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THE INVESTIGATION OF EFFECT OF SAND CONTENT ON SHEAR STRENGTH, COMPACTION AND COMPRESSIBILTY OF FIBROUS PEAT

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The Invastigation of Effect of Sand Content on Shear Strength, Compaction And Compressibility of Fibrous Peat

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Assoc.Prof.Dr. Hanifi ÇANAKÇI

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Fatih ÇELİK

ABSTRACT

THE INVESTIGATION OF EFFECT OF SAND CONTENT ON SHEAR STRENGTH, COMPACTION AND COMPRESSIBILTY OF FIBROUS PEAT

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Peat is totally or partially changed remains of dead plants which were accumulated under water for houndred to thousands of year. Peat can be generally seen in thick layers in limited areas, has high compressive deformation and low shear strength which often cause some difficulties when construction work is made on this deposit. The organic soil used in this study was obtained from Sakarya region, Turkey. In all tests the fibrous peat samples that remain on #100 (0.15 mm) sieve size and are called as fiber were used (ASTM D 1997-91). This organic soil is classified as Peat by Unified Soil Classification System (USCS). The rounded sand used for the test is poorly graded passing from 2 mm sieve size and retaining on 1 mm sieve size. The main reason of selecting this sieve range is to minimize the effect of size of the sand partical on test results. Standart compaction, direct shear and consolidation tests were done to observe the effect of the sand content on the compacted fibrous peats. Compaction test results were taken as reference to prepare the mixtures used in direct shear and consolidation tests. The mixtures were prepared as % 10,% 20,% 30,%40 and % 50 sand content respectively. All tests results showed that when sand content increases, optimum moisture content decreases on the other hand maximum dry density increases ; cohesion of peat decreases but internal friction angle increases with strong linear correlation; void ratio decreases and also C_c and C_r decreases; m_v firstly increases but then it starts to decrease.

Key Words: Fibrous peat, rounded sand, compaction, shear strength, consolidation of peats, soil improvement, classification of peats, moisture content, ash content.

ÖZ

KUM İÇERİĞİ'NİN LİFLİ ORGANİK ZEMİNLERİN KOMPAKSİYON,KESME DAYANIMI VE KONSOLİDASYON ÖZELLİKLERİ ÜZERİNDE Kİ ETKİSİ ÜZERİNE BİR İNCELEME

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46 sayfa

Sulak arazilerde su altında yüzlerce-binlerce yıl biriken ölü bitki kalıntılarının tamamının yada bir kısmının yapısının değişmesi ve bozulması sonucu oluşan zeminlere turba (peat) zeminler denir. Bu tür zeminler genellikle ince tabakalar halinde bulunur ve çok yüksek sıkışma deformasyonlarına ve çok düşük kayma dayanımına sahiptirler. Bu sebepten bir yapının inşaası esnasında bazı problemleride yanında getirirler. Bu çalışma boyunca kullanılan organik toprak Türkiye'nin Sakarya bölgesinden sağlanmıştır. Bütün deneylerde 100 nolu elek üzerinde kalan lifli organik toprak kullanılmıştır (ASTM D 1997-91). Bu toprak birleştirilmiş zemin sınıflama tekniğine (USCS) göre turba (peat) diye sınıflandırılmaktadır. Deneylerde 2 mm elek çapından geçen, 1 mm elek çapı üzerinde kalan dere kumu kullanılmıştır. Sıkıştırılmış lifli organik zeminlere kum içeriği değişiminin etksini gözlemlemek için kompaksiyon, direk kesme ve konslidasyon deneyleri yapılmıştır. Direk kesme ve konsolidasyon deneyleri için hazırlanan karışım numuneleri, kompaksiyon deneylerinde ki sonuçlar referans alınarak hazırlanmıştır. Bütün deney sonuçları göstermiştir ki; organik toprak içerisindeki kum içeriği arttığında, optimum su muhtevası azalmakta diğer taraftan kuru birim hacim ağırlık artmaktadır; organik toprağın kohezyonu azalmakta fakat içsel sürtünme açısı güçlü liner bir ilişkiyle artmaktadır; boşluk oranı, C_c ve C_r değerleri azalma göstermektedir; m_v değeri ise başlangıçta artarken sonrasında azalma eğilimi göstermektedir.

Anahtar Kelimeler: Lifli turba, dere kumu, kompaksiyon, kesme dayanımı, konsolidasyon, zemin iyileştirme, sınıflandırma, su muhtevası, kül içeriği.

To My Parents

ACKNOWLEDGEMENTS

This dissertation has been completed under the guidance of my advisor, **Assoc. Prof. Dr. Hanifi ÇANAKÇI.** Without his support, inspiration, dedication of time and energy throughout the past year, I could have never completed this work. I owe forever my sincerest gratitude to him, for opening my eyes to the innovative soil mechanic technology world, and for challening me with novel research ideas capable of solving real-world problems.

I also would like to thank to my best friends **Mustafa ŞAHAN** and **Ali AK** for their helps and valuable suggestion.

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CONTENTS **Pages**

LIST OF FIGURES

PAGES

LIST OF TABLES

PAGES

LIST OF SYMBOLS/ABBREVIATIONS

A	Cross sectional area of specimen in shear box test
CD	Consolidated drained test
c_u	Undrained shear strength
C_f	Function of clay content
c'	Cohesion intercept in terms of effective stresses
c	Cohesion intercept in terms of total stresses
D_r	Relative density
d	Diameter
e	Overall void ratio of soil
e_0	Initial void ratio
e_{cv}	Critical void ratio
e_{max}	Maximum void ratio
e_{sk}	Skeleton void ratio
f	Ratio of weight of fines to total weight of solids
h	Height
I_p	Plasticity index
LL	Liquid limit
N	Normal load
N_{60}	SPT blow count corrected for field procedures
OCR	Over consolidation ratio
P_h	Horizontal load
PI	Plasticity index
P_v	Vertical load
s_u	Undrained shear strength
T	Maximum torque
UU	Unconsolidated undrained
u	Pore water pressure
ψ	Angle of dilation

ε_v	Vertical strain
ϕ	Friction angle in terms of total stresses
ϕ'	Friction angle in terms of effective stresses
ϕ'_{max}	Maximum angle of shearing resistance
ϕ'_{cv}	Critical angle of shearing resistance
ϕ'_u	True angle of friction
λ	Unit weight
σ_f	Normal stress on failure plane
σ'	Effective normal stress
σ'_3	Effective minor principal stress in triaxial test
τ	Shear stress in shear box test and drained shear strength
τ_f	Shear stress on the failure plane
τ_u	Undrained shear strength

CHAPTER I

INTRODUCTION

1.1 Background

The main construction problem related to structure on soft soils such as peat are large compressibility and low shear strength .Especially ,because of low dry density high water content and low shear strength occurs in organic soil exceptionally. In addition, since the decomposition is still going on in organic soil, any structure of the stability constructed on peat soil could be affected by the mostly change of peat soil with time. Therefore, the construction build on peat deposit may cause excessive settlement and bearing capacity failure. Because of the low bearing capacity and hence the low shear strength, a surface foundation must be improved with respec to peat soil before construction works can begin. Suitable solution could be thought as replacing the poor soil by suitable soil using for fill . However this application may be very expensive. In addition , since waste excavated soil can be removed within an economically acceptable haul distance has to be needed (Jarret, 1997).This method also need maintenance work with respect to horizontal removing and long term consolidation (Magnan, 1994).

There are two types of peat: amorphous peat and fibrous peat (ASTM D4427). The compressibility behavior of the amorphous peat is known to be similar with clay soil which can be evaluated based on Terzaghi's theory of consolidation. Fibrous peat is peat with high organic and fiber content with low degree of humification. The behavior of fibrous peat is different from mineral soil because of different phase properties and microstructure (Edil, 2003), thus Terzaghi's theory of consolidation cannot be applied to predict the compression behavior of fibrous peat.

Many researchers (Berry and Poskitt, 1972; Ajlouni, 2000; Robinson, 2003) have examined fibrous peat from different parts of the world and their findings are quite different from one and another due to different content of peat soils. The properties of peat soils such as natural water content, acidity, degree of humification, fiber content, shear strength, and compressibility is affected by the formation of peat deposit. This indicates that in term of content, fibrous peat is different from one location to another location and detailed soil investigations need to be conducted for fibrous peat at a particular site where a building is intended to be constructed. The difference becomes particularly apparent especially under low vertical stresses or shallow depth. Thus assessment on the response of peat deposit to loading should be made before any construction has to take place at a particular site.

Most of the methods to predict compressibility characteristics of soil are developed based on the results of laboratory consolidation test. Several test methods have been used to study the compressibility of different type of soil including peat. The oldest and the most popular one is the conventional Oedometer test. This test is still used as a standard consolidation test method in Türkey as well as in many parts of the world.

The method used to assess the shear strength of peat is not well defined yet. For a fibrous peat, the shear strength can be determined in laboratory by the direct shear test which is a drained test. Most peat is considered frictional or non-cohesive material (Adam, 1965) due to the fiber content, thus the shear strength of peat is determined based on drained condition as: $\tau_{f} = \sigma_n \tan\Phi$. Direct shear and triaxial have been used to determine the shear strength of peat soil although the results of triaxial test on fibrous peat are difficult to interpret because fiber often act as horizantal reinforcement, so failure is seldom obtained in a drained test. In addition, triaxial test in drained condition may take several weeks for peat with low permeability.

1.2 Research Objectives and Scopes

The main objectives of this study are given as follows:

1) To determine engineering properties of the fibrous peat soil collected from Sakarya region, Turkey.

2) To observe how the rounded sand added in different ratios by mass into the fibrous peat soil used in the test affect on the compaction parameters of this soil.

3) To investigate the effect of the granular soil defined as rounded and between 1 mm and 2 mm sieve sizes on the shear strength properties of the compacted fibrous peat soil used in the study.

4) To observe the effect of the granular soil defined as rounded and between 1 mm and 2 mm sieve sizes on the consolidation parameters of the compacted fibrous peat soil used in the experiments.

In Chapter 2, engineering properties of fibrous peats, compaction properties of fibrous peats, shear strength properties of fibrous peats and consolidation properties of fibrous peats were given from literature. Chapter 3, experimental program , materials properties and test on compaction, shear strength and consolidation properties of fibrous peats were discussed. The results of the experimental studies were presented and discussed in Chapter 4. The conclusions of the research were presented in Chapter 5.

CHAPTER II

LITERATURE REVIEW

2.1 Organic Soil

2.1.1 Definition

Peat soil is defined as a mixture of fragmented organic material formed in wetlands under appropriate topographic and climatic conditions and it is come from vegetation that was chemically decomposed and fossilized (Edil and Dhowian, 1980). Peat is totally or partially changed remains of dead plants which were accumulated under water for houndred to thousands of year. Peat can be generally seen in thick layers in limited areas, has high compressive deformation and low shear strength which often cause some difficulties when construction work is doing on the deposit (Anggraini,2006).

Peat has high organic content that would exceed 75 %. The organic contents of peat are basically the plant remains for which rate of decay is slower than the rate of accumulation. The content of peat soil differs from location to location due to the factor such as humidity, temperature and the origin of fiber. Decomposition involves the loss of organic matter either in solution or in gas, the vanishing of physical structure and the change in chemical state (Huat, 2004).

Peat is usually found as an extremely loose, wet, unconsolidated surface deposit which forms as an integral part of a wetland system, therefore access to the peat deposit is usually very difficult as the water table exists at, near, or above the ground surface. The peat deposit is generally found in thick layers on limited areas.

Edil and Dhowian, 1979; Edil and Dhowian, 1981) have found that the behavior of amorphous peat is similar to clay soil, thus evaluation of its compressibility characteristics can be made based on Terzaghi one-dimensional theory of consolidation. Fibrous peat is the one that consists of fiber content more than 20 % (ASTM D4427). The behavior of fibrous peat is very different from clay due to the existence of the fiber in the soil. The fibrous peat has many void spaces existing between the solid grains. Due to the irregular shape of individual particles, fibrous peat deposits are porous and the soil is considered as a permeable material. Therefore the rate of consolidation of fibrous peat is high but the rate decreases significantly due to consolidation.

2.1.2 Physical and Chemical Characteristic

Variability of peat is extreme both horizontally and vertically. The variability results in a wide range of physical properties such as texture, color, water content, density, and specific gravity. The results of previous researches on the physical properties of peat around the world are presented in Table 2.1.

Fibrous peat generally has very high natural moisture content to absorbe more water keeping capacity. Soil content, defined by organic coarse particles, holds a very huge amount amount of water because the coarse particles are generally very loose, and the organic particle includes largely full of water and hollow. Unit weight of peat is lower than inorganic soils. The unit weight of water is about equal to or slightly lower to compared to the average unit weight of fibrous peat. Sharp reduction of unit weight was defined with respect to increasing of water content.

The percentage and composition of the organic content is an important parameter for specific gravity of peat .When an organic content is greater than 75 %, the specific gravity of peat ranges between 1.3 and 1.8 with an average of 1.5 (Davis, 1997). Because of the lower specific gravity low mineral content and low degree of decomposition occurs. The inorganic soils is generally lower than that of natural void ratio of peat because of their higher capacity for compression. The range of natural void ratio is changing as 5 – 15 respectively and a value as high as 25 was reported for fibrous peat (Hanrahan, 1954).

In general, peat soils are so acidic with low pH values, often ranges between 4 and 7 (Lea, 1956). Chemically, peat contains small amount of nitrogen, oxygen, hydrogen, and carbon. Previous researches (Soper and Obson, 1922; Chynoweth, 1983; Schelkoph et al., 1983; Cameron et al., 1989) showed that the percentage of small amount of nitrogen, hydrogen, and oxygen are in the ranges of 40-60 %, 20-40 %, 4-6 %, and 0-5 % respectively.

Table 2.1 Physical properties of peat based on location (Huat, 2004)

Soil deposits	Natural water content (ω_o, %)	Unit weight γ (kN/m^3)	Specific gravity (G_s)	Organic content (%)
Fibrous peat Quebec	370-450	8.7-10.4	-	-
Fibrous peat, Antoniny Poland	310-450	10.5-11.1	-	65-85
Fibrous peat, Co. Offaly Ireland	865-1400	10.2-11.3	-	98-99
Amorphous peat, Cork, Ireland	450	10.2	-	80
Cranberry bog peat, Massachusetts	759-946	10.1-10.4	-	60-77
Peat Austria	200-800	9.8-13.0	-	-
Peat Japan	334-1320	-	-	20-98
Peat Italy	200-300	10.2-14.3	-	70-80
Peat America	178-600	-	-	-
Peat Canada	223-1040	-	-	17-80
Peat Hokkaido	115-1150	9.5-11.2	-	20-98
Peat West Malaysia	200-700	8.3-11.5	1.38-1.70	65-97
Peat East Malaysia	200-2207	8.0-12.0	-	76-98
Peat Central Kalimantan	467-1224	8.0-14.0	1.50-1.77	41-99

2.1.3 Classification

The geotechnical characteristic, physical, and chemical used for classification of inorganic soil may not be suitable to the defining of peat. On the other side, properties which are not relevant to inorganic soil may be important for classification of peat. Moreover, the ranges of values applied for some properties of inorganic soil may not be relevant for peat soil. Generally, the classification of peat soil is developed based on the decomposition of fiber, the vegetation forming the fiber content, and organic content.

Von Post (1922) proposed the classification of peat based on the degree of decomposition in which the degree of decomposition is ranged into H_1 to H_{10}: when the number increase , the degree of decomposition increae also (Table 2.3).

Organic content is the most common used classification system in geotechnics (Table 2.4). Ash content is defined as the percentage of ash to the weight of dried peat. In addition, the peat is classified according to fiber content because the consolidation process of fibrous peat from that of organic soil or amorphous peat can be changed by presence of fiber. If fiber content is less than % 20 in any organic soil, this soil is called as amorphous peat (ASTM D4427). It includes mostly particles of colloidal size (less than 2 microns), and it absorbe the pore water around the particle surface. There are some similarities between the behavior of amorphous granular peat and clay soil. If fiber content is more than % 20 this soil is called as fibrous peat (ASTM D4427).

Generally while peat is classifying, consistency or atterberg limit is not used because there is a little indication to define the characteristics of peat with plasticity (Hobbs, 1986) and because of existence of fiber it is difficult or impossible to estimate the plastic limit and liquid limit of peat. Nevertheless, the liquid limit and plastic limit of fibrous peat soil was reported by some researchers (Huat, 2004). However these estimations are possible for amorphous or granular peat (MacFarlane, 1969).

Table 2.2: Classification peat soil from von Post (Huat, 2004)

Condition of peat before squeezing				Condition of peat on sequeezing		
Degree of Humifi cation	**Soil color**	**Degree of decompo-sition**	**Plant structure**	**Squeezed solution**	**Material extruded (passing between fingers)**	**Nature of Residue**
H_1	White or yellow	None	Easily identified	Clear, color-less water	Nothing	Not pasty
H_2	Very pale brown	Insignifi-cant	Easily identified	Yellowish water/pale brown-yellow	Nothing	Not pasty
H_3	Pale brown	Very slight	Still identified	Dark brown, muddy water not peat	Nothing	Not pasty
H_4	Pale brown	Slight	Not easily identified	Very dark brown muddy water	Some peat	Some what pasty
H_5	Brown	Moderate	Recognizabl e but vague	Very dark brown muddy water	Some peat	Strongly pasty
H_6	Brown	Moderately strong	Indistinct (more distinct after squeezing)	Very dark brown muddy water	About one-third of peat squeezed out	Very strongly pasty
H_7	Dark brown	Strong	Faintly recognizable	Very dark brown muddy water	About one-half of peat squeezed out	Very strongly pasty
H_8	Dark brown	Very strong	Very indistinct	Very dark brown pasty water	About two-third squeezed out	Very strongly pasty
H_9	Very dark brown	Nearly complete	Almost recognizable	Very dark brown muddy water	Nearly all the peat squeezed out as fairly uniform paste	Very strongly pasty
H_{10}	Black	Complete	Not discernible	Very dark brown muddy paste	All the peat passes between the fingers; no free water visible	N/A

Table 2.3: Classification of peat based on organic and fiber content

Classification peat soil based on ASTM standards	
Fiber Content (ASTM D1997)	Fibric : Peat with greater than 67 % fibers
	Hemic : Peat with between 33 % and 67 % fibers
	Sapric : Peat with less than 33 % fibers
Ash Content (ASTM D2974)	Low Ash : Peat with less than 5 % ash
	Medium Ash : Peat with between 5% and 15 % ash
	High Ash : Peat with more than 15 % ash
Acidity (ASTM D2976)	Highly Acidic : Peat with a pH less than 4.5
	Moderately Acidic : Peat with a pH between 4.5 and 5.5
	Moderately Acidic : Peat with a pH between 4.5 and 5.5
	Slighly Acidic : Peat with a pH greater than 5.5 and less than 7
	Basic : Peat with a pH equal or greater than 7

2.2 Some Studies on Engineering Properties of Fibrous Peats

2.2.1 Shear Strength Properties of Peats

Direct shear test is directed in according to ASTM D3080. Direct shear test is common for estimating the shear strength of soil with respect to friction. In a direct shear test, the prepared soil is put in a divided shear box and subjected to failure by making motion upper part of the container relative to lower. Schematic diagram of direct shear test is shown in Fig. 2.1.

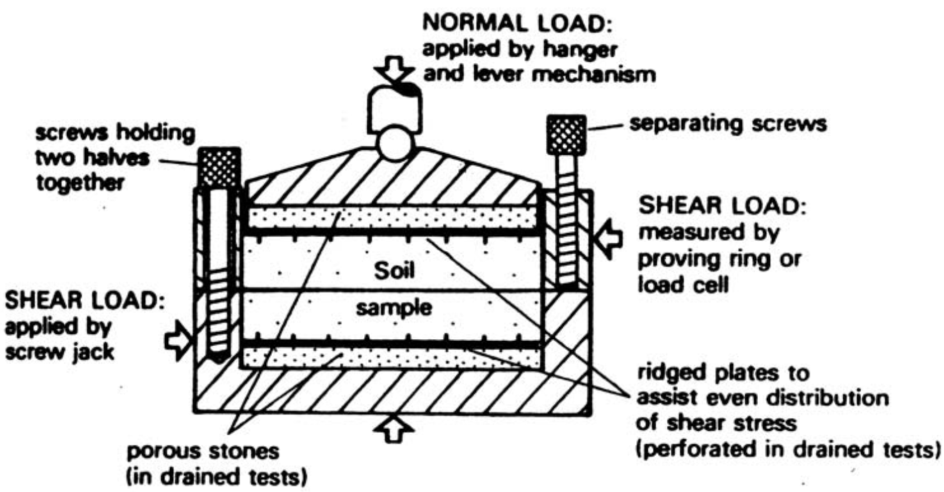


Figure 2.1 Direct shear apparatus (Whitlow, 2001)

A vertical normal force (N) is enforce to prepared specimen through a loading plate and shear stress is gradually occured on horizontal friction plane by causing the two divided shear box to move relative to each other. The shear displacement (Δl) being measured together with respect to shear force (T). Additionally the change in thickness (Δh) of the specimen could be measured. Minimum 3 number of specimens of the soil are tested under different normal forces, and the value of shear stress at failure is plotted against the normal stress for each test. Therefore it is easy to obtain the shear strength parameters from the best line fitting the plotted points.

The shear strength of peat is generally so low and the estimation of shear strength is always connected to the problems because of several variables such as degree of humification ,the origin of soil, organic content and water content. In addition, sample disturbance has an important great effect on the evaluation of shear strength of peat.

Some researches showed that shear strength properties of several types of peat with respect to laboratory applications and it was clearly seen that the behavior of the shear strength properties of peats is basically frictional, with high internal friction angles and usually low cohesion intercepts (Adam, 1965; Edil and Dhowian, 1981).

Edil and Dhowian (1981) also discussed that the friction of peat soil mostly depends on the fiber and the fiber is not always solid because it usually contains water and gas. Therefore , the high friction angle does not actually show the high shear strength of the soil. The higher angle of friction is generally seen in the more fibrous peat. According to Edil (2003), the existence of fiber always has an effect on the shear strength behavior of peat. The fiber cause to the shear strength since it is seen as reinforcement. The effect of reinforcement depends on the loading direction in relation to main fiber direction. In this condition where peat is loaded by the shear force, friction can develop among adjacent fibers and between the fill material and the fibers. When the load direction is placed on the same direction as the fibers, there is an effect of reinforcement on shear strength of peat. Water content that is parameter has an inportant effect on shear strength of organic soils. As it is seen in Fig. 2.2 cohesion of the organic soil has the highest value in dry condition. Then, while water content is increasing gradually chesion decreases. According to the Fig. 2.2 water content changing decrease the cohesion of the peat soils.

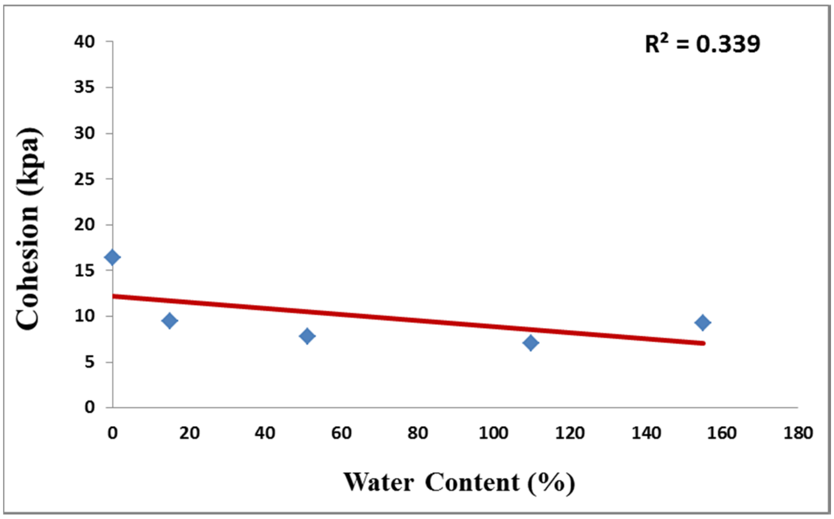


Figure 2.2: Water content – Cohesion Relation in Constant Density (Çelik and Çanakçı, 2010)

Also water content has an important effect on internal friction angle of organic soils. As it is seen in Fig. 2.3 increasing of water content decreases the internal friction angle of the organic soil gradually. Therefore , it can be said that water content increasing will decrease the shear strength of the organic soil.

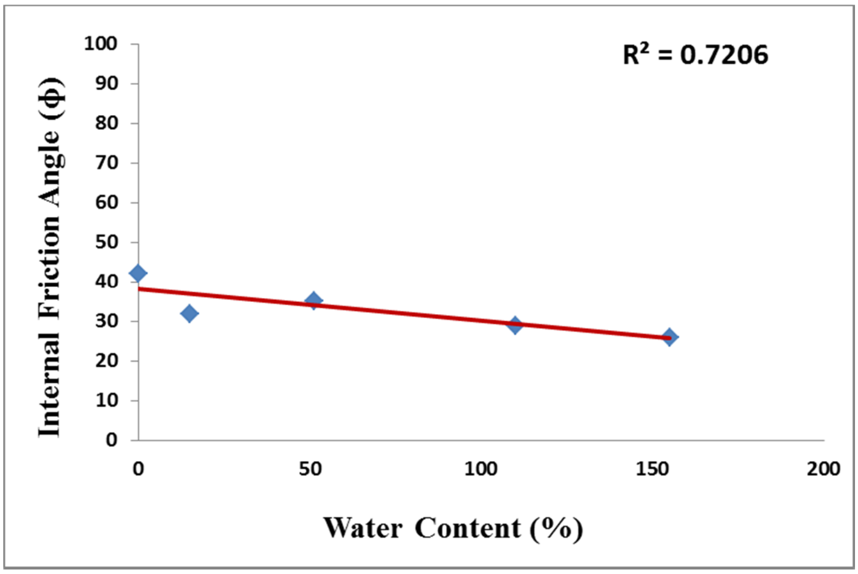


Figure 2.3 Water content – Internal Friction Angle Relation in Constant Density (Çelik and Çanakçı, 2010)

Sand content that is an important parameter has an important effect on the cohesion of the organic soils. As it is seen in Fig.2.4 sand content increasing of the organic soil decrease the cohesion of the soil regularly. In addition, sand content also affect the internal friction angle of the organic soils.As it is shown in Fig.2.5 when sand content of the organic soil increase internal friction angle of the organic soil increase also. According to these results it can be said that sand content increasing has an important effect on the shear strength of the organic soils.

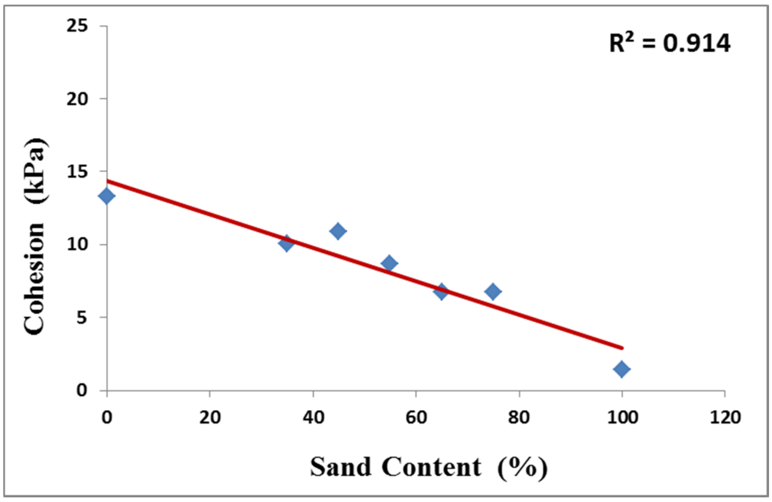


Figure 2.4 Sand Content – Internal Friction Angle Relation in Constant Density (Çelik and Çanakçı, 2010)

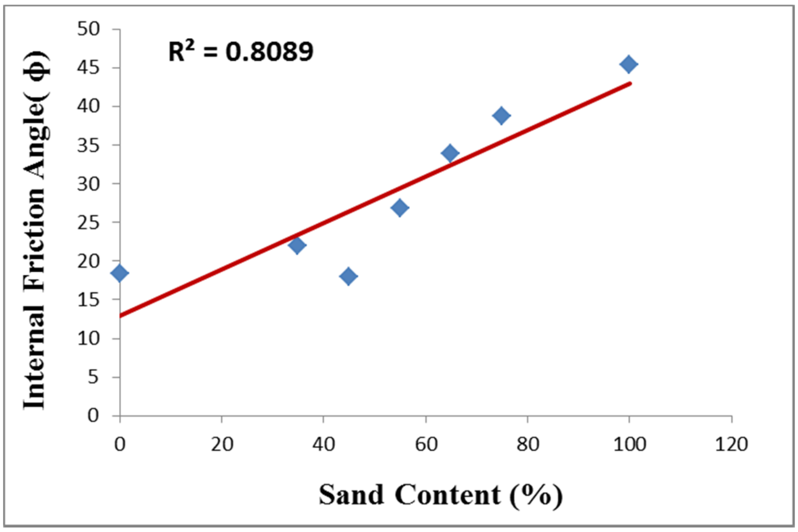


Figure 2.5 Sand Content – Internal Friction Angle Relation in Constant Density (Çelik and Çanakçı, 2010

Density that is an important parameter for the organic soils has an important effect on the cohesion. As it is seen in Fig.2.6 density of the organic soil increasing rise up tocohesion of the organic soil regularly. There is a strong positive linear correlation between these parameters. Also increasing of the density of the organic soil increase the internal friction angle of the organic soil as it is shown in Fig.2.7. there is a strong positive linear correlation between these parameters also. According to these results it can be said that increasing of the density of the organic soil will increase the shear strength of the organic soil.

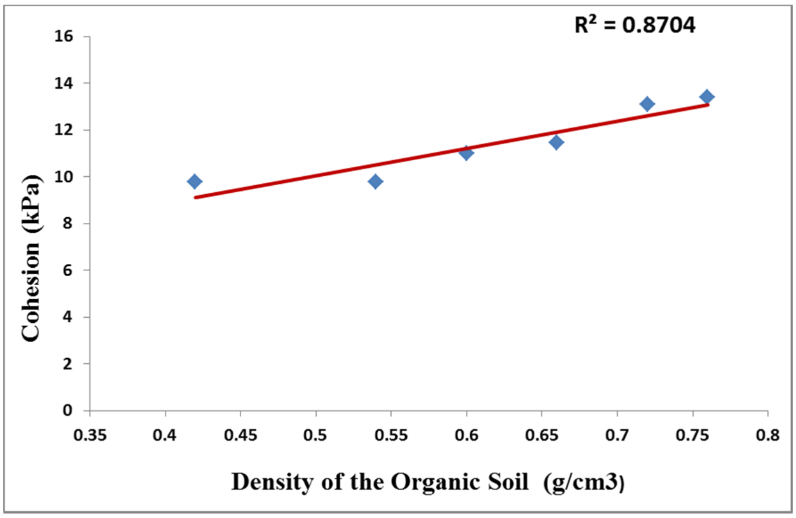


Figure 2.6 Sand Content – Internal Friction Angle Relation in Constant Density (Çelik and Çanakçı, 2010)

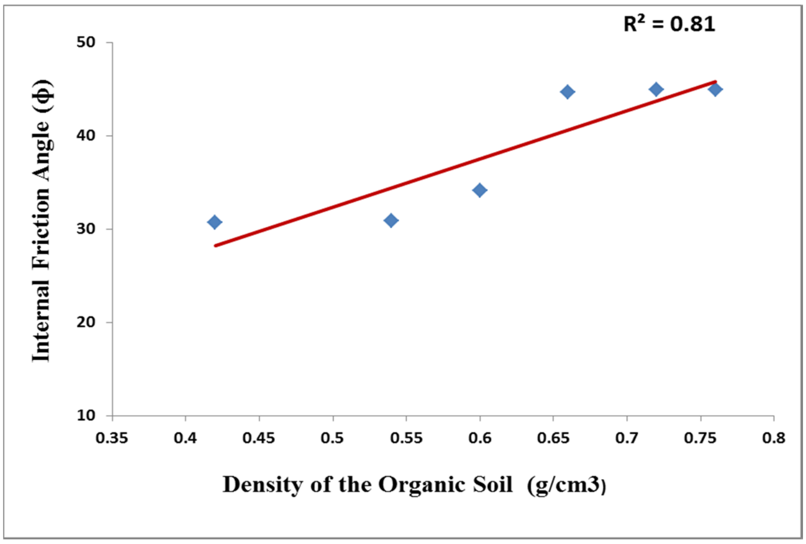


Figure 2.7 Sand Content – Internal Friction Angle Relation in Constant Density (Çelik and Çanakçı, 2010)

2.2.2 Soil Compressibility of Peats

In general, the compressibility of a soil studies on three stages, by the way of explanation first compression, secondary compression , and primary consolidation. While initial compression occurs instantaneously after the application of load,on the other side the primary and secondary compressions depend on time. The initial compression is affected by the compression of small pockets of gas within the pore voids and the elastic compression of soil grains. Primary consolidation depends on dissipation of excess pore water pressure caused by an increase in effective stress whereas secondary compression can be seen under constant effective stress after the completion of dissipation of excess pore water pressure.

The time required for the water to dissipate from the soil depends on the permeability of the soil itself. In granular soil, the process is rapid and hardly noticeable due to its high permeability. On the other hand, the consolidation process may take years in clay soil. For peat, the primary consolidation occurs rapidly due to high initial permeability and secondary compression takes a significant part of compression.

Fibrous peat undergoes large settlements in comparison to clays when subjected to loading. The compression behavior of fibrous peat varies from the compression behavior of other types of soils in two ways. First, the compression of peat is much larger than of other soils. Second, the creep portion of settlement plays a more significant role in determining the total settlement of peat than of other soil types.

Researches (Mesri and Rokhsar, 1974; Mesri and Choi, 1985b; Mesri and Lo, 1991; Lan, 1992) showed that Terzaghi’s theory of consolidation is not applicable for the prediction of the compression of fibrous peat. Subsequently, many theories of consolidation have been developed mainly as modifications to Terzaghi’s theory. Such modifications, mostly intended for soft clays and silts, include decrease in permeability with the progress of consolidation, the changes in compressibility during consolidation, time related compressibility during and after primary consolidation phase, the finite value of strains, and effect of self-weight. Of all methods, few theories were developed solely to model compressibility of fibrous peat (Gibson and Lo, 1961; Barden, 1968; Berry and Poskitt, 1972; den Haan, 1996)

Mesri and Rokhsar (1974) developed a theory of consolidation based on assumptions for soil properties that were more realistic than those in the original Terzaghi theory of one-dimensional consolidation. The assumptions were that:

1. The soil undergoes a finite strain.
2. The compressibility and the permeability of the soil are variable during consolidation.
3. The soil may display recompression and compression behavior.
4. A unique relationship between compressibility and effective stress and time.

Berry and Poskitt (1972) proposed two different Rheological models to symbolize the consolidation of amorphous and fibrous peat. The models consider peat properties such as:

1. Finite strain.
2. Linear relationship between void ratio and the logarithmic of effective stress.
3. Linear relationship between void ratio and logarithmic of coefficient of permeability.
4. Presence of time-related compressibility.

The compressibility characteristics of a soil are usually determined from consolidation tests. General laboratory tests for measurement of compression and consolidation characteristics of a soil are: Oedometer test, Constant Rate of Strain (CRS) test, and Rowe Cell test. The procedures for these tests are fully described in BS 1377-6 and Head (1982, 1986).

Although more sophisticated consolidation tests are now available, Oedometer test is still recognized as the standard test for determining the consolidation characteristics of soil. Oedometer cell can accommodate 50 mm diameter and 20 mm thick samples. The schematic diagram of consolidation test on Oedometer cell is shown in Fig.2.8.

Advantages and disadvantages of Oedometer test are outlined by Head (1986). Among the advantages is the relatively small size of specimen. The small specimen size gives a reasonable consolidation time and the test can be extended to observe the secondary compression. The test provides a reasonable estimate of the amount of settlement of structure on inorganic clay deposits.

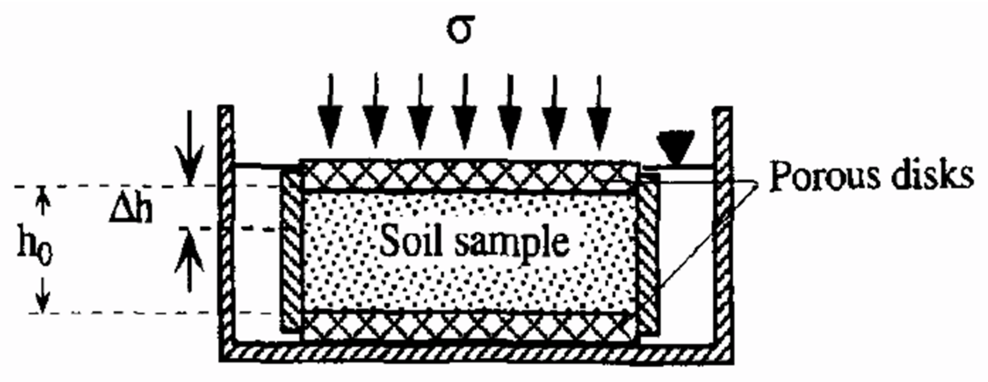


Figure 2.8 Schematic diagram of Oedometer cell (Bardet, 1997)

For standard test, the samples were subjected to consolidation pressures with load increment ratio of 1. The load is applied through a mechanical lever arm system, thus measurement can be easily affected by sudden shock. Excessive disturbance affects the e-log p' plot, gives low value of pre-consolidation pressure and high coefficient of volume compressibility at low stresses. Excessive disturbance also reduces the effect of secondary compression which is a very important characteristic of fibrous peat.

The analysis of compression of such soils show some difficulties when the conventional methods are used because the results are evaluated from the conventional Oedometer tests and the behavior presents by them show some differances from that of clay. In addition, such soils are more tending to decomposition during Oedometer testing is running.. Gas content and additional gas generation also may make it harder the interpretation of Oedometer tests (Edil, 2003).Some researchers (Berry and Poskitt, 1972; Ajlouni, 2000; Colleselli et al., 2000; Robinson, 2003) had presented the behavior of fibrous peat and the recent advances in formulating their behavior.

CHAPTER III

EXPERIMENTAL PROGRAM

3.1 Materials

3.1.1 Organic Soil

The organic soil used in this study was obtained from Sakarya region, Turkey. Some physical and chemical properties related with the organic soil used in tests are given Table 3.1. In all tests the fibrous peat samples that remain on #100 (0.15 mm) sieve size and are called as fiber were used (ASTM D 1997-91). This organic soil is classified as Peat by Unified Soil Classification System (USCS). and peat by classification system suggested by Wüst et al., (2003) in Fig. 3.1. Organic content was estimated by firing process at 440 ^{0}C in an oven for 4 hours according to ASTM D 2974. According to this process ash content of the soil was defined as % 40. Wet sieve analysis was carried out on ash and it was found that soil contains 15% silt and clay, 25% sand, and 60% organic materials. Liquid limit of the organic soil was estimated by fall cone test according to ASTM D 4318 and found to be % 125. The organic soil can be classified as fibric (ASTM D 1997), high ash (ASTM D 2974), moderately asidic (ASTM D 2976) and H_1-H_4 on degree of decomposition (Von Post, 1922). According to ASTM standarts Soil Classification System was given in Table 2.4. Close up view of the organic soil used in this study was given in Fig. 3.2.

Table 3.1: Engineering properties of the organic soil used in the study

Properties of Organic Soil	**Sand Content (%)**
Organic Content (%)	50-70
pH	4,5-6,5
Organic Carbon (%)	20-30
Water Keeping Capacity, (in volume, %)	85-95
Natural Water Content (%)	256
Liquid Limit (%)	125
Plastic Limit (%)	None Plastic
Specific Gravity (g/cm^3)	1.97

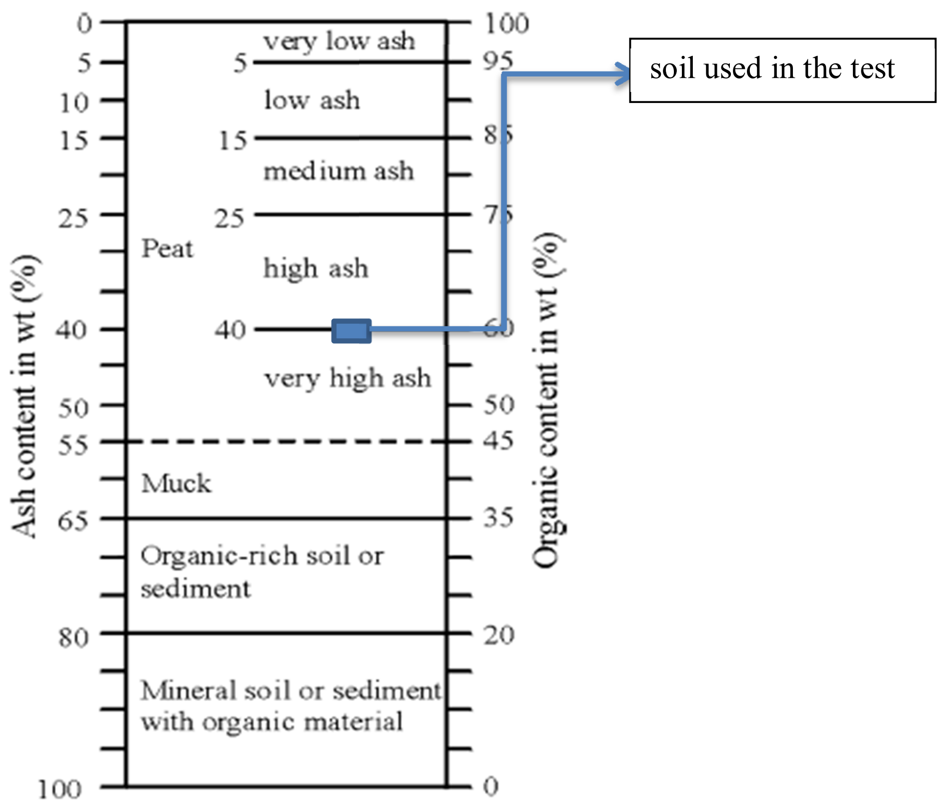


Figure 3.1 Classification system for peat deposits (Wüst et al.,2003)

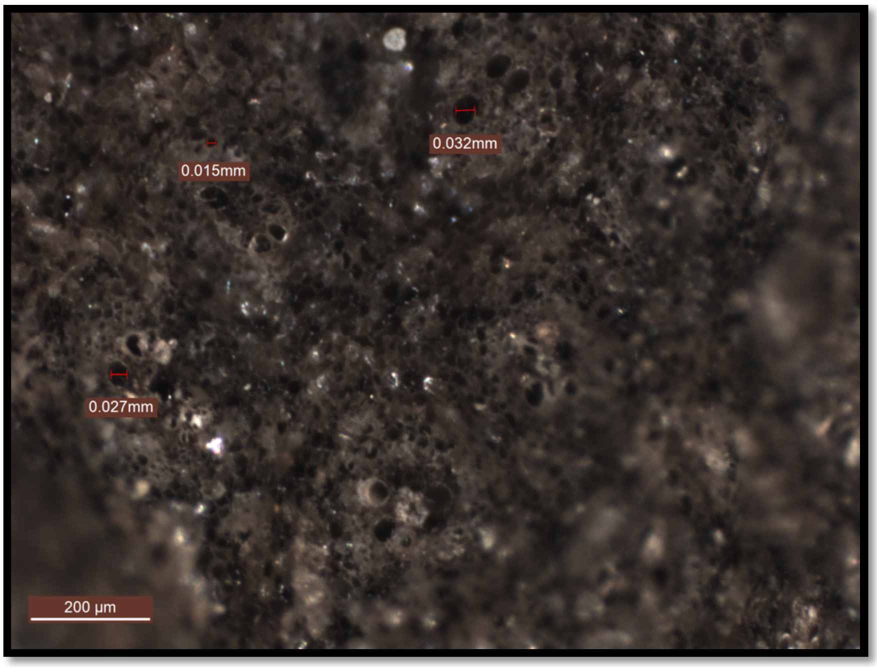


Figure 3.2 Close up view of organic soil (By LEICA Z16 APO electronic microscope.)

The peat is further classified with respect to fiber content because the attendance of fiber shows some alternatives in the consolidation process of fibrous peat from that of organic soil or amorphous peat. If fiber content of peat is less than % 20 these types of soils are called as amorphous peat(ASTM D 4427). It has particles of colloidal size less than 2 microns, and the pore water can be kept around the particle surface. The behavior of amorphous granular peat has some similarities with clay soil. If any peat has fiber content more than % 20 these soils are calle as fibrous peat according to ASTM D 4427. Fibrous peats have macro pores and micro pores inside of them.According to this information the organic soil used for the thesis was divided into two parts as fibrous peat and amorphous granular peat. In all tests fibrous peats were used.

3.1.2 Sand

The sand used for the test is poorly graded passing from 2 mm sieve size and retaining on 1 mm sieve size. The main reason of selecting this sieve range is to minimize the effect of size of the sand partical on test results, and also to only observe changing the ratio of sand amount in the organic soil by mass. Because of this reason poorly graded river sand was used in all tests. River sand particles used in the testing program are shown in Fig. 3.3

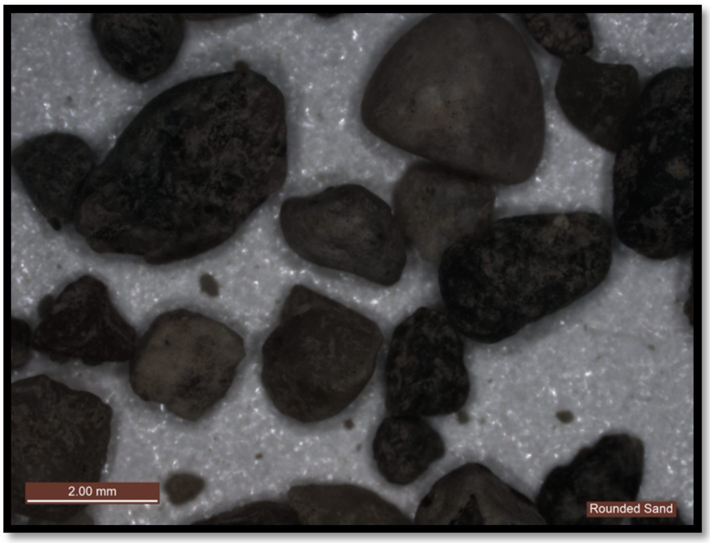


Figure 3.3 River sand particles used in the testing program (By LEICA Z16 APO electronic microscope.)

3.2 Methods

3.2.1 Standart Proctor Test

All compaction tests were done by using standart proctor test method according to ASTM D 698. In all tests ELE marked proctor test machine was used.The sand that has mentioned before was added by mass respectively as %10, %20, %30, %40 and %50 into the organic soil and sand-organic soil mixtures were obtained. Each mixture was compacted in five different moisture content and optimum moisture content (OMC) and maximum dry density (MDD) were determined for each mixture. Moisture content estimations were done according to ASTM D 2216.

3.2.2 Direct Shear Test

The direct shear tests were done by using the organic soil-sand mixtures. In all tests ELE marked direct shear test machine was used. In five different sand ratio organic-sand mictures were prepared. Then, these mixtures were compacted according to the proctor test results mentioned before. OMC and MDD of each mixture were taken from proctor test results. Because of that the mixtures used in the proctor test were used for also direct shear test.The sample specimens consisted of fibrous peat soil-sand mixture were prepared according to ASTM D 3080-03.The photos of shear apparatus used fort he laboratory testing is shown in Fig. 3.4

The test procedures of conducting direct shear test is done to the BS 1377: Part 7:1990 clause 4.5. The brief procedures of the direct shear test conducted to obtain the shear strength parameters of peat soil in Sakarya region are as follows:

1) The initial mass of peat soil prepared for the test is weighed.
2) The width and height of the shear box are measured.
3) The shear box is carefully assembled and placed in the direct shear device. Then retaining plate, porous stone and perforated plate are placed.

4) The compacted fibrous peat-sand soil mixtures prepared according to the compaction results is placed into the shear box and the top of shear box is leveled. The perforated plate and porous plate are placed after that.

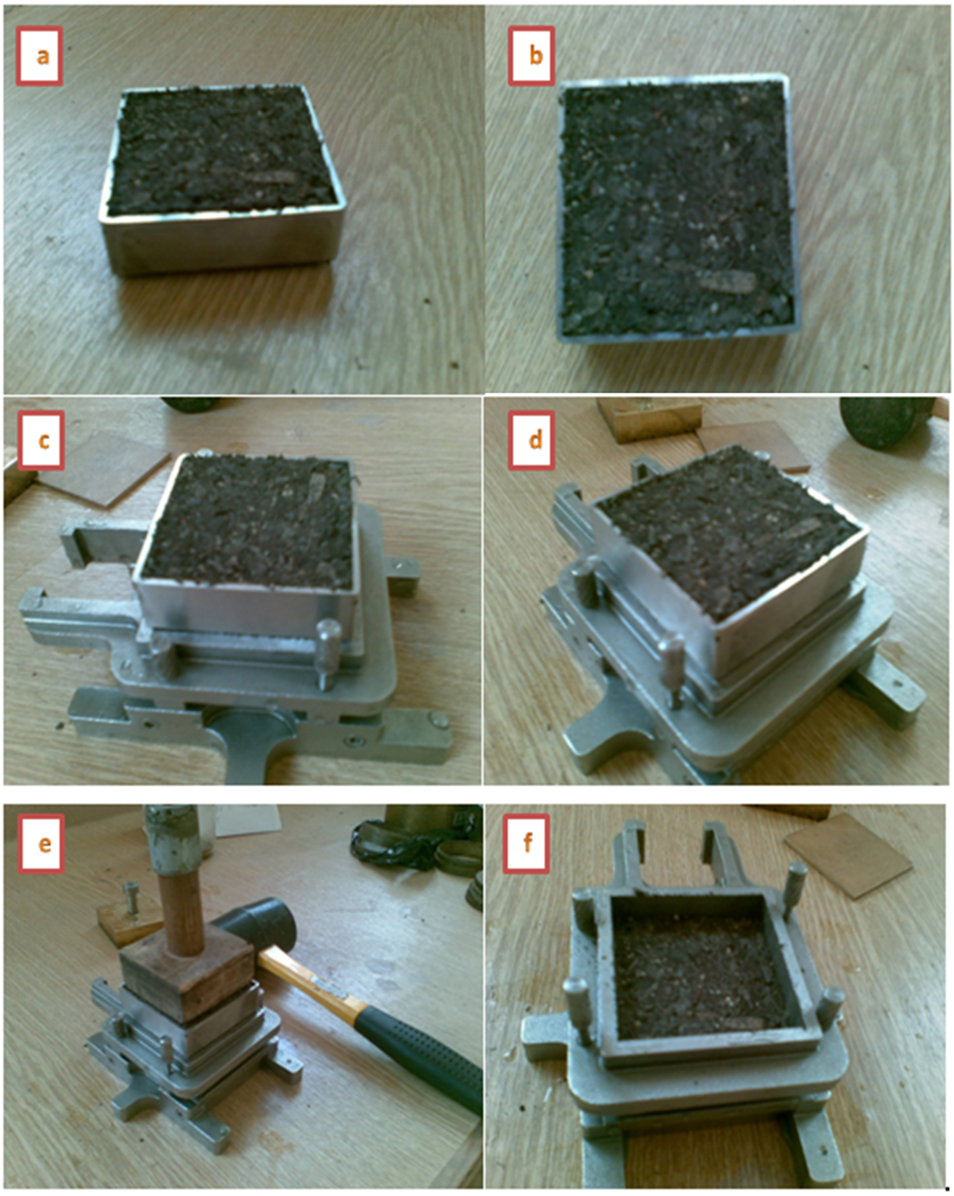


Figure 3.4 Sample preparing for direct shear test. a) sample compaction. b) compacted sample. c) test apparatus preparing d) prepared test apparatus. e) placing sample into test apparatus. f) ready compacted sample in test apparatus for the test.

5) Finally, the loading pad is placed on top.

6) The large aligment screws are removed from the shear box.

7) The assembly of the direct shear devices is completed and the three gauges, consist of horizontal displacement gauge, vertical displacement gauge and shear load gauge are set.
8) The vertical load is set to a predetermined value. In this experiment , the value of the vertical load are 1 kg, 2 kg and 4 kg respectively. After the vertical load setting, the load is applied to the soil by raising the toggle switch.
9) The test is started with the selected speed so that the rate of shearing is at selected constant rate(1 mm/min. speed rate was used in the test). The value of the horizontal displacement gauge, vertical displacement gauge and shear load gauge readings are obtained through the electronic data looger connected to the direct shear device.
10) The readings are taken until the horizontal shear load reached peak.
11) The moisture content of tested peat soils is obtained.

While the samples used in the test were preparing , maximum compactin values were obtained in all samples. The proctor test results were taken as referance. Optimum moisture content and maximum dry density values for each sample were used in different sand content. Therefore in all samples and tests maximum density was used and so the effect of density on the results was eleminated.

3.2.3 Consolidation Test

The standard consolidation test on Oedometer cell was conducted as preliminary tests to estimate the consolidation behavior of the fibrous peat samples. In all tests ELE marked consolidation test machine was used. The tests are carried out based on the standard procedure outlined in BS 1377-5. The Oedometer cell is 60 mm in diameter and 20 mm in height Since the sample was taken from shallow depth (1 to 2 m), and subsequently the in-situ stress is very low, then the consolidation test started at a very low pressure. The test is conducted with load increment ratio (LIR) of one, and applied loads were 23.5 kPa, 47 kPa, 117.5 kPa, 235 kPa, and 470 kPa. Each load was maintained for one day or 1440 minutes for loading stages during the first tests, but was modified to one week or 10,000 minutes upon determination of the end of primary consolidation (t_p) and secondary compression (t_s) of the soil. The standard consolidation test was conducted on twelve samples.

While the samples used in the test were preparing , maximum compactin values were obtained in all samples. The proctor test results were taken as referance. Optimum moisture content and maximum dry density values for each sample were used in different sand content. Therefore in all samples and tests maximum density was used and so the effect of density on the results was eleminated.

CHAPTER IV

RESULTS AND DISCUSSIONS

This chapter reports the results of standard laboratory tests carried out on peat obtained from Sakarya region in Turkey. The tests were done to identify the general characteristics of the soil including water content, specific gravity, and initial void ratio. Organic content and fiber content are used to determine the classification of the peat. The other properties disscused in this chapter are the fiber orientation, shear strength, compaction parameters, and compressibility obtained from the standard consolidation test on Oedometer cell.

4.1 Physical and Chemical Properties

The initial properties of the soil was made based on the index properties and classification processed on six samples. Index properties include the determination of moisture content, bulk unit weight, specific gravity, and the initial void ratio. The summary of index properties is presented in Table 4.1.

In-situ measurement of water content was not possible. Thus, sufficient care was taken during the sampling of the peat in order to maintain the natural water content. Three samples were acquired by piston sampler for water content determination in laboratory. The average natural water content obtained from laboratory tests is 236 % which indicates that the peat has a high water-holding capacity.

The average specific gravity obtained using kerosene on pycnometer test is 1.94-2.07 and it is within the range for fibrous peat (Table 4.1). As shown in Figure4.1, for water content of 236 %, specific gravity of about 1.94-2.07.

Table 4.1: Important physical and chemical properties for some fibrous peat deposits (comparing with present)

Peat type	Natural water content (%)	Bulk density (Mg/m^3)	Specific Gravity (G_s)	Acidity (pH)	Ash content (%)	Reference
Fibrous-woody	484-909	-	-	-	17	Colley (1950)
Fibrous	850	0.95-1.03	1.1-1.8	-	-	Hanrahan (1954)
Fibrous	605-1290	0.87-1.04	1.41-1.7	-	4.6-15.8	Samson and LaRochell, 1972
Coarse Fibrous	613-886	1.04	1.5	4.1	9.4	Berry and Vickers, 1975
Fibrous sedge	350	-	-	4.3	4.8	Levesqe et al. 1980
Fibrous Sphagnum	778	-	-	3.3	1	
Coarse Fibrous	202-1159	1.05	1.5	4.17	14.3	Berry ,1983
Fine Fibrous	660	1.05	1.58	6.9	23.9	NG and Eischen 1983
Peat Portage	600	0.96	1.72	7.3	19.5	Edil and Mochtar 1984
Peat Waupaca	460	0.96	1.68	6.2	15	
Fibrous Peat Middleton	510	0.91	1.41	7	12	
Fibrous Peat Noblesville	173-757	0.84	1.56	6.4	6.9-8.4	
Fibrous	660-1590	-	1.53-1.68	-	0.1-32.0	Lefebvre et al. 1984
Fibrous (Middleton)	510-850	0.99-1.1	1.47-1.64	4.2	5-7	Ajlouni, 2000
Fibrous (James Bay)	1000-1340	0.85-1.02	1.37-1.55	5.3	4.1	
Fibrous (Sakarya peat)	**236**	**1.12**	**1.94-2.07**	**4.5-6.5**	**40**	**Present study**

The average bulk density obtained from this study is a little bit lower than predicted by Huat (2004). The average unit weight of the peat is 11.2 kN/m^3 which give a bulk density of 1.12 Mg/m^3 (Fig. 4.1). The value is also within the range given in Table 4.1. The dry unit weight of the peat is 4.41 kN/m^3 and it is slightly less than predicted by Al Raziqi et al. (2003) based on the natural water content (Fig. 4.2).

According to the informations showed above, the unit weight of the peat in this study is near to the unit weight of water; hence in-situ effective stress is so low , on the other hand the void ratio of the peat is so high. The void ratio also includes the volume of gas generated during decomposition process.

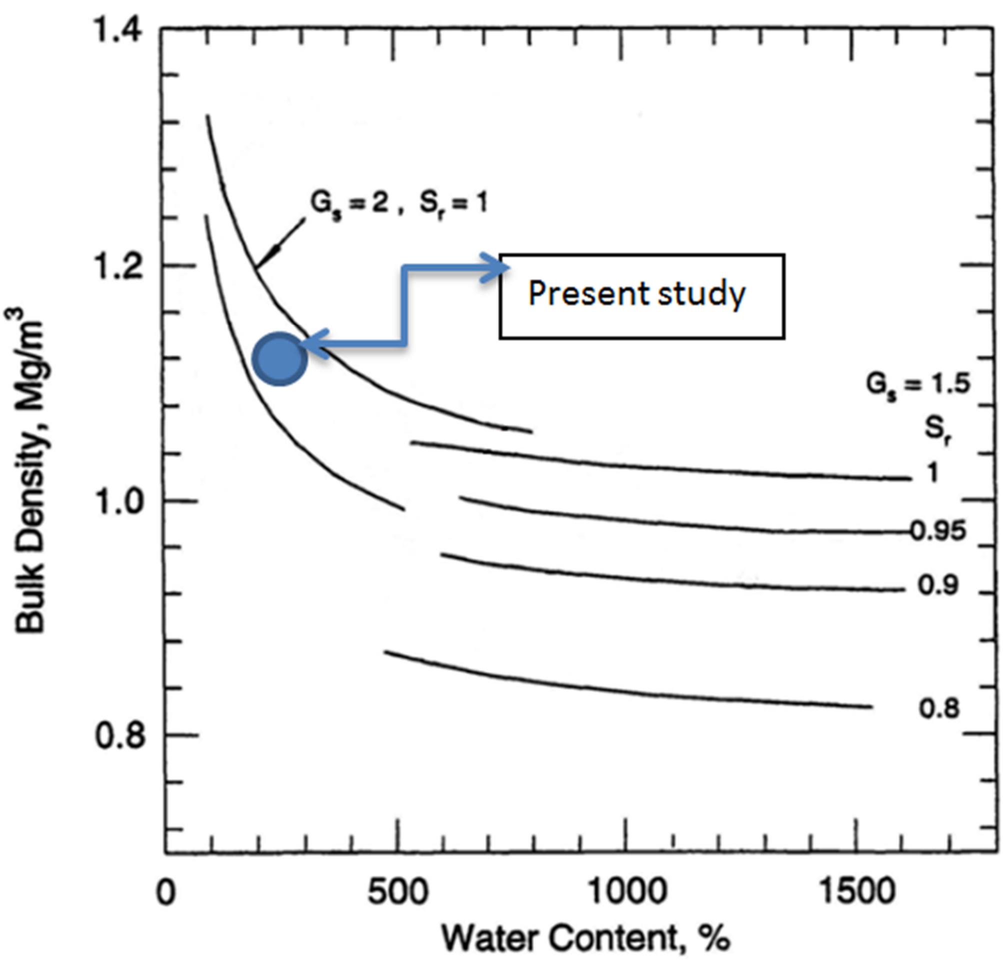


Figure 4.1 Correlation of bulk density, water content, specific gravity, and degree of saturation of fibrous peat (Hobbs, 1986)

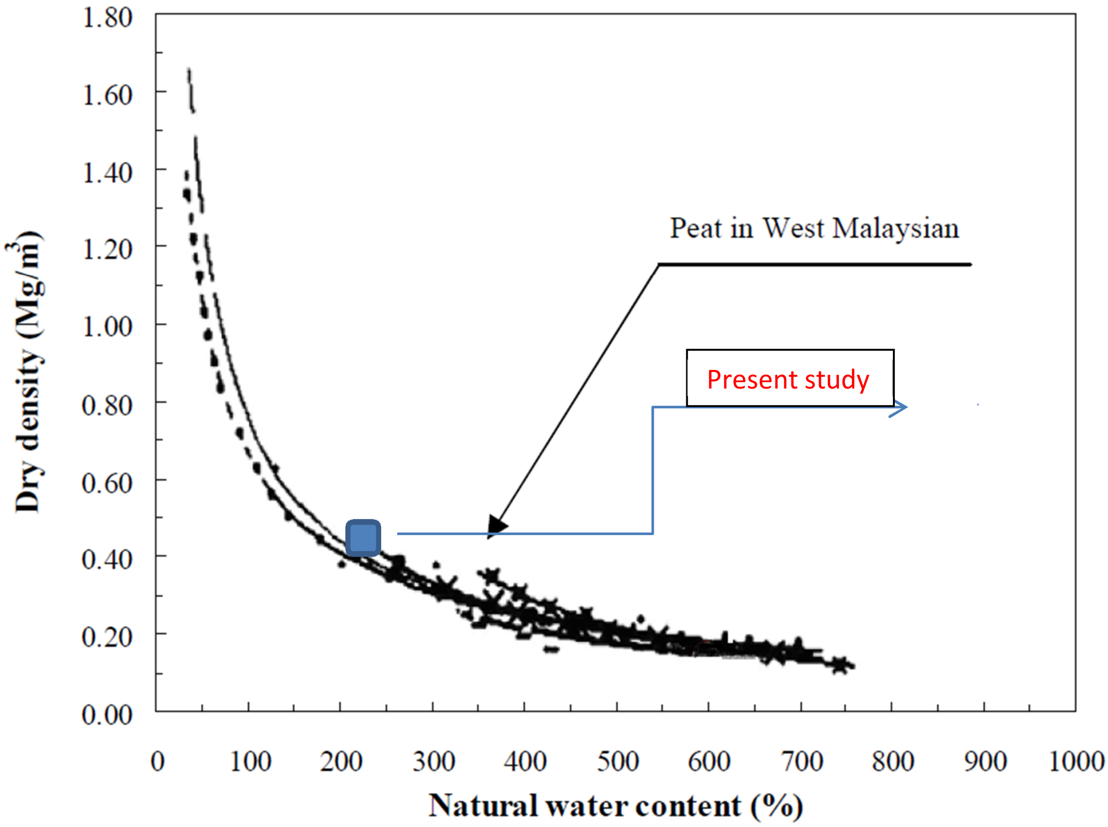


Figure 4.2 Correlation of dry density and natural water content for West Malaysian peat (Al-Raziqi et al., 2003)

4.2 Classification

The peat in this study was classified with respect to the degree of decomposition according to Von Post scale and also the fiber and the organic content. The von Post scale define the appearance of soil-water that is dissipate when a sample of the soil is compressed in the hand. When brown water reveal from the soil and a large amount of fiber left on the hand ,then the peat is classified as fibrous peat with H_4 degree of decomposition according to von Post scale.

The organic content of the peat is found as 60 % which is high but still correlate well with its specific gravity and water content (Fig. 4.3 and Fig. 4.4). The loss of ignition or ash content is 40 %. The fiber content of 84.2 % is considered very high as compared to published data around the world (Table 4.2) .

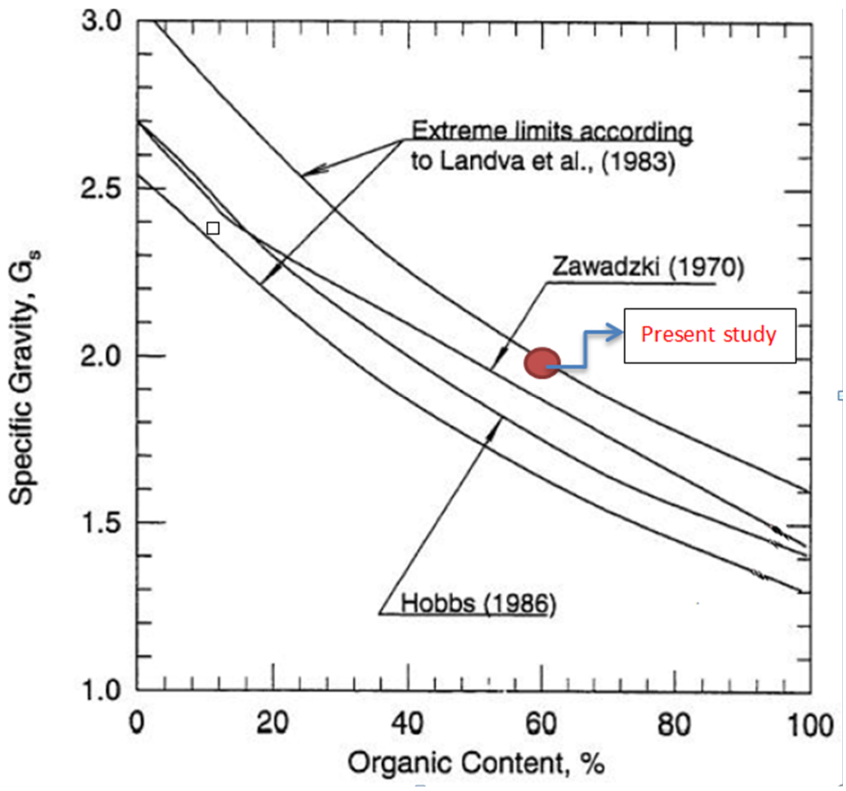


Figure 4.3 The range of organic content of fibrous peat based on specific gravity (Lechowicz et al., 1996)

Table 4.2: The summary classification test result

	Classification Peat Soil Based on ASTM Standards	The Organic Soil used in This Study
Fiber Content (ASTM D1997)	**Fibric** : Peat with greater than 67 % fibers	% 84.2 (Fibric)
	Hemic : Peat with between 33 % and 67 % fibers	
	Sapric : Peat with less than 33 % fibers	
Ash Content (ASTM D2974)	**Low Ash :** Peat with less than 5 % ash	% 40 (High Ash)
	Medium Ash : Peat with between 5% and 15 % ash	
	High Ash : Peat with more than 15 % ash	
Acidity (ASTM D2976)	**Highly Acidic :** Peat with a pH less than 4.5	4.5-6.5 (Moderately Acidic)
	Moderately Acidic : Peat with a pH between 4.5 and 5.5	
	Slighly Acidic : Peat with a pH greater than 5.5 and less than 7	
	Basic : Peat with a pH equal or greater than 7	
Degree of Decompsition (Von Post,1922)	Between H_1 and H_{10}	H_1-H_4 Fiber Ratio >%60 (Hartlen and Wolski, 1996).

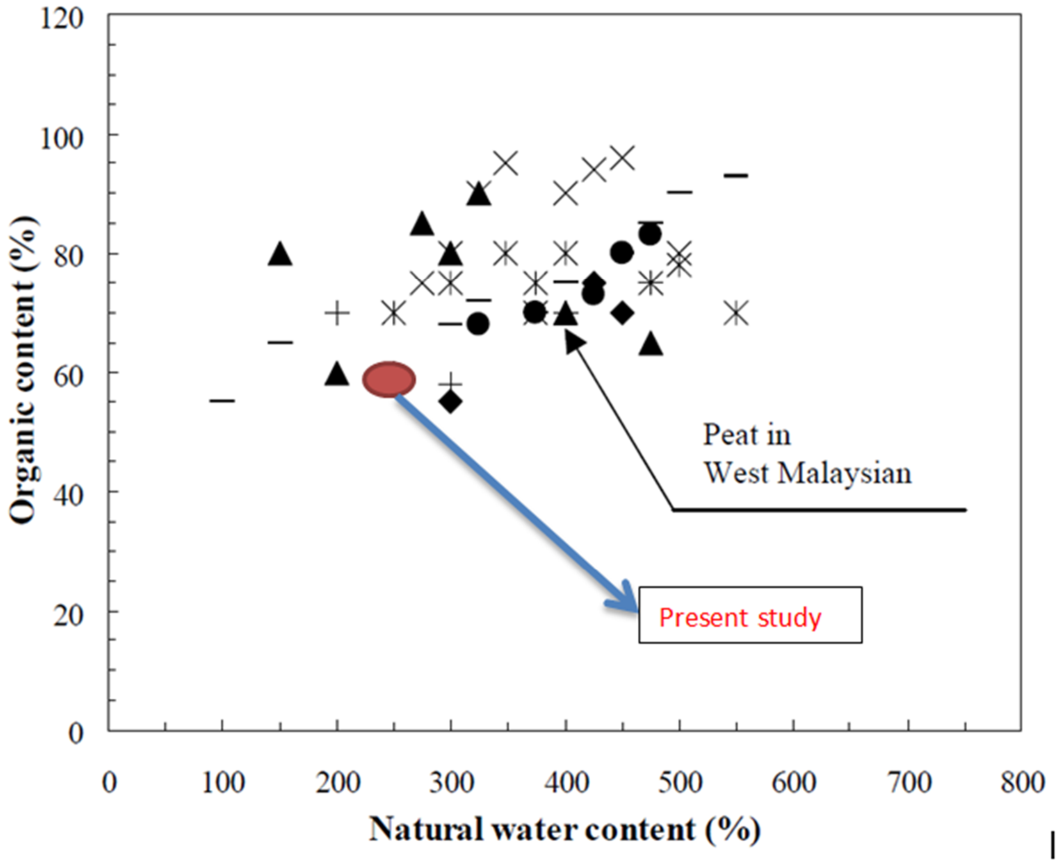


Figure 4.4 The range of organic content of fibrous peat based on water content (Al-Raziqi et al., 2003)

4.3 Compaction (Standart Proctor Test)

Compaction test results related with organic soil-sand mixing samples are given below. In five different contents of organic soil-sand mixtures standart proctor tests were done and their results were given. Sand content changing in organic soil has an important effect on compaction parameters of organc soils. The effect of the sand added into the organic soil in different ratios on the compaction parameters is seen clearly in Fig.4.5. In all sand ratios Dry Unit Weight (DUW)-Optimum Moisture Content (OMC) relation curve occures as Type A curve (Das B.M,2008). DUW-OMC curves for all sand ratios remain left side of the zero-air-void curve. This shows that there is no problem related with test results. As it is shown in Fig.4.5 while the sand ratio in the organic soil increase, DUW increases but OMC decreases. OMC and Maximum dry unit weight (MDUW) of natural organic soil are % 58 and

6.44 kN/m^3, respectively. % 10 sand adding into the organic soil increased MDUW of the soil as % 30.4 , on the other side it reduced OMC as % 24.1. Following each % 10 increase in sand ratio affect the compaction parameters less than first increase. As it is clearly seen in Fig. 4.5.a that OMC values with respect to each % 10 sand ratio increasing are evaluated as % 58, % 44, % 38, % 32, % 30 and % 26 , respectively. And also MDUW values are determined as 6.44 kN/m^3 , 8.4 kN/m^3, 8.9 kN/m^3, 9.4 kN/m^3, 10.2 kN/m^3 and 11.5 kN/m^3, respectively. It was observed from test result that total % 50 sand content change in the organic soil decreased OMC ,% 55.2; but it increased MDUW, % 79.2. It is clearly seen that sand content change in the organic soil has an important role on compaction parameters.

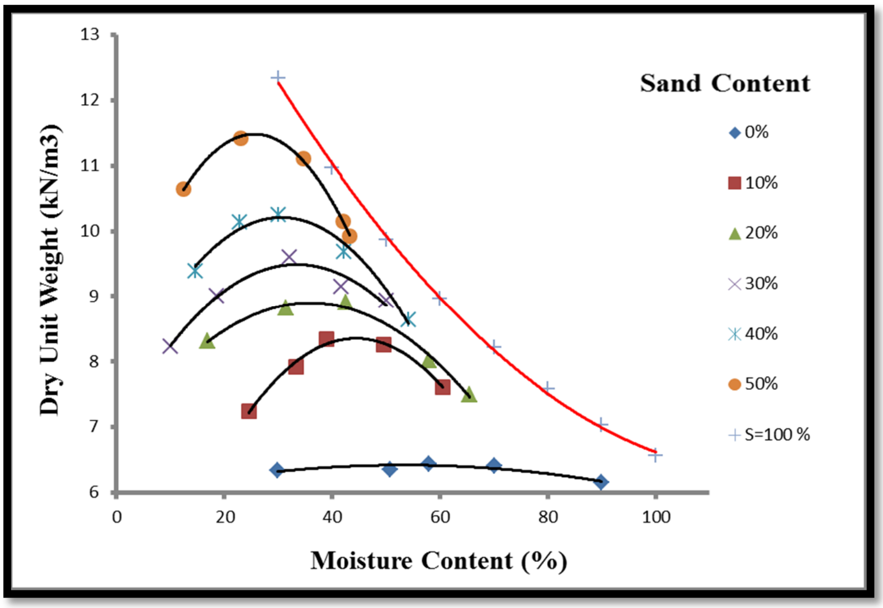
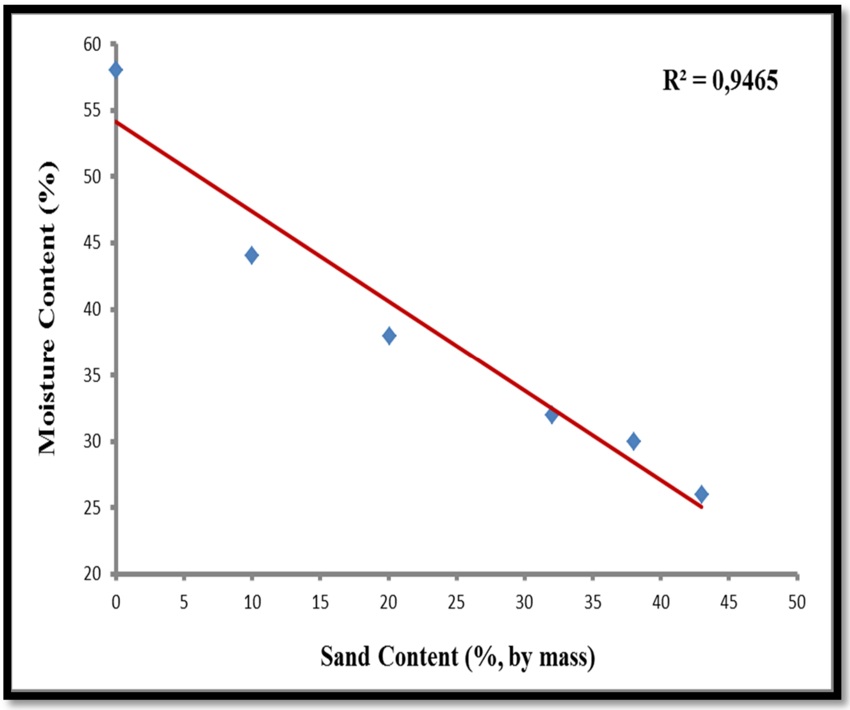
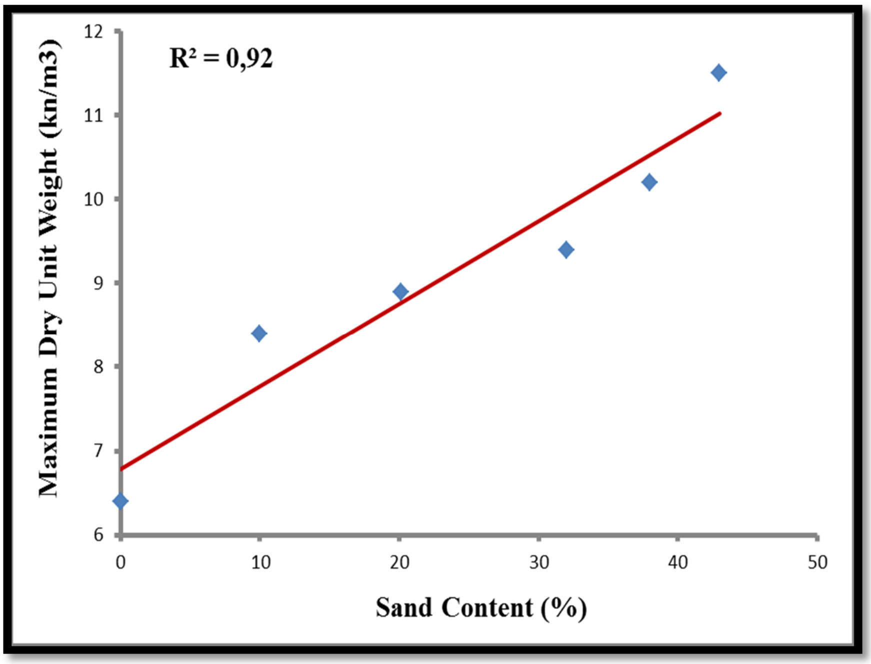


Figure 4.5 The effect of sand content on density and moisture content relations in organic soil

It is clearly seen in Fig.4.6-a that there is a strong negative linear correlation between sand content and OMC. As it has been mentioned above, since outer voids of organic soil were filled with sand particles OMC decreased. The reason of that being the sand particles have low water keeping capacity in outer voids of organic soil reduced the total water keeping capacity in the organic soil. As it is seen in Fig.4.6-b , there is a strong positive linear correlation between sand content and MDUW. As we mentioned before , the main reason of increasing is that the specific gravity of the sand is greater than the specific gravity of the organic soil, and also the water keeping capacity of the sand is less than the organic soil's. Test results showed that the compaction behavior of the organic soil is approaching to compaction behavior of the sand.



a.)



b.)

Figure 4.6 a) Sand Content- OMC relation. b) Sand Content-MDUW relation.

As it is clearly seen in Fig 4.6.a-b there is a strong liner correlation between parameters with respect to their R^2 value. Therefore, if the sand content of the fibrous peats is known their compaction parameters can be easily estimated from emprical formulas by the equations taken from liner correlation curves. The equations taken from Fig 4.6.a-b liner curves were given below as equation (1) and (2).

$$w_{opt} = [- 0.59 \text{ x } S_c] + 52.86 \quad (1)$$

$$\gamma_{(dry)max} = [0.0897 \text{ x } S_c] + 6.8905 \quad (2)$$

Here,

w_{opt} (%) = Optimum moisture content,
S_c (%) = Sand content,
$\gamma_{(dry)max}$ (kN/m^3) = Maximum dry unit weight.

4.4 Shear Strength Results

Shear strength test results related with organic soil-sand mixing samples are given in Table 3 below. Sand content changing in organic soil has an important effect on Shear Strength parameters of organc soils. The effect of the sand added into the organic soil in different ratios on the Shear Strength parameters is seen clearly in Fig.4.7 and Fig.4.8. As it is shown in Fig.4.7 while the sand ratio in the organic soil increase, Internal Friction Angle (IFA) increases . IFA of natural organic soil is 26.4^0. % 10 sand adding into the organic soil increased IFA of the soil as % 17.3 , on the other side it reduced Cohesion as % 13.6 .

As it is clearly seen in Fig.4.7 that IFA values with respect to each % 10 sand ratio increasing are evaluated as 26.4^0, 30.96^0, 33.2^0, 33.1^0, 33.2^0, 33.2^0 and 36.2^0, respectively. All stress values related with the test are given in table 4.3.

Table 4.3 Maximum shear stress values depends on vertical stress.

Sand Content (%)	Maximum Shear Stress , τ_f kPa		
	σ_n=28 kPa	σ_n=56 kPa	σ_n=112 kPa
0	24.72	41.34	66.71
10	26.73	44.24	76.90
20	25.96	45.06	80.73
30	28.45	44.06	82.32
40	22.41	49.74	78.83
50	28.03	44.77	82.20
60	26.91	44.53	87.30
80	22.18	40.40	79.80
100	12.30	24.37	40.93

τ_f shear stress of the mixtures, σ_n vertical normal stress applied to samples.

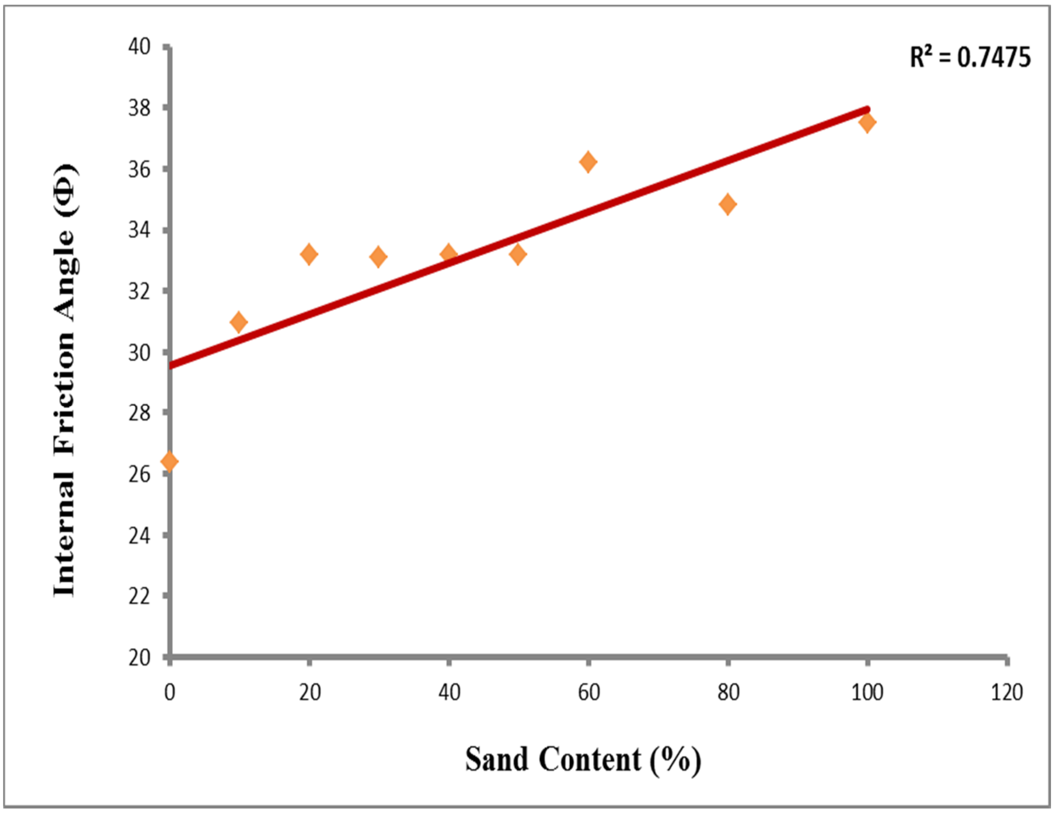


Figure 4.7 Sand content – Internal friction angle relation.

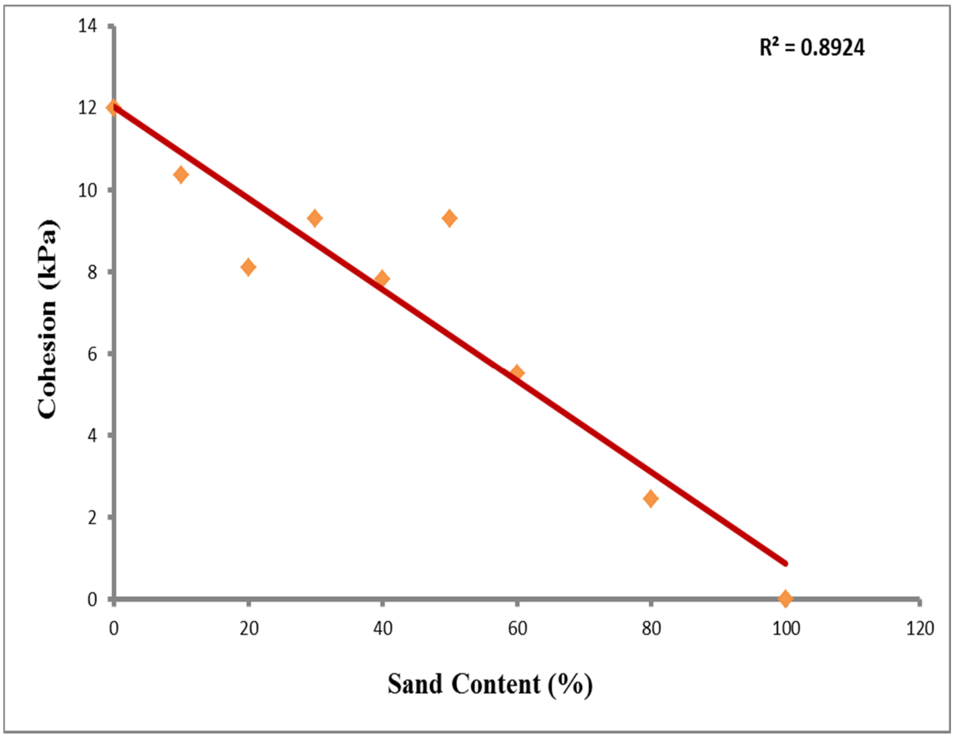


Figure 4.8 Sand content – Cohesion relation.

From this correlation seen in Fig. 4.7-4.8 two equations with respect to Φ and c can be obtained. The emprical equations are shown in eqn. 3 and 4.

$$\Phi = 0.0841S_c + 29.53 \quad (3)$$

$$c = - 0.1118S_c + 12.047 \quad (4)$$

here,

Φ = internal friction angle of the soil.

c = cohesion of the soil.

S_c = Sand content in the organic soil.

4.5 Consolidation Results

Consolidation tests were undertaken using the conventional odometer. The study particularly focused on three consolidation parameters: coefficient of volume compressibility (m_v), primary compression index (C_c) and recompression index (C_r). Five types of peat-sand mixtures were used;% 0, % 20, % 40, % 60 and % 80 sand content in compacted fibrous peat. The tests were performed under consolidation pressures ranging between 23.5 and 470 kPa. The e-log σ curves of mixture samples have mentioned above are shown in Fig.4.9. It is clear from these curves that the primary void ratio of the sample which were not added sand into is greater than other samples, indicating that the primary void ratio is decreasing with respect to sand content regularly.

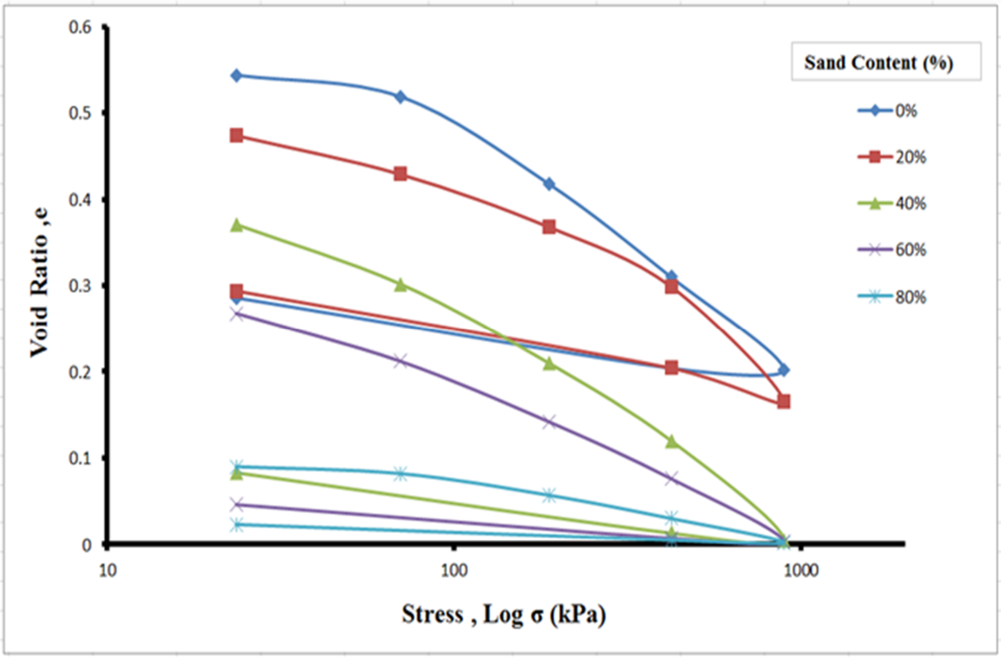


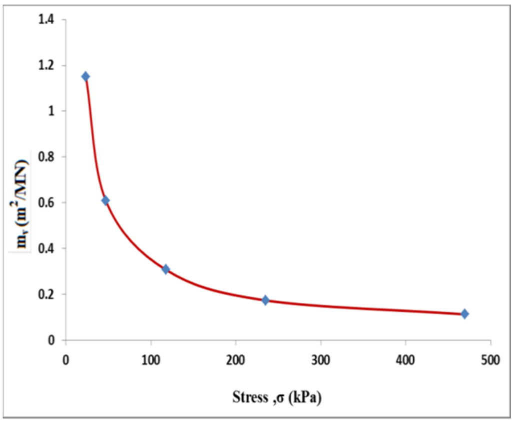
Figure 4.9 e versus log σ curves of the compacted fibrous peat-sand mixtures.

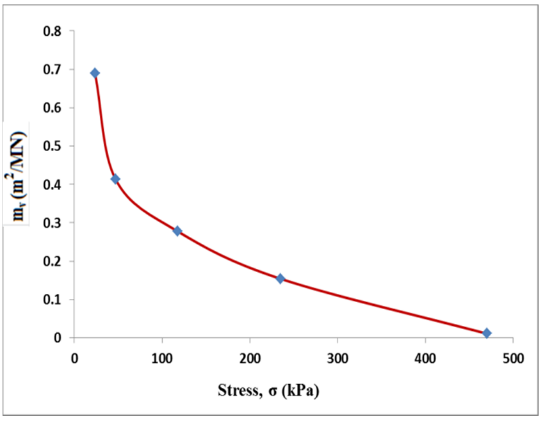
Table 4.4 Consolidation characteristics of the maximum compacted fibrous peat-sand mixtures under normal stresses ranging between 23.5 and 470 kPa.

Sand Content (%)	m_v (m^2/MN)	C_c	C_r	$\frac{C_r}{1+e_0}$	$\frac{C_c}{1+e_0}$
0	0.356-0.092	0.30	0.05	0.032	0.194
20	0.690-0.011	0.38	0.13	0.088	0.258
40	1.160-0.166	0.32	0.14	0.102	0.233
60	1.150-0.113	0.23	0.12	0.095	0.181
80	0.173-0.033	0.08	0.01	0.009	0.073

m_v coefficient of volume compressibility, C_c primary compression index, C_r recompression index, e_0 initial void ratio.

The ranges of the consolidation parameters at pressures of 23.5 and 470 kPa are given in table 4.4. The values of C_c in Table 4 were estimated from the linear part of the e-log σ curves of each specimen tested .The ranges are generally close to the lower bounds of those given in the literature(Duraisamy, 2007; Huat, 2004). Fig.4.10 shows the variation of m_v with consolidation pressure and indicates that m_v exhibits an exponential decrease with increase in stress.

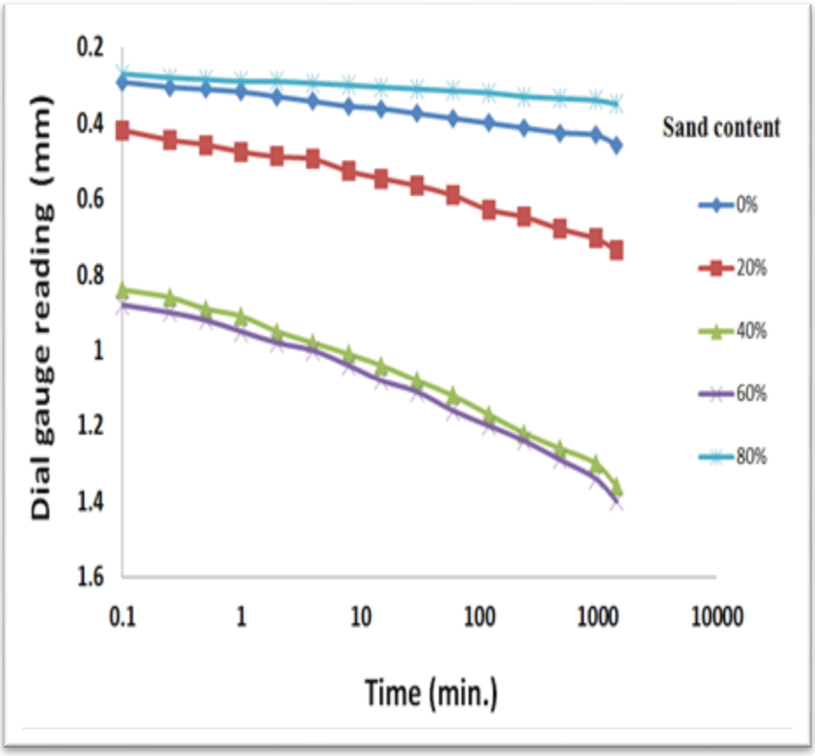




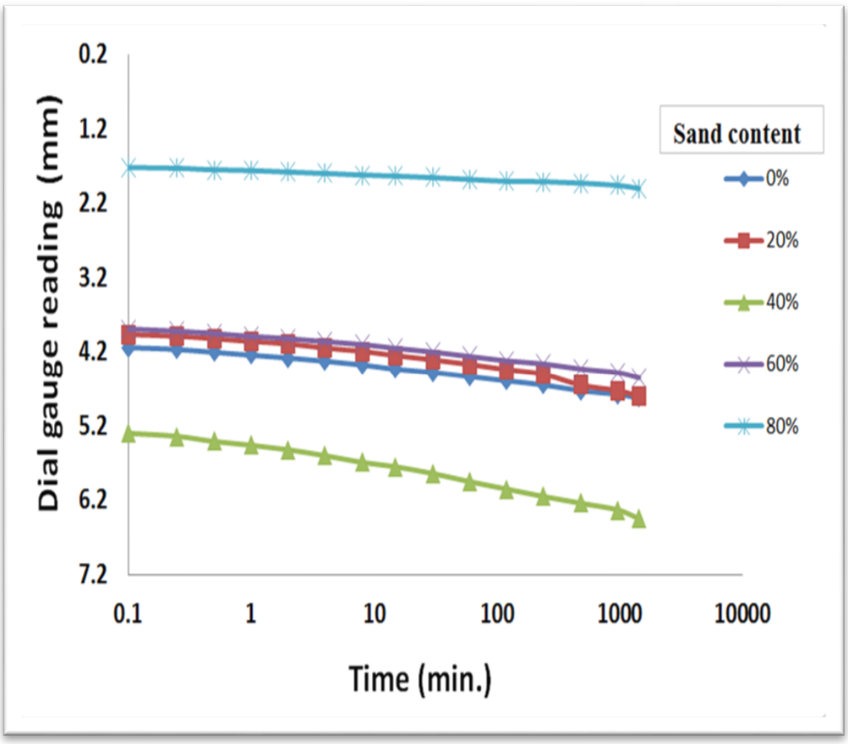
(a.) **(b.)**

Figure 4.10 Typical m_v-σ (log) graphs of the peat-sand mixtures taken from (a.) % 60 sand, by mass. (b.) % 20 sand, by mass.

Parameter C_c /1+e_0 is called compression ratio. According to O'Loughlin and Lehane (2003) , compression ratio for peat in the range of 0 to 0.05 is classified as very slightly compressible followed by slightly compressible for anything in between 0.05 to 0.10. Moderately compressible peat lies in the range of 0.10 to 0.20 and very compressible peat has ratio in between 0.20 to 0.35. Based on the compression ratios given in Table 4, this value is the lowest at % 80 sand content, slightly compressible (<0.05). On the other hand at % 20 and % 40 sand content this value is the highest, highly compressible (>0.20).



a.)



b.)

Figure 4.11 Typical examples of deformation-time behavior of mixing samples taken from (a.) under 23.5 kPa load (b.) under 470 kpa load.

Comparison between the two methods in previous studies on peats (Sing et al. 2008a, b) showed that the compression curves for peats best fit the Casegrande's method theoretical curve, hence this method was used in the present study. The log time versus deformation curves of compacted fibrous peat-sand mixing samples obtained for a stress range of 23.5–470 kPa are shown in Fig.4.1.a-b as typical examples. According to this figures settelment values of the sand-organic mixtures between % 0 and % 60 sand content with log time (min.) are coming closer to each other but also they are going far from the mixture including % 80 sand content when the vertical pressure applied to sample in the test increase. This indicate that the effect of the sand content by mass in compacted fibrous peats with respect to settelment values is reducing with increasing the pressure applied load. This situation is changing after % 80 sand content. At that value the behavior of the mixture is approaching to sand behavior.

CHAPTER V

CONCLUSION

The following are the main observartions related with compaction, shear strength and consolidation parameters of the compacted sand-organic mixtures.

1. Sand content changing in organic soil has an important effect on compaction parameters of fibrous peat soils. While the sand content ratio in the organic soil increase, DUW increases but OMC decreases.
2. % 10 sand by mass adding into the organic soil increased MDUW of the soil as % 30.4 , on the other side it reduced OMC as % 24.1. It was observed from test result that total % 50 sand content change in the organic soil decreased OMC ,% 55.2; but it increased MDUW, % 79.2.
3. OMC values with respect to each % 10 sand ratio increasing are evaluated as % 58, % 44, % 38, % 32, % 30 and % 26 , respectively. And also MDUW values are determined as 6.44 kN/m^3 , 8.4 kN/m^3, 8.9 kN/m^3, 9.4 kN/m^3, 10.2 kN/m^3 and 11.5 kN/m^3, respectively.
4. Sand content changing in organic soil has an important effect on Shear Strength parameters of organc soils.
5. While the sand ratio in the organic soil increase, IFA increases . IFA of natural organic soil is 26.4^0. % 10 sand adding into the organic soil increased IFA of the soil as % 17.3 , on the other side it reduced Cohesion as % 13.6 .
6. IFA values with respect to each % 10 sand ratio increasing are evaluated as 26.4^0, 30.96^0, 33.2^0, 33.1^0, 33.2^0, 33.2^0 and 36.2^0, respectively.
7. The primary void ratio of the sample which were not added sand into is greater than other samples, indicating that the primary void ratio is decreasing with respect to sand content regularly.
8. The variation of m_v with consolidation pressure indicates that m_v exhibits an exponential decrease with increase in stress.

9. Settelment values of the sand-organic mixtures between % 0 and % 60 sand content with log time (min.) are coming closer to each other but also they are going far from the mixture including % 80 sand content when the vertical pressure applied to sample in the test increase.
10. The effect of the sand content by mass in compacted fibrous peats with respect to settelment values is reducing with increasing the pressure applied load. This situation is changing after % 80 sand content. At that value the behavior of the mixture is approaching to sand behavior.

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