DETERMINATION OF TUNNEL SUPPORT SYSTEMS OF BELKAHVE (İZMİR) TUNNEL WITH EMPIRICAL AND NUMERICAL METHODS

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ABSTRACT

DETERMINATION OF TUNNEL SUPPORT SYSTEMS OF BELKAHVE (İZMİR) TUNNEL WITH EMPIRICAL AND NUMERICAL METHODS

Domaniç, Can Murat M.Sc., Department of Geological Engineering Supervisor: Prof. Dr. Tamer Topal June 2016, 287 pages

In this study, determining the geological and geotechnical characteristics of the Belkhave tunnel with a length of 1650 m and width of 16 m along Manisa-İzmir Highway, selecting the appropriate support system and verifying with numerical modeling are aimed.

Limestone and schist are the main lithologies along the Belkahve tunnel. RMR, Q and NATM classification systems are used to classify the rock mass. Appropriate support systems are determined by using these classification methods. In order to verify the determined support systems, 2D finite element analyses are performed to check the stabilities of seven sections through the tunnel route. The primary support systems determined according to RMR, Q and NATM and 4-6 m long bolt with intervals of 1-1.5 m, 10-30 cm shotcrete, steel sets wherever required are recommended. Moreover, numerical analyses are used to check the deformation at different sections of the tunnel and stabilities of the tunnel portals. Based on the analyses performed, tunnel deformations are found to be acceptable with the applied supports, and no slope failure is expected for the portals.

Keywords: Limestone, NATM, Numerical modeling, RMR system, Schist, Q system, tunnel support, Belkahve, Manisa, İzmir.

BELKAHVE (İZMİR) TÜNELİNİN DESTEK SİSTEMLERİNİN AMPİRİK VE SAYISAL YÖNTEMLERLE BELİRLENMESİ

Domaniç, Can Murat Yüksek Lisans, Jeoloji Mühendisliği Bölümü Tez Yöneticisi: Prof. Dr. Tamer Topal Haziran 2016, 287 sayfa

Bu çalışmada, Manisa-İzmir Otoyolu üzerinde bulunan, uzunluğu 1650 m. ve genişliği 16m. olan Belkahve tünelinin, jeolojik ve jeoteknik özelliklerini belirleyip, bu bağlamda, uygun destek sistemleri seçip, sayısal analizler ile sağlamasının yapılması amaçlanmıştır.

Kireçtaşı ve şist, tünel güzergâhı boyunca görülen hâkim birimlerdir. Kaya kütlesinin sınıflandırılması için RMR, Q ve NATM kaya sınıflamaları kullanılmıştır. Uygun destek sistemlerinin belirlenmesi, bu kaya sınıflamaları aracılığı ile yapılmıştır. Belirlenen destek sistemlerinin stabilitesi, tünel güzergâhı boyunca 7 ayrı kesitte 2boyutlu sonlu elemanlar analizi kullanılarak kontrol edilmiştir. RMR, Q ve NATM kaya sınıflamaları ışığında belirlenen ana destek sistemleri için, 4-6 m. boyunda 1-1,5 m. aralıklı bulon,10-30 cm. kalınlığında püskürtme beton ve gerektiğinde kullanılacak olan çelik iksa önerilmiştir. Ek olarak, sayısal analiz yapılarak, tünel güzergâhının değişik kesitlerinde ve tünel giriş çıkış portal bölgelerinde deformasyonlar kontrol edilmiştir. Analiz sonuçlarına göre, destek sistemleri uygulandıktan sonra oluşan deformasyonlar kabul edilebilir mertebelerde olup, portal bölgelerinde herhangi bir şev duraylılık problemi beklenmemektedir.

Anahtar Kelimeler: Kireçtaşı, NATM, Sayısal modelleme, RMR kaya sınıflama sistemi, Şist, Q sistemi, tünel destek, Belkahve, Manisa, İzmir.

(To myself...)

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TABLE OF CONTENTS

ABST	TRACTV
ÖZ	VI
ACK	NOWLEDGEMENTSVIII
TABI	LE OF CONTENTSIX
CHA	PTERS
1.INT	RODUCTION1
1.1	Purpose and Scope1
1.2	Location and Accessibility of the Study Area3
1.3	Climate and Vegetation4
1.4	Methodology4
1.5	Previous Studies5
2.GE	OLOGY 15
2.1	General Geology
2.2	Site Geology and Stratigraphy16
Belk	ahve Formation (Kb) 20
Belk	ahve Limestone Member (Kbk) 20
2.3	Structural Geology22

Fold	ds	22
Joir	nts	22
Fau	ılts	22
2.4	Seismicity of the Tunnel Area	. 24
3.EN	GINEERING GEOLOGY OF THE STUDY AREA	.27
3.1	Field Studies	. 27
3.2	Drillings	. 31
3.3	Hydrogeology of the Tunnel Route	. 33
3.4	Geotechnical Assessment of Formations	. 38
She	ear Zone	38
3.5	Laboratory Tests	. 39
4.RO	OCK MASS CLASSIFICATIONS OF THE ROCKS ALONG THE	
BEL	KAHVE TUNNEL	.45
4.1	Rock Mass Rating Classifications	. 45
4.2	GSI Classification of the Rocks Along the Tunnel	. 56
4.3	Q- Classification of the Rocks Along the Tunnel	. 62
4.4	NATM Classifications	. 65
4.5	Classifications involving stand up time	. 67
5.DE	TERMINATION OF SUPPORT SYSTEMS FOR THE BELKAHVE	
TUN	NEL USING EMPIRICAL METHODS	71

5.1	Support Systems Based on RMR Classification	71
5.2	Support Systems Based on Q system	74
5.3	Support systems depending on NATM	75
6.EST	FIMATION OF THE ROCK MASS STRENGTH PARAMETERS	77
6.1	Estimation of Rock Mass Parameters	77
6.2	Estimation of Deformation Modulus	87
7. TH	E VERIFICATION OF TUNNEL SUPPORT SYSTEMS WITH	
NUM	IERICAL ANALYSIS	. 91
7.1	Determining Support Properties for Numerical Analyses	92
7.2	Steps of Modeling with Finite Element Method	94
7.3	Slope Stability Analyses for Entrance Portal	95
7.4	Stability analyses of the tunnel	. 103
7.5	Slope Stability Analysis for Exit Portal	. 134
7.6	Sensitivity Analyses at Tunnel Section Km:399+700	. 140
7.7	Comparison of the Results Obtained from Numerical Analyses with Field Observations	. 147
DISC	CUSSIONS	151
CON	CLUSIONS AND RECOMMENDATIONS	153
REFI	ERENCES	157
APPI	ENDICES	
BOR	ING LOGS	165

CORE BOX PICTURES	
LABORATORY TEST RESULTS	

LIST OF TABLES

TABLES

Table 1. 1 Rock mass rating system (after Bieniawski, 1989)
Table 1. 2 Guidelines for excavation and support of 10 m span rock tunnels in
accordance with the RMR system (after Bieniawski, 1989)7
Table 1. 3 Classification of individual parameters in the Q system (After Barton et al.
1974)
Table 1. 4 Rock mass classification according to ÖNORM B 2203 (Geoconsult, 1993
and ONORM B 2203, 1994)
Table 3. 1 Classification of discontinuity orientation with respect to tunnel direction
(Bieniawski, 1989)
Table 3. 2 Strike and DIP of the discontinuities at the tunnel entrance portal
Table 3.3 Strike and DIP of the discontinuities at the tunnel exit portal. 30
Table 3.4 Location, coordinates and depth of the boreholes drilled along the tunnel.
Table 3.5 Groundwater levels measured at the boreholes
Table 3.6 Classification of lugeon values (Altuğ, 1971) 36
Table 3. 7 Results of packer tests performed in boreholes. 37
Table 3.8 Laboratory test results of the rocks along the tunnel 39
Table 4. 1 Rock Mass Rating System (After Bieniawski 1989). 45
Table 4. 2 The modified quantitative GSI system suggested by Sönmez and Ulusay
(2002)
Table 4.3 GSI guideline for jointed rocks (Hoek and Marinos, 2001) 60

Table 4. 4 Calculated GSI and RMR values along the tunnel route. 61
Table 4. 5 Comparison of GSI values for different section of the tunnel. 61
Table 4. 6 Q classifications of the rock masses for KM: 399+400 – KM: 399+700(SK-805)
Table 4. 7 Q classifications of the rock masses for KM: 399+700 – KM: 400+080(SK-807)
Table 4. 8 Q classifications of the rock masses for KM: 400+080 – KM: 400+150(SK-804)
Table 4. 9 Q classifications of the rock masses for KM: 400+080 – KM: 400+150(SK-808)
Table 4. 10 Q classifications of the rock masses for KM: 400+520 – KM: 400+750(SK-809)
Table 4. 11 NATM Classification though the tunnel route 66
Table 4. 12 Guideline for ESR value and excavation category. (After Barton et al., 1974)
Table 4. 13 Average stand up time according to rock mass classifications 69
Table 5. 1 Guidelines for excavation method and support system of 10 m span rock

Table 5. 2 Suggested excavation and support systems of for the Belkahve tunnel	
based on RMR classification	72
Table 5. 3 NATM support systems (Specifications of GDH, 2006)	.76

tunnels in accordance with the RMR system (Bieniawski, 1989)......71

Table 6.	1 Engineering	parameters of	of the roc	k mass	obtained f	from Roo	clab	
Table 6. 2	2 List of empir	ical equation	ns for est	imating	the defor	mation n	nodulus	

Table 6. 3 Estimation of deformation modulus of the rock masses along tunnel route				
	9			
Table 6. 4 Summary of the rock mass parameters to be used for numerical analyses.				
	0			

Table 7. 1 Properties of C2 support system 92
Table 7. 2 Properties of C3 support system 92
Table 7. 3 Properties of B3 support system
Table 7. 4 Properties of B2 support system 93
Table 7. 5 Supports used in modeling of the entrance portal
Table 7. 6 Supports used in the modeling of the tunnel at KM: 399+190 105
Table 7. 7 Support used in the modeling of the tunnel at KM: 399+700 111
Table 7. 8 Support used in the modeling of the tunnel at KM: 399+960 115
Table 7. 9 Support used in the modeling
Table 7. 10 Support used in the modeling
Table 7. 11 Support used in the modeling
Table 7. 12 Support used in the modeling of the tunnel at KM: 400+550 129
Table 7. 13 Support used in the modeling of the tunnel at KM:400+820132
Table 7. 14 Supports used in the modeling of the exit portal slope of the tunnel 135
Table 7. 15 Parameters used in the sensitivity analyses with reduction in cohesion of
the rock mass
Table 7. 16 Parameters used in the sensitivity analyses with reduction in internal
friction angle of the rock mass
Table 7. 17 Parameters used in the sensitivity analyses with reduction in deformation
modulus of the rock mass

Table 7. 18 Parameters used in the sensitivity analyses with red	luction in GSI value of
the rock mass	
Table 7. 19 Parameters used in the sensitivity analyses with red coefficient of the rock mass	
Table 7. 20 Measured Deformation values for right tube at the 1	
Table 7. 21 Measured Deformation values for left tube at the B	

LIST OF FIGURES

FIGURES

Figure 1. 1 Typical cross section of the tunnel (Scale:1/50)
Figure 1. 2 Location map of the study area
Figure 1. 3 Estimated support categories based on the Q system (Barton, 2002a)11
Figure 1. 4 The correlation between the classification systems RMR, Q and NATM (ONORM B 2203, 1994)
Figure 2. 1 Generalized stratigraphic columnar section of study area
Figure 2. 2 Geological map of study area (Akdeniz, 1986)
Figure 2. 3 Geological plan view of the tunnel route
Figure 2. 4 Longitudinal geological section of the tunnel route (Vertical scale:1/500
and Horizontal scale:1/2000)
Figure 2. 5 Folded schist layers in the study area
Figure 2. 6 A view of limestone block (Kbk) in the Belkahve formation along the
tunnel route
Figure 2. 7 The active fault map of tunnel route and the study area (MTA,2005) 23
Figure 2. 8 Seismic zonation map of Turkey and the study area (AFAD, 1996)25

Figure 3. 1 The pole concentration contours and dominant discontinuity sets seen a	at
the entrance portal of the tunnel	28
Figure 3. 2 The pole concentration contours and dominant discontinuity sets seen	at
the entrance portal of the tunnel	30

Figure 3. 3 Drilling machine at the middle section of the tunnel route	32
Figure 3. 4. Map showing borehole locations along the tunnel route.	34
Figure 3. 5 The longitudinal geological section of the tunnel with borehole location	S
show	35

Figure 4. 1. Basic and total RMR rating calculation with respect to SK-80247
Figure 4. 2 Basic and total RMR rating calculation with respect to SK-805
Figure 4. 3 Basic and total RMR rating calculation with respect to SK-80749
Figure 4. 4 Basic and total RMR rating calculation for shear zone
Figure 4. 5 Basic and total RMR rating calculation with respect to SK-80451
Figure 4. 6 Basic and total RMR rating calculation with respect to SK-808
Figure 4. 7 Basic and total RMR rating calculation for shear zone
Figure 4. 8 Basic and total RMR rating calculation with respect to SK-80954
Figure 4. 9 Basic and total RMR rating calculation with respect to SK-80655
Figure 4. 10 Basic and total RMR rating calculation with respect to SK-810
Figure 4. 11 Defination of the Q system
Figure 4. 12 Correlations among RMR, Q and NATM (ONORM B 2203, 1994) 66
Figure 4. 13 The relationship between the stand up time of an unsupported
underground excavation span and the CSIR Geomechanics Classification proposed
by Bieniawski (1976)
Figure 5. 1 Support categories based on Q-system (Barton, 2002)74
Figure 7. 1 The mesh and boundary condition of the section94
Figure 7. 2 Slope stability analysis for the side slopes at the entrance portal showing

Figure 7. 3 Slope stability analysis for the side slopes at the entrance portal showing
maximum shear strain under the effect of seismic load of kx=0.20 (3H/2V) (SF:
1.34)
Figure 7. 4 shotcrete and water pipes installed for side slope
Figure 7. 5 wire mesh and shotcrete installation for side slope
Figure 7. 6 Slope stability analysis for the forehead slopes at the entrance portal showing maximum shear strain under static condition (1H/3V) (SF: 1.75)
Figure 7. 7 Slope stability analysis for the forehead slopes at the entrance portal showing maximum shear strain under effect of seismic load of kx=0.20 (1H/3V)
(SF: 1.25)
Figure 7. 9 Another view of the supported forehead slope at the tunnel entrance 102
Figure 7. 10 A general view of the supported slopes at the tunnel entrance
Figure 7. 11 Steps of modeling of the tunnel104
Figure 7. 12 Reduction ratio vs. displacement graph for KM: 399+190 105
Figure 7. 13 Bending moment vs. axial force graph of 20 cm shotcrete, I160 steel sets spaced in 1.5 m intervals and wire mesh for the tunnel entrance
Figure 7. 14 Total displacements around tunnel section at KM: 399+190 107
Figure 7. 15 Total displacement around tunnel section under seismic effect (kx=0.20) at KM: 399+190
Figure 7. 16 Maximum shear strain around tunnel under seismic condition (kx=0.20) at KM: 399+190
Figure 7. 17 A close-up view of the excavation at the Belkahve tunnel entrance 109
Figure 7. 18 A general view of the excavation at the Belkhave tunnel entrance 109
Figure 7. 19 Reduction ratio vs. displacement graph for KM: 399+700 111

Figure 7. 20 Bending moment vs. axial force graph of 20 cm shotcrete, Q221/221
wire mesh for Km: 399+700112
Figure 7. 21 Total displacements around tunnel section KM: 399+700 113
Figure 7. 22 Total displacement around tunnel section under seismic effect (kx=0.20)
KM: 399+700113
Figure 7. 23 Maximum shear strain around tunnel under seismic condition (kx=0.20)
KM: 399+700
Figure 7. 24 Reduction ratio vs. displacement graph at KM: 399+960116
Figure 7. 25 Moment vs. axial force diagram of 15 cm shotcrete and Q221/221 wire
mesh for Km: 399+960
Figure 7. 26 Total displacements around the tunnel section at KM: 399+960 117
Figure 7. 27 Total displacement around tunnel section under seismic effect (kx=0.20)
at KM: 399+960
Figure 7. 28 Maximum shear strain around tunnel under seismic condition (kx=0.20)
at KM: 399+960
Figure 7. 29 Steel sets installation at Belkahve Tunnel
Figure 7. 30 Total displacements around tunnel section at KM:400+200 120
Figure 7. 31 Total displacement around tunnel section under seismic effect (kx=0.20)
at KM:400+200
Figure 7. 32 Maximum shear strain around tunnel under seismic condition (kx=0.20)
121
Figure 7. 33 Total displacements around the tunnel section at KM:400+240 123
Figure 7. 34 Total displacement around the tunnel section under seismic effect
(kx=0.20) at KM:400+240
Figure 7. 35 Maximum shear strain around the tunnel under seismic condition
(kx=0.20) at KM:400+240

Figure 7. 36 Total displacements around the tunnel section at KM:400+500 126
Figure 7. 37 Total displacement around tunnel section under seismic effect (kx=0.20) at KM:400+500
Figure 7. 38 Maximum shear strain around tunnel under seismic condition (kx=0.20) at KM:400+500
Figure 7. 39 Total displacements around the tunnel section at KM: 400+550 129
Figure 7. 40 Total displacement around the tunnel section under seismic effect (kx=0.20) at KM: 400+550
Figure 7. 41 Maximum shear strain around the tunnel under seismic condition (kx=0.20) at KM: 400+550
Figure 7. 42 Total displacements around the tunnel section at KM: 400+820 132
Figure 7. 43 Total displacement around the tunnel section under seismic effect (kx=0.20) at KM: 400+820
Figure 7. 44 Maximum shear strain around the tunnel under seismic condition (kx=0.20) at KM: 400+820
Figure 7. 45 Slope stability analysis of the exit portal side slope showing maximum shear strain under the static condition (3H/2V) (SF: 1. 59)
Figure 7. 46 Slope stability analysis of the exit portal side slope showing maximum shear strain under the effect of seismic load of $kx=0.20$ (3H/2V) (SF: 1.34)
Figure 7. 47 Wire mesh and shotcrete installation for the side slope of the exit portal
Figure 7. 48 Slope stability analysis for the forehead slopes of the exit portal showing maximum shear strain under static condition (1H/3V) (SF: 1.71)
Figure 7. 49 Slope stability analysis of for the forehead slopes of the exit portal showing maximum shear strain under the effect of seismic load of kx=0.20 (1H/3V) (SF: 1.21)

Figure 7. 50 A general view of the forehead slopes after all suggested supports are
installed139
Figure 7. 51 Part of the forehead slope after the supports are installed140
Figure 7. 52 Cohesion-total displacement graph for KM: 399+700 142
Figure 7. 53 Internal friction angle-total displacement graph for KM: 399+700 143
Figure 7. 54 Deformation modulus-total displacement graph for KM: 399+700 144
Figure 7. 55 GSI-total displacement graph for KM: 399+700145
Figure 7. 56 Seismic load coefficient-total displacement graph for KM: 399+700.146

LIST OF ABBREVIATIONS

c	Cohesion (kPa)			
ø	Internal friction angle (°)			
γ	Density of the rock (N/m ³)			
D	Disturbance factor			
E_i	Deformation modulus of intact rock (GPa)			
Erm	Deformation modulus of rock mass (GPa)			
J_a	Joint Alteration Number			
$\mathbf{J}_{\mathbf{n}}$	Joint Set Number			
$\mathbf{J}_{\mathbf{r}}$	Joint Roughness Number			
$J_{\rm w}$	Joint Water Reduction Factor			
SRF	Stress Reduction Factor			
k	Horizontal to vertical stress ratio			
σ_{c}	Uniaxial Compressive Strength (MPa)			
RQD	Rock Quality Designation			
RMR	Rock Mass Rating			
Q	Rock mass quality			
NATM	NATM New Austrian Tunneling Method			
GDH	General Directorate of Highways			
	~			

GWD Groundwater Depth

CHAPTER 1

INTRODUCTION

1.1 Purpose and Scope

Belkahve tunnel is planned to be constructed as part of Manisa – İzmir highway of İstanbul-Bursa-Balıkesir-İzmir Highway project. The length of the Manisa-İzmir highway is 57,698 kilometers with three lanes round-trip (2x3). There is only one tunnel along the highway route. The Belkahve tunnel is located approximately 30 km south east of İzmir, and between kilometers of 399+180 and 400+930. The length of the right tube and left tube of the tunnel is 1650 m 1750m, respectively. The maximum diameter of the tunnel section is 16 m. Belkahve Tunnel has 2.70% longitudinal slope. Through the tunnel route, the distance between the tubes is defined as 24 m which corresponds to 1.5 times of the tunnel width. Figure 1.1. shows the typical cross section of the Belkahve Tunnel. According to GDH, a tunnel with length greater than 1000m, have to contain emergency vehicle passage and emergency pedestrian passages. So, Belkahve Tunnel contains an emergency vehicle passage at the middle part of the tunnel route and two emergency pedestrian passages at two different sections.

The primary objective of this study is the classification of rock masses along the tunnel alignment, determination of engineering parameters and support systems of the tunnel, and verification of the determined support systems

In order to accomplish this task, available data were collected, field and laboratory studies were performed, samples were tested in the laboratory, rock masses were classified, support systems were determined and checked by numerical analyses.

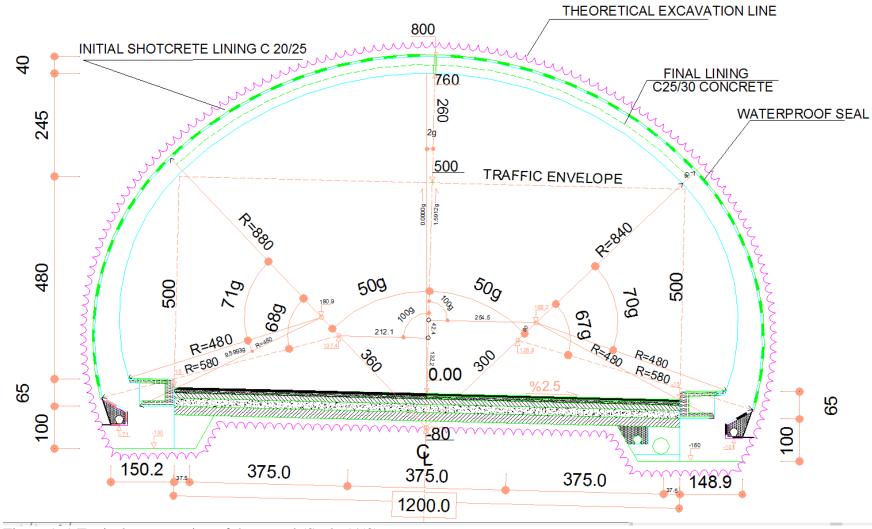


Figure 1. 1 Typical cross section of the tunnel (Scale:1/50)

2

1.2 Location and Accessibility of the Study Area

The location of the study area is in Belkahve pass near Kavaklıdere village and approximately 30 km southeast of İzmir. The tunnel is located between the longitudes N38°28'04" and N38°27'30" and the latitudes E27°19'30" and E27°18'37" (Google Earth Software, 2014). Figure 1.2. shows the location of the study area.

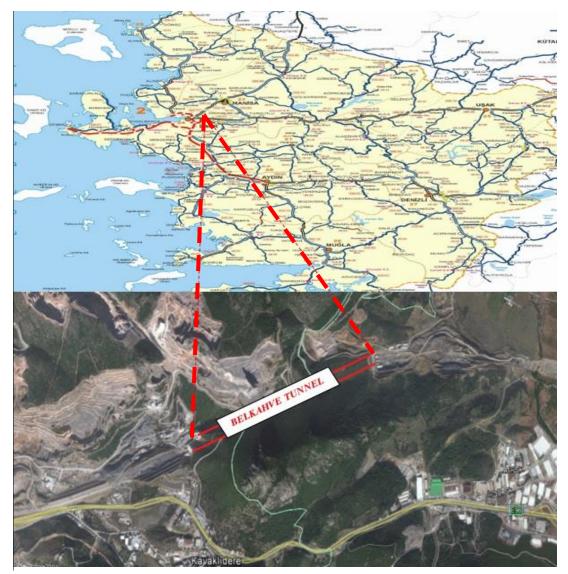


Figure 1. 2 Location map of the study area.

1.3 Climate and Vegetation

In the study area, Mediterranean climate characterized by long, hot and dry summers; and mild to cool, rainy winters, exists. The highest temperature is recorded in August (43°C), the coldest temperature is recorded in January (-6.4°C), with an average temperature of 17.93°C. The mean rainfall in İzmir is about 690.1 mm. 53 % of the annual rainfall occurs in winter. 22% of the annual rainfall occurs in spring, 1% of the annual rainfall occurs in summer and 24% of the annual rainfall occurs in Autumn. Oak is covering the most part of the region. The mean relative humidity is around 57.8 % (MGM, 2015).

1.4 Methodology

Several steps were followed for the purpose of succeeding the task of this thesis. At very first step; literature survey about geology of the study area (Manisa-İzmir), determination of engineering parameters of rock masses, several different rock mass classification systems and rock support applications were reviewed. Second stage of the study involves performing site investigation with the aim of obtaining geological and geotechnical information through the tunnel route. Site investigation program comprises field study which contains drilling of five boreholes by Fugro Sial Company (2012). The main goal of drilling is to identify the subsurface geology, to collect discontinuity conditions data and also to collect the hand specimens from the outcrops. In the third step of the study, laboratory tests were performed by Limit Lab. (2012). These bunch of tests aim to determine the unit weight, uniaxial compressive strength, point load strength and modulus of elasticity of the rock mass along the tunnel route. Following the third step, rock mass classifications and determination of support systems were utilized. In addition, determination of basic input parameters of numerical analyses was completed by determination of rock mass parameters. In the fifth step, slope stability analyses for the tunnel portals were performed. Finally, models of the Belkahve tunnel using computer software (Phase2) were used to verify the determined support systems.

1.5 Previous Studies

Previous reports and maps related to the study area are very important to plan a welldone site investigation programme. The Manisa –İzmir highway had been projected by Yüksel Domanic and Eser engineering companies in 1997. According to the scope of the project, the Belkahve tunnel has not been fully projected. There were several boreholes open at that time to prepare pre-project of the tunnel including only both portals.

Analyzing some very basic concepts of rock mass quality, rock mass strength parameters, how a rock mass around a tunnel distorts and how the support systems works in order to check over this distortion are essential for a good understanding of the process for designing tunnel support.

For over 100 years, the rock mass classification systems have been progressing. Ritter (1879) tried to put forward an experimental remark on tunnel design. Terzaghi (1946) was the first person to mention about the usage of rock mass classification for design of tunnel support. The definitions quoted from his paper are; intact rock, stratified rock, moderately jointed rock, blocky and seamy rock, crushed rock, squeezing rock and swelling rock. Lauffer (1958) introduced a relationship between stand up time for an unsupported span and quality of rock mass. In order to assess the rock mass quality, Deere et al. (1967) built up rock mass quality designation index (RQD). RQD is defined as the ratio of length of rock pieces equal or greater than 10 cm to total length of core run. RMR (rock mass rating system) is a rock mass quality classification. South African Council for Scientific and Industrial Research (CSIR) developed RMR by closely associated with excavation for the mining industry (Bieniawski, 1973).

So, in order to determine rock mass classification, uniaxial compressive strength of intact rock, drilling core quality RQD, spacing of discontinuities, conditions of discontinuities, groundwater condition, are used (see Table 1.1-1.4). RMR system charts which are used to determine the basic RMR value the rock mass and guidelines for excavation and support are presented in Tables 1.1 and 1.2.

	Pa	rameter			Range of values				
					, ,	(01)5			
	Strength of intact rock	Point-load strength index	>10 MPa	4 - 10 MPa	2 - 4 MPa	1 - 2 MPa	For this lo compressi preferred		
1	material	Uniaxial comp. strength	>250 MPa	100 - 250 MPa	50 - 100 MPa	25 - 50 MPa	5-25 MPa	1-5 MPa	<1 MPa
		Rating	15	12	7	4	2	1	0
	Drill o	ore Quality RQD	90% - 100%	75% - 90%	50% - 75%	25% - 50%		< 25%	
2	Rating		20	17	13	8		3	
Spacing of discontinuities > 2 m 0.6 - 2 . m 200 - 600 mm 60		60 - 200 mm	< 60 mm						
3		Rating	20	15	10	8	5		
4	Conditio	n of discontinuities (See E)	Very rough surfaces Not continuous No separation Unweathered wall rock	Slightly rough surfaces Separation < 1 mm Slightly weathered walls	Slightly rough surfaces Separation < 1 mm Highly weathered walls	Slickensided surfaces or Gouge < 5 mm thick or Separation 1-5 mm Continuous	Soft gouge >5 mm thick or Separation > 5 mm Continuous		
		Rating	30	25	20	10		0	
		flow per 10 m innel length (Vm)	None	< 10	10 - 25	25 - 125		> 125	
	· .	loint water press)/ Λajor principal σ)	0	< 0.1	0.1, - 0.2	0.2 - 0.5		> 0.5	
	G	eneral conditions	Completely dry	Damp	Wet	Dripping		Flowing	
		Rating	15	10	7	4		0	
B. RATING	G ADJUS	TMENT FOR DISCONTI	NUITY ORIENTATIONS (See	F)					
Strike and	l dip orient	ations	Very favourable	Favourable	Fair	Unfavourable	Very	Unfavoura	able
	Tunnels & mines Ratings Foundations		0	-2	-5	-10	-12		
Rating			0	-2	-7	-15	-25		
		Slopes	0	-5	-25	-50			
C. ROCK I	MASS CL	ASSES DETERMINED	ROM TOTAL RATINGS		_ .				
Rating			100 ← 81	80 ← 61	60 ← 41	40 ← 21		< 21	
Class num	nber		I	II	Ш	IV		۷	
Descriptior	n		Very good rock	Good rock	Fair rock	Poor rock	Ve	ry poor ro	ck
		OCK CLASSES							
Class num			 		 4 mmm h fan F an an an an	IV	20	V	
	stand-up tir		20 yrs for 15 m span	1 year for 10 m span 300 - 400	1 week for 5 m span 200 - 300	10 hrs for 2.5 m span			span
Cohesion o		ass (KPa) k mass (deg)	>400	300 - 400 35 - 45	200 - 300	100 - 200		< 100 < 15	
	<u> </u>				20-00	10-20		\$ 10	
		(persistence)	DISCONTINUITY condition: < 1 m	s 1-3 m	3 - 10 m	10 - 20 m		> 20 m	• • •
Rating	any rongen	(persietative)	6	4	2	1		0	
	n (aperture	e)	None	< 0.1 mm	0.1 - 1.0 mm	1 - 5 mm		> 5 mm	
Rating Roughness	s		6 Very rough	5 Rough	4 Slightly rough	1 Smooth	S	0 ickensider	1
Rating			6	5	3	1	Slickensided 0		
Infilling (gouge)			None	Hard filling < 5 mm	Hard filling > 5 mm	Soft filling < 5 mm	Soft	filling > 5	mm
Rating Weathering			6 Unweathered	4 Slightly weathered	2 Moderately weathered	2 Highly weathered	D	0 ecompose	d
Ratings	'ð		6	5	3	nigniy weathered		o 0	×
	T OF DIS	CONTINUITY STRIKE A	ND DIP ORIENTATION IN TU						
		Strike perper	dicular to tunnel axis		5	Strike parallel to tunnel axis			
Drive with dip - Dip 45 - 90°		dip - Dip 45 - 90°	Drive with dip -	Dip 20 - 45°	Dip 45 - 90°		Dip 20 - 45	•	
	Ver	y favourable	Favour	able	Very unfavourable		Fair		
Drive against dip - Dip 45-90°		nst dip - Dip 45-90°	Drive against di	o - Dip 20-45°	Dip 0-20 - Irrespective of strike°				
	Fair		Unfavourable		Fair				

Table 1. 1 Rock mass rating system (after Bieniawski, 1989)

* Some conditions are mutually exclusive . For example, if infilling is present, the roughness of the surface will be overshadowed by the influence of the gouge. In such cases use A.4 directly. ** Modified after Wickham et al (1972).

Table 1. 2 Rock tunnels Guideline for excavation and support of 10 m span rock tunnels in accordance to RMR value. (after Bieniawski, 1989)

Rock mass class	Excavation	Rock bolts (20 mm diameter, fully grouted)	Shotcrete	Steel sets
I - Very good rock <i>RMR</i> : 81-100	Full face, 3 m advance.	Generally no support re	quired except sp	ot bolting.
II - Good rock <i>RMR</i> : 61-80	Full face , 1-1.5 m advance. Complete support 20 m from face.	Locally, bolts in crown 3 m long, spaced 2.5 m with occasional wire mesh.	50 mm in crown where required.	None.
III - Fair rock <i>RMR</i> : 41-60	Top heading and bench 1.5-3 m advance in top heading. Commence support after each blast. Complete support 10 m from face.	Systematic bolts 4 m long, spaced 1.5 - 2 m in crown and walls with wire mesh in crown.	50-100 mm in crown and 30 mm in sides.	None.
IV - Poor rock RMR: 21-40	Top heading and bench 1.0-1.5 m advance in top heading. Install support concurrently with excavation, 10 m from face.	Systematic bolts 4-5 m long, spaced 1-1.5 m in crown and walls with wire mesh.	100-150 mm in crown and 100 mm in sides.	Light to medium ribs spaced 1.5 m where required.
V – Very poor rock <i>RMR</i> : < 20	Multiple drifts 0.5-1.5 m advance in top heading. Install support concurrently with excavation. Shotcrete as soon as possible after blasting.	Systematic bolts 5-6 m long, spaced 1-1.5 m in crown and walls with wire mesh. Bolt invert.	150-200 mm in crown, 150 mm in sides, and 50 mm on face.	Medium to heavy ribs spaced 0.75 m with steel lagging and forepoling if required. Close invert.

Barton et al. (1974, 1976) developed the Q system at the Norwegian Geotechnical Institute (NGI). The Q system includes six parameters which are:

RQD, Jn, Jr, Ja, Jw, SRF

Table 1.3 is used to determine each parameter given above.

DESCRIPTION	VALUE	NOTES
1. ROCK QUALITY DESIGNATION	RQD	,
A. Very poor	0 - 25	1. Where RQD is reported or measured as \leq 10 (including 0),
B. Poor	25 - 50	a nominal value of 10 is used to evaluate Q.
C. Fair	50 - 75	
D. Good	75 - 90	2. RQD intervals of 5, i.e. 100, 95, 90 etc. are sufficiently
E. Excellent	90 - 100	accurate.
2. JOINT SET NUMBER	Jn	•
A. Massive, no or few joints	0.5 - 1.0	
B. One joint set	2	
C. One joint set plus random	3	
D. Two joint sets	4	
E. Two joint sets plus random	6	
F. Three joint sets	9	1. For intersections use $(3.0 \times J_n)$
G. Three joint sets plus random	12	
H. Four or more joint sets, random,	15	2. For portals use $(2.0 \times J_n)$
heavily jointed, 'sugar cube', etc.		
J. Crushed rock, earthlike	20	
3. JOINT ROUGHNESS NUMBER a. Rock wall contact	J _r	
b. Rock wall contact before 10 cm shear		
A. Discontinuous joints	4	
B. Rough and irregular, undulating	3	
C. Smooth undulating	2	
D. Slickensided undulating	1.5	1. Add 1.0 if the mean spacing of the relevant joint set is
E. Rough or irregular, planar	1.5	greater than 3 m.
F. Smooth, planar	1.0	
G. Slickensided, planar	0.5	2. J_r = 0.5 can be used for planar, slickensided joints having
c. No rock wall contact when sheared		lineations, provided that the lineations are oriented for
H. Zones containing clay minerals thick	1.0	minimum strength.
enough to prevent rock wall contact	(nominal)	5
J. Sandy, gravely or crushed zone thick	1.0	
enough to prevent rock wall contact	(nominal)	
4. JOINT ALTERATION NUMBER		ár dogroog (opprov.)
a. Rock wall contact	J _a	<pre> ør degrees (approx.) </pre>
A. Tightly healed, hard, non-softening,	0.75	1. Values of ϕr , the residual friction angle,
impermeable filling		are intended as an approximate guide
B. Unaltered joint walls, surface staining only	1.0	25 - 35 to the mineralogical properties of the
C. Slightly altered joint walls, non-softening	2.0	25 - 30 alteration products, if present.
mineral coatings, sandy particles, clay-free		
disintegrated rock, etc.	3.0	20. 25
D. Silty-, or sandy-clay coatings, small clay- fraction (non softening)	5.0	20 - 25
fraction (non-softening)	4.0	0.40
E. Softening or low-friction clay mineral coatings,	4.0	8 - 16
i.e. kaolinite, mica. Also chlorite, talc, gypsum		
and graphite etc., and small quantities of swelling		
clays. (Discontinuous coatings, 1 - 2 mm or less)		

Table 1. 3 Q rock classification system with individual parameters shown (After Barton et al. 1974)

Table1.3 (continued)

4, JOINT ALTERATION NUMBER	, JOINT ALTERATION NUMBER J _a		φr degrees (approx.)		
b. Rock wall contact before 10 cm shear					
F. Sandy particles, clay-free, disintegrating rock etc.	4.0	25 - 30			
G. Strongly over-consolidated, non-softening	6.0	16 - 24			
clay mineral fillings (continuous < 5 mm thick)					
H. Medium or low over-consolidation, softening	8.0	12 - 16			
clay mineral fillings (continuous < 5 mm thick)					
J. Swelling clay fillings, i.e. montmorillonite,	8.0 - 12.0	6 - 12			
(continuous < 5 mm thick). Values of J_a					
depend on percent of swelling clay-size					
particles, and access to water.					
c. No rock wall contact when sheared					
K. Zones or bands of disintegrated or crushed	6.0				
L. rock and clay (see G, H and J for clay	8.0				
M. conditions)	8.0 - 12.0	6 - 24			
N. Zones or bands of silty- or sandy-clay, small	5.0				
clay fraction, non-softening					
O. Thick continuous zones or bands of clay	10.0 - 13.0				
P. & R. (see G.H and J for clay conditions)	6.0 - 24.0				
5. JOINT WATER REDUCTION	J _w	approx. wat	ter pressure (kgf/cm ²)		
A. Dry excavation or minor inflow i.e. < 5 l/m locally	1.0	< 1.0			
B. Medium inflow or pressure, occasional	0.66	1.0 - 2.5			
outwash of joint fillings					
C. Large inflow or high pressure in competent rock with unfilled joints	0.5	2.5 - 10.0	 Factors C to F are crude estimates; increase J_W if drainage installed. 		
D. Large inflow or high pressure	0.33	2.5 - 10.0			
E. Exceptionally high inflow or pressure at blasting, decaying with time	0.2 - 0.1	> 10	Special problems caused by ice formation are not considered.		
F. Exceptionally high inflow or pressure	0.1 - 0.05	> 10			
6. STRESS REDUCTION FACTOR a. Weakness zones intersecting excavation, whi	SRF				
cause loosening of rock mass when tunnel is	excavated				
 Multiple occurrences of weakness zones containing clay or chemically disintegrated rock, very loose surrounding rock any depth) 		10.0	 Reduce these values of SRF by 25 - 50% but only if the relevant shear zones influence do not intersect the excavation 		
B. Single weakness zones containing clay, or chemically dis- tegrated rock (excavation depth < 50 m)		5.0	nor more of the overlation		
C. Single weakness zones containing clay, or chemical	2.5				
tegrated rock (excavation depth > 50 m)					
 D. Multiple shear zones in competent rock (clay free), loose surrounding rock (any depth) 		7.5			
E. Single shear zone in competent rock (clay free). (depth of		5.0			
excavation < 50 m) F. Single shear zone in competent rock (clay free). (dep	2.5				
excavation > 50 m)	2.0				
G. Loose open joints, heavily jointed or 'sugar cube', (a	5.0				
o. Loose open jointe, nearing jointed of Sugar Cube, (a	ing deputy	0.0			

Table 1.3 (continued)

DESCRIPTION		VALUE		NOTES
6. STRESS REDUCTION FACTOR			SRF	
b. Competent rock, rock stress probl	ems			
	σ_c / σ_1	σ _t σ ₁		2. For strongly anisotropic virgin stress field
H. Low stress, near surface	> 200	> 13	2.5	(if measured): when $5 \le \sigma_1/\sigma_3 \le 10$, reduce σ_c
J. Medium stress	200 - 10	13 - 0.66	1.0	to 0.8 σ_c and σ_t to 0.8 σ_t . When $\sigma_1/\sigma_3 > 10$,
K. High stress, very tight structure	10 - 5	0.66 - 0.33	0.5 - 2	reduce σ_r and σ_t to 0.6 σ_r and 0.6 σ_t , where
(usually favourable to stability, may				σ_{c} = unconfined compressive strength, and
be unfavourable to wall stability)				$\sigma_{\rm f}$ = tensile strength (point load) and $\sigma_{\rm f}$ and
L. Mild rockburst (massive rock)	5 - 2.5	0.33 - 0.16	5 - 10	σ_3 are the major and minor principal stresses.
M. Heavy rockburst (massive rock)	< 2.5	< 0.16	10 - 20	3. Few case records available where depth of
c. Squeezing rock, plastic flow of in	competent roc	k		crown below surface is less than span width.
under influence of high rock pressure				Suggest SRF increase from 2.5 to 5 for such
N. Mild squeezing rock pressure			5 - 10	cases (see H).
O. Heavy squeezing rock pressure			10 - 20	
d. Swelling rock, chemical swelling	activity deper	nding on prese	nce of wate	9r
P. Mild swelling rock pressure			5 - 10	
R. Heavy swelling rock pressure			10 - 15	
tables: 1. When borehole core is unavailable, RO	s Quality (Q), tl QD can be estil	he following gu mated from the	number of j	, uld be followed in addition to the notes listed in the joints per unit volume, in which the number of joints powert this number to <i>RQD</i> for the case of clay free
				rm^3 (0 < RQD < 100 for 35 > J_V > 4.5).
				oliation, schistosity, slaty cleavage or bedding etc. I
				omplete joint set. However, if there are few 'joints will be more appropriate to count them as 'random
3. The parameters J_r and J_a (represent	iting shear str	ength) should	be relevant	to the weakest significant joint set or clay filled
				e minimum value of J_{f}/J_{a} is favourably oriented fo
stability, then a second, less favourabl	y oriented joint	set or disconti	nuity may so	metimes be more significant, and its higher value

stability, then a second, less favourably oriented joint set or discontinuity may sometimes be more significant, and its higher value of J_l/J_a should be used when evaluating Q. The value of J_l/J_a should in fact relate to the surface most likely to allow failure to initiate.

- 4. When a rock mass contains clay, the factor SRF appropriate to loosening loads should be evaluated. In such cases the strength of the intact rock is of little interest. However, when jointing is minimal and clay is completely absent, the strength of the intact rock may become the weakest link, and the stability will then depend on the ratio rock-stress/rock-strength. A strongly anisotropic stress field is unfavourable for stability and is roughly accounted for as in note 2 in the table for stress reduction factor evaluation.
- 5. The compressive and tensile strengths (σ_c and σ_t) of the intact rock should be evaluated in the saturated condition if this is appropriate to the present and future in situ conditions. A very conservative estimate of the strength should be made for those rocks that deteriorate when exposed to moist or saturated conditions.

Figure 1.3 shows the support categories with respect to Q system.

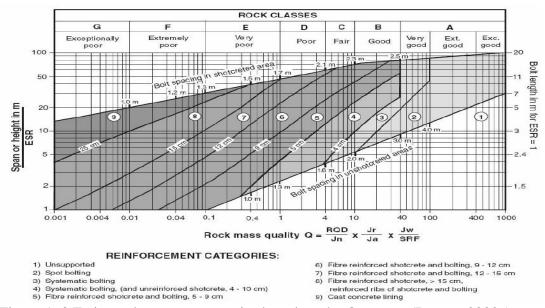


Figure 1. 3 Estimated support categories based on the Q system (Barton, 2002a)

There are some empirical equations in the literature for correlation between Q and RMR values. Most common of these equations is presented by Bieniawski (1989);

 $RMR = 9 * \ln Q + 44$

Another one based on statistics equation is given by Preston (1989);

RMR = 5.9 * ln Q + 43

Today one of the most popular method used in tunnel construction is The New Austrian Tunneling Method (NATM). Between 1957 and 1965 NATM was developed in Austria. Today the name known as NATM was given in London in 1962 to differentiate it from the old Austrian tunneling approach. The main idea behind the NATM which made it this much popular is to use the geological stress of the surrounding rock mass to stabilize the tunnel.

The NATM combines the principles of the behavior of rock masses under load and monitoring the performance of underground construction during construction. The NATM has often been referred to as a "design as you go" approach, by providing an optimized support based on observed ground conditions. Better definition, it can be described as a "design as you monitor" approach, based on observed convergence and divergence in the lining and mapping of prevailing rock conditions.

NATM is based on several features (Bieniawski, 1989) which are;

- Rock mass strength

The method relies on using the surrounding rock mass to support itself as a primary support system, thus rock mass strength is the most important parameter for NATM support system.

- Support system protection

Deformation of the rock must be minimized. For this purpose, a thin layer of shotcrete should be applied right after every span.

- Monitoring

Monitoring the displacements during excavation must be done correctly. This is achieved by installing measurement instruments.

- Flexible support

Since the primary lining is thin and aims to reflect recent strata conditions, additional flexible combination of support elements such as rock bolts, wire mesh are accounted for the support of the tunnel.

- Contractual arrangements

Because the monitoring measurements forms an important part of NATM philosophy, simultaneous changes in supporting and excavation method are possible during construction.

According to NATM, ground is classified qualitatively. The rock mass behavior and its classes are evaluated according to the criteria of Austrian Standard ONORM B 2203. Table 1.4 shows the different several rock mass classes with respect to NATM The correlation between the classification systems RMR, Q and NATM is presented in Figure 1.4.

Rock	Behaviour of Rock Mass				
Mass Class	ONORM B 2203 After Oct. 1994	ONORM B 2203 Before Oct. 1994	Explanations		
A	A1 Stable	A1 Stable	The rock mass behaves elastically. Deformations are small and decrease rapidly. There is no tendency of overbreaking after scaling of the rock portions disturbed by blasting. The rock mass is permanently stable without support.		
A	A2 Sligthly Overbreaking	A2 Sligthly Overbreaking	The rock mass behaves elastically. Deformations are small and decrease rapidly. A slight tendency of shallow overbreaks in the tunnel roof and in the upper portions of the sidewalls caused by discontin- uities and the dead weight of the rock mass exists.		
	B1 Friable	B1 Friable	Major parts of the rock mass behave elastically. Deformations are small and decrease rapidly. Low rock mass strength and limited stand-up times related to the prevailing discontinuity pattern yield overbreaks and loosening of the rock strata in tunnel roof and upper sidewalls if no support is installed in time.		
в	B2 Very Friable		This type of rock mass is characterised by large areas of nonelastic zones extending far into the surrounding rock mass. Immediate installation of the tunnel support, will ensure deformations can be kept small and cease rapidly. In case of a delayed installation or an insufficient quantity of support elements, the low strength of the rock mass yields deep loosening and loading of the initial support. Stand-up time and unsupported span are short. The potential of deep and sudden failure from roof, sidewalls and face is high.		
	B3 Rolling	B2 Very Friable			
	C1 Rock Bursting		C1 is characterized by plastic zones extending far into the surrounding rock mass and failure mechanisms		
	C2 Squeezing	C1 Squeezing	such as spalling, buckling, shearing and rupture of the rock structure, by squeezing behaviour or by tendency rock burst. Subject rock mass shows a moderate, but distinct time depending squeezing behaviour; deformations calm down slowly except in case of rock bursts. Magnitude and velocity of deformations at the cavity boundary are moderate.		
С	C3 Heavily Squeezing	C2 Heavily Squeezing	C2 is characterized by the development of deep failure zones and a rapid and significant movement of the rock mass into the cavity and deformations which decrease very slowly. Support elements may frequently be overstressed.		
	C4 Flowing	L1 Short-term-stable with high cohesion	By limitation of the unsupported spans at arch and face, the rock mass remain stable for a limited time.		
	C5 Swelling	L2 Short-term-stable with low cohesion	No stand up time without support by prior installation of forepolling or forepiling and shotcrete sealing of faces simultaneously with excavation. The low cohesion requires a number of subdivisions.		

Table 1. 4 NATM rock mass classification according to ÖNORM B 2203 (Geoconsult, 1993 and ONORM B 2203, 1994)

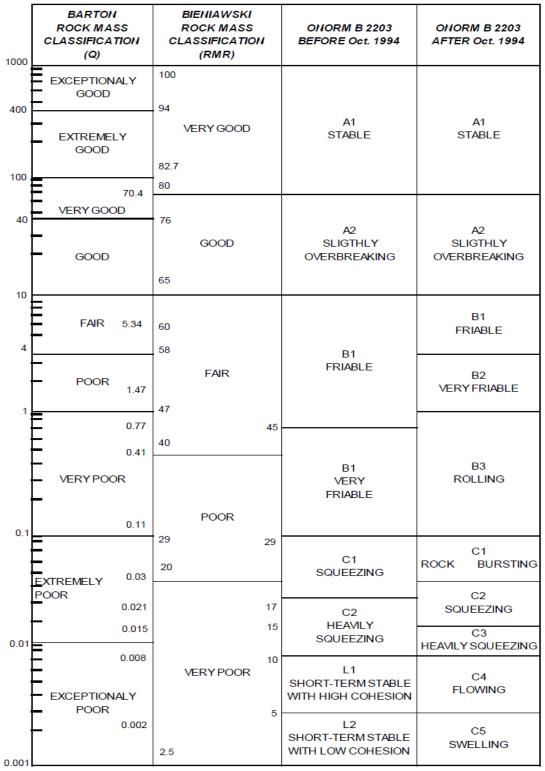


Figure 1. 4 The correlation between the classification systems RMR, Q and NATM (ONORM B 2203, 1994)

CHAPTER 2

GEOLOGY

2.1 General Geology

Belkahve tunnel takes place in south-western part of "İzmir-Ankara-Erzincan Zone" which can be characterized by Cretaceous ophiolitic mélange and highly deformed flysch units within Western Anatolian Horst and Graben province (Brinkmann, 1966). The zone lies between Sakarya continent to the north and Menderes massif to the east and southeast. The zone has been defined as 3 main rock packages; eastern part (a) ultramafics and low degree metaclastic basement, (b) above this "ophiolitic unit (mixtures of submarine volcanics, layered chert, limestone)" and (c) uppermost part by flysch (Kaya, 1972). This chaotic belt is unconformably overlain by Miocene clastics and volcanics (Öngür, 1972).

Dora (1964) was the first person to name the "Bornova flysh" within İzmir-Ankara-Erzincan Zone and also map the formation as phyllite, clay bearing schists and low grade metamorphosed quartzite, greywacke and very low grade metamorphosed arkose alternating with schists and phyllites. Crystalline schists are Paleozoic age. Later on, Oğuz (1966) described the formation as "flysch association" of Upper Cretaceous age with respect to regional correlations done. This unit is made up of chlorite schists, phyllite, metasandstone, albite-epidote schists, actinolite schists, spillite, cherty limestone, meta-conglomerate, bituminous schists which were metamorphosed under greenschist facies. However, the part with exotic blocks which contains of Permian, Triassic, Jurassic and Lower Cretaceous age limestones and serpantinites are named as "Bornova complex" of Maastrichtian- Danian age (Dönmez et al., 1998). The belt is unconformably sealed by the Miocene units (Figure 2.1). The Miocene volcanic rocks containing mineralizations in the study area are divided into three types as dacites, andesites and andesitic dykes by Dora (1964). Akdeniz et al. (1986) named these volcanics as "Yamanlar volcanites", meantime the ore bearing volcanics was named as "Altintepe volcanics" by Dönmez et al. (1998).

2.2 Site Geology and Stratigraphy

The study area where the tunnel will be constructed is characterized by Upper Cretaceous Anadağ limestone, Damlacık formation, Upper Cretaceous - Lower Paleocene Belkahve formation (Akdeniz et al., 1986) of "Bornova Flysch", colluvium, alluvium, and slope debris. According to the field studies and field observations, the Belkahve formation (Kb) is seen along the tunnel route. Geological maps and longitudinal geological section of the tunnel route are shown in Figures 2.2-2.4.

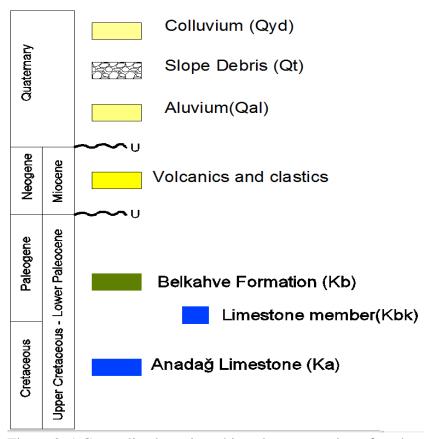
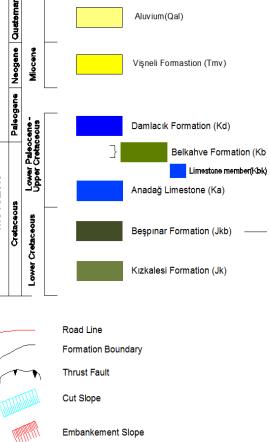


Figure 2. 1 Generalized stratigraphic columnar section of study area



Figure 2. 2 Geological map of study area (Akdeniz, 1986)



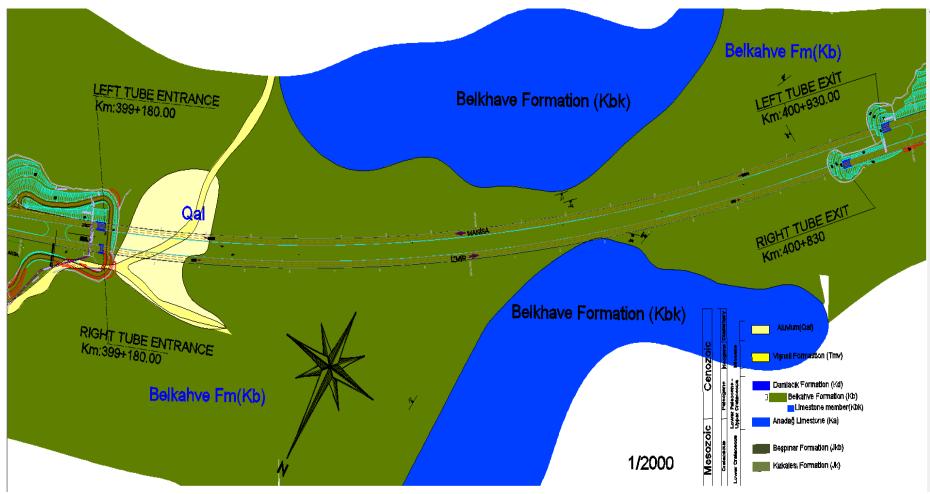


Figure 2. 3 Geological plan view of the tunnel route.

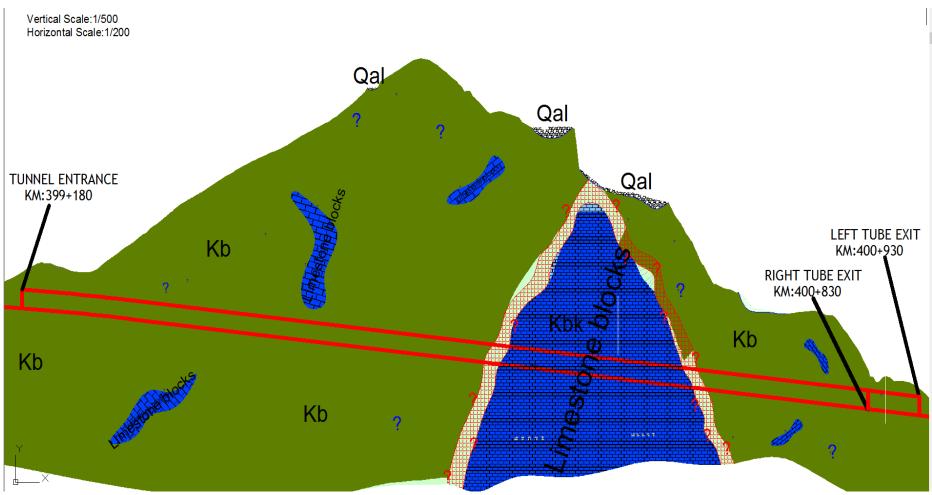


Figure 2. 4 Longitudinal geological section of the tunnel route (Vertical scale:1/500 and Horizontal scale:1/2000)

The detailed description and classification of rocks are essential parts of the geotechnical information obtained to design tunnel support. The description and classification have been done at very early stage of this study by tunnel route observation in the field. Two different geological units dominate the tunnel route which are Belkahve formation (Kb) and Belkahve formation-limestone member (Kbk).

Belkahve Formation (Kb)

This unit which covers large area around İzmir in the frame of "İzmir - Ankara Zone" (Brinkmann, 1966) has been named as "Bornova flysch formation" where it is observed widespread (Öngür, 1972). In general, it is made up of a matrix of clastics, radiolarite and basic volcanic rocks and blocks of various size, age and lithology. In most of the previous works, it was defined with various names, however, in regionwide concept "Bornova flysch" is widely excepted (Konak et al., 1980). In this thesis, "Belkahve" formation name (Akdeniz et al., 1986) is preferred. The Belkahve formation (Kb) consists of clastic rocks in flysch character with limestone blocks. The clastic rocks contain conglomerate-sandstone, shale-marl, clay bearing limestone alternations and and blocks of limestone, radiolarite, greywacke, tuff, spilite and serpentines. The age of the unit unit is Upper Cretaceous (Akdeniz et al., 1986). In the study area, the dominant lithology of the Belkahve formation is green, brownish green, brownish beige colored schists. The schist layers are intensely folded (Figure 2.5). The limestone blocks are also observed in thee unit.

Belkahve Limestone Member (Kbk)

Limestone defined in the Belkahve formation is correlated with Anadağ formation. According to Akdeniz et al. (1986), the Belkahve formation includes serpantinite, radiolarite, diabase and various limestone blocks. These limestone blocks are defined as allochtonous (Akdeniz et al., 1986). This allochtonous limestone is mostly observed at the northern and southern side of the tunnel route. In the study area, the Belkahve formation limestone is observed as beige, pinkish beige, gray, dark gray colored biomicritic limestone. The unit is highly fractured (Figure 2.6).

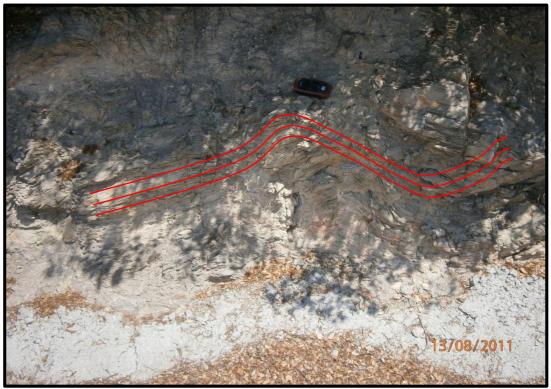


Figure 2. 5 Folded schist layers in the study area.



Figure 2. 6 A view of limestone block (Kbk) in the Belkahve formation along the tunnel route.

2.3 Structural Geology

In the study area, folded and jointed structures within the Belkahve formation are observed. The faults are the regional structures that affect tunnel area, too. However, there are no faults cross cutting the tunnel route.

Folds

Folds located within the İzmir-Ankara Zone being formed by thrust and fold structures are parallel to each other. Folds are generally oriented in the NE-SW direction. The shearing zones are observed along the fold axis. The Belkahve formation is in a NE-SW oriented syncline (Akdeniz et al., 1986). At the northern side of the tunnel route, dip of the schist belonging to the Belkahve formation is mainly towards east. Moreover, at the southern side of the tunnel route, dip of the schist is mainly towards west. This observation shows that the tunnel route passes through the axis of a syncline.

Joints

According to the field studies, at the entrance portal of the tunnel which is between Km: 399+180 - Km: 399+400, three joint sets and random joints exist. The dip amounts and dip directions of the main joint sets are (j1) 83/113, (j2) 80/338, (j3) 54/213. At the exit portal of the tunnel which is between Km: 400+750 - Km: 400+930, two joint sets and random joints exist. The dip amount and dip directions of the main joint sets are (j1) 89/115, (j2) 42/207. Kinematics analyses and the pole concentrations of these joint sets will be discussed and presented in Chapter 3.

Faults

İzmir and its surroundings take place in West Anatolian region which is dominated by tectonic regime developed during neotectonic period. The İzmir bay is settled in the western part of the graben of Gediz in east-west tectonic channel. Most of the tectonic structures, normal faults, are in E-W directions. NW-SE and NE-SW oriented faults are also seen around İzmir region. It can be stated that all neotectonic structures are

normal faults. Active fault mapping was performed by MTA (2005) for a circle of 50 km radius centered by the city of İzmir. These active faults are listed below and shown in the Figure 2.7.

- 1- Güzelhisar Fault
- 2- Menemen Fault Zone
- 3- Yenifoça Fault
- 4- İzmir Fault
- 5- Bornova Fault
- 6- Tuzla Fault
- 7- Seferihisar Fault
- 8- Gülbahçe Fault
- 9- Gümüldür Fault
- 10- Gediz Graben Fault
- 11-Dağkızılca Fault
- 12- Kemalpaşa Fault
- 13-Manisa Fault

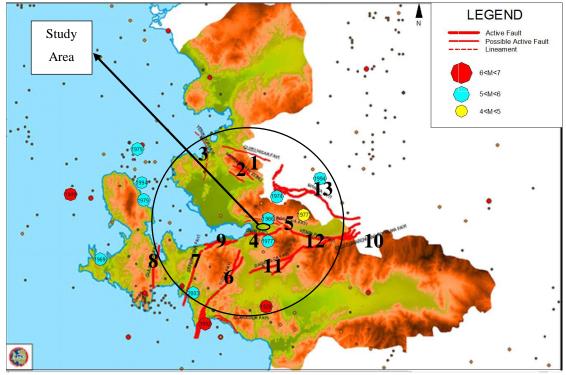


Figure 2. 7 The active fault map of tunnel route and the study area (MTA,2005)

2.4 Seismicity of the Tunnel Area

The geology of its surroundings and its historical earthquakes show that İzmir is one of the regions with high earthquake risk. There are active faults around İzmir region and most of them are close to the Belkahve tunnel route. Moreover, İzmir and the study area have been in the area of high seismic activity. Earthquake epicenter around the study area mostly seen at Aegean Sea, Karaburun, Sakız island, İzmir bay, Midilli island and Sisam Island (Figure 2.7).

According to the distribution of earthquake epicenters, some of the earthquakes occurred around Akhisar, Soma, and Manisa. In the last century, three devastating earthquakes affecting İzmir and its surroundings occurred. These are 1928 Torbalı earthquake possibly along the Tuzla fault (M: 6.5) (Salomon-Calvi et. al., 1940), 1949 Karaburun earthquake possibly along the Seferihisar fault (Jackson and McKenzie, 1984) and 1992 Seferihisar earthquake possibly along the Seferihisar fault (M: 6.0) (Türkelli et al., 1992, 1994).

According to AFAD, tunnel area located in the 1st degree of earthquake zone of Turkey (Figure 2.8) and ground acceleration value should be taken as A0=0.4g according to Technical Specification of GDH (2006). It is expected that, the Belkahve tunnel entrance and exit will be opened in weak and highly fractured schist. Damage of the tunnel due to earthquakes mostly expected where weak structures exist. Therefore, entrance and exit parts of the tunnel are considered to be critical.

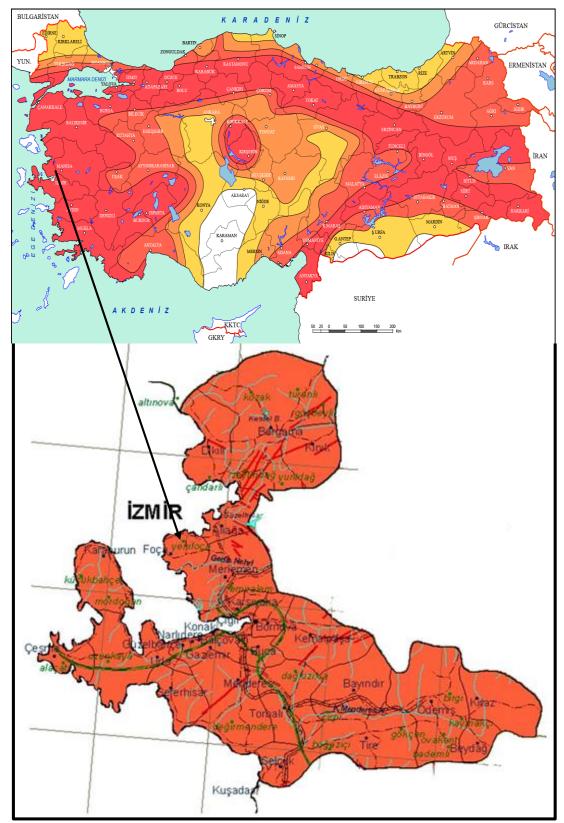


Figure 2. 8 Seismic zonation map of Turkey and the study area (AFAD, 1996)

CHAPTER 3

ENGINEERING GEOLOGY OF THE STUDY AREA

This chapter includes the assessment of engineering geological parameters of the rocks to be cut along the tunnel route. For this purpose, field and laboratory studies were performed. Then, rock mass classifications and strength parameters of the intact rock were determined.

3.1 Field Studies

Field studies were performed on outcrops of the geological units which can be seen through the tunnel route. With the purpose of defining the rock mass, type of discontinuity, spacing, aperture, persistence, roughness, infilling properties, strength and alteration degree of the discontinuity surface, joint water condition, number of sets were determined in accordance with ISRM (1981).

Tunnel portal is the most important part of the tunnel designing. In this context, discontinuity surveys were performed by scanline method (ISRM, 1981; Priest, 1993), especially at the entrance and exit part of the tunnel. The survey line is approximately 10 m. During the survey, at least 150-350 readings should be taken (Priest, 1993). However, in some cases, it was not possible to find outcrops wide enough to collect data in the field. In this thesis, 35-40 readings could be taken at each field exposure during the scanline survey. Classification of discontinuity orientations with respect to tunnel direction recommended by Barton (1989) is presented in Table 3.1.

Table 3. 1 Classification of discontinuity orientation with respect to tunnel dire	ction
(Bieniawski, 1989)	

EFFECT OF DISCONTINUTY STRIKE AND DIP ORIENTATION AT TUNNELING									
		~ ~ ~ ~ ~ ~							
Strike perpendicu	lar to tunnel axis	Strike parallel to t	unnel axis						
Drive with DIP-DIP 45-	Drive with DIP-DIP 20-	DIP 45-90°	DIP 20-						
90°	DIP 43-90*	45°							
Very Favorable	Favorable	Very Unfavorable	Fair						
Drive against DIP-DIP	DIP 20-45° irrest	bective of							
45-90°	strike								
Fair	Fair								

According to the field studies, at the entrance portal of the tunnel which is between Km: 399+180 -Km: 399+400, three joint sets and random joints exist. The dip amount and dip directions of the main joint sets are (j1) 83/113, (j2) 80/338, (j3) 54/213. DIPS software is used to obtain pole concentrations and the results are shown in Figure 3.1.

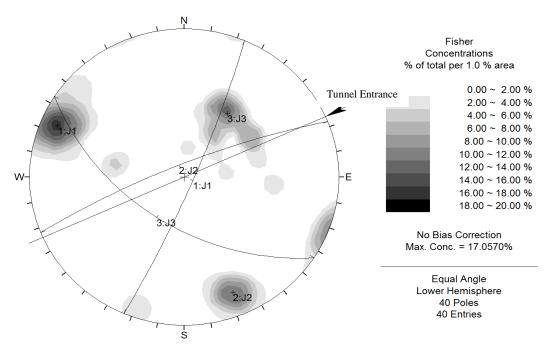


Figure 3. 1 The pole concentration contours and dominant discontinuity sets seen at the entrance portal of the tunnel.

As it seen in Figure 3.1, J1 is cutting the tunnel axis with high angle and driving with dip at an angle of 83°. According to the rock mass rating system (Bieniawski, 1989),

J1 is considered to be very favorable. J2 is parallel to tunnel axis and dip amount is 80°. According to the rock mass rating system, J2 is very unfavorable. J3 is almost perpendicular to the tunnel axis and driving against dip with an angle of 54°. According to the rock mass rating system, J3 is fair (Table 3.2).

Discontinuity	Strike	DIP	Definition	
J1 (83/113)	Perpendicular to tunnel axis	Drive with DIP 83°	Very Favorable	
J2 (80/338)	Parallel to tunnel axis	DIP 80°	Very Unfavorable	
J3 (54/213)	Perpendicular to tunnel axis	Drive against DIP 54°	Fair	

Table 3. 2 Strike and DIP of the discontinuities at the tunnel entrance portal

According to the results given in Table 3.2, for the tunnel entrance portal, the effect of discontinuity strike and dip amount for tunneling is stated to be "Fair" as an average of three joints' descriptions.

At the exit portal of the tunnel which is between Km: 400+750 -Km: 400+930, two joint sets and random joints exists. The dip amount and dip directions of the main joint sets are (j1) 89/115, (j2) 42/207. DIPS software is used to obtain pole concentrations and the results are shown in Figure 3.2.

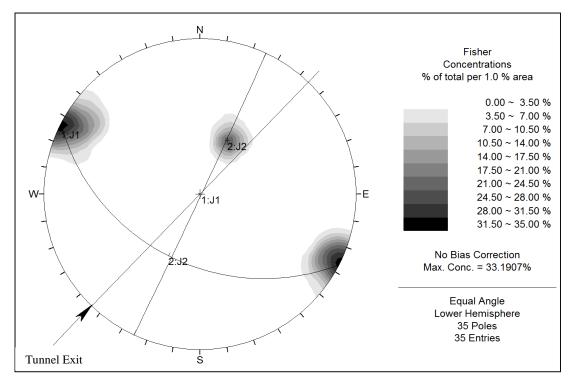


Figure 3. 2 The pole concentration contours and dominant discontinuity sets seen at the entrance portal of the tunnel.

As it seen in Figure 3.2, J1 is perpendicular to tunnel axis and driving with dip with an angle of 83°. According to the rock mass rating system (Bieniawski, 1989), J1 is very favorable. J2 is parallel to tunnel axis and dip angle is 80°. According to the rock mass rating system, J2 is very unfavorable (Table 3.3).

Discontinuity	Strike	DIP	Definition	
J1 (89/115)	Parellel to tunnel axis	DIP 89°	Very Unfavorable	
J2 (42/207)	Perpendicular to tunnel axis	Drive with DIP 42°	Favorable	

Table 3.3 Strike and DIP of the discontinuities at the tunnel exit portal.

According to the results given in Table 3.3, for the tunnel exit portal, the effect of discontinuity strike and dip amount for tunneling is concluded as "Unfavorable" as an average of two joints' descriptions.

3.2 Drillings

Eight boreholes were drilled (Table 3.4) with a total length of 641.5 m to finalize the cross-section and determine the geotechnical parameters of the rock mass through the tunnel route. ÖZTAY Group (2012) drilled the boreholes. During drilling, the rotary core drilling method with water swivel type double tube core barrel was used for obtaining core samples. During drillings, double mud pump wire line HQ and NQ equipped trucks, D-900 and D-750 were used (Figure 3.3). During drillings, lithological aspect of rocks, strength, alteration, discontinuity condition, roughness, TCR, RQD descriptions were done and logged as soon as possible.

Cores obtained from the drillings covered with paraffin in order not to loose its natural water content. Rock samples labeled with the name of the project, name of the borehole, rock sample type and depth right before sending them to the laboratory. During the drillings, groundwater depth (GWD) was measured very carefully 48 hours after the drillings were completed. To make the measurements properly, 50 mm diameter PVC pipe was placed into the borehole.

Photographs of the core box and the borehole logs are presented in Appendix A and Appendix B. Also the location of the boreholes is given in Figures 3.4 and 3.5.

Borehole No	Location	Coordinates		Depth (m)	Km	
Borenoie No	Location	Х	у	Deptii (III)	IXIII	
SK-802	Entrance	4259592	528418	42	KM: 399+310	
SK-804	Middle	4259115	527699	130	KM: 400+200	
SK-805	Middle	4259457	528157	90	KM: 399+600	
SK-807	Middle	4259315	527944	128	KM: 399+860	
SK-808	Middle	4258979	527505	100	KM: 400+415	
SK-809	Middle	4258845	527374	59	KM: 400+600	
SK-806	Exit	4258675	527212	45	KM: 400+836	
SK-810	Exit	4258582	527189	47,5	KM: 400+915	

Table 3.4 Location, coordinates and depth of the boreholes drilled along the tunnel.



Figure 3. 3 Drilling machine at the middle section of the tunnel route.

3.3 Hydrogeology of the Tunnel Route

The Belkahve formation will be cut through the tunnel route. The Belkahve limestone is highly fractured and contains groundwater. On the other hand, the schist involved in the Belkahve formation can be defined as impermeable. However, the sandstone layers included within the schist may contain some water. Along tunnel route, measured groundwater depths of the boreholes from the surface are presented in Table 3.5.

BOREHOLE NAME	GWD (m)
SK-802	5.91
SK-804	9.98
SK-805	29.50
SK-807	59.00
SK-808	47.00
SK-809	7.50
SK-806	5.46
SK-810	6.40

Table 3.5 Groundwater levels measured at the boreholes

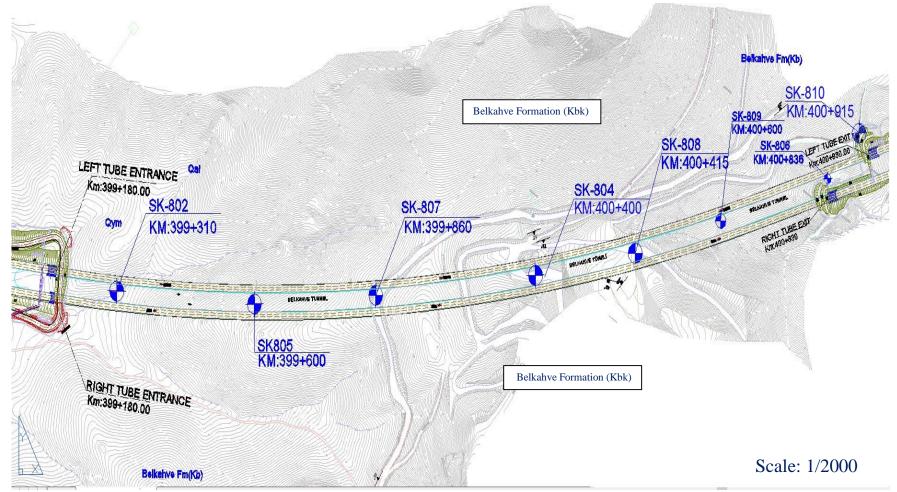


Figure 3. 4. Map showing borehole locations along the tunnel route.

34

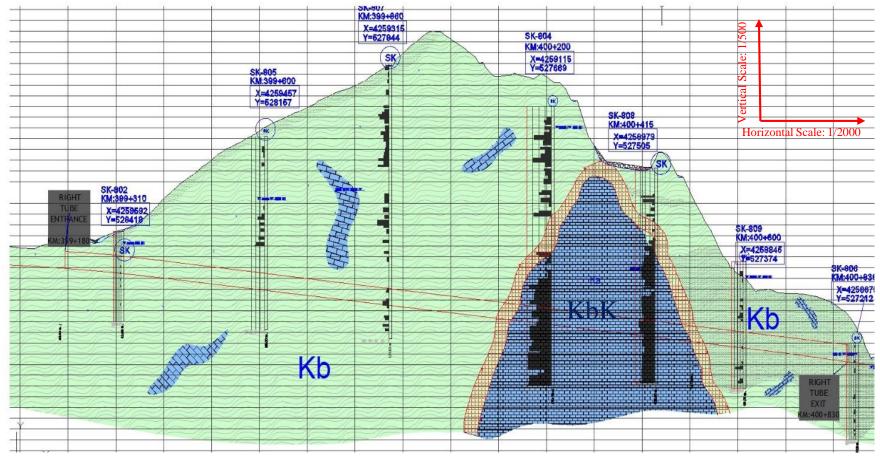


Figure 3. 5 The longitudinal geological section of the tunnel with borehole locations show.

According to the GWD measurements, groundwater table is close to the surface (5m-10m) at portal areas. However, at the middle section of the tunnel route, depth of the groundwater from the surface varies approximately between 30 m and 60 m.

According to GWL measurements, it can be easily stated that groundwater will be a problem for both open cuts at the entrance and exit of the tunnel. It's a known fact that groundwater has negative effects on the stability of the slopes. The main reason that creates this negative effect is the effective stress reduction due to pore pressure of the groundwater. Consequently, shear strength of the rock mass is reduced.

Packer (lugeon) tests were performed in boreholes SK -807 and SK-808. Packer Test consists of the measurement of the volume of escaping water from an unsealed section of a borehole under a specific pressure. Applied pressures to the borehole were selected as 2-4-6-8-10-8-6-4-2 atm. By measuring the volume of escaped water, lugeon values of the rock mass were determined. The manual prepared by Altuğ (1971) is used to calculate the Lugeon values. The classification of the Lugeon values is presented in Table 3.6 and the test results are shown in Table 3.7.

	8, ,
Lugeon value	Description
Less than 1	Impervious
1-5	Slightly pervious
5-25	Pervious
Greater than 25	Highly pervious

Table 3.6 Classification of lugeon values (Altuğ, 1971)

Borehole Name	Depth of Interv	Depth of Intervals	
SK-807	84,00 m.	87,00 m.	1,4
SK-807	90,00 m.	93,00 m.	2,76
SK-807	103,50 m.	106,50 m.	0,8
SK-807	106,50 m.	109,50 m.	0,27
SK-808	53,00 m.	56,00 m.	0,35
SK-808	59,00 m.	62,00 m.	0,32
SK-808	65,00 m.	68,00 m.	0,28
SK-808	71,00 m.	74,00 m.	2,66
SK-808	77,00 m.	80,00 m.	0,59
SK-808	83,00 m.	86,00 m.	1,16

Table 3. 7 Results of packer tests performed in boreholes.

In SK 807, at depth intervals of 84.0 m - 87.0 m, 90.0 m - 93.0 m, 103.5 m - 106.5 m, 106.5 m - 109.5 m, lugeon values were found to be 1.40, 2.76, 0.8, and 0.27, respectively. According to the lugeon values obtained, schist-sandstone interbedded unit can be defined as impervious to slightly pervious.

In SK-808, at depth intervals of 53.0 m - 56.0 m, 59.0 m - 62.0 m, 65.0 m - 68.0 m, 71.0 m - 74.0 m, 77.0 m - 80.0 m, 83.0 m - 86.0 m, lugeon values were found to be 0.35, 0.32, 0.28, 2,66, 0,59, and 1.16, respectively. According to the lugeon values obtained from the test, the limestone unit can be defined as impervious to slightly pervious. However, despite the high fractured nature of the limestone, low lugeon values can be interpreted as the filling of the fractures with chemicals used during drillings. Therefore, the limestone should be at least considered to be slightly pervious.

Moreover, two sections along the tunnel route have been described as "shear zone". They may cause possible groundwater inflow problems during tunnel excavation due to the highly fractured nature of the rock. Unfortunately, there is no lugeon test for the corresponding kilometers of the shear zones at the tunnel route. However, considering that the zones are expected to be highly pervious due to its highly fractured structure, some precautions should be taken during the excavations. These will be discussed at later part of this thesis.

3.4 Geotechnical Assessment of Formations

According to the field observations, schist belonging to the Belkhave formation can be defined as weak-very weak in strength. Laboratory test results performed on the samples obtained from Belkhave formation also proves that. In this respect, parts which will be excavated in the Belkahve formation, entrance and exit portals should be properly supported in order to eliminate stability problems due to the highly fractured nature (low RQD values) of the Belkahve formation. It's reasonable to worry about the stability problems which would be caused by groundwater. Therefore, additional geotechnical solutions, such as weep-hole drains could be installed in order to discharge the groundwater safely from the slopes.

The limestone (Kbk) which also belongs to the Belkahve formation, can be considered as strong rock however fractured nature of the limestone may be a problem for the tunnel. The limestone observed in the study area was not present directly along the tunnel route. So it is predicted that, only during tunnel excavation the limestone may be observed. In this unit, groundwater inflow is expected to be a problem during tunnel excavation due to the fractured limestone.

Shear Zone

According to the geological survey, Upper Cretaceous-Paleocene Belkahve formation and Upper Cretaceous limestone are incompatible with each other. Younger limestone is located within the schists of the Belkhave formation. Based on the drilling data, there exists a weak, highly fractured zone discovered at the contacts of the two formations. Due to the incompatibility of the two formations, it is decided to define the shearing zone in order to explain the relationship of these two formations. Moreover, according to the correlations done using the borehole data, it is predicted that this weak shear zone will be cut along the tunnel route at two different sections. However, it is very difficult to define the exact location of this kind of zone which couldn't be observed at the surface and only be predicted by limited number of boreholes.

3.5 Laboratory Tests

With the aim of determining the material properties of the rock mass, laboratory tests were performed by Limit Geotechnical Services Limited Company (2012) on the rock core samples. In Appendix C the results of laboratory tests are given. Also Table 3.8 shows the laboratory test results.

-

Borehole Nanne Borehole Nanne			Natural Unit Weight	Elastic Modulus	Poisson's Ratio	Uniaxial Comp. Strength Test	Point Load Strength Test
	m. from	m. to	γn	Е	υ	qc	Is (50)-AV
			kN/m ³	GPa	-	Kgf/cm ²	MPa
SK-802	4,5	8	25,7				0,49
SK-802	8	15	26,19				2,02
SK-802	16	23	26,68				2,89
SK-802	24	30	26,59				8,95
SK-802	31	36,5	26,68				3,62
SK-804	66,5	67	19,62	1,29	0,366	83	
SK-804	68,3	68,8	22,96	2,48	0,337	122	
SK-804	100	100,5	24,62	7,95	0,313	438	

 Table 3.8 Laboratory test results of the rocks along the tunnel

Table	3.8	continued
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10010 010	continued						
Borehole Nanme	Depth	Natural Unit Weight	Elastic Modulus	Poisson's Ratio	Uniaxial Comp. Strength Test	Point Load Strength Test	
H	m.	m.	γn	Е		q _c	Is (50)-AV
	from	to	kN/m ³	GPa	υ	Kgf/cm ²	MPa
SK-804	104,5	105	26,88	11,05	0,277	707	
SK-804	108	108,5	26,39	9,95	0,309	650	
SK-804	109,5	110	28,25	10,15	0,327	632	
SK-804	115	115,5	28,06	8,95	0,346	560	
SK-804	118	118,5	26,59	10,19	0,252	717	
SK-805	17,3	18,8	16,09				0,08
SK-805	32,5	34	26				0,3
SK-805	36	37,5	26,49	22,04	0,23	349,63	
SK-805	41,5	44,2	18,64				0,12
SK-805	46,9	48,2	16,09				0,66
SK-805	49,4	50,55	26,29	61,77	0,32	785,25	
SK-805	52,7	57	26,68				2,65
SK-805	73,4	75	26,68				4,05
SK-806	1,5	7	26,09				5,3
SK-806	8,6	9	25,41	8,83	0,281	435	
SK-806	13	15	25,9				4,12
SK-806	20	20,15	25,9				
SK-806	21	21,7	26,39				
SK-806	25,5	26	26				
SK-806	32,6	33	25,9				
SK-806	36,5	36,8	26,09				3,32
SK-807	22,5	23,5	26,09	57,11	0,18	546,83	
SK-807	31,5	33	26,29				1,72
SK-807	39	41	26	36,5	0,24	459,6	
SK-807	47,2	47,8	26,29	58,96	0,21	781,55	
SK-807	53	56,8	26,49				1,64
SK-807	70,4	72	26,49				0,37

Table 3.8 continued

Borehole Nanme	Depth		Natural Unit Weight	Elastic Modulus	Poisson's Ratio	Uniaxial Comp. Strength Test	Point Load Strength Test
B	m.	m.	γn	Е		q _c	Is (50)-AV
	from	to	kN/m ³	GPa	υ	Kgf/cm ²	MPa
SK-807	72,7	75,2	27,66	5,18	0,21	132,93	
SK-807	75,2	77	26,09				1,21
SK-807	82	83,2	26,09				3,28
SK-807	87,4	88,3	26,59	52,1	0,21	1575,09	
SK-807	90	92	26				3,75
SK-807	97	99,2	26,88				3,45
SK-807	102,1	103,5	26,29				5,3
SK-807	105,6	106,5	22,86				
SK-807	108,2	110,5	25,9				4,47
SK-807	110,5	112,5	26,49	50,92	0,19	1086,72	
SK-807	112,5	115,6	26,59				1,18
SK-807	117,3	119,3	26,29				6,32
SK-807	121,3	123,3	25,02				3,67
SK-808	18,35	22,35	25,51			131,3	0,16
SK-808	30,55	31,7	23,25				
SK-808	36,3	38,5	24,92	7,22	0,4	87,02	
SK-808	45,5	48,5	26,29	69,73	0,32	813,82	
SK-808	55,4	56	26,29	76,42	0,25	514,94	3,22
SK-808	59,6	62	26,39	52,05	0,33	320,17	
SK-808	65	71	26,29	54,95	0,27	551,09	2,34
SK-808	74	80	26,19	44,77	0,26	462,53	3,35
SK-808	83	86	26,49	54,15	0,32	192,85	
SK-808	90	96	24,92	38,17	0,4	270,28	3,05
SK-809	4,6	6,8	26,49				5,7
SK-809	9,5	12,5	26,68				5,46
SK-809	14	16,7	27,57				5,47
SK-809	20,4	22,3	26	31,39	0,2	454,34	7,57
SK-809	24	24,5	24,79	43,07	0,28	645,43	

Borehole Nanme	Depth		Natural Unit Weight	Elastic Modulus	Poisson's Ratio	Uniaxial Comp. Strength Test	Point Load Strength Test
	m.	m.	γn	Е		q _c	Is (50)-AV
	from	to	kN/m ³	GPa	υ	Kgf/cm ²	MPa
SK-809	27	28	26,19				3,59
SK-809	28,4	31	26,59				1,11
SK-809	33,3	35,8	20,99				0,07
SK-809	38,5	39,5	22,37	1,93	0,27	55,11	
SK-809	40,5	41,5	20,8				
SK-809	43,1	44,5	26,68				4,54
SK-809	45,2	45,7	26				
SK-809	46,5	48,5	26,29				3,41
SK-809	49	50	26,59	20,21	0,19	91,76	
SK-809	52,5	54,5	26				1,22
SK-809	55,5	56,5	26,39	44,85	0,16	688,9	
SK-810	Mar.50	Nis.50	25,6				0.40
SK-810	May.50	Haz.50	25,51				
SK-810	Ara.20	14.20	26,09				0.81
SK-810	23.90	24.50	26,19				2,660
SK-810	30.00	31.00	26				
SK-810	31.00	33.50	26,39				4,25
SK-810	44.00	47.50	26,49				2,67

Table 3.8 continued

According to the laboratory results given above in Table 3.8, for borehole SK- 802 drilled in the Belkahve formation, natural unit weight values range between 25,70 kN/m³ and 26,68 kN/m³, and point load strength values range between 0,49 MPa and 8,95 MPa.

For borehole SK- 804 drilled in the Belkahve formation, natural unit weight values vary from 19,62 kN/m³ to 28,25 kN/m³, Elastic modulus values vary from 1,290 GPa

to 11,050 GPa, poisson's ratio values vary from 0,252 to 0,366 and uniaxial compressive strength values vary from 83 Kgf/cm² to 717 Kgf/cm².

For borehole SK- 805 drilled in the Belkahve formation, natural unit weight values change between 16,09 kN/m³ and 26,68 kN/m³, elastic modulus values change between 22,04 GPa and 61,77 GPa, poisson's ratio values change between 0,23 and 0,32, uniaxial compressive strength values change between 349,63 Kgf/cm² and 785,25 Kgf/cm², and point load strength values change between 0,12 MPa and 4,05 MPa.

For borehole SK- 806 drilled in the Belkahve formation, natural unit weight values vary from 25,41 kN/m³ to 26,39 kN/m³, elastic modulus value is 8,83 GPa, poisson's ratio value is 0,28, uniaxial compressive strength value is 435 Kgf/cm² and point load strength values vary from 3,32 MPa to 5,30 MPa.

For borehole SK- 807 drilled in the Belkahve formation, natural unit weight values range between 25,90 kN/m³ and 27,66 kN/m³, elastic modulus values range between 5,18 GPa and 58,96 GPa, poisson's ratio values range between 0,18 and 0,24, uniaxial compressive strength values range between 132,93 Kgf/cm² and 1575,09 Kgf/cm², and point load strength values range between 0,37 MPa and 6,32 MPa.

For borehole SK- 808 drilled in the Belkahve formation, natural unit weight values vary from 22,86 kN/m³ to 26,49 kN/m³, elastic modulus values vary from 7,22 GPa to 76,42 GPa, poisson's ratio values vary from 0,25 to 0,4, uniaxial compressive strength values vary from 87,02 Kgf/cm² to 813,82 Kgf/cm², and point load strength values vary from 0,16 MPa to 3,35 MPa.

For borehole SK- 809 drilled in the Belkahve formation, natural unit weight values range between 22,86 kN/m³ and 26,49 kN/m³, elastic modulus values range between 1,93 GPa and 44,85 GPa, poisson's ratio values range between 0,16 and 0,28, uniaxial compressive strength values range between 55,11 Kgf/cm² and 688,90 Kgf/cm², and point load strength values range between 0,07 MPa and 7,57 MPa.

CHAPTER 4

ROCK MASS CLASSIFICATIONS OF THE ROCKS ALONG THE BELKAHVE TUNNEL

Rock mass rating classification (RMR), rock mass quality classification (Q), New Austrian Tunneling Method classification (NATM) and geological strength index (GSI) classifications have been used in this thesis based on the data collected from site,

4.1 Rock Mass Rating Classifications

The rock mass rating (RMR) system is a rock mass quality classification developed by South African Council for Scientific and Industrial Research (CSIR), closely associated with excavation for the mining industry (Bieniawski, 1973). Bieniawski (1976) published the details of a rock mass rating (RMR) system. Over the years, this system has been successively refined as more case records have been examined. In the application of the latest version of RMR classification system (Bieniawski 1989), the rock mass is divided into zones with uniform geotechnical characteristics in accordance with the geological units and major structural features. Five parameters, given below are determined for each of the geotechnical unit:

- 1- Strength of intact rock material
- 2- Drill Core Quality, RQD
- 3- Spacing of Discontinuities
- 4- Condition of Discontinuities
- 5- Groundwater Conditions of Groundwater

Table 4.1 shows The Rock Mass Rating (RMR) system is used to determine the ratings for each of the five parameters listed above. As final step, these ratings are summed to determine a value of basic RMR.

Table 4. 1 Rock Mass Rating System (After Bieniawski 1989).

Streng of intact ro materi	strength index ock Uniaxial comp.	>10 MPa		Range of values		For this low	
materi	and the second sec	>10 MPa 4 - 10 MPa		2 - 4 MPa	1 · 2 MPa	For this low range - uniaxial compressive test is preferred	
Drill c	al strength	>250 MPa	100 - 250 MPa	50 - 100 MPa	25 - 50 MPa	5-25 1	-5 <1
Drill c	Rating	15	12	7	4		1 0
-	ore Quality RQD	90% - 100%	75% - 90%	50% - 75%	25% - 50%	< 2	5%
2 Rating		20	17	13	8	3	
Spacing of discontinuities		> 2 m	0.6 - 2 . m	200 - 600 mm	60 - 200 mm	< 60	mm
3 Rating		20	15	10	8	5	
4 Condition of discontinuities (See E)		Very rough surfaces Not continuous No separation Unweathered wall rock	Slightly rough surfaces Separation < 1 mm Slightly weathered walls	Slightly rough surfaces Separation < 1 mm Highly weathered walls	Slickensided surfaces or Gouge < 5 mm thick or Separation 1-5 mm Continuous	Soft gouge >5 mm thick or Separation > 5 mm Continuous	
Rating		30	30 25		10	0	
Inflow per 10 m tunnel length (l/m)		None	< 10	10 - 25	25 - 125	> 125	
5 Ground water	(Joint water press)/ (Major principal σ)	0	< 0.1	0.1, - 0.2	0.2 - 0.5	> 0.5	
	General conditions	Completely dry	Damp	Wet	Dripping	Flowing	
	Rating	15	10	7	4		0
ATING A	DJUSTMENT FOR	DISCONTINUITY ORIE	NTATIONS (See F)		18	23	
e and dip	orientations	Very favourable	Favourable	Fair	Unfavourable	Very Unf	avourable
Tunnels & mines Ratings Foundations		0	-2	-5	-10	-12	
		0	-2	-7	-15	-25	
	Slopes	0	-5	-25	-50		
OCK MA	SS CLASSES DETE	ERMINED FROM TOTA	L RATINGS	w	NC	-	
Rating		100 - 81	80 ← 61	60 ← 41	40 ← 21	< 21	
Class number		1	II.	10	IV	V	
ription		Very good rock	Good rock	Fair rock	Poor rock	Very poor rock	
EANING	OF ROCK CLASSE	S		¢	10		
s numbe	r	1	II.	111	IV	1	V.
age stan	d-up time	20 yrs for 15 m span	1 year for 10 m span	1 week for 5 m span	10 hrs for 2.5 m span	30 min for 1 m spa	
esion of r	ock mass (kPa)	> 400	300 - 400	200 - 300	100 - 200	< 100	
on angle	of rock mass (deg)	> 45	35 - 45	25 - 35	15 - 25	< 15	
UIDELIN	ES FOR CLASSIFIC	ATION OF DISCONTI	NUITY conditions	8 2653 P	le internet		2
2000-00-00	length (persistence)	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 - 3 m	3 - 10 m	10 - 20 m	105.65	0 m
Rating Separation (specture)						0 >5mm	
Separation (aperture) Rating		6	5	4	1	5 mm 0	
Roughness		Very rough	Rough	Slightly rough	Smooth	Slickensided	
Rating Infiling (gouge) Rating		None	Hard filling < 5 mm	Hard filling > 5 mm	Soft filling < 5 mm	0 Soft filling > 5 mm 0	
Weathering Ratings		Unweathered 6	Slightly weathered 5	Moderately weathered 3	Highly weathered 1	Decomposed 0	
FECTO	F DISCONTINUITY	STRIKE AND DIP ORI	ENTATION IN TUNNED	LLING**			
	Strike perpend	dicular to tunnel axis		Strik	e parallel to tunnel axis		
Drive with dip - Dip 45 - 90°		Drive with dip -	Dip 20 - 45°	Dip 45 - 90°)ip 20 - 45°		
Very favourable		Favour	able	Very unfavourable		Fair	
Drive against dip - Dip 45-90°		Drive against di	p - Dip 20-45°	Dip 0-20 - Irrespective of strike*			
	water ATING A e and dip atings OCK MA ig s numbe cription EANING s numbe age stan storn of r on angle UIDELIN ontinuity ig station (a ig phness ig ng (goug ig thering igs FFECT C Drive wit ve	Rating A Ting Linflow per 10 m tunnel length (lim) Ground (Joint water press)/ (Major principal o) General conditions Rating ATING ADJUSTMENT FOR e and dip orientations Tunnels & mines atings Foundations Slopes OCK MASS CLASSES DETI g s number ription EANING OF ROCK CLASSE s number age stand-up time estion of rock mass (kPa) on angle of rock mass (k	Rating 30 Inflow per 10 m tunnel length (l/m) None Ground water Inflow per 10 m tunnel length (l/m) None Ground water (Joint water press)/ (Major principal d) 0 General conditions Completely dry Rating 15 ATING ADJUSTMENT FOR DISCONTINUITY ORIE e and dip orientations Very favourable Tunnels & mines 0 atings Foundations 0 Foundations 0 0 OCK MASS CLASSES DETERMINED FROM TOTA 1 ing 100 ← 81 s number 1 ription Very good rock EANING OF ROCK CLASSES s number 1 age stand-up time 20 yrs for 15 m span estion of rock mass (kPa) > 400 on angle of rock mass (deg) > 45 UDELINES FOR CLASSIFICATION OF DISCONTI off up the persistence) < 1 m	rock walls Rating 30 25 Inflow per 10 m None < 10	rockwallswallsRating302520Inflow per 10 m tunnel length (l/m)None< 1010 - 25Ground (Mini water press)/ (anit water press)/ (block water	rock waits waits Separation 1-5 mm Continuous Rating 30 25 20 10 Inflow per 10 m water Inflow per 10 m (inflow per 10 m) None < 10	rock walls walls Separation 1-5 mm Continuous Continuous Continuous Rating 30 25 20 10 10 Inflow per 10 m under length (Im) None <10

SK-802 is evaluated for rock mass classification of entrance section. According to drilling data and laboratory test results RMR rating determined and presented below in Figure 4.1.

Middle Section (KM: 399+400 – KM: 400+750)

SK-804, SK-805, SK-807, SK-808, SK-809 are evaluated for the rock mass classification of the middle section. This section is divided into seven geotechnical

zones. According to the drilling data and laboratory test results, RMR rating of the rocks determined and presented below for different kilometer ranges.

KM: 399+400 – KM: 399+700 (in accordance with SK-805)

Figure 4. 2 Basic and total RMR rating calculation with respect to SK-805				
Rating				
Uniaxial Compressive Strength, $\sigma_c(5~\text{MPa})$:1				
Rock Quality Designation (RQD <%25) :				
Spacing of Discontinuities <60 mm):5				
Persistence of Discontinuities (1-3 m):				
Aperture of Discontinuities (1.0-5.0 mm):1				
Roughness of Discontinuities (Slightly rough):0				
Infilling (Calcite<5mm) :				
Weathering (Highly weathered):1				
Groundwater condition (Damp):10				
Basic RMR:				
Discontinuity Orientation (Fair):5				
Total RMR Point:				
ClassPoor Rock				

KM: 399+700 - KM: 400+080 (in accordance with SK-807)

Figure 4. 3 Basic and total RMR rating calculation with respect to SK-807				
Rating				
Uniaxial Compressive Strength, $\sigma_c(10$ MPa):2				
Rock Quality Designation (RQD <%25):				
Spacing of Discontinuities (<60 mm):				
Persistence of Discontinuities (1-3 m):				
Aperture of Discontinuities (1.0-5.0 mm):				
Roughness of Discontinuities (Slightly rough):				
Infilling (Calcite-Quartz<5mm) :				
Weathering (Highly weathered):				
Groundwater condition (Damp):10				
Basic RMR:				
Discontinuity Orientation (Fair):5				
Total RMR Point:				
ClassPoor Rock				

KM: 400+080 - KM: 400+150

As it can be seen on the geological cross-section, this part of the tunnel route is defined as shear zone. From the point of geotechnical view, in order to be on the safe side, very poor rock class is assigned for shearing zone. However, the real specification and location of shear zone should only be determined during the excavation. Horizontal boreholes should be drilled from the face of the tunnel excavation. Geologically, this part can be defined as meta-sandstone-schist with clay matrix. According to the drilling logs RMR rating calculated for this weak zone and to be on the safe side, engineering parameters c= 20 kPa, $\emptyset = 25^{\circ}$, Erm= 100 MPa and weak strength rock are assumed for this section.

Rating

Figure 4. 4 Basic and total RMR rating calculation for shear zone.

Katin	s
Uniaxial Compressive Strength, $\sigma_c~(5~\text{MPa})$:2	
Rock Quality Designation (RQD %21):	
Spacing of Discontinuities (60-200 mm) :	
Persistence of Discontinuities (3-10 meter):	
Aperture of Discontinuities (0.1-1.0 mm):	
Roughness of Discontinuities (rough):0	
Infilling (hard filling<5mm) :	
Weathering (slightly weathered):	
Groundwater condition (Damp):10	
Basic RMR:	
Discontinuity Orientation (Unfavorable):10	0
Total RMR Point:	
Class	k

KM: 400+200 – KM: 400+450 (in accordance with SK-804)

Figure 4. 5 Basic and total RMR rating calculation with respect to SK-804
Rating
Uniaxial Compressive Strength, $\sigma_c(44~\text{MPa})$:4
Rock Quality Designation (RQD %50-%75) :
Spacing of Discontinuities (60-200 mm) :
Persistence of Discontinuities (10-20 meter):1
Aperture of Discontinuities (1-5.0 mm):
Roughness of Discontinuities (Slightly rough):
Infilling (Calcite<5mm) :
Weathering (Slightly weathered):
Groundwater condition (Damp):10
Basic RMR:
Discontinuity Orientation (Fair):5
Total RMR Point:
Class

KM: 400+200 - KM: 400+450 (in accordance with SK-808)

Figure 4. 6 Basic and total RMR rating calculation with respect to SK-808

Rating

Uniaxial Compressive Strength, $\sigma_c(50~\text{MPa})$:
Rock Quality Designation (RQD %21):
Spacing of Discontinuities (60-200 mm) :
Persistence of Discontinuities (3-10 meter):
Aperture of Discontinuities (0.1-1.0 mm):
Roughness of Discontinuities (rough):
Infilling (hard filling<5mm) :
Weathering (slightly weathered):
Groundwater condition (Damp):10
Basic RMR:
Discontinuity Orientation (Fair):5
Total RMR Point:
ClassFair Rock

KM: 400+450 - KM: 400+520

As it can be seen on the geological cross-section, this part of the tunnel route is defined as shear zone. From the point of geotechnical view, in order to be on the safe side, very poor rock class is assigned for shearing zone. However, the real specification and location of shear zone should only be determined during the excavation. Horizontal boreholes should be drilled from the face of the tunnel excavation. Geologically, this part can be defined as meta-sandstone-schist with clay matrix. According to the drilling logs RMR rating calculated for this weak zone and to be on the safe side, engineering parameters c=20 kPa, $\emptyset=25^{\circ}$, Erm= 100 MPa and weak strength rock are assumed for this section.

Figure 4. 7 Basic and total RMR rating calculation for shear zone.

Rating

Uniaxial Compressive Strength, $\sigma_c~(5~\text{MPa})$:
Rock Quality Designation (RQD %21):
Spacing of Discontinuities (60-200 mm) :
Persistence of Discontinuities (3-10 meter):2
Aperture of Discontinuities (0.1-1.0 mm):1
Roughness of Discontinuities (rough):0
Infilling (hard filling<5mm) :
Weathering (slightly weathered):
Groundwater condition (Damp):10
Basic RMR:
Discontinuity Orientation (Unfavorable):10
Total RMR Point:
ClassVery Poor Rock

KM: 400+520 – KM: 400+750 (in accordance with SK-809)

Figure 4. 8 Basic and total RMR rating calculation with respect to SK-809 Rating
Uniaxial Compressive Strength, $\sigma_c(25~\text{MPa})$:2
Rock Quality Designation (RQD %21):
Spacing of Discontinuities (60-200 mm) :
Persistence of Discontinuities (3-10 meter):
Aperture of Discontinuities (0.1-1.0 mm):1
Roughness of Discontinuities (rough):0
Infilling (hard filling<5mm) :
Weathering (slightly weathered):1
Groundwater condition (Damp):10
Basic RMR:
Discontinuity Orientation (Unfavorable):10
Total RMR Point:
ClassVery Poor Rock

Exit Section (KM: 400+750 – KM: 400+930) (in accordance with SK-806)

Figure 4. 9 Basic and total RMR rating calculation with respect to SK-806				
Rating				
Uniaxial Compressive Strength, σ_c (5 MPa):2				
Rock Quality Designation (RQD %12):				
Spacing of Discontinuities (<60 mm) :				
Persistence of Discontinuities (3-10 m):				
Aperture of Discontinuities (1-5.0 mm):1				
Roughness of Discontinuities (Slightly rough):0				
Infilling (Clay filling<5mm) :				
Weathering (Moderately weathered):1				
Groundwater condition (Damp):10				
Basic RMR:				
Discontinuity Orientation (Unfavourable):10				
Total RMR Point:				
ClassVery Poor Rock				

Exit Section (KM: 400+750 - KM: 400+930) (in accordance with SK-810)

Figure 4. 10 Basic and total RMR rating calculation with respect to SK-810 Rating
Uniaxial Compressive Strength, $\sigma_c~(5~\text{MPa})$:2
Rock Quality Designation (RQD %12):
Spacing of Discontinuities (<60 mm) :
Persistence of Discontinuities (3-10 m):
Aperture of Discontinuities (1-5.0 mm):1
Roughness of Discontinuities (Slightly rough):0
Infilling (Clay filling<5mm) :
Weathering (Moderately weathered):1
Groundwater condition (Damp):10
Basic RMR:
Discontinuity Orientation (Unfavourable):10
Total RMR Point:
Class

4.2 GSI Classification of the Rocks Along the Tunnel

According to Hoek and Brown rock-mass failure criterion would have no practical usage unless it could be related to geological observations that could be made quickly and easily by an engineering geologist or geologist in the field. They considered developing a new classification system during the evolution of the criterion in the late 1970s but they soon gave up the idea and settled for the already published RMR system.

In the early days the use of the RMR classification (modified as described above) worked well because most of the problems were in reasonable quality rock masses (30<RMR<70) under moderate stress conditions. However, it soon became obvious that the RMR system was difficult to apply to rock masses that are of very poor quality. The relationship between RMR and the constants m and s of the Hoek–Brown failure criterion begins to break down for severely fractured and weak rock masses.

Both the RMR and the Q classifications include are heavily dependent upon the RQD classification introduced by Deere (1964). Since RQD in most of the weak rock masses is essentially zero or less than 10, it became necessary to consider an alternative classification system. The required system would not include RQD, would place greater emphasis on basic geological observations of rock-mass characteristics, reflect the material, its structure and its geological history, and would be developed specifically for the estimation of rock mass properties rather than for tunnel reinforcement and support.

Hoek and Brown (1997) proposed a new classification called Geological Strength Index (GSI), instead of RMR due to the limitations in the RMR system for very poor quality rock masses. The GSI system based upon the visual impression on the rock mass structure has twenty codes to identify each rock mass category and estimates the GSI value ranging between 10 and 85. On the basis of the studies on the Athens schist by Hoek et al. (1998), a new rock mass category was introduced into the GSI system called 'foliated/laminated rock mass structure'. Hoek (1999a) also inserted an upper row to the GSI system to deal with 'intact or massive' rock. The index and its use for the Hoek and Brown failure criterion was further developed by Hoek (1994), Hoek et al. (1995) and Hoek and Brown (1997). However, due to lack of measurable and more representative parameters, and related interval limits of the discontinuities, the GSI for each rock mass category in the chart represents a range of values. In other words, it is possible to estimate different GSI values from the chart for the same rock mass by different persons, depending on their personal experience. Therefore, an attempt has been made by Sönmez and Ulusay (1999) to provide more quantitative assessment for evaluating the GSI and to suggest quantities that make more sense than that of the RMR system when used for the estimation of the rock mass strength as an additional tool.

The papers by Marinos and Hoek (2000, 2001) put more geology into the Hoek-Brown failure criterion, and introduced a new GSI chart for heterogeneous weak rock masses. Marinos and Hoek (2000) also slightly changed the upper most part of the current GSI chart. The 1997 and latest versions of the GSI chart are quite sufficient for field observations, since it is only necessary to note the code that identifies the rock mass category. It is also noted that the intention of Hoek and his co-workers was to present an approximate method for rock mass characterization using the GSI. Evert Hoek and Paul Marinos, incredibly dealing with difficult materials encountered in tunneling in Greece, developed the GSI system to the present form to include poor quality rock masses (Table 4.3) (Hoek et al. 1998; Marinos and Hoek 2000, 2001).

The main goal of GSI is to provide information to estimate the strength parameters of rock mass for different geological conditions. GSI value calculation system is shown in Table 4.2. GSI values are calculated by the equation $GSI=RMR_{89}-5 c = <100 kPa$, $\emptyset = <15^{\circ}$ (recommended by Bieniawski, 1989) for each borehole (Table 4.3).

During the process of obtaining GSI values by using RMR ratings, the basic RMR rating with dry condition was taken in to account. Table 4.3 presents the results. In order to estimate the intervals for GSI values, Table 4.2 is used. Table 4.4 shows the comparison of the GSI values calculated from RMR with GSI values determined based on the field observations. Values obtained from the field and the values obtained from RMR are found to be compatible to each other.

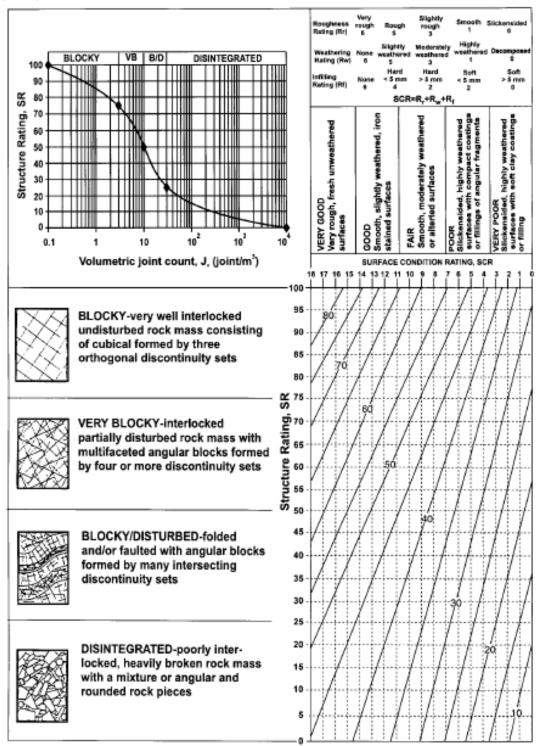
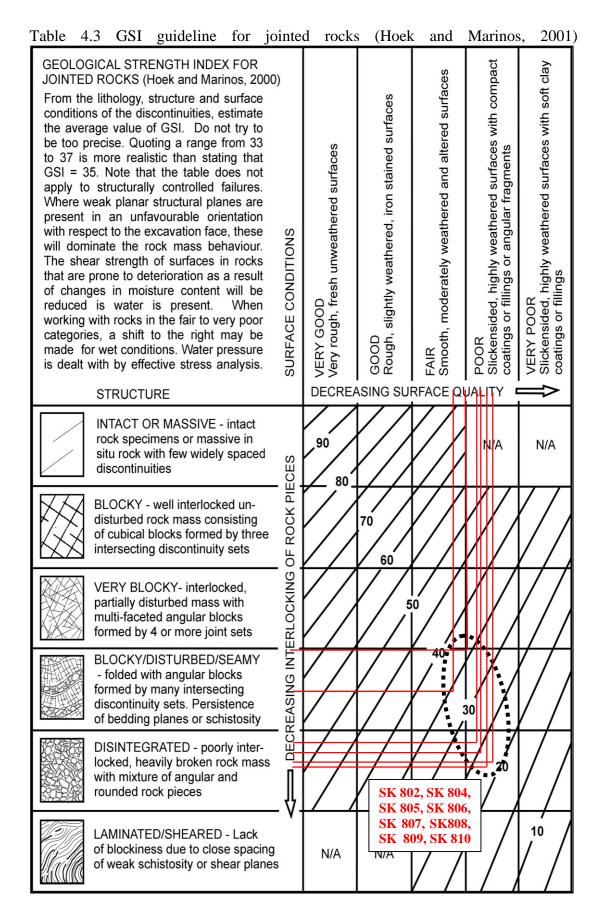


Table 4. 2 The modified quantitative GSI system suggested by Sönmez and Ulusay (2002).



Tunnel Section	Total RMR	Basic RMR	Rock Mass Class	GSI
Entrance Section (KM: 399+180 – KM: 399+400)	19	24	very poor rock	19
KM: 399+400 – KM: 399+700	22	27	poor rock	22
KM: 399+700 – KM: 400+080	23	28	poor rock	23
KM: 400+080 – KM: 400+150	-	-	very poor rock	-
KM: 400+200 – KM: 400+450	44	49	Fair rock	44
KM: 400+450 – KM: 400+520	-	-	very poor rock	-
KM: 400+520 – KM: 400+750	16	26	very poor rock	16
Exit Section (KM: 400+750 – KM: 400+930)	18	28	very poor rock	23

Table 4. 4 Calculated GSI and RMR values along the tunnel route.

Table 4. 5 Comparison of GSI values for different section of the tunnel.

Tunnel Section	GSI calcualted from Basic RMR	GSI determined from the field observations	Bore Hole
Entrance Section (KM: 399+180 – KM: 399+400)	19	16	SK 802
KM: 399+400 – KM: 399+700	22	23	SK 805
KM: 399+700 – KM: 400+080	23	21	SK 807
KM: 400+080 – KM: 400+150	Shearing zone	Shearing zone	SK 804
KM: 400+200 – KM: 400+450	44	36	SK 804, SK 808
KM: 400+450 – KM: 400+520	Shearing zone	Shearing zone	SK 808
KM: 400+520 – KM: 400+750	16	17	SK 809
Exit Section (KM: 400+750 – KM: 400+930)	23	21	SK 806, SK 810

4.3 Q- Classification of the Rocks Along the Tunnel

The Q system was developed at the Norwegian Geotechnical Institute (NGI) by Barton et al. (1974, 1975, 1976, 1988). Q System rating tables (Barton et al., 1974) are used for rock mass classifications based on borehole and field data. The equation used to define the Q-value is shown in Figure 4.11.

Figure 4. 11 Defination of the Q system

 $Q = (RQD/Jn)^*(Jr/Ja)^*(Jw/SRF)$ where;

RQD: rock quality designation

J_n : joint set number

J_r: joint roughness number

J_a: joint alteration number

J_w: joint water reduction factor

SRF: stress reduction factor

Calculated Q values through the tunnel route are shown in Tables 4.6-4.10.

Table 4. 6 Q classifications of the rock masses for KM: 399+400 – KM: 399+700 (SK-805)					
	BH NO	Q System Parameters	Description	Value	

BH NO	Q System Parameters	Value	
	RQD (%)	Very poor rock	5
	Joint Set Number (Jŋ)	Four joint sets plus random joints (x2 for portals)	15
	Joint Roughness Number (Jr)	Rough	0,5
SK-805	Joint Alteration Number (Ja)	Hard filling (Calcite)	4,0
	Joint Water Reduction (Jw) Dry excavation		1
	Stress Reduction Factor (SRF)	Loose, heavily jointed	2,5
	Rat	0.02	
	Descr	iption	Very Poor Rock

$$Q = (RQD/Jn)*(Jr/Ja)*(Jw/SRF) = (5/15)*(0.5/4.0)*(1/2.5) = 0.02$$

BH NO	Q System Parameters	Value		
	RQD (%)	Description Poor rock	6	
	Joint Set Number (Jŋ)	Three joint sets plus random joints	15	
	Joint Roughness Number (Jr)	Rough	0,5	
SK-807	Joint Alteration Number (Ja)	Hard filling (Calcite)	4	
	Joint Water Reduction (Jw) Dry excavation		1	
	Stress Reduction Factor (SRF)	Single shear zones, depth of excavation>50 m	2,5	
	Rat	0.02		
	Descr	intion	Very Poor Rock	
	Deser	Description		

Table 4. 7 Q classifications of the rock masses for KM: 399+700 – KM: 400+080 (SK-807)

 $Q = (RQD/Jn)^*(Jr/Ja)^*(Jw/SRF) = (6/15)^*(0.5/4)^*(1/2.5) = 0.02$

Table 4. 8 Q classifications of the rock masses for KM: 400+080 - KM: 400+150 (SK-804)

BH NO	Q System Parameters	Description	Value
SK-804	RQD (%)	Fair rock	53
	Joint Set Number (Jn)	Three joint sets plus random joints	12
	Joint Roughness Number (Jr)	Rough	2
	Joint Alteration Number (Ja)	Hard filling (Calcite)	0,75
	Joint Water Reduction (Jw)	Dry excavation	1
	Stress Reduction Factor (SRF)	Single shear zones, depth of excavation>50 m	2,5
	Rating		
	Deser	intion	Fair
	Descr	iption	Rock

Q = (RQD/Jn)*(Jr/Ja)*(Jw/SRF) = (53/12)*(2/0.75)*(1/2.5) = 4.7

Table 4. 9 Q classifications of the rock masses for KM: 400+080 - KM: 400+150 (SK-808)

BH NO	Q System Parameters	Description	Value
	RQD (%)	Very Poor Rock	56
	Joint Set Number (Jn)	Three joint sets plus random joints	12
	Joint Roughness Number (Jr)	Rough	2
SK-808	Joint Alteration Number (Ja)	Hard filling (Calcite)	0,75
	Joint Water Reduction (Jw)	Dry excavation	1
	Stress Reduction Factor (SRF) Single shear zones, excavation>50		2,5
	Rat	4,98	
	Descr	Fair Rock	

 $Q = (RQD/Jn)^*(Jr/Ja)^*(Jw/SRF) = (56/12)^*(2/0.75)^*(1/2.5) = 4.98$

Table 4. 10 Q classifications of the rock masses for KM: 400+520 – KM: 400+750 (SK-809)

BH NO	Q System Parameters	Value	
	RQD (%)	Description Very poor rock	6
	Joint Set Number (Jn)	Three joint sets plus random joints	15
	Joint Roughness Number (Jr)	Rough	0,5
SK-809	Joint Alteration Number (Ja)	Soft filling (Clay)	4
	Joint Water Reduction (Jw)	Dry excavation	1
	Stress Reduction Factor (SRF)	Single shear zones, depth of excavation<50 m	2,5
	Rat	0,016	
	Descr	Very Poor Rock	

Q = (RQD/Jn)*(Jr/Ja)*(Jw/SRF) = (6/15)*(0.5/4.0)*(1/2.5) = 0.016

Rock description obtained from Q classification for SK 805, SK 807, SK 804, SK 808, SK 809 are very poor rock, very poor rock, fair rock, fair rock, very poor rock, respectively. After comparing these rock mass classes with RMR, they are found to be compatible to each other.

4.4 NATM Classifications

NATM is a concept, or more precise, a mixture of design, contracting, excavation and active use of rock support experience. Müller (1978) indicates that "the NATM is rather a tunneling concept than a method, with a set of principles, which the tunneller tries to follow". These features have been systematized into the NATM concept where the different parties involved have worked out a splendid cooperation.

NATM has been developed to improve construction methods for tunneling in weak rocks. Definition of "weak rock" here represents material which requires the use of structural supports during excavation. The rock material itself may be soft or hard. According to Rabcewicz (1975), the goal of NATM is; "To provide safe and economic support in tunnels excavated in materials incapable of supporting themselves - e.g. crushed rock, debris, even soil. Support is achieved by mobilizing whatever humble strength the rock or earth possesses".

NATM, is a common application including many construction practices. As part of this, NATM is also available in its own rock mass classification. However, this classification system of NATM based on verbal approaches which make almost impossible to determine geotechnical parameters needed for numerical analysis. Because of this, it is reasonable to determine the support system with respect to empirical classifications systems such as RMR and Q. Figure 4.1 shows a cart which helps to determine the NATM support system with respect to RMR and Q.

NATM classes are determined after correlations of RMR and Q Ratings as given in Table 4.11. According to the Table 4.11, middle part of the tunnel has better NATM classes than the portals. For sections defined as shear zone, presence of meta-

sandstone-schist with clay matrix is assumed. Shear zone sections are also considered to have weak strength with very poor rock. NATM class C3 is assigned for these sections.

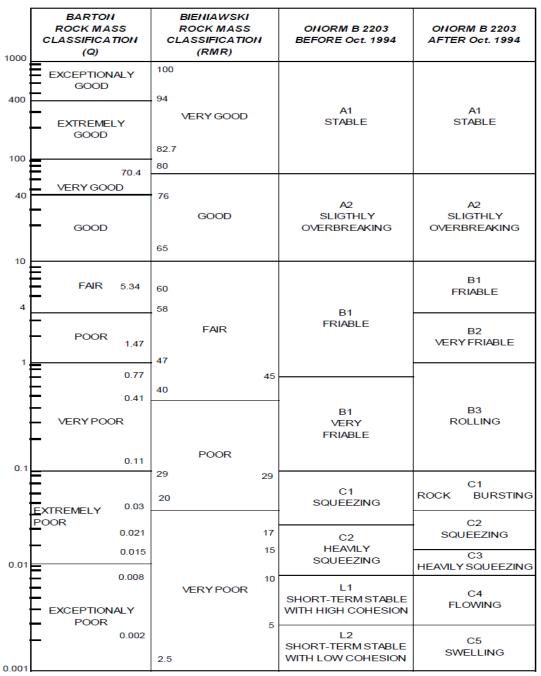


Figure 4. 12 Correlations among RMR, Q and NATM (ONORM B 2203, 1994) Table 4. 11 NATM Classification though the tunnel route

Intervals of	f KM	BH No	RMR Rating	Q Rating	NATM Classification
KM: 399+400	399+180-KM:	SK-802	19		C2
KM: 399+700	399+400-KM:	SK-805	22	0,02	C2
KM: 400+080	399+700-KM:	SK-807	23	0,02	C2
KM: 400+150	400+080-KM:				C3
KM: 400+200	400+150-KM:	SK-804			B3
KM: 400+400	400+200-KM:	SK-804	44	4,7	B2
KM: 400+400	400+200-KM:	SK-808	44	4,98	B2
KM: 400+450	400+400-KM:	SK-808			B3
KM: 400+520	400+450-KM:				C3
KM: 400+750	400+520-KM:	SK-809	16	0,016	C2
KM: 400+930	400+750-KM:	Sk-806	18		C2
KM: 400+930	400+750-KM:	SK-810	17		C2

4.5 Classifications involving stand up time

Hoek and Brown (1980) defined the unsupported span as the span of the tunnel or in other words the distance between the face and the nearest support. Also according to Lauffer (1958), the stand-up time for an unsupported span is related to the quality of rock mass. In other words, unsupported span distance would be higher with respect to the quality of the rock mass. Barton et al. (1976) create an equation which related the maximum unsupported length of tunnel to ESR and Q values: $S_u=2(ESR)Q^{0.4}$ (m)

Moreover, Barton et al. (1974) suggest the following guideline which explains the relationship between ESR values and the excavation category. (Table 4.12).

Table 4. 12 Guideline for ESR value and excavation category. (After Barton et al., 1974)

Exca	vation category	ESR
Α	Temporary mine openings.	3-5
В	Permanent mine openings, water tunnels for hydro power (excluding high pressure penstocks), pilot tunnels, drifts and headings for large excavations.	1.6
С	Storage rooms, water treatment plants, minor road and railway tunnels, surge chambers, access tunnels.	1.3
D	Power stations, major road and railway tunnels, civil defence chambers, portal intersections.	1.0
Е	Underground nuclear power stations, railway stations, sports and public facilities, factories.	0.8

Also, Bieniawski (1976) proposed a relationship between the standup time of an unsupported underground excavation span and geomechanics classification. This relationship is presented in Figure 4.2. Bieniawski (1989) also recommends stand up time according to the rock mass classifications. According to the rock mass classifications through the tunnel studied in this thesis, the stand up time and unsupported span time is presented in Table 4.13.

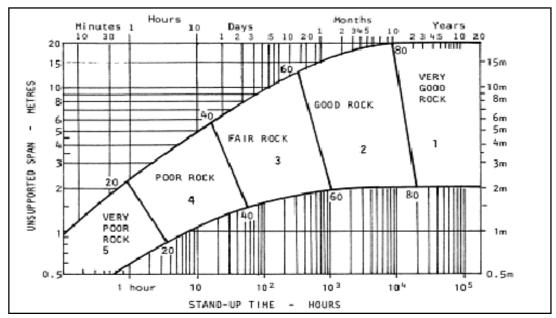


Figure 4. 13 The relationship between the stand up time of an unsupported underground excavation span and the CSIR Geomechanics Classification proposed by Bieniawski (1976)

Intervals of KM	Rock Mass Classification	Average Stand up Time for different Spans
KM: 399+180-KM: 399+400	Very Poor Rock	30 min. For 0.5 m span
KM: 399+400-KM: 399+700	Very Poor Rock	30 min. For 0.5 m span
KM: 399+700-KM: 400+080	Very Poor Rock	30 min. For 0.5 m span
KM: 400+080-KM: 400+150	Very Poor Rock	30 min. For 0.5 m span
KM: 400+150-KM: 400+200	Poor Rock	10 hrs. For 2.5 m span
KM: 400+200-KM: 400+400	Fair Rock	1 week for 5 m span
KM: 400+200-KM: 400+400	Fair Rock	1 week for 5 m span
KM: 400+400-KM: 400+450	Poor Rock	10 hrs. For 2.5 m span
KM: 400+450-KM: 400+520	Very Poor Rock	30 min. For 0.5 m span
KM: 400+520-KM: 400+750	Very Poor Rock	30 min. For 0.5 m span
KM: 400+750-KM: 400+930	Very Poor Rock	30 min. For 0.5 m span
KM: 400+750-KM: 400+930	Very Poor Rock	30 min. For 0.5 m span

Table 4. 13 Average stand up time according to rock mass classifications

CHAPTER 5

DETERMINATION OF SUPPORT SYSTEMS FOR THE BELKAHVE TUNNEL USING EMPIRICAL METHODS

The rock mass classification systems, which are RMR, Q and NATM, performed to determine the support systems for the Belkhave tunnel empirically.

5.1 Support Systems Based on RMR Classification

Bieniawski (1989) proposed a guideline in order to select the proper support in tunnel excavation. This guideline aims to explaining excavation methods and determining support systems of 10 m span rock tunnels with respect to RMR system (Table 5.1).

Rock mass class	Excavation	Rock bolts (20 mm diameter, fully grouted)	Shotcrete	Steel sets
I - Very good rock <i>RMR</i> : 81-100	Full face, 3 m advance.	Generally no support re	quired except sp	ot bolting.
II - Good rock <i>RMR</i> : 61-80	Full face , 1-1.5 m advance. Complete support 20 m from face.	Locally, bolts in crown 3 m long, spaced 2.5 m with occasional wire mesh.	50 mm in crown where required.	None.
III - Fair rock <i>RMR</i> : 41-60	Top heading and bench 1.5-3 m advance in top heading. Commence support after each blast. Complete support 10 m from face.	Systematic bolts 4 m long, spaced 1.5 - 2 m in crown and walls with wire mesh in crown.	50-100 mm in crown and 30 mm in sides.	None.
IV - Poor rock <i>RMR</i> : 21-40	Top heading and bench 1.0-1.5 m advance in top heading. Install support concurrently with excavation, 10 m from face.	Systematic bolts 4-5 m long, spaced 1-1.5 m in crown and walls with wire mesh.	100-150 mm in crown and 100 mm in sides.	Light to medium ribs spaced 1.5 m where required.
V – Very poor rock <i>RMR</i> : < 20	Multiple drifts 0.5-1.5 m advance in top heading. Install support concurrently with excavation. Shotcrete as soon as possible after blasting.	Systematic bolts 5-6 m long, spaced 1-1.5 m in crown and walls with wire mesh. Bolt invert.	150-200 mm in crown, 150 mm in sides, and 50 mm on face.	Medium to heavy ribs spaced 0.75 m with steel lagging and forepoling if required. Close invert.

Table 5. 1 Guidelines for excavation method and support system of 10 m span rock tunnels in accordance with the RMR system (Bieniawski, 1989)

Intervals of KM	RMR	Excavation	Rock Bolts (20 mm diameter, fully grouted)	Shotcrete	Steel Sets
399+180- 399+400	19	Multiple Dirfts 0,5- 1,5 m. Advance in top heading. Install support concyrrently with excavation. Shotcrete as soon as possible after blasting.	Systematic bolts 5-6 m long, spaced 1- 1,5 m in crown and walls with wire mesh. Bolt invert	150-200 mm in crown 150 mm in sides 50 mm on face	Medium to heavy ribs spaced 0,75 m. With steel lagging and forepoling if required. close invert.
399+400- 399+700	22	Top heading and bench 1,0-1,5 m advance in top heading. Install support concurrently with excavation 10 m from face	Systematic bolts 4-5 m long, spaced 1- 1,5 m in crown and walls with wire mesh. Bolt invert	100-150 mm in crown and 100 mm in sides.	Light to medium ribs spaced 1,5 m. Where required
399+700- 400+080	23	Top heading and bench 1,0-1,5 m advance in top heading. Install support concurrently with excavation 10 m from face	Systematic bolts 4-5 m long, spaced 1- 1,5 m in crown and walls with wire mesh. Bolt invert	100-150 mm in crown and 100 mm in sides.	Light to medium ribs spaced 1,5 m. Where required
400+080- 400+150		Multiple Dirfts 0,5- 1,5 m. Advance in top heading. Install support concyrrently with excavation. Shotcrete as soon as possible after blasting.	Systematic bolts 5-6 m long, spaced 1- 1,5 m in crown and walls with wire mesh	150-200 mm in crown 150 mm in sides 50 mm on face	Medium to heavy ribs spaced 0,75 m. With steel lagging and forepoling if required. close invert.
400+150- 400+200		Top heading and bench 1,0-1,5 m advance in top heading. İnstall support concurrently with excavation 10 m from face	Systematic bolts 4-5 m long, spaced 1- 1,5 m in crown and walls with wire mesh. Bolt invert	100-150 mm in crown and 100 mm in sides.	Light to medium ribs spaced 1,5 m. Where required

Table 5. 2 Suggested excavation and support systems of for the Belkahve tunnel based on RMR classification.

Table 5. 2 Continued

	Jonunu				
Intervals of KM	RMR	Excavation	Rock Bolts (20 mm diameter, fully grouted)	Shotcrete	Steel Sets
400+200- 400+400	44	Top heading and bench 1,5-3 m. advance in top heading. Commence support after each blast. Complete support 10 m. from face	Systematic bolts 4 m long, spaced 1.5-2.0 m in crown and walls with wire mesh in crown.	50-100 mm in crown and 30 mm in sides.	None
400+400- 400+450		Top heading and bench 1,0-1,5 m advance in top heading. Install support concurrently with excavation 10 m from face	Systematic bolts 4-5 m long, spaced 1- 1,5 m in crown and walls with wire mesh. Bolt invert	100-150 mm in crown and 100 mm in sides.	Light to medium ribs spaced 1,5 m. Where required
400+450- 400+520		Multiple Dirfts 0,5- 1,5 m. Advance in top heading. Install support concyrrently with excavation. Shotcrete as soon as possible after blasting.	Systematic bolts 5-6 m long, spaced 1- 1,5 m in crown and walls with wire mesh	150-200 mm in crown 150 mm in sides 50 mm on face	Medium to heavy ribs spaced 0,75 m. With steel lagging and forepoling if required. close invert.
400+520- 400+750	16	Multiple Dirfts 0,5- 1,5 m. Advance in top heading. Install support concyrrently with excavation. Shotcrete as soon as possible after blasting.	Systematic bolts 5-6 m long, spaced 1- 1,5 m in crown and walls with wire mesh	150-200 mm in crown 150 mm in sides 50 mm on face	Medium to heavy ribs spaced 0,75 m. With steel lagging and forepoling if required. close invert.
400+750- 400+930	18	Multiple Dirfts 0,5- 1,5 m. Advance in top heading. Install support concyrrently with excavation. Shotcrete as soon as possible after blasting.	Systematic bolts 5-6 m long, spaced 1- 1,5 m in crown and walls with wire mesh	150-200 mm in crown 150 mm in sides 50 mm on face	Medium to heavy ribs spaced 0,75 m. With steel lagging and forepoling if required. close invert.

Suggested excavation and support systems of for different sections of the Belkahve tunnel based on the RMR classification are given above in Table 5. 2.

5.2 Support Systems Based on Q system

The estimated support categories based on Q-system (Barton, 2002) are determined by using Figure 5.1. Q-values calculated in Chapter 4 are used here.

For Q value of 0.69; 1.5 m spaced rock bolt with a length of 4.8 m are recommended. Shotcrete with thickness of 12 cm. is suggested. For Q value of 4.3; 2.2m spaced rock bolt with a length of 4.2 m are recommended. Shotcrete with thickness of 5 cm. is suggested.

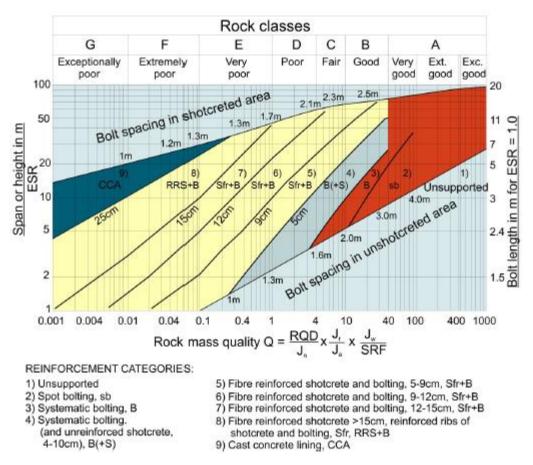


Figure 5. 1 Support categories based on Q-system (Barton, 2002)

For Q value of 12.1; 2.6 m spaced rock bolt with a length of 4.8 m are recommended. Shotcrete with thickness of 3-4 cm. is suggested. For Q value of 2.9; 1.8 m spaced rock bolt with a length of 4.0 m are recommended. Shotcrete with thickness of 7 cm. is suggested. For Q value of 0.1; 1.5 m spaced rock bolt with a length of 3.0 m are recommended. Shotcrete with thickness of 15 cm. is suggested. For Q value of 0.4; 1.5 m spaced rock bolt with a length of 3.8 m are recommended. Shotcrete with thickness of 9 cm. is suggested.

5.3 Support systems depending on NATM

The support systems according to the NATM classifications (Geoconsult, 1993 and ONORM B 2203, 1994) based on the classes obtained in Chapter 4 are presented in Table 5.3.

For NATM B3 class, the tunnel could be excavated by top heading (1,25m-1,50m.) and bench (3,0 m.). Excavation should be done with smooth blasting or mechanical excavation techniques. Shotcrete and systematic bolting are recommended. Wire mesh and Invert slab is suggested in case of necessary.

For NATM C2 class, the tunnel could be excavated by top heading (0,75m-1,25m.) and bench (2,0 m.) and invert slab. Excavation should be done with smooth blasting or mechanical excavation techniques. Shotcrete and systematic bolting are recommended at the tunnel face. Forepole application is also recommended along the upper part of the excavation. Wire mesh and Invert slab is suggested in case of necessary.

For NATM C3 class, the tunnel could be excavated by top heading (0,75m-1,00m.) and bench (1,5 m.) and invert slab. Excavation should be done with smooth blasting or mechanical excavation techniques. Shotcrete and systematic bolting should be applied to the tunnel face. Forepole application is also recommended along the upper part of the excavation. Systematic wire mesh and Invert slab is also recommended.

	NATM		Support Systems
Intervals of KM	Class	Excavation	
KM: 399+180- KM: 399+400	C2	Top heading (0.75-1.25 m) and bench (2.0 m). Smooth blasting or mechanical excavation.	Shotcrete and systematic bolting, forepoling, systematic Steel set, Wire mesh, Invert slab.
KM: 399+400- KM: 399+700	C2	Top heading (0.75-1.25 m) and bench (2.0 m). Smooth blasting or mechanical excavation.	Shotcrete and systematic bolting, forepoling, systematic Steel set, Wire mesh, Invert slab.
KM: 399+700- KM: 400+080	C2	Top heading (0.75-1.25 m) and bench (2.0 m). Smooth blasting or mechanical excavation.	Shotcrete and systematic bolting, forepoling, systematic Steel set, Wire mesh, Invert slab.
KM: 400+080- KM: 400+150	C3	Top heading (0.75-1.00 m) and bench (1.5 m). Smooth blasting or mechanical excavation.	Shotcrete and systematic bolting, forepoling, systematic Steel set, Wire mesh, Invert slab.
KM: 400+150- KM: 400+200	В3	Top heading (1.25-1.5 m) and bench (3.0 m). Smooth blasting or mechanical excavation.	Shotcrete and systematic bolting, forepoling, systematic Steel set. Wire mesh may be necessary. Invert slab may be necessary.
KM: 400+200- KM: 400+400	30% B3, 70% B2	Top heading (1.5-2.0 m) and bench (3.0-3.5 m). Smooth blasting.	Shotcrete and systematic bolting, forepoling. Invert slab may be necessary.
KM: 400+400- KM: 400+450	В3	Top heading (1.25-1.5 m) and bench (3.0 m). Smooth blasting or mechanical excavation.	Shotcrete and systematic bolting, forepoling, systematic Steel set. Wire mesh may be necessary. Invert slab may be necessary.
KM: 400+450- KM: 400+520	C3	Top heading (0.75-1.00 m) and bench (1.5 m). Smooth blasting or mechanical excavation.	Shotcrete and systematic bolting, forepoling, systematic Steel set, Wire mesh, Invert slab.
KM: 400+520- KM: 400+750	C2	Top heading (0.75-1.25 m) and bench (2.0 m). Smooth blasting or mechanical excavation.	Shotcrete and systematic bolting, forepoling, systematic Steel set, Wire mesh, Invert slab.
KM: 400+750- KM: 400+930	C2	Top heading (0.75-1.25 m) and bench (2.0 m). Smooth blasting or mechanical excavation.	Shotcrete and systematic bolting, forepoling, systematic Steel set, Wire mesh, Invert slab.

Table 5. 3 NATM support systems (Specifications of GDH, 2006)

CHAPTER 6

ESTIMATION OF THE ROCK MASS STRENGTH PARAMETERS

The most important preparation step for numerical modeling is the estimation of rock mass strength parameters. In-situ test is a method to determine these parameters ultimately. However, in the early stage of the design, rock mass strength parameters and support systems should be determined by using rock mass classification systems such as RMR, Q, GSI.

6.1 Estimation of Rock Mass Parameters

In order to determine the strength parameters (m, s, c, ø, E_{rm} , etc.) of the rock mass of the tunnel, the computer program Roclab 1.0 (2007) was used. The uniaxial compressive strength (σ_c), modulus of elasticity of intact rock (E_i) and unit weight (γ) are obtained from the laboratory tests and entered to the program as input parameters. The parameter of m_i value is selected from the Roclab software with respect to the rock type. Both, excellent quality blasting and poor quality blasting conditions were chosen by selecting the value of D= 0 or D= 0.7. Also, while determining the depth of tunnel, depth from ground level to the tunnel route level is taken into account. At Figure 6.1. all needed input parameters can be seen.

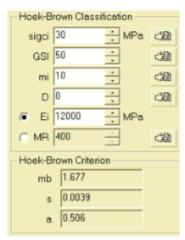


Figure 6. 1 needed input parameters for roclab.

Required parameters of the generalized Hoek-Brown failure criterion which are mb, s and a, has been determined by the software Roclab as a result of calculation performed by using given set of input parameters (sigci, GSI, mi, Ei and D). RocLab also calculates the deformation modulus of the rock mass Erm using the Generalized Hoek-Diederichs equation with respect to input value of intact modulus Ei (Hoek and Diederichs, 2006). In this thesis, all of these parameters are calculated using the latest version of the HoekBrown failure criterion. Furthermore, RocLab always calculates equivalent Mohr-Coulomb parameters (cohesion and friction angle) for the rock mass. Since most rock engineering software (both Mohr-Coulomb and Hoek-Brown is available for Phase 2) is still written in terms of the Mohr-Coulomb failure criterion, it is necessary to determine equivalent angles of friction and cohesive strengths for each rock mass and stress range.

This is done by fitting an average linear relationship to the curve generated by solving equation for a range of minor principal stress values defined by $\sigma_t < \sigma_3 < \sigma_{3max}$ as illustrated in Figure 6.2. The fitting process involves balancing the areas above and below the Mohr-Coulomb plot. This results in the following equations for the angle of friction ϕ and cohesive strength *c*':

Note that the value of σ'_{3max} , the upper limit of confining stress over which the relationship between the Hoek-Brown and the Mohr-Coulomb criteria is considered, has to be determined for each individual case. Guidelines for selecting these values for slopes as well as shallow and deep tunnels are presented later. The Mohr-Coulomb shear strength τ , for a given normal stress σ , is found by substitution of these values of '*c* and ' ϕ in to the equation:

$$\tau = c' + \sigma \tan \phi$$

The equivalent plot (Figure 6.2), in terms of the major and minor principal stresses, is defined by:

$$\sigma'_{1} = \frac{2c'\cos\phi'}{1-\sin\phi'} + \frac{1+\sin\phi'}{1-\sin\phi'}\sigma'_{3}$$

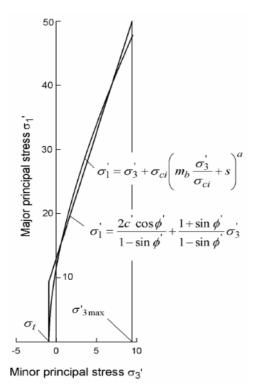


Figure 6. 2 Relationships between major and minor principal stresses for Hoek-Brown and equivalent Mohr-Coulomb criteria.

The engineering parameters of the rock masses for different sections of the tunnel are presented in Figures 6.3-6.15.

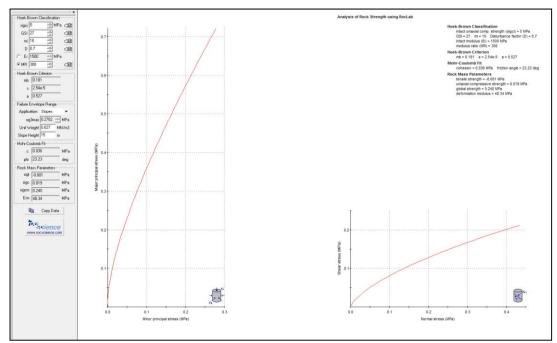


Figure 6. 3 Engineering parameters of the rock mass for D=0.7 (Entrance Section KM: 399+180 – KM: 399+400)

c= 36 kPa, $Ø = 23^{\circ}$ ve E_{rm}= 48 MPa

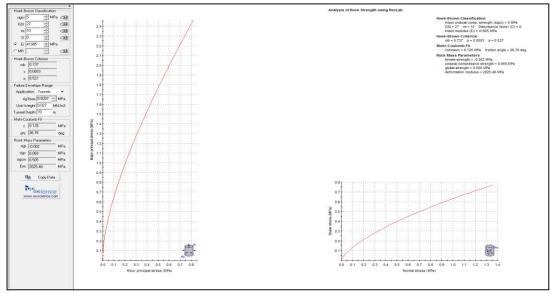


Figure 6. 4 Engineering parameters of the rock mass for D=0 (KM: 399+400 – KM: 399+700 in accordance with SK-805)

c= 125 kPa, $Ø= 27^{\circ}$ ve E_{rm}= 2825 MPa

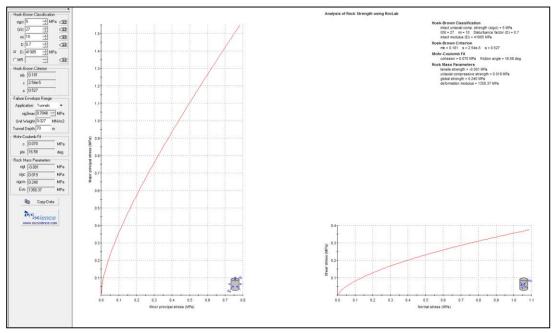


Figure 6. 5 Engineering parameters of the rock mass for D=0,7 (KM: 399+400 – KM: 399+700 in accordance with SK-805)

c= 70 kPa, Ø= 17° ve E_{rm}= 1350 MPa

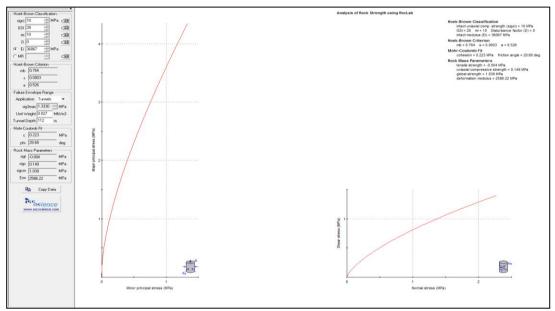


Figure 6. 6 Engineering parameters of the rock mass for D=0 (KM: 399+700 – KM: 400+080 in accordance with SK-807)

c= 223 kPa, $Ø= 29^{\circ}$ ve E_{rm}= 2586 MPa

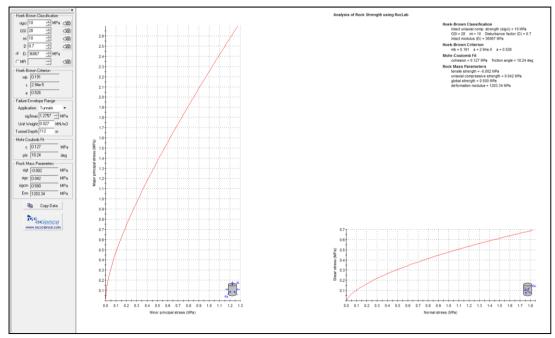


Figure 6. 7 Engineering parameters of the rock mass for D=0,7 (KM: 399+700 – KM: 400+080 in accordance with SK-807)

c= 127 kPa, Ø= 18° ve E_{rm}= 1203 MPa

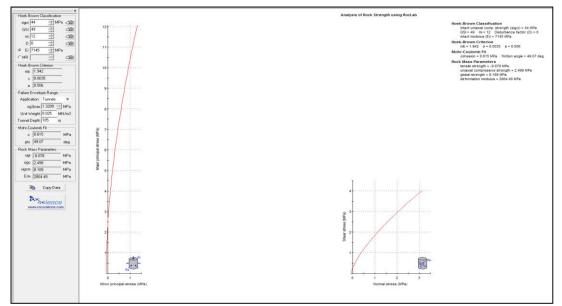


Figure 6. 8 Engineering parameters of the rock mass for D=0 (KM: 400+150 - KM: 400+200 in accordance with SK-804)

c= 615 kPa, Ø= 49° ve E_{rm}= 2064 MPa

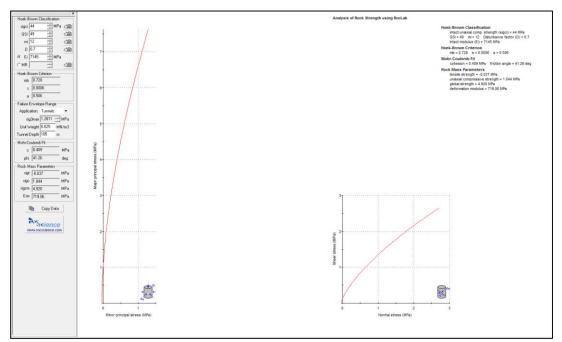


Figure 6. 9 Engineering parameters of the rock mass for D=0,7 (KM: 400+150 - KM: 400+200 in accordance with SK-804)

c= 409 kPa, \emptyset = 41° ve E_{rm}= 719 MPa

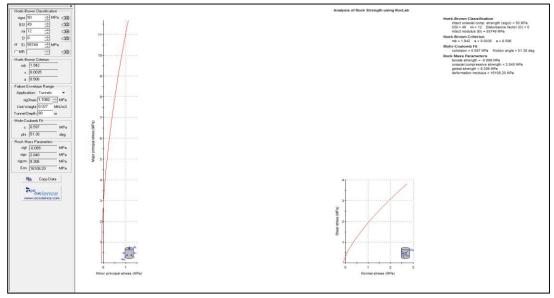


Figure 6. 10 Engineering parameters of the rock mass for D=0 (KM: 400+200 - KM: 400+520 in accordance with SK-808)

c= 597 kPa, Ø= 51° ve E_{rm}= 16108 MPa

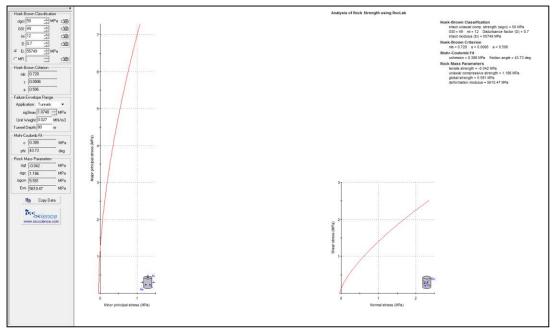


Figure 6. 11 Engineering parameters of the rock mass for D=0,7 (KM: 400+200 – KM: 400+520 in accordance with SK-808)

c= 388 kPa, \emptyset = 44° ve E_{rm}= 5610 MPa

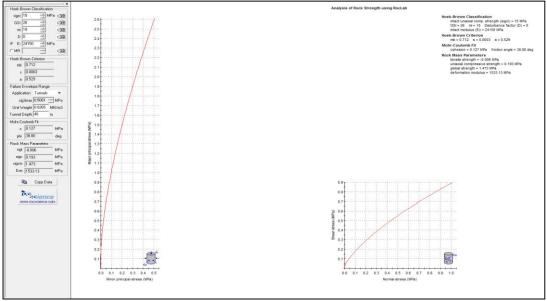


Figure 6. 12 Engineering parameters of the rock mass for D=0 (KM: 400+520 - KM: 400+750 in accordance with SK-809)

c= 127 kPa, Ø= 39° ve E_{rm}= 1533 MPa

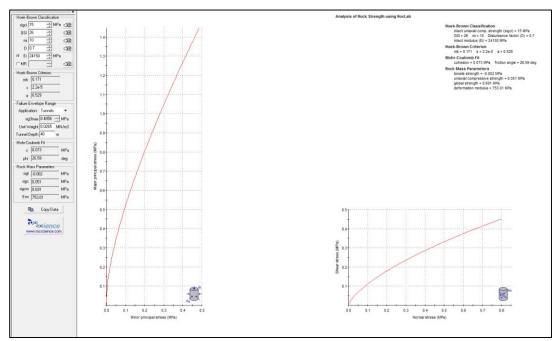


Figure 6. 13 Engineering parameters of the rock mass for D=0,7 (KM: 400+520 – KM: 400+750 in accordance with SK-809)

c= 73 kPa, Ø= 27° ve E_{rm}= 753 MPa

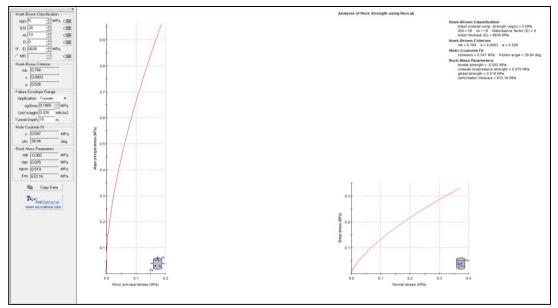


Figure 6. 14 Engineering parameters of the rock mass for D=0,7 (Exit Section KM: 400+750 - KM: 400+930 in accordance with SK-806)

c= 47 kPa, Ø= 39° ve E_{rm}= 633 MPa

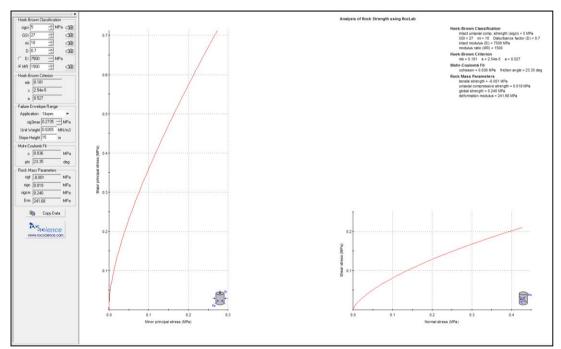


Figure 6. 15 Engineering parameters of the rock mass for D=0,7 (Exit Section KM: 400+750 – KM: 400+930 in accordance with SK-810)

c= 36 kPa, \emptyset = 23° ve E_{rm}= 242 MPa

Determination of necessary paramaters cohesion (c), angle of friction (\emptyset) and modulus of elasticity of the rock mass (Erm) for numerical modeling are completed by using roclab. Table 6.1 summarizes the rock mass parameters obtained in this study.

	Disturbance Factor (D)	Unit weight (kN/m2)	Cohesion (c) (kPa)	ø(°)	Depth (m)	Erm (MPa)
Entrance Portal	0.7	27	36	23	20	48
KM: 399+400-KM:	0	27	125	27	70	2825
399+700	0.7	27	70	17	70	1350
KM: 399+700-KM:	0	27	223	29	112	2586
400+080	0.7	27	127	18	112	1203
KM: 400+080-KM: 400+150	shearing zone		20	25	100	100
KM: 400+150-KM:	0	25	615	49	105	2064
400+200	0.7	25	409	41	105	719
KM: 400+200-KM:	0	27	597	51	80	16108
400+450	0.7	27	388	44	80	5610
KM: 400+450-KM: 400+520	shearing zone		20	25	100	100
KM: 400+520-KM:	0	26	127	39	40	1533
400+750	0.7	26	73	27	40	753
Exit Portal	0.7	26	36	23	15	242

Table 6. 1 Engineering parameters of the rock mass obtained from Roclab

6.2 Estimation of Deformation Modulus

Determinating the parameter of modulus of elasticity of rock mass (E_{rm}) is very important for numerical analyses. Roclab is an accepted method for determination of the deformation modulus of rock mass. However, in this study different empirical equations have been also used to determine the deformation modulus of rock mass.

All of the accepted equations are presented in Table 6.2. However, the mostly preferred equations (Bieniawski, 1978; Serafim and Pereira, 1983, Barton, 2002; Hoek and Diederichs, 2006) are used in this thesis. These equations are preferred because they need parameters of RMR, Q or GSI in order to calculate deformation value of the rock mass which makes the determination of rock strength parameters process related to field observation data. Calculated deformation modulus values are presented in Table 6.3.

Originator of Empirical Equation	Required Parameters	Limitations	Equations
Bienawski (1978)	RMR	RMR > 50	$E_{rm} = 2RMR - 100 (GPa)$
Serafim and Pereira (1983)	RMR	RMR < 50	$E_{rm} = 10^{[(RMR-10)/40]} (GPa)$
Barton (2002)	Q, σ _c	σ _c <100MPa	$E_{rm}=10Qc^{(1/3)}$ (GPa)
Hoek et al. (2002)	GSI , σ _c , D	σ _c <100MPa	$E_{rm=}(1-D/2)*((q_{o}/100)^{0.5})*(10^{(GSI-10)/40})~(GPa)$
		σ _c >100MPa	Erm=(1-D/2)* ((qc/100)0.5)* (10(GSI- 10)/40) (GPa)
Kayabaşı et al. (2003)	E _i , RQD, WD	-	<i>Erm</i> =0.135[(<i>Ei</i> (1+ <i>RQD</i> /100))/WD] (<i>Gpa</i>)
Gökçeoğlu et al. (2003)	E _i , RQD, WD, σc	-	Erm=0.001 [((Ei/qc)(1+RQD/100))/WD] ¹ . ¹⁸¹¹ GPa
Sönmez et al. (2004a)	E _i , s, a	-	$Erm=Ei~(s^a)^{0.4}~(Gpa)$
Hoek and Diederichs (2006)	GSI, D	-	$Erm = 100 \ 000*(1-(D/2)/1+e((75+25D-GSI)/11))$ (MPa)
Hoek and Diederichs (2006)	E _i , GSI, D	-	Erm=Ei ((1- D/2)/(1+e((60+15D- GSI)/11))) (MPa)
Sönmez et al. (2004b)	Ei, RMR	-	Erm=Ei10((RMR-100)*(100- RMR))/(4000*exp (- RMR/100)) (MPa)

 Table 6. 2 List of empirical equations for estimating the deformation modulus

Sections	E _{rm} =10Qc ^(1/3) (GPa) (Barton,2002)	Erm=Ei ((1- D/2)/(1+e ^{((60+15D- GSI)/11)})) (MPa) (Hoek&	E _{rm=} (1-D/2)* ((q _c /100) ^{0.5})* (10 ^{(GSI-10)/40}) (GPa) (Hoek,2002)	Erm=Ei10 ^{((RMR-100)*(100- RMR))/(4000*exp (- RMR/100)) (MPa) (Sönmez ve diğ.,2006)}	E _{rm} = 100 000*(1- (D/2)/1+e ^{((75+25D-GSI)/11)} (MPa)	GSI	Basic RMR	RMR	q_c (MPa)	Ei (lab& MR) (MPa)
	(Barton,2002)	Diederichs, 2006)	(110ek,2002)	(Sonmer ve uig.,2000)	2006)					
Entrance Portal	1,71 GPa	35,16 MPa	0,38 GPa	130,94 MPa	609,53 MPa	19	24	19	5	1500
KM: 399+400-KM: 399+700	1,71 GPa	1280,99 MPa	0,45 GPa	5078,94 MPa	799,25 MPa	22	27	22	5	41905
KM: 399+700-KM: 400+080	2,15 GPa	1204,02 MPa	0,67 GPa	4833,89 MPa	874,70 MPa	23	28	23	10	36067
KM: 400+150-KM: 400+200	3,53 GPa	1351,56 MPa	4,70 GPa	3709,79 MPa	5625,49 MPa	44	49	44	44	7145
KM: 400+200-KM: 400+450	3,68 GPa	10545,59 MPa	5,01 GPa	28945,69 MPa	5625,49 MPa	44	49	44	50	55749
KM: 400+520-KM: 400+750	2,47 GPa	675,84 MPa	0,73 GPa	1453,88 MPa	730,26 MPa	21	26	16	15	24150
Exit Portal	1,71 GPa	294,77 MPa	0,47 GPa	684,44 MPa	874,70 MPa	23	28	18	5	8830

Table 6. 3 Estimation of deformation modulus of the rock masses along tunnel route

For the exit section of the tunnel, 40 kPa, 25° are determined for the cohesion (c) and angle of friction (\emptyset) values, respectively. It can be said that the values determined for entrance section is worse than the values determined for entrance section (55 kPa and 25°). In the middle section of the tunnel, the highest parameters (c= 615 kPa and \emptyset = 49°) are obtained. According to Wood (2004), the dilation angle is calculated as 0.33 times of the friction angle. So, the dilation angle value 9° is taken into account for both entrance and exit sections of the tunnel. For the middle section of the tunnel, the dilation angle is taken between 7° and 16°. In Table 6.4 shows the summary of the rock mass parameters to be used for the numerical analyses.

Section	Disturbance Factor (D)	Unit weight (kN/m2)	Cohesion (c) (kPa)	ø(°)	Depth (m)	Erm (MPa)
Entrance Portal	0.7	27	40	25	20	350
KM: 399+400-KM:	0	27	125	27	70	2825
399+700	0.7	27	70	17	70	1350
KM: 399+700-KM:	0	27	223	29	112	2586
400+080	0.7	27	127	18	112	1203
KM: 400+080-KM: 400+150	shearing zone		20	25	100	100
KM: 400+150-KM:	0	25	615	49	105	2064
400+200	0.7	25	409	41	105	719
KM: 400+200-KM:	0	27	597	51	80	16108
400+450	0.7	27	388	44	80	5610
KM: 400+450-KM: 400+520	shearing zone		20	25	100	100
KM: 400+520-KM:	0	26	127	39	40	1533
400+750	0.7	26	73	27	40	753
Exit Portal	0.7	26	55	25	15	500

Table 6. 4 Summary of the rock mass parameters to be used for numerical analyses.

CHAPTER 7

THE VERIFICATION OF TUNNEL SUPPORT SYSTEMS WITH NUMERICAL ANALYSIS

Mostly applied methods for rock mass classification and rock support systems are the methodologies of Bieniawski (RMR) and Barton (Q). Nevertheless, thanks to the developments in Finite Element Methods, huge amounts of possibilities are also accomplished. The Finite Element Method (FEM) possesses a great capacity of analyzing the complex underground conditions through non homogeneities. The subsurface is modeled as continuum. Meshes consisting of limited number of elements form this model. The concepts of solving unknowns at each element cause highly complex matrix equations. However, in solving the formed complex matrix equations, the capability belongs to the FEM.

Several numerical analyses programs to be used for the purpose discussed above, is based on " finite elements" or "finite difference" methods. Phase 2 and Flac are the most common 2D finite elements programs. For 3D analysis Adina, 3DEC, Flac and Plaxis can be used.

In this thesis, Phase2 software was used to model the tunnel sections. It uses two dimensional finite element method. Phase 2 software was created by Toronto University and still being developed by Rocscience group. The program also provides applications of rock bolts and shotcrete which are the currently used temporary support systems for NATM tunneling. Safety factor in Phase 2 program is measured through c-ø reduction option of the finite element method. By using this option, strength properties of all material in the model have been decreased with an amount of

reduction factor and FEM analysis are reiterated again. In the event that the program cannot measure the model with reduced strength parameters, as a safety factor the ratio of reduction is taken.

To simulate the negative effect of groundwater, the coefficient of permeability was included in the analyses. Value of coefficient of permeability obtained from the laboratory test results which is given at appendix section in this thesis. After each analyses performed for different section of the tunnel, the strain values around the tubes and yielded bolt-liners are checked in the context of the tunnel stability. According to Hoek (2001), strain values around the tubes should be smaller than %1 in order to stay in the safe side.

7.1 Determining Support Properties for Numerical Analyses

According to General Directorate of Highways, the properties of the supports for the assigned NATM classes to be used in the numerical analyses are given below at Tables 7.1-7.4. In this study, properties of bolts, shotcrete, steel mesh, steel set and forepole have been determined based on the experience (accepted by General Directorate of Highways) of YUKSEL DOMANİÇ company.

Support Systems	C2
Bolt Diameter	28 mm
Bolt Spacing	1,0x1,0
Bolt length	4-6 m
Shotcrete class and thickness	C20/25(25cm)
steel mesh type	Q221/221
sieer mesn type	Double layer
Steel set type and spacing	HEA140,1,00m
Forepole spacing and length	t=0,5m, L=4-6 m
Span time	C2
Top heading	1,00 m
bench	2,0 m

Table 7. 1 Properties of C2 support system

Table 7. 2 Properties of C3 support system

Support Systems	C3
Bolt Diameter	28 mm
Bolt Spacing	1,0x1,0
Bolt length	6 m
Shotcrete class and thickness	C20/25(40cm)
steel mesh type	Q221/221
	Double layer
Steel set type and spacing	HEA140,1,00m
Forepole spacing and length	t=0,5m, L=4-6 m
Span time	C2
Top heading	0,75 m
Bench	1,5 m

Table 7. 3 Properties of B3 support system	Table 7.3	Properties	of B3 su	pport system
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Support Systems	B3		
Bolt Diameter	28 mm		
Bolt Spacing	1,5x1,5		
Bolt length	4m		
Shotcrete class and thickness	C20/25(20cm)		
stool moch tuno	Q221/221		
steel mesh type	Double layer		
Steel set type and spacing	HEA120,1,50m		
Forepole spacing and length	t=0,5m, L=4-6 m (if required)		
Span time	B3		
Top heading	1,50 m		
bench	3,00 m		

Table 7.4	Properties	of B2 st	upport s	ystem

Support Systems	B2
Bolt Diameter	28 mm
Bolt Spacing	2,0x-2,0
Bolt length	4m
Shotcrete class and thickness	C20/25(15cm)
steel mesh type	Q221/221
	TEK KAT
Steel set type and spacing	HEA100,2.0 m (if required)
Forepole spacing and length	-
Span time	B2
Top heading	2,00 m
bench	3,00 m

7.2 Steps of Modeling with Finite Element Method

The Belkave tunnel section is designed with finite element method. In order to design the tunnel, firstly, geotechnical sectors of the tunnel should be defined. Secondly, the section is separated into limited number of elements that are connected at nodal points. In this study, triangular element type is used. In the third step of the modeling, external boundary definition has been done. The upper part is designed as free boundary which can be define as $\sigma yy=0$. The parts of the section are restrain x (lubricated mixed boundary) which means $u_x=0$, σ_{xy} and $\sigma_{xz}=0$. The lower boundary of the section is called as restrain y (lubricated mixed boundary) so as to define uy=0, $\sigma xz=\sigma yz=0$ and $\sigma yy=\gamma L$. Mesh and boundary conditions can be seen below Figure 7.1.

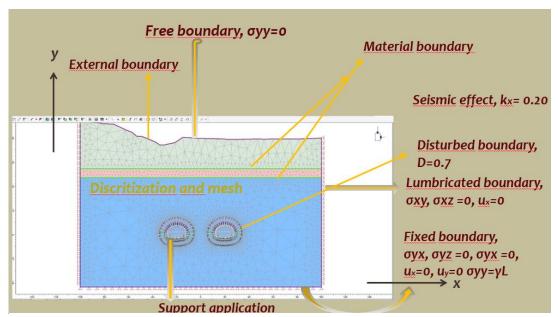


Figure 7.1 The mesh and boundary condition of the section

Poor blasting disturbance factor is taken into account for plastic boundary around the tunnel to be on the safe side. The thickness of the plastic boundary is taken as 0.5D, half of the of tunnel diameter in operation. There are several ways to determine the plastic boundary around the tunnel. However, in practice, 0.5D is accepted for the

plastic radius. Phase 2 (2008) software and RocSupport 3.0 (2007) software also verify this assumption. So, 6m. is taken as the radius of plastic zone in this study. In the next step of the modeling, assignment of the material properties is completed. Gravity type of field stress is chosen by using actual ground surface and predicting the horizontal to vertical stress ratio, k which is expanded as k=0.25+7Eh(0.001+(1/z)) according to Sheorey (1994).

After defining the number of steps in designing, support application which determined empirically is done in several steps. The timing of support application and support interaction with rock masses is not suitable for 2D models. To understand d and solve this issue, its needed to be underline two important stages before the application of the support systems. First one is that the rock mass should be allowed to be relaxed, and the second one is that rock mass should be allowed to carry some of the load itself. In Phase 2, there are two methods used to fulfill load split within rock mass and support systems. These two methods are called "load split" option and "material softening". In the designing of the tunnel sections to simulate 3D to 2D, material softening method is used in this study. The material stiffness is multiplied by a reduction factor β . β is the coefficient from 0 to 1 that is multiplied by the material stiffness to yield the material inside the tunnel. Seismic load is applied in the last step of the modeling. The coefficient of the seismic load is taken as 0.2 according to suggestion of GDH (2006). The strain around the tunnel and yielded support elements are checked right after computing the model.

7.3 Slope Stability Analyses for Entrance Portal

At this part, highest cut before entrance of the tunnel was modeled and stability analyses were performed. In practice excavation is performed from natural topography to the first float as the very first step. As soon as the first cut completed, the support elements installation (shotcrete, rock bolts) are to be completed. The excavation of the cut will be completed right after reaching to the road grade. According to the Technical Specifications of General Directorate of Highways (2006), the sufficient safety factors under static and dynamic conditions are 1.5 and 1.15, respectively. To analyze the stability of highest cut, the model was prepared in five steps. The slope of side was 3H:2V and forehead was 1H:3V (H: horizontal, V: vertical). In the first step, the natural condition of the surface was modeled. In the following steps, the cut and support applications were done. Seismic load was applied to the system as the final step.

For forehead slope which is the slope of tunnel entrance at KM: 399+400, the model was prepared in three stages. In the first step, the natural condition of the surface was modeled. In the following steps, the cut and support applications were done. Seismic load was applied to the system as the final step. Table 7.5 shows the specifications of supports used in analyses.

Table 7. 5 Supports used in modering of the entrance portai.			
Bolt spacing	1.5m*1.5m		
Bolt length	4 m		
Bolt diameter	32 mm		
Bolt modulus	200 000		
Tensile capacity	250 kN		
Shotcrete thickness	25 cm		
Young's modulus of shotcrete	15 000 MPa		

Table 7. 5 Supports used in modeling of the entrance portal.

For both static and seismic conditions, numerical analyses performed for the side slopes at the entrance portal in order to check the stability of the tunnel section. Because of the negative effect of groundwater on the strength of the rock mass, analyses were performed with effect of groundwater, thus it is aimed to stay in the safe side (Figures 7.2 and 7.3).

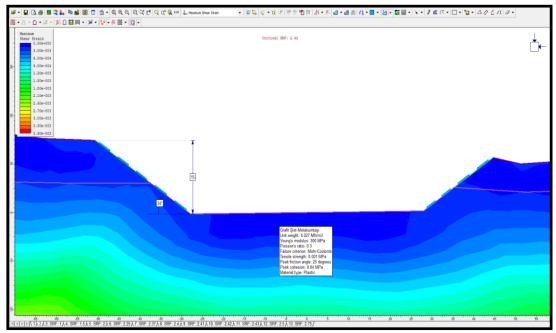


Figure 7. 2 Slope stability analysis for the side slopes at the entrance portal showing maximum shear strain under static condition (3H/2V) (SF: 2. 42)

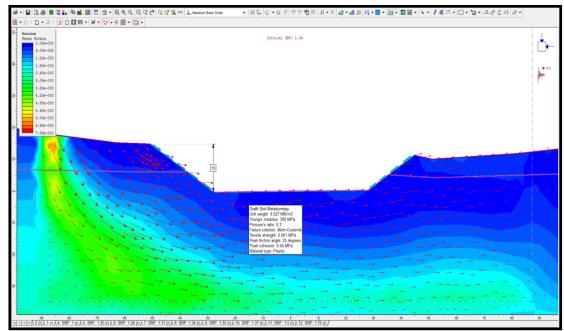


Figure 7. 3 Slope stability analysis for the side slopes at the entrance portal showing maximum shear strain under the effect of seismic load of kx=0.20 (3H/2V) (SF: 1.34)

When the cut is completed Total displacement is 3 cm under static condition. Value of 2.42 obtained at this stage for the safety factor. However, total displacement is increased to 4 cm after seismic load applied to the model (kx=0.20). At this stage, there are no yielded liners. Value of 1.34 obtained at this stage for the safety factor. According to the Technical Specifications of GDH (2006), the values are sufficient for the slope stability.

Figures 7.4 and 7.5 show the side slopes at entrance of the tunnel during excavation. The results obtained from numerical analyses for side slopes at entrance portal and real slopes (field performance) are compatible with each other. No slope instability problems have appeared during slope excavation as it was predicted by numerical analyses.



Figure 7. 4 shotcrete and water pipes installed for side slope



Figure 7. 5 wire mesh and shotcrete installation for side slope

For both static and dynamic (under seismic load) conditions, slope stability analyses were performed. Because of the negative effect of groundwater on the strength of the rock mass, analyses were performed with effect of groundwater, thus it is aimed to stay in the safe side. The results of analyses performed are shown in Figures 7.6 and 7.7.

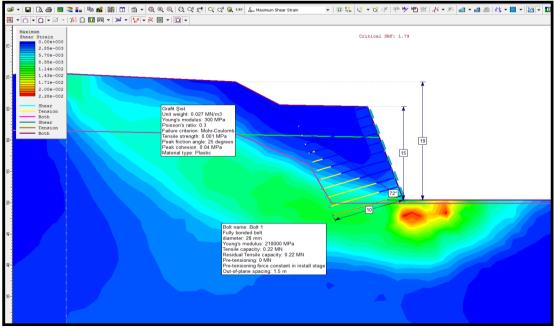


Figure 7. 6 Slope stability analysis for the forehead slopes at the entrance portal showing maximum shear strain under static condition (1H/3V) (SF: 1.75)

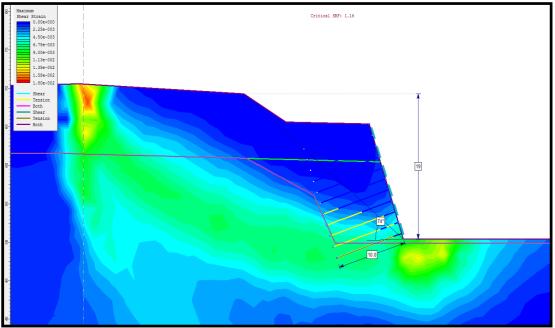


Figure 7. 7 Slope stability analysis for the forehead slopes at the entrance portal showing maximum shear strain under effect of seismic load of kx=0.20 (1H/3V) (SF: 1.25)

When the cut is completed Total displacement is 2 cm under static condition. Value of 1.75 obtained at this stage for the safety factor. However, total displacement is increased to 3 cm after seismic load applied to the model (kx=0.20). At this stage, there are no yielded liners but some of the bolt elements are yielded. Value of 1.25 obtained at this stage for the safety factor. According to the Technical Specifications of GDH (2006), the values are sufficient for the slope stability.

To sum up, results obtained from the slope stability analyses performed show that the slopes are on the safe side according to Technical Specifications of GDH (2006). Figures 7.8, 7.9 and 7.10 show the forehead slopes at the entrance portal of the tunnel during excavation. The results obtained from the numerical analyses for the forehead slopes at the entrance portal and real slopes (field performance) are compatible with each other. No slope instability problems have occurred during slope excavation as it was predicted by numerical analyses.



Figure 7. 8 A view of the supported forehead slope at the tunnel entrance.



Figure 7. 9 Another view of the supported forehead slope at the tunnel entrance.



Figure 7. 10 A general view of the supported slopes at the tunnel entrance.

7.4 Stability analyses of the tunnel

Km: 399+190 and Km: 400+820 are defined as critical sections for the entrance and exit s of the tunnel due to the lowest overburden. Because of lowest overburden and low engineering parameters, arching effect would not be occurred. At kilometers of 399+700, 399+960, 400+200, 400+240, 400+500, 400+550, the tunnel section analyses were performed because these are considered as critical sections.

At KM: 399+190, the entrance section of the tunnel was modeled in 14 stages. These steps are given below:

- Stage 1: inspection of in situ stress distributions
- Stage 2: upper part of right tube has been softened
- Stage 3: upper part of right tube excavation and supporting has been completed
- Stage 4: lower part of right tube has been softened
- Stage 5: lower part of right tube excavation and supporting has been completed
- Stage 6: invert excavation of right tube has been softened
- Stage 7: invert part of right tube excavation and supporting has been completed
- Stage 8: upper part of left tube has been softened
- Stage 9: upper part of left tube excavation and supporting has been completed
- Stage 10: lower part of left tube has been softened
- Stage 11: lower part of left tube excavation and supporting has been completed
- Stage 12: invert excavation of left tube has been softened
- Stage 13: invert part of left tube excavation and supporting has been completed Stage 14: seismic load has been applied to the model

Simulation of the stages explained above and support specification used for modeling are given in Figure 7.11 and Table7.6, respectively.

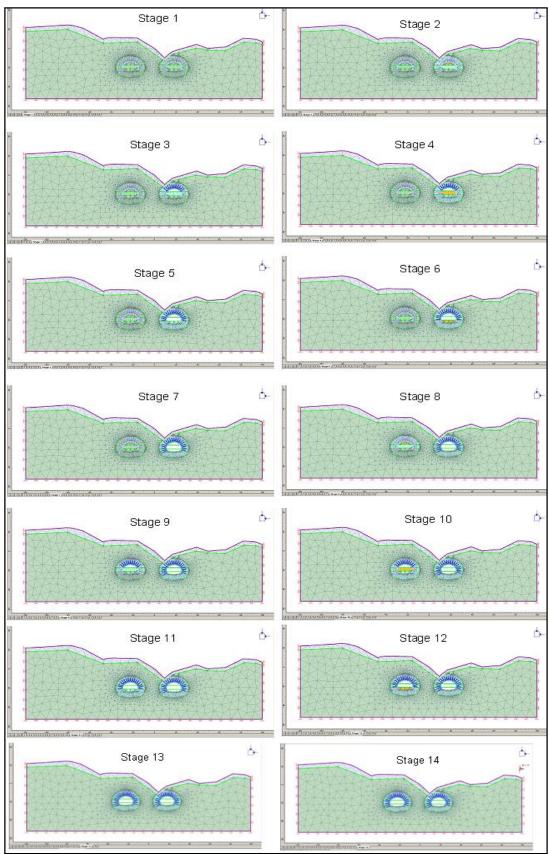


Figure 7. 11 Steps of modeling of the tunnel.

Bolt spacing	1 m*1 m
Bolt length	4 m
Bolt diameter	32 mm
Bolt modulus	200 000
Tensile capacity	250 kN
Shotcrete thickness	20 cm
Young's modulus of shotcrete	15 000 MPa

Table 7. 6 Supports used in the modeling of the tunnel at KM: 399+190

As the tunnel excavation moves on in three dimensions, displacement may be increased. Decreasing the stiffness of the filled material in the tunnel is used to simulate this effect in 2D model. With the aim of determining the proper softness ratio, stiffness versus displacement curve is generated. X-axis on the graph represents the displacements. On the y-axis, $1-\beta$ is plotted where β is coefficient varying from 0 to 1 (Figure 7.12). This coefficient can be defined as softening ratio of the material inside the tunnel (Phase2, 2008).

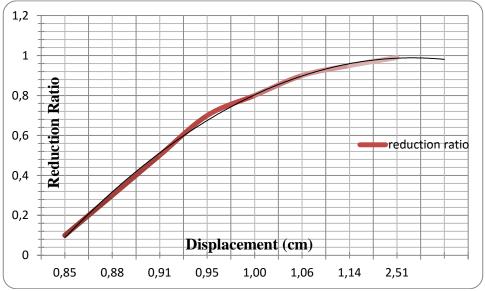


Figure 7. 12 Reduction ratio vs. displacement graph for KM: 399+190

As seen in Figure 7.12, at the point of 0,6 the linearity is disturbed. So, 0.6 reduction ratio is chosen to decrease the stiffness. 20 cm shotcrete and I160 steel sets spaced in 1.5 m intervals and Q221 wire mesh were applied. Figure 7.13. shows the diagram of the axial force - bending moment which was plotted for the shotcrete. According to Figure 7.13, 20 cm shotcrete is considered to be sufficient.

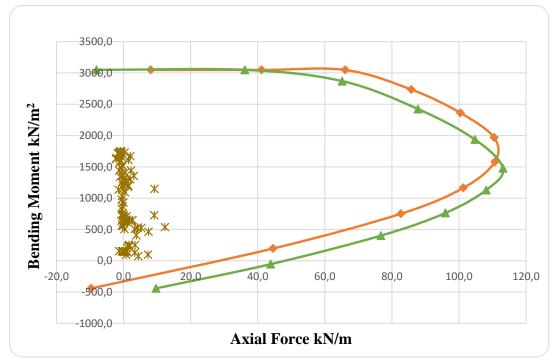


Figure 7. 13 Bending moment vs. axial force graph of 20 cm shotcrete, I160 steel sets spaced in 1.5 m intervals and wire mesh for the tunnel entrance

For both static and dynamic (under seismic load) conditions, slope stability analyses were performed. Because of the negative effect of groundwater on the strength of the rock mass, analyses were performed with effect of groundwater, thus it is aimed to stay in the safe side. Bolts and liners was not yielded. The results of analyses performed are shown in Figures 7.14 and 7.16.

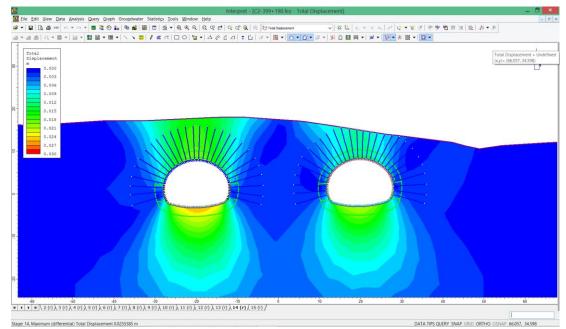
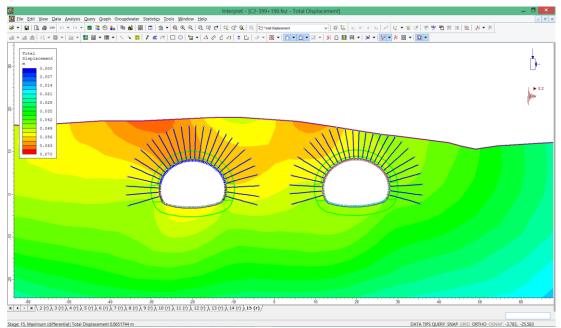


Figure 7. 14 Total displacements around tunnel section at KM: 399+190



State 15. Maximum (differential) Total Displacement around tunnel section under seismic effect (kx=0.20) at KM: 399+190

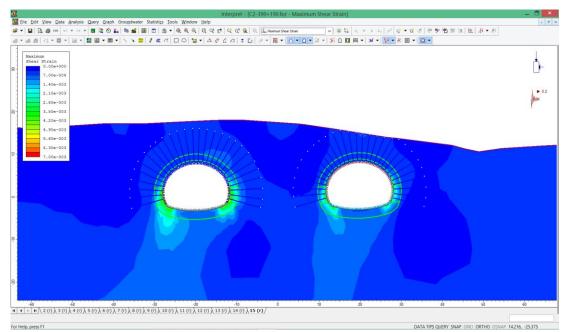


Figure 7. 16 Maximum shear strain around tunnel under seismic condition (kx=0.20) at KM: 399+190

Without effect of seismicity, total displacements at the peak point of the left and right tubes are 1.9 cm and 1.2 cm, respectively. For the left tube under seismic effect of kx= 0.20, the total displacement is raised to 2.1 cm, and for the right tube total displacement is raised to 1.3 cm. These results are acceptable and it can be stated that C2 support systems for the section of the tunnel is verified by numerical analyses.

According to strain values obtained from Phase 2 software, they never reach %1, specified by Hoek (2001). At figure 7.17 and 7.18, Belkahve tunnel entrance excavation is shown. No stability problems have occurred during the excavation.



Figure 7. 17 A close-up view of the excavation at the Belkahve tunnel entrance



Figure 7. 18 A general view of the excavation at the Belkhave tunnel entrance

The entrance section of the tunnel at KM: 399+700 was modeled by Phase 2 software. Modeling of the tunnel tubes was performed in 14 stages. These steps explained below:

Stage 1: inspection of in situ stress distributions
Stage 2: upper part of right tube has been softened
Stage 3: upper part of right tube excavation and supporting has been completed
Stage 4: lower part of right tube has been softened
Stage 5: lower part of right tube excavation and supporting has been completed
Stage 6: invert excavation of right tube has been softened
Stage 7: invert part of right tube excavation and supporting has been completed
Stage 8: upper part of left tube has been softened
Stage 9: upper part of left tube excavation and supporting has been completed
Stage 10: lower part of left tube has been softened
Stage 11: lower part of left tube excavation and supporting has been completed
Stage 12: invert excavation of left tube has been softened
Stage 13: invert part of left tube excavation and supporting has been completed

Table 7.7 presents the supports used in the numerical analyses. As seen in Figure 7.19, the linearity is disturbed at reduction ratio of 0.6. So, 0.6 reduction ratio is chosen to decrease the stiffness. 20 cm shotcrete were applied. Figure 7.20. shows the diagram of the axial force - bending moment which was plotted for the shotcrete. According to Figure 7.20, 20 cm shotcrete is considered to be sufficient.

Bolt spacing	1 m*1 m
Bolt length	4 m
Bolt diameter	32 mm
Bolt modulus	200 000
Tensile capacity	250 kN
Shotcrete thickness	20 cm
Young's modulus of shotcrete	15 000 MPa

Table 7. 7 Support used in the modeling of the tunnel at KM: 399+700

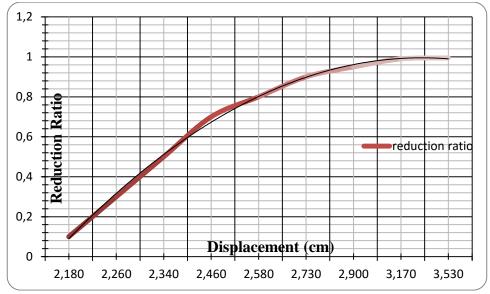


Figure 7. 19 Reduction ratio vs. displacement graph for KM: 399+700

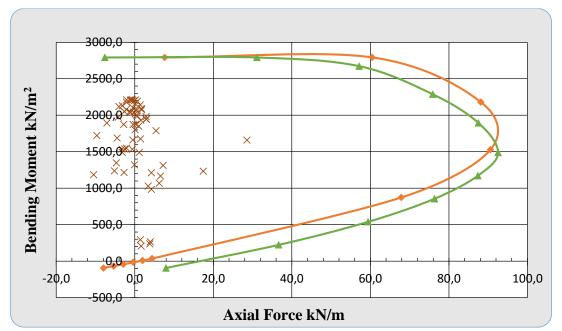


Figure 7. 20 Bending moment vs. axial force graph of 20 cm shotcrete, Q221/221 wire mesh for Km: 399+700

For both static and dynamic (under seismic load) conditions, total displacements were checked. Because of the negative effect of groundwater on the strength of the rock mass, analyses were performed with effect of groundwater, thus it is aimed to stay in the safe side. Liner elements were not yielded. However, some of the bolt elements were yielded. The results of analyses performed are shown in Figures 7.21 and 7.23.

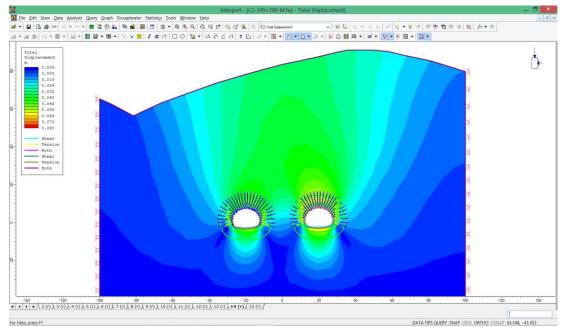


Figure 7. 21 Total displacements around tunnel section KM: 399+700

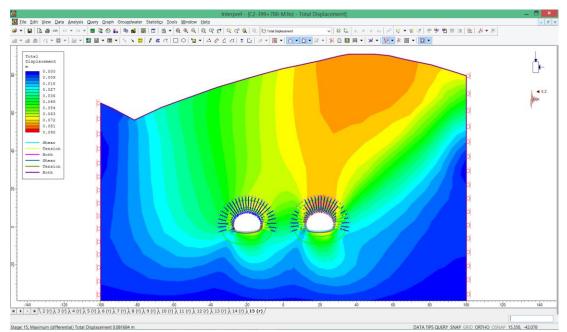


Figure 7. 22 Total displacement around tunnel section under seismic effect (kx=0.20) KM: 399+700

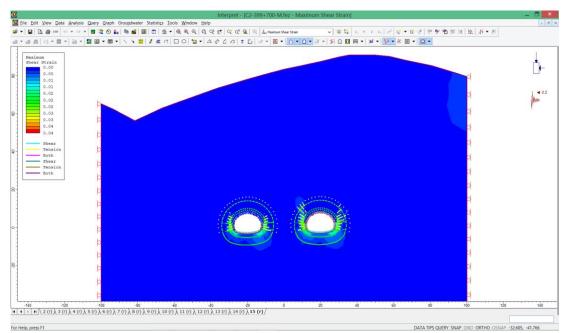


Figure 7. 23 Maximum shear strain around tunnel under seismic condition (kx=0.20) KM: 399+700

Without effect of the seismicity, total displacements at the peak point of left and right tubes are 5.6 cm and 6.3 cm, respectively. Under the seismic effect of kx=0.20, total displacement for left and right tubes are raised to 5.9 cm and 7.1 cm, respectively. These results are definitely acceptable and it can be stated that C2 category support systems for the section of the tunnel is verified by numerical analyses. According to the strain values obtained from the analysis, they never exceed %1 limiting value (Hoek, 2001). Therefore, no problem related to tunnel deformation is expected for this section of the tunnel.

The entrance section of the tunnel at KM: 399+960 was also modeled in 14 stages. These steps explained below:

Stage 1: inspection of in situ stress distributions
Stage 2: upper part of right tube has been softened
Stage 3: upper part of right tube excavation and supporting has been completed
Stage 4: lower part of right tube has been softened
Stage 5: lower part of right tube excavation and supporting has been completed
Stage 6: invert excavation of right tube has been softened
Stage 7: invert part of right tube excavation and supporting has been completed
Stage 8: upper part of left tube has been softened
Stage 9: upper part of left tube has been softened
Stage 10: lower part of left tube has been softened
Stage 11: lower part of left tube excavation and supporting has been completed
Stage 12: invert excavation of left tube has been softened
Stage 13: invert part of left tube excavation and supporting has been completed

Stage 14: seismic load has been applied to the model

The supports used in modeling are presented in Table 7.8.

Bolt spacing	1 m*1 m
Bolt length	4 m
Bolt diameter	32 mm
Bolt modulus	200 000
Tensile capacity	250 kN
Shotcrete thickness	20 cm
Young's modulus of shotcrete	10 000 MPa

Table 7. 8 Support used in the modeling of the tunnel at KM: 399+960

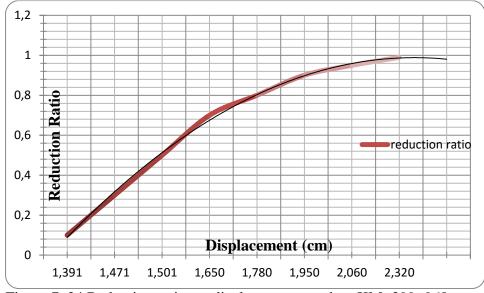


Figure 7. 24 Reduction ratio vs. displacement graph at KM: 399+960

As seen in Figure 7.24, at the point of 0,6 the linearity is disturbed. So, 0.6 reduction ratio is chosen to decrease the stiffness. 20 cm shotcrete were applied. Figure 7.25. shows the diagram of the axial force - bending moment which was plotted for the shotcrete. According to Figure 7.25, 20 cm shotcrete is considered to be sufficient.

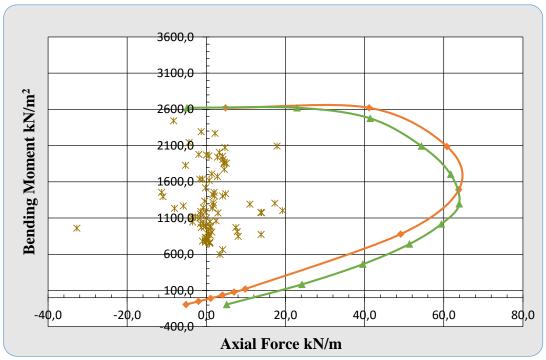


Figure 7. 25 Moment vs. axial force diagram of 15 cm shotcrete and Q221/221 wire mesh for Km: 399+960

For both static and dynamic (under seismic load) conditions, total displacements were checked. Liner elements were not yielded. However, some of the bolt elements were yielded. The results of analyses performed are shown in Figures 7.26 and 7.28.

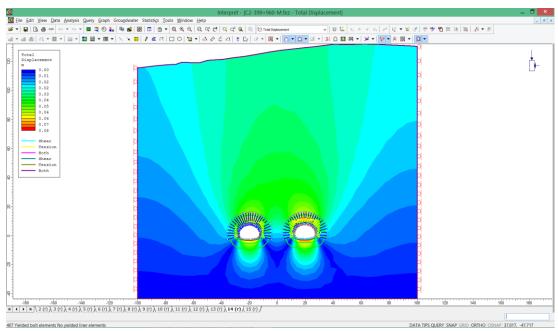


Figure 7. 26 Total displacements around the tunnel section at KM: 399+960

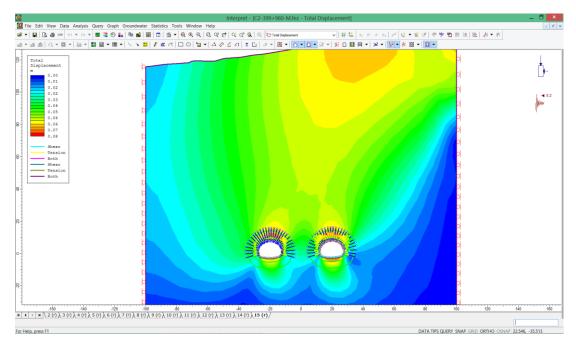


Figure 7. 27 Total displacement around tunnel section under seismic effect (kx=0.20) at KM: 399+960

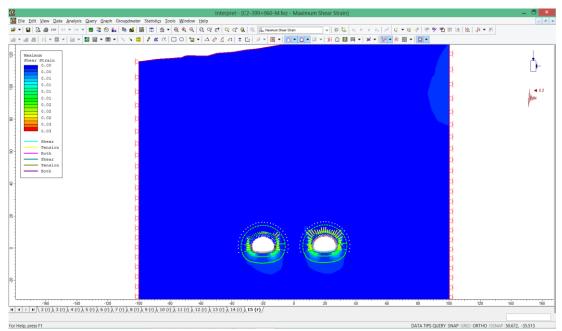


Figure 7. 28 Maximum shear strain around tunnel under seismic condition (kx=0.20) at KM: 399+960

Without effect of seismicity, total displacements at the peak point of the left and right tubes are 6.8 cm and 6.6 cm, respectively. Total displacements under seismic effect of kx=0.20, are raised to 7.0 cm for left tube and 7.1 cm for the right tube. These results are acceptable and it can be stated that C2 category support systems for the section of the tunnel is verified by numerical analyses.

According to the strain values obtained from the analysis, they never exceed %1 limiting values (Hoek, 2001). Therefore, no problem related to tunnel deformation is expected for this section of the tunnel. Steel rib application is shown in Figure 7.29.



Figure 7. 29 Steel sets installation at Belkahve Tunnel

The entrance section of the tunnel at KM: 400+200 was modeled by Phase 2 software. Modeling of the tunnel tubes was performed in 14 stages. These steps explained below:

Stage 1: inspection of in situ stress distributions

Stage 2: upper part of right tube has been softened

Stage 3: upper part of right tube excavation and supporting has been completed

Stage 4: lower part of right tube has been softened

Stage 5: lower part of right tube excavation and supporting has been completed

Stage 6: invert excavation of right tube has been softened

Stage 7: invert part of right tube excavation and supporting has been completed

Stage 8: upper part of left tube has been softened

Stage 9: upper part of left tube excavation and supporting has been completed

Stage 10: lower part of left tube has been softened

Stage 11: lower part of left tube excavation and supporting has been completed

Stage 12: invert excavation of left tube has been softened

Stage 13: invert part of left tube excavation and supporting has been completed

Stage 14: seismic load has been applied to the model

The supports used in modeling are presented in Table 7.9.

Table 7. 9 Support used in the modeling

Bolt spacing	1.5 m*1.5 m
Bolt length	4 m
Bolt diameter	32 mm
Bolt modulus	200 000
Tensile capacity	250 kN
Shotcrete thickness	15 cm
Young's modulus of shotcrete	15 000 MPa

For both static and seismic conditions, total displacements were checked around the both right and left tubes. According to results obtained, there were no yielded liners. Nevertheless, some of the bolt elements were yielded. The results of the analyses are presented in Figures 7.30-7.32.

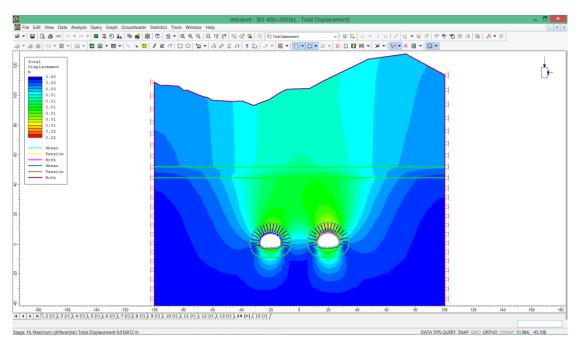
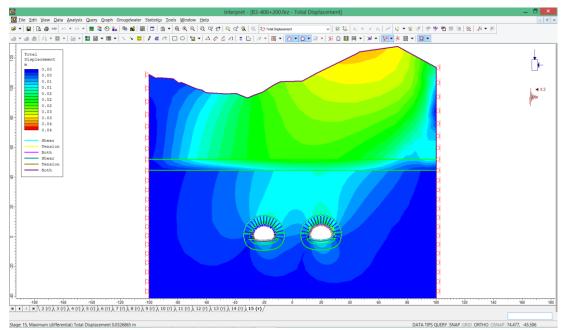


Figure 7. 30 Total displacements around tunnel section at KM:400+200



Stager 15. Maximum (differential) Total Displacement around tunnel section under seismic effect (kx=0.20) at KM:400+200

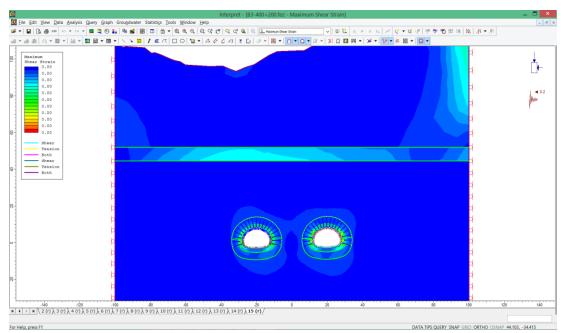


Figure 7. 32 Maximum shear strain around tunnel under seismic condition (kx=0.20) at KM:400+200

Without effect of seismicity, total displacements at the peak point of the left and right tubes are 1.1 cm and 2.1 cm, respectively. Under seismic effect of kx=0.20, for left tube total displacement is raised to 2.0 cm and for the right tube it is raised to 2.1 cm. These results are acceptable and it can be said that B3 category support systems for the section of the tunnel is verified by numerical analyses. According to the strain values obtained from Phase 2 software, they never exceed %1 limiting values (Hoek, 2001). Therefore, no problem related to tunnel deformation is expected for this section of the tunnel.

The entrance section of the tunnel at KM: 400+240 is modeled by Phase 2 software. Modeling of tunnel tubes is performed in 10 stages. These steps explained below:

Stage 1: inspection of in situ stress distributions
Stage 2: upper part of right tube has been softened
Stage 3: upper part of right tube excavation and supporting has been completed
Stage 4: lower part of right tube has been softened
Stage 5: lower part of right tube excavation and supporting has been completed
Stage 6: upper part of left tube has been softened
Stage 7: upper part of left tube excavation and supporting has been completed
Stage 8: lower part of left tube has been softened
Stage 9: lower part of left tube has been softened
Stage 9: lower part of left tube excavation and supporting has been completed
Stage 9: lower part of left tube has been softened

The supports used in modeling are presented in Table 7.10.

ruble 7: 10 Support used in the modeling	
Bolt spacing	2 m*2 m
Bolt length	4 m
Bolt diameter	32 mm
Bolt modulus	200 000
Tensile capacity	250 kN
Shotcrete thickness	10 cm
Young's modulus of shotcrete	15 000 MPa

Table 7. 10 Support used in the modeling

For both static and seismic conditions, total displacements were checked around the both right and left tubes. According to results obtained, there were no yielded liners. However, some of the bolt elements were yielded. The results of the analyses are presented in Figures 7.33 - 7.35.

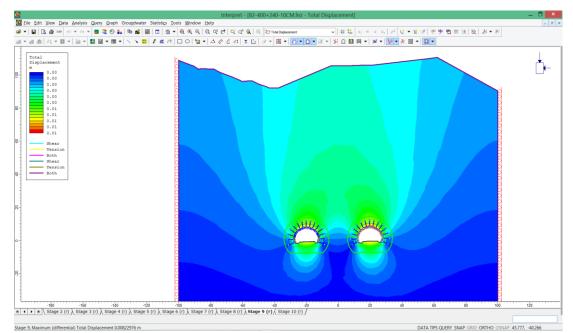


Figure 7. 33 Total displacements around the tunnel section at KM:400+240

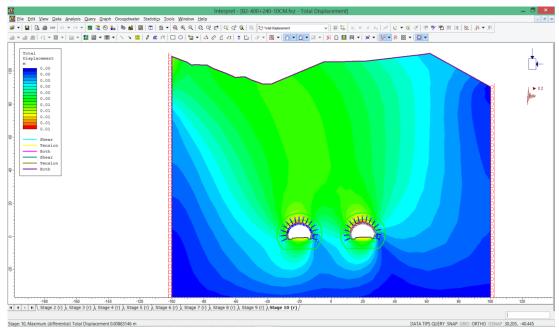


Figure 7. 34 Total displacement around the tunnel section under seismic effect (kx=0.20) at KM:400+240

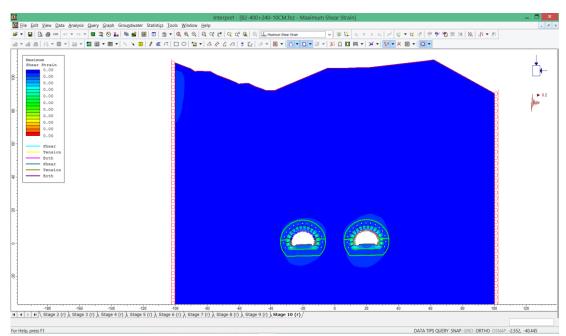


Figure 7. 35 Maximum shear strain around the tunnel under seismic condition (kx=0.20) at KM:400+240

Without effect of seismicity, total displacements at the peak point of the left and right tube are 1.1 cm and 1.1 cm, respectively. Under seismic effect of kx= 0.20, for left tube total displacement is raised to 1.2 cm and for the right tube the total displacement is raised to 1.3 cm. These results are acceptable and it can be said that B2 category support systems for the section of the tunnel is verified by numerical analyses. According to the strain values obtained from Phase 2 software, they never exceed %1 limiting value so (Hoek, 2001). Therefore, no problem related to tunnel deformation is expected for this section of the tunnel.

The entrance section of the tunnel at KM: 400+500 was modeled by Phase 2 software. Modeling of the tunnel tubes was performed in 14 stages. These steps explained below:

Stage 1: inspection of in situ stress distributions

Stage 2: upper part of right tube has been softened

Stage 3: upper part of right tube excavation and supporting has been completed

Stage 4: lower part of right tube has been softened

Stage 5: lower part of right tube excavation and supporting has been completed Stage 6: invert excavation of right tube has been softened

Stage 7: invert part of right tube excavation and supporting has been completed Stage 8: upper part of left tube has been softened

Stage 9: upper part of left tube excavation and supporting has been completed

Stage 10: lower part of left tube has been softened

Stage 11: lower part of left tube excavation and supporting has been completed

Stage 12: invert excavation of left tube has been softened

Stage 13: invert part of left tube excavation and supporting has been completed

Stage 14: seismic load has been applied to the model

The supports used in modelling are presented in Table 7.11.

Table 7. 11 Support used in the modeling

Bolt spacing	0.75m*0.75m
Bolt length	6 m
Bolt diameter	32 mm
Bolt modulus	200 000
Tensile capacity	250 kN
Shotcrete thickness	40 cm
Young's modulus of shotcrete	15 000 MPa

For both static and seismic conditions, total displacements were checked around the both right and left tubes. According to results obtained, there were no yielded liners. Nevertheless, some of the bolt elements were yielded. The results of the analyses are presented in Figures 7.36-7.38.

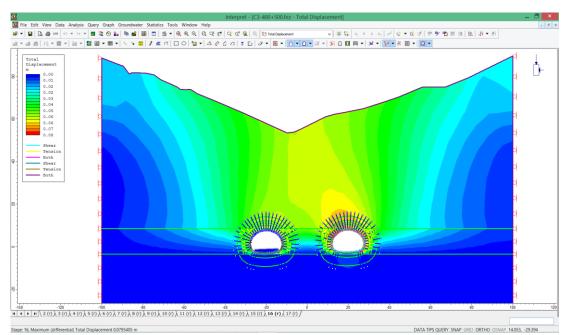
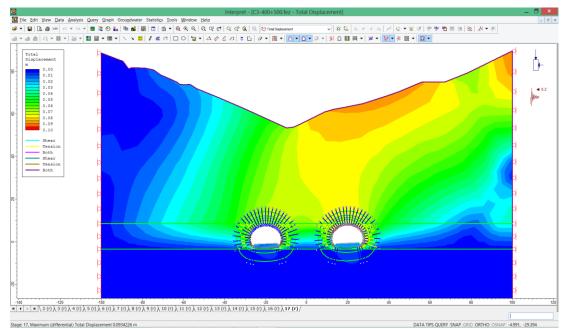
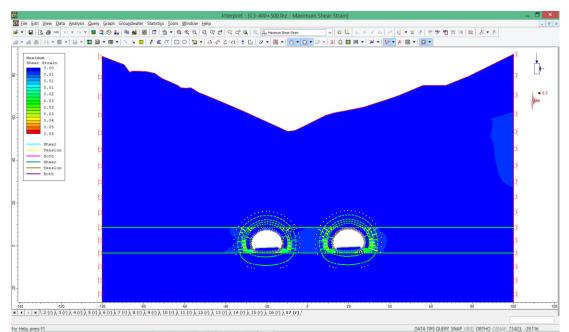


Figure 7. 36 Total displacements around the tunnel section at KM:400+500.



Stage 17. Maximum (differential) Total Displacement 00094226 m Figure 7. 37 Total displacement around tunnel section under seismic effect (kx=0.20) at KM:400+500



For Hele Deeps 71 Data TIPS CLERY SNAP CEED ORTHO COSTAP 73223, -28116 Figure 7. 38 Maximum shear strain around tunnel under seismic condition (kx=0.20) at KM:400+500

Without effect of seismicity, total displacements at the peak point of the left and right tubes are 5.6 cm and 6.7 cm. Under seismic effect of kx=0.20, for left tube total displacement is raised to 7.2 cm and for the right tube total displacement is raised to 7.8 cm. These results are acceptable and it can be said that C3 category support systems for the section of the tunnel is verified by numerical analyses. According to the strain values obtained from Phase 2 software, they never exceed %1 limiting value so (Hoek, 2001). Therefore, no problem related to tunnel deformation is expected for this section of the tunnel

The entrance section of the tunnel at KM: 400+550 was modeled by Phase 2 software. Modeling of the tunnel tubes was performed in 14 stages. These steps explained below:

Stage 1: inspection of in situ stress distributions
Stage 2: upper part of right tube has been softened
Stage 3: upper part of right tube excavation and supporting has been completed
Stage 4: lower part of right tube has been softened
Stage 5: lower part of right tube excavation and supporting has been completed
Stage 6: invert excavation of right tube has been softened
Stage 7: invert part of right tube excavation and supporting has been completed
Stage 8: upper part of left tube has been softened
Stage 9: upper part of left tube excavation and supporting has been completed
Stage 10: lower part of left tube has been softened
Stage 11: lower part of left tube excavation and supporting has been completed
Stage 12: invert excavation of left tube has been softened
Stage 13: invert part of left tube excavation and supporting has been completed

The supports used in modelling are presented in Table 7.12.

Bolt spacing	1 m*1 m				
Bolt length	4 m				
Bolt diameter	32 mm				
Bolt modulus	200 000				
Tensile capacity	250 kN				
Shotcrete thickness	20 cm				
Young's modulus of shotcrete	10 000 MPa				

Table 7. 12 Support used in the modeling of the tunnel at KM: 400+550

For both static and seismic conditions, total displacements were checked around the both right and left tubes. According to results obtained, there were no yielded liners. However, some of the bolt elements were yielded. The results of the analyses are presented in Figures 7.39-7.41.

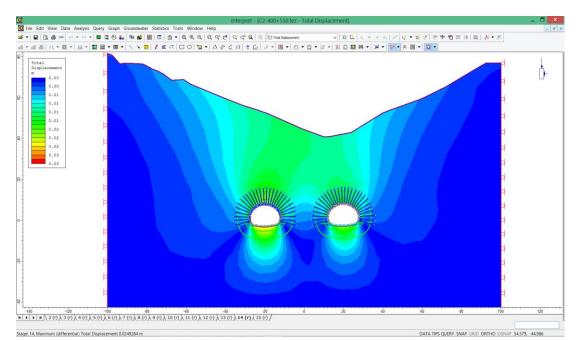


Figure 7. 39 Total displacements around the tunnel section at KM: 400+550

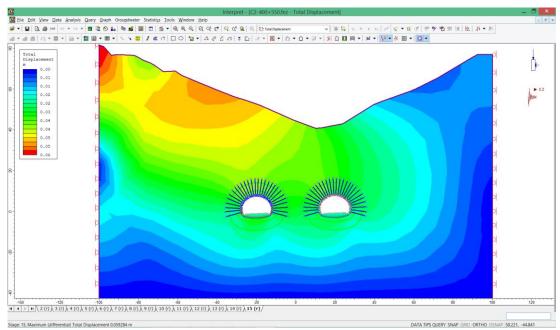
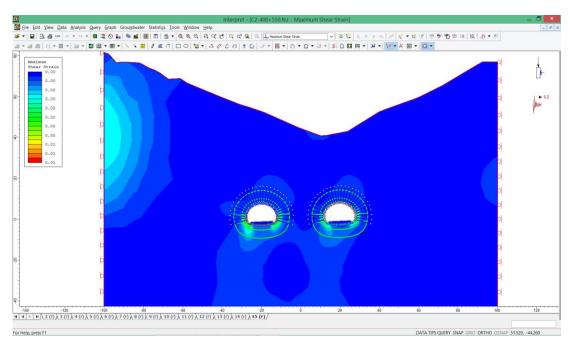


Figure 7. 40 Total displacement around the tunnel section under seismic effect (kx=0.20) at KM: 400+550



For their press 71 Data tipe cuery SNAP GRD ORTHO OSTAP 51528.-4200 Figure 7. 41 Maximum shear strain around the tunnel under seismic condition (kx=0.20) at KM: 400+550

Without effect of seismicity, total displacements at the peak point of the left and right tubes are 2.8 cm and 1.6 cm, respectively. Under seismic effect of kx=0.20, for left tube total displacement is raised to 4.1 cm and for the right tube total displacement is raised to 3.5 cm. These results are acceptable and it can be stated that C2 category support systems for the section of the tunnel is verified by numerical analyses. According to the strain values obtained from Phase 2 software, they never exceed %1 limiting value so (Hoek, 2001). Therefore, no problem related to tunnel deformation is expected for this section of the tunnel.

The entrance section of the tunnel at KM: 400+820 was modeled by Phase 2 software. Modeling of the tunnel tubes was performed in 14 stages. These steps given below:

Stage 1: inspection of in situ stress distributions

Stage 2: upper part of right tube has been softened

Stage 3: upper part of right tube excavation and supporting has been completed

Stage 4: lower part of right tube has been softened

Stage 5: lower part of right tube excavation and supporting has been completed

Stage 6: invert excavation of right tube has been softened

Stage 7: invert part of right tube excavation and supporting has been completed Stage 8: upper part of left tube has been softened

Stage 9: upper part of left tube excavation and supporting has been completed

Stage 10: lower part of left tube has been softened

Stage 11: lower part of left tube excavation and supporting has been completed

Stage 12: invert excavation of left tube has been softened

Stage 13: invert part of left tube excavation and supporting has been completed Stage 14: seismic load has been applied to the model

The supports used in modelling are presented in Table 7.13. below.

11 0	
Bolt spacing	1 m*1 m
Bolt length	4 m
Bolt diameter	32 mm
Bolt modulus	200 000
Tensile capacity	250 kN
Shotcrete thickness	20 cm
Young's modulus of shotcrete	10 000 MPa

Table 7. 13 Support used in the modeling of the tunnel at KM:400+820

For both static and seismic conditions, total displacements were checked around the both right and left tubes. According to results obtained, there were no yielded liners, but some of the bolt elements were yielded. The results of the analyses are presented in Figures 7.42 -7.44.

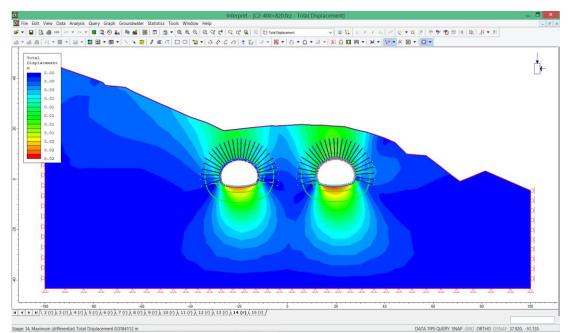


Figure 7. 42 Total displacements around the tunnel section at KM: 400+820

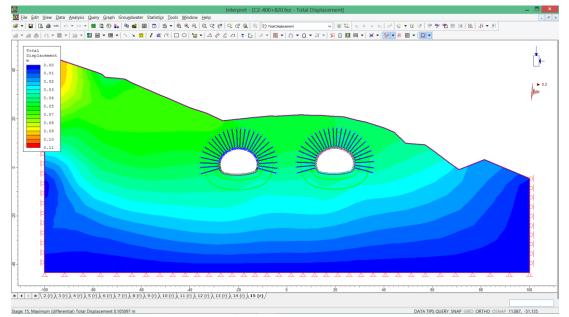


Figure 7. 43 Total displacement around the tunnel section under seismic effect (kx=0.20) at KM: 400+820

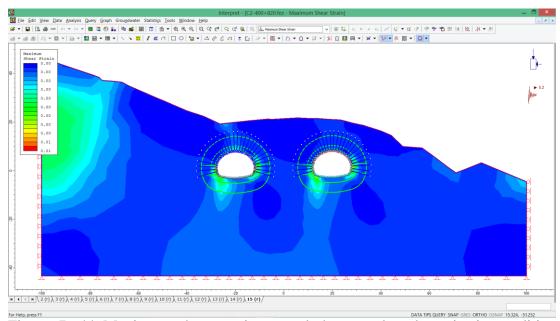


Figure 7. 44 Maximum shear strain around the tunnel under seismic condition (kx=0.20) at KM: 400+820

Without effect of seismicity, total displacements at the peak point of the left and right tubes are 1.1 cm and 1.3 cm, respectively. Under seismic effect of kx=0.20, for left tube total displacement is raised to 5.5 cm and for the right tube total displacement is raised to 4.9 cm. These results are acceptable and it can be stated that C2 category support systems for the section of the tunnel is verified by numerical analyses. According to the strain values obtained from Phase 2 software, they don't exceed %1 limiting values (Hoek, 2001). Therefore, no problem related to tunnel deformation is expected for this section of the tunnel.

7.5 Slope Stability Analysis for Exit Portal

At this part, highest cut before entrance of the tunnel was modeled and stability analyses were performed. In practice excavation is performed from natural topography to first float as very first step. As soon as first cut completed, the support elements installation (shotcrete, rock bolts) should be completed. The excavation of the cut will be completed right after reaching to the road grade. According to the Technical Specifications of General Directorate of Highways (2006), the sufficient safety factors under static and dynamic conditions are 1.5 and 1.15, respectively.

To analyze the stability of highest cut, the model was prepared in five steps. The slope of side was 3H:2V and forehead was 1H:3V (H: horizontal, V: vertical). In the first step, the natural condition of the surface was modeled. In the following steps, the cut and support applications were done. Seismic load was applied to the system as final step.

For forehead slope which is the slope of tunnel entrance at KM: 400+930, the model was prepared in three steps. As first step, the natural condition of the surface was modeled. In the following steps, the cut and support applications were done. Seismic load was applied to the system as final step. Table 7.14 shows the specifications of supports used in analyses.

Bolt spacing	2m*2m
Bolt length	4 m
Bolt diameter	32 mm
Bolt modulus	200 000
Tensile capacity	250 kN
Shotcrete thickness	20 cm
Young's modulus of shotcrete	15 000 MPa

Table 7. 14 Supports used in the modeling of the exit portal slope of the tunnel

For both static and dynamic (under seismic load) conditions, slope stability analyses were performed. Because of the negative effect of groundwater on the strength of the rock mass, analyses were performed with effect of groundwater, thus it is aimed to stay in the safe side. The results of analyses performed are shown in Figures 7.45 and 7.46.

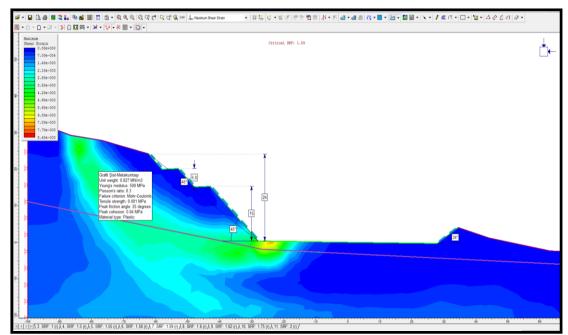


Figure 7. 45 Slope stability analysis of the exit portal side slope showing maximum shear strain under the static condition (3H/2V) (SF: 1. 59)

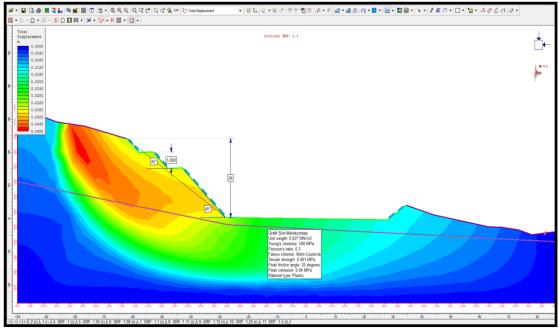


Figure 7. 46 Slope stability analysis of the exit portal side slope showing maximum shear strain under the effect of seismic load of kx=0.20 (3H/2V) (SF: 1.34)

When the cut is completed Total displacement is 3 cm under static condition. Value of 1.59 obtained at this stage for the safety factor. However, total displacement is increased to 4,2 cm after seismic load applied to the model (kx=0.20). At this stage, there are no yielded liners. Value of 1.37 obtained at this stage for the safety factor. According to the Technical Specifications of GDH (2006), the values are sufficient for the slope stability.



Figure 7. 47 Wire mesh and shotcrete installation for the side slope of the exit portal

For both static and dynamic (under seismic load) conditions, slope stability analyses were performed. Because of the negative effect of groundwater on the strength of the rock mass, analyses were performed with effect of groundwater, thus it is aimed to stay in the safe side. The results of analyses performed are shown in Figures 7.48 and 7.49.

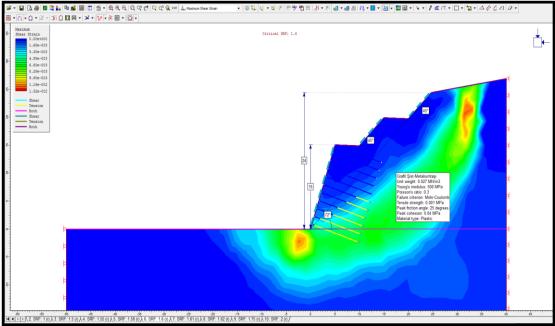


Figure 7. 48 Slope stability analysis for the forehead slopes of the exit portal showing maximum shear strain under static condition (1H/3V) (SF: 1.71)

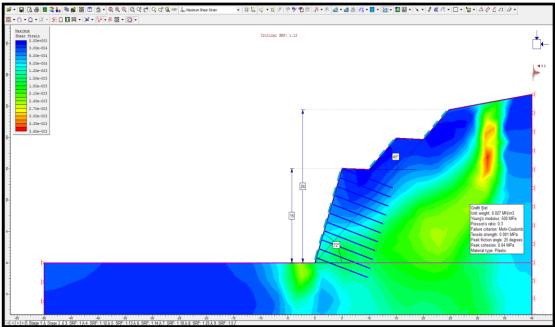


Figure 7. 49 Slope stability analysis of for the forehead slopes of the exit portal showing maximum shear strain under the effect of seismic load of kx=0.20 (1H/3V) (SF: 1.21)

When the cut is completed Total displacement is 3,4 cm under static condition. Value of 1.71 obtained at this stage for the safety factor. However, total displacement is increased to 4,5 cm after seismic load applied to the model (kx=0.20). At this stage, there are no yielded liners. Value of 1.21 obtained at this stage for the safety factor. According to the Technical Specifications of GDH (2006), the values are sufficient for the slope stability.

To sum up, the results obtained from the slope stability analyses performed with numerical analyses show that the slope is on the safe side according to Technical Specifications of GDH (2006). Figure 7.51 and 7.52 show safe slopes at the construction site.



Figure 7. 50 A general view of the forehead slopes after all suggested supports are installed



Figure 7. 51 Part of the forehead slope after the supports are installed

7.6 Sensitivity Analyses at Tunnel Section Km:399+700

Sensitivity analysis is a technique used to determine how different values of an independent variable will impact a particular dependent variable under a given set of assumptions. This technique is used within specific boundaries that will depend on one or more input variables.

For this study, it is important to understand the relationship between numerical analyses input parameters (C, \emptyset , E_{rm}, GSI, Seismic load coefficient) and deformations obtained from the numerical analyses (total displacements). Main goal for performing sensitivity analyses is testing the robustness of the results of a model or system in the presence of uncertainty.

For the five main input parameters mentioned above, the program was run by reducing the values systematically by 10%, and total vertical displacement value was attained at the peak point of tunnel section.

KM: 399+700 section was chosen for the sensitivity analyses in this thesis. The strength parameters of the rock mass for this section determined before (Chapter 6) is given below:

$$C = 223 \text{ kPa}$$

 $\emptyset = 29^{\circ}$
 $E_{rm} = 2586 \text{ MPa}$

Firstly, the cohesion value of the rock mass was reduced by 10% each time starting from 223 kPa. In the meantime, other strength parameters were kept unchanged and total displacement in the tunnel was measured. Parameters used in the sensitivity analyses are given in Table 7.15, and cohesion-total displacement graph is presented in Figure 7. 52. Based on this figure, one can easily state that as the cohesion of the rock mass decreases, total displacement increases.

Analyses no.	Cohesion (c) (kPa)	Reduction ratio	ø(°)	Unit weight (kN/m ³)	E _{rm} (MPa)	GSI	Seismic load coefficient	Total Displacement (cm)
1	223,00	0%	29	27	2825	25	0,2	1,61
2	200,70	10%	29	27	2825	25	0,2	1,69
3	178,40	20%	29	27	2825	25	0,2	1,82
4	156,10	30%	29	27	2825	25	0,2	2,04
5	133,80	40%	29	27	2825	25	0,2	2,49
6	111,50	50%	29	27	2825	25	0,2	3,61
7	89,20	60%	29	27	2825	25	0,2	9,08

Table 7. 15 Parameters used in the sensitivity analyses with reduction in cohesion of the rock mass

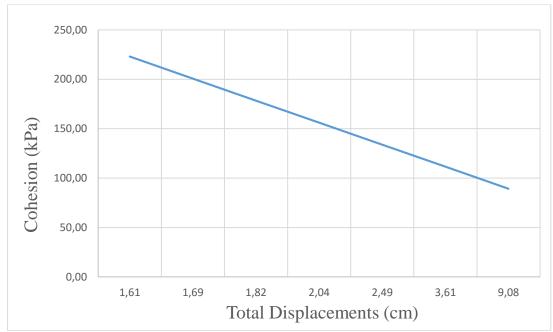


Figure 7. 52 Cohesion-total displacement graph for KM: 399+700

Secondly, the internal friction angle value of the rock mass was reduced by 10% each time starting from 29°. In the meantime, other strength parameters were kept unchanged and total displacement was measured. Parameters used in the sensitivity analyses are given in Table 7.16, and internal friction angle-total displacement graph is presented in Figure 7. 53. Based on this figure, similar to cohesion case, as the internal friction angle of the rock mass decreases, total displacement increases.

Table 7. 16 Parameters used in the sensitivity analyses with reduction in internal friction angle of the rock mass

Analyses no.	ø(°)	Reduction ratio	Cohesion (c) (kPa)	Unit weight (kN/m ³)	E _{rm} (MPa)	Total Displacement (cm)
1	29,00	0%	223	27	2825	1,61
2	26,10	10%	223	27	2825	1,71
3	23,20	20%	223	27	2825	2
4	20,30	30%	223	27	2825	2,4
5	17,40	40%	223	27	2825	3,45
6	14,50	50%	223	27	2825	5,7
7	11,60	60%	223	27	2825	35,94

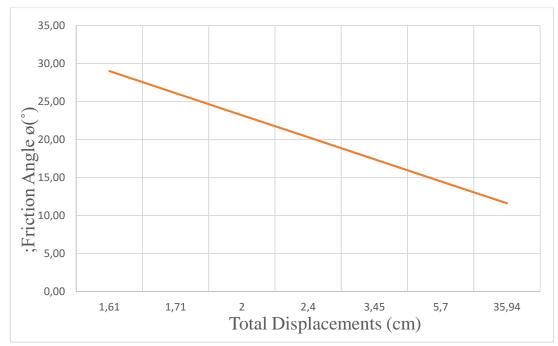


Figure 7. 53 Internal friction angle-total displacement graph for KM: 399+700

Thirdly, deformation modulus of rock mass value was reduced by 10% each time starting from 2586 MPa. In the meantime, other strength parameters were kept unchanged and total displacement was measured. Parameters used in the sensitivity analyses are given in Table 7.17, and deformation modulus-total displacement graph is presented in Figure 7. 54. Based on this figure, similar to cohesion and internal friction angle cases, as the deformation modulus of the rock mass decreases, total displacement increases.

Analyses no.	E _{rm} (MPa)	Reduction ratio	ø(°)	Unit weight (kN/m ³)	Cohesion (c) (kPa)	Total Displacement (cm)
1	2825,00	0%	29	27	223	1,61
2	2542,50	10%	29	27	223	1,63
3	2260,00	20%	29	27	223	1,83
4	1977,50	30%	29	27	223	2,1
5	1695,00	40%	29	27	223	2,4
6	1412,50	50%	29	27	223	2,93
7	1130,00	60%	29	27	223	3,66
8	847,50	70%	29	27	223	4,88
9	565,00	80%	29	27	223	7,32
10	282,50	90%	29	27	223	14,61

Table 7. 17 Parameters used in the sensitivity analyses with reduction in deformation modulus of the rock mass

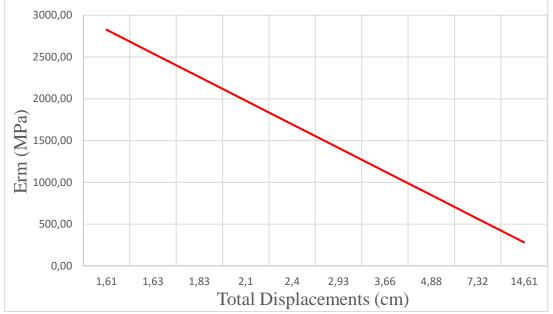


Figure 7. 54 Deformation modulus-total displacement graph for KM: 399+700

As the fourth step, GSI value of rock was reduced by 10% each time starting from 25 MPa. In the meantime, other strength parameters were kept unchanged and total displacement was measured. Parameters used in the sensitivity analyses are given in

Table 7.18, and GSI-total displacement graph is presented in Figure 7. 55. Similar to the other parameters, as the GSI of the rock mass decreases, total displacement increases.

Analyses no:	GSI	Reduction ratio	Ø(°)	Cohesion (c) (kPa)	E _{rm} (MPa)	Unit weight (kN/m ³)	Total Displacement (cm)
1	28,00	0%	29,00	223	2825	27,00	1,61
2	25,20	10%	27,70	207	2825	27,00	1,66
3	22,40	20%	26,76	192	2825	27,00	1,72
4	19,60	30%	25,70	177	2825	27,00	2
5	16,80	40%	24,67	161	2825	27,00	2,53
6	14,00	50%	23,53	145	2825	27,00	3,79
7	11,20	60%	22,31	128	2825	27,00	8,8
8	8,40	70%	21,00	111	2825	27,00	93

Table 7. 18 Parameters used in the sensitivity analyses with reduction in GSI value of the rock mass

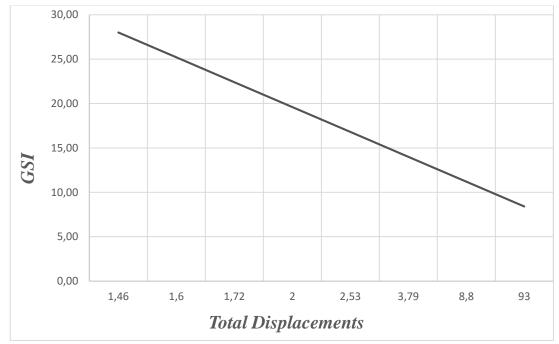


Figure 7. 55 GSI-total displacement graph for KM: 399+700

As the fourth step, seismic load coefficient value of system was increased by 10% each time starting from 0.2. In the meantime, other strength parameters were kept unchanged and total displacement in the tunnel was measured. Parameters used in the sensitivity analyses are given in Table 7.19, and seismic load coefficient-total displacement graph is presented in Figure 7. 56. It is observed that as the seismic coefficient increases, total displacement also increases.

Table 7. 19 Parameters used in the sensitivity analyses with reduction in seismic load coefficient of the rock mass

Analyses no:	Seismic Load Coefficient	Increase Ratio	ø(°)	Cohesion (c) (kPa)	E _{rm} (MPa)	GSI	Unit Weight (kN/m ³)	Total Displacement (cm)
1	0,20	0%	29	223	2825	25	27,00	1,61
2	0,22	10%	29	223	2825	25	27,00	1,73
3	0,24	20%	29	223	2825	25	27,00	2,01
4	0,26	30%	29	223	2825	25	27,00	2,1
5	0,28	40%	29	223	2825	25	27,00	2,25
6	0,30	50%	29	223	2825	25	27,00	2,36
7	0,32	60%	29	223	2825	25	27,00	2,54
8	0,34	70%	29	223	2825	25	27,00	2,65
9	0,36	80%	29	223	2825	25	27,00	2,77
10	0,38	90%	29	223	2825	25	27,00	2,84

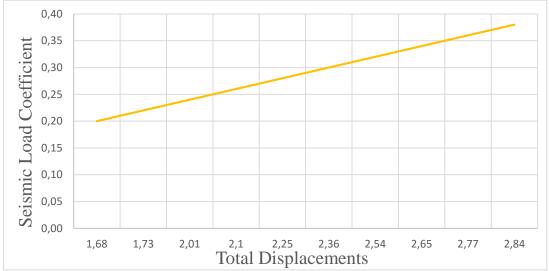


Figure 7. 56 Seismic load coefficient-total displacement graph for KM: 399+700 146

The sensitivity analyses at KM: 399+700 reveal that variation of the selected input parameters affects the deformation amount in the tunnel. Additionally, in case reduction ratio of the parameters is more than 60%, then the deformations in the tunnel exceed the acceptable strain limit (1%). At 60% reduction ratio, internal friction angle of the rock mass seems to be the most critical parameter affecting the total displacement. These are followed by cohesion and GSI. Nevertheless, increase in seismic load coefficient causes the least deformation change for the analysed section of the tunnel. All of these findings clearly indicate that correct assessment of rock mass parameters is of utmost importance for the support design of tunnel.

7.7 Comparison of the Results Obtained from Numerical Analyses with Field Observations

Since the Belkahve tunnel excavation is almost completed, it is a great opportunity to compare the results obtained from the numerical analyses with the measurements obtained from the field during the construction of the tunnel. However, most of the information couldn't be reached due to the decision of General Directorate of Highways. So the information given below in Tables 7.20 and 7.21 is not totally enough to make a healthy interpretation but it gives a general idea about the performance of the analyses.

	Right Tube								
intervals of Kilometers	Vertical Displacement At Top Point	First Measurement Date	Last Measurement Date	Displacements Obtained via Numerical Analyses					
399,662	216 mm.	15.3.2015	3.11.2015						
399,674	195 mm.	22.3.2015	3.11.2015						
399,687	195 mm.	30.3.2015	3.11.2015						
399,700	110 mm.	6.4.2015	3.11.2015	63 mm.					
399,713	116 mm.	14.4.2015	3.11.2015						
399,726	111 mm.	21.4.2105	3.11.2015						
399,738	103 mm.	28.4.2015	3.11.2015						
399,751	100 mm.	6.5.2015	3.11.2015						
399,852	39 mm.	6.7.2015	4.11.2015						
399,880	46 mm.	18.6.2015	4.11.2015						
399,960	39 mm.	31.3.2015	4.11.2015	70 mm.					
400,006	59 mm.	21.3.2015	4.11.2015						

Table 7. 20 Measured Deformation values for right tube at the Belkahve tunnel

 Table 7. 21
 Measured Deformation values for left tube at the Belkahve tunnel

Left Tube				
intervals of Kilometers	Vertical Displacement At Top Point	First Measurement Date	Last Measurement Date	Displacements Obtained via Numerical Analyses
399,265	11 mm.	19.9.2015	8.11.2015	
399,365	54 mm.	11.10.2014	8.11.2015	
399,373	64 mm.	15.10.2014	8.11.2015	
399,382	89 mm.	21.10.2014	8.11.2015	
399,391	179 mm.	26.10.2014	8.11.2015	
399,401	156 mm.	2.11.2014	8.11.2015	
399,409	172 mm.	7.11.2014	8.11.2015	
399,419	161 mm.	12.11.2014	8.11.2015	
399,700	72 mm.	29.6.2015	3.11.2015	56 mm.
399,960	21 mm.	20.6.2015	3.11.2015	68 mm.
400,001	18 mm.	12.6.2015	3.11.2015	
400,015	27 mm.	29.5.2015	3.11.2015	
400,029	32 mm.	19.5.2015	3.11.2015	
400,071	32 mm.	23.4.2015	3.11.2015	
400,099	44 mm.	9.4.2015	3.11.2015	
400,127	20 mm.	27.3.2015	3.11.2015	

According to the measurement values obtained from the tunnel, which is vectorial and for only top point of the tunnel section, there are some differences in the deformation amount obtained from numerical analyses and field measurements, although the differences are quite small.

At KM: 399+700, the displacements obtained from numerical analyses for the left and right tubes are 5.6 cm and 6.3 cm, respectively. The displacement measured in the tunnel at KM: 399+700 for the right tube is 11 cm and for the left tube 7.2 cm.

At KM: 399+960, the displacements obtained from the numerical analyses for the left and right tubes are 6.8 cm and 7.0 cm, respectively. The displacements measured at this section of the tunnel for right tube is 3.9 cm and for the left tube 2.1 cm

When the results compared with the measurements done in the field during tunnel excavation, measurements obtained in the tunnel for KM:399+700 is higher than the results obtained from the numerical analyses. For KM:399+960 measurements obtained in the tunnel is less than the results obtained from the numerical analyses. It can be said that at some sections displacement values show some variations. These results can be interpreted in several different ways. At very firstly, the differences between the values obtained from numerical analyses and field measurements, can be attributed to the unpredicted weak or highly fractured zones. In general, such zones may generally be seen during tunneling. Since it is nearly impossible to explore all the geological and geotechnical specifications of tunnel route by drillings from surface, it is highly recommended to perform horizontal drilling (probing ahead) at the tunnel face, face mapping during the excavation, in-situ testing and further testing in order to update the geological and geotechnical model of the tunnel.

CHAPTER 8

DISCUSSIONS

Engineering judgment and field observations are very important for assignment of the strength parameters to rock masses. However, it has not been possible to explore all of the options available to design tunnel in weak rock. At this point, empirical approaches are the key for determining the geotechnical parameters of the rock mass. Moreover, numerical analyses are the most common way to verify assigned support systems. The parameters are valid only for the given intervals.

According to the deformations measured during the excavation of the tunnel, it seems that there exist differences between measured deformations and expected displacements obtained via numerical analyses. These could be attributed to the presence of weak zones observed during tunneling which cannot be predicted during site investigation. To avoid negative effect of the weak zones, horizontal borehole drilling (probing ahead), face mapping after each run during excavation, in-situ monitoring and further tests if needed should be performed.

It could be stated that the tunnel was overdesigned based on the numerical analyses. However, the field measurements show that determined support systems for the Belkahve tunnel work well even under higher stress than expected.

According to the field observations, schists of the Belkhave formation are defined as weak-very weak strength. Therefore, entrance and exit portals in the Belkahve should be properly supported in order to eliminate any tability problems. Moreover, due to high fractured structure of the Belkahve formation, low RQD values also prove that the stability problems due to groundwater may occur. Although low lugeon values were obtained from the packer tests, chemicals used as drilling fluid might have sealed the boreholes. These may lead to extremely low values. For this reason, groundwater inflow into the tunnel especially in highly fractured and sheared zones is expected.

The sensitivity analyses at KM: 399+700 indicate that in case reduction ratio of the parameters is more than 60%, the deformations in the tunnel exceed the acceptable strain limit. Among the studied parameters, at 60% reduction ratio, internal friction angle of the rock mass is found to be the most critical parameter affecting the total displacement.

Braun (1930) stresses particularly in deep tunnels that timing of the rock support (bolts and shotcrete) installation is extremely important. It is, however, difficult to predict the time factor and its variations during tunneling even for the experienced tunnel engineer. In this respect, NATM recommends the use of tunnel support measures to avoid undesirable deformations of the surrounding rocks to occur. The optimal NATM involves also additional verification calculations carried out during the execution. Thus, geotechnical solutions should be taken into consideration such as checking and modifying the geology and rock mass classes during construction, preparing in-situ test and laboratory test program and mapping the face of the excavation systematically. This approach may eliminate problems related to the stability of the tunnel.

CHAPTER 9

CONCLUSIONS AND RECOMMENDATIONS

The Belkahve tunnel takes place in the Western Anatolian (Aegean) Horst and Graben Province which can be characterized by Cretaceous ophiolite and flysch rocks. According to the site investigation performed along the tunnel, the entrance section of the tunnel takes place in moderately weathered and moderately weak schist. The middle section of the tunnel is located in the strong limestone, and moderately weathered-moderately weak schist. In the tunnel exit section, moderately weathered and moderately weak schist crops out. According to the investigations carried out in the study area, there are some shear zones along the tunnel route.

Based on the statement of General Directorate of Disaster Affairs Earthquake, the tunnel area takes place in the 1st degree of earthquake zone of Turkey with a peak horizontal ground acceleration of 0.4g.

According to the field surveys, three joint sets and random joints (j1) 83/113, (j2) 80/338, (j3) 54/213 exist in the study area. However, at the exit part of the tunnel, only two joint sets and random joints are developed with the dip amount and dip directions of (j1) 89/115, (j2) 42/207.

In order to estimate the rock mass quality, NATM, RMR, and Q rock mass classification systems used. The entrance section of the tunnel between Km: 399+180 and Km: 399+400, according to RMR and Q classification systems, the rock mass is defined as "very poor rock" and according to NATM classified the rock mass is defined as C2. The middle section of the tunnel between Km: 399+400 and Km: 400+750 is divided into 6 parts. Between Km: 399+400 and Km: 399+700, the rock

mass is defined as "poor rock" according to RMR and Q, and classified as B3 according to NATM. Between Km: 399+700 and Km: 400+080, according to RMR and Q classification systems, the rock mass is defined as "poor rock" and according to NATM classified the rock mass is defined as B3, between Km: 400+080 and Km: 400+150, defined as "very fractured and weak shearing zone" according to drillings and geological survey and classified as C3 according to NATM, Between Km: 400+150 and Km: 400+450, according to RMR and Q classification systems, the rock mass is defined as "fair rock" and according to NATM classified the rock mass is defined as B2., between Km: 400+450 and Km: 400+520, defined as "very fractured and weak shearing zone" according to drillings and geological survey and classified as C3 according to NATM, Between Km: 400+520 and Km: 400+750, according to RMR and Q classification systems, the rock mass is defined as "very poor rock" and according to NATM classified the rock mass is defined as B3, the exit section of the tunnel between Km: 400+750 and Km: 400+930, according to RMR and Q classification systems, the rock mass is defined as "poor rock" and according to NATM classified the rock mass is defined as C2.

Between Km: 399+180 and Km: 399+400, according to RMR and Q classification systems, the rock mass is defined as "very poor rock" and according to NATM classified the rock mass is defined as C2.

Since it is not possible to explore all the geological and geotechnical properties of the rock masses, along the tunnel route, its highly recommended to have systematic face mapping of the excavation. Moreover, horizontal drillings (probing ahead), monitoring, and in-situ or further laboratory tests should be performed in order to better understand the behavior of the geological units. Last but not least, great attention should be given to the stand-up time determined for different NATM rock classes during excavation in order to prevent stability problems, especially in weak zones.

The groundwater level is measured from boreholes. The rock masses are generally defined as impervious to slightly pervious according to the lugeon tests performed. However, it is expected that the use of chemicals as drilling fluid may alter the test results. Therefore, groundwater inflow problem is expected in shear and highly fractured zones. In order to prevent negative effect of groundwater, it is needed to create groundwater flow by making possible hydraulic head difference. In this thesis, all slopes are protected by shotcrete which may cause a problem for the groundwater inflow. Therefore, discharging the groundwater with perforated pvc surrounded by geotextiles can be considered to be a solution. However, groundwater shouldn't have to travel long distance until reaching surface at lower elevations, otherwise the impervious layers (shotcrete) surrounding the groundwater, can be exposed to high pressure.

For both entrance and exit sections, slope stability analyses performed with Phase 2 with effect of groundwater. As a result, for both static and dynamic conditions indicated that the slopes are safe with factor of safety significantly higher than the accepted limiting values.

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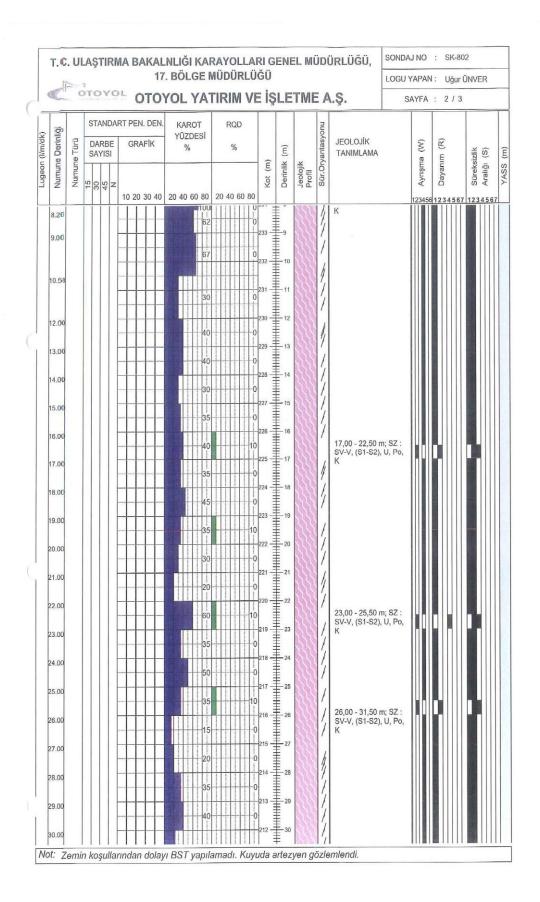
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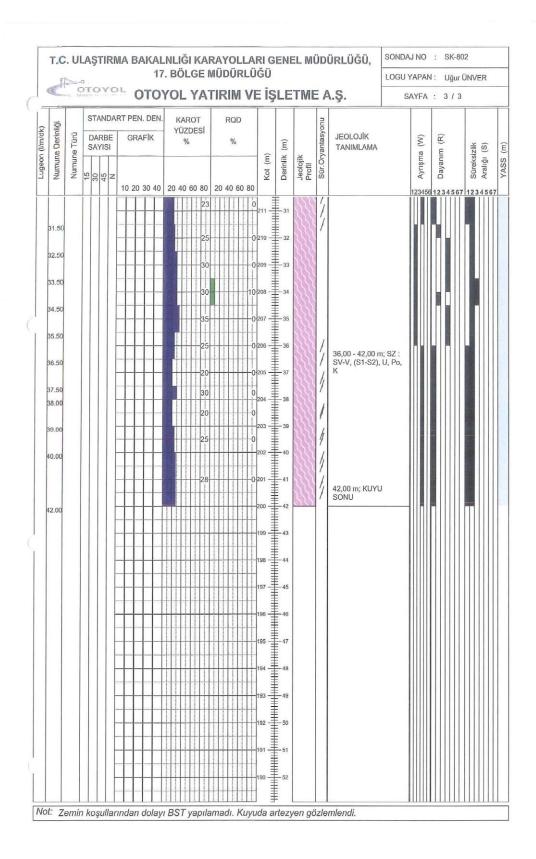
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APPENDIX A:

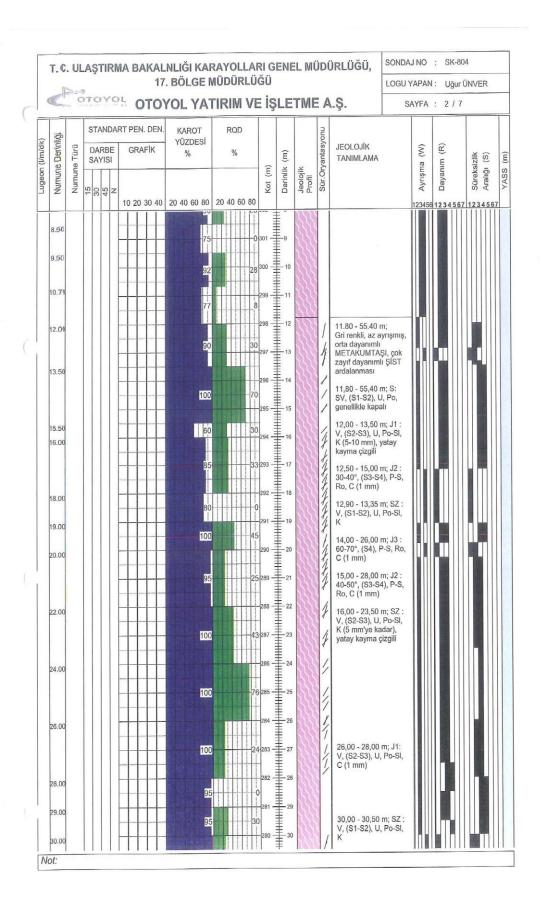
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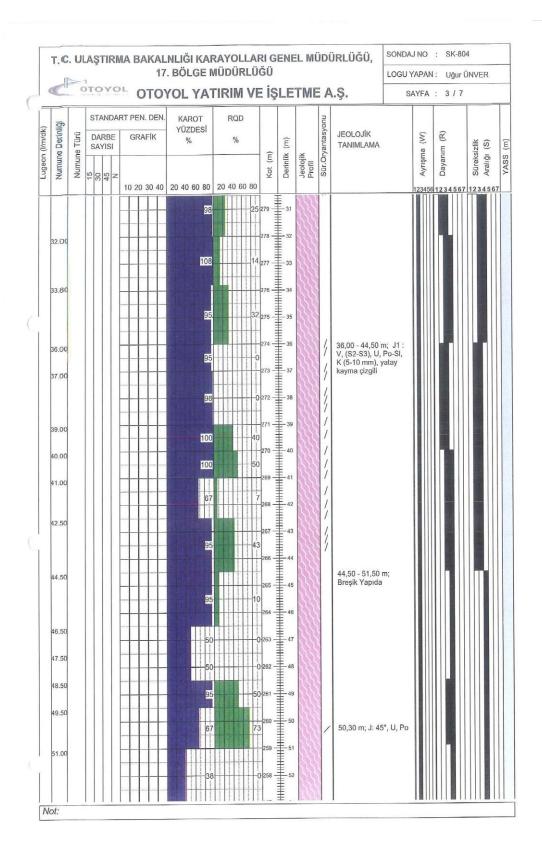
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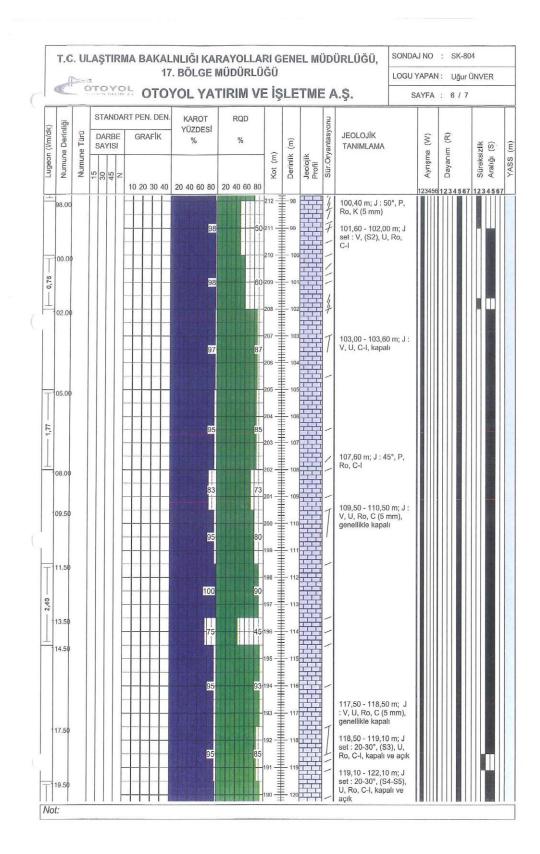
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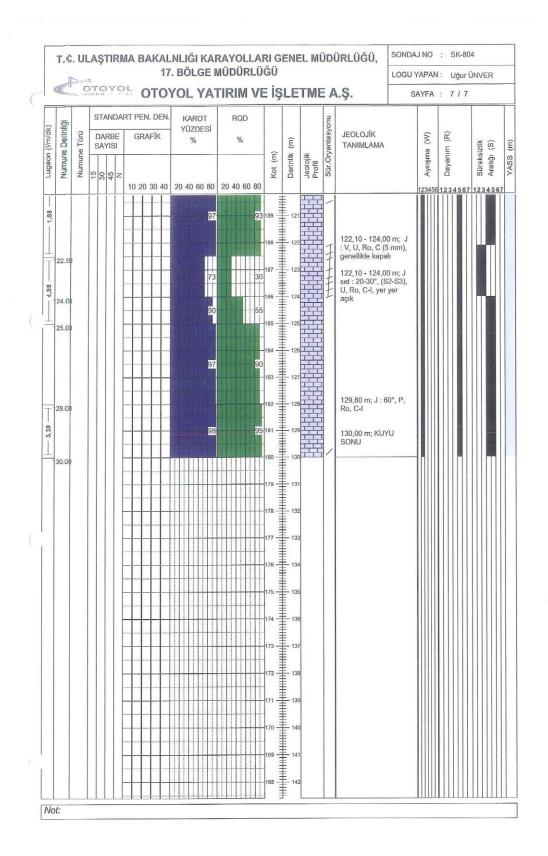




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Lugeon (I/m/dk)	Numune Derinliği	Numune Türü	SAYISI					Kot (m)	Derinlik (m)	Jeolojik Profil S(n.Onantasvonu	TANIMLAMA		Ayrışma (W)	Dayanım	Süreksizlik Aralığı (S)	
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	74.00					95		236 -	74		77,00 - 77,15 Kızılımsı kah boşluk KİLİ, f fisürler kayma	verenkli sürlü,				

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Lugeon (I/m/dk)	Numune Derinliği	Numune Türü	STANDA DARBE SAYISI	GRAFİK	KAROT YÜZDESI %	RQD %	Kot (m) Derinlik (m)	Jeolojik Profil	Sür.Oryantasyonu	Jeolojik Tanimlama		Ayrışma (W)	Dayanım (R)	Süreksizlik Aralığı (S)	
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	80.00				95		229 81		11	U, Ro, C-I, gen kapalı 69,30 m; J : 45 Ro, C-I 81,20 - 130.00	ellikle °, P, m;				
	83.00						227 - 83		シノノノ	Gri-beyaz renk ayrışmış, sağla dayanımlı KİRf 81,20 - 85,00 r : 45°, (S4), P, I yer yer kapalı 81,50 m; J : 20	am EÇTAŞI n; J set Ro, C-I,				
	85.00				989		225 85		1 1 1 1	Ro, C 82,00 - 82,50 r U, Ro, K-C (1 r 85,00 - 90,25 r : 20-30°, (S4-S Ro, C-I, kapali	mm) n; J set 55), U,				
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2,22	90.00				95	88	3-219 9			90,25 - 90,30 : 20-30°, (S2), C-I 90,30 - 118,50 set : 20-30°, (S U, Ro, C-I, kaj açık	U, Ro,) m; J S4-S5),				
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LİMİT Teknik Araştırma Proje, Uygulama, Müşavirlik San. ve Tic. A.Ş

10	dare		/ Administ	ration	T.C. U	laştırn	na De	nizcilik Müdür	ve l	Haber Kam	leşmi u Özi	e Bak el Sel	anlığı ktör Ortaklığ	Bölge Müdürlüğü	Kuyu No	/ Boreh	nole No			SK-	805	
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1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Kuyu Derinligi BH Depth	Ornek No Sample No	Örnek Derinliği Sample Depth	Örnek Türü Sample Type	Matkap Tipi/Çapi Bit Type/Diameter	Muhafaza Borusu	Dart # o	itandari e Sayı f Blows	(SF	etratic PT) N ₃₀ Grap	Grafi	it ği 1 ₃₀	Profili Symbol	Jeoteknik Ta Geotechnical L	nımlama Description	Karot Çapı Core Diameter	Örnek Yüzdesi Core Recovery	% Kaya Kalitesi RQD	H Kirklar B Fractures	Ayrışma Weathering	Dayanım Strength	selvered of the second
L	m		m		mm	mm	15	30 4	5	0 20	30 4	0 50	0.0000000			mm	%	%	#-m	_	_	t
	10	5	10.00	RC													75	-	>50	W3 W4	R1 R0	
		6	11.20	RC	-												73	-	>50	W3	R1	
	.12		12.50														_			W4	R0	-
	13	7		RC										BREŞİK METAKUMTA Siyahımsı - koyu gri rer 9.60 - 25.00 m'ler arası genelde orta derecede	ikli,		60	17	>50	W3 W4	R1 R0	
	-14		14.00											yer yer tamamen ayrışr çok zayıf - aşırı derece	nış, de zayıf dayanımlı,				4-10	W3	R1	
	- -15	8		RC										genelde parçalanmış, y 25.00 - 32.00 m'ler ara genelde çok ayrışmış, y	SI;		57	-	>50	W4	R0	-
	-	9	15.50	RC										genelde aşırı derecede yer yer orta derecede s	zayıf dayanımlı,		36		>50	W3 W4	R1 R0	
	-16 -		16.00											genelde parçalanmış, yer yer çok çatlaklı - kı follasyonlu.	rikli,					W4	R1	
	- -17	10		RC		4								Foliasyonlar; 70°, dalgalı, kaygan,		3.5	58	-	>50	W5	RO	
	- - -18 -	11	- 17.30	RC	- 96	114								genelde kapalı. <i>Çatlaklar;</i> 45* - 50* arasında, dalgalı, pürüzlü,		63.	73	48	4-10	W4 W5		
	- -19 -	12	- 18.8	RC	;									yer yer kapalı, kalsit damarlı.			54	-	>50	W4 W5	1 32	
	-	13	- 19.5	RC	>												70) -	>50	W4 W5		
	-20	14	- 20.0	R	>												56	5 -	>50	W	5 R	
	- -21 -	15		R													72	2 -	>50	w:	R	1
	- - -22 -	16	- 21.5	R													6	3 -	>5	w	R	1
	- -23 -		_ 23.0		-												6	2	>5	w	· · · · ·	21
	- - -24	17	24.0	R																W	14	
	-	18	24.5	R	С												6	0 -	>5	0 W	14 F	21

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	ldare		/ Adminis	stration	T.C. L	Jlaştır	ma D Gene	enizci I Müd	ilik ve Turlož	e Hal ib. Ki	berleş amu (me B Özel S	aka Sek	anlığı tör Ortaklıž	jı Bölge Müdürlüğü	Kuyu No	/ Boreh	ole No			SK-	805
	Deci-	em:	/ Deploct	Name	Gebze	e-Orh	angaz	zi-Izmi	ir (İzn	nit Kö	irfez G	eçişi v	re B	Bağlantı Yolla	rı Dahil) Otoyolu,	Sayfa	/ Sheel					7
	Proje i		/ Project		Manis	a - İzr	mir Ke	əsimi,	Belk	ahve	e Tün	eli (KA	M:3	98+300-KN	/:402+500 Arası)	İstasyon Sondal Yari	/ Statio		(KM)		399+ Tün	
	Görev Şirket	i	/ Appoint Company	led Y				0	toyol	Yat	iuw v	e İşlet	me	∋ A.Ş.		Sondaj Yeri Kuyu Derinliği	/BHL /BHD		1)		90.0	
	Kuyu Derinliği <i>BH Depti</i> r	Ornek No Sample No	Örnek Derinliği Sample Depth	Örnek Türü Sample Type	Matkap Tipi/Çapı Bit Type/Diameter	Muhafaza Borusu		standart Stand be Sa	ard P (S ayisi	enetr SPT)	ation 1	afiği	'İ	Profili Symbol	Jeoteknik Ta Geolechnical D		Karot Çapı Core Diameter	Örnek Yüzdesi Core Recovery	Kaya Kalitesi RQD	Kiriklar Fractures	Аулşта Weathering	Dayanım Strength
Ļ	m	00	Ф 0 т	00	nm mm	≥ cò mm	15	30	45	10	20 30	40 5	0	E 00	Geolechnical D	escription	mm	%	%	#-m	~ -	
	-25 - -	19		RC														57	-	11-50 >50	W2 W4	R3 R0
	- -26		26,00		-															-		
	- - -27	20	27.00	RC		114												23	-	>50	W4	R0
	- 21	21	27.00	RC														33	-	11-50 >50	W2 W4	R3 R0
	-28		28,00												Yukarısı gibidir.							-
	- - -29 -	22		RC														43	-	>50	W4	R
	- - -30	23	29.50	RC														38	-	>50	W4	R
	- - -31	24	30.50	RC	-													55	-	>50	W4	R
	- - -32	25	31.50	RC											32.00	m	-	45	-	>50	W3	R
			32,50		- 96						********			~~~	-		63.5				W4	F
	-33	26		RC										~ ~ ~	GRAFİT ŞİST - METAKI ARDALANMASI;	UMTAŞI		59	6	>50	W4	R
	-34 -	27	34.00	RC										~ ~ ~	Siyahımsı - gri - koyu gr 32.00 - 51.70 m'ler aras genelde orta derecede -	u;		44	-	>50	W4	R
	- -35 -		35.00		-									~ ~ ~	yer yer az ayrışmış, nadiren tamamen ayrışı genelde zayıf - çok zayı	f dayanımlı,		45	-	200	W5 W3	R
	- - -36	28	35.00	RC	_										yer yer aşırı derecede z yer yer orta derecede sı genelde parçalanmış,	ağlam dayanımlı,		45		>50	W4	R
	- -	29		RC										~~~~	yer yer çok çatlaklı - kın Foliasyonlar;			60	17	4-10	W2	F
	-37 - -		- 37.50	,										~~~~	70°, dalgalı, kaygan, pa genelde kapalı, yer yer breşik yapılı.	irlak,			-	>50	W4	F
	- -38 -	30		RC										~ ~ ~	Çatlaklar; 45° - 50° arasında,			69	39	4-10	W2	F
	- -39		38.80	, 	-									~ ~ ~	dalgalı, pürüzlü, yer yer kapalı, kalsit damarlı.					>50	W4 W3	F
	-	31		RC					1					~~~~				66	-	>50	W4	1

LİMİT Teknik Araştırma Proje, Uygulama, Müşavirlik San. ve Tic. A.Ş

Idare		/ Administ	tration	T.C. U Karay	llaştırı olları (ma Denizc Genel Müd	ilik ve ürlüği	Haber 1, Kam	leşme u Özel	Bal I Se	anlığı ktör Ortaklığ	ı Bölge Müdürlüğü	Kuyu No	/ Borel	iole No			SK- 8	81
Proje I	ie mi	/ Project I	Vama	Gebze	a-Orha	angazi-lzm	ir (İzm	il Körfe:	z Geçiş	i ve	Bağlantı Yolla	rı Dahil) Otoyolu,	Sayfa	/ Shee				4 /	
				Manis	a - Izr	nir Kesimi,	Belka	anve T	uneli (KM:	398+300-KV	1:402+500 Arası)	İstasyon Sondaj Yeri	/ Slatic / BH L		(KM)		Tün	-
Görev Şirket		/ Appointe Company			,	c	toyol	Yatırın	n ve İşi	letm	e A.Ş.		Kuyu Derinliği		epth (n		т	90.0	_
Kuyu Derinliği BH Dəpth	Örnek No Sample No	Örnek Derinliği Sampie Depth	Örnek Türü Sample Type	Matkap Tipi/Çapı Bit Type/Diameter	Muhafaza Borusu	Darbe Sa # of Blow	ard Pe (S Iyisi Vs	netratio PT) N ₃₀ Grap	Grafiğ h of N	ji 30	Profili Symbol	Jeoteknik Ta Geotechnical I		Karot Çapi Core Diameter	Örnek Yüzdesi Core Recovery	Kaya Kalitesi RQD	Kırıklar Fractures	Ayrışma Weathering	
m -40	31	m	RC	mm	mm	15 30	45	10 20	30 40	50				mm	% 66	-	#-m >50	W3 W4	ĺ
-	32	40.30	RC								~ ~ ~ ~ ~ ~ ~ ~				79	28	>50	WЗ	
-41 - -		41.50									~ ~ ~							W4	
-42 -	33		RC		-						~ ~ ~				63	-	>50	W3 W4	
-43	34	43,00	RC								~ ~ ~				79	26	>50	W3 W4	
-44 - ^	35	44.20	RC	-							~ ~ ~				58	-	>50	W3 W4	
- -45	36	45.00	RC	-								Yukarısı gibidir.		5	76	-	>50	W3	
- - -46		45.50		96							~ ~ ~			63	68		250	w3	
-	37		RC	_							~~~~						>50	W4	
-47 - -	38	46,90	RC								~~~~				75	33	4-10	W2	
-48		48.20		_							~~~~				75		>50	W3	
-49 - -	39	49.40	RC	_							~~~~						11-50	W4	
- -50 -	40	- 50.55	RC								~~~				78	48	>50	W3 W4	
- - -51	41	51.00	RC		_									-	93	56	11-50	W3 W4	
-	42	51.70	RC	_							~ ~ ~				61	-	>50		
-52 - -	43		RC								~ ~ ~	51.70 - 81.30 m'ler ara genelde çok - tamame yer yer orta derecede genelde çok zayıf - aş	an ayrışmış, ayrışmış,		35	5 -	>50	W	
- -53	44	52.70	RC	26							~~~~	geneide çok zayır - aş dayanımlı, yer yer zay nadiren sağlam dayar	ıf dayanımlı,	47.6	28	3 -	>50	W4 W5	
-	45		RC				-				~~~	genelde parçalanmış,			44	1 -	>50	W4 W5	
-54 - -	46	- 54.00	RC	;	1778						~ ~ ~				36	5 -	>50	W2	

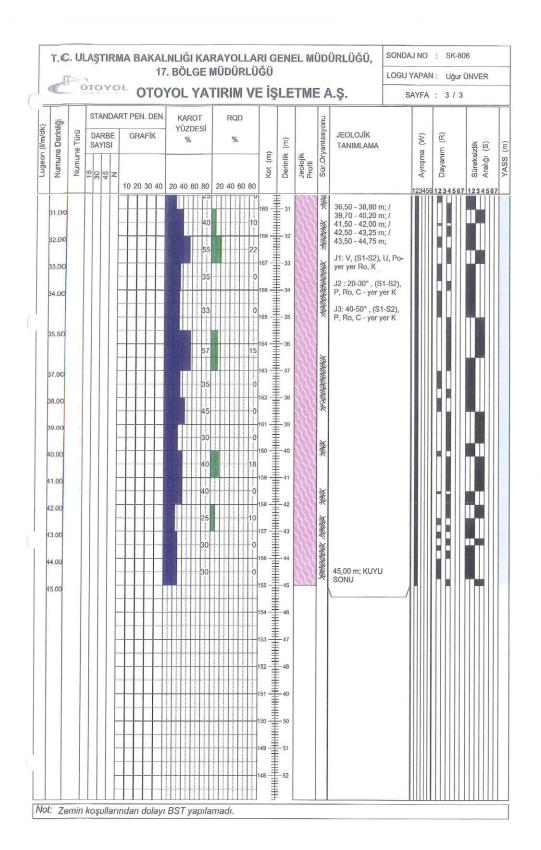
Idare		/ Adminis	tration	T.C. U Karayo	laştirn olları G	ha De Genel	Müd	ilik ve ürlüğ	е нас ü, Ka	amu (şme Ba Özel S	akanıı ektör	gı Ortaklığı	Bölge Müdürlüğü	Kuyu No	/Bore	hole No			SK-		_
(Proje l	sm1	/ Project	Name	Gebze	-Orha	ngaz	-lzm	ir (lzn	nit Kö	rfez G	eçişi ve	e Bağlı A-308-	antı Yollar	n Dahii) Otoyolu, 1:402+500 Arası)	Sayfa İstasyon	/ Shee		(KM)		5 j 399+	7 600	_
		/ Appointe		Manis	a - izm	nir Ke		-			10.00			.402.000711007	Sondaj Yeri		ocation	(run)		Tün	el	_
Görev Şirket		Company									e İşleti	_	Ş.		Kuyu Derinliği	/BH [Depth (n)		90.0		L.
Kuyu Derinliği BH Depth	Örnek No Sample ivo	Örnek Derinliği Sample Depth	Örnek Türü Sample Type	Matkap Tipi/Çapı Bit Type/Diameter	Muhafaza Borusu		ndar Stand	ard P	enetra SPT)	ation	Deneyi Test rafiği		lin Jod	Jeoteknik Ta	animlama	Karot Çapı Core Diameter	Örnek Yüzdesi Core Recovery	Kaya Kalitesi RQD	Kırıklar Fractures	Aynşma Weathering	Dayanım Strength	Yerinde Deneyler
BH Du	Ôme	m	Örne Samj	Bit T	Boru	# 0	f Blov	NS	G	raph o	of N 30	0	Symbol	Geotechnical L		M Kar Cor	20°0 %	% Ka	# Kir #-m	Ayr	Str	Ye
-55 - -	4'	55.00	RC									-	~~~				35	-	>50	W4 W5	R1 R0	
- -56 -		56.00										-	~ ~				36		>50	W4	R1	
- - -57	43	57.00	RC														30		>50	W5	R0	
-	49		RC									認識	~~~				56	-	>50	W4 W5	R1 R0	
-58 - -	5	58.00	RC										~ ~				71		>50	W4	R1	
-59		59,30											~ ~ ~				_		-	W5 W4	R0 R1	-
- -60	51	60.10	RC	_									~ ~ ~				73	~	>50	W5 W4	R0 R1	-
- - -61	52	- 61.00	RC										~ ~ ~				33	-	>50	W5	R0	-
-	53		RC									1 100100	~~~~	Yukarısı gibidir.			35	-	>50	W4 W5	R1 R0	
-62 - -	54	- 62.00	RC	76									~ ~ ~			47.6		-	>50	W4 W5	R1 R0	
-63 - -	55	- 63.00	RC										~ ~ ~				73	-	>50	W4	R1	-
-64 -		- 64.3										1 1 1	~ ~ ~	-			_	+	-	W5		-
- -65 -	56	- 65.5	RC										~ ~ ~ ~ ~ ~ ~ ~ ~				64	-	>50	W5	R	
- -66 -	57	00.0	RC										~ ~ ~				8		>50	we		
- -67 -	58	66.8	0 RC	;									<u></u>				4	7 .	. >5	D W4		
- - -68	59	- 67.5	0 R										~ ~ ~				5	2	. >5	·		
•		- 68.6											~ ~ ~ ~	2			_	+		w	+	_
-69 - -	60	69.9	R										~~~~	-			7	3	- >5			

ldar	re	/ Adm	inistratior	Kara	olları	Gene	l Müd	ūrlüğ	ū, Ka	mu	Özel	l Se		ı Bölge Müdürlüğü	Kuyu No	/ Borei				SK-		
Pro	je İsmi	/ Proj	ect Name	Gebz	e-Orha	angaz mir Ke	i-lzmi ssimi	ir (İzm Belk	it Kör ahve	fez (Tür	Geçiş neli (l	i ve KM:	Bağlantı Yoll 398+300-Ki	rı Dahil) Otoyolu, A:402+500 Arası)	Sayfa Istasyon	/ Shee		(KM)		399+	600	_
Gö	evli	/ App	pinted	-											Sondaj Yeri	/BH L				Tü		_
Şirk		Comp	any		1								ie A,Ş.		Kuyu Derinliği	/BH D	epth (n	n) Г		90,	00	5
Kuyu Derinliği	BH Depth Ornek No	Örnek Derinliği	Örnek Türü Sample Tvoe	Matkap Tipi/Çapı Bit Type/Diameter	Muhafaza Borusu	Darl # c	Standi be Sa of Blov	iyisi vs	enetra PT) N; Gra	tion 30 G aph	Test irafiği of N 3	i w	Profili Symbol	Jeoteknik Ta Geotechnical (Karot Çapı Core Diameter	Örnek Yüzdesi Core Recovery	Kaya Kalitesi RQD	Kiriklar Fractures	Ayrışma Weathering	Dayanım Strength	Yerinde Deneyler
-70 -		m	RC	mm	mm	15	30	45	10 2	0 3	0 40	50	~ ~ ~			, ,	% 66	%	#-m >50	W4	R1	
- - -71		- 71.											~ ~ ~							W5	RO	
-	62		RC										~~~~				75	-	>50	W4	R1	
-72 - -		- 72.	50	_									~~~							W5	R0	
-73 -	63		RC										~~~				78		>50	W4 W5	R1 R0	
- - -74	64	73.	RC										~~~				50	-	11-50	W3	R2	
-	65		RC														65	-	>50	W4 W5	R1 R0	
-75	66	- 75	00 RC										~ ~ ~				58		>50	W4	R1	
- -76		- 76		_									~~~~	Yukarısı gibidir.						W5	RO	
- - -77	67	- 77.	RC										~~~				60	-	>50	W4 W5	RO	_
-	68		RC	76									~~~~			47.6	65	-	>50	W4 W5	R0	
-78		- 78											~~~							W4		
- -79 -	69		RC										~ ~ ~				68		>50	W5	R0	
- - -80	70	79) 80	RC	-									~ ~ ~				78	-	>50	W4 W5	R0	
- - -81	7'	81	RC	:									~ ~ ~				62	-	>50	W4 W5	R0	
- - -82	73		RC	;									~ ~ ~	81.30 - 90.00 m'ler aras tamamen ayrışmış, aşırı derecede zayıf daş	-		67	-	>50	W5	RO	
-	7:	82	RU	;									~~~~	parçalanmış.			71	-	>50	W5	R0	
- -83 -	74		RC	;									~ ~ ~				75	-	>50	W5	R0	
-84	-	83	.80										~ ~ ~									-
-	7		RC														79	-	>50	W5	RO	

	ldare		/ Admini	stration	Karay	ulaştır olları	ma D Gene	enizcili I Mūdū	k ve rlüğü	Hab I, Ka	erleş mu (me E Özel (lakanlığı Sektör Ort	aklığ	ı Bölge Müdürlüğü	Kuyu No	/Bore	shole N	b		SK-	805	
	Proje	Ismi	/ Project	Name	Gebz	e-Orh	angaz mir Ke	i-İzmir əsimi F	(İzmi Selka	t Körl	fez G Tüne	eçişi v	e Bağlantı	Yolla	rı Dahil) Otoyolu, /:402+500 Arası)	Sayfa	/ She					17	
	Görev	riá	/ Appoin	ted		- 1 <u>6</u>						-		0-111	1.402+500 Alasi)	Istasyon Sondaj Yeri	/ Stat	ion Locatio	(KM)			+600 nel	
	Şirket		Compan		ļ							-	tme A.Ş.			Kuyu Derinliği		Depth (.00	_
	BH Depth	Örnek No Sample No	3 Örnek Derinliği Sample Depth	Örnek Türü Sample Type	Bit Type/Diameter		Darl # c	indart F Standar be Sayi of Blows	d Per (Si	netrat PT) N ₃ Gra	ion T o Gra oh ol	est afiği f N ₃₀	Profili Svmbol		Jeoleknik Ta Geolechnical D		B Karot Çapı B Core Diameter	[%] Ornek Yüzdesi Core Recovery	kaya Kalitesi RQD	 Kinklar Fractures 	Ayrışma Weathering	Dayanım Sirengtr	Yerinde Denevler
	-85 - -	76		RC									~~~					61	-	>50	W5	RO	Γ
	- -86 -	77	85.70	RC				11111					~~~	-				66	-	>50	W5	R0	
	- - -87	78	86.60	RC									~~~	_	Yukarısı gibidir.			61	-	>50	W5	RO	
	-	79	87.60		76										ananai gibian.		47.6	80	-	>50	W5	R0	
	- -88 -	80		RC									~~~	_				51	.	>50	W5	R0	
	- - -89	81	88,50	RC									~ ~					66	-	>50	W5	R0	
	- - -90	82	89.20 90,00	RC									~~~	_				59	-	>50	W5	R0	
	- 30		90,00												90.00 KUYU S(
	-91 -																						
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3	r	D	P	roj							ANİ LTD				laj : AY C	GRU	P S	OND	AJ				atırım ve İş RBİLİMLER					LTD.Ş	τi.
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	11111	JKC			11. SS		п 00	n											-	LİK ÇAF		220	114 mm 0,00-16,00)m; 96mm	/ 16,0	00-45,00r	n; 76m	m	-
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	inliği	ü				-			DEI	N.		ARO			RC	D					syonu	IEO	LOJÍK		0	0			
	Numune Derinliği	Numune Türü			RBE		GI	RAI	FİK			%			%	5		(m)	lik (m)	¥	Sür.Oryantasyonu		IIMLAMA		ma (W)	nım (R)	Süreksizlik	ğı (S)	(m) S
	Numu	Numu	15	30	42 N		10 2	20 3	304	0	20 4	0 60	80	20	40	60	80	Kot (Derinlik	Jeolojik Profil	Sür.O				emşiry 15342	mineyed 6 153426		uğıları 4567	YASS
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LİMİT Teknik Araştırma Proje, Uygulama, Müşavirlik San. ve Tic. A.Ş

	Idare		/ Administ	tration	T.C. (Karay	Jlaştırr olları (na D Sene	eniza I Müc	ilik ve Iürlöğ	e Hal jü, Ki	berle amu	şme Öze	e Ba el Se	akar ektö	ılığı ir Ortaklığ	ı Bölge Müdürlüğü	Kuyu No	/ Boreh	ole No			SK-	
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	iĝi	Örnek No Sample No	Örnek Derinliği Sample Dopth	Örnek Türü Sample Type	Matkap Tipi/Çapı Bit Type/Diameter	1	Dai #	rbe S of Blo	lard P (ayısı ws	Penetr (SPT)	ation N ₃₀ G Traph	Grafi	iği V 30		Profili Symbol	Jeoteknik Ta Geolechnical I	inimlama Description	E Karot Çapı Core Diameter	Core Recovery	<pre>% Kaya Kalitesi % ROD</pre>	# Kunklar 3 Fractures	Ayrışma Weathering	Dayanım
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	- - -12	8	11,40	RC															88	-	>50	W4	
	-		12.30		1										~ ~ ~						>50	W4	
	-13 -	9		RC											~ ~ ~	GRAFIT ŞIST - METAK ARDALANMASI; Siyahımsı - gri renkli, 10.50 - 25.90 m'ler ara			100	12	11-5	w2	
	- -14															genelde orta derecede yer yer az ayrışmış,					>50	W	+
	- -		14.40												~~~~	nadiren taze ayrışmış, genelde çok zayıf - aşı yer yer zayıf - orta dere		.,	54	-	>5(w	3
	-15 - -	10	15.50	RC											~ ~ ~	genelde parçalanmış, yer yer çok çatlaklı - kı				+	-	w	
	- -16 -	11		RC											~ ~ ~ ~	yer yer foliasyonlu, yer yer breşik yapılı. Foliasyonlar;			70		>5) W	
	- - -17	-	16.6	5	1										~~~~		ygan, parlak,	5				w	13
	- - -18	12		RC	96										~ ~ ~	Çatlaklar - 1;		63	7	5	. >5	1	/4
	-	-	- 18.5	•											~ ~ ^		krarii,				_		
	-19 - -	13		R	;			~							~ ~ ~	6 - 20 cm arasında te		2	8	2	- >	Ľ	V3
	- -20 -	14	19.6	R											~~~	yer yer kalsit dolgulu, yer yer kapalı.			9	10	17 >	50 V	V2
	- - -21	15		R	5										~~~	EZİK ZON; 11.00 - 13.00 m'ler,			e	34	. >	50 \	N3
	- - -22	16	21.0	R	c										~~~	-				96	17 >	50 -	W2
	-	17	22.	50 R											~~	 şist kaya parçalı. 				92	27	50	W1 W2
	-23 - -		23.												~~~				-		-+	-	w:
	- -24 -	18	B 24.	20 R	c															97		-†	W:
	-	1	9	R	c			ļ											ľ	100	36	>50	W

ldare		/ Adminis	tration	T.C. L Karay	Jlaştırı olları (ma Deniz Senel Mü	cilik ve dürlüğ	e Habe ü, Kan	rleşı nu Ö	me Ba)zel Se	kanlığı ektör Ortaklığ	ı Bölge Müdürlüğü	Kuyu No	/ Boreh	iale No			SK-	
Proje	smi	/ Project I	Vame	Cabr	Orby	nanzilzr	nir /lag	vit Vörfe	a7 G4	acisi ve	Bağlantı Yolla	rı Dahil) Otoyolu, A:402+500 Arası)	Sayfa İstasyon	/ Sheel		(KM)		3 399+	/ 9 850
Görev		/ Appointe		wants	a - 121								Sondaj Yeri	/BHL				Tür	nel
Şirket		Company			ı—						ne A.Ş.		Kuyu Derinliği	/BH D	opth (n	"	—	128	.00
	Örnek No Sample No		Örnek Türü Sample Type	Matkap Tipi/Çapı Bit Type/Diameter	Muhafaza Borusu	Darbe S # of Bk	dard Pi (S ayısı Sayısı	enetrati SPT) N ₃₀	on Te G Gra ph of	est afiği f N ₃₀	Profil Symbol	Jeoteknik T Geotechnical		B Karot Çapı S Core Diameter	Core Recovery	& Kaya Kalitesi RQD	 Kırıklar Fractures 	Ayrışma Weathering	Dayanım
-25		<u>m</u>		៣៣	mm	15 30	40		T		~ ~ ~						4-10	W2	R3
-	19		RC								~~~~				100	36		,	R2
- -26		25.90		-							~~~				<u> </u>		>50	W4	RO
-		20.00									~~~~						>50	W3	R1
- - -27	20		RC								~~~				94	18	11-50	W2	R
-		27.70															>50	W2 W3	R
-28 - -	21	21.10	RC								~ ~ ~				83	-	>50	W2 W3	R
- -29	<u> </u>	28.90									~~~				<u> </u>	-	>50	W3	R
-											~~~~						4-10	W2	F
- -30 -	22		RC								~ ~ ~				75	16	>50	W3	F
- - -31	23	30.50	RC								~ ~ ~				85	13	>50	W2 W3	
-		31.50		-							~ ~ ~	,			\mid				
-32 - -	24		RC	96							~~~~	25.90 - 47.80 m'ler ara genelde az - orta dere		63.5	81	33	11-50	W2 W3	
-33		- 33.00		-							~~~~	yer yer çok ayrışmış, genelde zayıf - orta de dayanımlı, yer yer çok				-	>50	W3	+
- -34 - - -35 -	25		RC								~ ~ ~	nadiren sağlam dayar genelde çok çatlaklı - yer yer parçalanmış, nadiren kırıklı,			93	22	11-50	wz w3	1
- - -36		- 36.00	,	_							~~~								+
- - -37 - - -38	26		RC												90	-	11-5	o w:	
- - -39	_	- 39.0	0	_							~ ~ ~							w	2
-	27		RC												9	5 18	5 11-5	io W	3

dare		/ Adminis	ration	T.C. U Karav	llaştırm olları G	na Deni Senel M	izcilik v lüdürlü	ve Ha iğū, k	aberle Kamu	şme Ba Özel Se	kanlığı ektör Ortaklığı	Bölge Müdürlüğü	Kuyu No	/ Boreh	ole No			SK- 8	07	
	lami	/ Project l	lamo	Cohr	Orha	ngazi-l	zmir (la	mit K	örfez (Gecisi ve	Bağlantı Yollar	n Dahil) Otovolu,	Sayfa	/ Sheet		0.000		4 / 399+8		
Proje				Manis	a - Izm	iir Kesi						:402+500 Arası)	Istasyon Sondaj Yeri	/ Statio	_	(KM)		Tün		_
Görev Şirket	1	/ Appointe Company					Otoy	ol Ya	tırım v	ve İşletn	ne A.Ş.		Kuyu Derinliği	/BH D)		128.		SL
BH Depth	Ornek No Sample No	3 Ormek Derinliği Sample Depth	Örnek Türü Sample Type	Bit Type/Diameter	Borusu	Sta Darbe # of L	andard Sayıs Blows	Penel (SPT	ration) N ₃₀ G Graph		Profili Symbol	Jeoteknik T Geotechnical	anımlama Description	B Karot Çapı Core Diameter	Örnek Yüzdesi Core Recovery	Raya Kalitesi RQD	# Kiriklar 3 Fractures	Aynşma Weathering	Dayanım Strength	Yerinde Deneyler
40	27		RC								~ ~ ~				95	15	11-50	W2 W3	R3 R2	
-41 - - -42	28	41.00	RC	-							~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~				95	19	11-50	W2 W3	R3 R2	
-43	29	42.70	RC								~ ~ ~	Yukansı gibidir.			85	11	11-50	W3	R2	
-44 -4	30	44.10	RC	-							2 2 2 2 2 2				89	42	>50 4-10	W4 W2	R1 R3	
-45 -	_	45.10									~~~	3			-		>50	W4	R1	-
-46 - -	31		RC								~ ~ ~				90	-	>50	W2 W3	R3 R2	
-47 - -	32	47.20	RC	96							~~~~			63.5	83	30	>50 4-10	W3 W2	R2 R4	
-48 - - -49	33	- 47.80	RC	;							~ ~ ~ ~	47.80 - 55.50 m'ler ar çok ayrışmış, genelde zayıf - çok za nadiren aşırı dereced	ayıf dayanımlı,		79	-	>50	W4	R1 R0	
- - -50	34	49.2	RC	;							~~~~	parçalanmış,			85	-	>50	W4	R2 R1	
- - -51 -	35	- 50.5	R	>							~ ~ ~	47.60 - 49.20 m'ler,			92	2 -	>50	• vv4	R	
- -52 - -	36	- 51.8	R	-							~~~	-	inde metakumtaşı -		96	3 -	>50) w	R	
-53 - - - -54 -	37	- 53.0	0 R(c							~ ~ ~ ~				8	8 -	>5	p vv	1	12
-		54.8	80	_									İT Teknik Araştırma		Livers	-	Mileari	rille C.		

	ldare	_	/ Admini	stration									akanlığı ektör Ortal	ığı Bölge Müdürlüğü	Киуи No	/ Borei		,		SK-		
. with	Proje	Ismi	/ Project	Name										ları Dahil) Otoyolu, (M:402+500 Arası)	Sayfa İstasyon	/ Shee / Static		(KM)		5 399+	9	
	Görev	F	/ Appoin										me A.Ş.		Sondaj Yeri	/ BH L	ocation)		Tür	nel	_
	Şirket		Compan	и Г		-	Sta					eneyi		I	Kuyu Derinliği	1	Depth (r			128		٦ آ
	Kuyu Derinliği BH Depth	Ornek No Sample No	Örnek Derinliği Sample Depth	Örnek Türü Sample Type	Matkap Tipi/Çapı Bit Type/Diameter	Muhafaza Borusu	3	Stand	iard Pi (S ayisi	enetra SPT) N	tion Ti 30 Gra	est afiği	Profili Symbol	Jeoteknik Ta	nımlama	Karot Çapı Core Diameter	Örnek Yüzdesi Core Recovery	Kaya Kalitesi ROD	Kiriklar Fractures	Ayrışma Weathering	Dayanım Strength	Yerinde Deneyler
	m	58	ວິຮຶ m	១ន	₩ Mm	∑ mm	15		- 1			40 50	>	Geolechnical E	lescription	<u>x ö</u> mm	<u>ठेउँ</u> %	% %	<u>*</u> π	£3	ධ ශ R2	×
	-55 -	38	55,50	RC									~~~	-			71	-	>50	W4	R1	
	- -56 -	39		RC	n fan de ferste fenske fenske fenske fenske fenske fenske fenske fenske fenske fenske fenske fenske fenske fen								~~~	55.50 - 65.00 m'ler arası genelde orta derecede - yer yer az ayrışmış,	çok ayrışmış,		85	-	>50	W3 W4	R3 R2	
	-57	40	56.80	RC									~ ~ ~	genelde zayıf - orta dere dayanımlı, yer yer çok za genelde parçalanmış,			80	-	>50	W3 W4	R3 R2	
	-		57,50		96									yer yer çok çatlaklı - kırıl	ડો,	63.5				W3	R3	
	-58 -	41	58.30	RC									~~~	-			71	-	>50	W4	R2	
	- - -59	42		RC									~ ~ ~				85	-	>50	₩3 ₩4	R3 R2	
	-		59.50										~~~							W3	R3	-
	-60 -	43	60.50	RC		_							~~~	-			80	-	>50	W4	R2	-
	- -61 - -	44		RC									~~~	Yukarısı gibidir.			67	10	>50	W3 W4	R3 R2	
	- -62 -		62.00		-								~ ~ ~	-					>50	W3 W4	R2 R1	-
	- -63 -	45		RC							4		~ ~ ~				100	17	11-50	W3	R3 R2	
	-64 -												~~~						>50	W3 W4	R2 R1	
		46	64.60	RC	1											_	100		>50	W4	R1	1
	-65 - - -66	47	65.00	RC	76								~~~	65.00 - 62.00 m³ler aras geneide orta derecede -		47.6	100	-	>50	W3 W4	` Ri R0	
	- - - -67		67.00										~ ~ ~	yer yer az ayrışmış, genelde çok zayıf - zayı yer yer aşırı derecede z genelde parçalanmış,						714		
	-67 - - -68	48	07.00	RC									~~~	yer yer çok çatlaklı - kırı	klı,		100	23	>50	W3		
	- - -												~~~							W4	R1	
	-69 - -	49	69.00	RC									~~~				96		>50	W3		
	-	L	I]							0000	1 1147	Teknik Araştırma F	Proje	-		Ünavid	W4		

ldare		/ Adminis	Instian	T.C. L	Jlaştırr	na De	nizcilik '	ve Ha	aberle	LOG şme Ba	kanlığı		Kuyu No	/ Borel	hole Na	,		SK- 8	307
		7 Palitanas	·									i Bölge Müdürlüğü	Sayfa	/ Shee				6	9
Proje	Ismi	/ Project	Name	Bursa	- Orha	ingazi	Kesimi	, Bur	sa - S	seçişi ve usurluk	Kesimi	m Dahil) Otoyolu,	Istasyon	/ Static	n N	(KM)		399+	850
Görev		/ Appoint					Otoy	ol Ya	tirim v	re İşletn	ne A.Ş.		Sondaj Yerł Kuyu Derinliği	/ BH Li / BH D				Tün 128.	_
Şirkət		Compan;		ipi/Çapı liarrreter		Star S	landard	netra Penet (SPT	ration	Deneyi Təst			Kuyu Deninigi						
3 Kuyu Derinliği BH Depth	Örnek No Sample No	3 Örnek Derinliği Sample Depth	Örnek Türü Sample Type	Bit Type/Diameter	Muhafaza Borusu	# of	e Sayıs Blows 30 45		N ₃₀ G Graph 20 3		Profili Symbol	Jeoteknik Ti Geotechnical		B Karot Çapı B Core Diameter	Core Recovery	Kaya Katitesi RQD	# Kunklar B Fractures		Dayanım
-70	49	70.40	RC								~~~~				96	-	>50	W3 W4	R
- -71	50		RC								~ ~ ~				100	18	11-50	W3	R
-72		72.00									~~~						>50		R
-	51	72.70	RC	_			1				~~~~	Yukarısı gibidir.			91	-	>50	WЗ	я
-73 - - -74 -	52	12.10	RC								~ ~ ~ ~ ~ ~ ~ ~				100	46	11-50	W2 W3	F
- -75 -		- 75.20	,								~~~						11-50	<u> </u>	
- -76	53	76.20	RC								~ ~ ~				100	22	>50	W3 W4	
- - -77	54	- 77.00	RC								~ ~ ~				96	-	>50	W3 W4	
- - -78 -	55	- 77,00	RC	76							~~~~			47.6	100	5	>50	W3 W4	
- -79 -		79,0	o	-							~~~								
- -80 - - - -81 -	56		RC								~~~~				10	0 -	>50	W3 W4	
- -82 - -	57	- 82.0	0 RC		-						~ ~ ~				10	0 25	£1-50		
-83 - -	-	- B3.2	0	_							~~~	- - 				_		W3	+
- -84	58		RC	;		-					~~~				10	ю -	>50		1
-	59	84.4	R												9	2 -	>50	W3	

	ldare		/ Adminis	tration	T.C. I Karay	ilaştırı olları (na D Genei	en/zcil Müdü	ık ve irlüğü	Habe I, Kar	erieş mu (șme î Özel	≝aki Sek	anlığı tör Ortaklı	ı Bölge Müdürlüğü	Kuyu No	/ Borel	iole No	>		SK-		
ĺ.	Proje	İsmi	/ Project	Name		e-Orha									rı Dahil) Otoyolu,	Sayfa İstasyon	/ Shee		(KM)		7 3994	/ 9	
	Görev	1	/ Appoint	ed		- 011	ungu									Sondaj Yeri	/BH Lo	-			Tü		
	Şirket		Company			·	,		-					∍ A.Ş.		Kuyu Derinliği	/BHD	eplh (I	n)		128	00,	L
	∃ Kuyu Derinliği <i>BH Dəpti</i> i	Ornek Na Sample No	3 Örnek Derinliği Sample Depth	Örnek Türü Səmple Type	Matkap Tipi/Çapı	Muhafaza Borusu	Dari # c	ndart Standa De Say If Blow	rd Pei (SI /ISI s	netrəti PT) N ₃₀ Gra	ion T o Gri iph a	afiği Kost		Profili Symbol	Jeoteknik Ta Geolechnical D		Karot Çapı Core Diameter	Cone Recovery	<pre>% Kaya Kalitesi RQD</pre>	 Kirtklar Fractures 	Ayrışma Wsathering	Dayanım Strength	Yerinde Deneyler
	-85 -	60	85.00	RC										~ ~ ~				92	-	>50	W3	R3 R2	
	- -86 -	61	85.70	RC										~~~				100	-	>50	W3 W4	R2 R1	Y LOE
	- - -87	62	86.40	RC										~ ~ ~				100	-	>50	W3	R3 R2	
	-	63	87,40	RC										~~~~				95	-	>50	W3 W4	R2 R1 R2	
	-88 -	64	88.30	RĈ										~ ~ ~ ~~~~				100	20	>50	W2 W3	R5 R3	
	- - -89	65		RC										~ ~ ~	82,00 - 128,00 m'ier araa	51'		100	-	>50	W3 W4	R3 R2	
	- - - -90	66	89.30 90.00	RC										~~~	genelde orta derecede - yer yer az ayrışmış, genelde zayıf - orta dere	çok ayrışmış,		98	-	>50	W3 W4	R2 R1	
	- - -91 -	67		RC										~~~~	dayanımlı, yər yər çok za nadiren sağlam - çok sa geneldə parçalanmış, yer yer çok çatlaklı - kırıl nadiren az çatlaklı - kırık	ayıf dayanımlı, ğlam dayanımlı, klı,		100	8	>50	W2 W3	R3 R2	
	-92	68	92.00	RC	76									~ ~ ~ ~ ~ ~			47.6	67	-	>50	W3	R3 R2	
		69	92.60	RC													4	83	-	>50	W3	R3 R3 R3	ľ
	-93	70	93.00	RC								aran ar		~ ~ ~				63 77	-	>50 >50	W4 W3 W4	R2 R2 R1	
	-94 - -		94.50		-									~~~							W3	R2	-
	-95	72	95.50	RC										~ ~ ~				98	-	>50	W4	R1	
	-	73		RC	1													92	-	>50	W3 W4	R2 R1	
	-96 - -	74	96.00	RC						*********				~ ~ ~				80	-	>50	W3		
	- -97 -		97,00	RC	-									~ ~ ~				100	- -	>50	W4 W3	-	
	-98		98.00		_									~ ~ ~							W4	R2	-
	- - -99	76		RC										~ ~ ~				100) -	>50	W3 W4		
	-	77	99.20	RC										~~~				100) -	>50	W3 W4	R2 R1	

Idare	_	/ Adminis		Gebze	e-Orha	ingaz	i-lzm	ir (İzn	nit Körl	fez G	eçişi v	ve Ba	ağlanlı Yoli	jı Bölge Müdürlüğü arı Dahil) Otoyolu,	Kuyu No Sayfa	/ Shee	hole No			8	807	
Proje	15m	/ Project	Name	Bursa	- Orh	angaz	i Ke	simi,	Bursa	1 - SI	usurlu	ık Ke	esimi		Istasyon	/ Stati		(KM)		399+		_
Görev Şirket		/ Appoint Compan	led y				0	toyol	Yatır	ım v	e İşle	tme	A.Ş.		Sondaj Yeri Kuyu Derinliĝi		ocatior epth (r			Tür 128		
Kuyu Derinliği BH Depth	Črnek No Sample No	Örnek Derinliği Sample Depth	Örnek Türü Sample Type	Matkap Tipi/Çapi Bit Type/Diameter	Muhafaza Borusu	Dark # o	Stand be Sa f Blov	and Pic (S ayısı vs	Gra	tion 1 30 Gr aph o	rest rafiği af N 30		Profili Symbol	Jeoteknik Te Geotechnical I	inimiama	Karot Çapı Core Diameter	Örnek Yüzdesi Core Recovery	Kaya Kalitesi RQD	Kırıklar Fracturas	Aynşma Weathering	Dayanım Strength	
m -100		m 100.00	<u> </u>	mm	mm	15	30	45	10 2	0 30	40 5	0	~ ~ ~			mm	%	%	#-m			-
- -	78		RC										~~~~				100	-	>50	W3 W4	R2 R1	
-101 - -	79	101.00	RC									- Antonio	~~~~				100	-	>50	W3 W4	R2 R1	
-102 - -	80	102.10	RC	-									~ ~ ~				96	-	11-50	W2	R5	-
-103 - -		103.50											~ ~ ~ ~							W3 W3	R4 R3	-
- -104 -	81	104.30	RC										<u> </u>				69	-	>50	W4	R2	
- -105 -	82		RC									A	~~~~				81	7	>50	W4 W3	R2 R1 R3	
- - -106 -	83	105.60	RC										~~~~	Yukarısı gibidir.			67	11	11-50 >50	W4 W4	R1 R0 R1	1
- - -107	84	106.50 107.00	RC										~ ~ ~				66	-	>50	W4	R2 R1	
- - - -108	85		RC	76									~ ~ ~			47.6	83	-	>50	W3 W4	R3 R2	
- - - -109	86	108.20	RC										~ ~ ~ ~				77		>50	W3 W4	R3 R2	
-		109.50											~~~~				80	12	>50	W3	R2	:
-110 - -	87	110.50	RC										~~~~					12	11-50	W2	R4	
- -111 -												h	~ ~ ~						>50	W3	R2	-
- - -112	88		RC										~ ~ ~	-			75	25	2-3 >50	W2 W3		
-	<u> </u>	112.50	,											-					-		+	
- -113 -	89		RC										~ ~ ~				100	8 0	2-3 >50	W2 W4	P3	3
- - -114 -	90	113.70	RC	-									~ ~ ~				81		>50	W3	R2	2
-																				W4	R1	1

-	Idare		/ Admini	stration	Karay	olları (Genel N	üdürlüğ	ğü, Ka	imu Ö	zel S		ğı Bölge Müdürlüğü	Kuyu No	/ Bore		0		SK-		
(Proje	smi	/ Project	Name								e Bağlantı Yolla Kesimi	arı Dahil) Otoyolu,	Sayfa Istasyon	/ Shee		(KM)			/ 9 +850	
	Görev Şirket	li	/ Appoin Compan					Otoyo	l Yatır	ım ve	İşletr	me A.Ş.		Sondaj Yeri Kuyu Derinliği	/BHL		1		Tü 128		_
	Kuyu Derinliği BH Depth	Ornek No Sample No	Örnek Derinliği Sample Depth	Örnek Türü Sample Type	Matkap Tipi/Çapı Bit Type/Diameter	Muhafaza Borusu	Sta Darbe # of E	Sayısı Iows	Penetra SPT) N Gr	tion Te 30 Grai aph of	st fiği N ₃₀	Profili Symbol	Jeoteknik Ti Geotechnica/	anımlama	Karot Çapı Core Diameter	Örnek Yüzdesi Core Recovery	Kaya Kalitesi RQD	Kiriklar Fractures	Ayrışma Weathering	Dayanım Strength	Yerinde Deneyler
		90	m	RC	mm	mm	15 3	0 45	10 2	0 30 4	10 50	~ ~ ~			mm	% 81	%	#-m	W3	R2	t
	- - -116	91	115.60									~ ~ ~				97		>50	W4 W3	R1 R2	-
	-		116.30									~~~~							W4 W3	R1 R2	-
	-117 -	92	117.30	RC								~ ~ ~ ~				100		>50	W4	R1 R5	-
	- ¹¹⁸	93	4000	RC								~ ~ ~				100	20	11-50 >50	W2 W3 W4	R4 R3 R2	-
	- - -119	94	118.30	RC								~ ~ ~				100	15	>50	W3 W2	R2 R4	-
	-	95	119,30	RC								~~~~				100		>50	W4 W3	R3 R2	-
	-120 - -		120,30									~ ~ ~	Yukona aikidir						W4 W3	R1 R2	-
	- -121 -	96	121.30	RC	76							~~~	Yukarısı gibidir.		47.6	100	-	>50	W4 W2	R1 R4	_
	- - -122	97		RC								~ ~ ~				100	25	>50	W3 W4	R2 R1	
	- - -123	98	122.30	RC								~ ~ ~				100	-	>50	W3 W4	R3 R2	
	-	99	123,30	RC								~~~~				100	15	>50	W3	R3	-
	-124 - -		124.30									~ ~ ~				-		-	W4 W3	R2 R3	-
	- -125 -	100	125.50	RC								~~~				83		>50	W4	R2	
	- -126 -	101		RC								~ ~ ~				100		>50	W3 W4	R3 R2	
	- - -127		126,50									~ ~ ~							W3		
	-	102		RC								~~~~				87	-	>50	W4	R2	
	-128 - -		128.00										128 KUYU :	.00 m. SONU							
	-129																				
													1 jair	Teknik Araştırma F	Proje /	wante		Ongul	lik Ger	1 10 7	TIE

an	/ Administration of the second	Vame rd ni ni	Gebzi Manis VI Fugro	e-Orh sa - İzr OTC Siat ` Ltd. Ş	anga mir k Yuks Yerbi ti. ULU	izi-İzn (esimi el Dor ilimier iandar stand stand of Bio	nir (Izr i, Beli Otoyo maniq ri Müş ri Müş ri Per dard F (: ayısı	mit Kö kahvi I Yatı S Müł S.ve	nendis 8.0 11.0 18.0 18.0 19.0 19.0 19.0 19.0 19.0 10.0 10.0 10	eçişi i bili (Ki e İşle lik Lt bate 09,1 09,1 est	ve Ba M:39 tme td. Şt	ağlantı Yolia 98+300-Ki A.Ş.	YAS Der. <i>GW depth</i> , m 59.65 47.00	olu,	Kuyu No Sayfa Istasyon Sondaj Yeri Kuyu Derinliği, m Başlangıç Tarihl Biliş Tarihl Biliş Tarihl Kot, m Koordinatlar, m <i>(ED-50/27-6°)</i> Sapma, m	/ Borel / Shee / Static / BH L / BH L / Start / Finisl / Grou / Com	f ocation Depth (r Date h Date nd Elev dinates	KM. m) vation s N E		400+ Tü	1 7 +400 nel .201 .201 4
OULIEK NO	/ Appointer Company / Technication / Technication / Doll Rig Subo m m 1.50	A Ornek Türü Sample Type	Matkap Tipi/Çapi Si Type/Diameter	Sa- Izi Siai' Siai' Ltd. Ş	rüks Yerbi ti. ULU Da #	(esimi el Dor illimier illimier standar stand of Bio	i, Beli Otoyo maniq ri Müş ri Müş ri Müş ayısı (i ws	kahve I Yatı Mül Ş.ve Getras SPT)	e Tüne Inm ve hendis T 8.0 18. syon D ation T	eli (Ki elsle lik Lt oarih Date 09,1 09,1 09,1	M:39 tme td. \$t	A.Ş. ti.	YAS Der. <i>GW depth</i> , m 59.65	ası) Açıklama Remarks	İstasyon Sondaj Yeri Kuyu Derinliği, m Başlangıç Tarihi Bitiş Tarihi Kot, m Koordinatlar, m (ED-50/27-6*)	/ Static / BH L / BH D / Start / Grou / Corr / Offse	on ocation Date h Date nd Elev dinates	n) vation s N E		4004 Tür 100 25.06	+400 nel),00 .201 4
	Company / Designed / Technica Consultant / Drift Methics / Dri	A Ornek Türü Sample Type	Matkap Tipi/Çapi Z 2 2 5 1	Muhafaza Siat, Trq. 2 Siat, Muhafaza	Yerbl Yerbl ti. ULU Da #	el Doi ilimier iandai Stand	Otoyo maniq ri Müş rt Per dard F (: (: ws	A Wüh	nendis	e Işle lik Lt arih Date 09,1 Deney est	tme td. Şt	A.Ş. ti. Derinlik	YAS Der. GW depth, m 59.65	Açıklama Remarks	Sondaj Yeri Kuyu Derinliği, m Başlangıç Tarihi Biliş Tarihi Kot, m Koordinatlar, m (<i>ED-50/27-6*</i>)	/ BH L / BH D / Start / Finish / Grou / Coon	ocation Pepth (r Date h Date nd Elev dinates	n) vation s N E		Tü 100 25.06	nel),00 .201 .201 4
	Company / Designed / Technica Consultant / Drift Methics / Dri	A Ornek Türü Sample Type	Matkap Tipi/Capi St Um High A	Sial V Ltd. Ş NRY S 1000 nsnug	Yüksi Yerbi tti. ULU St Da #	el Doi ilimier iandai Stand of Blo	rt Per dard F (ayısı	; Müh ; ve enetras enetr SPT) G	T 8.0 18. syon D ation T	lik Lt arih Date 07.12 09.1 eney est	ld. Şi	ti. Derinlik	<i>GW depth,</i> m 59.65	Remarks	Kuyu Derinliği, m Başlangıç Tarihi Biliş Tarihi Kot, m Koordinatlar, m (ED-50/27-6*)	/ BH D / Start / Finish / Grou / Coom / Offse	Depth (n Date h Date nd Elev dinates	n) vation S N E		100 25.06	0.00 .201 .201 4
Dmek No Sample No	/ Technica consultari / Drill Mell ignuria ignuria ignuria galaga yetung m m 1.50	Drek Türü Sample Type	Matkap Tipi/Çapi GI 20 MG 1 Bit Type/Diameter - V 0.05	Muthafaza Siat , Trg. č Nuthafaza Borusu Borusu	Yerbi ti. ULU St Da	ilimler anda Stand rbe S of Blo	ri Müş rt Per dard F (1 ayısı	s.ve netras Penetra SPT) G	T B.(1B. syon D ation T	arih Dale 07.12 09.1 Deney est	2	Derinlik	<i>GW depth,</i> m 59.65	Remarks	Bitiş Tarihi Kot, m Koordinatlar, m (ED-50/27-6*)	/ Finisl / Grou / Coon / Offse	h Date nd Elei dinates at	E			4
Dmek No Sample No	/ Technica consultari / Drill Mell ignuria ignuria ignuria galaga yetung m m 1.50	Drek Türü Sample Type	Matkap Tipi/Çapi GI 20 MG 1 Bit Type/Diameter - V 0.05	Muthafaza Siat , Trg. č Nuthafaza Borusu Borusu	Yerbi ti. ULU St Da	ilimler anda Stand rbe S of Blo	ri Müş rt Per dard F (1 ayısı	s.ve netras Penetra SPT) G	T B.(1B. syon D ation T	arih Dale 07.12 09.1 Deney est	2	Derinlik	<i>GW depth,</i> m 59.65	Remarks	Kot, m Koordinatlar, m (ED-50/27-6*)	/ Grou / Coon / Offse	nd Eler dinates at	E		02.07	4
Dmek No Sample No	Consultan / Dnitt Meth / Dnitt Rig iDit Used or order W S m 1.50	A Ornek Türü A Sample Type	Matkap Tipi/Çapı CI 20 M Bit Type/Diameter	Muthafaza 0000 Borusu Borusu	ti. ULU St Da	anda Sland rbe S of Blo	rt Per dard P (ayısı ws	netras Penetri SPT) G	8.0 18. syon D ation Tr	07.12 09.1 09.1 eney est	2		<i>GW depth,</i> m 59.65	Remarks	Koordinatlar, m (ED-50/27-6°)	/ Coon	dinates at	E			
Drine No	/ Drill Rig under Seduction (10) (10) (10) (10) (10) (10) (10) (10)	A Ornek Türü A Sample Type	Matkap Tipi/Çapi <u>51</u> 20 Bit Type/Diameter	Muhafaza Borusu	ULU St Da	anda Sland rbe S of Blo	dard F (ayısı ws	Penetri SPT) G	18. syon D ation Tr	09,1 eney est	2		59.65	-	(ED-50/27-6°)	/ Offse	et	E			
DUTER NO	Sample Coptri Sample Coptri	RC	Matkap Tipi/Çapı Bit Type/Diameter	Muhafaza Borusu	Da #	Stand rbe Si of Blo	dard F (ayısı ws	Penetri SPT) G	syon D ation T A ₃₀ Gra	eney est	+		47.00	-	Sapma, m	1					
1		RC			Da #	Stand rbe Si of Blo	dard F (ayısı ws	Penetri SPT) G	ation T I	est	yi										ļ
1		RC				rbe S of Blo	ayısı ws	SPT) G	l ₃₀ Gra		_					1 5	18 2	1 122			ŧ.,
1		RC				of Blo	ws	G		afiği						Karot Çapı Core Diameter	Örnek Yüzdesi Core Recovery	Kaya Kalitesi RQD	<i>"</i>	л D	F
1		RC								6 4.7		Profili Symbol	Je.	oteknik Ta	nımlama	a Die	a Re	20	Kinklar Fractures	Aynşma Weathering	Dayanım
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									20 30	11		0.0000				mm	70	70	#-(7)		h
2		RC				1						0.00 De0	YOL DOLGU	su			19	-			
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2	3.00	RC		1							5	<u> </u>	Yeşilimsi kah				⊢				
2	3.00	RC										000	çakıllı, kumlu	, killi BLOK.							
	3.00										C		Bloklar ve ça	kıllar; köşel			22	-			
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			96									~~~~	GRAFIT ŞİST	r;		63.5					١.
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		_											parçalanmış,								
5		RC										~~~~	foalisyonlu.				97	·	>50	W4	,
	7.00			1								~~~~	Foliasyon Dü	izlemleri;			L			-	Ľ
6		RC											30° - 40° ara				83	.	>50	W4	
	7,70												2 - 6 cm aras düzlemsel, d				L	<u> </u>	ļ	ļ	Ľ
l												~ ~ ~ ~		3 10. 1							
7		RC										~ ~ ~	Çatlaklar;		skip		100	-	>50	W4	ľ
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<u> </u>													Ł	vamalı,			100				1
°		кс										~ ~ ~	eçik - Kapalı.				100	1	>50	W4	
				<u> </u>	1	1	L				DEČ		IRMESI (SOU	ROCKE		<u> </u>	1	1	L		1
ICE D	ANEL / F	INE GI	RAINED)	Г												1	KIRIKL	AR / FF	RACTU	RES
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8	Orta Katı		/M. Sill			N30 :	11 - 3	iÔ	Orta S		1	M. Dense		50 - 75 9	6 Orla / Feir		4	- 10	Kinkli		1Fi
10	Çok Kalı		/ Very Stil	r				N)		liki											
	Sert SMA / WE		/ Hard		+-			n	ΑΥΑΝ	IM ZS	STRF	NGTH		KISALT	ALAR / ARREVIAT	IONS	-	NC	TLAP	REMA	R K
30	-		Fresh		Rů	Aşırı	Derece	de Zay		;	Ed.W	leak Rock	q,= 0.25 - 1.0 MPa	UD : Şelbi	Tüp /Shelby Tuba		(*) Kı	rıklar - a	ayrışma	- dayar	nım
30 AYRI	mış ecede Ayrışı	niş	Moderatel	ly West.	R2	Zayıf	Kayaç				Wesk I	Rock	q_= 5.0 - 25 MPa	SPT : St. Pe	netrasyon Den, / St. Penetratio		olduğ	u yerler	rde kil di	olgusu	geç
30 AYRI aze z Aynşı		-	Highly We	esthered	R3	Orta	Derece	de Sağ	jlam Kay				q,= 25 - 50 МРа q,= 50 - 109 МРа	PD : Paker	Deneyi / Packer Yest						
30 AYRI aze z Aynşı hta Den lok Aynı		rak)			R5	Çok S	Sağlam	Kayaç			Very st	bang Rock	q _e = 100 - 250 MPa							~	1
8 ICI 2 4 8	B D	B,00 B,00 B B Cok Variage Cok Variage Variage	B,00 Color RC B,00 Color RC	S.00 RC S.00 RC RC Column 20 RC RC Column 20 RC Column 20 RC Column 20	B.000 RC B.000 RC RC B.000 RC RC RC Convertigence Convertence Convertence Convertence Convertence	7 RC 9,00 RC 3 RC 6 DANELI/FINE GRAINED Cok yumapak /Yany saft Yumingak /Jast Orfa Kati /Jast Vorgingak /Vary saft Yorgingak /Vary saft Yorgingak /Vary saft YRISMA/ WEATHERING RR Vinginga Stelph Weethmed 10brecode Aryginga Hodewished Weet. Argingang Hodewished Weet. Battent Argingang Compressioned RR Battent Argingang Compressioned RR Battent Argingang Compressioned RR	7 RC 9,00 RC 3 RC 6 RC 7 RC 9,00 RC 9,00 RC 9,00 RC 9,00 RC 9,00 RC 9,00 RC 9,00 RC 9,00 RC 9,00 RC 9,01 RD 9,01 RD 9,01 RD 9,01 RD 9,01 RD 9,01 RD 9,01 RD 9,01 RD 9,01 RD 9,01 RD 9,01 RD 9,01 RD 9,01 RD 9,01 RD 9,01 RD 9,01 RD 9,01 RD 10,01 RD 10,01 RD 10,01 RD	7 RC 9,000 RC 3 RC ChanceLI/Fine GRAINED Image: Solid	RC ZEMI 9,00 RC Image: Comparison of the state of t	Product RC ZEMIN - K/J 3 RC ZEMIN - K/J EDANELI / FINE GRAINED IRI DANELI RD AND Cok youngak / Very sett Noc : 0 - 4 Cok Youngak Yumugak / Jost Noc : 5 - 10 Garge Ortal Kati / Add M Noc : 5 - 10 Garge Valid / Mass / Mass 5 - 10 Garge Volta Kati / Mass Noc : 3 - 50 Skit Volta Kati / Head Noc : 3 - 50 Cok Kati YRISMA / WEATHERING R0 Agan Detrocold Zayrif Kayag Agargang Adoverlay Weekhawerd R1 Cok Zayrif Kayag Agargang Idaphatered R3 Orta Detrocold Zayrif Kayag Rational Science Addressed R3 Orta Detrocold Zayrif Kayag R3 Orta Detrocold Zayrif Kayag Agargang Idaphatered R3 Orta Detrocold Zayrif Kayag R3 Orta Detrocold Zayrif Kayag Addit Zemin (Torkol) Masketered R3 Orta Detrocold Zayrif Kayag R3 Orta Detrocold Zayrif Kayag Addit Zemin (Torkol) Rasotal Salam Kayag R5 Cok Salagham	RC ZEMIN - KAYA 3 RC ZEMIN - KAYA E DANELI / FINE GRAINED IRI DANELI / COL RC Go kyumapak //lwy.sat Na;: 0 - 4 Cok Gouge Ymmipak //sot Na;: 5 - 10 Gonyak Orta Istati //sot Na;: 5 - 10 Orta (Sati Vati / Kati //sot Na;: 5 - 10 Orta (Sati Vata / Kati //sot Na;: 31 - 50 Saki Ock Kati //lweit Na;: 5 - 50 Cok Sati Soft //lweit Na;: 31 - 50 Saki Vragmap Salphi / Weithiewid Na; 2 Zayf Kayag, R1 Cok Zayif Kayag, Agramping Madweidey Weet R2 Zayf Kayag, R3 Orta Detraceda Zajian Kayag, Agramping Complexity framed Zayif Kayag, R3 Orta Detraceda Zajian Kayag, R4 Sajian Kayag, Agramping Complexity framed Zayif Kayag, R4 Sajian Kayag, R4 Sajian Kayag,	RC ZEMIN - KAYA DEC 3 RC III DANELI / FINE GRAINED IRI DANELI / COARSI Ca yumapak / Yay saft Nac: 0 - 4 Cok Govpok Yumrapak / Soft Nac: 5 - 10 Gorayak Orta Iscati / Xuo saft Nac: 5 - 10 Gorayak Orta Iscati / Yumrapak / Yum / Soft Nac: 10 - 30 Grab Saft Vita Yasti Nac: 10 - 30 Grab Saft / Yum / Saft Nac: 10 - 30 Grab Saft Vita Yasti Nac: 10 - 30 Grab Saft / Yum / Saft Nac: 10 - 30 Grab Saft Vita Yasti Nac: 10 - 30 Grab Saft Nac: 31 - 50 Site / Yum /	7 RC	RC Solo Cattaktar; x ~ x ~ x Cattaktar; yer yer düşey x ~ x ~ x 3 RC	RC Solo Catlakiar; 9,00	RC Solo Catalakiar; 9,00	RC No. Catalaklar; Nervey yer yer düşey- düşey- düşeye yakın, Nervey yer yer düşey- düşeye yakın, Nervey yer yer düşey- düşeye yakın, Nervey yer yer düşey- düşeye yakın, Nervey yer yer düşey- düşeye yakın, Nervey yer yer düşey- düşeye yakın, Nervey yer yer düşey- düşeye yakın, Nervey yer yer düşey- düşeye yakın, Nervey yer yer düşey- düşeye yakın, Nervey yer yer düşey- düşeye yakın, Nervey yer yer düşey- düşeye yakın, Nervey yer yer düşey- düşeye yakın, Nervey yer yer düşeye yakın, Nervey yer yer düşeye yakın, Nervey yer yer düşeye yakın, Nervey yer yer düşeye yakın, Nervey yer yer düşeye yakın, Nervey yer yer düşeye yakın, Nervey yer yer düşeye yakın, Nervey yer yer düşeye yakın, Nervey yer yer düşeye yakın, Nervey yer yer düşeye yakın, Nervey yer yer düşeye yakın, Nervey yer yer düşeye yakın, Nervey yer yer düşeye yakın, Nervey yer yer düşeye yakın, Nervey yer yer düşeye yakın, Nervey yer yer düşeye yakın, Nervey yer yer düşeye yakın, Nerveye yer yer yer yer yer düşeye yakın, Nerveye yer yer yer yer yer yer düşeye yakın, Nerveye yer yer yer yer yer yer yer düşeye yakın, Nerveye yer yer yer yer yer yer yer yer yer	7 RC	r RC Image: Second Sec	r RC	RC Image: Constraint of the second seco

LİMİT Teknik Araştırma Proje, Uygulama, Müşavirlik San. ve Tic. A.Ş

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.ºroje l	IS MI	/ Project		Manis	a - Izm	nir Kes	simi,	Belk	ahve	Tüne	eli (K	(M:3	398+300-KI	f:402+500 Arası)		/ Static		(KM)		400+4 Tün	_
Görev Şirket		/ Appoint Company	ed ∕	Ċ	oro	YOL	0	toyol	Yatı	rım v	e İşle	etm	e A.Ş.				ocation epth (n	<u> </u>		100.	_
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Kuyu Derinliği BH Depth	Örnek No Sample No	Örnek Derinliği Sample Depth	Ornek Türü Sample Type	Matkap Tipi/Çapı Bit Type/Diameter	Muhafaza Borusu	Darb # of	e Sa Blow	yist	N	I ₃₀ Gr raph o		,	Profili Symbol	Jeoteknik Ta Geotechnical E		Karot Çapı Core Diameter	Ornek Yüzdesi Core Recovery	Kaya Kalitesi RQD	Kiriklar Fractures	Ayrışma Weathering	
m		m		mm	mm	15	30	45	10	20 30	40	50	~~~~		,	m	%	%	#-m		~
-10 -	8		RC										~ ~ ~				100	-	>50	W4	
.	9	10.50	RC										~~~~				80	-	>50	W4	
11	10	11.00	RC										~ ~ ~ ~	Yukarısı gibidir.			90	-	>50	W4	
	11	11.50	RC										~~~~				100	-	>50	W3 W4	
12		12.00											~~~~							W3	
	12		RC										~~~~				90	10	>50		
13		13.00											~ ~ ~	12.80					11-50	W4	
	13		RC											BREŞİK METAKUMTAŞ Siyahımsı - gri renkli,	il;	ļ	100	69	11-50	W2 W3	
14		13.75												genelde az - orta derece yer yer çok ayrışmiş,	ede ayrışmış,				15.50	W3	
, •	14	44.45	RC											genelde zayıf - orta dere dayanımlı, yer yer çok :			86	-	11-50	W4	
		14.45												genelde çok çatlaklı - kı yer yer az çatlaklı - kırık	rikli,				2-3	W2	
15	15		RC											yer yer az çatlaklı - kirik 15.30 METAKUMTAŞI; Koyu			96	60			
		15.80												az - orta derecede ayrış	mış, zayıf dayanımlı,				11-50	W2 W3	
6		15.80												çok çatlaklı - kırıklı, par Ç <i>atlaklar;</i> 40° düşeye y	akın, 2 - 6 cm					W2	
	16		RC											arasında tekrarlı, dalgal sıvamalı, kapalı. 16.50			89	10	>50	W3	
17													~ ~ ~	GRAFIT ŞİST;		5	_				
		17,15		96									~~~~	Siyahımsı - gri renkli,		63.5			44 50	W2	
18	17		RC										~~~~	genelde az - orta derec yer yer çok ayrışmış,			100	22	11-50	W3	
		18.35	<u> </u>											genelde zayıf dayanıml yer yer çok zayıf dayan				-	-	•	
19														nadiren aşırı derecede genelde çok çatlaklı - k						W2	
	18	-	RC											yer yer parçalanmış, foalisyonlu.		1	91	19	4-10		
																				W3	
20		20.00) 	1								and the second second	~~~~	Foliasyonlar; 20° - 30° arası,					11-50	W2	
	19		RC		ļ									2 - 6 cm arasında tekra düzlemsel, dalgalı, yer			100		<u> </u>	W3	
21														Çatlaklar;					11-50	W2 W3	
		21.30												yer yer düşey - düşeye yer yer 25" - 35° arası,	yakın,					W2	2
-22	20		RC											düzlemsel, dalgalı, pür	üzlū,		100	30	4-10	ws	3
		22.3	5	-								****		demiroksit sıvamalı, kapalı.					4-10	W2V	V
-23	21		RC											16.50 - 24,50 m'ler ara	sı;		10	- Io	11-50	W	
		23.4	5	_										breşik yapılı.						W3	;
		20.4							$\left \right $				~~~~	<i>EZİK ZON;</i> 18.20 - 18.65 m'ler,						w2	,
-24 -	22		RC											20.50 - 20.75 m'ler			10	0 10	11-50	w	
-	23	- 24.6	5 RC	-									~~~~	22.50 - 22.70 m'ler ara	SI.		10	0 -	11-50	W2V	

Idare		/ Adminis	iration	T.C. U	laştırm olları G	a De	nizci	ilik ve orloč	Hał	oerleş amu (şme Öz∈	e Bai el Se	kanlığı ktör Ortaklıč	Bölge Müdürlüğü	Kuyu No	/ Borel	hole No		:	SK- 8	38
<u> </u>				Gohze	Orha	0.097	-lzmi	ir (İzm	vit Kö	rfez G	eci	isi ve	Bağlantı Yolla	n Dahil) Otoyolu,	Sayfa	/ Shee		_		31	_
Proje	smi	/ Project I	Vame	Manis	a - Izm	ir Ke	simi,	Belk	ahve	Tün	eti	(KM:	398+300-KI	1:402+500 Arası)	Istasyon	/ Static		(KM)		400+4 Tüne	
Görev Şirket		/ Appoint Company					0	toyol	Yat	irim v	e Iş	şletr	e A.Ş.		Sondaj Yeri Kuyu Derinliği		ocation Depth (m)		100.0	_
F		 1		Matkap Tipi/Çapı Bit Type/Diameter	g	Sta	ndar Stand	ard P	etras enetr SPT)	syon I ation	Der Test	neyi t				Karot Çapı Core Dismeter	Örnek Yüzdesi Core Recovery	Kaya Kalitesi RQD	L See	aring	e e
BH Depth	Örnek No Sample No	Örnek Derinliği Sampte Depth	Örnek Türü Sample Type	Bit Type/	Borusu		be Sa f Blov 30	NS	G	√ ₃₀ Gi iraph o 20 30	of N	30	Profili Symbol	Jeoteknik Ta Geotechnical L	nimiama Description	H Karot Core D	©rnek Core R	& Kaya	 Kiriklar Fractures 	Weathering	Dayanim
-25		25,00											~~~~				83	-	11-50	W2 W3	R
- -26	24	25.90	RC	-									~ ~ ~				67		11-50	W2 W3	R
-	25	26.20	RC	-									~ ~ ~				89		>50	W2	R
- 27	26	27,10	RC										~~~~				89		>50	W3 W3	R
-	27	27.55	RC	-									~~~~				90	-	11-50	W2 W3	R
-28	28	- 28.55	RC	_									~~~~					-	-	-	
-29	29		RČ										~~~~	KAYMA ZONU; 25.10 - 25.90 m'ler,			100	13	>50	W2 W3	F
-	30	- 29,35	RC	-									~~~~	28.15 - 28.55 m'ier, 29.00 - 29.35 m'ier,			100		>50	W3	1
-30 -	30	- 30.55											~~~~	30.30 - 32.50 m'ler, 38.80 - 40.20 m'ler ara siyahımsı gri - koyu gri					-	•	L
- -31	31	00.00	RC											KİL matriks içerisinde ı kaya parçalı.			100	-	-	-	
-		- 31.70											~~~~~					_	-		
-32 -	32		RC	96									~ ~ ~			63.5	100	- 1	-	-	
- - -33		- 32.5											~~~~				68	10	11-50	W2	
-	33		RC										~~~~	Yukarısı gibidir.				-	-	W3	
-34 -	34	33.8	RC										~ ~ ~				10	0 30	11-50		
- -35													~~~							W3	
-		35.1											~~~	-			10	0 15	11-50	W2	
-36	35	36.3	ю 	_									~ ~ ~						+	W3	+
-37											-			- -						W2	
-	36	3	R										~~~	-			10	20 46	4-10	Wa	,
-38													~~~	-					>50		
-		- 38.I	50																4-10) W2 W3	
-39 -	3	7	R	c										~		~	9	8 2	3 >50	w	4
													- ~						Müşavi		

	Idare		/ Adminis	stration	T.C. I Karay	Jlaştırı /olları (na De Genel	nizcilik v Müdürlü	re Habe ğü, Kan	rleşr nu Ö	ne Ba zel S	akanlığı ektör Ortaklı	ğı Bölge Müdürlüğü	Kuyu No	/ Bore	hole No			SK-	808	
(²roie	Ismi	/ Project	Name									arı Dahil) Otoyolu,	Sayfa	/ Shee					17	_
	Görev		/ Appoint		Manis	sa - Izr	nir Kes						W:402+500 Arası)	Istasyon Sondaj Yeri	/ Statio	on ocation	(KM)	_	400+ Tür		_
	Şirket		Compan					Otoyo	ol Yatırır	m ve	İşleti	me A.Ş.		Kuyu Derinliği		Depth (n	-		100	.00	_
	Kuyu Derinliği BH Depth	Örnek No Sample No	Örnek Derinliği Sample Depth	Örnek Türü Sample Type	Matkap Tipi/Çapı Bit Type/Diameter	Muhafaza Borusu	S Darb # of	e Sayısı <i>Blows</i>	Penetratii (SPT) N ₃₀ Graj	on Te Gra ph of	nfiği N 30	Profili Symbol	Jeoteknik Ta Geolechnical I		Karot Çapı Core Diameter	Örnek Yüzdesi Core Recovery	Kaya Kalitesi RQD	Kırıklar Fractures	Ayrışma Weathering	Dayanım Strength	Yerinde Denevler
	m -40		m		mm	mm	15	30 45	10 20	30	40 50	~~~~	Yukarısı gibidir.		mm	%	%	#-m	-	-	-
	-	37	40.50	RC									40.20	m. ———		98	28	4-10	W1 W2	R4	
C	-41 - -42 - - - 43 -	38	43.50	RC												100	55	4-10	W1 W2	R4	
	- -44 - - -45	39	43.50	RC									KİREÇTAŞI; Gri - açık gri renkli, genelde taze - az ayrışır nadiren orta derecede a genelde sağlam dayanır	yrışmış,		95	59	4-10	W1 W2	R4	
	- -46 - - -47 - - -48	40	45.50	RC	96								yer yer orta derecede sa genelde kırıklı, yer yer az çatlaklı - kırık Çatlaklar, yer yer düşey - düşeye y 40° - 50° arası, düzlemsel, dalgalı, pürü kil ve kalsit dolgulu, yer yer erime boşluklu, kapalı.	ı, parçalanmış. akın,	63.5	100	70	4-10	W1 W2	R4	
	- -49 - - -50 - - -51 -	41		RC									51.30 - 51.50 m'ler, 52.10 - 52.40 m'ler, 52.90 - 53.05 m'ler, 55.00 - 56.15 m'ler, 57.00 - 57.15 m'ler, 57.70 - 58.10 m'ler,			100	67	4-10	W1 W2	R4	
	-		51.50	-								111	58.40 - 59.50 m'ler aras			-	-		-	-	·
	- -52												sarımsı kahverenkli çak geçilmiştir.	III KIL DOLGUSU				4-10	W1	R4	
																		-	-	-	1
	-																	4-10	W1	R4	
	-53 - -	42		RC												100	46	-		-	-
	-54 -		54.50															4-10	W1	R4	
		43	01.00	RC									1			100	20	>50	W3	R2	

dare		/ Adminis	stration	T.C. L Karay	llaştırr olları (na Denizcilik Senel Müdürl	ve H oğü,	iaberleş Kamu (şme Ba Özel Se	kanlığı ktör Ortaklığ	ı Bölge Müdürlüğü	Kuyu No	/ Borel	hole No			SK-		
roje l	smi	/ Project	Name	Gebze	-Orha	ngazi-İzmir (ZED)#	Körfez G	ecisi ve	Bağlantı Yolla	rı Dahil) Otoyolu, 1:402+500 Arası)	Sayfa İstasyon	/ Shee / Static		(KM)		5 400+	/ 7 400	
Sörev	li	/ Appoint	led					atırım v				Sondaj Yeri	/BH L	ocation			Tür 100		
Şirket		Compan	y 	ق ت		Standart P						Kuyu Derinliği		epth (m		Ĩ		.00	
Kuyu Derinliği BH Depth	Örnek No Sampte No	Örnek Derinliği Sample Depth	Örnek Türü Sample Type	Matkap Tipl/Çapı Bit Type/Diameter	Muhafaza Borusu	Standard Darbe Sayıs # of Blows	(SP	N ₃₀ Gr Graph o	rest rafiği of N 30	Profili Symbol	Jeoteknik T Geotechnical		B Karot Çapı B Core Diameter	Örnek Yüzdesi Core Recovery	% Kaya Kalitesi RQD	# Kinklar 3 Fractures	Ayrışma Weathering	Dayanım Strengtlı	
m -55	43	m	RC	mm	mm	15 30 45	5 10	0 20 30	40 50	111				100	20				İ
		55,40	<u> </u>															R4	
-56	44	56,00	RC											100	58	4-10 -	W2	-	
																4-10	W2	R4	
	45		RC											100					
57																- 4-10	- W2	- R4	
		57.70																	
58																4-10	- W2	R4	
	46		RC										1	97	18				
59																-	-	-	
		59.60		_										\vdash		4-10	W2W3	R2	
60	47		RC											100	68	2-3	W1 W2	R4 R3	
										! !									
		62.00									Yukarısı gibidir.					4-10	W2	R4	
62 63 64 -64	48	- 65.0	RC	96	A A A A A A A A A A A A A A A A A A A								63.5	98	66	2-3 4-10	W1 W2	R4	-
-66 - - - - - 67 -	49		RC											100	63	. 4-10	W1	R4	,
-68 - - - -69 -	50	- 68.0	RC		-									100	53	4-10 >50 4-10	W1	R	

þ	dare		/ Adminis	stration	T.C. I Karay	Jlaştırı olları (ma Di Genel	enizcil Müdü	ik ve Irlüği	i Habi ü, Kai	erleş mu Ö	me E Özel S	Baka Sek	anlığı lör Ortaklı	ğı Bölge Müdürlüğü	Kuyu No	/ Bore	hole No	,		SK-	808	
ما ^س ے	roie	smi	/ Project	Name	Gebz	e-Orha	ingaz	i-lzmi	(lzm	iit Körl	ez G	eçişi	ve B	ağlantı Yoli	arı Dahil) Otoyolu,	Sayfa	/ Shee					17	
Ł					Manis	sa - Izr	nir Ke	isimi,	Beika	ahve	Tüne	eli (Ki	M:3	98+300-K	M:402+500 Arası)	İstasyon Sondaj Yeri	/ Stati	on ocation	(KM)			⊧400 nel	
	Sörev Sirket	1	/ Appoint Compan	ed V				Ot	oyol	Yatırı	m Ve	e İşle	tme	A,Ş.		Kuyu Derinliği		Depth (r	_			0.00	_
	Kuyu Derinliği BH Depth	Örnek No Sample No	Örnek Derinliği Sample Depth	Örnek Türü Sample Type	Matkap Tipi/Çapı Bit Type/Diameter	Muhafaza Borusu	Dart # o	ndart Standa De Say f Blow	rd Pe (S ns:	iPT) N ₃ Gra	ion T o Gra ph ol	est afiği fN ໜ		Profili Symbol		Tanimlama al Description	Karot Çapı Core Diameter	Örnek Yüzdesi Core Recovery	Kaya Kalitesí RQD	Kırıklar Fractures	Ayrışma Weathering	Dayanım Strength	Varinda Danevlar
L	m 70	50	m	RC	mm	mm	15	30	45	10 20	0 30	40 5	50				mm	% 100	57	#-m 4-10 >50 4-10	W1 W2	R4	
71 72		51	71.00	RC		The second state and a second balance of		An Andrea (a America)										100	82	2-3	W1 W2	R4	
74 -		52	74.00	RC														100	72	2-3	W1	R4	
77	5	3	80.00	RC	96										Yukarısı gibidir.		63.5	100	58	4-10	W1 W2	R4 R3	
-8	31	54		RC									-					99	61	4-10	W1	R4 R3	
-	33	55	83,00	RC														97	53	4-10	W1 W2	R4 R3	

1	dare		/ Adminis	tration	Karay	olları (na De Senel	Müdü	uk ve Drlüğ	ıü, Ka	imu (özel S	akanlığı ektör Ortaklı	jı Bölge Müdürlüğü	Kuyu No	/ Bore	hole No			SK-	808
- `` ار	Proje I	emi	/ Project	Name	Gebz	e-Orha	ingaz	i-Izmii	r (İzn Bolk	nil Kör	fez G	ieçişi v	e Bağlantı Yoli	arı Dahil) Otoyolu, 4:402+500 Arası)	Sayfa İstasyon	/ Shee		(KM)		400	/ 7
-	Görev		/ Appoint		Mariis	ia - 120								1.402 · 000 / 1031/	Sondaj Yeri		ocation				nel
	Şirket		Company	/									ne A.Ş.		Kuyu Derinliği	/BH [)epth (n	n)		100	,00
	Kuyu Derinliği BH Depth	Örnek No Sample No		Örnek Türü Sample Type	Matkap Tipi/Çapı Bit Type/Diameter		Dart # o	ndart Standa De Say f Blow 30	visi yisi s	enetra SPT) N ₁ Gri	tion 1 30 Gr aph c		Profiji Symbol	Jeoteknik T Geotechnical	anımlarna Description	a Karot Çapı a Core Diameter	& Örnek Yüzdesi Core Recovery	Kaya Kalitesi RQD	 Kiriklar Fractures 	Ayrışma Weathering	Dayanım Strength
	m 85	55	m	RC	mm	mm	15	30	40								97	53	4-10	W1 W2	R4 R3
	86 87 88	56	86.00	RC		A AAA AANKA				a sum de la constante de la constante de la con							100	64	4-10	W1 W2	R4 R3
	89	57	89.00	RC										Yukarısı gibidir.			100	57	4-10	W1 W2	R4 R3
-	·90		90.00											90,95 - 91.45 m'ler ara	: Si;				4-10	W1 W2	R4
	.92	58		RC	96									bloklu, kumlu, çakıllı K	İL birimi geçilmiştir.	63.5	100	63	4-10	W1 W2	R4 R3
	-93 	59	93.00	RC													100	68	4-10	W1	R
	-96 - -97 - -98 -	60	96.00	RC	There are a second and as sec												100	65	4-10	w1	
	-99 -	61	99,00	RC	-									-	SONU		100	0 75	4-10	wi wi	
Ŀ	-100		100.00	L	<u> </u>	-		1			1			10	0,00 m. F Teknik Araştırma	Proie	lynuls	ma M	lisavi	rlik Sa	n, ve

				T.C. L	llaştırr	ma D	enizci	lik ve	Hab	erleşr	ne Ba	kanlığı			Kungu Mo	/ D '	hale M			sĸ-	800	
ldare		/ Adminis	tration	Karay	oliarı (Gene	I Müd	ürlüğü	i, Ka	mu Ö	zel Se	ktör Ortaklı	ğı Bölge Müdi		Kuyu No	/ Borel					809	
^o roje i	sni	/ Project	Name										an Dahil) Otoy M:402+500 A		Sayfa Istasyon	/ Shee / Static		KM.		400+		
Sörev		/ Appoint	ed	LD-	a 14.									,	Sondaj Yeri	/BH L				Tü		_
Sirket		Company		ć.	OTO	YO	<u> </u>	toyol	Yatır	ım ve	Işletn	le A.Ş.			Kuyu Derinliği, m	/ BH D		n)		59,		
roje		/ Designe	er.	VI	7 Y	'ükse	l Don	naniç I	Vühe	endisl	ik Ltd.	Şti.			Başlangıç Tarihi Bitiş Tarihi	/ Start / Finisl				01.07		
irma:		(Tesheis		E	Sial Y	(arbil	mlari	Miles	<u>,</u>	Γ_ τ ,	arih	Derinlik	YAS Der.	Açıklama	Kot, m	/ Grou		ation		10.07		37.
'eknik Danışı		/ Technic Consulta			Ltd. Şt		men	aluş.v	"		ale	Depth, m	GW depth, m	Remarks	Koordinatlar, m	/ Coon					4 25	8 8
'önter	n	/ Drill Me	thod	ROTA		JLU					9.12		7.30		(ED-50/27-6°)			E			52	27 3
lakin	8	/ Drill Rig		D-900	, 			-			. 9.12		7.50	-	Sapma, m	/ Offse	et I	· · · · ·				1
in l		æ,		Matkap Tipi/Çapı Bit Type/Diameter			andart Standi									2	iesi v					lie
Ë s	₽₹	Örnek Derinliği Sample Depth	Örnek Türü Sample Type	Dian	EZ3	<u> </u>		(SI	PT)			-				Karot Çapı Core Diameter	Örnek Yüzdesi Core Recovery	Kaya Kalitesi RQD	_ s	la Ning	Ē,	Yerinde Deneyler
Ruyu Dermigi BH Depth	Örnek No Sample No	nek [npie	note note	Type	Muhafaza Borusu		be Sa			e Gra		Profii Symbol	L l	eoteknik Ta	nimlama	Karot Çapı Core Diame	ле s Х g	žθ	Kırıklar Frectures	Ayrışma Weathering	Dayanım Strengtin	rind
<u>5</u> 2	Sar		58				of Blow			aph of	40 50	1 2 2	G	eotechnical D	escription	2 S mm	<u>ເວັບິ</u>	× 5 8 0 8 0	¥.m	Ϋ́Ň	0 X	۲
m		m		mm	mm	15	30	45	10 2		10 50	·				1	- 70	73	* 111			F
												5300										
.	1		RC									1.000				ł	52	-				
1												0.0										ļ
-		1.50		ļ									YAMAÇ MOL				-					
												2000	Yeşilimsi - sa									
2	2		RC										kumlu, çakılı	I, DIDKIU NIL			47					
	2		110						ĺ			.0	Çakıllar ve b	loklar; köşel	i,							
												:-:	kumtaşı, kire	çtaşı köken	lidir.							
3		3.00										PJU?										
	3		RC									000					67					
	-											. <u>.ō</u> .										
4		4.00		-												-		1			<u> </u>	1
	4		RC														92	•	>50	W2 W3	R4	ļ
		4.60											METAKUMT	AŞI;		5		1		W2	R5	1
5	5		RC	8	114				1				Koyu gri - gr			63.5	60	-	11-50	1		
	č							ļ					genelde az - yer yer çok a		de ayrışmış,					W3	R4	
		5.60		1											ğlam dayanımlı,	1	\vdash	+				1
5													yer yer zayıf	- orta derec	ede sağlam					W2	R5	
	6		RC										dayanımlı,	1	-1		83	20	>50			
													çok çatlaklı	 kışıkı, parç 	alanmış.				1	W3	R4	
,	7	6.80	RC	1									Çatlaklar;				88	-	>50	W2	R4	1
		7.20		-											er düşey - yatay,					W3	R3	1
	8		RC			1							: düz, dalgalı,	demiroksit	sivamalı.		58	-	>50	W3 W4	R3 R2	
в		7.80													ı. ———	4	-	1	1			-
]					1		W3	R3	
	9		RC										Tanuminer-	arka en de d	adur		56	-	>50			
												000000	. ammama	arka sayfadi	2001.					W4	R2	
													1								1	
ł		9,50		1									-				-	+			R4	-
	10		RC									<u>passissis</u>	4				40	-	>50	W2	K4	
	NOT	AND		the later									DIRMESI/SO		ALUATION			KIRIKI	AR / FF	ACTI	RES IN	i m'
ا ۵۰ : ۵۰		Cok yumuş		/Very sol			N30 :	0-4	I DA		ievşek	Very Loose		0 - 25	% Çok Zayıf / Very Poor		\top	<1	Masif		/Massiv	/a
a): 3. 30: 5.	4	Yumuşak		/Soft /M.SHT			N30;			Gevşe Orta S		/Loose /M. Desse		25 - 50 50 - 75			1	2 - 3 - 10	Az çatla Kırikli	akla-karinkl	/S.creck	
₁₆ : 9-	- 15	Orta Kalı Katı		/ 56%			N30 :	31 - 50		Siki		/ Dense		75 - 90	% <mark>iyi</mark> ∕Gaad		1	1 - 50	Çok çat		k /H.crac	kod l
ao: 16 ao: >3		Çok Katı Sert		/ Very Sill / Herd	f		N ₃₀ :	>50		Çok S	akı	/Very Dense		90 - 100	% Çok İyi /Encellent			> 50	Parçala	ranış	/ Crush	нf
	AYR	IŞMA / W	EATHE	RING		_						RENGTH			MALAR / ABBREVIAT			N	DTLAR	/REMA	RKS	
	Taze Az Aynş	สพร		Freeh Stightly W	eathered		Aşırı İ. Cok Z			f Kayaç		t. Week Rock ny Week Rock	q.= 0.25 - 1.0 MPa q.= 1.0 - 5.0 MPa	UD : Şelbi RC : Karot								
₩3	Orta De	recede Ayra	ទូការទ្	Moderate	iy Weat.	R2	Zayıf	Kayaç			и	eek Rock edian Strong Rock	q,≈ 5.0 - 25 МРа q,= 25 - 50 МРа	SPT : St. Pr	inetrasyon Dan. / St. Penetrati	on Test						
₩5		en Ayrışınış		Highly We Complete	iy Wost	R4	Orta D Sağlar	m Kayag	;	am Kay	ş	rong Rock	q,≠ 50 - 100 MPa		genlik Deneyi / Permability	Test					1	
	Rezidüe	Zemin (To	prak)	Residual		R5	Çok S Aşın î	ağlam K	(ayaç	han Maa		ery strong Rock d.Sieving Rock	q,=100-250 MPa q,=>250 MPa	Pr : Presi	ometre Den. / Pressureme	ler Tesl				A	1	
		Sondör						CEYL/		-an ha	-Y - E				ühendis / Engineer			an OK		- Street	6	

LİMİT Teknik Araştırma Proje, Uygulama, Müşavirlik San. ve Tic. A.Ş

lda	_	100-2.5	ImP								șme Ba				Kuyu No	/ Borei	hale M			sĸ-	809	
ldare	_	/ Adminis	tration	Karay	oliarı (Gene	I Müd	dürlüğ	ü, Ka	mu	Özel Se	ktör Ortaklı	ğı Bölge Müdi		Sayfa	/ Borel					1 5	
Proje	lsni	/ Project	Name										an Dahil) Otoy M:402+500 A		Istasyon	/ Static		KM.		400+		
Görev	nti	/ Appoint	ed		sith			Manual	Valu		e İşletn				Sondaj Yeri	/BH L	ocation			Tü		
Şirket		Company	/	C	OTO	YO	5.	NUYO	rau	BU V	e işleti	ю Л.Ş.			Kuyu Deriniliği, m	/BH D		n)		59,		
Proje Firma	=;	/ Designe	M	YL	9 Y	ükse	l Dor	naniç	Müh	endi	slik Ltd.	Şti.			Başlangıç Tarihi Bitiş Tarihi	/ Start / Finisi				01.07		
Teknil	-	/ Technic	al	Fuaro	Sial Y	'erbil	imleri	i Müs	ve	<u> </u>	Farih	Derinlik	YAS Der.	Açıklama	Kot, m	/ Grou		ration				37.8
Danış		Consulta		Müh. I	Ltd. Şi	i					Dale	Depth, m	GW depih, m	Remarks	Koordinatlar, m	/ Coor	dinales				4 25	
Yönte		/ Drill Me	thod	ROTA D-900		JLU					.09.12		7.30		(ED-50/27-6*) Sapma, m	/ Offse	at .	E			52	27 3
Makin		/ Drill Rig				Ste	ndar	t Pen	etras	<u>ن</u>	Deneyi	1	7,50		Joapina, in	/ 0//30						ler
D)		Örnek Derinliği Sample Depth	- 9	Matkap Tipi/Çapı Bit Type/Diameter				lard P								ter	Örnek Yüzdesi Core Recovery	esi				Yerinde Deneyler
Kuyu Derinliği BH Depth	2 S	Den	Örnek Türü Sample Type	P Tip	Muhafaza Borusu					~						Karot Çapı Core Diameter	ζ Υü2	Kaya Kalitesi RQD	ar	Ayrışma Westhering	Dayanım Strength	de D
uyu H De	Örnek No Sample No	rmek	ample	it Typ	luhat		be Sa of Blov				afiği xf N ₃₀	Profili Symbol		eoteknik Ta		Carot	Sone P	aya 20D	Kırıklar Frectures	Veath Veath	Daya	(erin
ж ю́	00	:0 03 m	00	<u>≥ ຫ</u>	≥ m mm	15	30	45	10 2	0 30	40 50	6.0	6	eolechnical D	өзспраят	mm	%	%	#m	4.5		Ĺ
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	1		RC														52	-				
.1												0.0										
.		1,50										- <u>-</u> .Q.	YAMAÇ MOL	OZU								
		1.50										500	Yeşilimsi - si		ahverenkli,							
2												1000	kumlu, çakıll	ı, bloklu KİL			47					
	2		RC									0.0	Çakıllar ve b	loklar; köşe	i,		47					
												·	kumtaşı, kire									
3		3.00										FIV:										
	3		RC									1000					67	.				
4	<u> </u>	4.00												— 4.00 n).	-				W2		1
	4		RC														92	-	>50	W3	R4	
.		4.60			4								METAKUMT			- 40				W2	R5	
5	5		RC	8	114								Koyu gri - gr genelde az -		de ayrışmış,	63	60	-	11-50			
		5.60											yer yer çok a	iyrişmiş,						W3	R4	
		5.00											genelde sağ yer yer zayıf		iğlam dayanımlı, ada sağlam					W2	R5	
6	6		RC										dayanımlı,	- 0110 00100	buo augiani		83	20	>50			
						ļ							çok çatlaklı	- kırıklı, parç	alanmış.			1		W3	R4	
_	7	6.80	RC		ļ								Çatlaklar;				88		>50	W2	R4	-
7	7	7.20	NO										- ·	ısında, yer y	er düşey - yatay,		H	+		W3	R3	-
	8		RC										düz, dalgalı,	demiroksit	sıvamalı.		58	-	>50	W3	R3 R2	
8		7.80													n. ————	4	\vdash		-	₩4		-
Ĭ																		1		WЗ	R3	
	9		RC										Tanımlama	arka soufed	adır		56	-	>50			
9													, ann marria	ana sayidu						W4	R2	
	10	9,50	RC	1													40	-	>50	W2	R4	
	L."							L	TEAN			FČERI EN	IRMESI/SO	I - ROCK F							<u> </u>	1
	INCE D	ANEL1/	FINE G	RAINED	,	1		1	RI DA	NEL	I/COAF	RSE GRAINE		K/	YA KALITESI / ROD				AR / FF	RACTU		
l ₃₀ ∶0 l ₃₀ ∶3		Çok yumuş Yumuşak	ak	/Very solt /Solt	!		N ₃₀ : Nos :	0 - 4 5 - 10	,	Çok Gev	Gevşek sek	/VeryLsone /Loose		0 - 25 25 - 50	% Çok Zayıf / Very Poor % Zayıf / Poor			<1 2-3	Masií Az çatla	akla-kan kl	/Massiv /S.creci	
l ₃₀ : 5	- 8	Orta Kalı		/M.SHT			N ₃₀ :	11 - 3	0		Siki	/M. Danso / Danse		50 - 75 75 - 90	% Orta /Fair		1	- 10 1 - 50	Kirikli		/Freclu	rel
	5 - 30	Katı Çok Katı		/ SEH / Very SEH	,		N ₃₀ : N ₃₀ :	31 - 5 >50	J		Sıkı	/ Dense / Very Dense			% lyt /Good % Çok İyi /Excellent			> 50	Çok çal Parçala		/ Crush	
l ₃₀ ;≻:		Sert ISMA / W	EATHE	/Hard RING		-			D	AYA	NIM / S7	RENGTH		KISALT	MALAR / ABBREVIAT	IONS	+	NC	TLAR	/REMA	RKS	
	Taze			Freeh				Derece	de Zay		aç E	d. Week Rock	q.= 0.25 - 1.0 MPa q.= 1.0 - 5.0 MPa	UD : Şelbi	Tüp / Sheiby Tubi		+					
₩з		recede Ayra	mış	Slightly W Moderate	iy Weat.	R2	Zayıf	Zayıf Ka Kayaç			и	ory Wesk Rock leek Rock	q,= 5.0 - 25 MPa		enetrasyon Den. / St. Penetral	ion Test						
	Çok Ayr Tamama	ışmış an Ayrışmış		Highly We Complete				Derece en Kay		lam K		ledium Strong Rock trong Rock	q,≠ 50 - 100 MPa		r Deneyi / Pecker Tasi genlik Deneyi / Permasbili)						1	
		Zemin (To	prak)	Residuel		R5	Çok S	Sağlam	Kayaç	lam P	v	ery strong Rock Xi Strong Rock	q_= 100 - 250 MPs q_= > 250 MPs		yometre Den. /Pressureme		1			A	1	
						1 40	74ş0)	Derece	ve Oid	ាននាវរ៍ ពី	αχαγ Ε	newsering 1964	19 APR 06.0	-			Hak				100	

	Idare	_	/ Admini	istration	Karay	olları	Gene	I Mü	dürlü	ğü, Ka	amu	Özel S		ığı Bölge Müdürlüğü	Kuyu No	/ Bore	hole N	0		SK-	80
	roje	lsmi	/ Project		Manis	sa - Izi	anga: mir K	zi-lzm esimi	nir (İz . Bel	nit Kör kahve	rfez G Tün	Beçişi v Ieli (Kl	e Bağlantı Yo #:398+300-1	ları Dahil) Otoyolu, (M:402+500 Arası)	Sayfa	/ Shee		000			1
	Görev		/ Appoin	led	¢.										İstasyon Sondaj Yeri	/ Static / BH L		(KM)	-	400 Tü	+6 ine
	Şirket		Compan	by			_					-	me A.S.		Kuyu Derinliği	/BHE				59	_
	BH Depth	Õrnek No Sampie No	3 Örnek Derinliği Sample Depth	Örnek Türü Sample Type	Bit Type/Diameter	Borusu	Dar # (andar Stanc be Sa of Blor	iard F (ayısı ws	enetra SPT) N; Gri	ation 1 30 Gr aph o		Profili Symbol	Jeoteknik Ta Geotechnical I		Karot Çapı Core Diameter	Örnek Yüzdesi Core Recovery	Kaya Kalitesi RQD	# Kirklar = Fractures	Ayrışma Weathering	-
ŀ	-10	10		RC					-10			T				mm	40	- 70	>50	W3	t
		11	10.50	RC																1415	$\left \right $
	-11		11.00														36	-	>50	W3 W4	┞
	12	12		RĊ													50	-	>50	W2 W3	
		13	12.50	RC													46		>50	W3	ł
-	13		13.00			114								METAKUMTAŞI; Siyahımsı - koyu gri reni	kli,					W4 W3	
-		14		RC										8.20 - 30.00 m'ler arası;	-		35	-	>50	W4	
-	14		14.00											genelde orta derecede - yer yer az ayrışmış,	çok ayrışmış,					W3	
-		15	14.60	RC										genelde zayıf - orta dere dayanımlı,	cede sağlam		25	-	>50	W4 W3	
-	15	16	15.20	RC										yer yer sağlam - çok sağ nadiren çok zayıf dayanı			23	-	>50	W4	
-		17		RC								-		nadıren çok zayıf dayanı genelde parçalanmış, yər yer çok çatlaklı - kırıl			73	-	>50	W3 W4	ALL DALL DALL DALL DALL DALL DALL DALL
-	16	18	16.00	RC													54	-	>50	W3	
-	17	19	16.70	PC		_														W4 W3	ł
-	"	20	17.10	RC RC	96											3.5	35 50	-	>50 >50	W4 W3 W4	
-	ļ		17.50		-											63				W4 W3	
-	18	21	18.50	RC										Foliasyonlar;			40	-	>50	W4	
-	19	22	19.00	RC										70° - 75° arasında,			40	-	>50	W3 W4	Ì
-	~	23	19.30	RC										dalgalı, kaygan, parlak, yer yer kapalı.			33	-	>50	W3 W4	ļ
-		24	10.00	RC										Çatlaklar;			50	-	>50	W3 W4	
-	20	25	19,90	RC										45° - 50° arasında, yer ye dalgalı, kaygan, parlak,	er düşeye yakın,		70	-	>50	W3 W4	İ
-	21	26	20.40	RC										yer yer kapalı, kalsit dolgulu,			79	26	>50	W3 W4	
-			21.10											8.20 - 17.50 m'ler arası;						W3	
-2	22	27		RC										Breşik metakumtaşının k derecede zayıf dayanıml olduğundan bağlayıcısın	(Grafit Şist)		83	-	>50	W4	ĺ
	f	28	22.30	RC										ereaganaan bayaydisif)	ı əa ⊄nunişШ,		79	-	>50	W3 W4	
-2	23	29	23.00	RC													100	-	>50	W3	
-	Ì	30	23.40	RC													83	-	>50	W4 W3	
-2	24 -	31	24.00	RC													100	25	11-50	W4 W3	
-	F	32	24.50	RC													93	20	11-50	W3	
-											1	1	Personal Per		eknik Araştırma P						L

ldar	e 	/ Admin	istration	Karay	/olları	Gene	Müd	ürlüğ	ū, Kar	mu Ö	zel S		ğı Bölge Müdürlüğü	Kuyu No	/ Bore	hole N	0		SK-	- 80
Proj	e Ismi	/ Projec	t Name	Gebz	e-Orha sa - İzı	angaz nir Ke	i-Izmi simi,	r (İzm Belki	iit Körfi ahve `	iez Ge Tünel	içişi ve li (KN	e Bağlantı Yol 1:398+300-K	arı Dahil) Otoyolu, M:402+500 Arası)	Sayfa Istasyon	/ Shee / Stati		(KM)		3 400	31
Göre		/ Appoir Compai										ne A.Ş.	··· •	Sondaj Yeri	/BH L	ocation	3		Τi	ine
Şirk	Τ	<u> </u>	"/ 	ā		Sta			etrasy			,		Kuyu Derinliği	/BH [Depth (i	m)		59	1.0 T
Kuyu Derinliği BH Danth	Örnek No Sample No	Örnek Derinliği Sampie Depth	Örnek Türü Sample Type	Matkap Tipi/Çapı Bit Type/Diameter	Muhafaza Borusu	Dart # o	Slanda De Sa f Blow	ard Pe (S yısı 's	PT) PT) N ₃₀ Graj	ion Te g Grat ph of i	fiği N ₃₀	Profil Symbol	Jeoteknik Ta Geotechnical I		Karot Çapı Core Diameter	Örnek Yüzdesi Core Recovery	Kaya Kalitesi RQD	Kiriklar Fractures	Ayrışma Weathering	
-25	32	m	RC	mm	mm	15	30	45	10 20	30 4	40 50				mm	% 93	% 20	#-m >50	W4	+
-	33	25.20	LKC													30	-	>50	W3 W4	┢
- -26 -	34		RC													88	14	11-50	W4	
-	35	26.50	RC													50	<u> </u>	11-50	W3 W4	t
27	36	27.00	RC													88	14	11-50	W2 W3	
28	37	28.00	RC																	ł
29	38	28.40														50 81	-	>50 >50	W3 W3	╞
19	39	29.20	RC						A1							56	_	>50	W4 W3	╞
30		30.00											20.00 48.50						W4	ł
	40		RC										30.00 - 48.50 m'ler arası çok - tamamen ayrışmış, yer yer az - orta dereced	e ayrışmış,			-	>50	W4 W5	
1	41	31.00	RC										genelde çok zayıf dayanı yer yer zayıf - aşırı derec dayanımlı, nadiren sağlam - çok saş	cede zayıf		60		>50	W4 W5	
32	42	32.00	RC	96									parçalanmış,		63.5	72	-	>50	W4 W5	t
33	43	32.70	RC													75		>50	W4 W5	-
34	44	33.30	RC													76	60	>50	W4 W5	-
		34.20																	W4	
35	45		RC													81	36	>50	W5	
36	46	35,80	RC						M							75	30	>50	W4 W5	
37	47		RC						The second second second second second second second second second second second second second second second se							69	-	>50	W4 W5	
8	48	37.40	RC													67	-	>50	W4 W5	
	49	38.50	RC													64	32	>50	W4 W5	ſ
9	50		RC													100	84	>50	W4 W5	-
	51	39.50	RC													100	51	>50	W4	-

ldar	е	/A	Administ	ration	T.C. I Kara	Jlaştır olları	ma D Gene)eniz el Mü	cilik v dürlü	e Ha ğü, k	aberi (ami	ieşn u Öi	ne B zel S	aka Sekti	nlıgı ör Ortaklı	jı Bölgə Müdürlüğü	Kuyu No	/ Bore	hole No)		SK-	809
. []		/0	- Project M	loma												arı Dahil) Otoyolu, M:402+500 Arası)	Sayfa	/ Shee	et				15
	e Ismi				Manis	sa - Izr	nir K	esim	i, Bell	kahv	e Ti	inel	li (KN	M:39	8+300-K	1:402+500 Arası)	Istasyon	/ Stati		(KM)		400-	
Gör Şirk			hppointe ompary						Otoyo	l Ya	tırım	i ve	İşlet	lme	A.Ş.		Sondaj Yeri Kuyu Derintiĝi		ocation Depth (r			Tü 59	
		-			i/Çapı meter			anda Stan	rt Per	Penel	ration	n De n Te	eney st	ń			,,	Τ	1				
Kuyu Derinliği	Örnek No	Sample Nor	Sample Depth	Örnek Türü Sample Type	Matkap Tipi/Çapı Bit Type/Diameter		Dai #	of Bk	ayısı ws	(N ₃₀ (Grapi	h of i	N 30		Profili Symbol	Jeoteknik T Geotechnical		Karot Çapı Core Diameter	Örnek Yüzdesi Core Recovery	Kaya Kalitesi RQD	kinklar Fractures	Ayrışma Weathering	Dayanım
-40 -	51		m	RC	mm	mm	15	30	45	10	20	30 4	40 5	0				mm	% 100	51	#-m >50	W4 W5	R2 R1
- - -41	52		40.50	RC										0.00000000					90	62	>50	W4	R1
- - -			41.50											100 Alberto								W5	
- -42 -	53	- 4	42.10-	RĊ	96													63.5	93 100	22	>50 >50	W4 W5 W4	R1 R1
-	54	7'	42.50	RC															68	-	>50	W5 W4	R0 R1 R0
-43 - -	56	- 4	43.10	RC															72	-	>50	W5 W3	R4
- -44 -	5		44.00	RC		-										Yukarısı gibidir.			78	-	11-50		R3 R5 R4
- - -45	58	- 4	44.50	RC															93		>50	W3 W4 W5	R/ R/
-	5)	45.20	RC										10.00 (C					90	-	>50	W3 W4	R
- -46 -	60		45.70	RC															72	-	>50	W4 W5	Ri Ri
- - -47	6		46,50	RC															65	12	>50	W4 W5	R
-			47,50																75		11-50 >50	W2 W3	R
- -48	6	- 4	47.90	RC RC															80	-	>50	W5 W4 W5	R
- - -49	6	1	48,50 49.00	RC		-													100	20	11-50		R
-	6			RC	76		-											47.6	100	66	4-10 >50	W3	R
- -50 -			50.00													48.50 - 59.00 m'ler ara orta derecede - çok ay	rişmiş,		-			W4	+
- - -51	6		51.00	RC												genelde çok zayıf - zay yer yer orta derecede s genelde kırıklı - parçal	ağlam dayanımlı,		55	-	>50	W4	R
- - -52	6	7		RC												yer yer çok çatlaklı - kı	nku.		63	-	11-50	wa	R
-	6		52,50	RC	-														66		4-10	wa	R
-			53.50																		>50	-	R
-54 -	1 6			RC															80	-	>50	wa	R
-	7		54.50	RC	1														100	0 30	4-10	wa	R

Idare /Administration Karayolian Genel Mudurlöği, Kamu Özel Saktrö Ortakliği Bölge Mudurlöği Mudurlöği
Observed Sixtet /Appointed Company Used (Company) Us
Oldernik Chopolary (Kayu Coopening Kuyu Derinliği Hubben (m) Sikket
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-57 72 RC ¹⁰⁰ / ₁ - 4-10 -58 73 RC - 100 - 4-10 -58 73 RC - - 100 - >50 - 59.00 - - 100 - >50 -59 59.00 - - - - - -60 - - - - - - -61 - - - - - - - - - - - - -
- 57.50 - 57.50 - 58.50 - 74 - 59.00 m. - 59.00 m. - 59.00 m. - 600
- 74 RC 100 - >50 - 59.00 m. 59.00 m. 59.00 m. 100 - >50 - 60
- KUYU SONU - KUYU SONU - 60 - 60 - 61 - 61 - 61 - 61 - 61 - 61 - 61 - 61

	dare		/ Adminis	stration										anlığı			Kuyu No	/ Bare	hole No	,		SK-	810
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	Proje I	smi	/Project	Name	Gebz	e-Orha sa - Ìzr	angaz nir Ke	-Izmir simi, I	r (izm Belki	iit Kö ahve	rfez (: Tür	3eçişi neli (K	ve i M::	Bağlantı Yoll: 398+300-Ki	arı Dahil) Öloy M:402+500 Aı	olu, 'ası)	Sayfa Istasyon	/ Shee		KM.		400-	923
ŀ	Görevl	i	/ Appoint	led		kril					_		_				Sondaj Yeri		ocation			Po	
	Şirket		Compan		C.	OTO	YOL	Ot	oyol	Yatı	rim \	/e Işle	etm	e A.Ş.			Kuyu Derinliği, m	/BH [Depth (r	n)		47	50
	Proje		/Designe	ər	YE		'üksel	Doma	anic	Müh	endi	slik L	td,	Sti.			Başlangıç Tarihi	/ Start				28.08	
ŀ	Firmas				Lazonen												Bitiş Tarihi	/ Finis				01.09	.2012
	Teknik Danışr		/ Techsic Consula			Sial \ Ltd. Ş		nleri I	Müş.	Vê		Tarih Date		Derinlik Depth, m	YAS Der. GW depth, m	Açıklama Remarks	Kot, m Koordinatlar, m		ind Elev dinates				42
- H	Yönter		/ Drill Ne	thod		ARY S					2	.09.1	2.		6.10	-	(ED-50/27-6*)			E			5
Ĩ	Makine	9	/ Drill Rig		D-900						1	3,09.1	2		6,40	-	Sapma, m	/ Offse	el				
			ĝi		Matkap Tipi/Çapı Bif Type/Diameter			ndart I S <i>tand</i> a					yi						z si				
	Kuyu Derinliği BH Depth	<u>0</u> 9	Ornek Derinliği Sample Depth	Örnek Türü Sample Type	Tipi/ Diam	e				PT)								Karot Çapı Core Diameter	Örnek Yüzdesi Core Recovery	Kaya Kalitesi RQD	6	ing.	F
	Sept	ek N Ple V	A A A	H H H	ype/	Muhafaza Borusu	Dart	e Say	/151			rafiği		12		eoteknik Ta		Karot Çapı Core Diame	Υ Έ Έ	20	Kiriklar Fractures	Ayrışma Weathering	Dayanım Strenoth
ł	ΣË	Örnek No Sample No	Orn	E Sar	Mat Biť 7	Muhafa Borusu		f Blows				of N 30		Profili Symbol		eotechnical D			မီစီ	X B D	Ϋ́Ε	Ayr	Day
	m		m		mm	mm	15	30	45	10 2	20 3	0 40 5	50					mm	%	%	#-m		
	.																					W3	R2
	_	1		RC															67	-	>50		
-	-1																					W4	R1
.	- [1.50																				
ŀ			,																		>50	W3	R2
-	-2	2		RC															95	10		W4	
-	- [2,50												METAKUMT. Yeşilimsi gri		arankli				4-10	W2	R3
	[2,00													,	çok ayrışmış,				4-10	W2	R2
-	-3	3		RC											yer yer az ay				95	12	>50	W3	R1
ŀ	-		2.50												genelde zayı		dayanımlı, ğlam dayanımlı,						
	[_	3.50		1										geneide paro		giarri dayariiriin,						
	4	4		RC											yer yer çok ç		dı, kırıklı,		98	25	11-50	W2	R2
-	-								1														
-	-		4.50		1										Çatlaklar;							W2	
	-5	5		RC	8	114										sında, yer y	er düşeye yakın,	63.5	95	10	11-50	1.2	R2
-	-									-					çatlak düzler		ı, pürüzlü,	Ĩ		1	>50	W3	
ŀ	-		5.50												açık - kapalı, ver yer kalsit					\square	>50	W3	1
	-6	6		RC	-										9.10 m'ye ka				95	34		W2	R
-	-				1										demiroksit s	vamalı.					11-50	VV2	
-	-		6.50	<u> </u>	1					Ì					Foliasyonlar				-	1	11-50	W2	R
1-	.7	7		RC											düşeye yakır				95	-		- **2	
ŀ	-									ĺ	-				dalgalı, kayg						>50	W3	R
ŀ	-		7.50		1										kapalı.					1	1		1
ľ	-8	8		RC															90	-	>50	wэ	R
-	-												1		1							1	
ŀ	-	-	8.50		1														-	1-	1	<u>†</u>	1
1	-9	9		RC															83	-	>50	W3	R
	-		9.10		1															1	1	1	1
ŀ	-	10		RC															90	-	>50	W3	R
ľ	-		9.80		1									<u>p</u>				1		1	<u> </u>	<u> </u>	1
ŀ		NCEP	ANELI		PAINER	<u> </u>	-							EGERLEND SE GRAINED	RMESI / SO		ALUATION			KIDIW	AR/F	ACTI	DEC
-	N ₃₀ : 0-	2	Çok yumuş		/ Very sof			N ₃₀ : 0	1 - 4	a DP	Çok	Gevşe		/Very Loose		0 - 25	% Çok Zayıf / Very Poor		+	< 1	Masif		/ Mas
	N ₃₀ : 3 - N ₃₀ : 5 -		Yumuşak Orta Katı		/Solt /M.SEE			N ₃₀ : 5 N ₃₀ : 1		•		rşek a Sıkı		/Loose /M.Danse		25 - 50 50 - 75				2 - 3 - 10	Az çallı Kırıklı	ekli-kirikl	/ S.cn / Frac
þ	N30: 9-	15	Katı		/ SEF			N ₃₀ : 3	11 - 50		Şıkı	1		/ Densa		75 - 90	% İyi /Good		1	1 - 50	Çok çal		d/H.a
	N ₃₀ : 16 N ₃₀ : >3		Çek Kalı Sert		/ Very Stil / Hard	1		N ₃₀ : >	-50			Sıkı		/ Very Dense		98 - 100 1				> 50	Parçala	nmiş	/Civa
ļ		AYRI	ŞMA/W	EATHE	RING									RENGTH Weak Rock	g_=0.25-1.0 MPa		MALAR / ABBREVIAT			N	OTLAR	/ REMA	RKS
		Az Ayrışı			Fresh Silohily W			Aşırı De Çok Zay			vt Kay	aç		l. Weak Rock ry Weak Rock	q_= 1.0 - 5,0 MPA	UD : Şelbi RC : Karot							
•	W3		ecede Ayrış	şməş	Moderate Highly We		R2	Zayıf Ka Orta De	ayaç		lam K	avar		eek Rock skuns Strong Rock	q,≓ 5.0 - 26 MPa q,≍ 25 - 50 MPa		enetrasyon Den, / St. Penetrat						
	VV4															1 · - · rensi							
	W5	Tamame	n Ayrışmış Zemín (Toj		Complete Residuel		R4	Sağlam Çok Saj	Kaya					ang Rock Iy strong Rock	g_= 50 - 100 MP# g_≠ 190 - 250 MP#		genäk Deneyi – / Permoodia vometre Den. – / Pressurerre						

LİMİT Teknik Araştırma Proje, Uygulama, Müşavirlik Şan. ve Tic. A.Ş

idare		/ Adminis	tration	T.C. U Karayi	ilaştırr olları (na De Genel	nizcili Müdü	k ve H rlüğü,	labe Karr	rleş nu (jme E Özel 1	Baka Sek	anlığı tör Ortaklığ	ı Bölge Müdürlüğü	Kuyu No	/ Bore	noie Na	,		SK- 8	
· · · ·	1	/ Project l		Gebze	-Orha	ngazi	-lzmir	(İzmit	Körfe	z G	eçişi	ve B	Bağlantı Yolia	arı Dahli) Otoyolu,	Sayfa	/ Shee				2 /	-
, ² roje	12110	л највал	vanio	Manis	a - Izn	nir Ke	simi, l	Belkał	ive T	füne	eli (K	M:3	98+300-KI	A:402+500 Arası}	Istasyon Sondaj Yeri	/ Static	on ocation	(KM)		Port	_
Görev Şirket		/ Appointe Company	eđ /	Ł	OTO	YOI	Ot	oyol Y	atırır	n ve	e İşle	etme	ə A.Ş.		Kuyu Derinliği		epth (r	_		47.5	_
Kuyu Derinliği BH Depth	1	Örnek Derinliği Sample Depth	Örnek Türü Sample Type	Matkap Tipi/Çapı Bit Type/Diameter	Muhafaza Borusu	Dark # o	ndart Standa De Say	rd Pen (SP risi	etratii T) N ₃₀ Graj	on T Gr	rest afiği af N ₃₀		Profili Symbol	Jeoteknik Ta Geotechnical		B Karot Çapı Gore Diameler	Core Recovery	kaya Kalitesi ROD	 Kiriklar Fractures 	Ayrışma Weathering	Dayanım
-10		m	RC	mm	mm	15	30	45 1	0 20	30	40 8	50		Yukarısı gibidir.		1101	83	- -	>50	W3	F
-	11	10,50											~ ~ ~	10.50	m	_	100	-	>50	W5	F
- -11	12	11.00	RC		114								~~~~					-		W4	F
- - -12	13		RC										~~~~				83	-	>50	W5	F
-	14	12.20	RC	-									~ ~ ~ ~				78	-	>50	W3 W4	F
-13	15	12.90	RC	-									~~~~				77	-	>50	W3 W4	F
-	16	13.50	RC	-									~~~~				93	-	>50	W3 W4	1
-14 -	-	14.20											~ ~ ~				86		>50	WЗ	
- -15	17	15.20	RC										~~~~	GRAFIT ŞIST; Siyahımsı gri renkli, genelde orta derecede	- çok ayrışmış,					W4	
-	18		RC										~~~~	yer yer az ayrışmış, nadiren tamamen ayrış genelde zayıf - çok zay			50	-	>50	W3 W4	
-16 -	19	- 16.00	RC										~ ~ ~	nadiren aşırı derecede genelde parçalanmış,	zayıf dayanımlı,		45	-	>50	W3	
- -17		- 17.00	-	-									~~~~	nadiren çok çatlaklı - k kil matriks içerisinde m kaya parçalı.		s.		+	-	W4 W3	
-	20		RC	96									~~~~	Follasyonlar; düşeye yakın, düzlem:		83	50	-	>50	W4	
(-18	21	- 18.00	RC										~~~~	duşeye yakın, duzienn	561.		56	-	>50	W3 W4	+
- -19	22		RC										~~~~				80) -	>50	W3 W4	
-		- 19.50		-									~~~~	-			81		>50	W3	+
-20	23	- 20.3	RC										~ ~ ~				-	-	-	W4 W3	T
- -21	24		RC										~ ~ ~ ~	•			9	5 -	>50	W4	
- - -22	25	- 21.3	RC	;									~ ~ ~				9	7 18	3 11-5	W2 W3	
- - -23		22.5											~~~~				8	8 -	>50	W3	-
-	26		RO										~~~~	-						W4	-
-24 -	27		R	;									~ ~ ~				7	3 -	>50	W2 W3	
-	28	- 24.5	R										~~~	-			5	7 -	>50	wa	,

idare		/ Admin	istration			ma Den	izcilik	vel	Haber	leşm	ne Ba	kanlığı		Kuyu No	/ Bore	hole Ne	,		sk-	810	
								-					ğı Bölge Müdürlüğü arı Dahil) Otoyolu,	Sayfa	/ Shee					1 4	
²roje	Ismi	/ Projec	t Name										V:402+500 Arası)	Istasyon	/ Stati		(KM)		400+	_	
Göre Şirke		/ Appoi Compa	nted nv				Oto	yol Y	'atırım	n ve l	İşletri	ne A.Ş.		Sondaj Yeri		ocation			Por 47.		
ŞIIKE	1	1	,,,y	āı	r	Stand	lart P	enet	rasvo	n De	nevi			Kuyu Derinliği	7BH L	Depth (i	n)		47.	50	ler
BH Death	Ömek No	 Örnek Derinliği Sample Depth 	Örnek Türü Sample Type	Matkap Tipl/Çapl Bit Type/Diameter	Borusu	Sta Darbe # of £	Sayı: Sayı: Blows	d Pen (SP	etratio PT)	n Tes Grafi h of N	st Iği V 30	Profili Symbol	Jeoteknik Ta Geotechnicał D		B Karot Çapı Core Diameter	S Core Recovery	s Kaya Kalitesi RQD	Kiriklar B Fractures	Ayrışma Weathering	Dayanım Strength	Yerinde Denevler
-25	28		RC	1				1				~~~~				57		>50	WЗ	R2	Γ
-		25,4		-								~~~~							WЗ		
- -26 -	29		RC									~~~~	23.50 - 23.90 m'ler,			66	-	>50	W4	R2	
-	30	26.4	RC	1								~~~~	25.40 - 26.40 m'ler, 27.70 - 28,20 m'ler arasi	;		62		>50	W3 W4	R1 R0	
-27 -	31	- 26.8	RC									~~~~	<i>EZİK ZON</i> kil matriks içerisinde me kaya parçalı.	takumtaşı		71	-	>50	W3 W4	R2 R1	
28	32	- 27.8	RC	-								~ ~ ~	Kaja paryan			56	-	>50	W5 W3	R1 R2	-
-	-	28.3										~ ~ ~ ~	-						W4 W2	R1 R2	
- -29 -	33	- 29.3	RC									~~~~				66	-	>50	W3		_
- - -30	34	- 30.0	RC									~~~~	Yukarısı gibidir.			71		>50	W2 W3	R2	-
-	35		RC									~~~~				76	16	>50	W2 W3	R2	
-31 - -	36	31.0	RC									~~~~				73		>50	W2	R2	
-32 - -	L	- 32.5	0	66								~~~~			63.5				W3		_
- -33	37		RC									~~~~				82	-	>50	W2 W3	R2	
- - -34	38	33,5	RC									~~~~				75	-	>50	W2 W3	R2	-
	39	- 34.1 - 34.3		-								~~~~	34.30	m	_	100		>50	W2	R2	-
- - -35	40	- 35,0	RC													67	-	>50	W4	R1	_
-	41	- 35,5	RC	-												98	-	>50	W4	R1	_
- -36	42	- 36.0	RC	-									BREŞİK METAKUMTAŞ Yeşilimsi açık kahveren	kii,		74	-	>50	W4	R1	_
- - -37	43		RC										genelde orta derecede - nadiren az ayrışmış, zayıf - çok zayıf dayanın parçalanmış,			82	-	>50	W4	R1	
- - -	44	- 37.5	RC										çok zayıf kil bağlayıcılı,			88	-	>50	W4	R1	-
-38 -	45	- 38.0	RC													90	-	>50	W3	R2	-
-	46	38.5	RC													84		>50	WЗ	R2	-
-39	47	- 39.0	RC													60	-	>50	wз	R2	_
Ľ	48	1	RC	1									1			46		>50	W2	R2	ł

LİMİT Teknik Araştırma Proje, Uygulama, Müşavirlik San. ve Te. AŞ

ldare		/ Adminis	tration	T.C. L Karav	Jlaştırr oliarı (na De Senel	enizc Müd	ilik ve Iürlüğ	e Hai jü, Ki	berle amu	şme B Özel S	laka Sek	anlığı tör Ortaklı	ğı Bölge Müdürlüğü	Ku	iyu No	/ Bore	hole No	,		SK-	810	
2roie	smi	/ Project	Name	Gebze	e-Orha	ngaz	i-lzm	ir (izn	nit Kö	rfez (Seçişi v	re B	lağlantı Yoli	arı Dahil) Otoyolu,		ayfa	/ Shee					14	
Görev		/ Appoint		Manis	a - Izn	nir Ke						_		M;402+500 Arası)	_	asyon ondaj Yeri	/ Statio		(KM)		400- Po	+923 rtal	
Şirket		Company	eu /				C	toyo	Yatı	rım v	re İşlet	tme	e A.Ş.			ıyu Derinliği		epth (r				.50	
∃ Kuyu Derintiği <i>BH Depth</i>	Örnek No Sample No	3 Örnek Derìnliği Sample Depth	Örnek Türü Sample Type	Matkap Tipi/Çapı Bit Type/Diameter	Muhafaza Borusu	Dart # c	Stand be Sa f Blov	and P (S ayrsi vs	enetri SPT) N G	ation I ₃₀ Gi raph (Deney Test rafiği of N 30	-	Profili Symbol	Jeoteknik T Geotechnical			Karot Çapı Zore Diameter	^S Örnek Yüzdesi Core Recovery	Kaya Kalitesi RQD	 Kinklar Fractures 	Аупşma Weethering	Dayanım Strength	Yerinde Deneyler
-40	48	10	RC	11811		10	30	15		Ī		Ť						46	-	>50	WЗ	R2	Γ
- - -41	49	40.50	RC															53	-	>50	W3	R2	
-		41.50																			W4	R1	-
-42	50	42.50	RC															52	-	>50	W3	R2	_
13	51	43.00	RC											Yukarısı gibidir.				60	-	>50	W3	R2	-
-	52		RC	96													63.5	50	-	>50	W3	R2	
-44 - •	53	44.00	RC						******									59	-	>50	W3	R2	
-45	53	45.00	RC															62	-	>50	W3	R2	
- -46 -		46,00											~ ~ ~	GRAFIT ŞİST;	0 m.		-	\vdash			W2	R3	-
- -47	54		RC										~ ~ ~ ~	Siyahımsı gri renkli, az - orta derecede ayrı zayıf - orta derecede s çok çatlaklı - kırıklı.				52	-	11-50		R2	
- -48		47,50												l	0 m. SON								
.																							
-49 •																							
- -																							
-50 -																							
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-	L		1				L							UMIT	Tek	nik Araştırma F	Proje, L		ma. M	üsavir	lik Sa	n. ve 1	Lic

APPENDIX B

CORE BOX PICTURES

Sk- 802











SK-804



a series and a series PROSE: GRACE - IZMIA ATOYOLU, MANISA-IDMIA KESINI DEL KAHVE + ONECI KUMMO SE-ROQ SAMPIK: 2/177 7.50-12 dom Bistanays Tor: 16.02-20N Bittle Ter: JI 02 OCH

PROSE: GERTE - TEMIA OTOYOLUSMANISA - IZMIN ESSIMI RELKANYE TÜNGLİ KU. YUNO STOOL SANDIE - 3/27 12-00-16.00M BASEPHONE TAR = 16-02-2011 BITIS TAR = 27.02.2011

PROJE = GEBLE - IZMIR OTOYOLU - MINNISA - IZMIR KESTMI BELKAAVE TÜNELI 2040 10= 804 16.00-20.00 m SANDIK = 4/27 NASLANGIS. TAR=16.02-2011 MIT 15 TAR = 27.02.2011



ORDJE = GEBZE - IZMIR OTOYOLU - MANISA - IZMIR RESIMI BELKAHVE JUNELI 2044 NO =58804 SANDIX = 6/27 SANDIR = 5/27 BASLANICIS= 16.02-2011, 24.00- 28.00m BITIS TAR = 28 02 2011







REAL CLARE ICANE OT OVOLU-MANAGE IT Min vectors; DELIKAHVE FÜNEL WYLI = SK BOG SADDIK = 10/27 40.00- 44.50m BASLANGIC TAR: 16-02,2011 BITIS TAR-27.02.2011



DROJE - GEOZE- IZAWA OTOYOLU MANISA- IZAWA KESIMI WELLAAMME TOWELI 1.910 = 5K- 804 SANDIK = 12/27 54 45.50-54.504 BASLANGIC TAK - 16 02 2011 R TIS TAR = 27.07 2011

PROJE - GEBZE - IZMUR OTOYOLU MARASA - LEMIR KESIMI KUYU - 5K-804 SANDIK - 13/2+ 54 50-60 50 M BASLANGIC TAR= 16.02 2011 RITIS TAR = 27 02.2011

PROJE = GEBZE-IZMIR CTOYOLU MANGA THER LESIMI BELLENINE TUNEL KUYU = 5K-804 SANDIK- 14/27 60.50-6 3.00m BASUARKIG TARE 16.02. (1 TIS TAK 27.02.2011 - A. To puter the state of the



PROFE OFFICE INTE OFFICIUS MERICALISHIE EFENIL BELLEHUE THREE K. WILL SK ROK SANIONE-16/27 6300-7400L PESSENCE (FRE- 16.02.1) Stor &



A second s PROVE - GEBLE- RAMIR OTOYOGU MANASA - TRAVIR KE SIMI REL RAHNE TOMELT KU111 = 5K 304 30.00- 85.00 m 50NOK = 18/27 BASLANGIC TAR: 16-52-2011 BIT15 TAR = 27.02.2011

A State of the second sec PROSE - GEDZE- IZMIR OTOYOLY MANISAT 12MIR LESIAN RELEDING TUNELI KUYU= 54 804 samme - 19/27 85.00 - 90.00 min NASLONGIG TAR = 16 02 2011 hitis TAR = 27.02.201

and the second states of the s PROSE - GARAGE - FAIR CONTROL MALCO-RIVE KESIMI BELICHNE TRALEU 90 m - 45.00m SANDIL-20/27 PETTICHARIE TON=/US2-2011

MAILISA-19MIR LESINI FREDE-GEBLE-FRANK OTOTALD BELXANNE TUNEL AUTUE 54-804 95.66-100 m SAU04-21/27 BASCACCOLS TAR-16:02.201 SITTS TAR- 27.02.201





MENGER - 21-12 CTOTOLY MANISAIZHIE RASINI ELBERT = 58-304 BELMANNE INKAELI 109-50-14.50



WELE-SERE- BINE OTHOU WINE DAIR KESMI BECCALLE TUNEL AUHU= SK-894 119.50-125,00 M DANDIK=26/27 GANSIG TREE 16 02 2011 1912=27.02.2011



SK-805







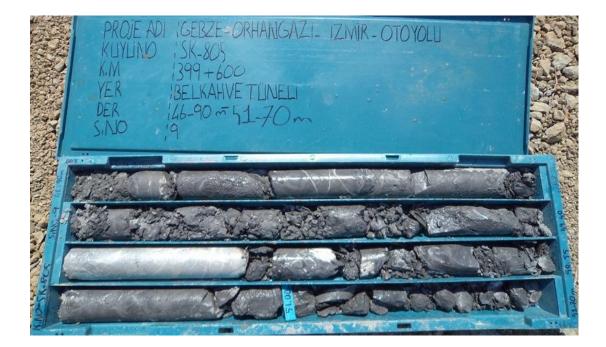


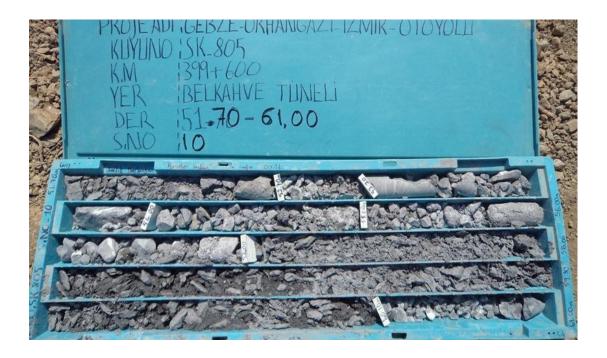
















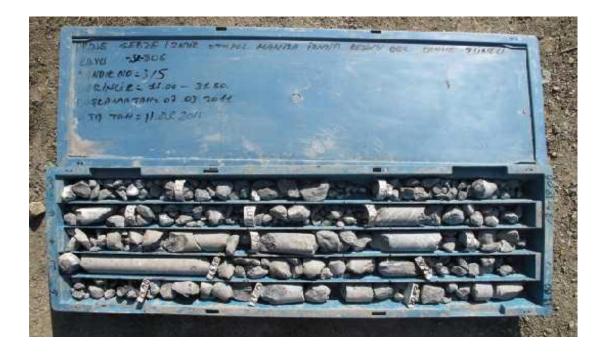
PROJE ADI-GEBZE. ORHANGAZI-TUNIR OTOYOU KUYU NO = SK-805 KM = 399+600 YER -BELKANNE TÜNEU DER = 75.00- 82.15m Si Ho = 13 SIMO



KUYD NO = SK-805 КМ = 399+600 YER = BEIKAME TÜNELİ DER -89.20-9900m S,HO BITIS TARIHI: 15-08-2012 KARDIAR SUDAN - SAĜA DIJIA -であると The second second - 21 . . -17 1.40



PROVE OF ROF 12 KIND - TO 9721 INTEL ATTAILED PROVE - SE-SES FRANKE - 2/5 TRUCTIC - 8:00 - 1600 DISSINGUA 70H= 03 70 500 TISSINGUA 70H= 03 70 500 TISSINGUA 70H= 03 70 500 TISSINGUA 70H= 03 70 500 TISSINGUA 70H= 03 70 500 TISSINGUA 70H= 03 70 500 TISSINGUA 70H= 03 70 500 TISSINGUA 70H= 03 70 500 TISSINGUA 70H= 00 70 500 TISSINGUA 70H= 00 70 500 TISSINGUA 70H= 00 70 500 TISSINGUA 70H= 00 70 500 TISSINGUA 70H= 00 70 500 TISSINGUA 70H= 00 70 500 TISSINGUA 70H= 00 70 500 TISSINGUA 70H= 00 70 500 TISSINGUA 70H= 00 70 500 TISSINGUA 70H= 00 70 TISSINGUA 70 TISSIN



PROJE - GED IL IDNIR CIEVILLI N'H 11 AUNA = SE-301 SPADIK NO = 4/5 DERIVER = 31.00 - 42.00 BASLANA TAN: 09.03-05/1 100 BITIS THM: 11.03. 2011 - A



















PROJE ADI =GEBLE-OBHANGAZI-ILMIR KUYU NO -807 KM = 399+850 - BEIKAHNE TÜNELI YER = 33,00 = 37,00m DER-S,NO=9

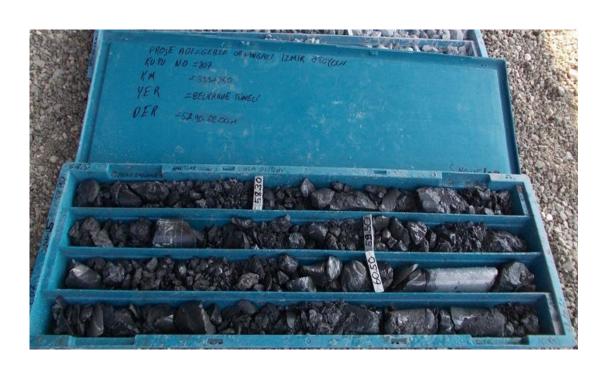


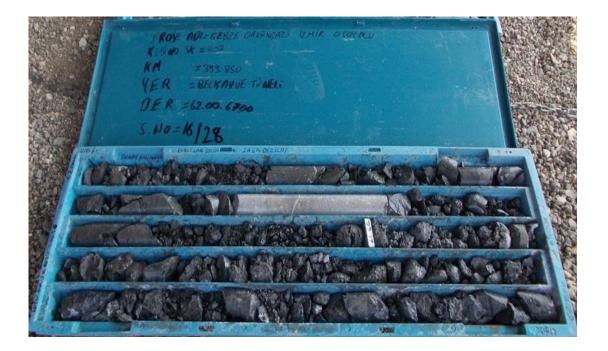
All and the second second PROSE ADI-GEBZE-OKHANGAZI -IZMIR O TOYOLG KUTUNO =807 KH 3997-850 YER = BELKANUE TOWELI YER DER_ = 4100-45.10 M.





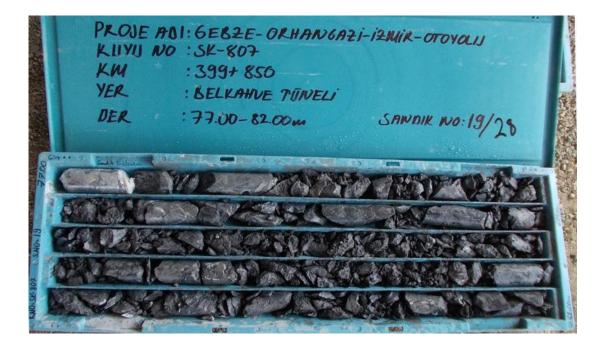














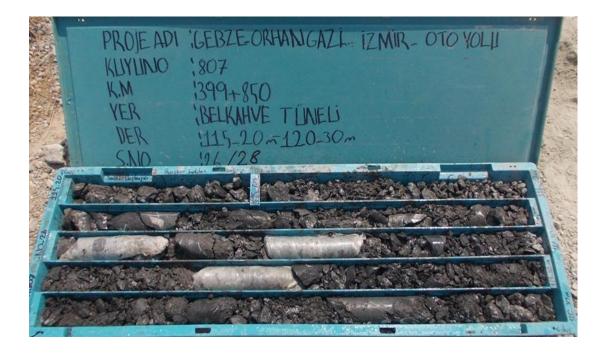


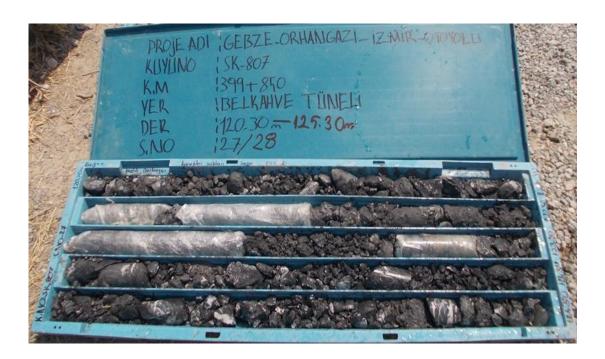




































PROJE ADI= GEB 22 WEARAGE - 12/11 K.No = 808 KM = 400 +400 YER = BELKAHUE TÜAVELI DFR=46.85m 50.85m S.No= 12 S, NO= 12



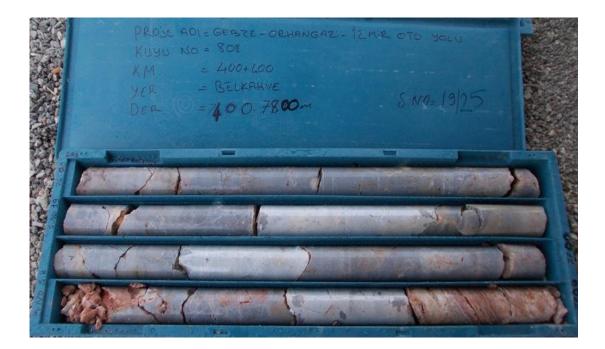














-82.90-86.00 10 M. st.







 PROJE
 NOI:= GEBZE. ORHANGAZ:- 12MSE
 OTO
 YOLU

 KUYU
 NO:= 808
 Bit. Tarihi: 01-07-2012

 KM
 = 400+400
 Bas. Torihi:= 25.00-2012

 YER
 = BELKARVE TÜNEL:
 KUYH SOND NO=











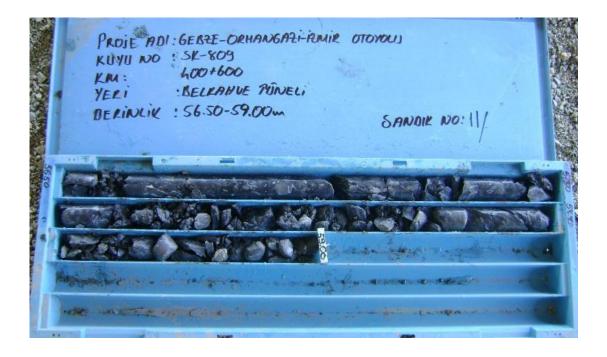




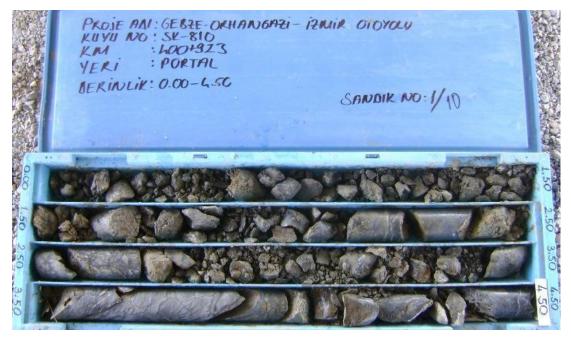


PROJE ANI : GEBTE-OLHANGAZI-IZMIR OTOYOLI SONDAJ NO: SK-809 : 600+600 KM : BELKAHIVE PRINELI YERI DERINLIK : 46.00-50.00m SANDIK NO:3/

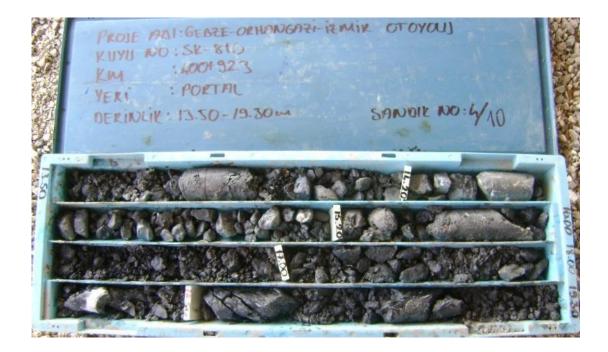




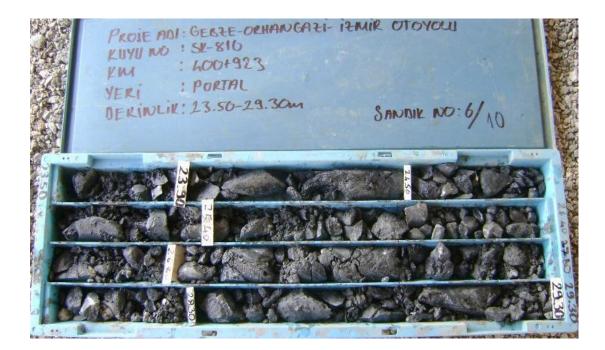
SK-810







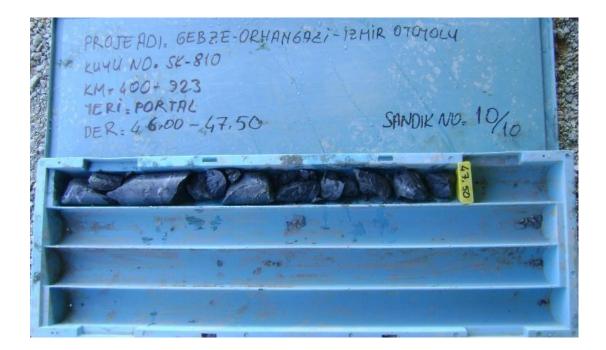












APPENDIX C:

LABORATORY TEST RESULTS

limit

LİMİT Teknik Araştırma, Proje, Uygulama, Müşavirlik, Sanayi ve Ticaret A.Ş. İvedik OSB, 1354. Cadde, 1395. Sokak, No.1, 06378 Yenimahalle/ Ankara/ TÜRKİYE Tel : (00.312) 394.53.63. Fax : (90.312) 394.63.64. e-mail: labiglimitleknik.com

ProjeAdı Vojerd Name	: Get	oze - Ort	iangazi -	- İzmir	(İzmit k	Şti. Grfez G	ecisi ve	Baālar				DIU, Man		mir	Report Numu Sample Lab. P		iş Tarihi ^{re Date}	•	10.10.20 15.09.20 LMT12-09
		1			1	1	1	T							Bakan	lik Kay		:	336826
Auju: Aç No Burende / T/2 No	Örnek No Sampie Mo		erinlik Depth	Su Muhtevasi Molatione Contene			Özgül Agırlık Specific Gravity	Boşluk Oranı Vold Raha	Porozite Porasity	Su Emme Water Absorbtion	Görünür Porozite Appearant Porosity	Tek Eksenli Basınç Dayanımı Uniaxiai Compressive Strength	Elastisite Modůlů Elastis Modulu	Poisson Oranı Poisson's Ratio	Ba Day De Tri Comp	Eksenli Isinç ranımı eneyi axial Xessive gih Test	Nokta Yuk İndeksi Point Load Index	Indirek Çekme Day. (Brazilian)	Noti Note
		m.'den from	m.'ye	Wn	Yn	Ya	G,	0	n	l _v	na	qu	E	υ	c	φ	I _{s(50)}	στ	1
56-805	RC-11	17.00		%	g/cm	-	-	-	%	%	%	kg/cm ²	GPa	-	kg/cm ²	0	MPa	MPa	
SK-805	RC-11 RC-26	17.30	18.80	3.14	1.64	-						1*					0.08		
SK-805	RC-26	32.50 36.00	34.00	1.20	2.65	2.62											0.30		
SK-805	RC-33-34	41.50	37.50	0.49	2.70	2.68						349.63	22.04	0.23				-	
SK 805	RC-38	41.50	44.20	1.09	1.90	1.88						1*	1*	1*			0.12		
SK 805	RC-40	-	48.20	3.79	1.64	1.58											0.66		
SK-805	RC-44-48	49.40	50.55	0.70	2.68	2.66						785.25	61.77	0.32					
	RC-44-48	52.70	57.00	0.12	2.72	2.72		-									2.65		
SK-807	RC-17	73.40	75.00	0.72	2.72	2.70											4.05		
SK-807	RC-17 RC-24	22.50	23.50	0.42	2.66	2.65	1.1					546.83	57.11	0.18					
SK-807	RC-24	31.50	33.00	0.10	2.68	2.68	-							-			1.72		
SK-807		39.00	41.00	0.65	2.65	2.63		_				459.60	36.50	0.24					
	RC-32	47.20	47.80	0.59	2.68	2.66						781.55	58.96	0.21			-		
SK-807	RC-37-39 RC-50	53.00	56.80	0.17	2.70	2.69											1.64		
1-485-0-0-00		70.40	72.00	0.82	2.70	2.68											0.37		
SK-807	RC-52 RC-53-54	72.70	75.20	0.43	2.82	2.81	-		-			132.93	5.18	0.21					
		75.20	77.00	0.31	2.66	2.65		-									1.21	5	
SK-807	RC-57	82.00	83.20	0.15	2.66	2.66											3.28	-	
	RC-64	87.40	88.30	0.38	2.71	2.70						1575.09	52.10	0.21	-			-	
	RC-67	90.00	92.00	0.19	2.65	2.64											3.75		
	C-75-76	97.00	99,20	0.37	2.74	2.73											3.45	-	
	RC-80	102.10	103.50	0,08	2.68	2.68							-				5.30		
-		105.60	106.50	3 86	2.33	2.24						1.	1.	1.					
A.710-1		108.20	110.50	0.26	2.64	2.63											4.47		-
			112.50	0.47	2.70	2.69						1086.72	50.92	0.19	-			-	
SK-807 R0	C-89-90 arks ;		115.60	1.09	2.71	2.68 kırıldığı içir							-			t	1.18		

FORM No: K1

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LIMIT Teknik Araştırma, Proje, Uygulama, Müşavirlik, Sanayi ve Ticaret A.Ş. İvedik OSB, 1354. Cadde, 1395. Sokak, No.1, 0578 Yenimahalle / Ankara / TURKIYE Tel : (90.312) 394 53 63 Fax : (90.312) 394 53 64 e-mail : lab@limitleknik.com

1

FirstsAdi CorstsSony Neme ProsestName	: Get	- oze - Orł	naniç Mü nangazi - kahve Tü	İzmir	(İzmit K	örfez G	eçişi ve)2+500	Bağlar Arası)	ntı Yolla	ri Dahil)) Otoyo	olu, Man	isa - İzı	mir	Report Numu Sample Lab. K Lab. R Bakan	ine Geli e Receiv Kayıt No egistratio nlık Kay	iş Tarihi ve Date o on No.	:	10 1 15.0 LMT1 336
Kuyu / A.Q. Ne Borense / T.Per I.o	Örmek No Sample Mo		erinlik Depth	Su Muhtevası Moisture Contect	⇒ Doğal Birim Hacim Agırlık Natural Unit Weight		Digul Ağırlık Specific Gravity	Boşluk Oranı Voki Ratio	Porozite Porosity	Su Emme Water Absorbion	Görünür Porozite Appearant Porozity	Tek Eksenli Basınç Dayanımı Unlarlal Compressive Strength	Elastisite Modûlû Elastic Modûlû	Poisson Orani Poisson's Rado	Üç E Ba Day De	Eksenli asınç yanımı eneyl iaxial oressive gth Test	Nokta Yūk İndeksi Pairt Load index	İndirek Çekme Day. (Brazilian) Indirect Tenzile Str. (by Brazilian) Test	
		from	m.'ye to	%	-	Yd		e	n	i,	n,	qu	E	U	c	φ	I _{s(50)}	at	
	RC-93-94	117.30	119.30	-	g/cm ³	g/cm ³		17	%	%	%	kg/cm ²	GPa		kg/cm ²	٥	MPa	MPa	
5K-807	RC-97-98		119.30	1.59	2.68	2.64		-			-	1.			-		6.32		
SK808	RC-18-20		22.35	0.88	2.55	2.50						1.	1.	1.	-		3.67		
SK808	RC-31	30.55	31.70	3.15	2.60	2.57				× 142		131.30		-6-	-	-	0,16	-	1
SK808	RC-36	36.30	38.50	0.47	2.37	2.30						1*	1*	1*		_		_	
SK-808	RC-40	45.50	48.50	0.74	2.68	2.66						87.02	7.22	0.40					
51<-808	RC-44	55.40	56.00	0.87	2.68	2.65						813.82	69.73	0.32	_				
SK-808	RC-47	59.60	62.00	0.84	2.69	2.67						514.94	76.42	0.25			3.22		
SK-808	RC-49-50	65.00	71.00	0.67	2.68	2.66						320.17	52.05	0.33					
5K-808	RC-52-53	74.00	80.00	0.84	2.67	2.65						551.09	54.95	0.27			2.34		
SK-808	RC-55	83.00	86.00	0.77	2.70	2.68						462.53	44.77	0.26	-		3.35		
	RC-58-59	90.00	96.00	0.78	2.54	2.52						192.85	54.15	0.32					
5K-809	RC-5-6	4.60	6.80	0.15	2.70	2.70						270.28	38.17	0.40			3.05		
	RC-10-12	9.50	12.50	0.20	2.72	2.72											5.70	_	
SK-809	RC-15-18	14.00	16.70	0.17	2.81	2.81			-	-					_		5.46		
SK-809	RC-26-27	20.40	22.30	0.78	2.65	2.63		-	-								5.47		
SK-809	RC-31	24.00	24.50	0.48	2.67	2.66						454.34	31.39	0.20			7.57		
SK-809	RC-36	27.00	28.00	0.23	2.67	2.66				-	-	645.43	43.07	0.28					
	RC-38-40	28.40	31.00	0.23	2.71	2.70	- +										3.59		
SK-809 F	RC-44-45	33.30	35.80	2.45	2.14	2.09						1.					1.11		
	RC-50	38.50	39.50	3.49	2.28	2.21					-+		1*	1.			0.07		
	RC-52	40.50	41.50	3.18	2.12	2.05						55.11	1.93	0.27	-		-		
	RC-56-57	43.10		0.29	2.72	2.71						1*	1.	1*					
and the second s	RC-59	45.20	45.70	0.35	2.65	2.64											4.54		-
a second the	RC-61-63	46.50			2.68	2.67						1*	1*	1*					
çıklamalar I Ren	narks :	N					n deney y	/apilamar	nıştır.								3.41		
Açıklamalar I Ren		N	lot 1* : C	brnek ke	silirken k		n deney y	/apilamar	nıştır.			Lab, Den	ING GEN	endisi / i Ç, Jeo, N / Certificate	Iun./Geo.	Wising En Eng.	3.41	iead	1

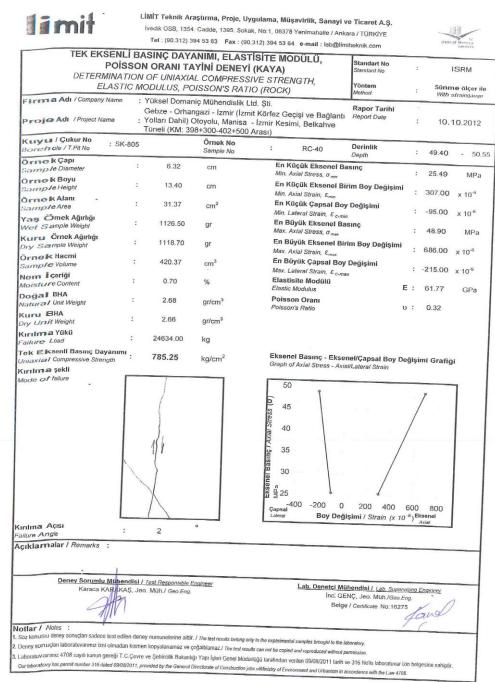
Filma Adı Gelopanıv Me Projo Adı Pronot Name	: G	'üksēl Do iebze - O esimi, Be)rhangaz	ri - İzmi	r (İzmi	d. Şti.	Casial			ATOR	r TES	STS (R	оск)		Rapo	r Tarihi			10.10.20
						50+300-	402+50	/e Bağla 0 Arası)	antı Yol)	ları Dah	il) Otoj	yolu, Ma	nisa - I.	zmir	Numi Sampi Lab. I Lab. R Bakar	une Gel le Roceiv Kayıt Ni legistratii nlık Kay	o on No. rit No	:	15.09 20 LMT12-09 336826/
Kuyu / AÇ No Borende / T.P.E.No	Örnek No Sample No		Derinlik Depth		Matture Content Dogal Birim Hacim Agurlik	Kuru Drv Un		Boşluk Oranı Vöid Ratio	Porozite Porozity	Su Emme Water Absorbition	Görünür Porozite	Tek Eksenli Basınç Dayanımı Unlarılal Compessive Smooth	Elastisite Modülü Elastis Modülü	Poisson Orani Poisson's Ratio	Üç I Bi Day De	y Registi Eksenii asınç /anımı eneyi iaxia/ oressive gth Test	Nokta Yūk İndeksi Poirit Load index	İndirek Çekme Day. (Brazilian) Indrect Tensile Str. (by Brazilan) Test	Notlar Notes
		m.'de from		e W	-	-	G,	e	n	l _v	n.	qu	E	U	c	ф	I _{s(50)}	στ	
SK-805	RC-11	17.30	0 18.8	-	g/ci 4 1.6		-		%	%	%	kg/cm	² GPa		kg/cm ²	٥	MPa	MPa	1
SK-805	RC-26				-		-				-	1.	-				0.08		
SK-805	RC-29	36.00			-		-			1		-	-		-		0.30		
SK 805	RC-33-3	4 41.50	44.20	1.05	-	2.00	-					349.63	EE.04	0.23		_			
SK-805	RC-38	46.90	48.20		-	-		-				1.	1*	1.			0.12		
SK-805	RC-40	49.40	50.55	0.70	2.68	2.66						785.25					0.66		
SK-805	RC-44-48	52.70	57.00	0.12	2.72	2.72						785.25	61.77	0.32					
SK-805	RC-64-65	73.40	75.00	0.72	2.72	2.70	-					-					2.65		
SK-807	RC-17	22.50	23.50	0.42	2.66	2.65						546 83	57.11	0.18			4.05		
5K 807	RC-24	31.50	33.00	0.10	2.68	2.68						540.83	\$7.11	0.18					
SK-807	RC-27	39.00	41.00	0.65	2.65	2.63						459.60	36.50	0.24			1.72		
SK-807	RC-32	47.20	47.80	0.59	2.68	2.66						781.55	58.96	0.24					
SK-807	RC-37-39	53.00	56.80	0.17	2.70	2.69											1.64		
SK-807	RC-50	70.40	72.00	0.82	2.70	2.68											0.37		
SK-807	RC-52	72.70	75.20	0.43	2.82	2.81						132.93	5.18	0.21	-		0.57	1.1.1	
SK-807	RC-53-54	75.20	77.00	0.31	2.66	2.65										-	1.21	-	
SK-807	RC-57 RC-64	82.00	83.20	0.15	2.66	2.66		-							-		3.28		
SK-807	RC-64 RC-67	87.40	88.30	0.38	2.71	2.70						1575.09	52.10	0.21		-	-		
SK-807	RC-67 RC-75-76	90.00 97.00	92.00	0.19	2.65	2.64							-				3.75		
SK-807	RC-75-76	97.00	99.20	0.37	2.74	2.73											3.45		
SK-807	RC-83	102.10	103.50	0.08	2.68	2.68								-		t	5.30		
SK-807	RC-86-87	108.20	106.50	3.86	2.33	2.24						1*	1*	1*					
SK-807			110.50	0.26	2.64	2.63											4.47		
31-001		-	115.60		2.70	2.69						1086.72	50.92	0.19		-			
SK-807	UC-03-90			1.08				apilamar									1.18		

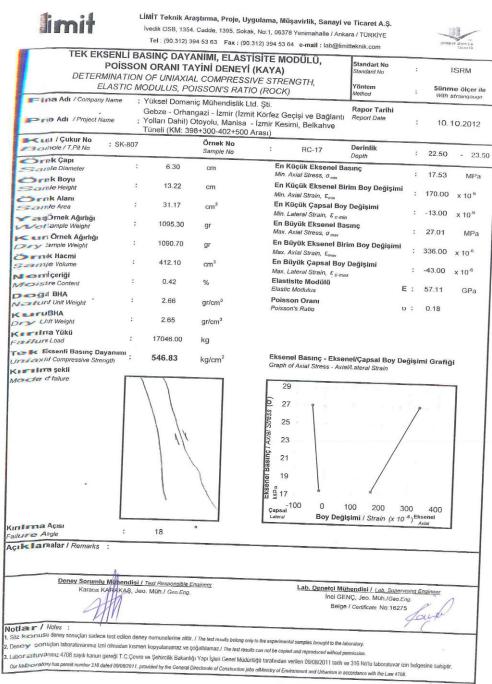
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LİMİT Teknik Araştırma, Proje, Uygulama, Müşavirlik, Sanayi ve Ticaret A.Ş. İvedik OSB, 1354. Cadde, 1395. Sokak, No:1, 06378 Yenimahalle / Ankara / TÜRKİYE Tel. (90.312) 394 53 63 Fax : (90.312) 394 53 64 e-mail : lab@limitteknik.com



DETERM	INATION	OF UNIAXI	ANIMI, ELAST AYINI DENEYI AL COMPRESS	(KAYA)	North	Standart No Standard No	:		ISRM
LL	43110 10	ODULUS, PO	DISSON'S RAT	IO (ROCK)	NGTH,	Yöntem Method	:	Sünn	ne ölçer
Firma Adı / Company M	lame : ne :	Yüksel Doma Gebze - Orha Yolları Dahil)	niç Mühendislik L ngazi - İzmir (İzm Otoyolu, Manisa 98+300-402+500	td. Şti. iit Körfez Ge			:		straingaug
Borenole / T.Fit No	: SK-805		Örnek No Sample No	:	RC-29	Derinlik Depth	;	36.00	- 37
Örnek Çapı Sample Diameter	:	6.30	cm	En K	üçük Eksenel B				57
Örnek Boyu Sample Height	:	14.44	cm	En K	Axial Stress, σ _{min} üçük Eksenel B	irim Boy Değişimi	:	6.48	MPa
Örnek Alanı Sample Area	:	31.17	cm ²	En K	üçük Çapsal Bo	v Dečisimi	:	214.00	x 10 ⁶
Yaş Örnek Ağırlığı Net Sample Weight	:	1214.40	qr	En B	ateral Strain, ε _{c-m} üyük Eksenel Ba	in the second seco	:	-48.00	x 10 ⁻⁶
Curu Örnek Ağırlığı Ory Sample Weight	:	1208.50	gr	Max. A	xial Stress, o max	rim Boy Değişimi	:	14.48	MPa
ornek Hacmi				Wax. A	Xial Strain, Emax		:	577.00	× 10 ⁻⁶
Sample Volume Nem İçeriği	:	450.13	cm ³	Max. L	iyük Çapsal Boy ateral Strain, ε _{c-m}	/ Değişimi	:	-132.00	x 10 ⁻⁶
noisture Content	:	0.49	%	Elasti Elastic	site Modülü Modulus		:	22.04	GPa
latural Unit Weight	:	2.70	gr/cm ³		on Oranı n's Ratio	ι) :	0.23	
ry Unit Weight	:	2.68	gr/cm ³						
ar ılma Yükü _{ailur} e Load ek Eksenli Basınç Daya	:	10899.00	kg						
Ilma Açısı Jure Angle	:	15	0	(0) 232 (0)	00 00	200 400 İşimi / Strain (x 10		600 senet xial	
iklamalar / Remarks :									
7	lühendisi / RAKAŞ, Jeo	<u>Test Responsible E</u> . Müh./ Geo.Eng.	ngineer		nici GE	ihendisi / Lab. Supervi NÇ, Jeo, Müh./Geo.Er / Certificate No:16275	ng.	ngineer and	2
tlar / Notes : z konusu deney sonuçları sadece te ney sonuçları laborattıvarımız izni o boratuvarımız 4708 sayılı kanun ger raboratory has permit number 316 dated	edi T.C.Covre I	nopytatilitanaz ve ç	ogaiulamaz./ The test result	ts can not be copied	and reproduced without p	ermission.			-





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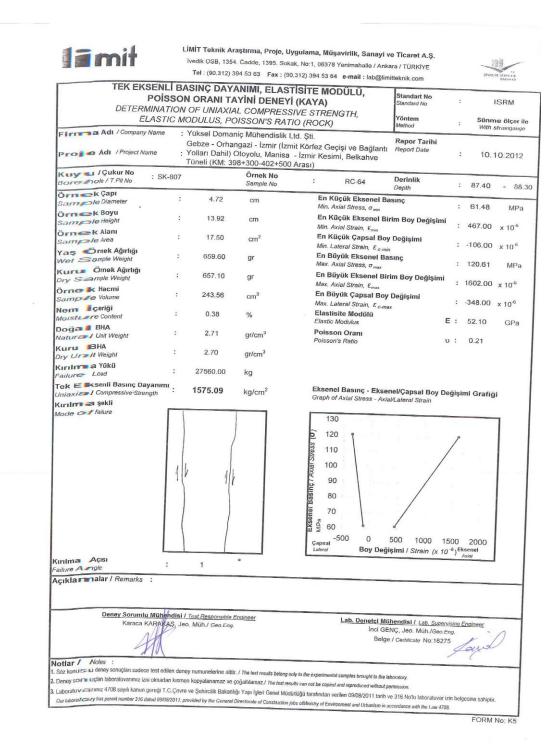
LİMİT Teknik Araştırma, Proje, Uygulama, Müşavirlik, Sanayi ve Ticaret A.Ş. İvedik OSB, 1354. Cadde, 1395. Sokak, No:1, 06378 Yenimahalle / Ankara / TÜRKİYE Tel : (90.312) 394 53 63 Fax : (90.312) 394 53 64 e-mail : lab@limitteknik.com

SEVER VE SPILLS

IEK EKSEN	ILI BA	SINÇ DAY	NIMI, ELAST	ISITE MODÜLÜ,	Standart No	-		
DETERMINA	ATION	OF UNIAXIA	YINI DENEYI	IVE STOENOTU	Standard No	:		ISRM
ELAS	TIC MC	DULUS, PC	SSON'S RATI	O (ROCK)	Yöntem Method	:	Sünn	ne ölçer straingaux
Firma Adı / Company Name	: `	Gebze - Orhar Yolları Dahil) (niç Mühendislik L ngazi - İzmir (İzm Dtoyolu, Manisa 18+300-402+500	it Körfez Geçişi ve Bağlantı	Rapor Tarihi Report Date	:		10.201:
Borchole / T.Pit No : Si	K-807		Örnek No Sample No	: RC-27	Derinlik Depth	;	39.00	- 4
Örmek Çapı Sample Diameter	:	6.32	cm	En Küçük Eksenel Ba Min. Axial Stress, σ _{min}		:	15.66	MP
Örnek Boyu Sample Height	:	14.56	cm	En Küçük Eksenel Bi	im Boy Değlşimi		137.00	
Örnek Alanı Sample Area	:	31.37	cm ²	Min. Axial Strain, ɛ _{min} En Küçük Çapsal Boy Min. Lateral Strain, ɛ _{c-min}	Değişimi		-21.00	x 10 ⁻⁶
Yaş Örnek Ağırlığı- Wet Sample Weight	:	1208.70	gr	En Büyük Eksenel Ba Max. Axial Stress, σ _{max}	sınç		23.47	x 10*
Kuru Örnek Ağırlığı Dry Sample Weight	:	1200.90	gr	En Büyük Eksenel Bir	im Boy Değişimi		351.00	
Örnek Hacmi Sample Volume	:	456.76	cm ³	Max. Axial Strain, E _{max} En Büyük Çapsal Boy	Değişimi			x 10 ⁻⁶
Nem İçeriği Moisture Content	:	0.65	%	Max. Lateral Strain, ε _{c-ma} . Elastisite Modülü Elastic Modulus		E :	36.50	x 10 ⁻⁶ GPa
Natural Unit Weight	:	2.65	gr/cm ³	Poisson Orani Poisson's Ratio			0.24	GPa
Curu BHA	:	2.63	gr/cm ³				7.07	
Airiima Yükü Failure Load	:	14418.00	kg					
Tek Eksenli Basınç Dayanır Iniaxial Compressive Strength	^{nı} :	459.60	kg/cm ²	Eksenel Basınç - Ekser Graph of Axial Stress - Axia	iel/Çapsal Boy D	eğişi	mi Grafig	ji
for a sekli node of failure				orapir of Axial Stress - Axia	VLateral Strain			
irilma Açısı ilure Angle		14	0	Vapsal	000 200 s şimi / Strain (x 10	800 p-6) El	400 (sanel ^{Axia}	
ciklamalar / Remarks :								
۸.								
Deney Sorumlu Müh	endisi /	Test Responsible F	nniones					
Karaca KARAI	KAŞ, Jeo	. Müh./ Geo.Eng.	and leer	Lab. Denetçi Mü	hendisi / <u>Lab. Super</u> NÇ, Jeo. Müh./Geo.E	vising	Engineer	
An	1			Belge	/ Certificate No:1627	5	but	0
otlar / Notes :						/	C	
	dilen dene	v numunelerine aittir	. / The test results belong on	ly to the experimental samples brought to the le				
Soz konu su deney sonuçları sadece test e Deney sonuçları laboratuvarımız izni olmak								- 1
Söz konu Sü deney sonuçları sadacce test e Deney sonuçları laboratuvarımız izni olmak aboraluv arımız 4708 sayılı kanun gereği Dur laboratory has permit number 316 dated Opr	T.C.Cevre	r kopyalanamaz ve ç ve Sehircilik Bakanlı	ogaltilamaz./ The lest resu	Its can not be copied and reproduced without pe	emission.			

TEK EKSENLİ BASINÇ DAYANIMI, ELASTİSİTE MODÜLÜ, POİSSON ORANI TAYİNİ DENEY (KAYA) Standart No Standart No DETERMINATION CF UNIXXIAL COMPRESSIVE STRENGTH, ELASTIC MODULUS, POISSON'S RATIO (ROCK) Yatem Standart No Filma Adı / Compiny Nume Yüksel Domaniç Mühendislik Lü, Şü. Gebez - Orhangazi - Lamir (Izmit Kofriz Geçişi ve Bağlanti Gebez - Orhangazi - Lamir (Izmit Kofriz Geçişi ve Bağlanti Report Tarihi Gebez - Orhangazi - Lamir (Izmit Kofriz Geçişi ve Bağlanti Report Tarihi Gebez - Orhangazi - Lamir (Izmit Kofriz Geçişi ve Bağlanti Report Tarihi Gebez - Orhangazi - Lamir (Izmit Kofriz Geçişi ve Bağlanti Report Tarihi Gebez - Orhangazi - Lamir (Izmit Kofriz Geçişi ve Bağlanti Report Tarihi Gebez - Orhangazi - Lamir (Izmit Kofriz Geçişi ve Bağlanti Report Zate Tarihi (IXM: 398+300-402+500 Aras) Maport Tarihi Report Tarihi Gebez - Orhangazi - Lamir (Izmit Kofriz Geçişi ve Bağlanti Report Zate Sample No Report Tarihi Report Zate Sample No Report Tarihi Report Zate Sample No Report Tarihi Report Zate Sample No Report Tarihi Report Zate Sample No Report Tarihi Report Zate Sample No Report Tarihi Report Zate Sample No Report Tarihi Report Zate Sample No Report Tarihi Report Zate Sample No Report Tarihi Report Zate Sample No Report Tarihi Report Zate Sample No Report Tarihi Report Zate Sample No Report Zate Sample No Report Zate Sample No Report Zate Sample No Report Zate Sample No Report Zate Sample No Report Zate Sample No Report Zate Sample No Report Zate Sample No Report Zate Sample No Report Zate Sample No <th>TEK EK</th> <th>SENLÍ BA</th> <th>SINC DAY</th> <th>NIMI, ELAST</th> <th>312) 394 53 64 e-mail : lab@</th> <th></th> <th></th> <th>geve</th>	TEK EK	SENLÍ BA	SINC DAY	NIMI, ELAST	312) 394 53 64 e-mail : lab@			geve
ELASTIC MODULUS, POISSON'S RATIO (ROCK) Description Summer Fina Adi / Company Name : Yüksel Domaniç Mühendislik Ltd. Şü. Rapor Tarihi Gebze - Orhangaz - Izmir (Izmir Körle Körlez Geçişi ve Bağlantı Repor Date : Yul / Cukur No : SK-807 Örnek No : Repor Date : 10 Somple No : RC-32 Derinlik Engeht : 47.20 Somple No : RC-32 Derinlik : 47.20 Somple No : RC-32 Derinlik : 47.20 Somple No : RC-32 Derinlik : 47.20 Somple No : RC-32 Derinlik : 47.20 Somple No : RC-32 Derinlik : 47.20 Somple No : RC-32 Derinlik : 47.20 Somple Nogati : 15.38 cm : RC-32 Derinlik : Somple Nogati : 15.38 cm : : : : : : : : : : : : : : : : :<		POISSON	ORANI TA	YINI DENEYI	(KAVA)	Standart No Standard No	:	
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Kurul na Actsi Parashole / Telt No : SK-807 Ornek No Sample No : RC-32 Derinik Depth : 47.2 Inok Capi Sample Diameler 6.30 cm En Küçük Eksenel Basınç : 41.7 Sample Diameler : 15.38 cm En Küçük Eksenel Basınç : 41.7 Sample No : R. Küçük Eksenel Basınç : 41.7 Sample No : In Küçük Eksenel Basınç : 41.7 Sample No : In Küçük Eksenel Basınç : 428.0 Sample Area : 31.17 cm² En Küçük Eksenel Basınç : 60.94 Sample Area : 31.17 cm² En Büyük Eksenel Basınç : 60.94 Vari Sample Weight : 1283.20 gr En Büyük Eksenel Basınç : 60.94 Sample Veight : 1275.70 gr En Büyük Eksenel Basınç : 60.94 Sample Veight : 1275.70 gr En Büyük Eksenel Basınç : 60.94 Mar. Iserial Strain, E.omas En Büyük Eksenel Basınç : 60.94 : 69.94 Mar. Atali Strain, E.omas En Büyük Eksenel Basınç : 58.96 : 69.95 Mar. Iserial Stra		ame :	Gebze - Orhar (olları Dahil) (ngazi - İzmir (İzm Otovolu, Manisa	it Körfez Geçişi ve Bağla - İzmir Keşimi, Belkabya	Rapor Tarihi nti Report Date	:	10
Cape Cape				Örnek No			:	47.2
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Karaca KAPAKAŞ, Jeo. Müh./ Geo.Eng. Inci GENÇ, Jeo. Müh./ Geo.Eng. Belne (Construction Leader State St	Fallure Angle Açıklamalar / Remarks Deney Sorumi Karaca Notlar / Notes : . Soz konusu deney sonuçları sade	u Mühendisi i KARAKAŞ, Je	<u>Test Rosponsible</u> o. Müh./ Geo.Eng.	Engineer I The tast results boloose	Çapsal 200 0 Lateral Boy I Lateral Boy I Lab. Deneto Inc	Değişimi / Strain (x İ Mühendişi / Lab. Sup İ GENÇ, Jeo. Müh //Cec Jelge / Certificate No:163	10 ⁻⁶) ^{EI} vervising o.Eng.	ksenel Axial Engineer

TEK EKSENLİ BASINÇ DAYANIMI, ELASTI POİSSON ORANI TAYİNİ DENEYİ DETERMINATION OF UNIAXIAL COMPRESSI ELASTIC MODULUS, POISSON'S RATIC Gebes - Orhangazi - Izmir (Izmi Proje Adı / Project Name : Yüksel Domaniç Mühendislik Lu Borehole / IPR No : SK-807 Kuyu / Çukur No Borehole / IPR No : SK-807 Örnek No Sample No Örnek Çap Sumple Diameter 4.72 cm Örnek Adari Sample Name 10.30 cm Örnek Adari Sample Name 10.30 cm Örnek Adari Sample Neight 509.10 gr Kuru Örnek Ağırlığı Dıry Sample Veight 506.90 gr Örnek Hacmi Sample Volume 180.22 cm³ Natural Ünik Weight 2.81 gr/cm³ Kuru BHA Dıry Unit Weight 2.81 gr/cm³ Kuru BHA Dıry Unit Weight 2.82 gr/cm³ Kuru BHA Dıry Unit Weight 132.93 kg/cm² Kuru BHA Dıry Unit Weight 132.93 kg/cm² Kuruma şekli Mode of failure ° Açıklarmalar / Remarks 17	(KAYA) Standard No ISRM IVE STRENGTH, IVE STRENGTH, O (ROCK) Yontem Method Sünme ölçer With straingaun Vinter Method Sünme ölçer With straingaun It SRM Sünme ölçer With straingaun It SRM Sünme ölçer With straingaun It SRM Sünme ölçer With straingaun It SRM Rapor Tarihi Report Date It SRM Rapor Tarihi Report Date It RC-52 Derinlik Depth It SRM 72.70 - 7 En Küçük Eksenel Basınç Min. Axial Strass, oranı En Küçük Eksenel Birin Boy Değişimi En Küçük Çapsal Boy Değişimi
POISSON ORANI TAYINI DENEYI DETERMINATION OF UNIAXIAL COMPRESSI ELASTIC MODULUS, POISSON'S RATU Firma Adi / Company Name Yüksel Domaniç Mühendislik Lit. Gebze - Orhangazi - Izmir (Izmi Gebze - Orhangazi - Izmir (Izmi Bachole/ TPH No Proje Adi / Project Name Yüları Dahil) Otoyolu, Manisa - Tüneli (KM: 398+300-402+500 / Tüneli (KI: 508,10 gr Örnek Agirliği 508,10 gr Örnek Ağırliği 508,90 gr Örnek Hacmi 180,22 cm³ Sample Weight 2.82 gr/cm³ Kuru BHA 2.81 gr/cm³ Kuru BHA 2.326.00 kg Tokair Compressive Strength 132.93 kg/cm² Kuru BHA 2.81 gr/cm³ Mode of failure ° Vi Unit Weight 12.93 kg/cm² <th>(KAYA) Standard No ISRM IVE STRENGTH, IVE STRENGTH, O (ROCK) Yontem Method Sünme ölçer With straingaun Vinter Method Sünme ölçer With straingaun It SRM Sünme ölçer With straingaun It SRM Sünme ölçer With straingaun It SRM Sünme ölçer With straingaun It SRM Rapor Tarihi Report Date It SRM Rapor Tarihi Report Date It RC-52 Derinlik Depth It SRM 72.70 - 7 En Küçük Eksenel Basınç Min. Axial Strass, oranı En Küçük Eksenel Birin Boy Değişimi En Küçük Çapsal Boy Değişimi</th>	(KAYA) Standard No ISRM IVE STRENGTH, IVE STRENGTH, O (ROCK) Yontem Method Sünme ölçer With straingaun Vinter Method Sünme ölçer With straingaun It SRM Sünme ölçer With straingaun It SRM Sünme ölçer With straingaun It SRM Sünme ölçer With straingaun It SRM Rapor Tarihi Report Date It SRM Rapor Tarihi Report Date It RC-52 Derinlik Depth It SRM 72.70 - 7 En Küçük Eksenel Basınç Min. Axial Strass, oranı En Küçük Eksenel Birin Boy Değişimi En Küçük Çapsal Boy Değişimi
DETERMINATION OF UNIAXIAL COMPRESSI ELASTIC MODULUS, POISSON'S RATU Firma Adi / Company Name : Yuksel Domaniç Mühendisik Li Gebze - Orhangazi - Izmir (Izmi Proje Adi / Project Name : Yolları Dahil) Otoyolu, Manisa Türneli (KM: 398+300-402+500 / Kuyu / Çukur No Borehole / TPit No : SK-807 Sample No Örnok Qapi Sample Diameter : 4.72 cm Örnok Royu : 10.30 cm Örnok Kapu Sample Height : 10.30 cm Örnok Alanı : 17.50 cm ² Yaş Örnek Ağırlığı : 509.10 gr Kuru Örnek Ağırlığı : 506.90 gr Örnok Hacmi Sample Weight : 2.82 gr/cm ³ Nom İçeriği : 0.43 % Doğal BHA New İçeriği : 2.82 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.81 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.82 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.81 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.82 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.82 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.81 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.82 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.81 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.82 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.84 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.81 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.81 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.81 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.81 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.81 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.81 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.81 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.81 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.81 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.81 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.81 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.81 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.81 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.81 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.81 gr/cm ³ Kuru BHA Mode of failure Mata Agısı Failure Agısı Failure Agısı Suru Agıs	IVE STRENGTH, (O (ROCK)) Yöntem Method Sünme ölçer With straingaun Id. Şti. İt Körfez Geçişi ve Bağlantı - Izmir Kesimi, Belkahve Rapor Tarihi Report Date : 10.10.201 - Izmir Kesimi, Belkahve Derinlik Depth : 72.70 - Image: Strain Strain Strain Min. Axial Strass, orman : 5.60 MF En Küçük Eksenel Barın Boy Değişimi Min. Axial Strain, Ema En Küçük Çapsal Boy Değişimi : 825.00 × 10 ⁻⁰
Firma Adı / Company Name : Yüksel Domaniç Mühendislik Lt. Gebze - Orhangazi - Izmir (Izmi 'Yolları Dahil) Otoyolu, Manisa - Tüneli (KM: 398+300-402+500 / Kuyu / Çukur No : SK-807 Örnek No Sample No Örnek Capi : 4.72 cm Örnek Boyu : 10.30 cm Örnek Alam : 17.50 cm² Yaş Örnek Ağırlığı : 509.10 gr Kuru Örnek Ağırlığı : 506.90 gr Örnek Hacmi : 180.22 cm³ Nom İçeriği Moisture Content : 0.43 % Doğal BHA Natural Unit Weight : 2.82 gr/cm³ Kuru BHA Doy Unit Weight : 2.81 gr/cm³ Kuru BHA Natural Unit Weight : 132.93 kg/cm² Kurilma Şekli Mode of feilure Kırılma Açısı : 17 Açıklarınalar / Remarks :	Identical Method With straingaue Vol. (ROCK) Method With straingaue Id. Stil. Rapor Tarihi itk Körfez Geçişi ve Bağlantı Report Date - Izmir Kesimi, Belkahve 10.10.201 Arası) Image: Strain
Gebze - Orhangazi - Izmir (Izmi Toneli (KM: 398+300-402+500 / Toneli (KM: 398+300-402+500 / Toneli (KM: 398+300-402+500 / Tonelk (KM: 398+300-402+500 / Tonelk (Zapi Sample Diameter Kuyu / Çukur No Borehole / TPit No : SK-807 Örnek No Örnek Capi Sample Diameter : 4.72 cm Örnek Röyu : 10.30 cm Sample Height : 509,10 gr Wet Sample Keight : 509,10 gr Kuru Örnek Ağırlığı : 506,90 gr Örnek Hami Sample Volume : 180,22 cm ³ Nem İçeriği : 0.43 % Doğal BHA Natural Unit Weight : 2.82 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.31 gr/cm ³ Kuru BHA Natural Compressive Strength : 132.93 kg/cm ² Kurul Başekli : 132.93 kg/cm ² Mode of failure : 17 ° Açıklarmalar / Remarks : : 17 °	It Körfez Geçişi ve Bağlantı - İzmir Kesimi, Belkahve Report Date 10.10.201 - İzmir Kesimi, Belkahve It Beport Date 10.10.201 Arası) It RC-52 Derinlik Depth It 72.70 7 En Küçük Eksenel Basınç Min. Axial Strass, oranı It 5.60 MF En Küçük Eksenel Birin Boy Değişimi Min. Axial Strain, Emin En Küçük Çapsal Boy Değişimi 825.00 x 10 ⁴⁰
Proje Adi / Project Name : Yollari Dahil) Otoyolu, Manisa - Tüneli (KM: 398+300-402+500 Ruyu / Çukur No Borehole / TPit No : SK-807 Örnek No Sample No Örnok Çapi Sample Idiameter : 4.72 cm Örnok Alan : 17.50 cm ² Yaş Örnek Ağırlığı Wet Sample Weight : 509.10 gr Kuru Örnek Ağırlığı Dry Sample Weight : 506.90 gr Örnek Hacmi : 180.22 cm ³ Nom İçeriği : 0.43 % Doğal BHA Natural Unit Weight : 2.82 gr/cm ³ Kuru BHA Natural Unit Weight : 2.81 gr/cm ³ Kuru BHA Natural Unit Weight : 132.93 kg/cm ² Kırılma Şekli Mode of feilure Kırılma Açısı : 17 Açıklarmalar / Remarks :	- Izmir Kesimi, Belkahve Arası) : RC-52 Derinlik Depth : 72.70 - 7 En Küçük Eksenel Basınç Min. Axial Strass, amı En Küçük Eksenel Birlim Boy Değişimi Min. Axial Strain, Emin En Küçük Çapsal Boy Değişimi
Borehole / TPIL No Sample No Grnok Capi Sample Diameter : 4.72 cm Örnok Röyu Sample Height : 10.30 cm Örnok Alani Sample Height : 10.30 cm Örnok Alani Sample Meight : 509.10 gr Yaş Örnek Ağırlığı Wer Sample Weight : 506.90 gr Örnok Haemi Sample Volume : 180.22 cm ³ Nem İceriği Moisture Content : 0.43 % Doğal BHA Natural Unit Weight : 2.82 gr/cm ³ Kuru BHA Dıy Unit Weight : 2.326.00 kg Tok Eksenli Basınç Dayanımı Uniaxial Compressive Strength : 132.93 kg/cm ² Kırılma şekli : : 132.93 kg/cm ² Mode of feilure : : : : : Kırılma Açısı "alure Angie : : : : : Kurü BHA : : : : : : Kurü BHA : : : : : : Kırııma şek	En Küçük Eksenel Basınç Min. Axial Stress, amı En Küçük Eksenel Birim Boy Değişimi Min. Axial Strain, Emin En Küçük Çapsal Boy Değişimi En Küçük Çapsal Boy Değişimi
Sample Diameter : 4.72 cm Örnek Boyu : 10.30 cm Örnek Alanı : 17.50 cm ² Yaş Örnek Ağırlığı : 509.10 gr Kuru Örnek Ağırlığı : 506.90 gr Örnek Hacmi : 180.22 cm ³ Nem Çeriği : 0.43 % Doğal BHA : 2.82 gr/cm ³ Kuru BHA : 2.81 gr/cm ³ Kuru BHA : 2.81 gr/cm ³ Kuru BHA : 2326.00 kg Tok Eksenil Basınç Dayanımı : 132.93 kg/cm ² Kırılma Şekli Mode of Failure Kırılma Açısı : 17	Min. Axial Stress, o min En Küçük Eksenel Birim Boy Değişimi Min. Axial Strain, Emis En Küçük Çapsal Boy Değişimi
Örnek Boyu : 10.30 cm Sample Height : 10.30 cm Örnek Alan : 17.50 cm ² Yaş Örnek Ağırlığı : 509.10 gr Kuru Örnek Ağırlığı : 506.90 gr Örnek Hacmi : 180.22 cm ³ Sample Volume : 0.43 % Doğal BHA : 2.82 gr/cm ³ Kuru BHA : 2.81 gr/cm ³ Kuru BHA : 2.81 gr/cm ³ Kuru BHA : 2.81 gr/cm ³ Kuru BHA : 2.81 gr/cm ³ Kuru BHA : 2.81 gr/cm ³ Kuru Basınç Dayanımı : 132.93 kg/cm ² Tak EkSenli Basınç Dayanımı : 132.93 kg/cm ² Kırılma şekli : 132.93 kg/cm ² Kuru Başaya : 17 * Saya - Saya : 17 * Suiture Angie : 17 * Ku	En Küçük Eksenel Birim Boy Değişimi : 825.00 x 10 ⁻⁰ Min. Axial Strain, E _{min} En Küçük Çapsal Boy Değişimi
Sample Area : 17.50 cm ² Yaş Örnek Ağırlığı Wer Sample Weight : 509.10 gr Kuru Örnek Ağırlığı : 506.90 gr Örnek Hacmi : 180.22 cm ³ Nom İçeriği Moisture Content : 0.43 % Doğal BHA Natural Unit Weight : 2.82 gr/cm ³ Kuru BHA Day Unit Weight : 2.81 gr/cm ³ Kurima Yükü : 2326.00 kg Tek Eksenit Basınç Dayanımı Uniaxial Compressive Strength Kurima şekli Mode of feilure Carima Açısı Salure Angie : 17 °	En Küçük Çapsal Boy Değişimi
Summe Vector gr Vac Örnek Ağırlığı : 509.10 gr Kuru Örnek Ağırlığı : 506.90 gr Örnek Hacmi : 180.22 cm³ Nem İçeriği : 0.43 % Doğal BHA : 2.82 gr/cm³ Kuru BHA : 2.81 gr/cm³ Kuru BHA : 2.326.00 kg Tek Eksenli Basınç Dayanımı : 132.93 kg/cm² Kırılma Yükü : 2326.00 kg Tek Eksenli Basınç Dayanımı : 132.93 kg/cm² Kırılma şekli Mode of Failure	
Wet Sample Weight : 509.10 gr Kuru Örnek Ağırlığı : 506.90 gr Örnek Hacmi : 180.22 cm³ Nem İçeriği : 0.43 % Doğal BHA : 2.82 gr/cm³ Kuru BHA : 2.81 gr/cm³ Kuru BHA : 2.326.00 kg Tek Eksenli Basınç Dayanımı : 132.93 kg/cm² Kurilma Yükü : 2326.00 kg Tek Eksenli Basınç Dayanımı : 132.93 kg/cm² Kurilma Şekli : 132.93 kg/cm² Kurilma Şekli : : 132.93 kg/cm² Kurilma Şekli : : : : Mode of Failure : : : : Kurilma Açısı : : : : Kurilma Açısı : : : : Kurilma Açısı : : : : Kurilma Yükü : : : : M	Min. Lateral Strain, E _{c-min} : -109.00 x 10 ⁻⁶
Dry Sample Weight : : 506.90 gr O'rnek Hacmi : : 180.22 cm ³ Nom İçeriği : 0.43 % Doğal BHA Sutural Unit Weight : 2.82 gr/cm ³ Kuru BHA Dry Unit Weight : 2.81 gr/cm ³ Kurima Yükü : 2326.00 kg Tek Eksenli Basınç Dayanımı Inaxial Compressive Strength Kırılma Şekli Mode of failure Kırılma Açısı allure Angle : 17 ° Cycumu Mutgendisi / Test Responsible Engineer	Max. Axial Stress, σ _{max} : 6.31 MP
Sample Volume : 180.22 cm ³ Nom içeriği Moisture Content : 0.43 % Doğal BHA Natural Unit Weight : 2.82 gr/cm ³ Kuru BHA : 2.81 gr/cm ³ Kurima Yükü : 2326.00 kg Tek Eksenit Basınç Dayanımı Uniaxial Compressive Strength : 132.93 kg/cm ² Kırılma şekli Mode of Failure Kırılma Açısı ialure Angie : 17 ° Açıklamalar / Remarks :	En Büyük Eksenel Birim Boy Değişimi : 962.00 x 10 ⁻⁶ Max. Axial Strain, E _{max}
Moisture Content : 0.43 % Doğal BHA Natural Unit Weight : 2.82 gr/cm ³ Kuru BHA Dry Unit Weight : 2.81 gr/cm ³ Kuru BHA Failure Load : 2326.00 kg Tok Eksenil Basınç Dayanımı Inixiai Compressive Strength : 132.93 kg/cm ² Kuru Şekli Mode of Failure Kuru Açısı allure Angle : 17 ° Carima Açısı allure Angle : 17 °	En Büyük Çapsal Boy Değişimi Max. Lateral Strain, ε_{c-max} : -138.00 x 10 ⁻⁶
Natural Unit Weight : 2.82 gr/cm ³ Kuru BHA : 2.81 gr/cm ³ Kuru BHA : 2.81 gr/cm ³ Kirilma Yükü : 2326.00 kg Tok Eksenli Basınç Dayanımı : 132.93 kg/cm ² Kirilma Şekli Mode of Feilure Kuruma Açısı alure Angle : 17 ° Kırılma Açısı alure Angle : 17	Elastisite Modülus E : 5.18 GP
Dry Unit Weight : 2.81 gr/cm ³ Krrilma Yükü : 2326.00 kg Tok Eksenli Basınç Dayanımı : 132.93 kg/cm ² Krrilma şekli Mode of Failure Kırılma Açısı allure Argie : 17 Curilma Açısı allure Argie : 17	Poisson Oranı Poisson's Ratio v: 0.21
Failure Load : 2326.00 kg Tok Eksenii Basınç Dayanımı Inixizial Compressive Strength : 132.93 kg/cm ² Kırılma şekli Mode of failure Kırılma Açısı allure Angle : 17 ° Açıklarınalar / Remarks :	
Uniaxial Compressive Strength Kurilma şekli Mode of failure Kurilma Açısı allure Argie i 17 Curilma Açısı allure Argie i 17 Deney Sorumlu Metyendisi / Test Responsible Engineer	
Kinima Açısı Alınıma Alınıma A	Eksenel Basınç - Eksenel/Çapsal Boy Değişimi Grafiği
Mode of Failure	Graph of Axial Stress - Axial/Lateral Strain
ailure Angle : 17 Açıklamalar / Remarks : Deney Sorumlu Mutyendisi / Test Responsible Engineer	6.4
ailure Angle : 17 Açıklamalar / Remarks : Deney Sorumlu Mutyendisi / Test Responsible Engineer	6.3 7
ailure Angle : 17 Açıklamalar / Remarks : Deney Sorumlu Mutyendisi / Test Responsible Engineer	6.2
ailure Angle : 17 Açıklamalar / Remarks : Deney Sorumlu Metyendisi / Test Responsible Engineer	5.6 5.7 5.6 5.5 5.5 5.5
ailure Angle : 17 Açıklamalar / Remarks : Deney Sorumlu Metyendisi / Test Responsible Engineer	度 6
ailure Angle : 17 Açıklamalar / Remarks : Deney Sorumlu Metyendisi / Test Responsible Engineer	Š 5.9
ailure Angle : 17 Açıklamalar / Remarks : Deney Sorumlu Metyendisi / Test Responsible Engineer	5.8
ailure Angle : 17 Açıklamalar / Remarks : Deney Sorumlu Mutyendisi / Test Responsible Engineer	5.7
ailure Angle : 17 Açıklamalar / Remarks : Deney Sorumlu Mutyendisi / Test Responsible Engineer	5.6
ailure Angle : 17 Açıklamalar / Remarks : Deney Sorumlu Mutyendisi / Test Responsible Engineer	S ⇔ 5.5
ailure Angle : 17 Açıklamalar / Remarks : Deney Sorumlu Mutyendisi / Test Responsible Engineer	-200 0 200 400 600 800 1000
ailure Angle : 17 Açıklamalar / Remarks : Deney Sorumlu Mutyendisi / Test Responsible Engineer	Lateral Boy Değişimi / Strain (x 10 ⁻⁶) ^{Eksenel}
Açıklarmalar / Remarks : Deney Sorumlu Muttendisi / Test Responsible Engineer	
Deney Sorumlu Mattendisi / Test Responsible Engineer	
Deney Sorumlu Matgendisi / Test Responsible Engineer Karaca KARAKAS, Jeo. Müh / Geo.Eng.	
Deney Sorumlu Mathendisi / Test Responsible Engineer Karaca KARAKAŞ, Jeo. Müh./ Geo.Eng.	
Karaca KARAKAŞ, Jeo. Müh./ Geo.Eng.	Lab. Depotel Müher Politik
	Lab. Denetci Mühendisi I Lab. Supervising Engineer Inci GENÇ, Jeo. Müh./Geo.Eng.
ANT	Belge / Certificate No: 16275
- ///	
Söz konusu deney sonuçları sadece test edilen deney numunelerine aittir. / The test results belond	
Deney sonuçları laboratuvarımız izni olmadan kısmen kopyalanamaz ve çoğaltılamaz./ The test r	g only to the experimental samples brought to the laboratory.
Laboratuvanmiz 4708 sayili kanun gereği T.C.Çevre ve Şehircilik Bakanlığı Yapı İşleri Genel Mi Our laboratory has permit number 316 dated 09/08/2011, provided by the General Directorate of Construction	results can not be conied and reproduced without permission



TEK EKSEN	NLI BA	SINÇ DAYA	NIMI, ELAST	312) 394 53 64 e-mail : lab@lin	1			AND REAL
PO	ISSON	ORANI TA	YINI DENEYI	(KAYA) IVE STRENGTH,	Standart No Standard No	:	1:	SRM
ELAS	STIC MC	DULUS, PO	SSON'S RATI	O (ROCK)	Yöntem Method	:	Sünme With si	e ölçer ile traingauge
Firma Adi / Company Nam	:)	Gebze - Orhar Yolları Dahil) (niç Mühendislik Lt ngazi - İzmir (İzmi Otoyolu, Manisa 18+300-402+500	it Körfez Geçişi ve Bağlantı - İzmir Keşimi, Belkahve	Rapor Tarihi Report Date	:	10.1	0.2012
Achoe / T.Pit No	SK-807		Örnek No Sample No	: RC-88	Derinlik Depth	:	110.50	- 112.0
OmekÇapı SampleDiameter	:	4.70	cm	En Küçük Eksenel B			31.13	MPa
Önek Boyu Sample Height	:	12.66	cm	Min. Axial Stress, σ _{min} En Küçük Eksenel B	irim Boy Değişimi		862.00	x 10 ⁻⁶
ornek Alanı Sample Area	:	17.35	cm ²	Min. Axial Strain, ɛ _{min} En Küçük Çapsal Bo	y Değişimi			
aş Örnek Ağırlığı	:	593.20	gr	Min. Lateral Strain, E _{c-m} En Büyük Eksenel B	ⁱⁿ asınç		-132.00	
Sarrole Weight	:	590.40	gr	Max. Axial Stress, σ _{max} En Büyük Eksenel B			1404.00	MPa
Örnek Hacmi	:	219.64	cm ³	Max. Axial Strain, ɛ _{max} En Büyük Çapsal Bo	y Değişimi			
Nem İçeriği Moisture Content	÷	0.47	%	Max. Lateral Strain, ɛ _{c-n} Elastisite Modülü Elastic Modulus	ax	Е:	-233.00	x 10 ⁻⁶ GPa
Doğal EHA Natural Unit Weight	:	2.70	gr/cm ³	Elastic Modulus Poisson Orani Poisson's Ratio		ι. υ:	0.19	GPa
Vnit Weight	:	2.69	gr/cm ³	TOISSON'S RAID			0.10	
	:	18854.00	kg					
	nımı ,	18854.00 1086.72	kg kg/cm ²	Eksenel Basınç - Eks	enel/Çapsal Boy D	leğişi	mi Grafiğ	įI
Failure Load Tok Eksenli Basınç Dayan Uniaxial Compressive Strength Kırrılma şekli	nımı ,			Eksenel Basınç - Eks Graph of Axial Stress - Ax 60	enel/Çapsal Boy E ial/Lateral Strain	leğişi	lmi Grafiğ))
Faifure Lead To k Eksenli Basinç Dayan Uni avial Compressive Strength Kırılma şokli Mode of failure	nımı ,	1086.72		60 9 55 8 50 9 55 45 45 45 45 40 8 35 9 50 0 60 9 55 8 30 0 0 0 0 0 0 0 0 0 0 0 0 0	enel/Çapsal Boy D ia//Lateral Strain 500 10 ğişimi / Strain (x 1	00	1500	
Faifure Lead Tok Eksenli Basınç Dayan Uni zaial Compressive Strength Kırılma şekli Mo de of failure	nımı ,	1086.72	kg/cm ²	60 9 55 8 50 9 55 45 45 45 45 40 8 35 9 50 0 60 9 55 8 30 0 0 0 0 0 0 0 0 0 0 0 0 0	ia//Lateral Strain	00	1500	
Forflure Lead Tok Eksenli Basınç Dayan Unriavial Compressive Strength Kırrılma şekli Mo de of feiture Kırrılma Açısı aiture Angle Açıklamalar / Remarks :	:	1086.72	kg/cm ²	60 60 55 50 55 45 50 60 55 50 60 55 50 60 55 50 60 55 50 60 55 50 60 60 55 50 60 60 55 50 60 60 60 55 50 60 60 60 55 50 60 60 60 60 60 60 60 60 60 6	ia//Lateral Strain	000 0-6}E	1500 Iksenel Axia	

