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M.Sc. in Civil Engineering

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HASAN KALYONCU UNIVERSITY

GRADUATE SCHOOL OF

NATURAL & APPLIED SCIENCES

EFFECT OF CEMENT BASED GROUT ON DIFFERENT WATER/CEMENT RATIOS ON UNIT SOCKET RESISTANCE FOR GAZİANTEP BASALT STONE

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HASAN BOZKURT

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Effect Of Cement Based Grout On Different Water/Cement Ratios On Unit Socket Resistance For Gaziantep Basalt Stone

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Hasan BOZKURT

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	GRADUATE SCHOOL OF NATURAL & APPLIED SCIENCES INSTITUTE M.Sc. ACCEPTANCE AND APPROVAL FROM

Civil Engineering Department, Civil Engineering Master programme student **Hasan BOZKURT** prepared and submitted the thesis titled **"Effect Of Cement Based Grout On Different Water/Cement Ratios On Unit Socket Resistance For Gaziantep Basalt Stone"** defended successfully at thse VIVA on the date of 29/06/2020 and accepted by the jury as a M.Sc. thesis.

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

Hasan BOZKURT

ABSTRACT

EFFECT OF CEMENT BASED GROUT ON DIFFERENT WATER/CEMENT RATIOS ON UNIT SOCKET RESISTANCE FOR GAZİANTEP BASALT STONE

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The main purpose of this study is to investigate the relationship between unit perimeter friction and uniaxial compressive strength of basalt stone in Gaziantep and surrounding provinces. Basalt stone uniaxial compressive strength is expected to be significant differences in the ventilating and smooth, experiments were carried out for different water-cement ratio conditions on samples taken from different sites in Gaziantep. For Gaziantep basalt stone, especially in hollow rocks, much lower environmental friction and low assumptions were observed than the real situation. For this purpose, this research was needed. In this study, the resistance of grouts has been increased with changes in water-cement ratio, but no serious changes have been detected in unit perimeter friction. The reason for this can be said to be the low tensile strength of concrete. Gaziantep basalt stone was found to be nearly two times stronger than the ventilating stone even though the basalt stone is not close in both ventilating and smooth. As a reason for this, the friction resistance is low since the smooth and gapless carried without holes are high compressive strength and the surface area is smooth. In this study a linear correlation Gaziantep basalt transported unit will be recommended for use in skin friction estimate. Therefore, the lower limit of some methods used in this work would be safer for said design.

Key Words: Compressive Strength, Rock, Basalt, Socket Resistance

ÖZET

ÇİMENTO BAZLI GROUTUN GAZİANTEP BASALT TAŞ İÇİN ÜNİTE SOKET DİRENCİ ÜZERİNE FARKLI SU / ÇİMENTO ORANLARINA ETKİSİ

BOZKURT, Hasan
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Tez Yöneticisi: Dr.Öğr. Üyesi Muhammet ÇINAR
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Bu çalışmanın amacı, Gaziantep ve civar illerde bulunan bazalt taşının birim çevre sürtünmesi ile tek eksenli basınç dayanımı arasındaki ilişkinin deneysel olarak incelenmesidir. Bazalt taşının tek eksenli basınç dayanımının delikli ve pürüzsüz kayaçlar arasında ciddi farklar beklenmektedir, deneyler Gaziantep'te farklı sahalardan alınan bazalt numuneleri üzerinde farklı su-çimento oranındaki durumlar için gerçekleştirilmiştir , Gaziantep bazalt taşı için özellikle delikli kayaçlarda gerçek durumdan çok daha düşük çevre sürtünmeleri ve düşük kabuller görülmüştür.Bunun için bu araştırmaya gerek duyulmuştur. Bu çalışmada su-çimento oranındaki değişimler ile groutların dayanımı artırılmıştır ancak birim çevre sürtünmesinde ciddi değişikler saptanmamıştır.Bunun sebebi olarak groutun düşük çekme dayanımı söylenebilir. Gaziantep bazalt taşının delikli ve deliksiz durumlarda sıyrılma açının çok yakın olmadığı ikisininde bazalt taşı olmasına rağmen deliksiz taşın yaklaşık iki kat dayanım gösterdiği saptanmıştır. Buna gerekçe olarak deliksiz taşın pürüzsüz ve boşluksuz olduğundan basınç dayanımı yüksek iken, yüzey alanı pürüzsüz olduğudan sürtünme direnci düşüktür.Bu ampirik çalışma sonucunda Gaziantep bazalt taşının birim cilt sürtünmesi için bir doğrusal korelasyon önerilecektir.Bu nedenle bu tezde bahsedilen bazı yöntem ve metotların alt limitleri kullanılması tasarımı güvenli tarafta kılacaktır.

Anahtar Kelimeler: Bazalt taşı, Çevre Sürtünmesi, Kaya, Basınç Dayanımı,

To my lovely family

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I sincerely acknowledge the guidance of my research supervisors Asst. Prof. Dr. Muhammet Çınar for his continuous support and additives during this work. I also thanks to Prof. Dr. Hanifi Çanakçı for his valuable additives especially during the experimental works. And I especially thank to my family and my friends for their support and endurance during my works.

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LIST OF SYMBOLS/ ABBREVIATION

AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Societyfor Testing and Materials
ISRM	International Society for Rock Mechanics
MTA	Turkey General Directorate ofMineral Research and Exploration
MEP	Multi Expression Programming
GEP	Gene Expression Programming
LGP	Linear Genetic Programming
UCS	Uniaxial Compressive Strength
CFEM	Canadian Faundation Engineering Manual
LRFD	Load and Resistance Factor Design
LVDT	Linear Variable Differential Transformer
γdry	Dry Unit Weight
γsat	Saturated Unit Weight
Wg	Water Absorption by Weight
q_{dry}	Compressive Strength, Dry
σ_{dry}	Tensile Strength, Dry
USP νdry	USP Velocity, Dry
E_{dry}	Modulus of Elasticity, Dry
q_s	Unit Socket Resistance
P_a	Reference Pressure
q_u	UniaxialCompressive Strength of Rock
b	Empirical Coefficient
pd	Dry Density
md	Dry Weight
Bv	Bulk Volume
Ps	Saturated Density
ms	Saturated Weight
pn	Natural Density

mn	Natural Weight
n	Porosity
pv	Pore Volume
W	Water Content
Ww	Pore Water Weight
f_{ck}	Characteristic Compressive Strength
R	Correlation Coefficient

CHAPTER 1

INTRODUCTION

1.1 General

Basalt constitutes the most common volcanic rock group in nature. They have lava flows spread over very large areas and can sometimes be found to cover hundreds of square kilometers (plateau basalts). The thickness of such lava flows can be in meters or kilometers depending on the topography on which it flows. Basalts can also be found in the form of dyke, sil and flue fillings developed under subvolcanic conditions.

Basalt is a hard, durable gray and black colored volcanic rock and it is widely available in this nature. Basalt rocks are widely used as construction materials such as concrete and asphalt, dam and breakwaters rock fill aggregate, crushed gravel on the basis of railway ballast and airway (Goodman, 1993).

Basalt occurring in Gaziantep region is called Yavuzeli Basalt. This extrusive and basic igneous rock is reddish dark brown; dark gray and blackish colored and very thick layered place to place. It has vesicular amygdaloidal texture. Some of the vesicles are filled with calcite. This unit was generally formed by flow of lava. It overlies on some pyroclastic deposits. These have different ideas about the formation of lava. Some groups illustrate the lava flow of the East Anatolian Fault and other faults related to the main fault. Others explain it with activated tectonic movements during the Middle Miocene (Çanakcı, 2002).

One of the most important structural material has been natural stones in the humanity life since ago hundred years. They have been selected a time in the past and nowadays so their special properties such as their extensive and various types in nature, their workability by simple methods and tools , their high compressive strength etc.

Figure 1.1. Location of Gaziantep city in Turkey where the basalt rock sample are collected

The properties of basaltic rock in Gaziantep in Turkey are considered in this article. The geological map of the study area and the region is shown in Figure 1.1. The rock studied is composed of 1.1 geological structure basalt and pyroclastics. (Tolun & Pamir, 1975) Yavuzeli is called basalt. It was formed in the middle upper Miocene age in Yavuzeli basalt tertiary (MTA, 1994).

In this study, basalt stones were collected in Gaziantep.These samples were cut into cubes. This cylindrical specimen was taken one each from the cube.The cylindrical hole were filled with grout.Then there was grout in cubic uniaxial compressive strength.The results were compared with the literature.

1.2 Thesis sections

The thesis consists of 5 chapters arranged as follows;

The literature review of the general characteristics of basalt is given in section 2.

Experimental studies are described in chapter 3.

Chapter 4 contains test results

Chapter 5 includes the discussion

Suggestions for future studies

CHAPTER 2

LITERATURE REVIEW

2.1 Basalt Stone

Basalt is formed by the flow of solid and basic lavas perpendicular to the cooling surface in the form of columns with five and six sides. Also, the outer parts of the lava that come into contact with the air and the discharge ends may be hollow. This gives the stone a slag appearance. Gas particles coming out of the lava that is cooling provides the formation of these cavities. As you go to the interior of the stone, the gaps become smaller and their number decreases. This type of basalta is called porous basalt. It absorbs more water and absorbs more. The nonporous basalt has a flat structure.

2.1.1 Geochemistry

Volcanic rocks are formed when the magma solidifies at depths quite close to the earth. Magma, which is the main source of volcanic rocks, reaches the earth with a crack, cleft or a channel gap opened as a result of any tectonic event. Due to the fact that the magma is fluid, rich in liquid solutions and under high temperature and pressure, the magma that has not yet solidified, reaches the earth. The liquid magma reaching the earth undergoes a sudden cooling in atmospheric conditions with the physicochemical conditions in the deep and a sudden drop in temperature. Solidified lavas (volcanic rocks) acquire glassy or semi-glassy textures due to environmental conditions.

Various volcanic rocks encountered on earth, according to the ratio of SiO_2 (quartz) in its composition; They are divided into three groups as basaltic (50% SiO_2), andesitic (60% SiO_2) and rhyolitic (70% SiO_2) rocks. Karacadağ volcanics consist of basaltic lavas and very rare pyroclastics. The basic elements in the mineralogical composition of the basalt stone formed as a result of the lava erupted by Karacadağ, an old volcanic mountain; Si, Fe, Mg, Al, Ca, Na, K and Ti are generally known to be of moderately alkaline natüre (Bağırsakçı, 1995).

2.1.2 Physical characteristics

Although the specific weights of basalt, which are considered as the most dense stones, vary between 2.3-2.9, some of their varieties increase to 3.3. Although various types of basalts are very strong and very easy to remove from the hearth, they are very heavy and hard, they restrict their color and appearance, and they are formed by the solidification of the lava, which is a volcanic stone, in the form of five and six-edged columns perpendicular to the cooling surface. Also, the outer parts of the lava that come into contact with the air and the discharge ends may be hollow. This gives the stone a slag appearance. Gas particles coming out of the lava that is cooling provides the formation of these cavities. As you go to the interior of the stone, the gaps become smaller and their number decreases.

2.1.3 Types of Basalt

Turkey, Diyarbakir, Elazig, Gaziantep, Kastamonu, Kahramanmaras, Sivas, Çorlu, Ankara, Manisa is located in Kızılcahamam-Ankara and basalt.It forms wide plains between Diyarbakır, Şanlıurfa, Gaziantep, Fevzipaşa in Southeastern Anatolia or is seen on pointed hills. Basalt lavas, which originate from the Karacadağ volcano in the Piliocene in the Diyarbakır-Şanlıurfa plain, are spread in a circle with a radius of 130-140 kilometers. Southeastern Anatolia Region wideIt is covered with basalt lava. The unit, which started in the vicinity of Diyarbakır, is located within the borders of Mardin and Şanlıurfa. Basalt lava of Karacadağ in the southwest of Diyarbakır has an area of approximately 80 meters thick and 10000 km^2 and it spreads in the form of an ellipse in the north-south direction. Diyarbakır city is located on these basalts.

With the marble sector developing in the Southeastern Anatolia Region in recent years, the fact that basalt, which has a large reserve amount in the region, started to take its place in the industry, contributes significantly to the economy of the region. Basalt be formed in Gaziantep location is called Yavuzeli Basalt. This extrusive and basic volcanic rock is reddy brown; dark gray and darkish colored and very intense layered place to place. It has vesicle amygdaloidal tissue. Some of the vesicles are filled with calcite. The unit was normally formed by flow of lava. It overlies on some deposits. Different types about the formation of this lava. Some groups illustrate the lava flow of the East Anatolian Fault and other faults related to the main fault. Others announces that with the activated tectonic movements during the Middle Miocene (Toktamış, et al., 2017)

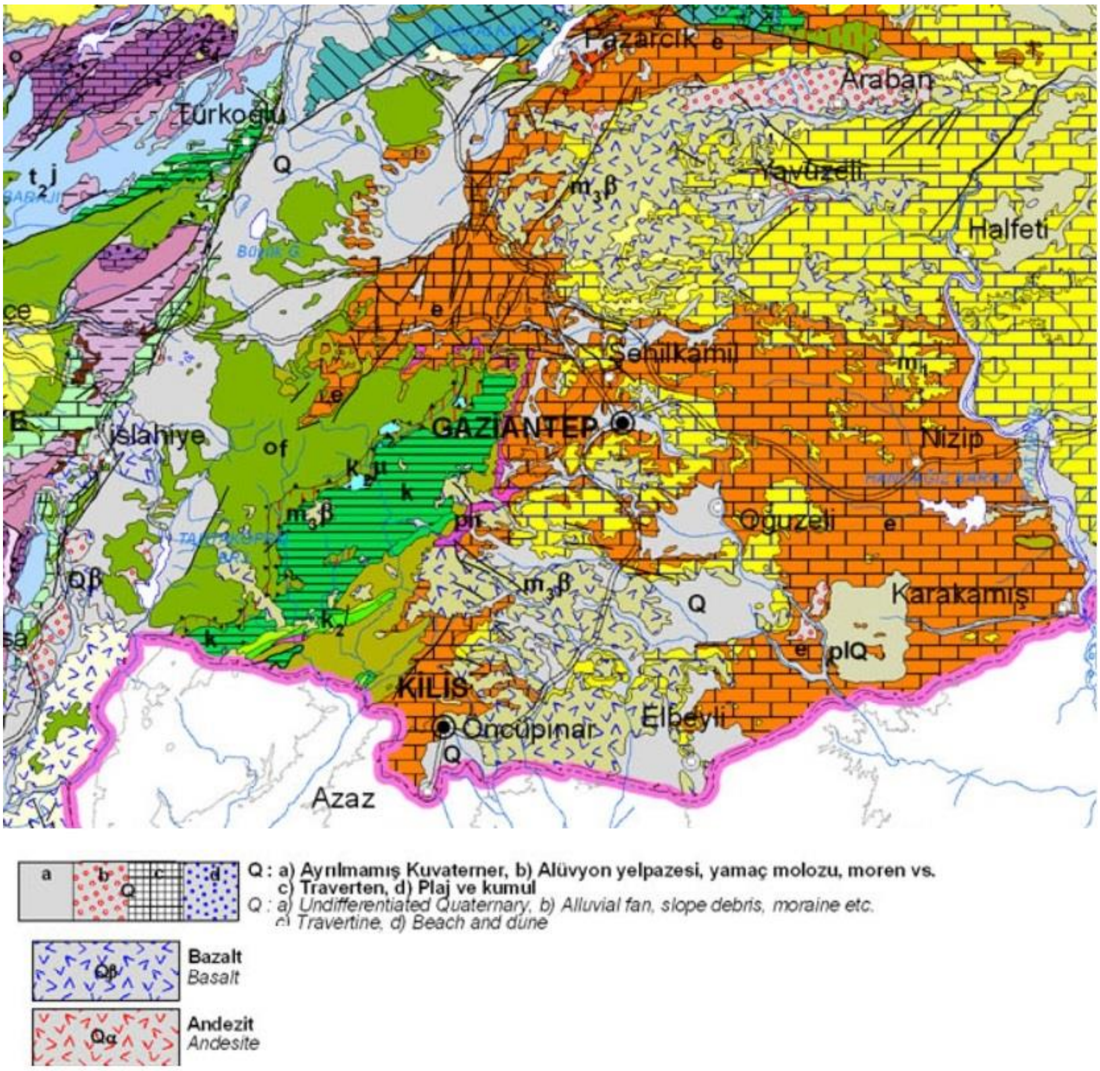

Figure 2.1.MTA Geological Maps Of Turkey 2018

2.1.4 Some Basic Properties of Gaziantep Basalt

In the work given out in the details at the Canakcı (2009); In paper, basalts were collected from Gaziantep region in Turkey.The results get are also in characterizing the Gaziantep basalts for practical applications. Mechanical properties is basaltic rocks within the Gaziantep region . The geological formation of the studied rock is named as Yavuzeli basalt which is composed of basaltic and pyroclastic rocks. The basalt core samples were tested for tensile strength, uniaxial compressive strength , density ,water absorption and ultrasonic pulse velocity. Canakcı et al. (2007) by in this work achieved performing uniaxial pressure tests on a total of 52 cores taken from basalt the results were explored by a series of genetic programming methods defined above. For uniaxial pressure tests, blocks of 150mm height and 60mm diameter were prepared in accordance with ISRM (1981) standards. NX dimesion drill core samples with 2.5 height/diameter ratio were prepared from rock blocks. (ISRM, 1981)

Sample sizes were calibrate in accordance with ISRM for each test. Compressive strengths of the basalt were 20,4 and 119,4 MPa.

Table 2.1. Properties of basalt in Çanakçı (2009)

Test	**Min.**	**Max.**	**Mean**
UCS(Mpa)	20,4	119,4	53
Dry Density (g/cm3)	2,05	2,77	2,44

Çanakcı, et al. (2009) in study gene expression programming (GEP) known as a series of genetic programming techniques using the tensile strength and pressure of the basalt was tried to be estimated. According to the results of this work, the mean value for uniaxial compressive strength (UCS) of basalt is 53 MPa. The results achieved is changed range between 20,4 MPa and 119,4 MPa. When the frequency was examined, it was found that the majority of the samples tested had $50 \leq UCS \leq 100$ MPa.Based on the outcome of this work, the strength of basalt samples used in this study can generally be classified as moderate strength according to ISRM (1981). The same, the uniaxial compressive strength of the blocks import that the samples of basalt, which are tested on the base of the range of values recommended by Ramamurthy and Arora (1993), are mostly in the moderate strength.

Table 2.2. Strength classification of jointed and intact rocks (Ramamurthy ,1993)

Class	Description	UCS (MPa)
A	Very high strength	> 250
B	High strength	100-250
C	Moderate strength	50-100
D	Medium strength	25-50
E	Low strength	5-25
F	Very low strength	<5

2.2 Based Grout

2.2.1 Cement

It is accepted that Portland cement was discovered in 1824 by Joseph Aspdin, a bricklayer in England. Aspdin has obtained a greenish gray cement with superior strength and durability by mixing 3 parts of limestone and 1 part of clay to obtain a suitable composition instead of natural clay limestones and cook at high temperature. Since its color resembles clayey limestones in the Portland peninsula in southern England, the cement was registered under the name Portland Cement. However, similar and more developed cements started to be produced in other countries in the 19th century. In the time that has passed, Portland cement has continuously improved in terms of features and production processes.

Portland cement is generally gray powdered substance. To obtain it, first limestone, clay and, if necessary, some aluminum and iron oxides are proportionally blended and ground to provide the desired chemical composition. The raw material mixture, called Farin, is baked in a rotary oven to a temperature of around 1450 ° C. The grains of raw meal towards the exit end of the furnace form pellets called clinker by melting first and then as a result of various reactions. In order to obtain Portland cement, clinker must be ground with a small amount of calcium sulfate (eg gypsum). It is increasingly common to produce different types of cement during the grinding of calcium sulfate with clinker or by adding some mineral additives to the cement obtained in this way.

The EN 197 standard prepared for General Cements in Europe is also applied as the Turkish Standard TS EN 197 in our country. According to this standard, it is possible to produce “CEM cement” in the following main groups and CEM II 42,5 R was used in the experiment. (SHIRU, 2015)

The amount of mineral additives in CEM II Group is between 6-35%. Depending on the type of additive, the cements in this group take names such as Portland Slag, Portland Fly ash, Portland Puzolanlı, Portland Calcareous and multiple additives can be used together in Portland Composite Cement.

2.2.2 Water

The water to be used in the jet grout application must be fresh water, free from sediment and foreign matter, and it must be kept in sufficient amount. Suspected cases of water or chemical analysis must be done necessarily.

2.2.3 Water-Cement Ratio (W/C)

The strength properties of based are inversely proportional to the water / cement ratio. Basically this means that the based mixture you use more water (too fluid) to mix the based is weaker. The less water (slightly dry but workable) based mixture you use to mix the based is stronger. Concrete mixing accurate ratios can be obtained by measuring scoop or measuring device using another type of dry material.

Besides water content, this largely determines the strength and workability of grout. The amount of water increases, the more concrete workability (more fluid) will have. However, reducing the strength of the grout. If you keep a very low water, the water will be reduced processability. Therefore, it would be difficult to place concrete in such structures. The amount of water may vary for the same volume of grout required for various w/c classes. Therefore, there must be a balance in the construction field during grout mixing (Sallah, 2017).

2.3 Process for Determining Side Friction from UCS

Friction formed between building materials and rocks is known to be a carrier value. It has been studied by researchers for a long time.The reason for this is the friction force between the building material and the rock.For example rock bolts, rock sockets, piles, bored piles, etc.The lateral friction force has a bearing capacity.

The bearing capacities of piles with rock sockets can be calculated by various empirical (experimental) methods. These methods were obtained by back analysis of pile loading experiments. Ground parameter rock free pressure, which is mostly taken into account strength, Pa is its value. Empirical methods generally take into account the environmental and lead capacity separately.

The mechanism of movement on the embedded surface is complex. Cohesion and friction on the surface affect normal tension.There are several suggestions for determining a numerical value.One of them (Serrano & Olalla, 2004) created estimation intervals with empirical methods.

A single-axis pressure test is performed to estimate the lateral friction value formed with pile-rock.Experimental and empirical methods are preferred because it is difficult and expensive to do in reality.There are many methods in the literature review.In researches, UCS directly affected the lateral friction, but in some methods the structure of the rock was not taken into account.It is not thought that the structure of the rock will seriously affect the lateral friction.Some techniques and formulas will be given below.

(CFEM, 2006) in a well-known method is proposed:

$$qs/Pa=b(qu/Pa)^{0.5} \quad (2.1)$$

Compressive strength rock of Pa is in the formula, b is accepted as an empirical value and UCS of rock had been qu.

(Carter & Kulhawy, 1992) proposed the "b" value as 0.63 by move down bounce value while it was recommed as 0.63 - 0.94 for design of limit by Horvath et al (1983). Another study (Rowe & Armitage, 1984) are provided in the b value 1.41.In studies where the lateral friction uniaxial compressive strength are linearly related. Some methods and formulas will be given below in chronological order:

qs = 0.3qu (Reynolds & Kaderabek, 1981) (2.2)

qs = 0.2qu (Gupton & Logan, 1984) (2.3)

qs = 0.15qu (Reese & O'Neill, 1988) (2.4)

qs = 0.25qu (Toh et al.1989) (2.5)

As seen in the above studies, the UCS value ranges from 0.15 to 0.30 for lateral friction on rock.

Some other formulas and methods include on listed:

qs = $0.34qu^{0.51}$(Rosenberg & Journeaux, 1976) (2.6)

qs = $0.21qu^{0.5}$ (Horvath & Kenney, 1979) (2.7)

(as suggested) (AASHTO LRFD, 2007)

qs = 0.22qu$^{0.6}$ (Meigh & Wolski, 1979) (2.8)

qs = 0.21qu$^{0.5}$ (Williams, et al., 1980) (2.9)

The following are formulas that take into account the surface of the rock.:

qs = 0.41qu$^{0.57}$ (Rowe & Armitage, 1984) (2.10)

qs =(0.45-0.6) qu$^{0.5}$ (Rowe & Armitage, 1987) (2.11)

The lower limit value in our work for the socket interface is clean and smooth in all experiments were considered. Rowe and Armitage (1987) study, the existing shaft resistance data were collected in the database.

The above methods and formulas may not be fully compatible with basalt stone. However, friction is used for most of the side surfaces of the formulas in the literature, it was decided to use in this study.Binding between the rock bolts rock surface with an embedded strength, it is another area of use of the side friction value. Elias and Jura (1991), side friction value for basalt studies in 500 to 600 are given in kPa.

Reese and O'neill (1988) and Reynolds and Kaderabek (1981) In another study carried out by the most used methods were analyzed by a trusted database (almost merging all data from literature). The results of the linear relationship that leads to excessive friction values as predicted, the relationship of forces has revealed that perform better for basalt stone.

CHAPTER 3

RESEARCH PLAN AND TEST METHODOLOGY

3.1 Experimental Study

Basalt sample is needed in Gaziantep for the experiment. As a result of the researches, the regions to be sampled were decided. The blocks were taken from the Gaziantep Karataş and Yavuzeli regions. The samples were brought to 150 * 150 * 150 mm (WidthxLengthxHeight) sizes. A total of 24 samples were collected.

Figure 3.1. Karataş Region

Figure 3.2. Basalts Block

This experimental study was carried out in the geotechnical laboratory of Hasan Kalyoncu University. The first part of this study, samples were obtained from different regions of Gaziantep. The dimensions of the blocks were determined as 15x15x15 cm (width-height-height). 24 samples were created while 12 of them were ventilating and 12 were smooth blocks.

Cylindrical samples were taken in the middle of the cubic blocks. Basalt samples were all tested according to the methods recommended in ISRM 2007.Thus, 0.01 Mpa precision UTEST UT 42000 having 0550 bp-type testing machine with a load capacity of each block (FIG 3.x). Examples of height / diameter ratio H / D = 150/60 = 2.50, respectively, and load speed ISRM (2007) from the range 0.7 to 1.0 MPa / s to 0.7 mPa / s was chosen. As a result, each smooth and porous uniaxial compressive strength was determined from each block.

Figure 3.3. Drilling Core (Carrot)

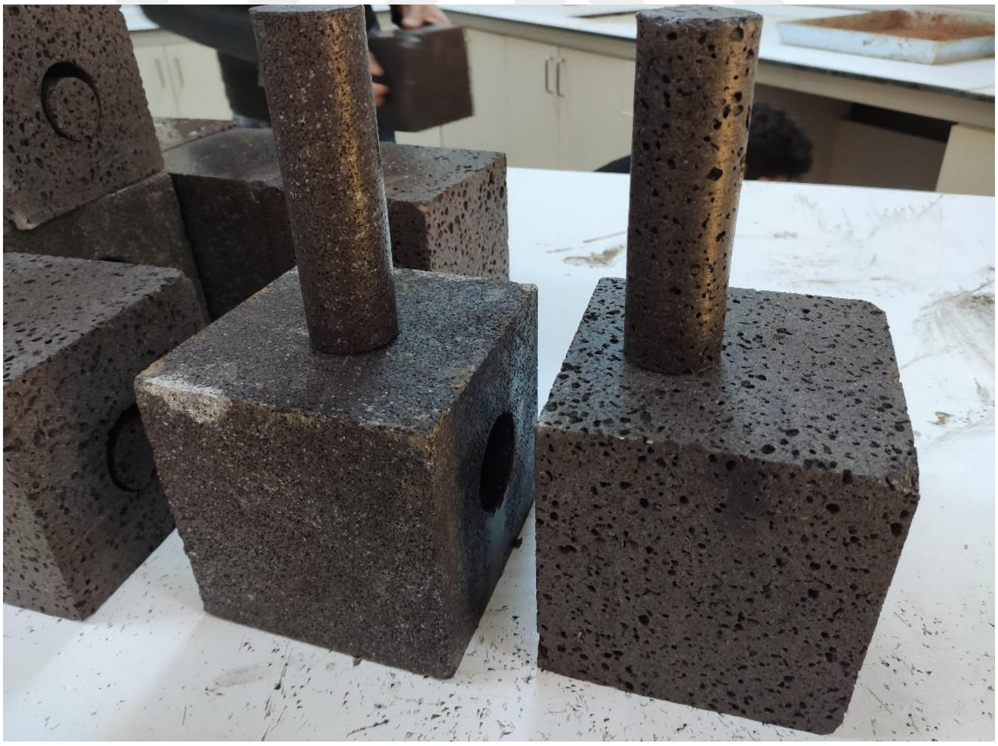

Figure 3.4.A Basalt block after sample taken from the middle

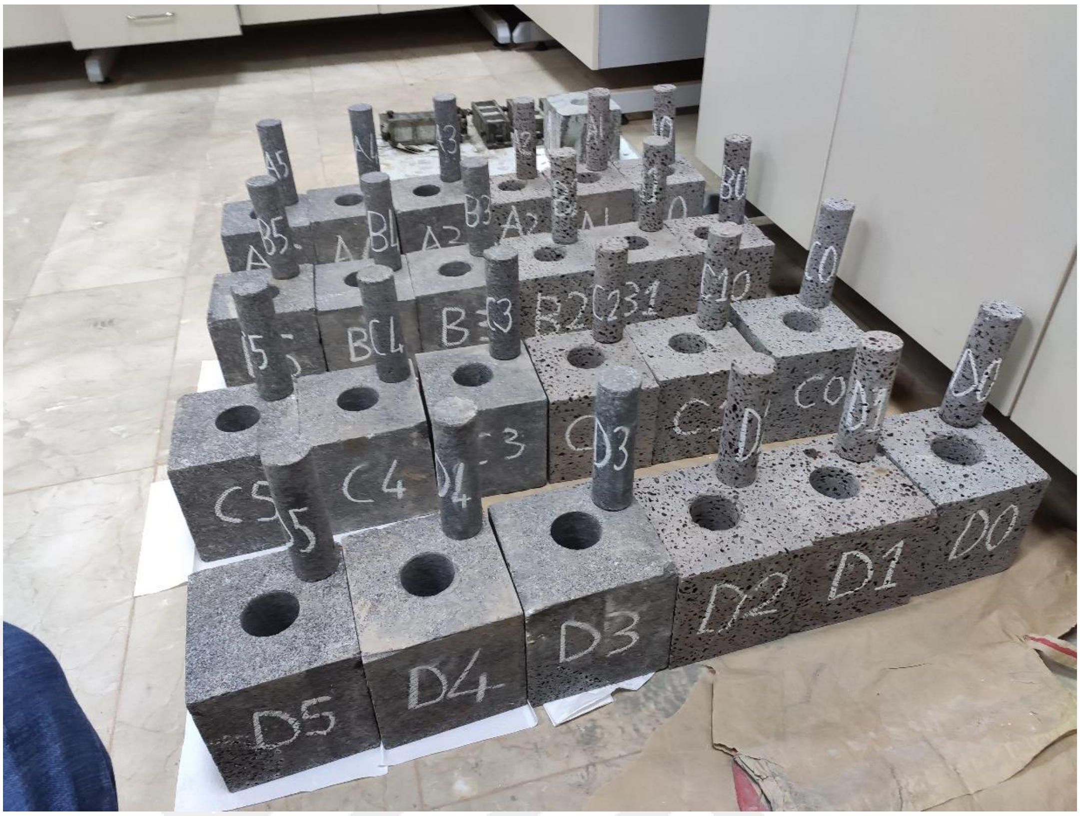

Figure 3.5. Samples were numbered

Figure 3.6. Uniaxial-compression testing device

The experiment consists of a total of 24 basalt stones. 12 samples are ventilating basalt and the other 12 samples are smooth basalt stones. Based with a water cement ratio of 50% was poured into the basalt numbered A and these were examined on the 3rd day, 7th day and 28th day and their pressure resistance. In the same process B samples, the water cement rate was applied as 60% and for each test day, the sample was poured into the core pit taken from a ventilating and smooth basalt and the sample has a 80% water cement rate. D samples have a 100% water cement ratio. Samples were taken from mortars for A, B, C and D samples and pressure resistance test was done on the 3rd day, 7th day and 28th day.

Figure 3.7. Laboratory weigher

Figure 3.8. Infilled concrete sample Uniaxial compression test

Water cement ratios were 50%,60%,80% and 1. Based in these proportions were poured into smooth and porous basalts. CEM II 42.5 cement class was used for concrete production and the characteristic compressive strength was determined according to ASTM C39 (ASTM, 2018) standard .Get the straight compressive strength of poured based. The upper and lower ends of the cylindrical based were cleaned with a suitable scraper before being tested to obtain a plane loading surface. At the end of the third day, uniaxial pressure test was applied to the grout and the sample. It was repeated within 7 and 28 days.

Cylindrical specimen, a sidewall thickness of 45 mm, NX-dimensional samples of holes = IC diameter had been drilled and after the base D was filled 54.7 mm, the hole of the height (H = 150 mm) block.(Basalt = 54.7 mm) for the defense of the unit as the resistance of the blocks as shown in Figure 3.13 certain compression tester (UTEST UTS-0860) was applied.A loading piston is filled based core (DIC = 54.7 mm) slightly smaller diameter (DLP = 50mm) had (Figure 3.14), based connected to charging system kernel to load rock block axially without side friction.In addition, a rigid steel case with a hole in the central with a slightly wider dimeter from the base core (Dh = 65mm) was placed under the block to allow the displacement of the base cylinder in the basalt block to shift (as shown in Figure 11).It was made by (Tabur, 2019). Rigid steel box, the base of the basalt block during testing to maintain any action (widthxlength = 17x34cm) to the larger surface (widthxlength = 15x15cm) had.Unaxial loads, tenderness 0.001% were recorded with a 100 kN load capacity bore.During the tests underwent a displacement-controlled test system. To determine the proper substitution ratio of 0.001 - 0.1 mm / s test is performed on control blocks for the displacement changing ratio for both smooth and ventilating conditions.The resulting side abrasion values for the range of displacement rate tested in a very limited bandwidth (since ± 5%) changed, the displacement rate of 0.01 mm / s is selected.This ratio was considered reasonable to try and displacement time.Each side friction basalt units, the failure of the last load, the lack of immediate success was determined by dividing the internal bore of each inner bore surface contact area.View of the sample block test system and test are shown in Figure 3.11.

Figure 3.9. Steel box and Loading piston

Figure 3.10. Caliper and cydrical sample

Figure 3.11. View during the experiment

CHAPTER 4

TEST RESULTS AND CORRELATIONS

4.1 Experimental Study

As described in the previous sections, the specific gravity of Basalt in this section is referred to by me as the required strength and pressure in the filler.Then, the test results were compared with data from the available literature and comparisons were made on the basis of discussions. Furthermore, the skin resistance of Gaziantep basalts has been appreciated for estimating the single-axis compressive strength (qu) linear linkage of basalt (qs).

4.1.1 Density of Gaziantep Basalt

Some basic properties of basalt were determined during this experiment. While specific gravity of the ventilating blocks varied between 2.27-2.32 g / cm3, the unit weight of the ventilating sample was less than 2.46-2.53 g / cm3. is related to the pores and voids in its structure. These results are in the comparable range with Çanakcı (2009)

Table 4.1. Density of Basalts

Sample Pro.	Sample No	Weight(g)	Volume(cm3)	Density (g/cm3)	Density Ava.
Ventilating	A0	528,7	228	2,32	**2,29 g/cm3**
	A1	518,4	228	2,27	
	A2	523,4	228	2,30	
	B0	519,6	228	2,28	
	B1	521,6	228	2,29	
	B2	518,9	228	2,28	
	C0	524,3	228	2,30	
	C1	522,1	228	2,29	
	C2	528,7	228	2,32	
	D0	522,16	228	2,29	
	D1	522,87	228	2,29	
	D2	523,12	228	2,29	
Smooth	A3	563,6	228	2,47	**2,5 g/cm3**
	A4	577,7	228	2,53	
	A5	568,7	228	2,49	
	B3	561,9	228	2,46	
	B4	576,2	228	2,53	
	B5	569,1	228	2,50	
	C3	577,38	228	2,53	
	C4	567,91	228	2,49	
	C5	568,8	228	2,49	
	D3	572,3	228	2,51	
	D4	576,1	228	2,53	
	D5	569,9	228	2,50	

4.1.2 Compressive Strength in Basalts

As previously described, 24 cylindrical samples were obtained for the uniaxial pressure test. The test procedure, as discussed in the previous section ISRM (1981) were performed according to test procedures. 12 hole basalt stones and 12 smooth basalt stones were tested. The uniaxial compressive strength in basalt samples ranges from qu = 26.25 to 121.86 MPa. Reduction in the uniaxial compressive strength between Gaziantep basalt stone and smooth conditions of the hollow 21:54% - 51.15 acceptable ranges and the results averaged 37%. Results of experiments are given in Table. Examples photographs taken during experiments is given in Figure 4.1 and 4.2.

Table 4.2. Uniaxial Compression Tests Results

Sample Pro.	Sample No	qu (Mpa)	Avarage (Mpa)	Sample Pro.	Sample No	qu (Mpa)	Avarage (Mpa)
Ventilating	A0	35,73	**36,34**	**Smooth**	A3	100,41	**98,05**
	A1	40,40			A4	84,03	
	A2	26,25			A5	121,86	
	B0	40,66			B3	84,59	
	B1	37,05			B4	98,18	
	B2	35,86			B5	111,14	
	C0	38,21			C3	103,40	
	C1	35,05			C4	99,46	
	C2	35,41			C5	101,17	
	D0	37,13			D3	103,20	
	D1	35,97			D4	89,70	
	D2	38,40			D5	79,48	

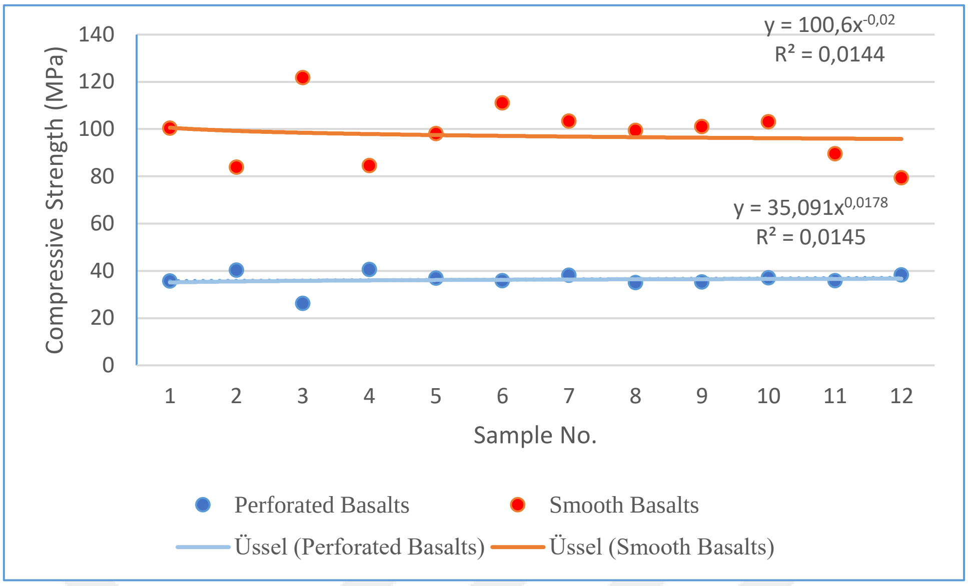

Figure 4.1. Uniaxial Compression Tests Results

Figure 4.2. Ventilating Sample UCS Test

Figure 4.3. Samples UCS Test

4.1.3 Test Result of Infilled Concrete

In order to guide the test program, 24 basalt blocks from two different regions were provided in Gaziantep. Each sample is divided into two as ventilating and smooth.They are filled with W / C based (0.5-0.6-0.8-1.0) ratios.

Infilling based was had water and CEM II 42.5 cement. The blocks, ASTM C39 for determining the compressive strength (ASTM Standards, 2012) according to the recommended test procedures were tested.The compressive strength of the samples is shown in table 5. Therefore, side friction values obtained during the experiments was controlled by the addition of the filler compatibility. A significant difference was observed. A photo taken during the experiments is given in Figure 4.4.

Different W / C ratios were chosen for the experiment. When the water ratio decreased, the workability decreased. However, the mortar resistance increased. The tensile strength was more important than the pressure resistance between the mortar and the basalt surface. The reason for choosing a different W / C ratio was that the mortar was well placed. Results W / C ratio was not very effective in unit skin resistance.

Table 4.3. Different Water/Cement compressive strength on different days

W/C-Days	3 days	7 days	28 days
W/C=0,50	16,49	25,24	31,13
W/C=0,50	18,58	26,44	28,38
W/C=0,50	15,20	26,76	27,21
W/C=0,60	9,78	12,98	20,40
W/C=0,60	8,71	12,13	17,29
W/C=0,60	9,33	11,64	19,47
W/C=0,80	7,56	10,58	9,82
W/C=0,80	7,16	8,58	14,62
W/C=0,80	6,44	10,98	12,80
W/C=1,00	5,69	9,51	10,00
W/C=1,00	6,93	8,89	10,93
W/C=1,00	6,62	6,31	13,56

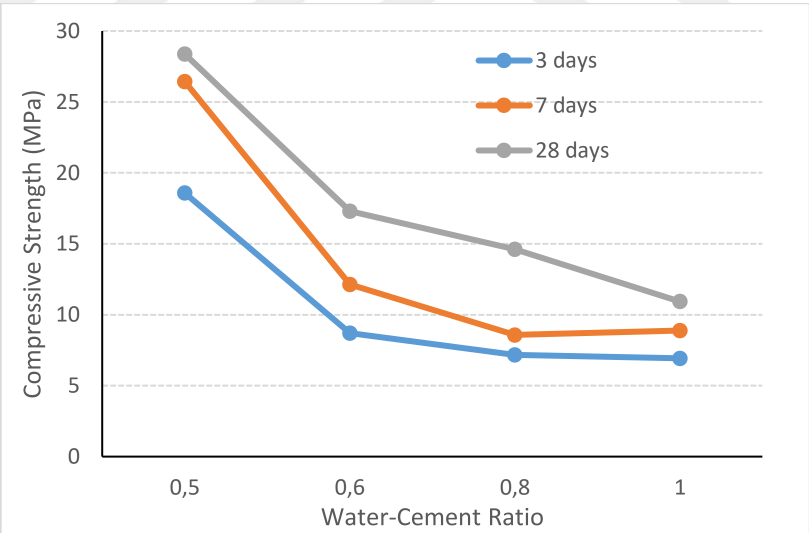

Figure 4.4. Compressive Strength on the grout

Figure 4.5. Cubic based (15x15x15 cm) UCS Test

4.1.4 Unit Skin Resistance of Gaziantep Basalt

The unit socket resistance between grout and Gaziantep basalt was worked by the experimental system established for this design, the information of which was given in the previous chapter of this study. 24 blocks were used in this study. The experiment consists of a total of 24 basalt stones.12 sample ventilating basalt and 12 other smooth basalt stones. The unit socket resistance of the samples were came by dividing the optimum axial load to the drilling core inner surface area of the blocks.

As assumed in this first part of the work, the skin resistance of the smooth block unit is substantially reduced compared to that observed significant ventilating blocks. The unit skin resistance of smooth samples were varying in the range of qs = 14,81-17,35 MPa for a rock uniaxial compressive strength range of qu = 79,48-121,86 MPa. The experiment results have divulge that the unit socket resistance of the ventilating samples were in between qs = 14,89-16,66 MPa for a basalt rock uniaxial compressive strength range of qu = 26,25-40,66 MPa. The unit socket skin resistance of the smooth samples was observed to unchange remarkably as compared to that of ventilating samples. However, significant differences can be said that compared to the compressive strength

Despite the percentage landing in uniaxial compressive strength between ventilating and smooth different water cement ratio conditions of Gaziantep basalt stone is in the 35.40 - 41.96 limited band, the percentage decrease in unit socket skin resistance varies between 22.96 - 63.32%. This reality is attributed to changes in the drilling core inner surface structure of each sample tested. In the observations made, it has been observed that the water cement ratio does not directly affect the surface friction resistance, but it does not affect the compressive strength. The same no difference in the skin resistance was observed between the ventilating and smooth basalts, but compressive strength close to 2 times was determined. However, the socket skin resistance values obtained divulge an interesting behavior designated in detail in the following sections of this section. The socket skin resistance values achieved for each sample block are given in Table 7.

Table 4.4.UCS Results

Sample Pro.		Sample No	qu (Mpa)	Sample No	qu (Mpa)
Ventilating	**wc 0,5**	A0	16,23	A3	16,11
		A1	16,32	A4	16,27
		A2	16,38	A5	16,33
	wc 0,6	B0	16,11	B3	15,96
		B1	16,26	B4	16,25
		B2	16,28	B5	16,22
	wc 0,8	C0	15,97	C3	15,92
		C1	16,2	C4	16,12
		C2	16,11	C5	16,07
	wc 1,0	D0	15,91	D3	15,87
		D1	16,11	D4	16,01
		D2	16,05	D5	15,96

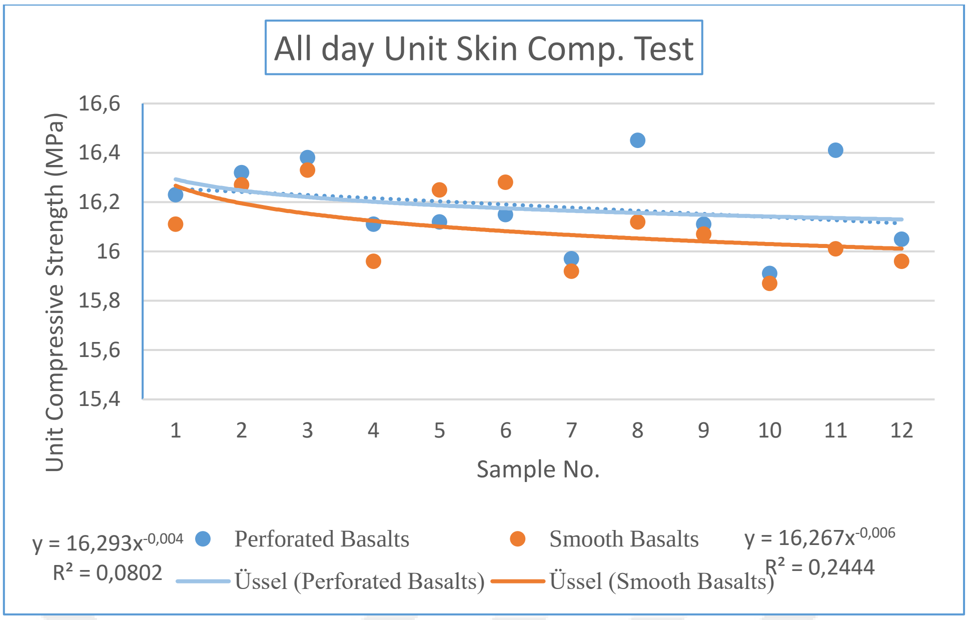

Figure 4.6. Shown UCS in graph

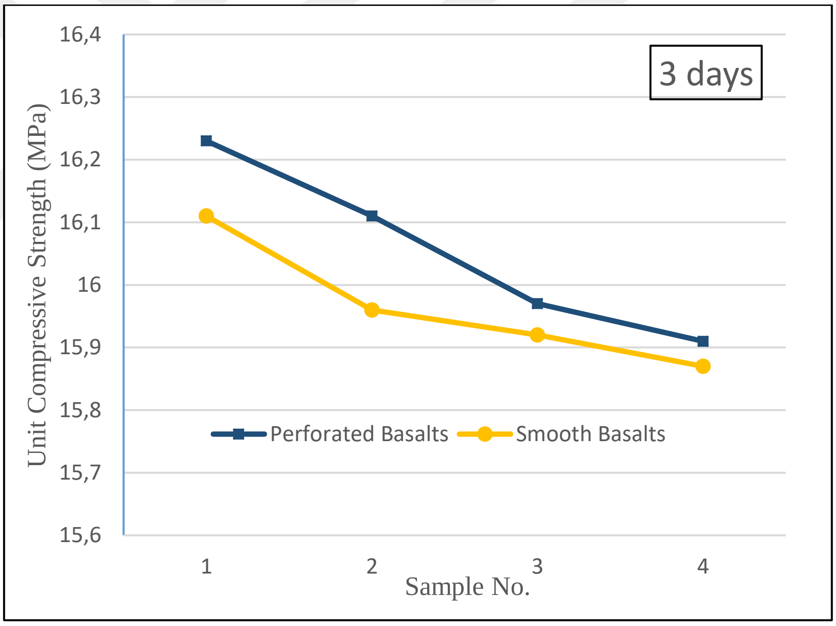

Figure 4.7.UCS test after 3 days

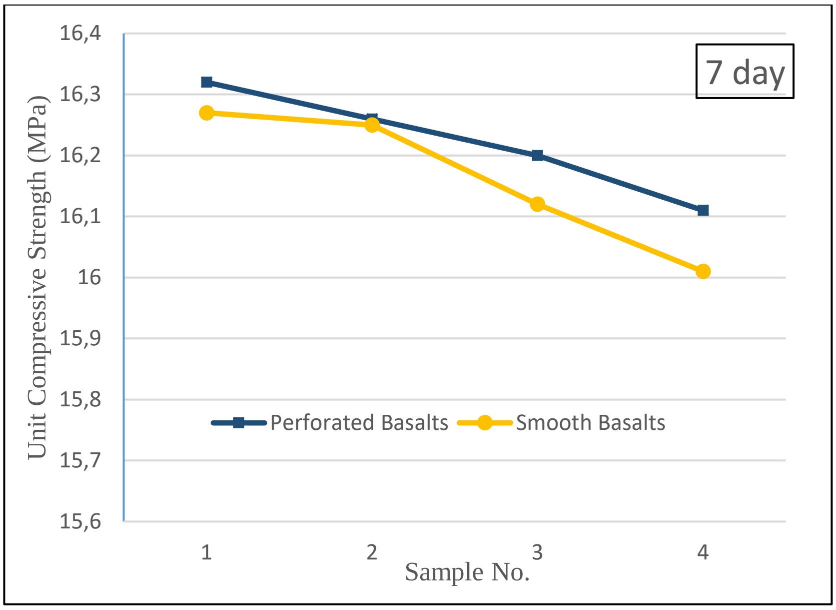

Figure 4.8.UCS test after 7 days

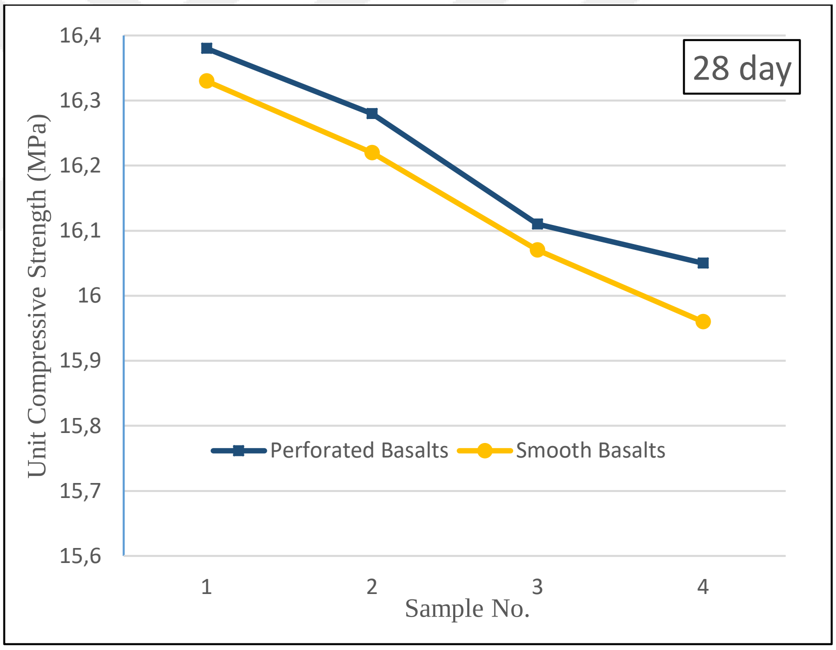

Figure 4.9.UCS test after 28 days

4.2 Discussing the Results

As stated in the previous stages of this thesis, the main purpose is to investigate the change in the unit skin resistance of Gaziantep basalt stone with uniaxial compressive strength under ventilating and smooth basalt change in different water cement rate and conditions.

The relations given in the literature which correlate the uniaxial compressive strength of rocks (qu) with the unit skin resistance (qs) may be divided into two main groups.In literature scans, the relation between unit skin resistance (qs) and uniaxial compressive strength (qu) of rocks can be examined in two parts. Linear correlations of the experimental results are compared with linear correlations in this section was made.

4.2.1 Exploratory Results

As it was dedicated in the literature analysis, the proffer linear correlations of Reynolds and Kaderabek, (1981), Gupton and Logan (1984), Reese and O'neill (1988) and Toh et al. (1989) estimate a unit skin friction changing between 0.15 to 0.30 of the unit compressive strength of the rock (see Equation 2.2 – 2.5). These datas were plotted on Table 7, together with the data get from this experiment. As it can be observe on this table, even the procedure with the approximate linear coefficient (qs = 0,15*qu) significantly estimated unit skin resistance of Gaziantep basalt. This case was also reported by (Akgüner & Kirit, 2011)for a great database of unit skin resistance values achieve for different rock from different places of Turkey. However, it was determined that this situation changed according to the quality of the basalt. Approximate this value (qs = 0.45 * qu) was observed in ventilating basalt. Estimated value can be tricky to safe design.

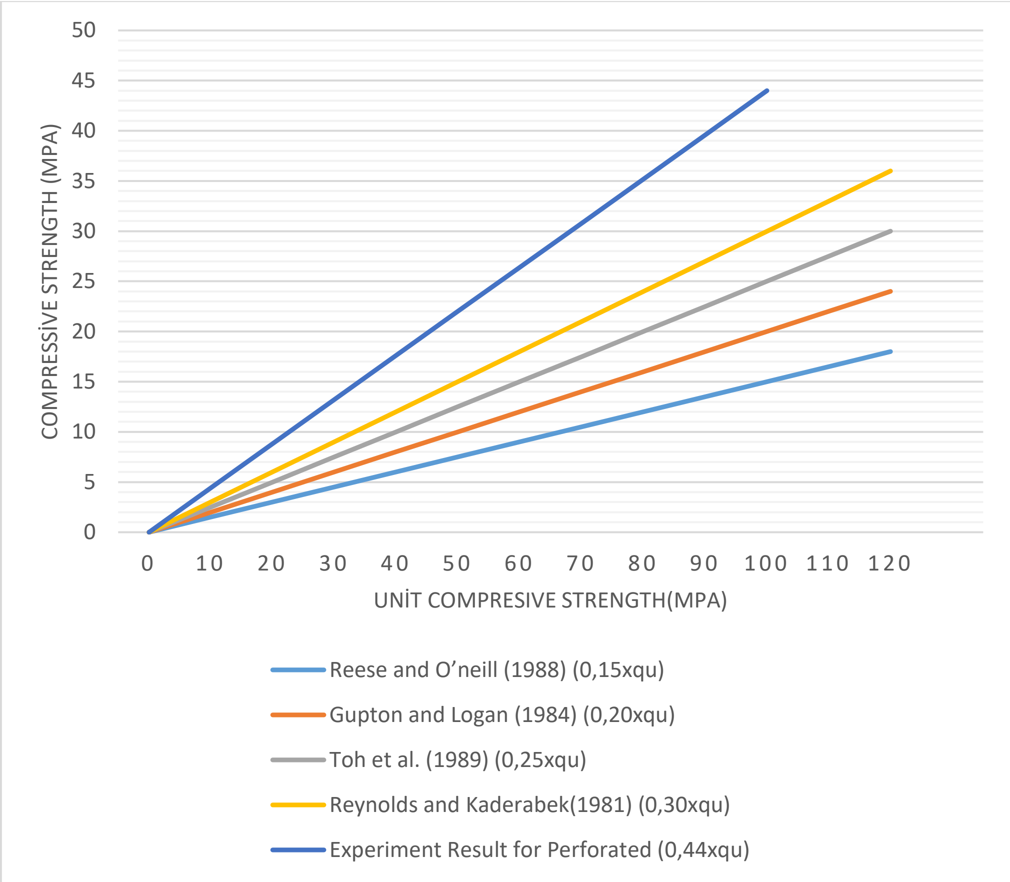

Figure 4.10. Linear Correlations for Comparison of Test Results

CHAPTER 5

CONCLUSIONS

This experiment was performed on basalt stones are located in Gaziantep.Two types of basalt stones were provided. One was a ventilating stone and the other was a smooth stone.Through the experiment, the unit skin friction of Gaziantep basalt was researched experimentally for ventilating and smooth status and the outcomes were correlated with the independ compressive strength of the basalt block.

This rock type, applied to the surface friction pile models were examined.The first inspection was the physical properties of the rock. Ventilating stones were gray, while smooth basalt was dark gray.Hollow rock was thought to be more durable but more resistant.Indeed, it ultimately became.

The secondary examination was carried out in a laboratory environment.They are characterized basalt.Here, specific weights of basalt, compressive strength and unit skin friction were calculated.When the hand is reasonable, and the results were compared with literature results obtained close.

In order to direct the test program, 24 basalt blocks were procured from rocks different two sites in Gaziantep. Each sample is divided into two as ventilating and smooth. They were infilled with based in W / C (0.5-0.6-0.8-1.0) ratios.As a result, 24 independ compressive strength tests and 24 skin friction resistance tests were carried out at the geotechnical laboratory of HKU besides the already defined ratio and concrete ucs tests.Different W / C ratios were selected for the experiment.When the water rate decreased, the workability decreased.However, grout resistance increased.Tensile strength was more important than compressive strength between grout and basalt surface.The reason for choosing a different W / C ratio is that the grout is well placed and the pores are filled.Results It was found that W / C ratio is not very effective in unit skin resistance.W / C ratio should be selected according to the loads to be carried by the piles.It was determined that it did not affect the lateral friction.The reason for this is that there is no change in the surface structure of the grout.

Only compressive strength was affected.The strength of the ventilating basalt stones was found to be lower than that of smooth 36.10 – 42.86% (≈40%). However, they still showed approximately equal unit friction resistance. It exceeded the predictions in the literature review.The reason for this can be said that the holes on the surface increase the friction coefficient.

The unit skin resistance of the basalt rock single axis was often associated with a relative compressive strength in the literature. Unit that provides a correlation between skin friction resistance and uniaxial compression strength in the linear part methods may be categorized. The results of this study were compared with both the linear correlation.

In comparison with known linear connection of the unit of skin resistance it is measured in Gaziantep basalt are set forth with particularly significant linear correlations from both smooth bore and patients. Alternatively, with a moderate correlation coefficient for two new linear correlation was suggested basalt Gaziantep

The comparison by the linear relationships have divulge that the unit skin resistance of Gaziantep basalt was significantly low estimated by the linear correlations for ventilating rock. Otherwise a new linear correlation was recommed for Gaziantep ventilating basalt with a sensible correlation coefficient

Consequently, in this study, the upper and lower limits values that can be used in calculating unit skin friction in Gaziantep basalt stone are determined.It is determined that uniaxial compressive strength depends on the condition of the surface. It is concluded that the structure and strength of the rock is important. It is sensible to use the lower bound solutions of Reese and O'neill, (1988) and this study.

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