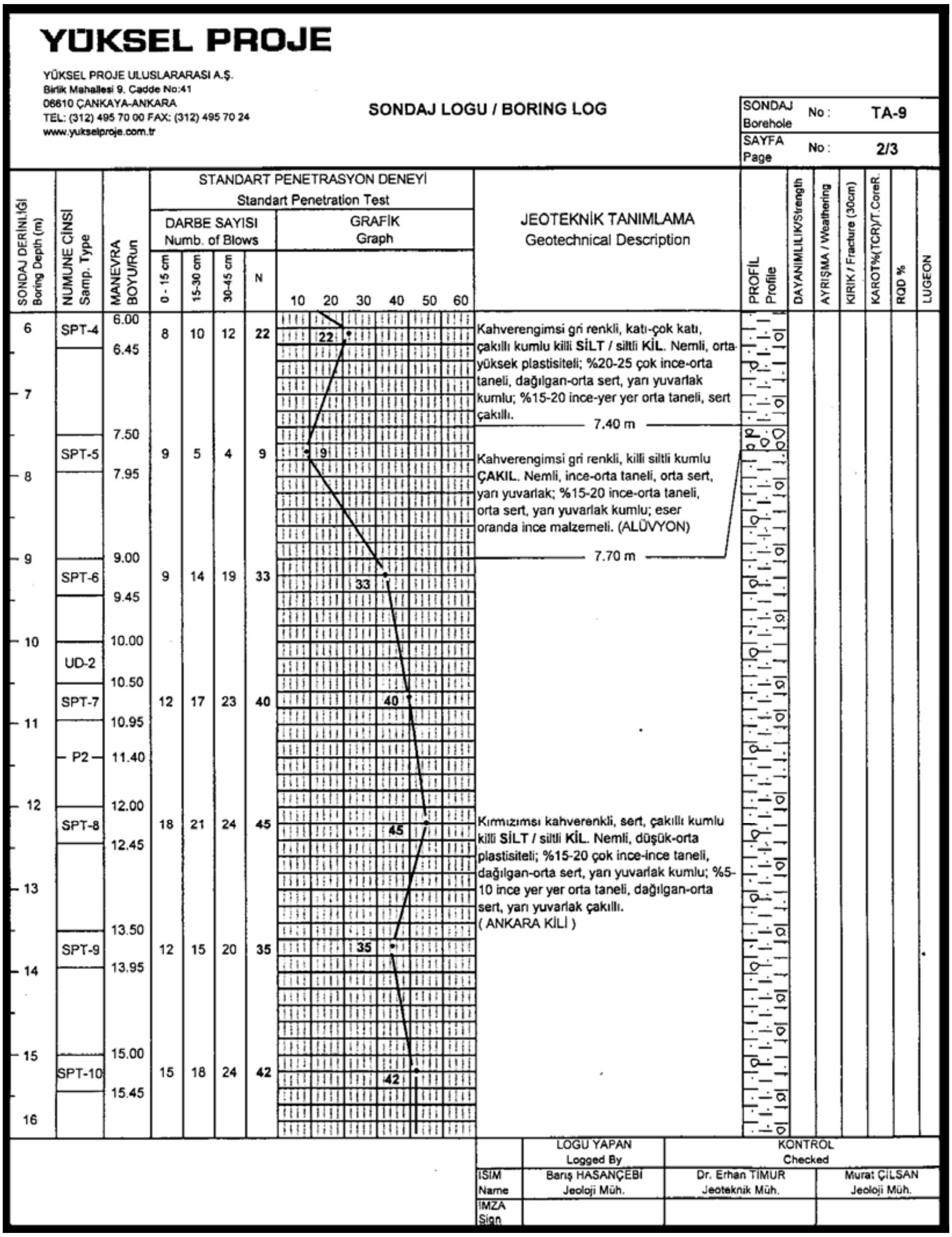
ORANLAR - Proportions

% 5	PEK AZ	Slightly	% 5	PEK AZ	Slightl
% 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
D	Örselenmiş Numune Disturbed sample
UD	Örselenmemiş Numune Undisturbed Sample
K	Karot Numunesi Core Sample
P	Pressiyometre Deneyi Pressuremeter Test
VS	Veyn Deneyi Vane Shear Test

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-9



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 : TA-9
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
6	SPT-4	6.00 6.45	8	10	12	22
7						
	SPT-5	7.50 7.95	9	5	4	9
8						
9	SPT-6	9.00 9.45	9	14	19	33
10	UD-2	10.00 10.50				
	SPT-7	10.50 10.95	12	17	23	40
11	P2	11.40				
12	SPT-8	12.00 12.45	18	21	24	45
13						
	SPT-9	13.50 13.95	12	15	20	35
14						
15	SPT-10	15.00 15.45	15	18	24	42
16						

JEOTEKNİK TANIMLAMA
Geotechnical Description

Kahverengimsi gri renkli, katı-çok katı, çakıllı kumlu killi **SİLT / siltli KİL**. Nemli, orta-yüksek plastisiteli; %20-25 çok ince-orta taneli, dağılgan-orta sert, yarı yuvarlak kumlu; %15-20 ince-yer yer orta taneli, sert çakıllı.

7.40 m

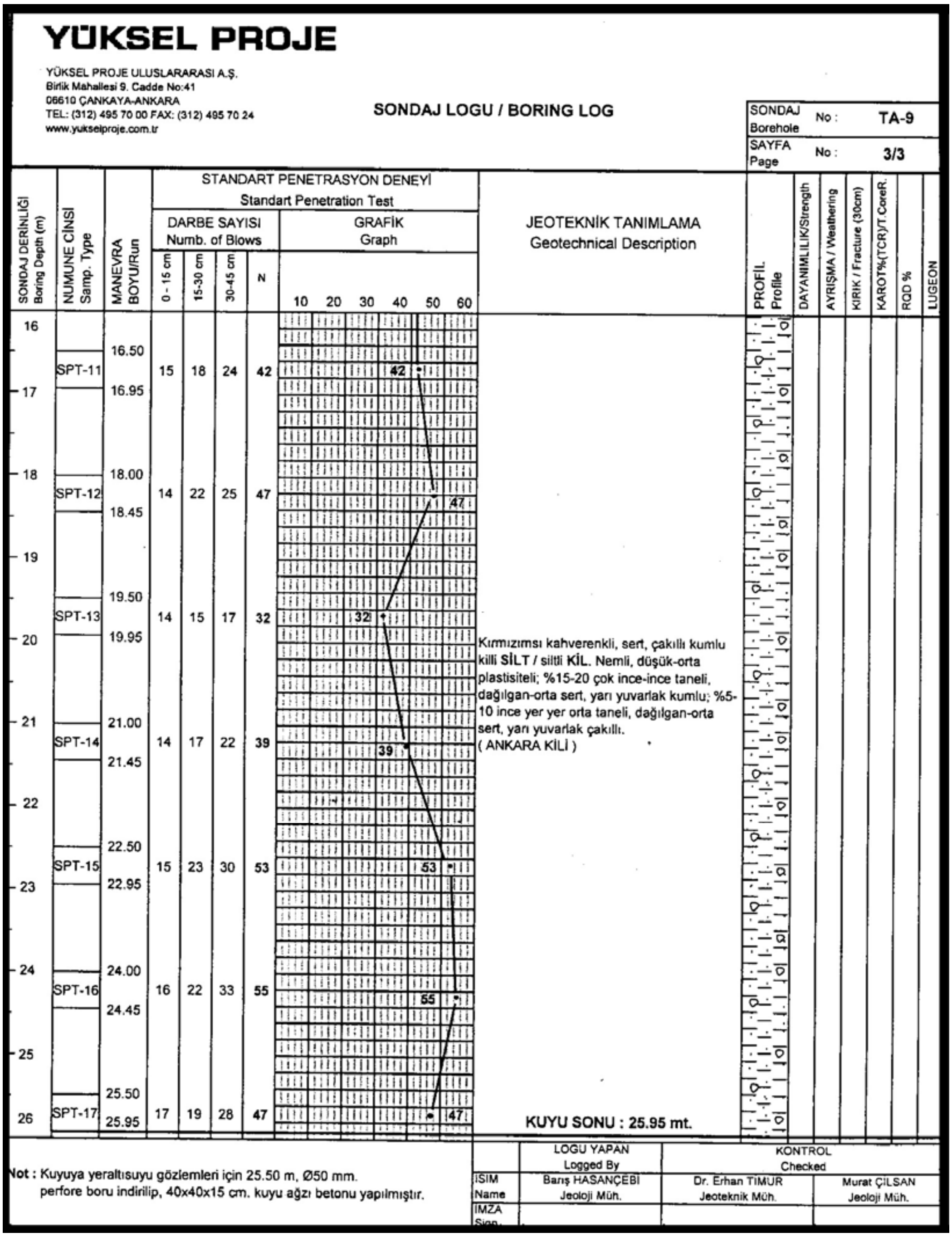
Kahverengimsi gri renkli, killi siltli kumlu **ÇAKIL**. Nemli, ince-orta taneli, orta sert, yarı yuvarlak; %15-20 ince-orta taneli, orta sert, yarı yuvarlak kumlu; eser oranda ince malzemeli. (ALÜVYON)

7.70 m

Kırmızımsı kahverenkli, sert, çakıllı kumlu killi **SİLT / siltli KİL**. Nemli, düşük-orta plastisiteli; %15-20 çok ince-ince taneli, dağılgan-orta sert, yarı yuvarlak kumlu; %5-10 ince yer yer orta taneli, dağılgan-orta sert, yarı yuvarlak çakıllı.
(ANKARA KİLİ)

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇİLSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-9



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 : **TA-9**
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
16						
	SPT-11	16.50 16.95	15	18	24	42
17						
18	SPT-12	18.00 18.45	14	22	25	47
19						
	SPT-13	19.50 19.95	14	15	17	32
20						
21	SPT-14	21.00 21.45	14	17	22	39
22						
	SPT-15	22.50 22.95	15	23	30	53
23						
24	SPT-16	24.00 24.45	16	22	33	55
25						
26	SPT-17	25.50 25.95	17	19	28	47

JEOTEKNİK TANIMLAMA
Geotechnical Description

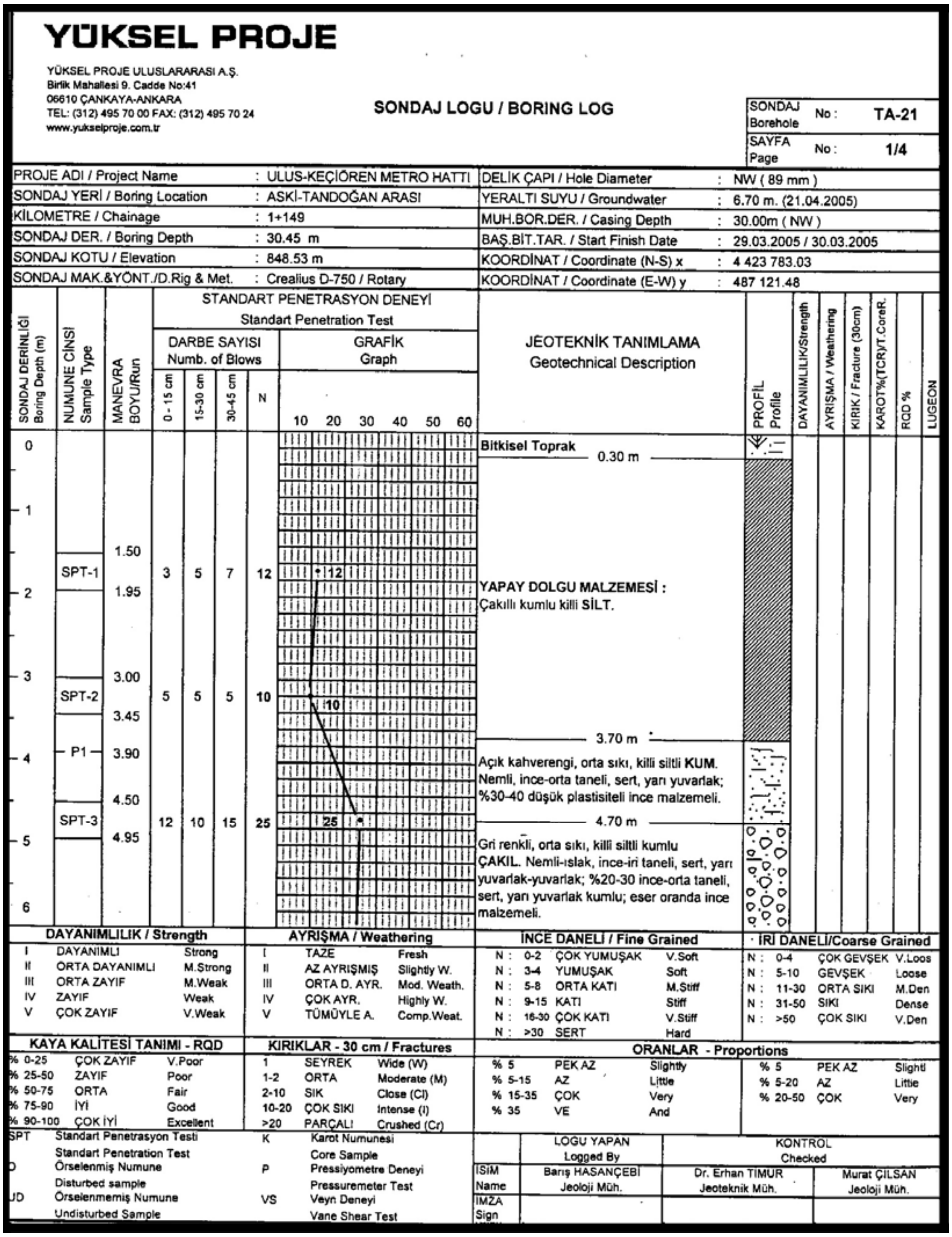
Kırmızımsı kahverenkli, sert, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, düşük-orta plastisiteli; %15-20 çok ince-ince taneli, dağılgan-orta sert, yarı yuvarlak kumlu; %5-10 ince yer yer orta taneli, dağılgan-orta sert, yarı yuvarlak çakıllı.
(ANKARA KİLİ)

KUYU SONU : 25.95 mt.

Not : Kuyuya yeraltısuyu gözlemleri için 25.50 m, Ø50 mm. perfore boru indirilip, 40x40x15 cm. kuyu ağzı betonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked	
İSIM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TIMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
IMZA Sign.			

C.10. Borehole TA-21



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 : **TA-21**
SAYFA Page No : **1/4**

PROJE ADI / Project Name	: ULUS-KEÇİÖREN METRO HATTI	DELİK ÇAPI / Hole Diameter	: NW (89 mm)
SONDAJ YERİ / Boring Location	: ASKİ-TANDOĞAN ARASI	YERALTI SUYU / Groundwater	: 6.70 m. (21.04.2005)
KİLOMETRE / Chainage	: 1+149	MUH.BOR.DER. / Casing Depth	: 30.00m (NW)
SONDAJ DER. / Boring Depth	: 30.45 m	BAŞ.BİT.TAR. / Start Finish Date	: 29.03.2005 / 30.03.2005
SONDAJ KOTU / Elevation	: 848.53 m	KOORDİNAT / Coordinate (N-S) x	: 4 423 783.03
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Crealius D-750 / Rotary	KOORDİNAT / Coordinate (E-W) y	: 487 121.48

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
0							**Bitkisel Toprak**
0.30 m							**YAPAY DOLGU MALZEMESİ :** Çakıllı kumlu killi **SİLT**.
1.50	SPT-1	1.50 – 1.95	3	5	7	12	
3.00	SPT-2	3.00 – 3.45	5	5	5	10	
3.70 m							Açık kahverengi, orta sıkı, killi siltli **KUM**. Nemli, ince-orta taneli, sert, yarı yuvarlak; %30-40 düşük plastisiteli ince malzemeli.
3.90	P1	3.45 – 3.90					
4.50	SPT-3	4.50 – 4.95	12	10	15	25	
4.70 m							Gri renkli, orta sıkı, killi siltli kumlu **ÇAKIL**. Nemli-ıslak, ince-iri taneli, sert, yarı yuvarlak-yuvarlak; %20-30 ince-orta taneli, sert, yarı yuvarlak kumlu; eser oranda ince malzemeli.

DAYANIMLILIK / Strength

I	DAYANIMLI	Strong
II	ORTA DAYANIMLI	M.Strong
III	ORTA ZAYIF	M.Weak
IV	ZAYIF	Weak
V	ÇOK ZAYIF	V.Weak

AYRIŞMA / Weathering

I	TAZE	Fresh
II	AZ AYRIŞMIŞ	Slightly W.
III	ORTA D. AYR.	Mod. Weath.
IV	ÇOK AYR.	Highly W.
V	TÜMÜYLE A.	Comp.Weat.

İNCE DANELİ / Fine Grained

N :	0-2	ÇOK YUMUŞAK	V.Soft
N :	3-4	YUMUŞAK	Soft
N :	5-8	ORTA KATI	M.Stiff
N :	9-15	KATI	Stiff
N :	16-30	ÇOK KATI	V.Stiff
N :	>30	SERT	Hard

İRİ DANELİ/Coarse Grained

N :	0-4	ÇOK GEVŞEK	V.Loos
N :	5-10	GEVŞEK	Loose
N :	11-30	ORTA SIKI	M.Den
N :	31-50	SIKI	Dense
N :	>50	ÇOK SIKI	V.Den

KAYA KALİTESİ TANIMI - RQD

% 0-25	ÇOK ZAYIF	V.Poor
% 25-50	ZAYIF	Poor
% 50-75	ORTA	Fair
% 75-90	İYİ	Good
% 90-100	ÇOK İYİ	Excellent

KIRIKLAR - 30 cm / Fractures

1	SEYREK	Wide (W)
1-2	ORTA	Moderate (M)
2-10	SIK	Close (Cl)
10-20	ÇOK SIKI	Intense (I)
>20	PARÇALI	Crushed (Cr)

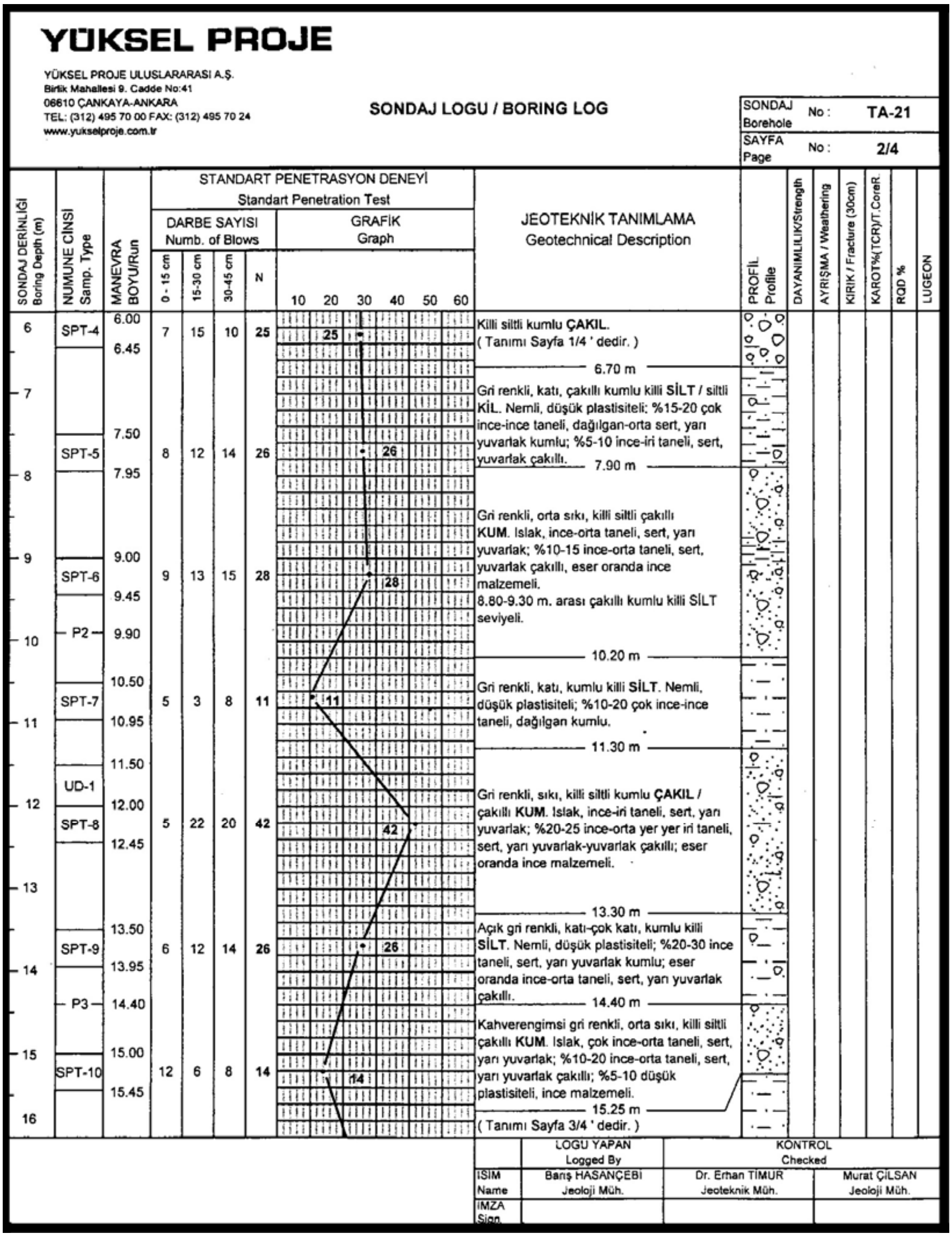
ORANLAR - Proportions

% 5	PEK AZ	Slightly	% 5	PEK AZ	Slightl
% 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	Örselenmiş Numune Disturbed sample	P	Pressiyometre Deneyi Pressuremeter Test
UD	Örselenmemiş Numune Undisturbed Sample	VS	Veyn Deneyi Vane Shear Test

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TIMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-21



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 : TA-21
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
6	SPT-4	6.00 6.45	7	15	10	25
7						
	SPT-5	7.50 7.95	8	12	14	26
8						
9	SPT-6	9.00 9.45	9	13	15	28
	P2	9.90				
10						
	SPT-7	10.50 10.95	5	3	8	11
11						
	UD-1	11.50 12.00				
12	SPT-8	12.00 12.45	5	22	20	42
13						
	SPT-9	13.50 13.95	6	12	14	26
14						
	P3	14.40				
15	SPT-10	15.00 15.45	12	6	8	14
16						

JEOTEKNİK TANIMLAMA
Geotechnical Description

Killi siltli kumlu **ÇAKIL**.
(Tanımı Sayfa 1/4 ' dedir.)

6.70 m

Gri renkli, katı, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, düşük plastisiteli; %15-20 çok ince-ince taneli, dağılgan-orta sert, yarı yuvarlak kumlu; %5-10 ince-iri taneli, sert, yuvarlak çakıllı.

7.90 m

Gri renkli, orta sıkı, killi siltli çakıllı **KUM**. Islak, ince-orta taneli, sert, yarı yuvarlak; %10-15 ince-orta taneli, sert, yuvarlak çakıllı, eser oranda ince malzemeli.
8.80-9.30 m. arası çakıllı kumlu killi SİLT seviyeli.

10.20 m

Gri renkli, katı, kumlu killi **SİLT**. Nemli, düşük plastisiteli; %10-20 çok ince-ince taneli, dağılgan kumlu.

11.30 m

Gri renkli, sıkı, killi siltli kumlu **ÇAKIL** / çakıllı **KUM**. Islak, ince-iri taneli, sert, yarı yuvarlak; %20-25 ince-orta yer yer iri taneli, sert, yarı yuvarlak-yuvarlak çakıllı; eser oranda ince malzemeli.

13.30 m

Açık gri renkli, katı-çok katı, kumlu killi **SİLT**. Nemli, düşük plastisiteli; %20-30 ince taneli, sert, yarı yuvarlak kumlu; eser oranda ince-orta taneli, sert, yarı yuvarlak çakıllı.

14.40 m

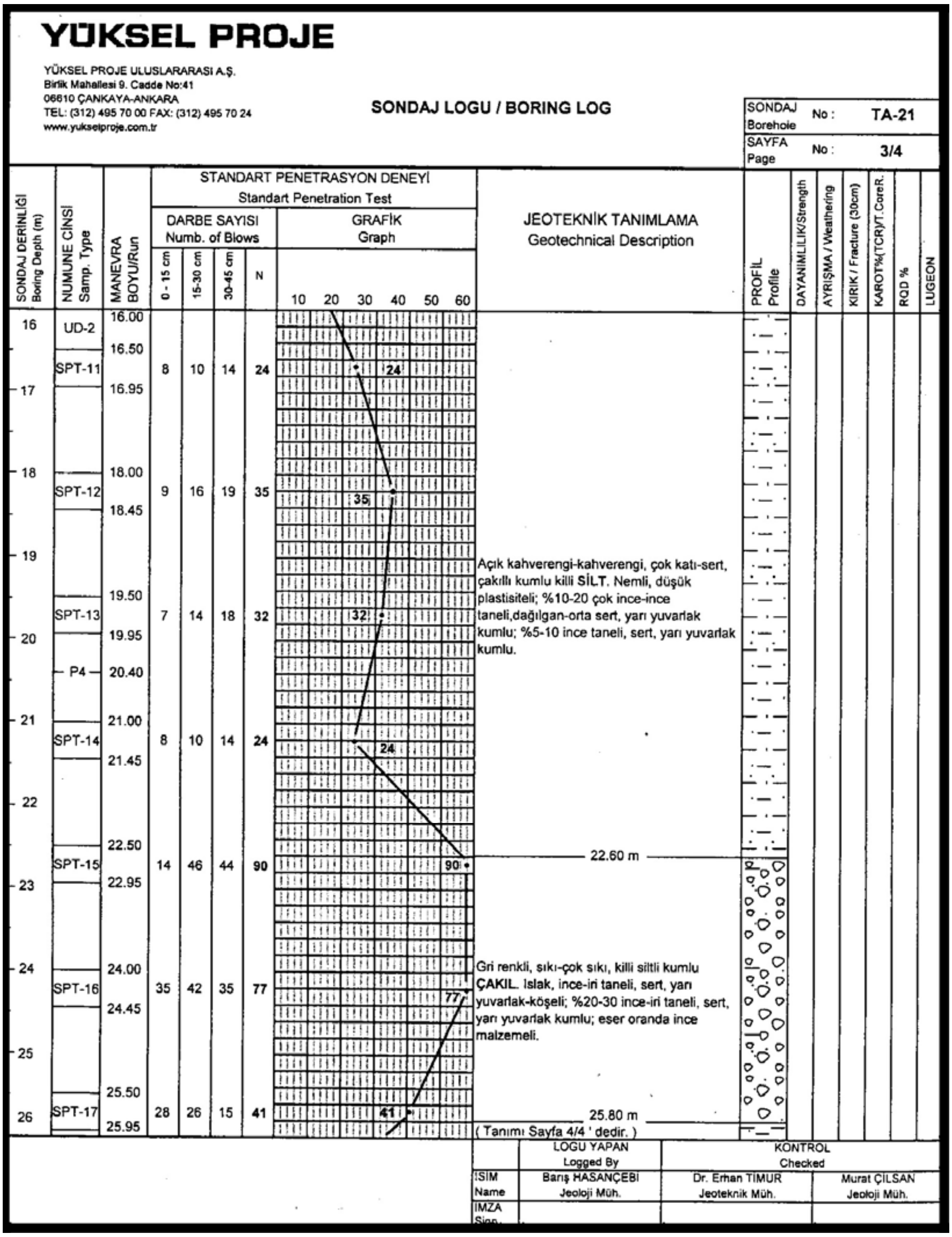
Kahverengimsi gri renkli, orta sıkı, killi siltli çakıllı **KUM**. Islak, çok ince-orta taneli, sert, yarı yuvarlak; %10-20 ince-orta taneli, sert, yarı yuvarlak çakıllı; %5-10 düşük plastisiteli, ince malzemeli.

15.25 m

(Tanımı Sayfa 3/4 ' dedir.)

	LOGU YAPAN Logged By	KONTROL Checked	
ISIM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇİLSAN Jeoloji Müh.
IMZA Sign.			

Continuation of Borehole TA-21



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

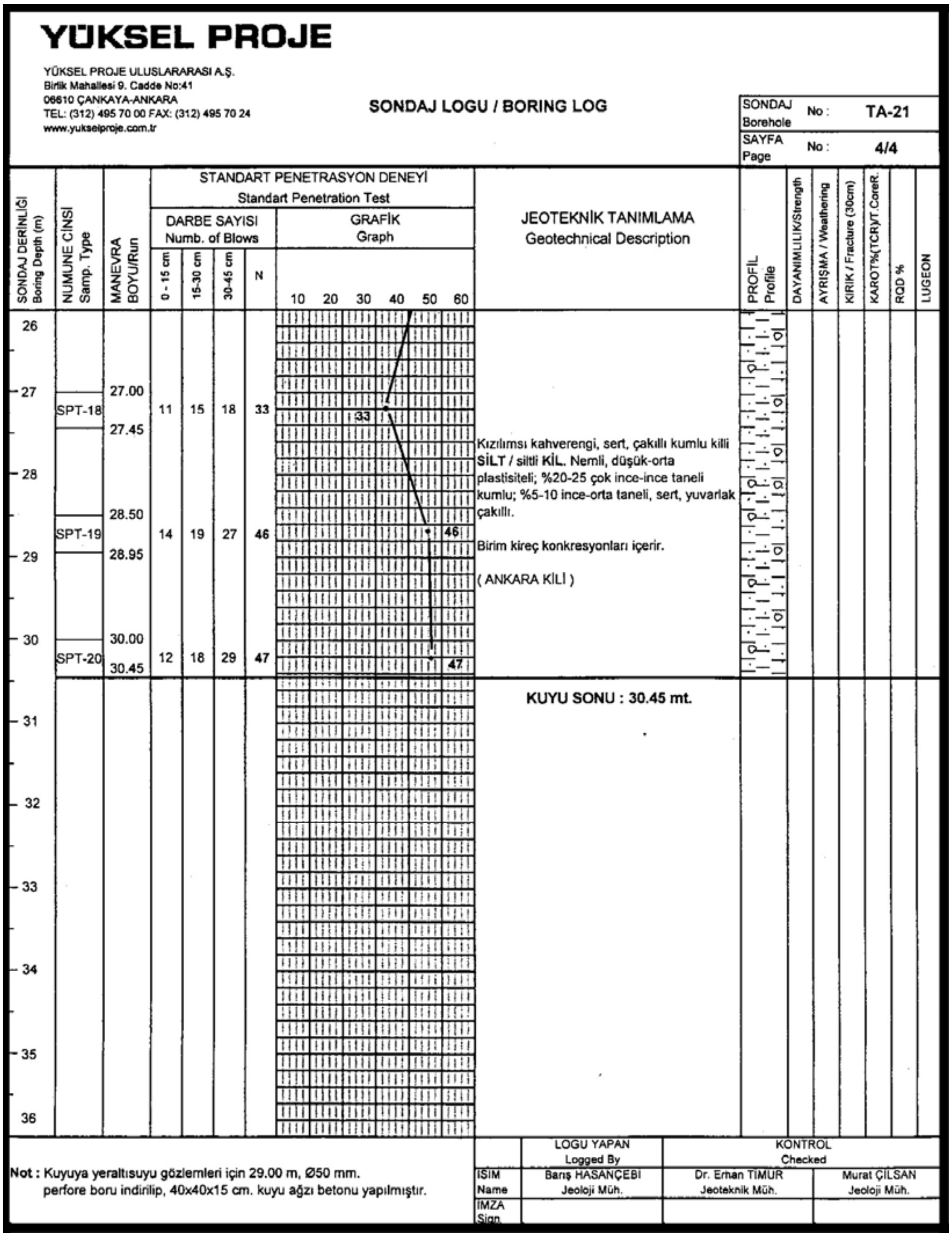
SONDAJ LOGU / BORING LOG

SONDAJ Borehole	No :	TA-21
SAYFA Page	No :	3/4

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	JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
16	UD-2	16.00													
		16.50													
	SPT-11		8	10	14	24									
17		16.95													
18		18.00													
	SPT-12		9	16	19	35									
		18.45													
19								Açık kahverengi-kahverengi, çok katı-sert, çakıllı kumlu killi **SİLT**. Nemli, düşük plastisiteli; %10-20 çok ince-ince taneli,dağılgan-orta sert, yarı yuvarlak kumlu; %5-10 ince taneli, sert, yarı yuvarlak kumlu.							
		19.50													
	SPT-13		7	14	18	32									
20		19.95													
	P4	20.40													
21		21.00													
	SPT-14		8	10	14	24									
		21.45													
22															
		22.50						22.60 m							
	SPT-15		14	46	44	90									
23		22.95													
24		24.00						Gri renkli, sıkı-çok sıkı, killi siltli kumlu **ÇAKIL**. Islak, ince-iri taneli, sert, yarı yuvarlak-köşeli; %20-30 ince-iri taneli, sert, yarı yuvarlak kumlu; eser oranda ince malzemeli.							
	SPT-16		35	42	35	77									
		24.45													
25															
		25.50													
26	SPT-17		28	26	15	41		25.80 m							
		25.95						(Tanımı Sayfa 4/4 ' dedir.)							

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign.			

Continuation of Borehole TA-21



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 : TA-21
SAYFA Page No : 4/4

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
SPT-18	27.00 27.45	11	15	18	33
SPT-19	28.50 28.95	14	19	27	46
SPT-20	30.00 30.45	12	18	29	47

JEOTEKNİK TANIMLAMA
Geotechnical Description

Kızılımsı kahverengi, sert, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, düşük-orta plastisiteli; %20-25 çok ince-ince taneli kumlu; %5-10 ince-orta taneli, sert, yuvarlak çakıllı.

Birim kireç konkresyonları içerir.

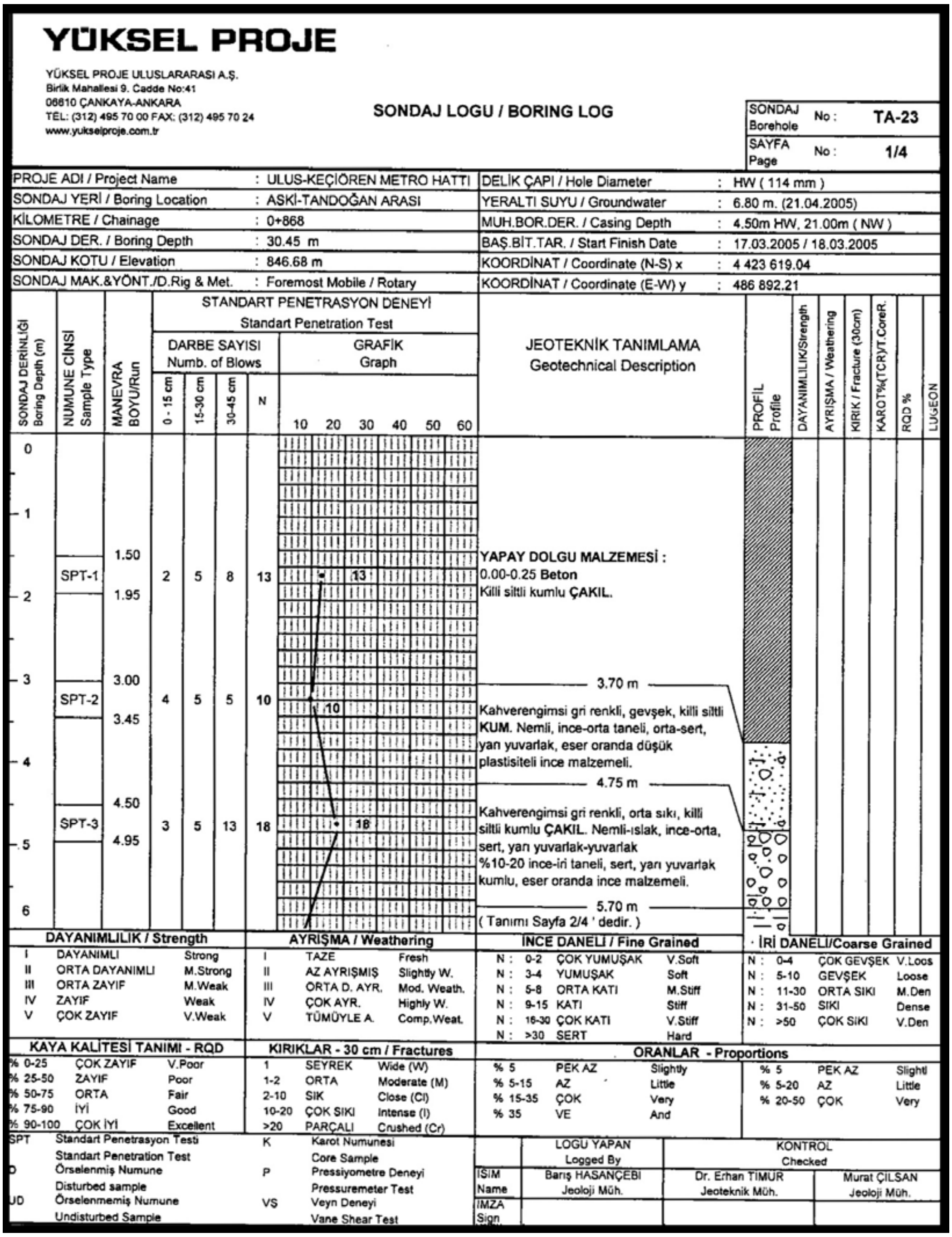
(ANKARA KİLİ)

KUYU SONU : 30.45 mt.

Not : Kuyuya yeraltısuyu gözlemleri için 29.00 m, Ø50 mm. perfore boru indirilip, 40x40x15 cm. kuyu ağzı betonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇİLSAN Jeoloji Müh.
İMZA Sign.			

C.11. Borehole TA-23



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 :	TA-23
SAYFA Page	No :	1/4

PROJE ADI / Project Name	: ULUS-KEÇİÖREN METRO HATTI	DELİK ÇAPI / Hole Diameter	: HW (114 mm)
SONDAJ YERİ / Boring Location	: ASKİ-TANDOĞAN ARASI	YERALTI SUYU / Groundwater	: 6.80 m. (21.04.2005)
KİLOMETRE / Chainage	: 0+868	MUH.BOR.DER. / Casing Depth	: 4.50m HW, 21.00m (NW)
SONDAJ DER. / Boring Depth	: 30.45 m	BAŞ.BİT.TAR. / Start Finish Date	: 17.03.2005 / 18.03.2005
SONDAJ KOTU / Elevation	: 846.68 m	KOORDİNAT / Coordinate (N-S) x	: 4 423 619.04
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Foremost Mobile / Rotary	KOORDİNAT / Coordinate (E-W) y	: 486 892.21

STANDART PENETRASYON DENEYİ
Standart Penetration Test

NUMUNE CİNSİ Sample Type	MANEVRA BOYU/Run	DARBE SAYISI Numb. of Blows 0 - 15 cm	15-30 cm	30-45 cm	N
SPT-1	1.50 1.95	2	5	8	13
SPT-2	3.00 3.45	4	5	5	10
SPT-3	4.50 4.95	3	5	13	18

JEOTEKNİK TANIMLAMA
Geotechnical Description

YAPAY DOLGU MALZEMESİ :
0.00-0.25 **Beton**
Killi siltli kumlu **ÇAKIL.**

3.70 m

Kahverengimsi gri renkli, gevşek, killi siltli **KUM.** Nemli, ince-orta taneli, orta-sert, yarı yuvarlak, eser oranda düşük plastisiteli ince malzemeli.

4.75 m

Kahverengimsi gri renkli, orta sıkı, killi siltli kumlu **ÇAKIL.** Nemli-ıslak, ince-orta, sert, yarı yuvarlak-yuvarlak %10-20 ince-iri taneli, sert, yarı yuvarlak kumlu, eser oranda ince malzemeli.

5.70 m

(Tanımı Sayfa 2/4 ' dedir.)

DAYANIMLILIK / Strength

I	DAYANIMLI	Strong
II	ORTA DAYANIMLI	M.Strong
III	ORTA ZAYIF	M.Weak
IV	ZAYIF	Weak
V	ÇOK ZAYIF	V.Weak

AYRIŞMA / Weathering

I	TAZE	Fresh
II	AZ AYRIŞMIŞ	Slightly W.
III	ORTA D. AYR.	Mod. Weath.
IV	ÇOK AYR.	Highly W.
V	TÜMÜYLE A.	Comp.Weat.

İNCE DANELİ / Fine Grained

N :	0-2	ÇOK YUMUŞAK	V.Soft
N :	3-4	YUMUŞAK	Soft
N :	5-8	ORTA KATI	M.Stiff
N :	9-15	KATI	Stiff
N :	16-30	ÇOK KATI	V.Stiff
N :	>30	SERT	Hard

İRİ DANELİ/Coarse Grained

N :	0-4	ÇOK GEVŞEK	V.Loos
N :	5-10	GEVŞEK	Loose
N :	11-30	ORTA SIKI	M.Den
N :	31-50	SIKI	Dense
N :	>50	ÇOK SIKI	V.Den

KAYA KALİTESİ TANIMI - RQD

% 0-25	ÇOK ZAYIF	V.Poor
% 25-50	ZAYIF	Poor
% 50-75	ORTA	Fair
% 75-90	İYİ	Good
% 90-100	ÇOK İYİ	Excellent

KIRIKLAR - 30 cm / Fractures

1	SEYREK	Wide (W)
1-2	ORTA	Moderate (M)
2-10	SIK	Close (Cl)
10-20	ÇOK SIKI	Intense (I)
>20	PARÇALI	Crushed (Cr)

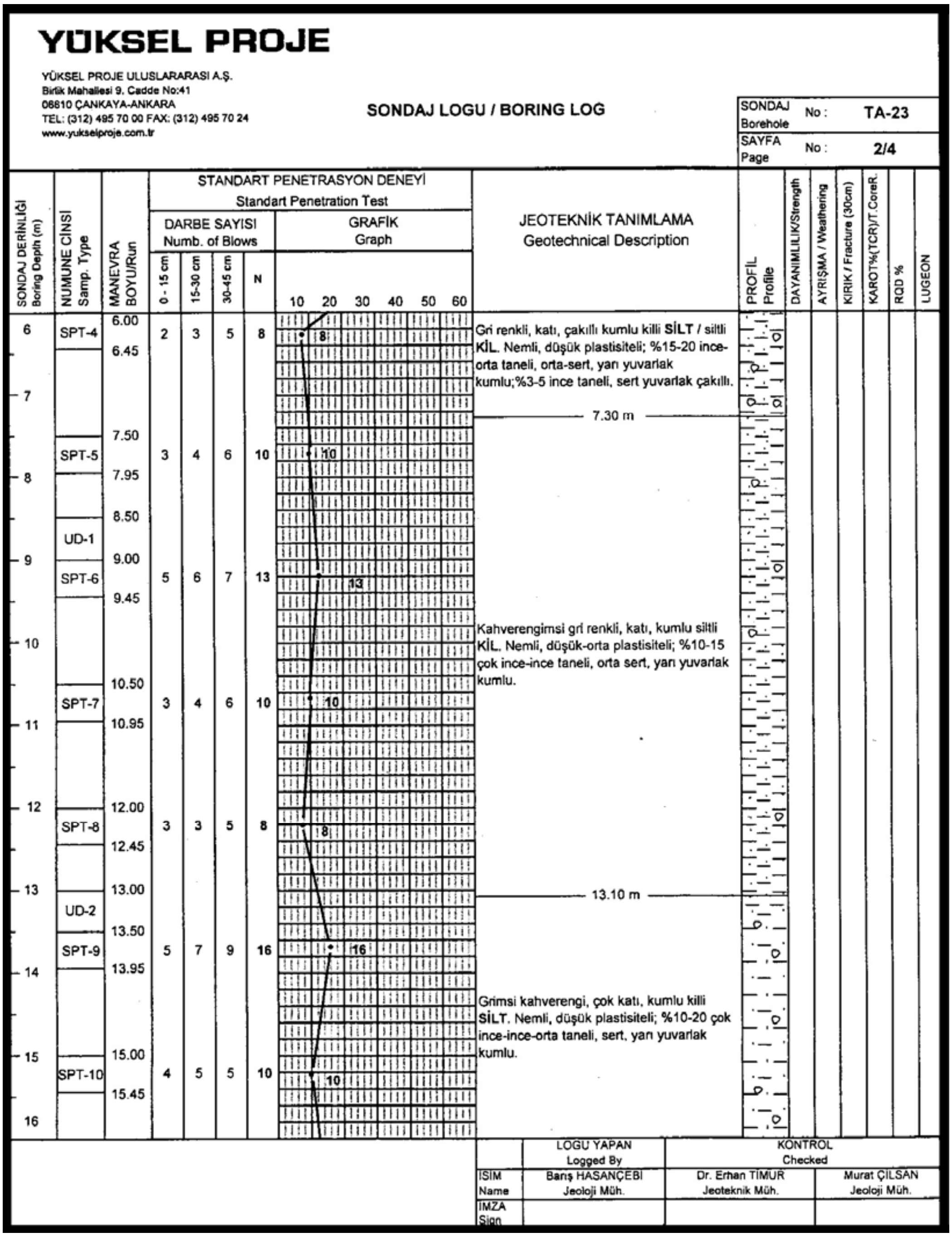
ORANLAR - Proportions

% 5	PEK AZ	Slightly	% 5	PEK AZ	Slightl
% 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
D	Örselenmiş Numune Disturbed sample
UD	Örselenmemiş Numune Undisturbed Sample
K	Karot Numunesi Core Sample
P	Pressiyometre Deneyi Pressuremeter Test
VS	Veyn Deneyi Vane Shear Test

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TIMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-23



YÜKSEL PROJE

YÜKSEL PROJE ULUSLARARASI A.Ş.
Birlik Mahallesi 9. Cadde No:41
06810 ÇANKAYA-ANKARA
TEL: (312) 495 70 00 FAX: (312) 495 70 24
www.yukselproje.com.tr

SONDAJ LOGU / BORING LOG

SONDAJ Borehole No : TA-23
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 Numb. of Blows: 0 - 15 cm	15-30 cm	30-45 cm	N
6	SPT-4	6.00 6.45	2	3	5	8
7						
	SPT-5	7.50 7.95	3	4	6	10
8						
	UD-1	8.50 9.00				
9	SPT-6	9.00 9.45	5	6	7	13
10						
	SPT-7	10.50 10.95	3	4	6	10
11						
12	SPT-8	12.00 12.45	3	3	5	8
13	UD-2	13.00 13.50				
	SPT-9	13.50 13.95	5	7	9	16
14						
15	SPT-10	15.00 15.45	4	5	5	10
16						

JEOTEKNİK TANIMLAMA
Geotechnical Description

Gri renkli, katı, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, düşük plastisiteli; %15-20 ince-orta taneli, orta-sert, yarı yuvarlak kumlu;%3-5 ince taneli, sert yuvarlak çakıllı.

7.30 m

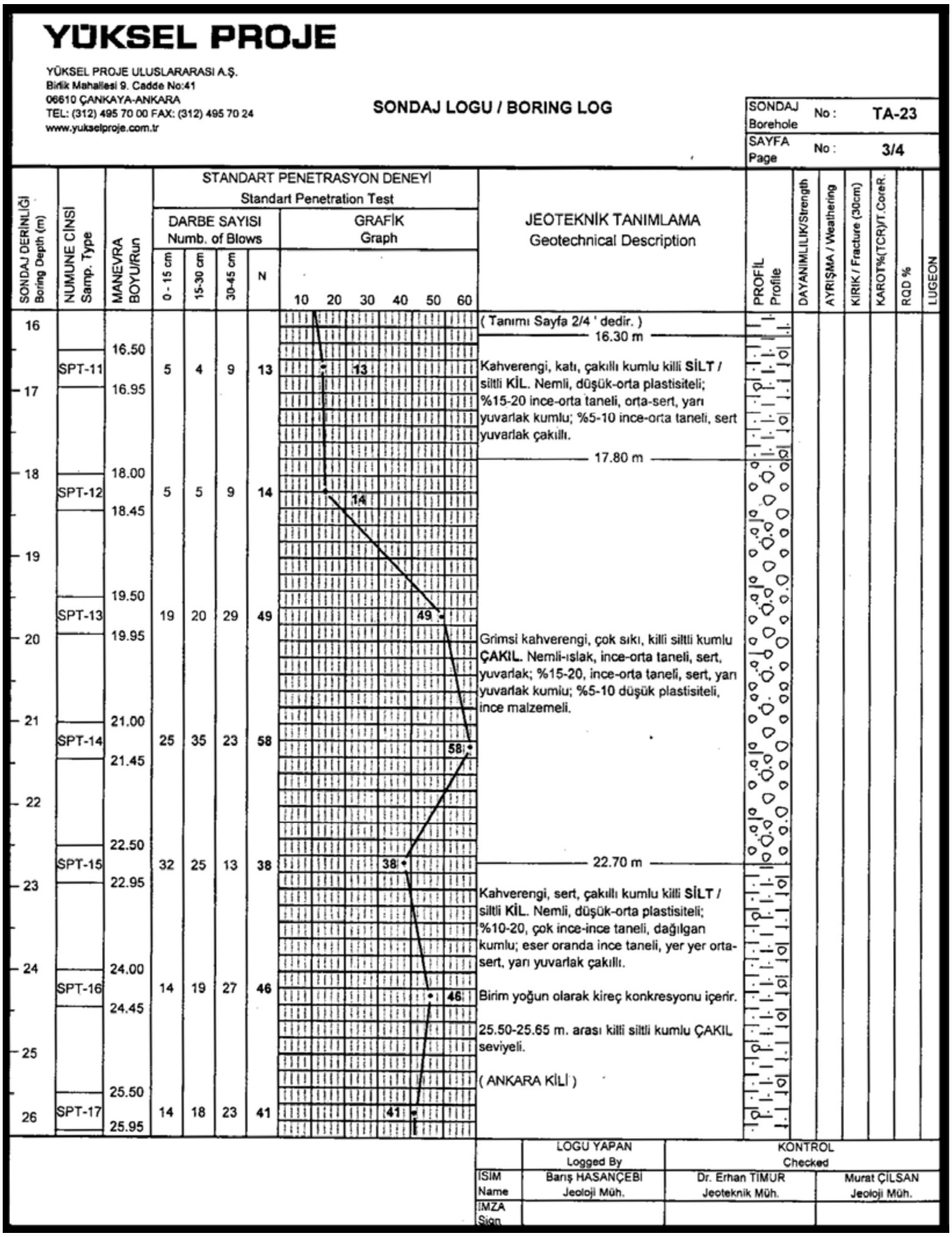
Kahverengimsi gri renkli, katı, kumlu siltli **KİL**. Nemli, düşük-orta plastisiteli; %10-15 çok ince-ince taneli, orta sert, yarı yuvarlak kumlu.

13.10 m

Grimsi kahverengi, çok katı, kumlu killi **SİLT**. Nemli, düşük plastisiteli; %10-20 çok ince-ince-orta taneli, sert, yarı yuvarlak kumlu.

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-23



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 : **TA-23**
SAYFA Page No : **3/4**

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
16						
	SPT-11	16.50 16.95	5	4	9	**13**
17						
18	SPT-12	18.00 18.45	5	5	9	**14**
19						
	SPT-13	19.50 19.95	19	20	29	**49**
20						
21	SPT-14	21.00 21.45	25	35	23	**58**
22						
	SPT-15	22.50 22.95	32	25	13	**38**
23						
24	SPT-16	24.00 24.45	14	19	27	**46**
25						
26	SPT-17	25.50 25.95	14	18	23	**41**

JEOTEKNİK TANIMLAMA
Geotechnical Description

(Tanımı Sayfa 2/4 ' dedir.)

16.30 m

Kahverengi, katı, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, düşük-orta plastisiteli; %15-20 ince-orta taneli, orta-sert, yarı yuvarlak kumlu; %5-10 ince-orta taneli, sert yuvarlak çakıllı.

17.80 m

Grimsi kahverengi, çok sıkı, killi siltli kumlu **ÇAKIL**. Nemli-ıslak, ince-orta taneli, sert, yuvarlak; %15-20, ince-orta taneli, sert, yarı yuvarlak kumlu; %5-10 düşük plastisiteli, ince malzemeli.

22.70 m

Kahverengi, sert, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, düşük-orta plastisiteli; %10-20, çok ince-ince taneli, dağılgan kumlu; eser oranda ince taneli, yer yer orta-sert, yarı yuvarlak çakıllı.

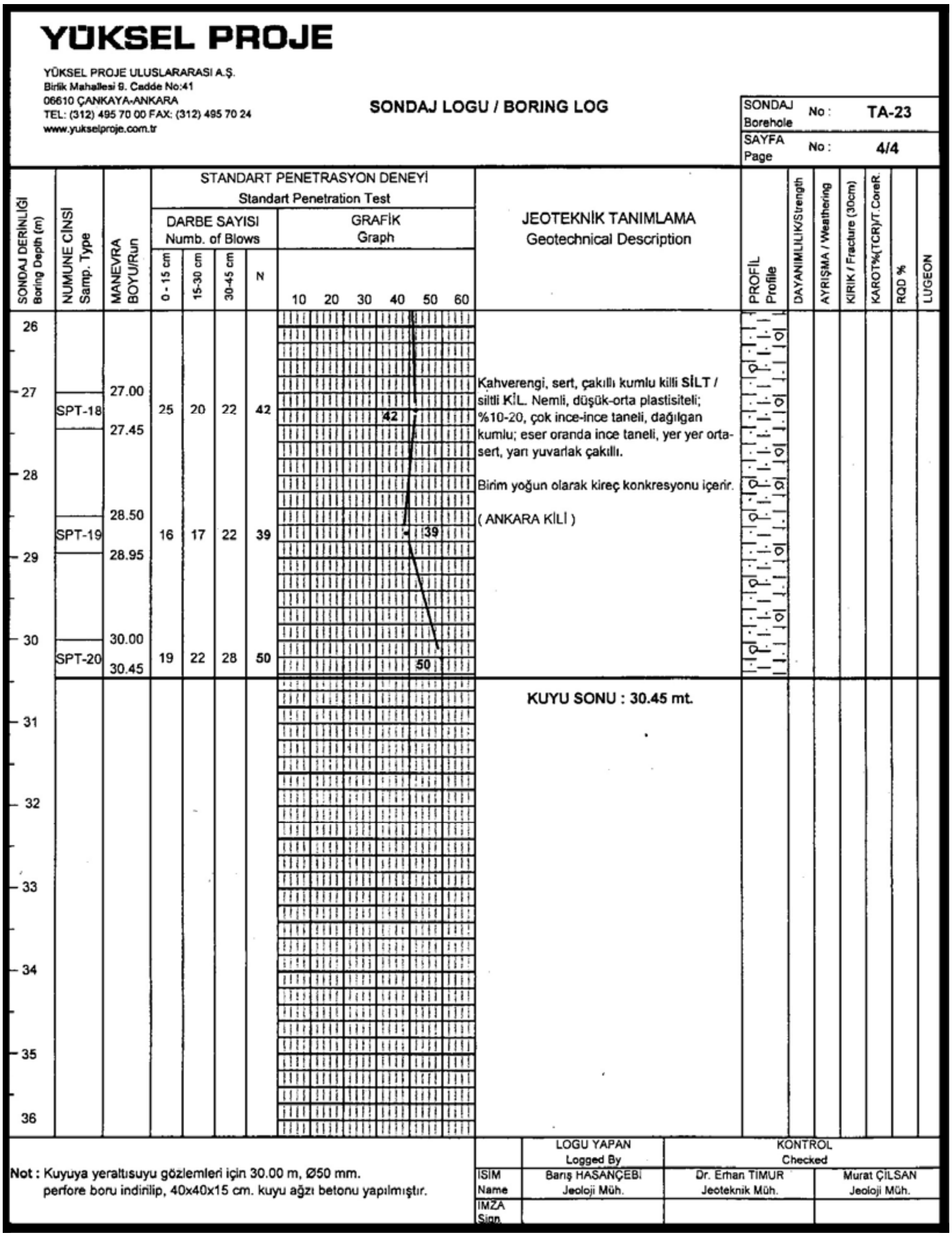
Birim yoğun olarak kireç konkresyonu içerir.

25.50-25.65 m. arası killi siltli kumlu ÇAKIL seviyeli.

(ANKARA KİLİ)

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-23



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

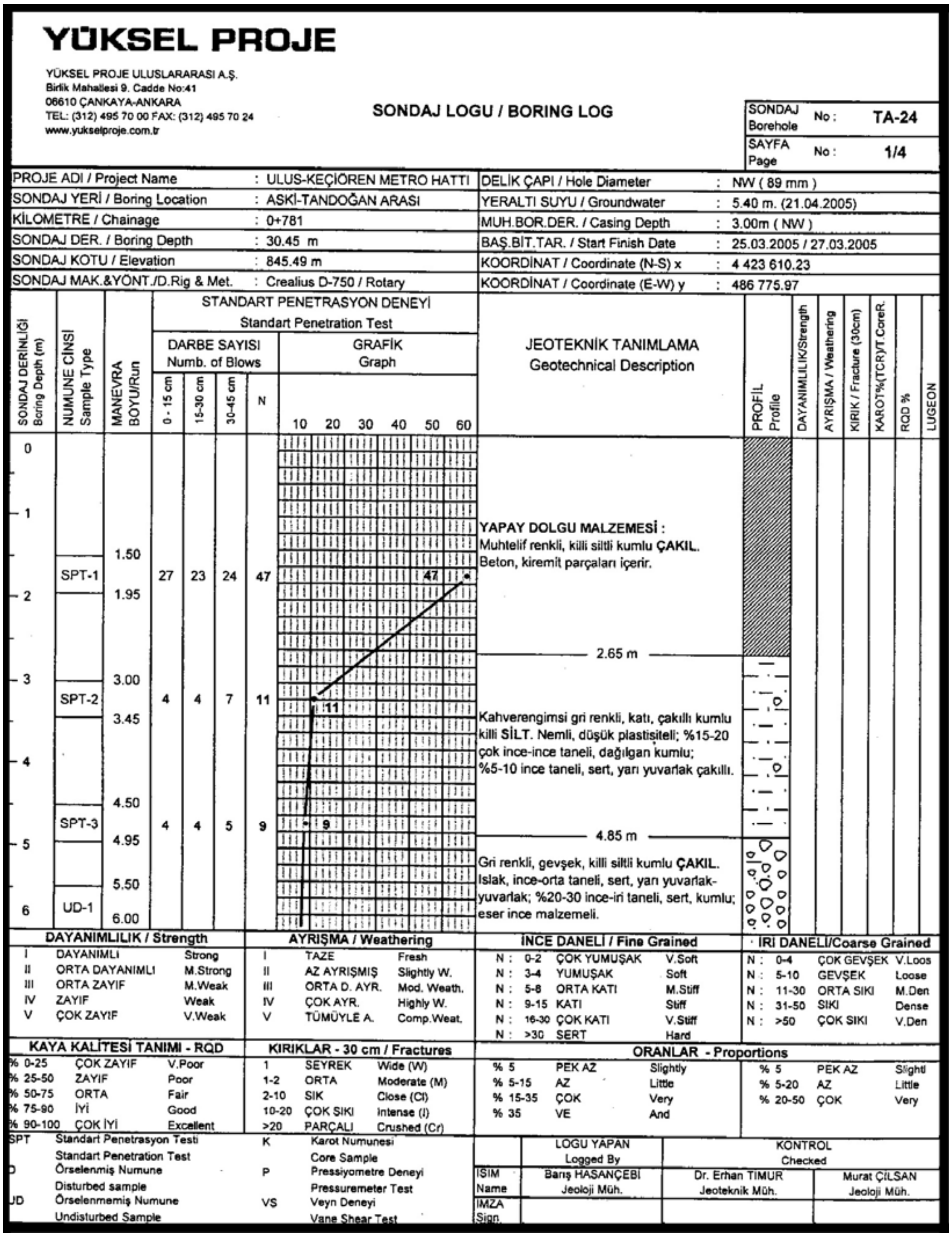
SONDAJ Borehole	No :	TA-23
SAYFA Page	No :	4/4

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	JEOTEKNİK TANIMLAMA Geotechnical Description
27	SPT-18	27.00 27.45	25	20	22	42	Kahverengi, sert, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, düşük-orta plastisiteli; %10-20, çok ince-ince taneli, dağılgan kumlu; eser oranda ince taneli, yer yer orta-sert, yarı yuvarlak çakıllı. Birim yoğun olarak kireç konkresyonu içerir. (ANKARA KİLİ)
28	SPT-19	28.50 28.95	16	17	22	39	
30	SPT-20	30.00 30.45	19	22	28	50	
							KUYU SONU : 30.45 mt.

Not : Kuyuya yeraltısuyu gözlemleri için 30.00 m, Ø50 mm. perfore boru indirilip, 40x40x15 cm. kuyu ağzı betonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TIMUR Jeoteknik Müh.	Murat ÇİLSAN Jeoloji Müh.
İMZA Sign.			

C.12. Borehole TA-24



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 : **TA-24**
SAYFA Page No : **1/4**

PROJE ADI / Project Name	: ULUS-KEÇİÖREN METRO HATTI	DELİK ÇAPI / Hole Diameter	: NW (89 mm)
SONDAJ YERİ / Boring Location	: ASKİ-TANDOĞAN ARASI	YERALTI SUYU / Groundwater	: 5.40 m. (21.04.2005)
KİLOMETRE / Chainage	: 0+781	MUH.BOR.DER. / Casing Depth	: 3.00m (NW)
SONDAJ DER. / Boring Depth	: 30.45 m	BAŞ.BİT.TAR. / Start Finish Date	: 25.03.2005 / 27.03.2005
SONDAJ KOTU / Elevation	: 845.49 m	KOORDİNAT / Coordinate (N-S) x	: 4 423 610.23
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Crealius D-750 / Rotary	KOORDİNAT / Coordinate (E-W) y	: 486 775.97

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							**YAPAY DOLGU MALZEMESİ :** Muhtelif renkli, killi siltli kumlu **ÇAKIL**. Beton, kiremit parçaları içerir.
1							
		1.50					
	SPT-1		27	23	24	47	
2		1.95					
							2.65 m
3		3.00					Kahverengimsi gri renkli, katı, çakıllı kumlu killi **SİLT**. Nemli, düşük plastisiteli; %15-20 çok ince-ince taneli, dağılgan kumlu; %5-10 ince taneli, sert, yarı yuvarlak çakıllı.
	SPT-2		4	4	7	11	
		3.45					
4							
		4.50					
	SPT-3		4	4	5	9	
							4.85 m
5		4.95					Gri renkli, gevşek, killi siltli kumlu **ÇAKIL**. Islak, ince-orta taneli, sert, yarı yuvarlak-yuvarlak; %20-30 ince-iri taneli, sert, kumlu; eser ince malzemeli.
		5.50					
6	UD-1	6.00					

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.	Highly W.
V	ÇOK ZAYIF	V.Weak	V	TÜMÜYLE A.	Comp.Weat.

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

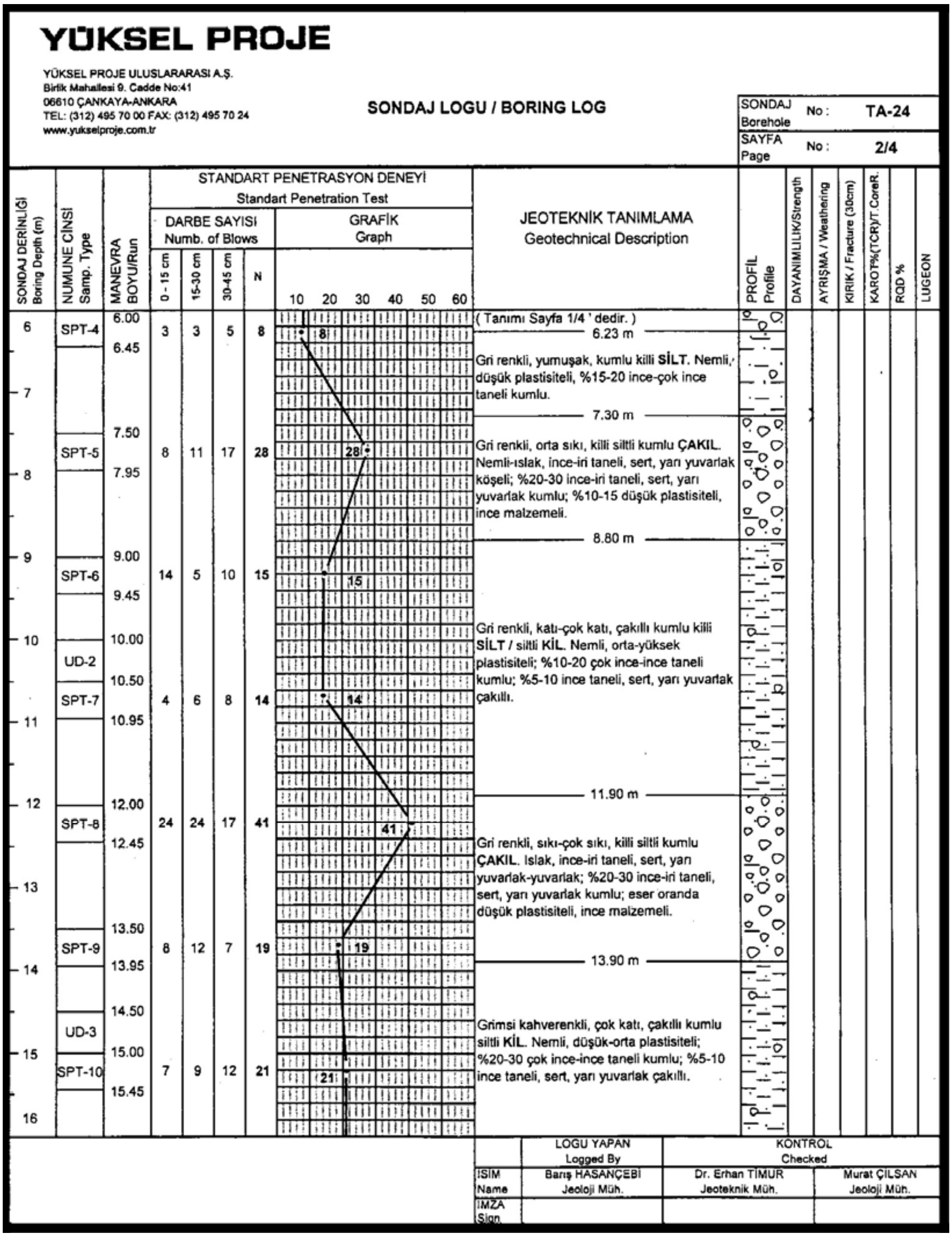
KAYA KALİTESİ TANIMI - RQD			KIRIKLAR - 30 cm / Fractures		
% 0-25	ÇOK ZAYIF	V.Poor	1	SEYREK	Wide (W)
% 25-50	ZAYIF	Poor	1-2	ORTA	Moderate (M)
% 50-75	ORTA	Fair	2-10	SIK	Close (Cl)
% 75-90	İYİ	Good	10-20	ÇOK SIKI	Intense (I)
% 90-100	ÇOK İYİ	Excellent	>20	PARÇALI	Crushed (Cr)

ORANLAR - Proportions					
% 5	PEK AZ	Slightly	% 5	PEK AZ	Slightl
% 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	Örselenmiş Numune Disturbed sample	P	Pressiyometre Deneyi Pressuremeter Test
UD	Örselenmemiş Numune Undisturbed Sample	VS	Veyn Deneyi Vane Shear Test

	LOGU YAPAN Logged By	KONTROL Checked	
İSIM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TIMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign.			

Continuation of Borehole TA-24



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 : TA-24
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
6	SPT-4	6.00 6.45	3	3	5	8
7	SPT-5	7.50 7.95	8	11	17	28
8						
9	SPT-6	9.00 9.45	14	5	10	15
10	UD-2	10.00 10.50				
	SPT-7	10.50 10.95	4	6	8	14
11						
12	SPT-8	12.00 12.45	24	24	17	41
13	SPT-9	13.50 13.95	8	12	7	19
14	UD-3	14.50 15.00				
15	SPT-10	15.00 15.45	7	9	12	21
16						

JEOTEKNİK TANIMLAMA
Geotechnical Description

(Tanımı Sayfa 1/4 ' dedir.)

6.23 m

Gri renkli, yumuşak, kumlu killi **SİLT**. Nemli, düşük plastisiteli, %15-20 ince-çok ince taneli kumlu.

7.30 m

Gri renkli, orta sıkı, killi siltli kumlu **ÇAKIL**. Nemli-ıslak, ince-iri taneli, sert, yarı yuvarlak köşeli; %20-30 ince-iri taneli, sert, yarı yuvarlak kumlu; %10-15 düşük plastisiteli, ince malzemeli.

8.80 m

Gri renkli, katı-çok katı, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, orta-yüksek plastisiteli; %10-20 çok ince-ince taneli kumlu; %5-10 ince taneli, sert, yarı yuvarlak çakıllı.

11.90 m

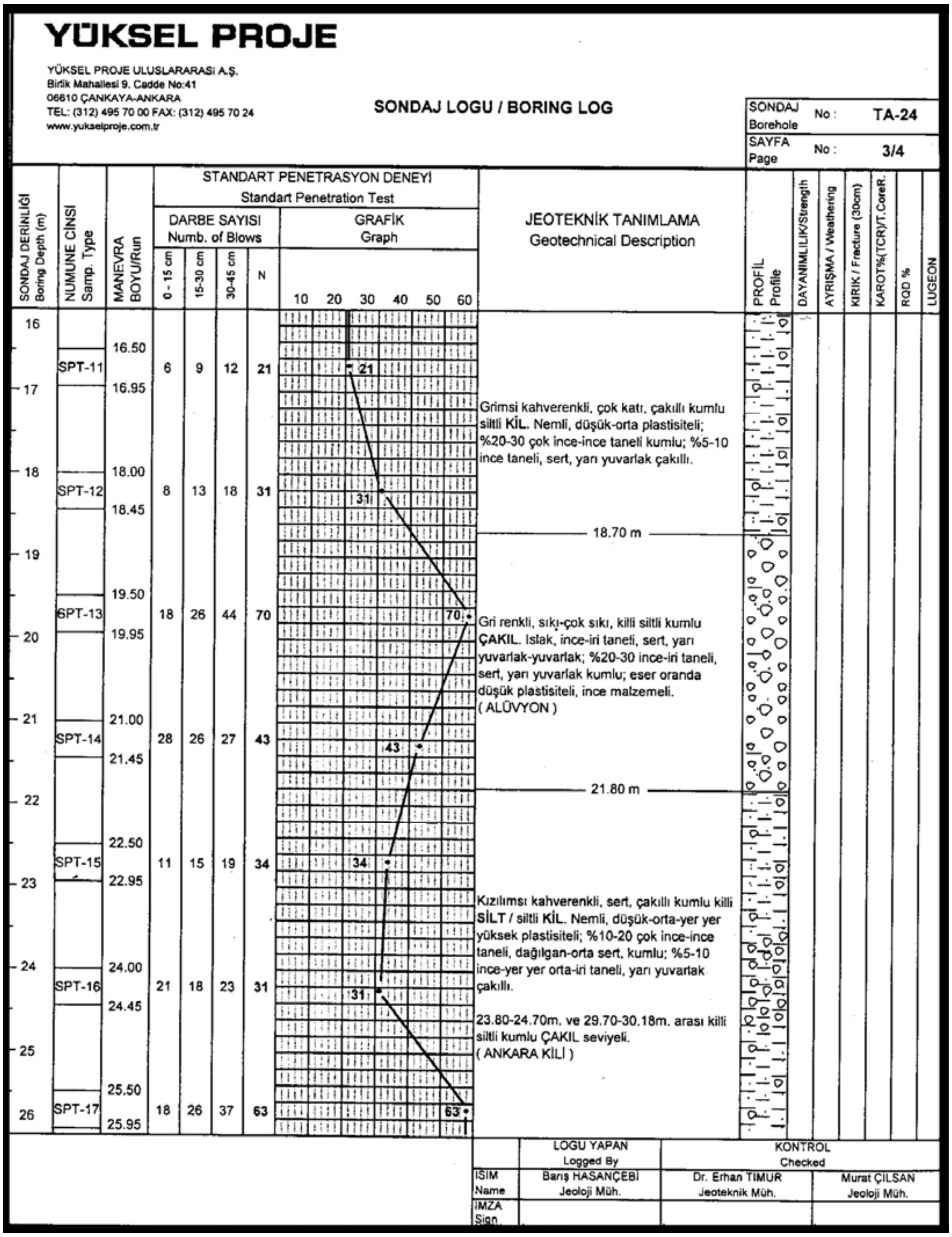
Gri renkli, sıkı-çok sıkı, killi siltli kumlu **ÇAKIL**. Islak, ince-iri taneli, sert, yarı yuvarlak-yuvarlak; %20-30 ince-iri taneli, sert, yarı yuvarlak kumlu; eser oranda düşük plastisiteli, ince malzemeli.

13.90 m

Grimsi kahverenkli, çok katı, çakıllı kumlu siltli **KİL**. Nemli, düşük-orta plastisiteli; %20-30 çok ince-ince taneli kumlu; %5-10 ince taneli, sert, yarı yuvarlak çakıllı.

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-24



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 :	TA-24
SAYFA Page	No :	3/4

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
16						
	SPT-11	16.50 16.95	6	9	12	21
17						
18						
	SPT-12	18.00 18.45	8	13	18	31
19						
	SPT-13	19.50 19.95	18	26	44	70
20						
21						
	SPT-14	21.00 21.45	28	26	27	43
22						
	SPT-15	22.50 22.95	11	15	19	34
23						
24						
	SPT-16	24.00 24.45	21	18	23	31
25						
26	SPT-17	25.50 25.95	18	26	37	63

GRAFİK Graph: 10 20 30 40 50 60 — 21, 31, 70, 43, 34, 31, 63

JEOTEKNİK TANIMLAMA
Geotechnical Description

Grimsi kahverenkli, çok katı, çakıllı kumlu siltli **KİL**. Nemli, düşük-orta plastisiteli; %20-30 çok ince-ince taneli kumlu; %5-10 ince taneli, sert, yarı yuvarlak çakıllı.

18.70 m

Gri renkli, sıkı-çok sıkı, killi siltli kumlu **ÇAKIL**. Islak, ince-iri taneli, sert, yarı yuvarlak-yuvarlak; %20-30 ince-iri taneli, sert, yarı yuvarlak kumlu; eser oranda düşük plastisiteli, ince malzemeli.
(ALÜVYON)

21.80 m

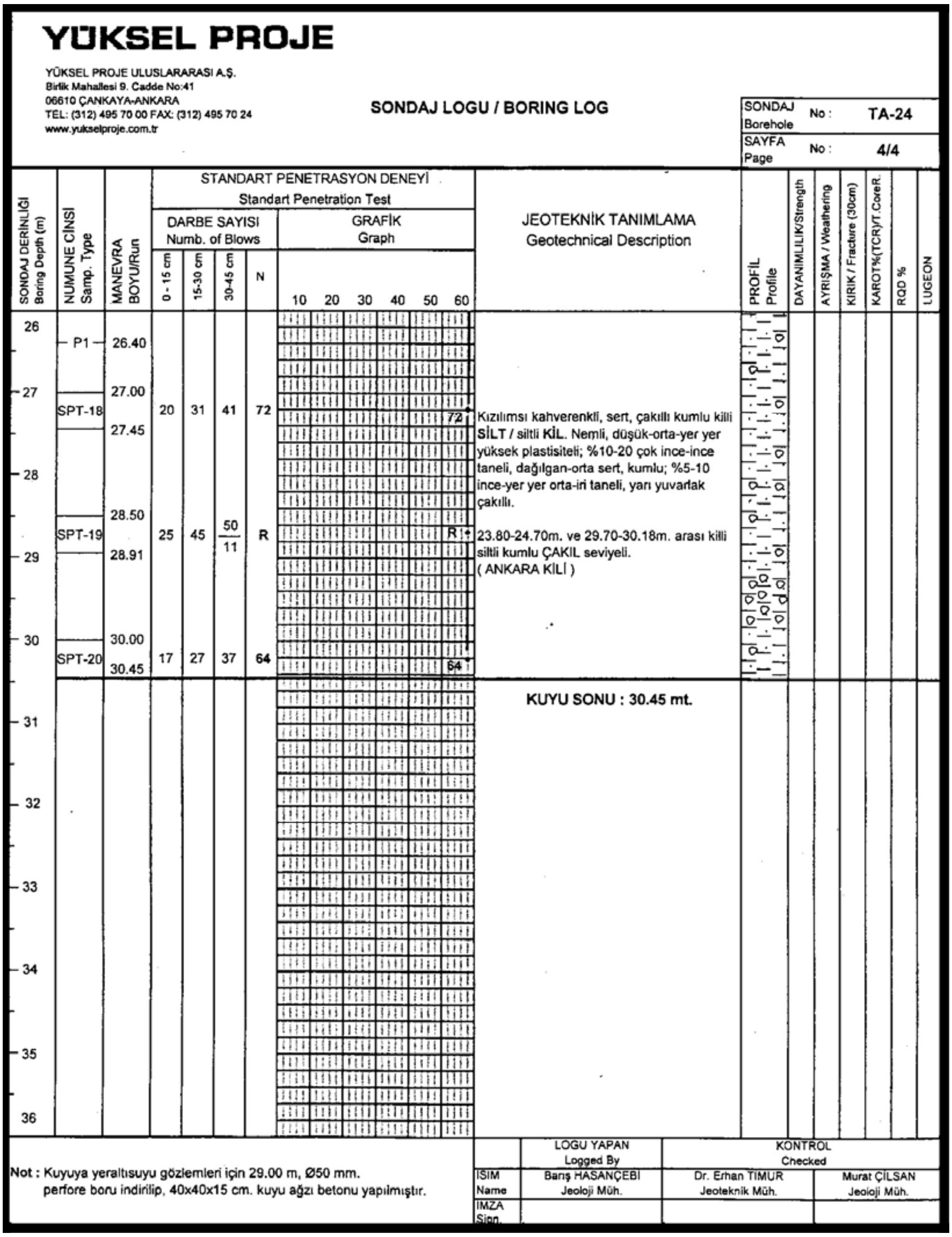
Kızılımsı kahverenkli, sert, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, düşük-orta-yer yer yüksek plastisiteli; %10-20 çok ince-ince taneli, dağılgan-orta sert, kumlu; %5-10 ince-yer yer orta-iri taneli, yarı yuvarlak çakıllı.

23.80-24.70m. ve 29.70-30.18m. arası killi siltli kumlu ÇAKIL seviyeli.
(ANKARA KİLİ)

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

	LOGU YAPAN Logged By	KONTROL Checked	
İSIM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign.			

Continuation of Borehole TA-24



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

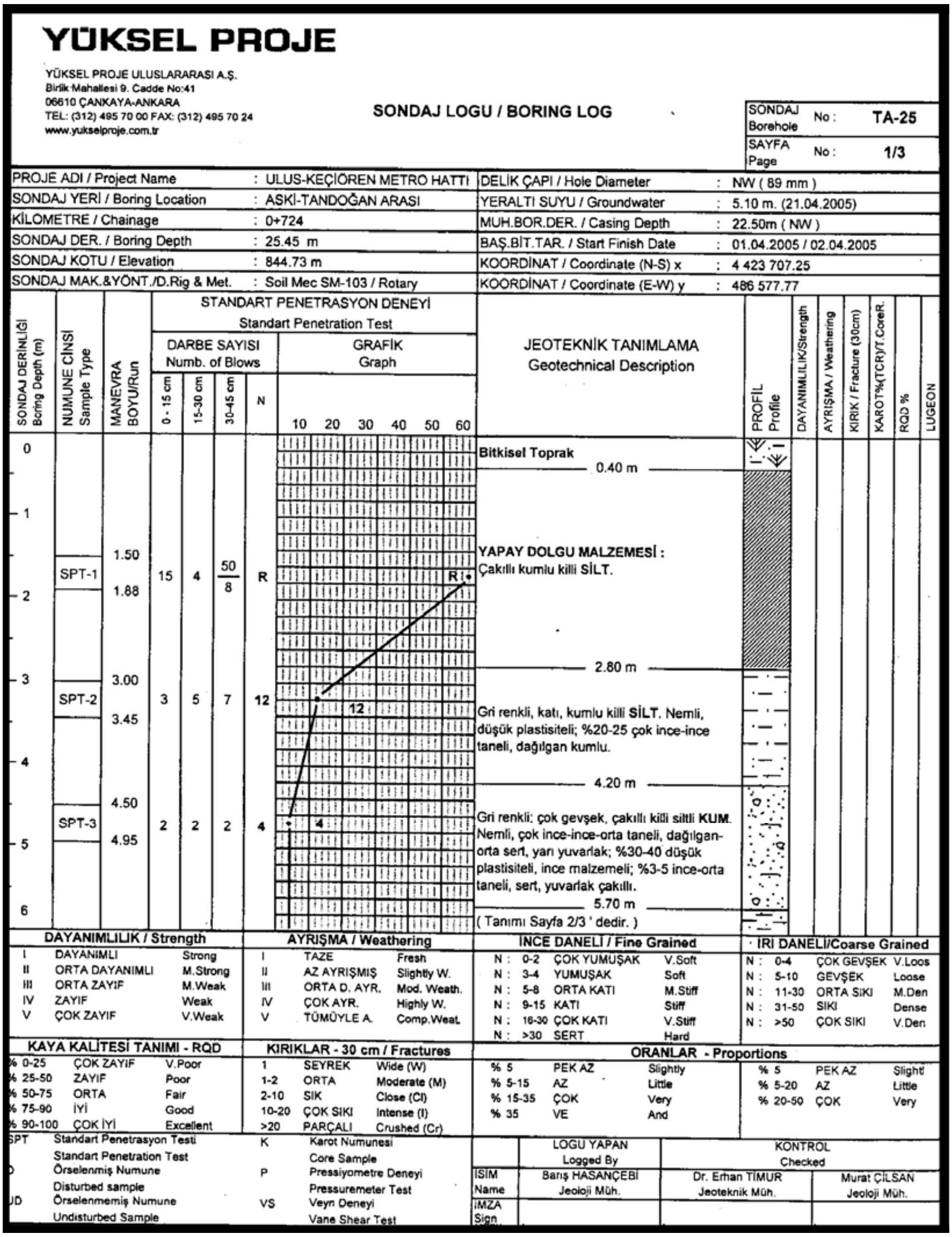
SONDAJ Borehole	No :	TA-24
SAYFA Page	No :	4/4

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Run	STANDART PENETRASYON DENEYİ Standart Penetration Test					JEOTEKNİK TANIMLAMA Geotechnical Description	PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
			DARBE SAYISI Numb. of Blows 0 - 15 cm	15-30 cm	30-45 cm	N	GRAFİK Graph 10 20 30 40 50 60								
26															
	P1	26.40													
27		27.00													
	SPT-18		20	31	41	72	72	Kızılımsı kahverenkli, sert, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, düşük-orta-yer yer yüksek plastisiteli; %10-20 çok ince-ince taneli, dağılgan-orta sert, kumlu; %5-10 ince-yer yer orta-iri taneli, yarı yuvarlak çakıllı.							
		27.45													
28															
		28.50													
	SPT-19		25	45	50/11	R	R	23.80-24.70m. ve 29.70-30.18m. arası killi siltli kumlu ÇAKIL seviyeli. (ANKARA KİLİ)							
29		28.91													
30		30.00													
	SPT-20	30.45	17	27	37	64	64								
31								**KUYU SONU : 30.45 mt.**							
32															
33															
34															
35															
36															

Not : Kuyuya yeraltısuyu gözlemleri için 29.00 m, Ø50 mm. perfore boru indirilip, 40x40x15 cm. kuyu ağzı betonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked	
ISIM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TIMUR Jeoteknik Müh.	Murat ÇİLSAN Jeoloji Müh.
IMZA Sign.			

C.13. Borehole TA-25



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 :	TA-25
SAYFA Page	No :	1/3

PROJE ADI / Project Name	: ULUS-KEÇİÖREN METRO HATTI	DELİK ÇAPI / Hole Diameter	: NW (89 mm)
SONDAJ YERİ / Boring Location	: ASKİ-TANDOĞAN ARASI	YERALTI SUYU / Groundwater	: 5.10 m. (21.04.2005)
KİLOMETRE / Chainage	: 0+724	MUH.BOR.DER. / Casing Depth	: 22.50m (NW)
SONDAJ DER. / Boring Depth	: 25.45 m	BAŞ.BİT.TAR. / Start Finish Date	: 01.04.2005 / 02.04.2005
SONDAJ KOTU / Elevation	: 844.73 m	KOORDİNAT / Coordinate (N-S) x	: 4 423 707.25
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Soil Mec SM-103 / Rotary	KOORDİNAT / Coordinate (E-W) y	: 486 577.77

STANDART PENETRASYON DENEYİ
Standart Penetration Test

NUMUNE CİNSİ Sample Type	MANEVRA BOYU/Run	DARBE SAYISI Numb. of Blows 0 - 15 cm	15-30 cm	30-45 cm	N
SPT-1	1.50 1.88	15	4	50/8	R
SPT-2	3.00 3.45	3	5	7	12
SPT-3	4.50 4.95	2	2	2	4

JEOTEKNİK TANIMLAMA
Geotechnical Description

Bitkisel Toprak
0.40 m

YAPAY DOLGU MALZEMESİ :
Çakıllı kumlu killi **SİLT**.
2.80 m

Gri renkli, katı, kumlu killi **SİLT**. Nemli, düşük plastisiteli; %20-25 çok ince-ince taneli, dağılgan kumlu.
4.20 m

Gri renkli; çok gevşek, çakıllı killi siltli **KUM**. Nemli, çok ince-ince-orta taneli, dağılgan-orta sert, yarı yuvarlak; %30-40 düşük plastisiteli, ince malzemeli; %3-5 ince-orta taneli, sert, yuvarlak çakıllı.
5.70 m
(Tanımı Sayfa 2/3 ' dedir.)

DAYANIMLILIK / Strength

I	DAYANIMLI	Strong
II	ORTA DAYANIMLI	M.Strong
III	ORTA ZAYIF	M.Weak
IV	ZAYIF	Weak
V	ÇOK ZAYIF	V.Weak

AYRIŞMA / Weathering

I	TAZE	Fresh
II	AZ AYRIŞMIŞ	Slightly W.
III	ORTA D. AYR.	Mod. Weath.
IV	ÇOK AYR.	Highly W.
V	TÜMÜYLE A.	Comp.Weat.

İNCE DANELİ / Fine Grained

N :	0-2	ÇOK YUMUŞAK	V.Soft
N :	3-4	YUMUŞAK	Soft
N :	5-8	ORTA KATI	M.Stiff
N :	9-15	KATI	Stiff
N :	16-30	ÇOK KATI	V.Stiff
N :	>30	SERT	Hard

IRI DANELİ/Coarse Grained

N :	0-4	ÇOK GEVŞEK	V.Loos
N :	5-10	GEVŞEK	Loose
N :	11-30	ORTA SIKI	M.Den
N :	31-50	SIKI	Dense
N :	>50	ÇOK SIKI	V.Den

KAYA KALİTESİ TANIMI - RQD

% 0-25	ÇOK ZAYIF	V.Poor
% 25-50	ZAYIF	Poor
% 50-75	ORTA	Fair
% 75-90	İYİ	Good
% 90-100	ÇOK İYİ	Excellent

KIRIKLAR - 30 cm / Fractures

1	SEYREK	Wide (W)
1-2	ORTA	Moderate (M)
2-10	SIK	Close (Cl)
10-20	ÇOK SIKI	Intense (I)
>20	PARÇALI	Crushed (Cr)

ORANLAR - Proportions

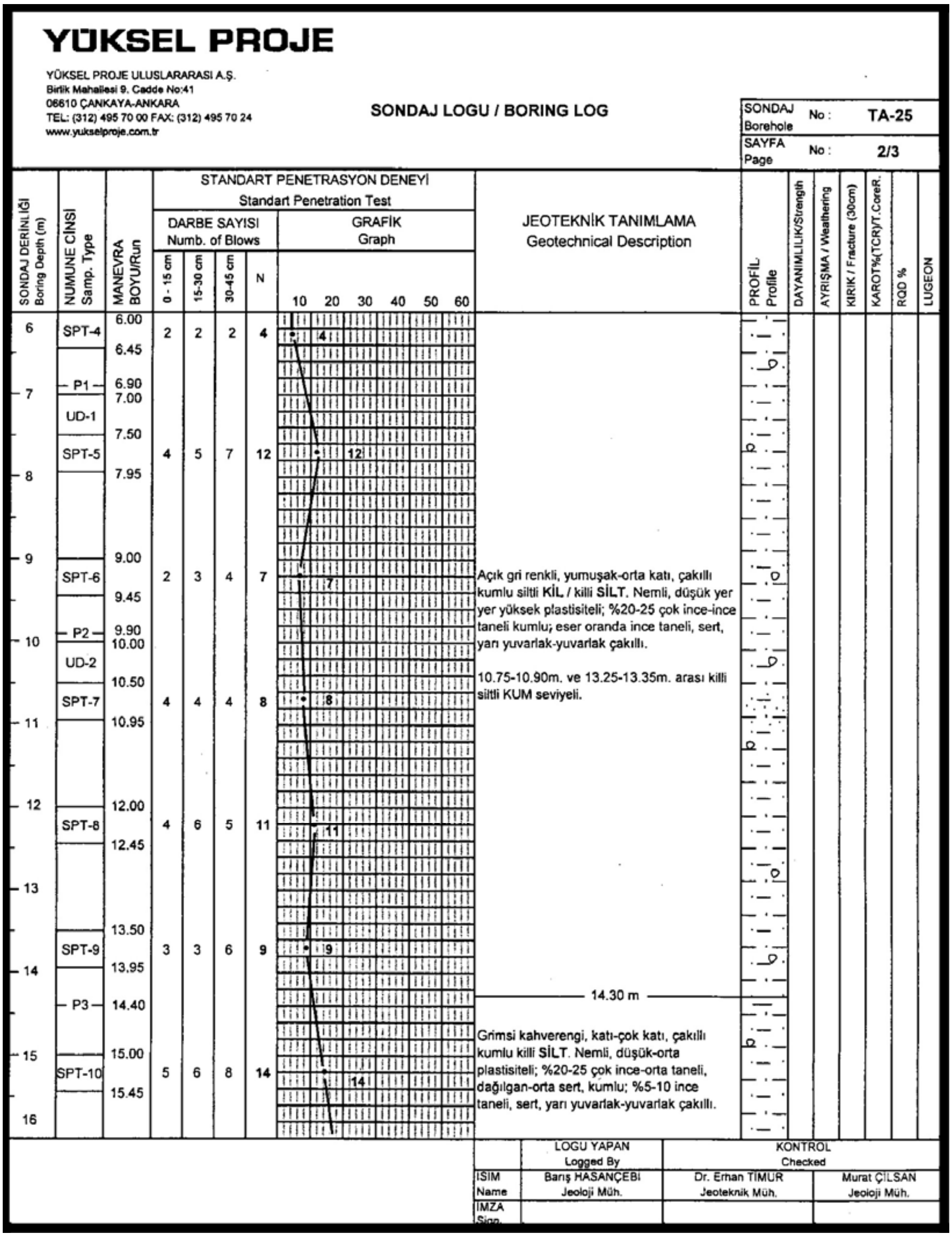
% 5	PEK AZ	Slightly
% 5-15	AZ	Little
% 15-35	ÇOK	Very
% 35	VE	And

% 5	PEK AZ	Slight
% 5-20	AZ	Little
% 20-50	ÇOK	Very

SPT	Standart Penetrasyon Testi Standart Penetration Test
D	Örselenmiş Numune Disturbed sample
UD	Örselenmemiş Numune Undisturbed Sample
K	Karot Numunesi Core Sample
P	Pressiyometre Deneyi Pressuremeter Test
VS	Veyn Deneyi Vane Shear Test

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇİLSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole TA-25



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 : TA-25
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
6	SPT-4	6.00 6.45	2	2	2	4
7	P1	6.90				
	UD-1	7.00 7.50				
	SPT-5	7.50 7.95	4	5	7	12
8						
9	SPT-6	9.00 9.45	2	3	4	7
10	P2	9.90				
	UD-2	10.00 10.50				
	SPT-7	10.50 10.95	4	4	4	8
11						
12	SPT-8	12.00 12.45	4	6	5	11
13						
	SPT-9	13.50 13.95	3	3	6	9
14	P3	14.40				
15	SPT-10	15.00 15.45	5	6	8	14
16						

JEOTEKNİK TANIMLAMA
Geotechnical Description

Açık gri renkli, yumuşak-orta katı, çakıllı kumlu siltli **KİL** / killi **SİLT**. Nemli, düşük yer yer yüksek plastisiteli; %20-25 çok ince-ince taneli kumlu; eser oranda ince taneli, sert, yarı yuvarlak-yuvarlak çakıllı.

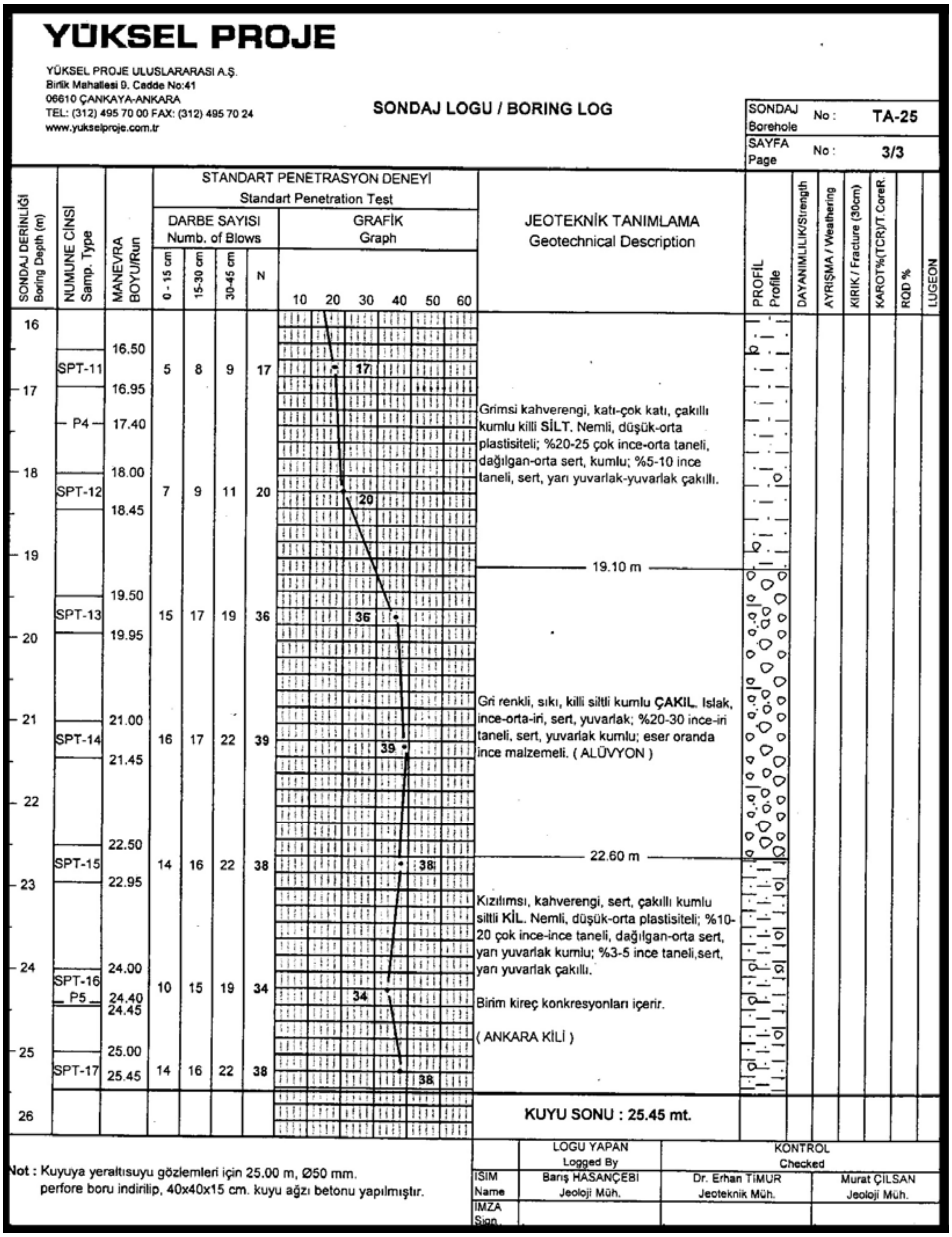
10.75-10.90m. ve 13.25-13.35m. arası killi siltli KUM seviyeli.

14.30 m

Grimsi kahverengi, katı-çok katı, çakıllı kumlu killi **SİLT**. Nemli, düşük-orta plastisiteli; %20-25 çok ince-orta taneli, dağılgan-orta sert, kumlu; %5-10 ince taneli, sert, yarı yuvarlak-yuvarlak çakıllı.

	LOGU YAPAN Logged By	KONTROL Checked	
İSIM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇİLSAN Jeoloji Müh.
IMZA Sign.			

Continuation of Borehole TA-25



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 : **TA-25**
SAYFA Page No : **3/3**

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
SPT-11	16.50 16.95	5	8	9	17
P4	17.40				
SPT-12	18.00 18.45	7	9	11	20
SPT-13	19.50 19.95	15	17	19	36
SPT-14	21.00 21.45	16	17	22	39
SPT-15	22.50 22.95	14	16	22	38
SPT-16 P5	24.00 24.40 24.45	10	15	19	34
SPT-17	25.00 25.45	14	16	22	38

SONDAJ DERİNLİĞİ Boring Depth (m) · GRAFİK Graph · PROFİL Profile · DAYANIMLILIK/Strength · AYRIŞMA / Weathering · KIRIK / Fracture (30cm) · KAROT%(TCR)/T.CoreR. · RQD % · LUGEON

JEOTEKNİK TANIMLAMA
Geotechnical Description

Grimsi kahverengi, katı-çok katı, çakıllı kumlu killi **SİLT**. Nemli, düşük-orta plastisiteli; %20-25 çok ince-orta taneli, dağılgan-orta sert, kumlu; %5-10 ince taneli, sert, yarı yuvarlak-yuvarlak çakıllı.

19.10 m

Gri renkli, sıkı, killi siltli kumlu **ÇAKIL**. Islak, ince-orta-iri, sert, yuvarlak; %20-30 ince-iri taneli, sert, yuvarlak kumlu; eser oranda ince malzemeli. (ALÜVYON)

22.60 m

Kızılımsı, kahverengi, sert, çakıllı kumlu siltli **KİL**. Nemli, düşük-orta plastisiteli; %10-20 çok ince-ince taneli, dağılgan-orta sert, yarı yuvarlak kumlu; %3-5 ince taneli,sert, yarı yuvarlak çakıllı.

Birim kireç konkresyonları içerir.

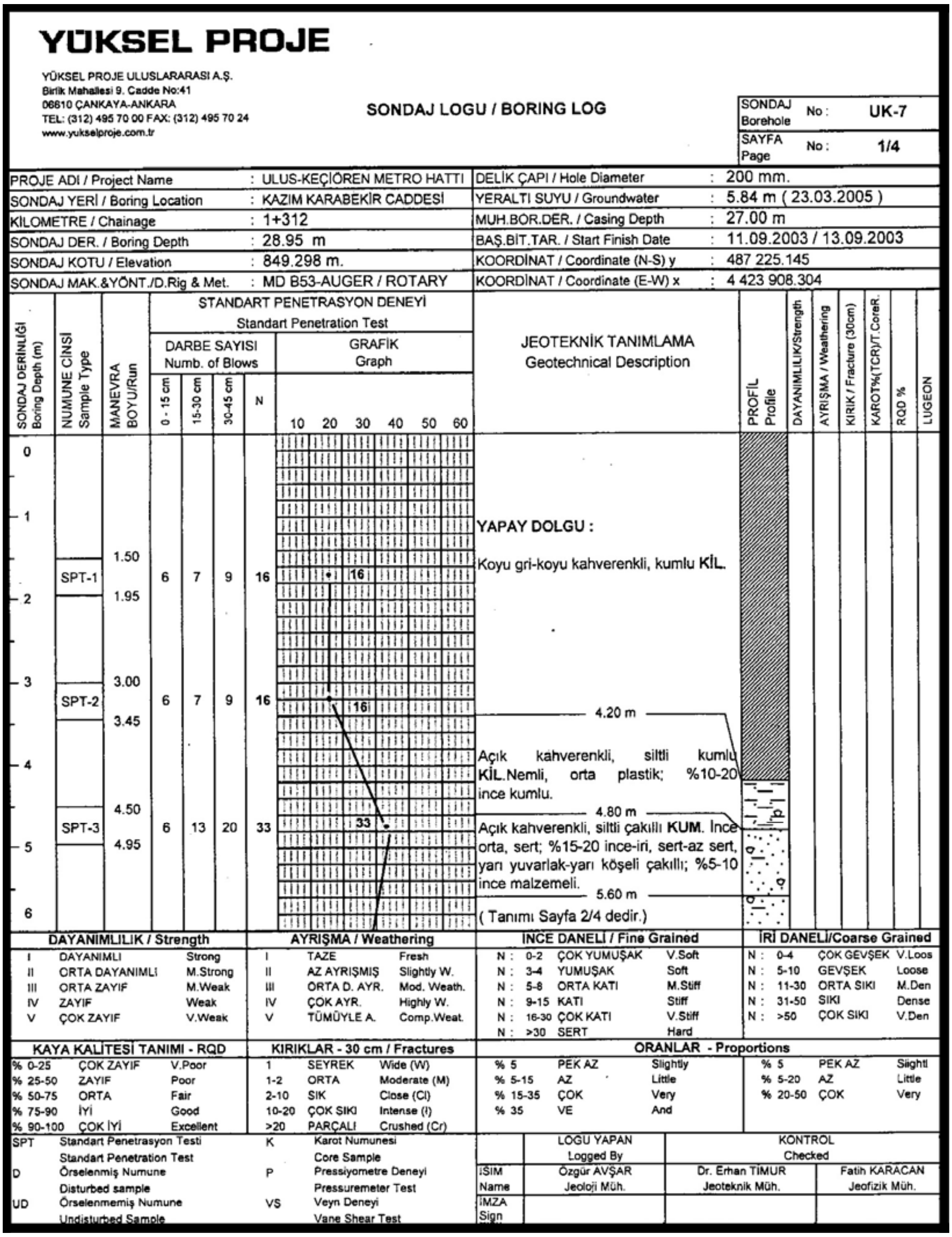
(ANKARA KİLİ)

KUYU SONU : 25.45 mt.

Not : Kuyuya yeraltısuyu gözlemleri için 25.00 m, Ø50 mm. perfore boru indirilip, 40x40x15 cm. kuyu ağzı betonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign.			

C.14. Borehole UK-7



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 :	UK-7
SAYFA Page	No :	1/4

PROJE ADI / Project Name	: ULUS-KEÇİÖREN METRO HATTI
SONDAJ YERİ / Boring Location	: KAZIM KARABEKİR CADDESİ
KİLOMETRE / Chainage	: 1+312
SONDAJ DER. / Boring Depth	: 28.95 m
SONDAJ KOTU / Elevation	: 849.298 m.
SONDAJ MAK.&YÖNT./D.Rig & Met.	: MD B53-AUGER / ROTARY
DELİK ÇAPI / Hole Diameter	: 200 mm.
YERALTI SUYU / Groundwater	: 5.84 m (23.03.2005)
MUH.BOR.DER. / Casing Depth	: 27.00 m
BAŞ.BİT.TAR. / Start Finish Date	: 11.09.2003 / 13.09.2003
KOORDİNAT / Coordinate (N-S) y	: 487 225.145
KOORDİNAT / Coordinate (E-W) x	: 4 423 908.304

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	GRAFİK Graph
1.50 – 1.95	SPT-1	1.50 1.95	6	7	9	16	16
3.00 – 3.45	SPT-2	3.00 3.45	6	7	9	16	16
4.50 – 4.95	SPT-3	4.50 4.95	6	13	20	33	33

JEOTEKNİK TANIMLAMA / Geotechnical Description

YAPAY DOLGU :

Koyu gri-koyu kahverenkli, kumlu **KİL**.

4.20 m

Açık kahverenkli, siltli kumlu **KİL**.Nemli, orta plastik; %10-20 ince kumlu.

4.80 m

Açık kahverenkli, siltli çakıllı **KUM**. İnce orta, sert; %15-20 ince-iri, sert-az sert, yarı yuvarlak-yarı köşeli çakıllı; %5-10 ince malzemeli.

5.60 m

(Tanımı Sayfa 2/4 dedir.)

DAYANIMLILIK / Strength

I	DAYANIMLI	Strong
II	ORTA DAYANIMLI	M.Strong
III	ORTA ZAYIF	M.Weak
IV	ZAYIF	Weak
V	ÇOK ZAYIF	V.Weak

AYRIŞMA / Weathering

I	TAZE	Fresh
II	AZ AYRIŞMIŞ	Slightly W.
III	ORTA D. AYR.	Mod. Weath.
IV	ÇOK AYR.	Highly W.
V	TÜMÜYLE A.	Comp.Weat.

İNCE DANELİ / Fine Grained

N :	0-2	ÇOK YUMUŞAK	V.Soft
N :	3-4	YUMUŞAK	Soft
N :	5-8	ORTA KATI	M.Stiff
N :	9-15	KATI	Stiff
N :	16-30	ÇOK KATI	V.Stiff
N :	>30	SERT	Hard

İRİ DANELİ/Coarse Grained

N :	0-4	ÇOK GEVŞEK	V.Loos
N :	5-10	GEVŞEK	Loose
N :	11-30	ORTA SIKI	M.Den
N :	31-50	SIKI	Dense
N :	>50	ÇOK SIKI	V.Den

KAYA KALİTESİ TANIMI - RQD

% 0-25	ÇOK ZAYIF	V.Poor
% 25-50	ZAYIF	Poor
% 50-75	ORTA	Fair
% 75-90	İYİ	Good
% 90-100	ÇOK İYİ	Excellent

KIRIKLAR - 30 cm / Fractures

1	SEYREK	Wide (W)
1-2	ORTA	Moderate (M)
2-10	SIK	Close (Cl)
10-20	ÇOK SIKI	Intense (I)
>20	PARÇALI	Crushed (Cr)

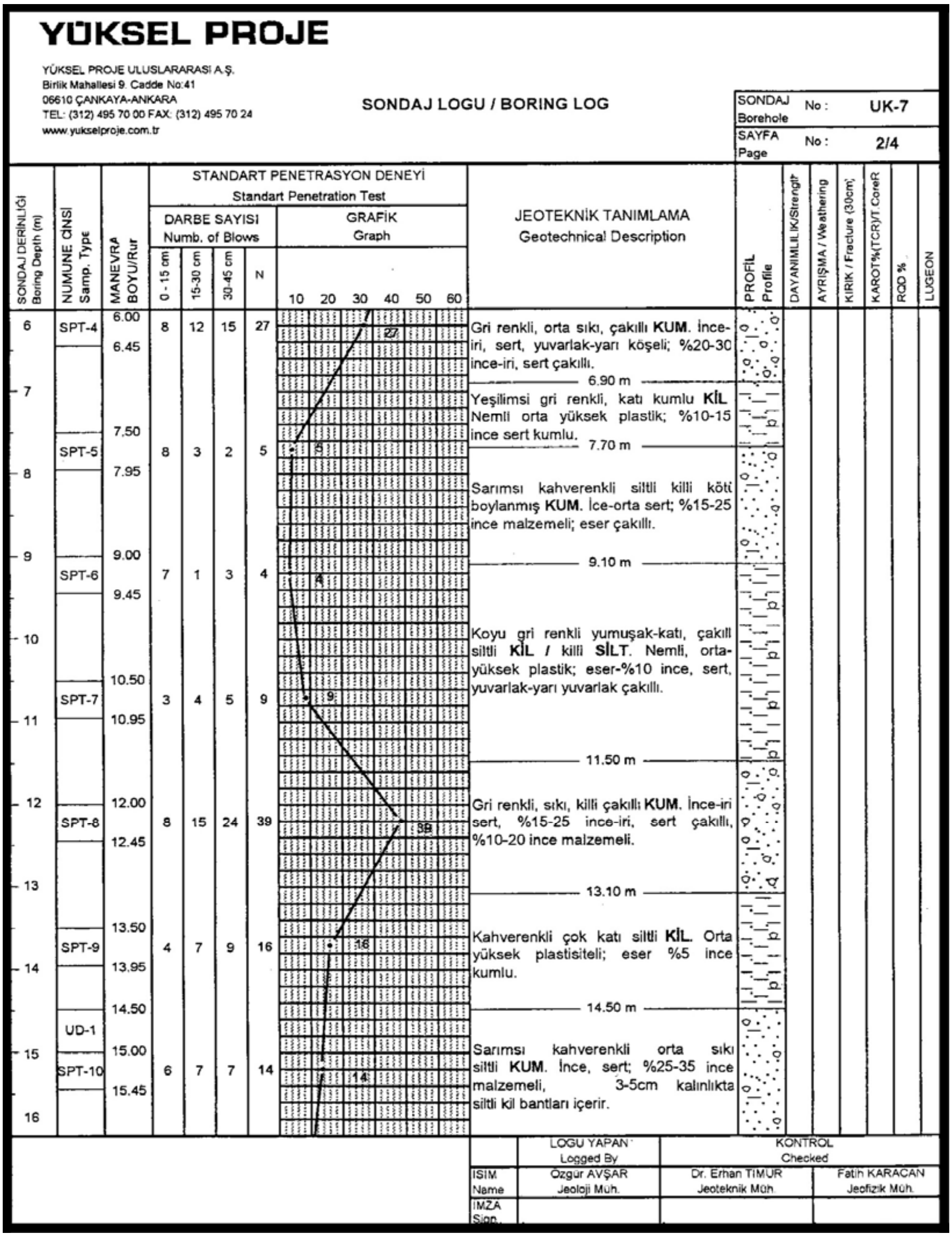
ORANLAR - Proportions

% 5	PEK AZ	Slightly	% 5	PEK AZ	Slightl
% 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	Örselenmiş Numune Disturbed sample	P	Pressiyometre Deneyi Pressuremeter Test
UD	Örselenmemiş Numune Undisturbed Sample	VS	Veyn Deneyi Vane Shear Test

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Özgür AVŞAR Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Fatih KARACAN Jeofizik Müh.
İMZA Sign			

Continuation of Borehole UK-7



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 : UK-7
SAYFA Page No : 2/4

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Rur	STANDART PENETRASYON DENEYİ Standart Penetration Test — DARBE SAYISI Numb. of Blows 0 - 15 cm	15-30 cm	30-45 cm	N
6	SPT-4	6.00 6.45	8	12	15	27
	SPT-5	7.50 7.95	8	3	2	5
	SPT-6	9.00 9.45	7	1	3	4
	SPT-7	10.50 10.95	3	4	5	9
	SPT-8	12.00 12.45	8	15	24	39
	SPT-9	13.50 13.95	4	7	9	16
	UD-1	14.50 15.00				
	SPT-10	15.00 15.45	6	7	7	14

GRAFİK Graph

JEOTEKNİK TANIMLAMA
Geotechnical Description

Gri renkli, orta sıkı, çakıllı **KUM**. İnce-iri, sert, yuvarlak-yarı köşeli; %20-30 ince-iri, sert çakıllı.

6.90 m

Yeşilimsi gri renkli, katı kumlu **KİL** Nemli orta yüksek plastik; %10-15 ince sert kumlu.

7.70 m

Sarımsı kahverenkli siltli killi köti boylanmış **KUM**. İce-orta sert; %15-25 ince malzemeli; eser çakıllı.

9.10 m

Koyu gri renkli yumuşak-katı, çakıll siltli **KİL** / killi **SİLT**. Nemli, orta-yüksek plastik; eser-%10 ince, sert, yuvarlak-yarı yuvarlak çakıllı.

11.50 m

Gri renkli, sıkı, killi çakıllı **KUM**. İnce-iri sert, %15-25 ince-iri, sert çakıllı, %10-20 ince malzemeli.

13.10 m

Kahverenkli çok katı siltli **KİL**. Orta yüksek plastisiteli; eser %5 ince kumlu.

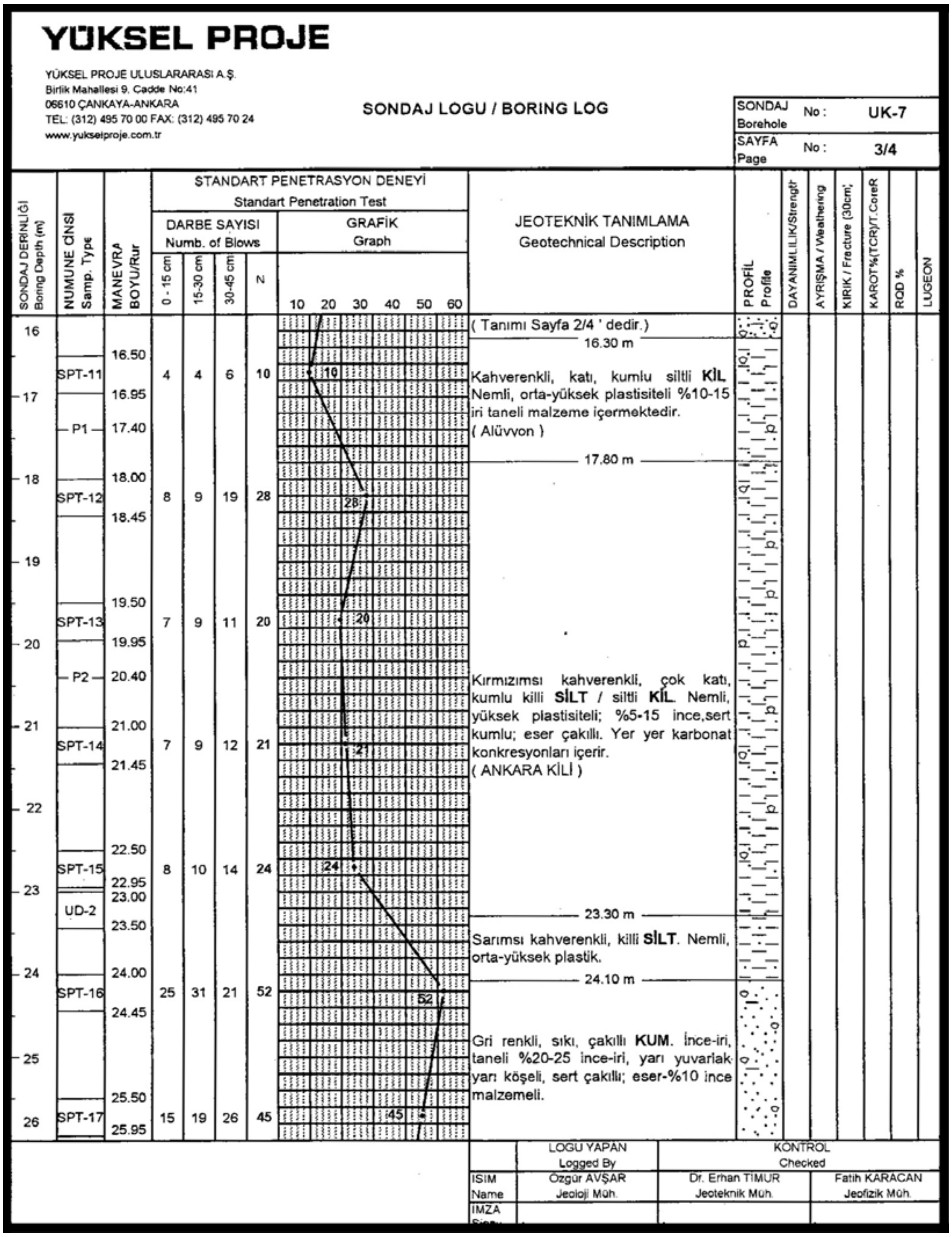
14.50 m

Sarımsı kahverenkli orta sıkı siltli **KUM**. İnce, sert; %25-35 ince malzemeli, 3-5cm kalınlıkta siltli kil bantları içerir.

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

	LOGU YAPAN Logged By	KONTROL Checked	
ISIM Name	Özgür AVŞAR Jeoloji Müh.	Dr. Erhan TIMUR Jeoteknik Müh.	Fatih KARACAN Jeofizik Müh.
IMZA Sign.			

Continuation of Borehole UK-7



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 :	UK-7
SAYFA Page	No :	3/4

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Rur	STANDART PENETRASYON DENEYİ Standart Penetration Test DARBE SAYISI Numb. of Blows 0 - 15 cm	15-30 cm	30-45 cm	N	GRAFİK Graph
16							
		16.50					
	SPT-11		4	4	6	10	10
17		16.95					
	P1	17.40					
18		18.00					
	SPT-12		8	9	19	28	28
		18.45					
19							
		19.50					
	SPT-13		7	9	11	20	20
20		19.95					
	P2	20.40					
21		21.00					
	SPT-14		7	9	12	21	21
		21.45					
22							
		22.50					
	SPT-15		8	10	14	24	24
23		22.95					
	UD-2	23.00					
		23.50					
24		24.00					
	SPT-16		25	31	21	52	52
		24.45					
25							
		25.50					
26	SPT-17		15	19	26	45	45
		25.95					

JEOTEKNİK TANIMLAMA
Geotechnical Description

(Tanımı Sayfa 2/4 ' dedir.)

16.30 m

Kahverenkli, katı, kumlu siltli **KİL** Nemli, orta-yüksek plastisiteli %10-15 iri taneli malzeme içermektedir.
(Alüvyon)

17.80 m

Kırmızımsı kahverenkli, çok katı, kumlu killi **SİLT** / siltli **KİL**. Nemli, yüksek plastisiteli; %5-15 ince,sert kumlu; eser çakıllı. Yer yer karbonat konkresyonları içerir.
(ANKARA KİLİ)

23.30 m

Sarımsı kahverenkli, killi **SİLT**. Nemli, orta-yüksek plastik.

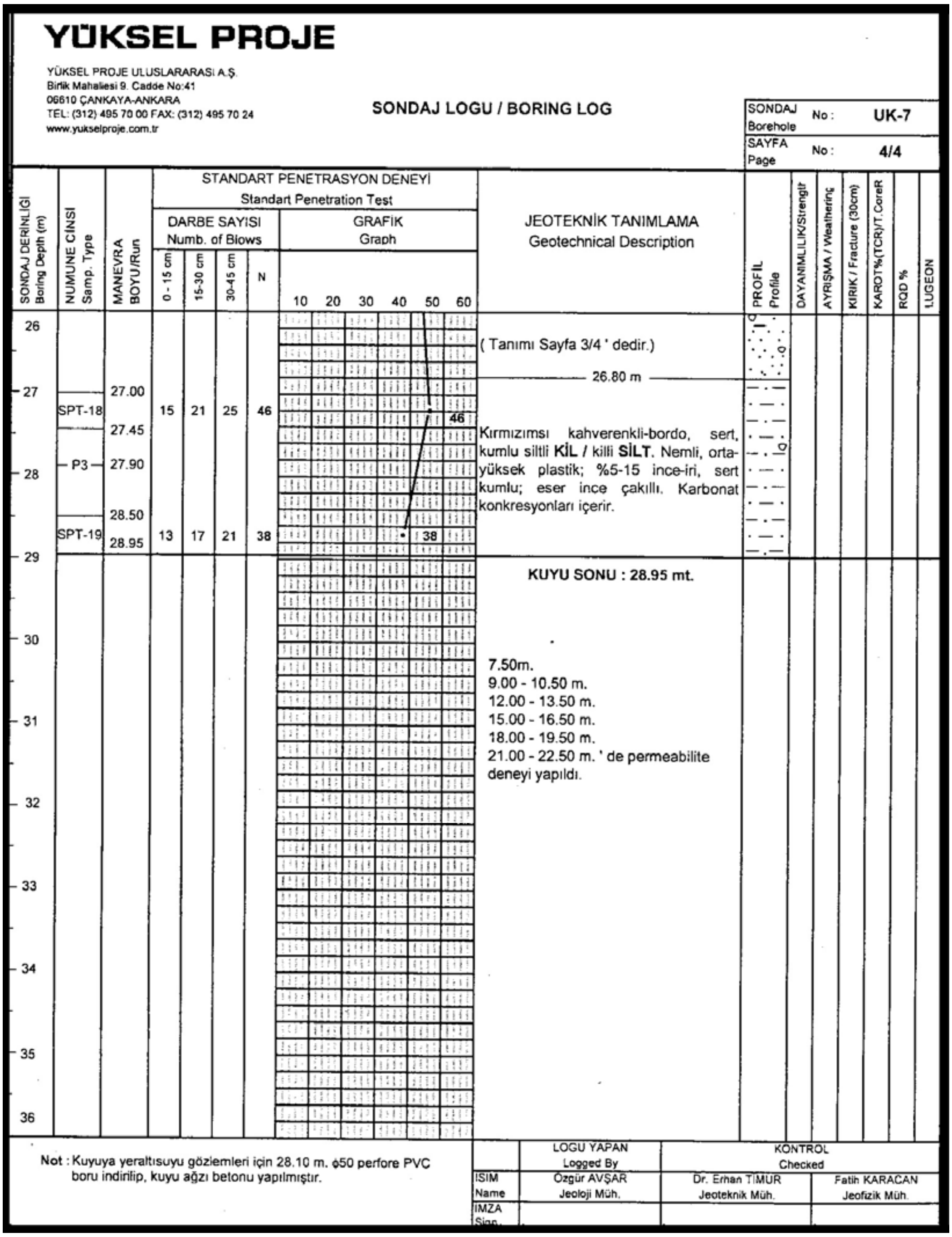
24.10 m

Gri renkli, sıkı, çakıllı **KUM**. İnce-iri, taneli %20-25 ince-iri, yarı yuvarlak yarı köşeli, sert çakıllı; eser-%10 ince malzemeli.

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

	LOGU YAPAN Logged By	KONTROL Checked	
ISIM Name	Özgür AVŞAR Jeoloji Müh.	Dr. Erhan TIMUR Jeoteknik Müh.	Fatih KARACAN Jeofizik Müh.
IMZA Sign.			

Continuation of Borehole UK-7



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

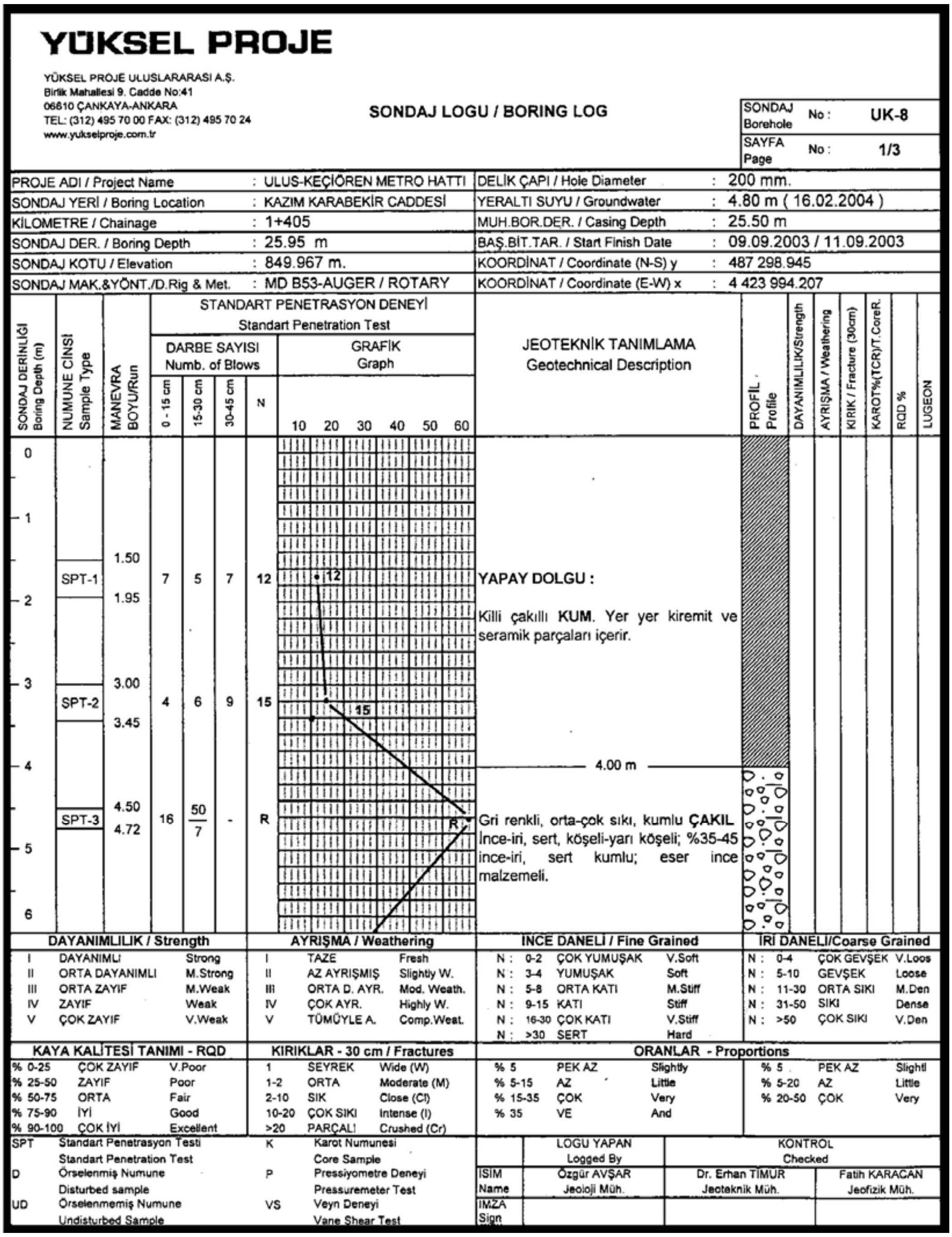
SONDAJ Borehole	No :	UK-7
SAYFA Page	No :	4/4

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								(Tanımı Sayfa 3/4 ' dedir.)							
								26.80 m							
27		27.00													
	SPT-18		15	21	25	46	46	Kırmızımsı kahverenkli-bordo, sert, kumlu siltli **KİL / killi SİLT**. Nemli, orta-yüksek plastik; %5-15 ince-iri, sert kumlu; eser ince çakıllı. Karbonat konkresyonları içerir.							
		27.45													
28	P3	27.90													
		28.50													
	SPT-19	28.95	13	17	21	38	38								
29								**KUYU SONU : 28.95 mt.**							
30								7.50m. 9.00 - 10.50 m. 12.00 - 13.50 m. 15.00 - 16.50 m. 18.00 - 19.50 m. 21.00 - 22.50 m. ' de permeabilite deneyi yapıldı.							
31															
32															
33															
34															
35															
36															

Not : Kuyuya yeraltısuyu gözlemleri için 28.10 m. ϕ50 perfore PVC boru indirilip, kuyu ağzı betonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked	
ISIM Name	Özgür AVŞAR Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Fatih KARACAN Jeofizik Müh.
IMZA Sign.			

C.15. Borehole UK-8



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 :	UK-8
SAYFA Page	No :	1/3

PROJE ADI / Project Name	: ULUS-KEÇİÖREN METRO HATTI	DELİK ÇAPI / Hole Diameter	: 200 mm.
SONDAJ YERİ / Boring Location	: KAZIM KARABEKİR CADDESİ	YERALTI SUYU / Groundwater	: 4.80 m (16.02.2004)
KİLOMETRE / Chainage	: 1+405	MUH.BOR.DER. / Casing Depth	: 25.50 m
SONDAJ DER. / Boring Depth	: 25.95 m	BAŞ.BİT.TAR. / Start Finish Date	: 09.09.2003 / 11.09.2003
SONDAJ KOTU / Elevation	: 849.967 m.	KOORDİNAT / Coordinate (N-S) y	: 487 298.945
SONDAJ MAK.&YÖNT./D.Rig & Met.	: MD B53-AUGER / ROTARY	KOORDİNAT / Coordinate (E-W) x	: 4 423 994.207

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	7	5	7	12	12	**YAPAY DOLGU :** Killi çakıllı **KUM**. Yer yer kiremit ve seramik parçaları içerir.							
2															
3	SPT-2	3.00 3.45	4	6	9	15	15								
4								4.00 m							
	SPT-3	4.50 4.72	16	$\frac{50}{7}$	-	R	R	Gri renkli, orta-çok sıkı, kumlu **ÇAKIL**. İnce-iri, sert, köşeli-yarı köşeli; %35-45 ince-iri, sert kumlu; eser ince malzemeli.							
5															
6															

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.	Highly 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.Loos
N : 3-4	YUMUŞAK	Soft	N : 5-10	GEVŞEK	Loose
N : 5-8	ORTA KATI	M.Stiff	N : 11-30	ORTA SIKI	M.Den
N : 9-15	KATI	Stiff	N : 31-50	SIKI	Dense
N : 16-30	ÇOK KATI	V.Stiff	N : >50	ÇOK SIKI	V.Den
N : >30	SERT	Hard			

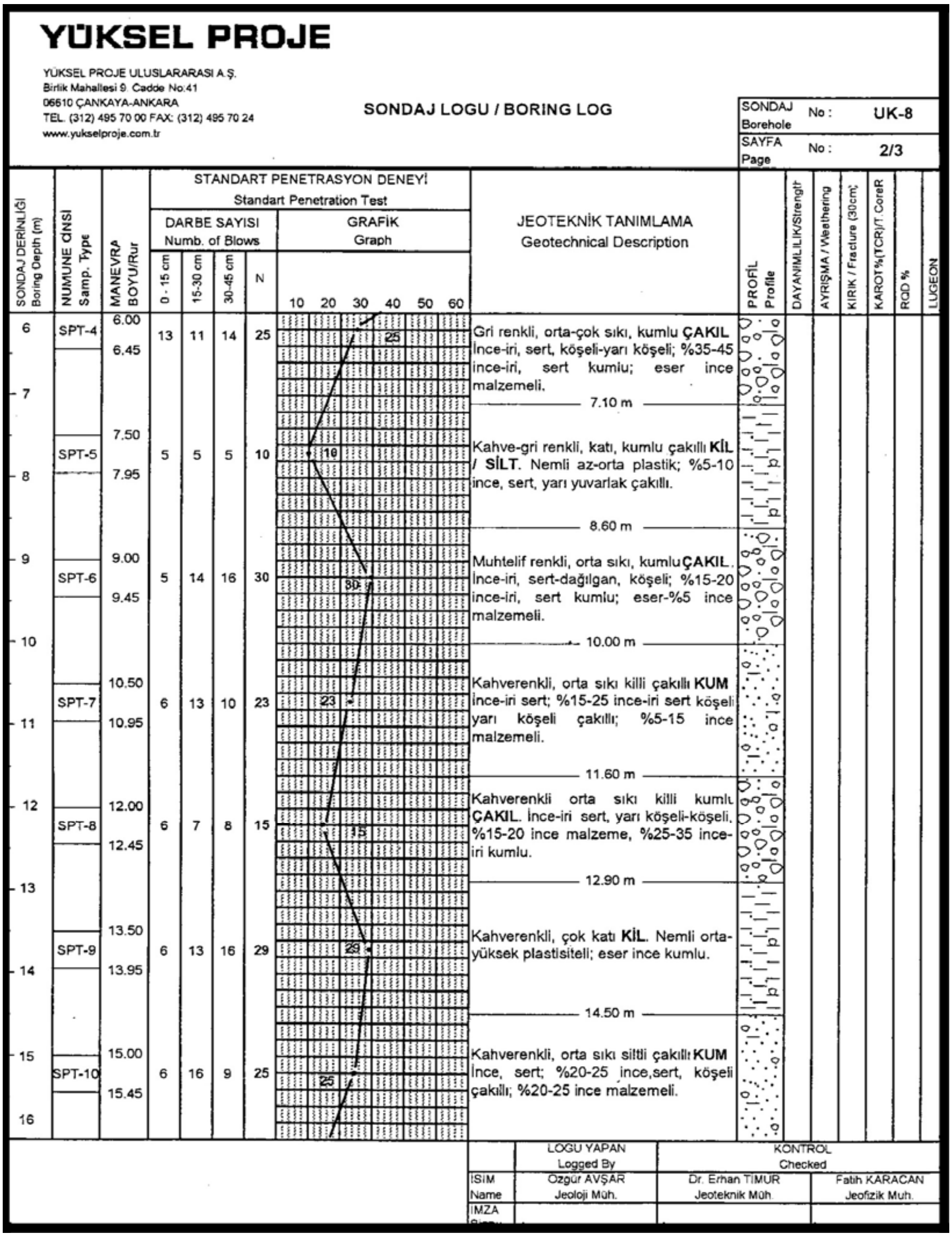
KAYA KALİTESİ TANIMI - RQD			KIRIKLAR - 30 cm / Fractures		
% 0-25	ÇOK ZAYIF	V.Poor	1	SEYREK	Wide (W)
% 25-50	ZAYIF	Poor	1-2	ORTA	Moderate (M)
% 50-75	ORTA	Fair	2-10	SIK	Close (Cl)
% 75-90	İYİ	Good	10-20	ÇOK SIKI	Intense (I)
% 90-100	ÇOK İYİ	Excellent	>20	PARÇALI	Crushed (Cr)

ORANLAR - Proportions					
% 5	PEK AZ	Slightly	% 5	PEK AZ	Slightl
% 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	Örselenmiş Numune Disturbed sample	P	Pressiyometre Deneyi Pressuremeter Test
UD	Örselenmemiş Numune Undisturbed Sample	VS	Veyn Deneyi Vane Shear Test

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Özgür AVŞAR Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Fatih KARACAN Jeofizik Müh.
İMZA Sign			

Continuation of Borehole UK-8



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

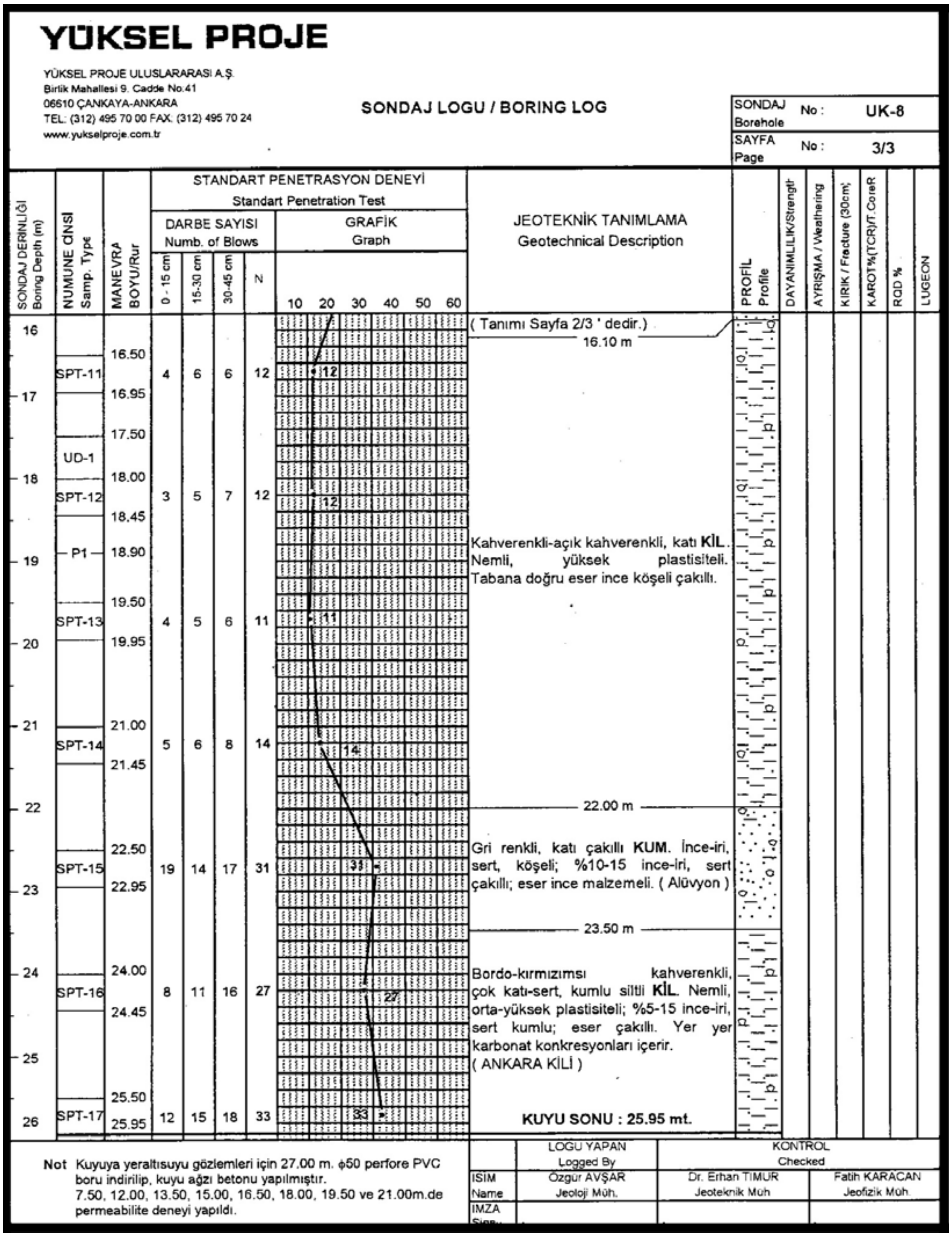
SONDAJ LOGU / BORING LOG

SONDAJ Borehole	No :	UK-8
SAYFA Page	No :	2/3

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Rur	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
6 7	SPT-4	6.00 6.45	13	11	14	25	25	Gri renkli, orta-çok sıkı, kumlu **ÇAKIL** İnce-iri, sert, köşeli-yarı köşeli; %35-45 ince-iri, sert kumlu; eser ince malzemeli. 7.10 m							
8	SPT-5	7.50 7.95	5	5	5	10	10	Kahve-gri renkli, katı, kumlu çakıllı **KİL / SİLT**. Nemli az-orta plastik; %5-10 ince, sert, yarı yuvarlak çakıllı. 8.60 m							
9 10	SPT-6	9.00 9.45	5	14	16	30	30	Muhtelif renkli, orta sıkı, kumlu **ÇAKIL**. İnce-iri, sert-dağılgan, köşeli; %15-20 ince-iri, sert kumlu; eser-%5 ince malzemeli. 10.00 m							
11	SPT-7	10.50 10.95	6	13	10	23	23	Kahverenkli, orta sıkı killi çakıllı **KUM** İnce-iri sert; %15-25 ince-iri sert köşeli yarı köşeli çakıllı; %5-15 ince malzemeli. 11.60 m							
12 13	SPT-8	12.00 12.45	6	7	8	15	15	Kahverenkli orta sıkı killi kumlu **ÇAKIL**. İnce-iri sert, yarı köşeli-köşeli, %15-20 ince malzeme, %25-35 ince-iri kumlu. 12.90 m							
14	SPT-9	13.50 13.95	6	13	16	29	29	Kahverenkli, çok katı **KİL**. Nemli orta-yüksek plastisiteli; eser ince kumlu. 14.50 m							
15 16	SPT-10	15.00 15.45	6	16	9	25	25	Kahverenkli, orta sıkı siltli çakıllı **KUM** İnce, sert; %20-25 ince,sert, köşeli çakıllı; %20-25 ince malzemeli.							

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Özgür AVŞAR Jeoloji Müh.	Dr. Erhan TIMUR Jeoteknik Müh.	Fatih KARACAN Jeofizik Müh.
İMZA Sign.			

Continuation of Borehole UK-8



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 : UK-8
SAYFA Page No : 3/3

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Rur	STANDART PENETRASYON DENEYİ Standart Penetration Test – DARBE SAYISI Numb. of Blows 0 - 15 cm	15-30 cm	30-45 cm	N
16						
17	SPT-11	16.50 16.95	4	6	6	12
	UD-1	17.50 18.00				
18	SPT-12	18.00 18.45	3	5	7	12
19	P1	18.90				
20	SPT-13	19.50 19.95	4	5	6	11
21	SPT-14	21.00 21.45	5	6	8	14
22						
23	SPT-15	22.50 22.95	19	14	17	31
24	SPT-16	24.00 24.45	8	11	16	27
25						
26	SPT-17	25.50 25.95	12	15	18	33

GRAFİK Graph: 10 20 30 40 50 60

JEOTEKNİK TANIMLAMA Geotechnical Description

(Tanımı Sayfa 2/3 ' dedir.)

16.10 m

Kahverenkli-açık kahverenkli, katı **KİL**. Nemli, yüksek plastisiteli. Tabana doğru eser ince köşeli çakıllı.

22.00 m

Gri renkli, katı çakıllı **KUM**. İnce-iri, sert, köşeli; %10-15 ince-iri, sert çakıllı; eser ince malzemeli. (Alüvyon)

23.50 m

Bordo-kırmızımsı kahverenkli, çok katı-sert, kumlu siltli **KİL**. Nemli, orta-yüksek plastisiteli; %5-15 ince-iri, sert kumlu; eser çakıllı. Yer yer karbonat konkresyonları içerir. (ANKARA KİLİ)

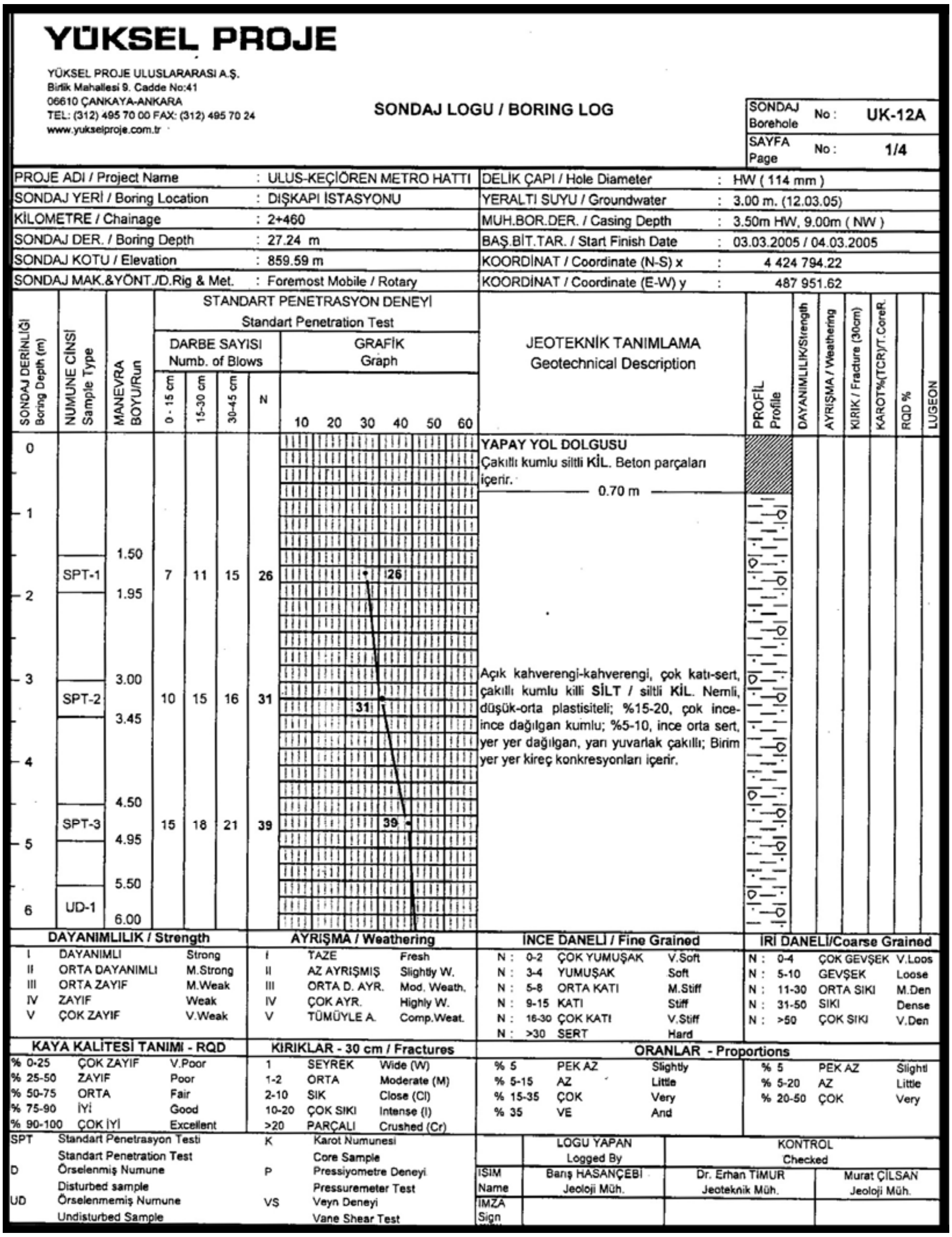
KUYU SONU : 25.95 mt.

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

Not Kuyuya yeraltısuyu gözlemleri için 27.00 m. ϕ50 perfore PVC boru indirilip, kuyu ağzı betonu yapılmıştır.
7.50, 12.00, 13.50, 15.00, 16.50, 18.00, 19.50 ve 21.00m.de permeabilite deneyi yapıldı.

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Özgür AVŞAR Jeoloji Müh.	Dr. Erhan TIMUR Jeoteknik Müh	Fatih KARACAN Jeofizik Müh.
IMZA Sign.			

C.16. Borehole UK-12A



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 :	**UK-12A**
SAYFA Page	No :	**1/4**

PROJE ADI / Project Name	: ULUS-KEÇİÖREN METRO HATTI	DELİK ÇAPI / Hole Diameter	: HW (114 mm)
SONDAJ YERİ / Boring Location	: DIŞKAPI İSTASYONU	YERALTI SUYU / Groundwater	: 3.00 m. (12.03.05)
KİLOMETRE / Chainage	: 2+460	MUH.BOR.DER. / Casing Depth	: 3.50m HW, 9.00m (NW)
SONDAJ DER. / Boring Depth	: 27.24 m	BAŞ.BİT.TAR. / Start Finish Date	: 03.03.2005 / 04.03.2005
SONDAJ KOTU / Elevation	: 859.59 m	KOORDİNAT / Coordinate (N-S) x	: 4 424 794.22
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Foremost Mobile / Rotary	KOORDİNAT / Coordinate (E-W) y	: 487 951.62

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								**YAPAY YOL DOLGUSU** Çakıllı kumlu siltli **KİL**. Beton parçaları içerir. 0.70 m							
1								Açık kahverengi-kahverengi, çok katı-sert, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, düşük-orta plastisiteli; %15-20, çok ince-ince dağılgan kumlu; %5-10, ince orta sert, yer yer dağılgan, yarı yuvarlak çakıllı; Birim yer yer kireç konkresyonları içerir.							
2	SPT-1	1.50 1.95	7	11	15	26	26								
3	SPT-2	3.00 3.45	10	15	16	31	31								
4															
5	SPT-3	4.50 4.95	15	18	21	39	39								
6	UD-1	5.50 6.00													

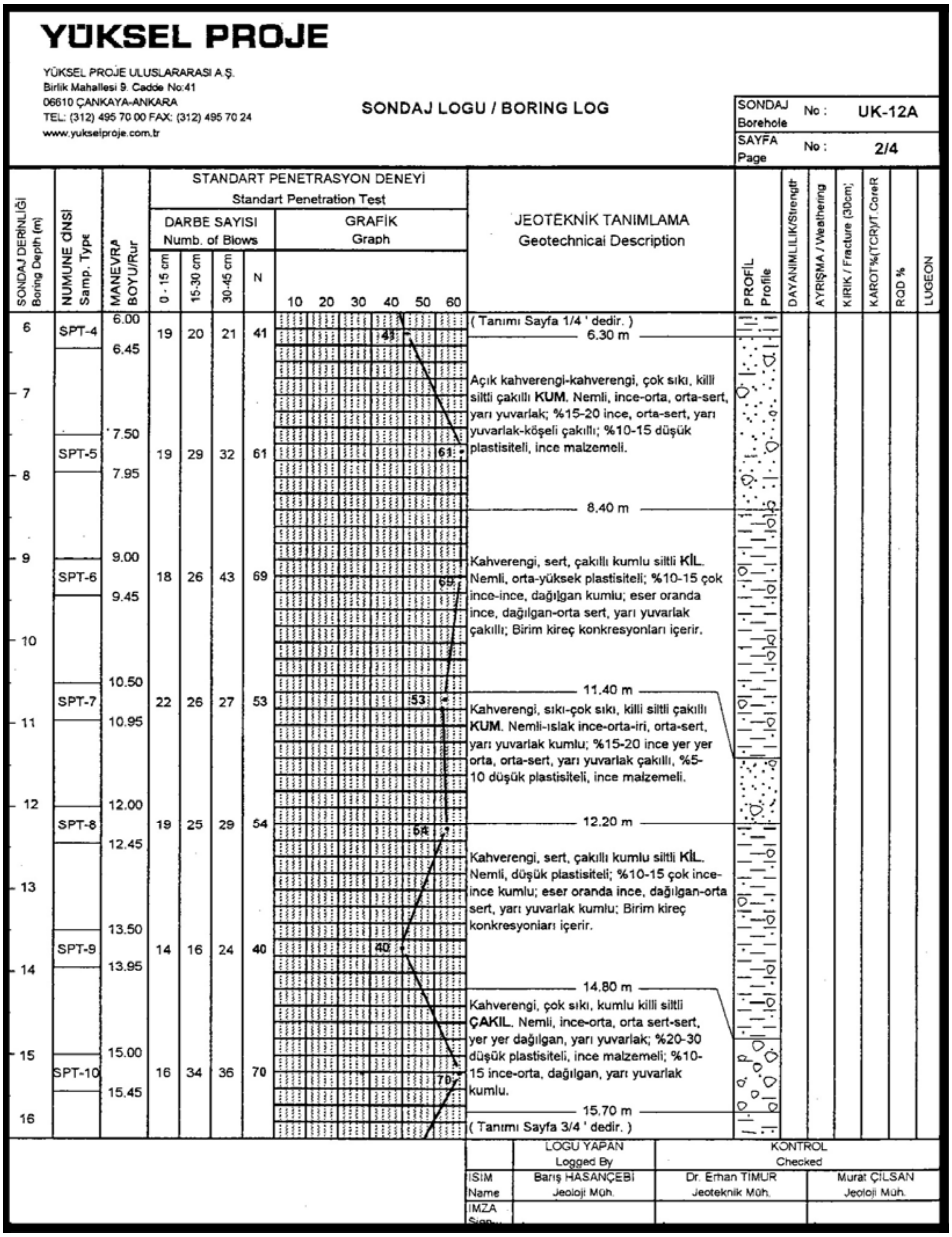
DAYANIMLILIK / Strength			AYRIŞMA / Weathering			İNCE DANELİ / Fine Grained			İRİ DANELİ/Coarse Grained		
I	DAYANIMLI	Strong	I	TAZE	Fresh	N : 0-2	ÇOK YUMUŞAK	V.Soft	N : 0-4	ÇOK GEVŞEK	V.Loos
II	ORTA DAYANIMLI	M.Strong	II	AZ AYRIŞMIŞ	Slightly W.	N : 3-4	YUMUŞAK	Soft	N : 5-10	GEVŞEK	Loose
III	ORTA ZAYIF	M.Weak	III	ORTA D. AYR.	Mod. Weath.	N : 5-8	ORTA KATI	M.Stiff	N : 11-30	ORTA SIKI	M.Den
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.Den
						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	Slightl
% 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
D	Örselenmiş Numune Disturbed sample	P	Pressiyometre Deneyi Pressuremeter Test
UD	Örselenmemiş Numune Undisturbed Sample	VS	Veyn Deneyi Vane Shear Test

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇİLSAN Jeoloji Müh.
İMZA Sign			

Continuation of Borehole UK-12A



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 :	UK-12A
SAYFA Page	No :	2/4

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Rur	STANDART PENETRASYON DENEYİ Standart Penetration Test: DARBE SAYISI Numb. of Blows 0 - 15 cm	15-30 cm	30-45 cm	N
6	SPT-4	6.00 6.45	19	20	21	41
7						
	SPT-5	7.50 7.95	19	29	32	61
8						
9	SPT-6	9.00 9.45	18	26	43	69
10						
	SPT-7	10.50 10.95	22	26	27	53
11						
12	SPT-8	12.00 12.45	19	25	29	54
13						
	SPT-9	13.50 13.95	14	16	24	40
14						
15	SPT-10	15.00 15.45	16	34	36	70
16						

JEOTEKNİK TANIMLAMA
Geotechnical Description

(Tanımı Sayfa 1/4 ' dedir.)

6.30 m

Açık kahverengi-kahverengi, çok sıkı, killi siltli çakıllı **KUM**. Nemli, ince-orta, orta-sert, yarı yuvarlak; %15-20 ince, orta-sert, yarı yuvarlak-köşeli çakıllı; %10-15 düşük plastisiteli, ince malzemeli.

8.40 m

Kahverengi, sert, çakıllı kumlu siltli **KİL**. Nemli, orta-yüksek plastisiteli; %10-15 çok ince-ince, dağılgan kumlu; eser oranda ince, dağılgan-orta sert, yarı yuvarlak çakıllı; Birim kireç konkresyonları içerir.

11.40 m

Kahverengi, sıkı-çok sıkı, killi siltli çakıllı **KUM**. Nemli-ıslak ince-orta-iri, orta-sert, yarı yuvarlak kumlu; %15-20 ince yer yer orta, orta-sert, yarı yuvarlak çakıllı, %5-10 düşük plastisiteli, ince malzemeli.

12.20 m

Kahverengi, sert, çakıllı kumlu siltli **KİL**. Nemli, düşük plastisiteli; %10-15 çok ince-ince kumlu; eser oranda ince, dağılgan-orta sert, yarı yuvarlak kumlu; Birim kireç konkresyonları içerir.

14.80 m

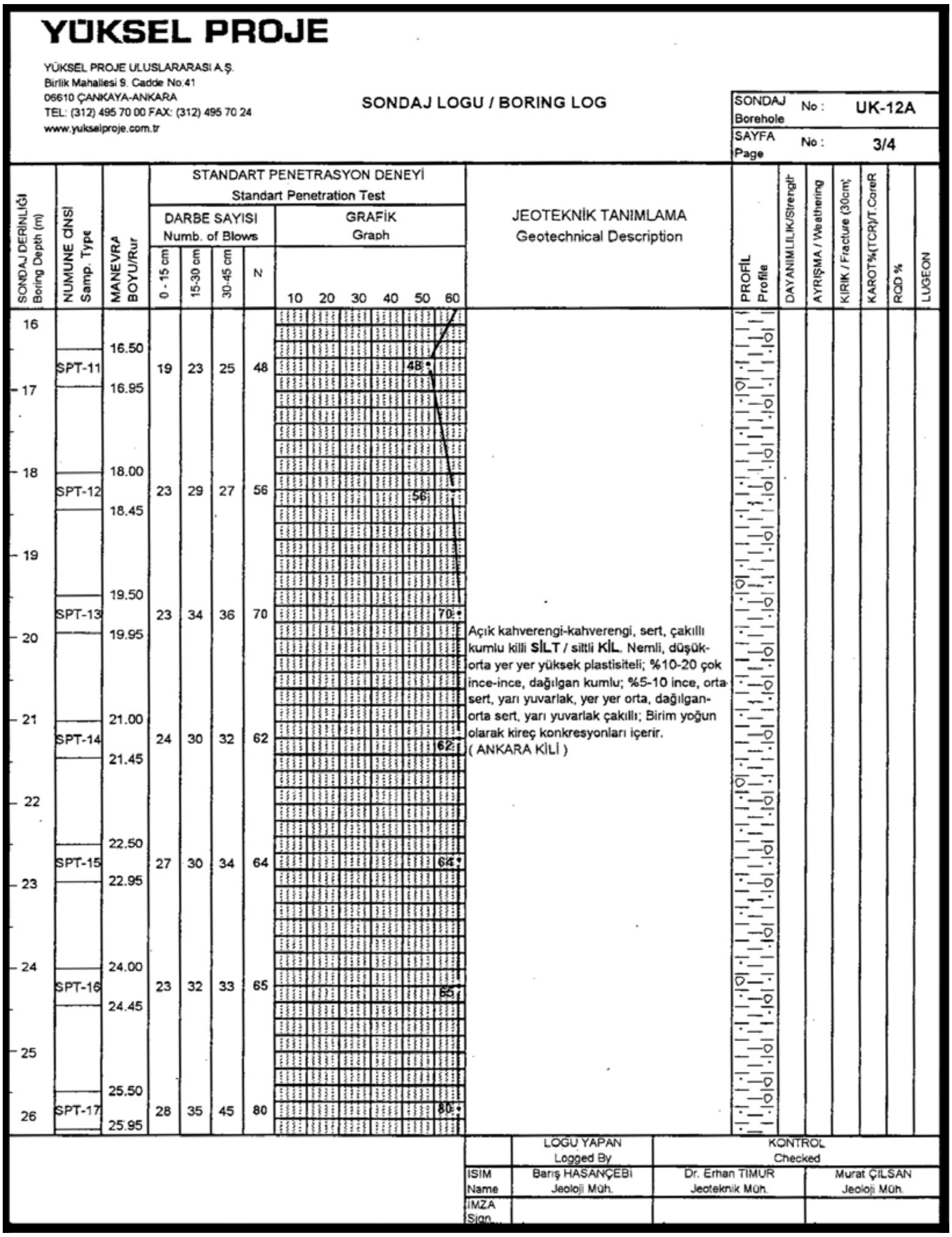
Kahverengi, çok sıkı, kumlu killi siltli **ÇAKIL**. Nemli, ince-orta, orta sert-sert, yer yer dağılgan, yarı yuvarlak; %20-30 düşük plastisiteli, ince malzemeli; %10-15 ince-orta, dağılgan, yarı yuvarlak kumlu.

15.70 m

(Tanımı Sayfa 3/4 ' dedir.)

	LOGU YAPAN Logged By	KONTROL Checked	
ISIM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TIMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
IMZA Sign.			

Continuation of Borehole UK-12A



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 : UK-12A
SAYFA Page No : 3/4

SONDAJ DERİNLİĞİ Boring Depth (m)	NUMUNE CİNSİ Samp. Type	MANEVRA BOYU/Rur	0 - 15 cm	15-30 cm	30-45 cm	N
16						
		16.50				
	SPT-11		19	23	25	48
17		16.95				
18		18.00				
	SPT-12		23	29	27	56
		18.45				
19						
		19.50				
	SPT-13		23	34	36	70
20		19.95				
21		21.00				
	SPT-14		24	30	32	62
		21.45				
22						
		22.50				
	SPT-15		27	30	34	64
23		22.95				
24		24.00				
	SPT-16		23	32	33	65
		24.45				
25						
		25.50				
26	SPT-17	25.95	28	35	45	80

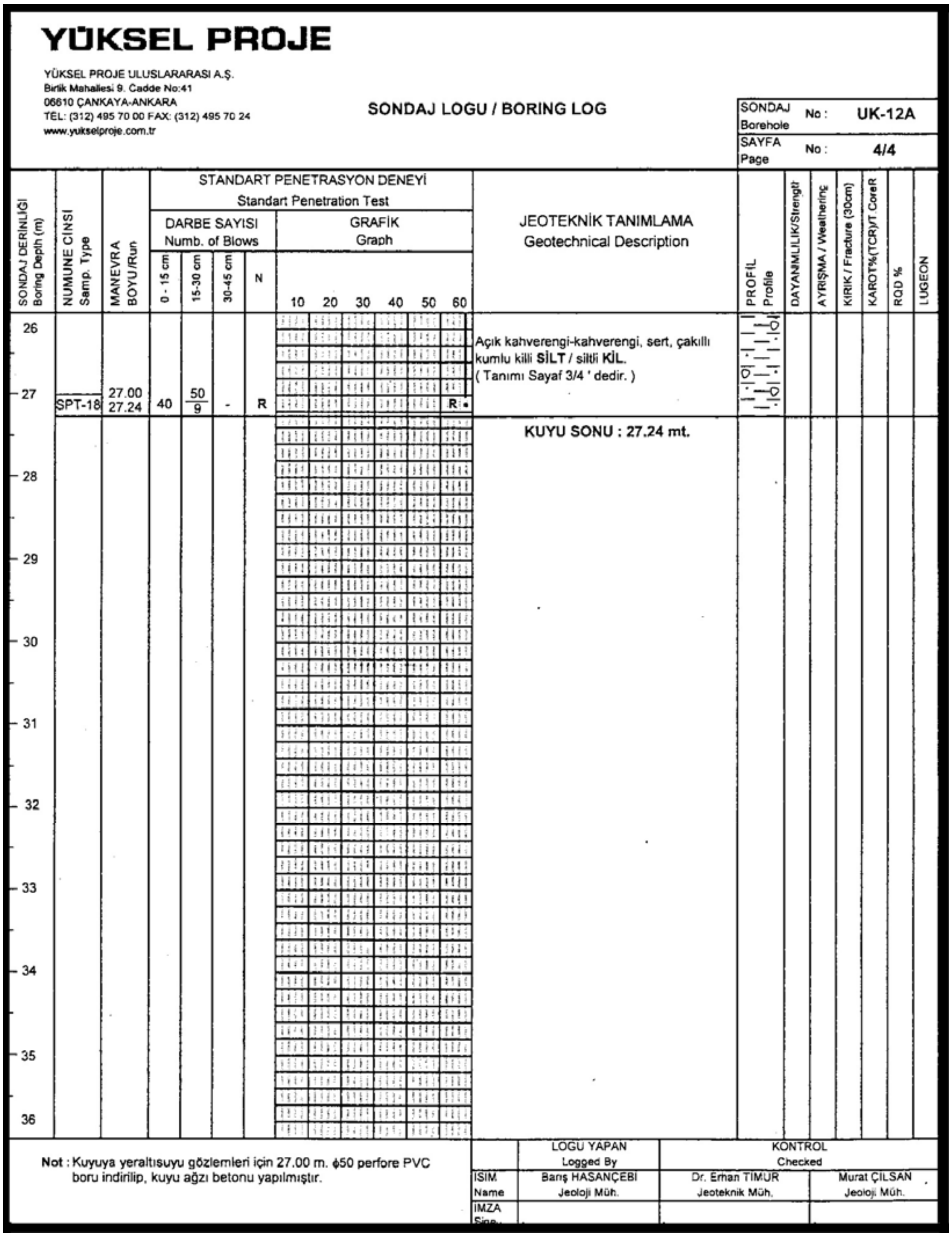
STANDART PENETRASYON DENEYİ / Standart Penetration Test — DARBE SAYISI / Numb. of Blows — GRAFİK / Graph

JEOTEKNİK TANIMLAMA
Geotechnical Description

Açık kahverengi-kahverengi, sert, çakıllı kumlu killi **SİLT** / siltli **KİL**. Nemli, düşük-orta yer yer yüksek plastisiteli; %10-20 çok ince-ince, dağılgan kumlu; %5-10 ince, orta-sert, yarı yuvarlak, yer yer orta, dağılgan-orta sert, yarı yuvarlak çakıllı; Birim yoğun olarak kireç konkresyonları içerir.
(ANKARA KİLİ)

	LOGU YAPAN Logged By	KONTROL Checked	
İSIM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TIMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
İMZA Sign.			

Continuation of Borehole UK-12A



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

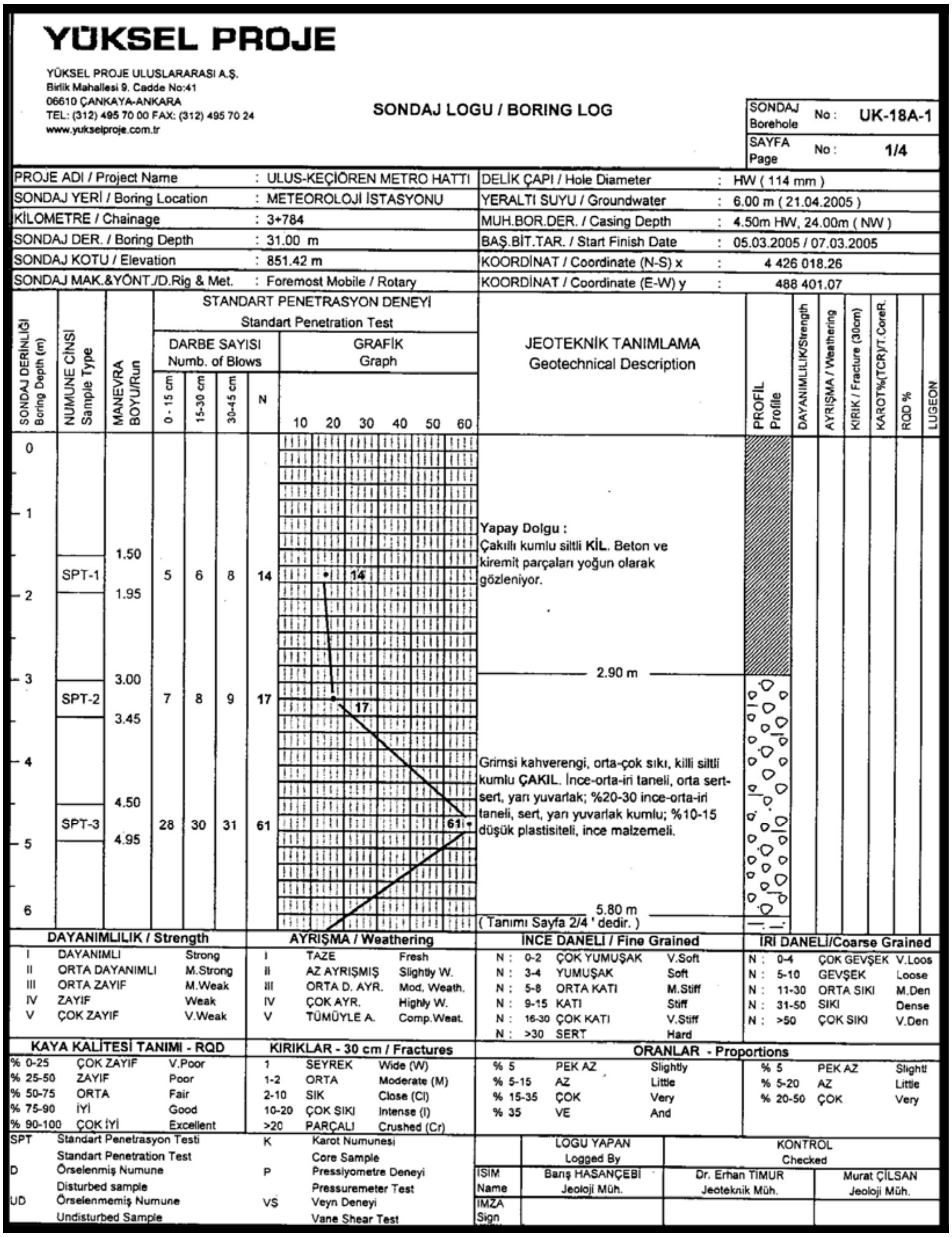
SONDAJ Borehole No : **UK-12A**
SAYFA Page No : **4/4**

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								Açık kahverengi-kahverengi, sert, çakıllı kumlu killi **SİLT** / siltli **KİL**. (Tanımı Sayaf 3/4 ' dedir.)							
27	SPT-18	27.00 27.24	40	$\frac{50}{9}$	-	R	R								
								KUYU SONU : 27.24 mt.							
28															
29															
30															
31															
32															
33															
34															
35															
36															

Not : Kuyuya yeraltısuyu gözlemleri için 27.00 m. ϕ50 perfore PVC boru indirilip, kuyu ağzı betonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked	
ISIM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
IMZA Sign.			

C.17. Borehole UK-18A-1



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 :	UK-18A-1
SAYFA Page	No :	1/4

PROJE ADI / Project Name	: ULUS-KEÇİÖREN METRO HATTI	DELİK ÇAPI / Hole Diameter	: HW (114 mm)
SONDAJ YERİ / Boring Location	: METEOROLOJİ İSTASYONU	YERALTI SUYU / Groundwater	: 6.00 m (21.04.2005)
KİLOMETRE / Chainage	: 3+784	MUH.BOR.DER. / Casing Depth	: 4.50m HW, 24.00m (NW)
SONDAJ DER. / Boring Depth	: 31.00 m	BAŞ.BİT.TAR. / Start Finish Date	: 05.03.2005 / 07.03.2005
SONDAJ KOTU / Elevation	: 851.42 m	KOORDİNAT / Coordinate (N-S) x	: 4 426 018.26
SONDAJ MAK.&YÖNT./D.Rig & Met.	: Foremost Mobile / Rotary	KOORDİNAT / Coordinate (E-W) y	: 488 401.07

STANDART PENETRASYON DENEYİ
Standart Penetration Test

NUMUNE CİNSİ Sample Type	MANEVRA BOYU/Run	DARBE SAYISI Numb. of Blows 0 - 15 cm	15-30 cm	30-45 cm	N
SPT-1	1.50 1.95	5	6	8	14
SPT-2	3.00 3.45	7	8	9	17
SPT-3	4.50 4.95	28	30	31	61

JEOTEKNİK TANIMLAMA
Geotechnical Description

Yapay Dolgu :
Çakıllı kumlu siltli **KİL**. Beton ve kiremit parçaları yoğun olarak gözleniyor.

2.90 m

Grimsi kahverengi, orta-çok sıkı, killi siltli kumlu **ÇAKIL**. İnce-orta-iri taneli, orta sert-sert, yarı yuvarlak; %20-30 ince-orta-iri taneli, sert, yarı yuvarlak kumlu; %10-15 düşük plastisiteli, ince malzemeli.

5.80 m
(Tanımı Sayfa 2/4 ' dedir.)

DAYANIMLILIK / Strength		
I	DAYANIMLI	Strong
II	ORTA DAYANIMLI	M.Strong
III	ORTA ZAYIF	M.Weak
IV	ZAYIF	Weak
V	ÇOK ZAYIF	V.Weak

AYRIŞMA / Weathering		
I	TAZE	Fresh
II	AZ AYRIŞMIŞ	Slightly W.
III	ORTA D. AYR.	Mod. Weath.
IV	ÇOK AYR.	Highly W.
V	TÜMÜYLE A.	Comp.Weat.

İNCE DANELİ / Fine Grained			
N :	0-2	ÇOK YUMUŞAK	V.Soft
N :	3-4	YUMUŞAK	Soft
N :	5-8	ORTA KATI	M.Stiff
N :	9-15	KATI	Stiff
N :	16-30	ÇOK KATI	V.Stiff
N :	>30	SERT	Hard

İRİ DANELİ/Coarse Grained			
N :	0-4	ÇOK GEVŞEK	V.Loos
N :	5-10	GEVŞEK	Loose
N :	11-30	ORTA SIKI	M.Den
N :	31-50	SIKI	Dense
N :	>50	ÇOK SIKI	V.Den

KAYA KALİTESİ TANIMI - RQD		
% 0-25	ÇOK ZAYIF	V.Poor
% 25-50	ZAYIF	Poor
% 50-75	ORTA	Fair
% 75-90	İYİ	Good
% 90-100	ÇOK İYİ	Excellent

KIRIKLAR - 30 cm / Fractures		
1	SEYREK	Wide (W)
1-2	ORTA	Moderate (M)
2-10	SIK	Close (Cl)
10-20	ÇOK SIKI	Intense (I)
>20	PARÇALI	Crushed (Cr)

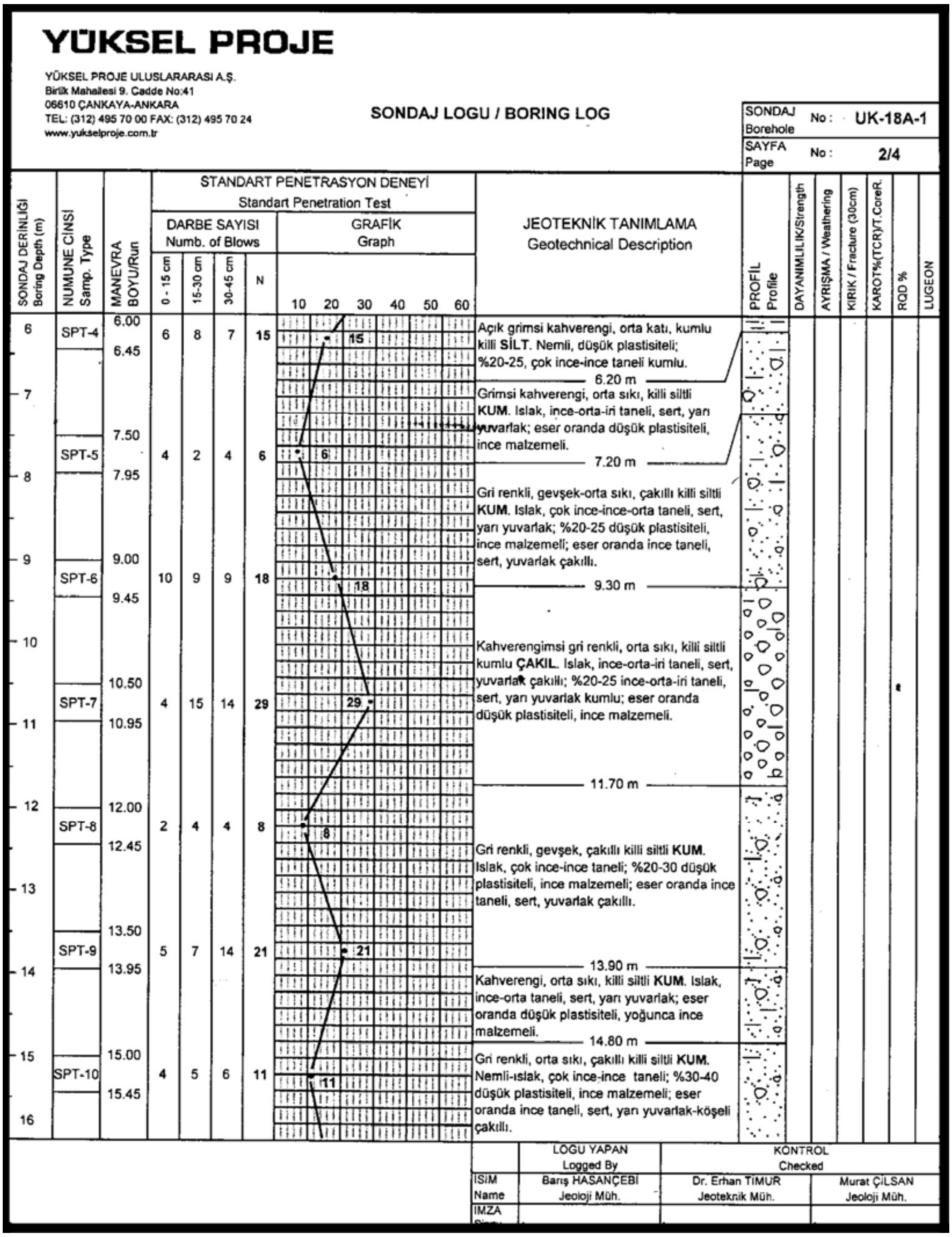
ORANLAR - Proportions

% 5	PEK AZ	Slightly	% 5	PEK AZ	Slight!
% 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	Örselenmiş Numune Disturbed sample	P	Pressiyometre Deneyi Pressuremeter Test
UD	Örselenmemiş Numune Undisturbed Sample	VS	Veyn Deneyi Vane Shear Test

	LOGU YAPAN Logged By	KONTROL Checked	
ISIM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇİLSAN Jeoloji Müh.
IMZA Sign			

Continuation of Borehole UK-18A-1



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 : UK-18A-1
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
6	SPT-4	6.00 6.45	6	8	7	15
7						
	SPT-5	7.50 7.95	4	2	4	6
8						
9	SPT-6	9.00 9.45	10	9	9	18
10						
	SPT-7	10.50 10.95	4	15	14	29
11						
12	SPT-8	12.00 12.45	2	4	4	8
13						
	SPT-9	13.50 13.95	5	7	14	21
14						
15	SPT-10	15.00 15.45	4	5	6	11
16						

JEOTEKNİK TANIMLAMA / Geotechnical Description

Açık grimsi kahverengi, orta katı, kumlu killi **SİLT**. Nemli, düşük plastisiteli; %20-25, çok ince-ince taneli kumlu.

6.20 m

Grimsi kahverengi, orta sıkı, killi siltli **KUM**. Islak, ince-orta-iri taneli, sert, yarı yuvarlak; eser oranda düşük plastisiteli, ince malzemeli.

7.20 m

Gri renkli, gevşek-orta sıkı, çakıllı killi siltli **KUM**. Islak, çok ince-ince-orta taneli, sert, yarı yuvarlak; %20-25 düşük plastisiteli, ince malzemeli; eser oranda ince taneli, sert, yuvarlak çakıllı.

9.30 m

Kahverengimsi gri renkli, orta sıkı, killi siltli kumlu **ÇAKIL**. Islak, ince-orta-iri taneli, sert, yuvarlak çakıllı; %20-25 ince-orta-iri taneli, sert, yarı yuvarlak kumlu; eser oranda düşük plastisiteli, ince malzemeli.

11.70 m

Gri renkli, gevşek, çakıllı killi siltli **KUM**. Islak, çok ince-ince taneli; %20-30 düşük plastisiteli, ince malzemeli; eser oranda ince taneli, sert, yuvarlak çakıllı.

13.90 m

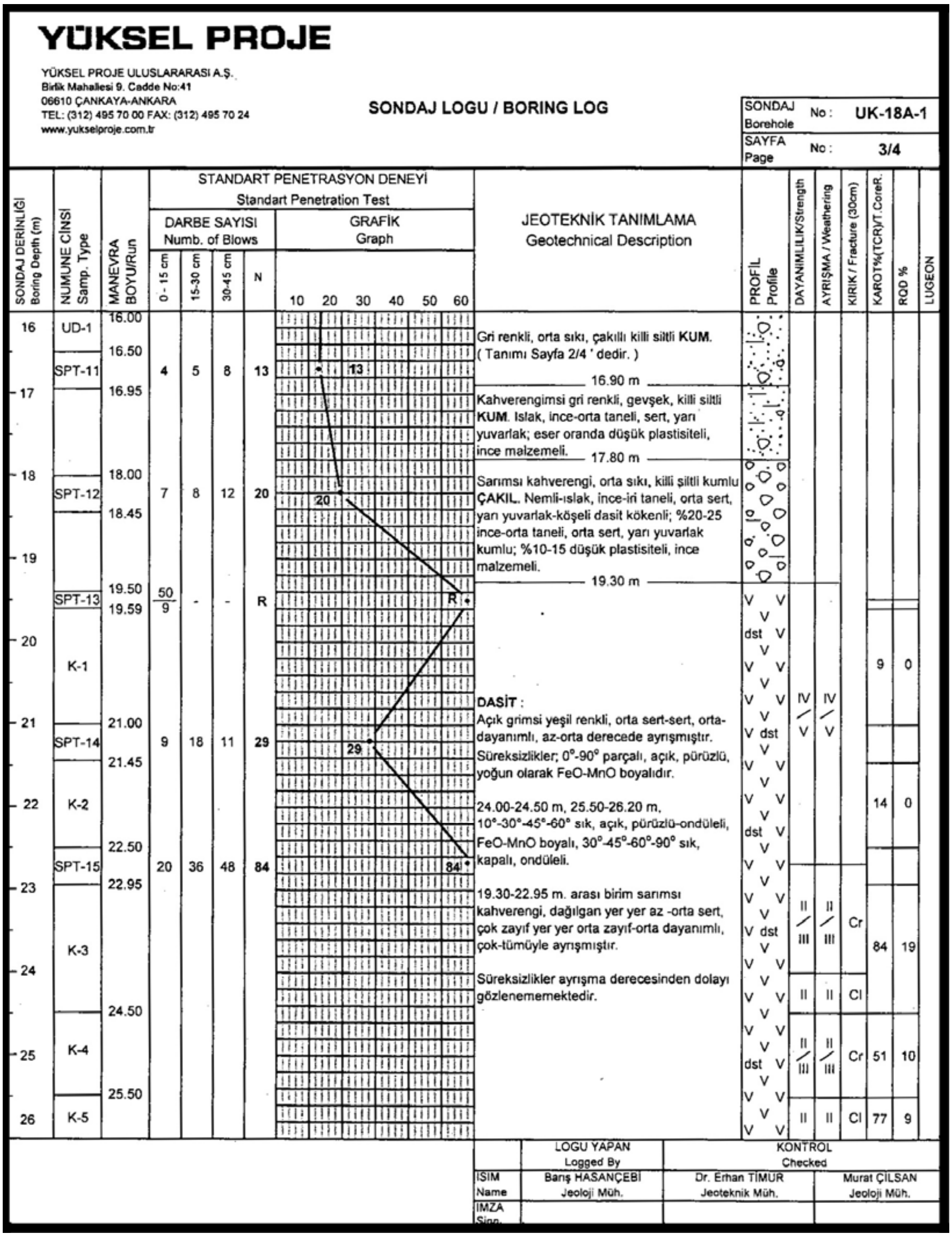
Kahverengi, orta sıkı, killi siltli **KUM**. Islak, ince-orta taneli, sert, yarı yuvarlak; eser oranda düşük plastisiteli, yoğunca ince malzemeli.

14.80 m

Gri renkli, orta sıkı, çakıllı killi siltli **KUM**. Nemli-ıslak, çok ince-ince taneli; %30-40 düşük plastisiteli, ince malzemeli; eser oranda ince taneli, sert, yarı yuvarlak-köşeli çakıllı.

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇİLSAN Jeoloji Müh.
İMZA Signature			

Continuation of Borehole UK-18A-1



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 : UK-18A-1
SAYFA Page No : 3/4

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
16	UD-1	16.00				
		16.50				
	SPT-11		4	5	8	13
17		16.95				
18		18.00				
	SPT-12		7	8	12	20
		18.45				
19						
		19.50	50/9	-	-	R
	SPT-13	19.59				
20						
	K-1					
21		21.00				
	SPT-14		9	18	11	29
		21.45				
22	K-2					
		22.50				
	SPT-15		20	36	48	84
23		22.95				
	K-3					
24						
		24.50				
25	K-4					
		25.50				
26	K-5					

JEOTEKNİK TANIMLAMA
Geotechnical Description

Gri renkli, orta sıkı, çakıllı killi siltli **KUM**.
(Tanımı Sayfa 2/4 ' dedir.)

16.90 m

Kahverengimsi gri renkli, gevşek, killi siltli **KUM**. Islak, ince-orta taneli, sert, yarı yuvarlak; eser oranda düşük plastisiteli, ince malzemeli.

17.80 m

Sarımsı kahverengi, orta sıkı, killi şiltli kumlu **ÇAKIL**. Nemli-ıslak, ince-iri taneli, orta sert, yarı yuvarlak-köşeli dasit kökenli; %20-25 ince-orta taneli, orta sert, yarı yuvarlak kumlu; %10-15 düşük plastisiteli, ince malzemeli.

19.30 m

DASİT :
Açık grimsi yeşil renkli, orta sert-sert, orta-dayanımlı, az-orta derecede ayrışmıştır.
Süreksizlikler; 0°-90° parçalı, açık, pürüzlü, yoğun olarak FeO-MnO boyalıdır.

24.00-24.50 m, 25.50-26.20 m, 10°-30°-45°-60° sık, açık, pürüzlü-ondüleli, FeO-MnO boyalı, 30°-45°-60°-90° sık, kapalı, ondüleli.

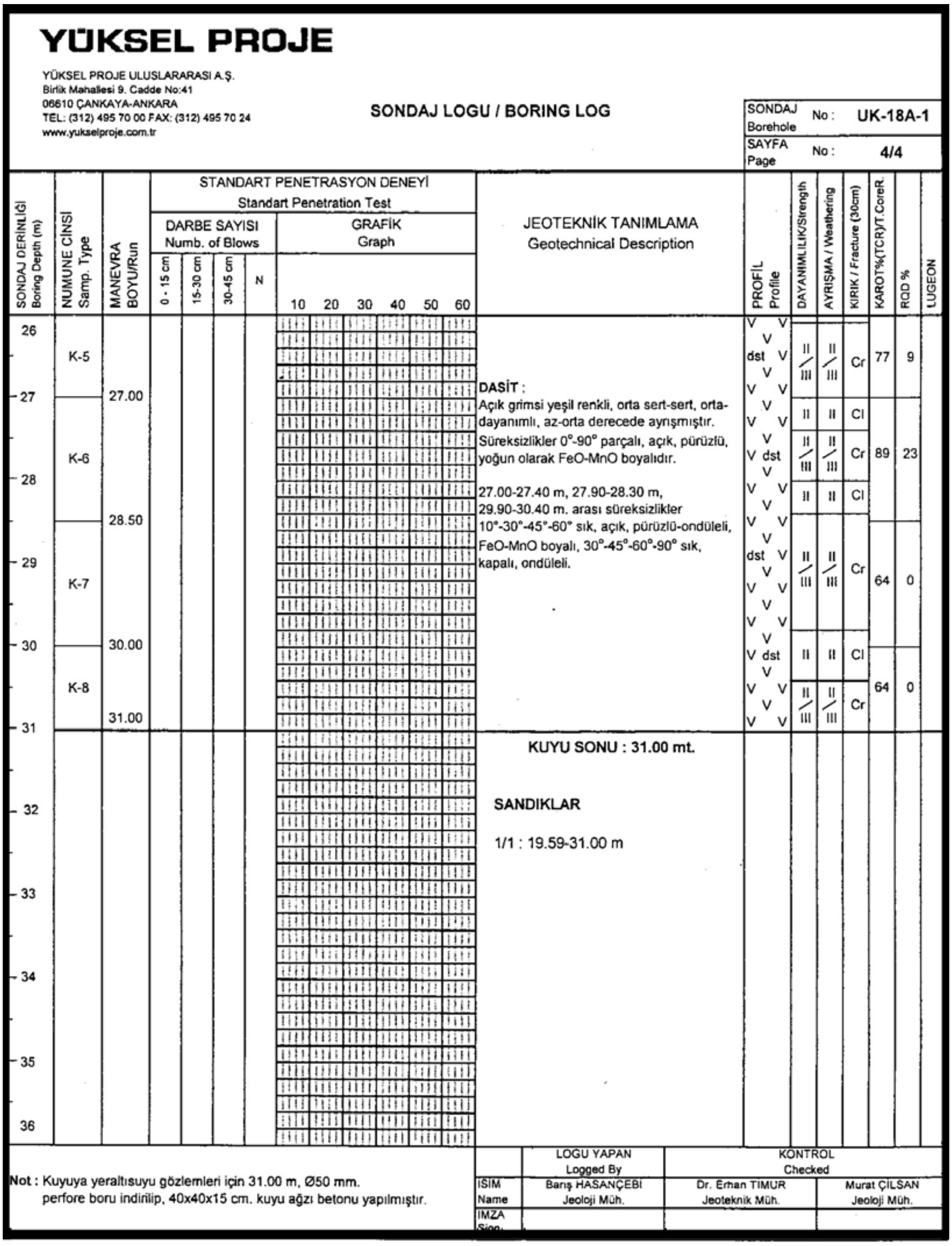
19.30-22.95 m. arası birim sarımsı kahverengi, dağılgan yer yer az -orta sert, çok zayıf yer yer orta zayıf-orta dayanımlı, çok-tümüyle ayrışmıştır.

Süreksizlikler ayrışma derecesinden dolayı gözlenememektedir.

PROFİL Profile	DAYANIMLILIK/Strength	AYRIŞMA / Weathering	KIRIK / Fracture (30cm)	KAROT%(TCR)/T.CoreR.	RQD %	LUGEON
dst				9	0	
dst	IV/V	IV/V				
dst				14	0	
dst	II/III	II/III	Cr	84	19	
	II	II	Cl			
dst	II/III	II/III	Cr	51	10	
	II	II	Cl	77	9	

	LOGU YAPAN Logged By	KONTROL Checked	
ISIM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TİMUR Jeoteknik Müh.	Murat ÇILSAN Jeoloji Müh.
IMZA Sign.			

Continuation of Borehole UK-18A-1



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 : **UK-18A-1**
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-5	27.00						**DASİT :** Açık grimsi yeşil renkli, orta sert-sert, orta-dayanımlı, az-orta derecede ayrışmıştır. Süreksizlikler 0°-90° parçalı, açık, pürüzlü, yoğun olarak FeO-MnO boyalıdır. 27.00-27.40 m, 27.90-28.30 m, 29.90-30.40 m. arası süreksizlikler 10°-30°-45°-60° sık, açık, pürüzlü-ondüleli, FeO-MnO boyalı, 30°-45°-60°-90° sık, kapalı, ondüleli.	V V V dst V V V V	II/III	II/III	Cr	77	9	
27									V V V	II	II	Cl			
	K-6	28.50							V V dst V	II/III	II/III	Cr	89	23	
28									V V V	II	II	Cl			
29	K-7	30.00							V V V dst V V V V V V V	II/III	II/III	Cr	64	0	
30									V V dst V	II	II	Cl			
	K-8	31.00							V V V V V	II/III	II/III	Cr	64	0	
31								**KUYU SONU : 31.00 mt.** **SANDIKLAR** 1/1 : 19.59-31.00 m							
32															
33															
34															
35															
36															

Not : Kuyuya yeraltısuyu gözlemleri için 31.00 m, Ø50 mm. perfore boru indirilip, 40x40x15 cm. kuyu ağzı betonu yapılmıştır.

	LOGU YAPAN Logged By	KONTROL Checked	
İSİM Name	Barış HASANÇEBİ Jeoloji Müh.	Dr. Erhan TIMUR Jeoteknik Müh.	Murat ÇİLSAN Jeoloji Müh.
IMZA Sign.			