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Appraisal of Bhatta Waste as an Admixture for the Stabilization of Fill Soil

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Abstract
Testing of soil and knowing its strength parameter's is one of the basic components in construction. Testing of soil is carried out to find whether the existing soil can endure the burden of structure withheld upon it or not. In case of a weak soil, one can find difficult to pursue construction or any development project. While talking of solutions, there are many methods to improve its strength and properties: one of them which we decided to work on is 'Appraisal of Bhatta Waste as an Admixture for the Stabilization of Fill Soil'. It's a kind of cost effective & economical means of improving soil, as the basic material required for stabilization is Bhatta waste, which is normally easily available material. The main objective of our test is to check the effectiveness of Bhatta waste on mechanical properties of filled material. The testing comprised of performing Atterberg limit, UCS, direct shear test, sieve analysis, Moisture dry density and Permeability test. The Bhatta waste passing no. 40 sieve is mixed with fill soil and testing on different proportions was carried out. Summary was prepared for explanation of engineering properties of different proportions, while further testing on higher proportions is recommended.

Keywords: Fill soil; Bhatta waste.

Introduction

This chapter provides a preface to examining of soil, explaining the purpose and targets of performing this particular experiment.

1.1 Introduction to topic

Soil stabilization is the process to enhance the physical properties of soil by alteration and thus the stabilization can increase its engineering properties of soil as shear strength of soil, ground improvement to support sub-grade, this can increase structural integrity, load bearing capacity and aging control of soil.

Soil stabilization is required when the sub grade material available is not suitable to meet the purpose. It reduces the shear strength, permeability, construction and compressibility of soil thus for stabilization of soil clay and granular soil can be used. The degree of stability depends upon the shear strength and load bearing. The soil are utilize for different engineering properties on parking areas, sub-soil, site improvement projects and development of air airport.

The Bhatta waste is one of the common materials, which is formed after the production of bricks that is highly used in building construction and demolition. The stabilization of waste will be reducing the cost of construction in project as developing the social and environmental impressions in construction. The fill soil is used to stabilize the Bhatta waste. It improves the plasticity and strength of Bhatta waste so the stable is ready to reuse in construction, consultation and geotechnical engineering.

The main experiment of the project is to find out the effects in replacement of soil in Bhatta waste. In Bhatta production bricks are heated at 180 degree centigrade for 40 to 150 hours then the properties of clay change into solid, hard and low absorption, consequence non plastic soil is formed that will not appropriate to use in highway embankment. If the cohesive soil is mixed, then plasticity of soil will be developed having increased load-bearing capacity. It is also capable to resistance in seasonal variation moisture. Stabilization can be best characterized by mixing with respect to Alterberg limits (liquid limits and plastics limit) and particle size distribution curve. From different trials and classification indicate the best expected derivation for the suitability of soil to enhance its shear strength and load bearing capacity as desired requirement.

1.2 Bhatta Waste

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Figure STYLEREF 1 \s 1 SEQ Figure_ * ARABIC \s 1 1: Bhatta waste

1.3 Soil Stabilization

Soil stabilization is the changing in naturals or derived soil for any physicals, mechanicals, chemicals or combined methods to meet their required engineering resolution. Natural's soil has different properties such as complex and variable material. Some particles have low bearing capacity and shear strength as unsuited while someone have good and suited, so to meet the desire necessity the different proportion are mixed together through size distribution curve and Atterbeg limit (Liquid limit and plastic limit).

The Bhatta waste has different properties, which is non-plasticity material, permeable, and strong in strength to enhance its non- permeability the compaction, stabilization & composition is provided. Some additives are used as the composition materials, like acrylic copolymer resin, an enzyme some cementing materials. Different proportion is used to come across diverse requirement accordingly. To controls non-plasticity some cohesive soils are replaced, when the composition of both Bhatta waste and fill soil are deeply mixed together so that it could develop stabilized and non-plastic property which controls it smoothly. The fill soil have impermeable, plastic and interconnected properties by which the Bhatta waste become stable and can be used for construction and geotechnical engineering. The Bhatta waste is occupied the allocation space in the environment which can be removed by stabilization and can be reused efficiently as it reduces the construction cost and easy to place instead of extraction the soil from the deep of earth or take out from the hill.

1.4 Production of Bhatta Waste

Bhatta waste is basically bricks debris which emanate from the fundamental production of bricks. The building unit brick is composed byproduct of cement, sand, clay and water bonding as fired in the kiln. The three steps are performed in production of the bricks after crushing, grinding and filtering the raw material. This process includes to shape the brick is extrusion, molding, pressing, drying and firing it. During this process the bricks develop cracks and become debris.

When the bricks are heated in high temperature some of them are cracked & some of them is over hearted burnt, increased in size and unable to used so, these all are converted into Bhatta waste. During the bricks transportation, assembling and drying then it becomes sticky, crushed and hit one another and develop in to Bhatta waste as shown in Figure below.

Figure 12: Production of Bhatta Waste

1.5 Soil Stabilization Using Bhatta Waste

Abundant researches and literature are available on the soil stabilization by utilizing different additives and other constituent part like sand, clay and cement that could increase the strength of soil. Our experiment improved its Physicals, mechanicals and chemicals properties from A-6 soil to A-4 soil. Some effective literature and researches as Izwan johari hush ash (2011), Ramashansyah Putra Jaya and Badruld Hisham clay ash (2000), Gutierrez and Delvasta on lime ash(1999), Danupon et al,2007 on high lime (CaO), A lot of further researches like (Celik and Sabah, 2007; Zorluer and usta, 2003 ; Almedia et al, 2007, Tegethoff, 2001) have stated that Bhatta waste can develop necessary strength due to high weight and its reinforce properties of soil by putting on different application.

1.6 Methodology

Bricks debris is actually the generation of construction and demolition waste expanse which is developed systematically during collection, transportation and dumping of bricks. The debris is comprised of bricks, clay, soil, sand and concrete. The different vital properties of bricks debris are conveniently deliberated under physically, mechanical, durable and thermal properties.

In debris there are many forms of aggregate having different sizes but they are sieved by passing through sieve number 40. Mostly debris is black brown in shape. Density of which depends upon the clay material of bricks and it is approximately 1200 kg/cubic meter to 1600 kg/cubic meter. In mechanical wise, bricks

debris is strong in load bearing and its compressive strength depends upon aggregate bounding.
Thermally, bricks are fired under high temperature and its conducts heat and porosity. Ideal bricks debris is strong and hard & absorbs less water so that, debris can be used for insulation of heat but the durability of bricks debris depends upon the porosity or absorption value, frost resistance and efflorescence.

1.7 Clay Fills Properties

Clay is a minuscule grained particle which is composed of one or more minerals of quartz, metal oxides and organic matter made from natural rocks or other soil materials. The clay has plastic properties due to its magnitude and geometry. The clay are fired or dried, so that it became hard and brittle altering from plastic to non-plastic properties.
Clay has deposits of different grained particles as silts, clay and sand but the clay particles consist of 40% minerals. The size distribution methods are put on to discriminate the silt and clay (clay is smaller in size as compare to silt). The geotechnical properties such as, plasticity are determined through Atterberg limit. Clay has different colures including deep red, white, brown & orange light. Clay has strong bearing-capacity and strength when it is in hard form & low bearing capacity in soft form.

1.8 A-6 Soil Properties

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Literature Review

1.9 General

The worldwide great deal of examinations has been done regarding **Bhatta Waste** through different application and methods. The optimistic outputs are covered by the literatures in the soil bearing- capacity and strength values. The American Ceramic Society Bulletin (1990-1993, Robinson Gilbert C 2001), Book" Brick and Tile Making" by (Willi and Frank Handle 1995), Book "A Breakthrough in the Reduction Firing of Bricks" by (L S. Millberg (September, 1992), and the book "Brick Manufacture from Past to Present" by (Richards and Robert May, 1990), pp,(807-813) all of them reported the production of bricks debris and environmental affects by these, resolution to recover it and the processes required for upgrading efficient stabilization of other loose soil by using these debris with performance regarding test, as shear box test, Atterberg limit, particle size distribution ,Unconfined Compressive Test (UCS) etc.

1.10 Making of bricks (R**.**Sumathi 2016)

He has researched in making of bricks using construction debris (R**.**Sumathi Decmber 12, 2016) this present study about the generated amount of bricks debris on the cause of construction and demolition. Systematic process and investigation by which the bricks debris can reused potentially by replacing their constituents with clay. First he characterized the properties like strength with performing different test as water absorption test, shear box test, Atterberg limit, compressive strength test and efflorescence. The well-organized management would be beneficial for the environment and society by recycling the construction and demolition material.

1.11 Laboratory Evaluation of Finely Milled Bricks Debris (Cesar Hidalgo 2019)

They wrote articles on "Laboratory Evaluation of Finely Milled Bricks Debris"(cesar hidalgo February 14, 2019) as a Soil Stabilizer" the conclusion of this article which represent that soil is the basic unit which is used in the construction material and generated hugely worldwide waste. The annual estimation of construction and demolition waste (CDW) of different countries is given which lies between 30 to 60%. They investigated the debris soil, and found it as cemetery material which can be used to improve the strength of non-stabilized soil and reuse 90% of waste again.

Their laboratory result refers that the construction and demolition waste aggregate reproduces the cement, motors, pavement and other binding construction material. They also concentration of particles having size which is below 0.035mm and the conduct of soil stabilization performing unconfined compressive strength at different temperature, moisture and curing. The properties of non-stabilized material by mixing fine particles which can improve it strength 1.6 - 2.3 times that is big revolution on fill soil stabilization by developing the construction progress effectively as making environmental magnificent.

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1.12 **Consolidation Behavior of soil (Dhowian, A. W., and Edil, T, B. 1980)**

In the book "Consolidation Behavior of soil" they classified the soil into different group and sub-group having identical and non-identical properties regarding soil engineering. They obey the classification system mostly that is American Association of State Highway and Transportation Officials (ASSHTO) and Unified Soil Classification System (USCS) by considering the partials size distribution and Atterberg limit. The guideline table is given to classify the soil classification according to its major seven group (A-1 to A-7) are specified. They make boundary line to differentiate the granular soil to silt and clay soil with passing of particles from the sieve No. 200. The particle passing less than 35% are called granular soil that are named group A-1, A-2, and A-3 other particle having passing more than 35% named group A-4, A-5, A-6 and A-7 that are called silt and clay.

1.13 **Study about the sub-grade weaker soil (Ankur Dobriya 2018)**

They present study about the sub-grade weaker soil which is used in pavement and the practice to develop the weak soil. The weak soil will be affecting the strength, performance and life span of road infrastructure. There are different methods to improve the weak soil through various construction and demolition waste debris. Annually millions of tons are generated in terms of waste debris like concrete, bricks, metals, plastics and wood.

In pavement and construction industry there is huge demand of aggregate required, but the bigger gap is present between the pavement supply and demands to reduce these divergences, the industry have to systematize the recycling of waste.

They conducted several tests on the natural soil and demolished brick waste as various proportions are mixed in the weak soil altering their properties affected at different percentages. The conclusion of test are, when the 40% of bricks debris are blended with cohesive soil it gave the maximum strength as compare to natural soil

Methodology

This Chapter includes the steps and the method that were followed to approaches the targets sets.

1.14 Methodology of complete project

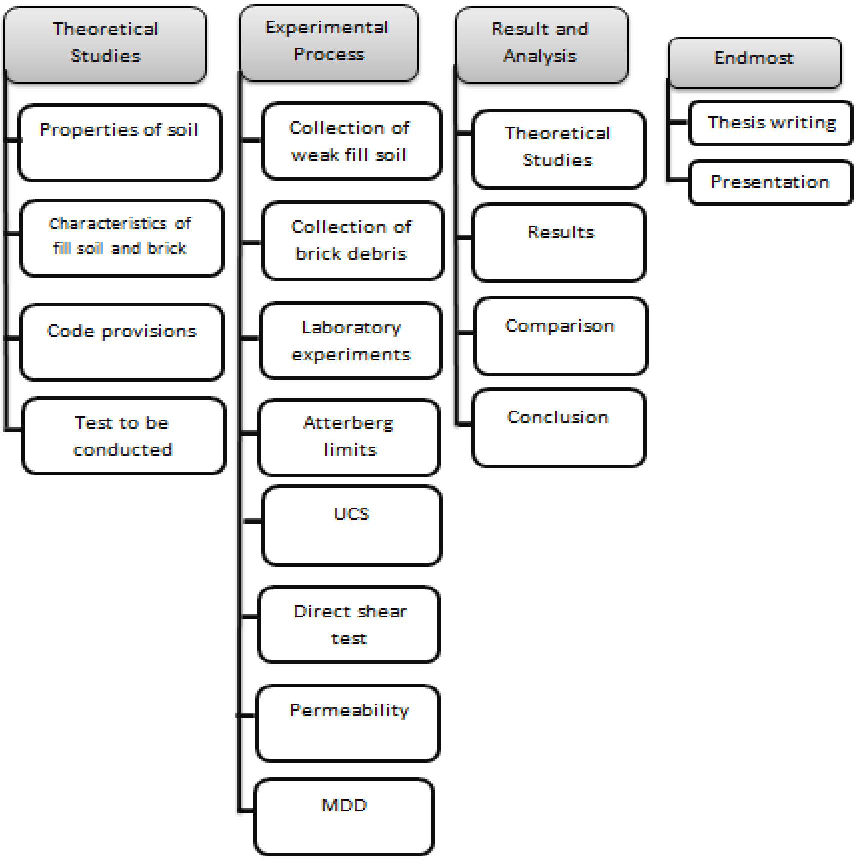


Figure 31: Methodology of Complete Project

1.15 **Methodology of experimental part**

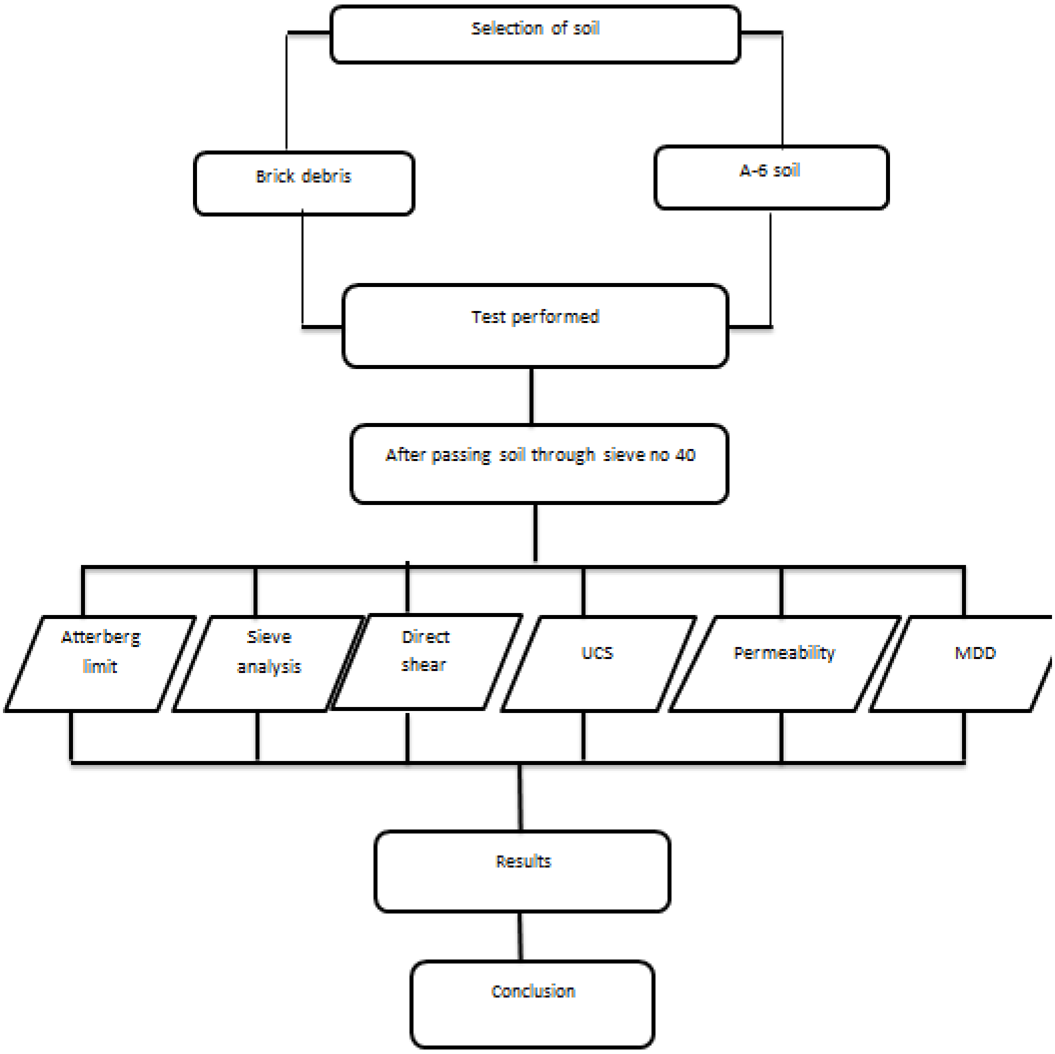


Figure 32: Methodology of experimental Project

1.16 **Description of Whole Project**

As according to the original title of our project "*Appraisal of Bhatta Waste as an Admixture for the Stabilization of Fill Soil*" we are required to improve strength and properties of soil using an admixture. For this purpose we choose Bhatta waste, as Bhatta waste is a kind of material that is left after the production of brick at brick kiln. Brick debris comprises of clay, silt, sand, limestone and other binding material. Among the other ways of improving soil properties it is a kind of method that is cheap, efficient, economic and durable. For this purpose we are required to have a weak soil so that we can analyze its performance against addition of Bhatta waste. We took our soil for initial testing from OPF society near japan road Islamabad that is used there for some kind of fill purpose, than we took brick debris from nearby brick kiln that is situated outside premises of naval anchorage Islamabad.

After we obtained our samples for testing we conducted initial test of Atterberg limit for classifying soil as it is according to our requirement or not? So carrying out test of liquid limit, plastic limit, and sieve analysis implied that our soil is A-6, that is a kind of weak clayey soil and we can pursue further testing. So made hierarchy of test that we are going to conduct on soil that includes liquid & plastic limit test, unconfined compression test, direct shear test, permeability test, sieve analysis and moisture dry density test (MDD). These tests will depict and indicate the improvement of original soil in terms of strength, endurance and characteristics. The fill soil is used for multiple purpose such as in pavement, foundation and any subsequent filling etc.

Now for testing we initially put samples into oven for 24 hours at 102 degree Celsius so that the entire moisture can removed. After that we broke sample using hammer so that it can pass through sieve no 40 and all of our samples including brick debris is oven dried and passed through sieve no 40, so that all particles are fine and no gravel remain in it. We performed test on samples with including percentages of 0, 5, 10, 15 and 20% brick debris. The quantity of brick debris in each test is kept in accordance with the previously mentioned percentages and whole quantity required for sample preparation is kept in accordance with the standard requirement.

After obtaining results we analyzed them in a manner that we kept result of 0% with no brick debris as a bench mark and compared it against the samples including percentages of 5, 10, 15 & 20%. The testing lasted for approximately two months and after generating summary of results we can conclude that soil strength has been improved by **1.5** to **2.3** percent. The results are further discussed thoroughly in next sections.

Material & Tests

In this chapter we are going to discuss the procedure we adopted to conduct different experiment's and the technique implemented to achieve objectives. Material taken, sample preparation, procedure and all experiment relevant measure are discussed.

1.17 Fill Soil

A fill soil is used to occupy the cavity created during excavation. After the construction phase is done, the fill soil is dumped in the space created between the periphery of uncut soil and structure.

1.18 Brick Debris

Brick debris is commonly found around brick kiln and generated usually during bricks transportation, placement and often can be obtained by crushing of bricks.

1.19 Classification of soil

The classification of various types of soil using AASHTO classification system is given below.

Table 41: Soil classification chart

AASHTO Soil Classification System (from AASHTO M 145 or ASTM D3282)											
General Classification	**Granular Materials (35% or less passing the 0.075 mm sieve)**							**Silt-Clay Materials (>35% passing the 0.075 mm sieve)**			
Group Classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5 A-7-6
Sieve Analysis, % passing											
2.00 mm (No. 10)	50 max	…	…	…	…	…	…	…	…	…	…
0.425 (No. 40)	30 max	50 max	51 min	…	…	…	…	…	…	…	…
0.075 (No. 200)	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
Characteristics of fraction passing											

0.425 mm (No. 40)										
Liquid Limit	…	…	40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
Plasticity Index	6 max	N.P.	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min
Usual types of significant constituent materials	stone fragments, gravel and sand	fine sand	silty or clayey gravel and sand				silty soils		clayey soils	
General rating as a subgrade	excellent to good						fair to poor			

1.20 **Test on soil**

1.20.1 Sieve Analysis

This test is performed for particle size distribution and drawing the gradation curve, for the purpose knowing passing percentages against each sieve and number of fine or coarse particle present in it.

1.20.2 Liquid Test

It is a basic measure of the moisture content present in fine grained soil. On the basis of water content the soil state exist like solid, semi-solid, and liquid etc. the plastic limit test can be used to describe the soil type as it is silt, clay or other types of soil. The casagrande's method includes pouring the clay into porcelain bowel of approximately, a groove is used to cut the soil from the Centre while the clay is poured into it. A spatula is used for thorough mixing of the soil. A blow count of 25 is used to measure the plastic limit against the moisture content. Basically liquid limit is moisture content at which soil changes it characteristics. Apparatus picture is shown below in Figure 4.1

Figure STYLEREF 1 \s 4 SEQ Figure_ * ARABIC \s 1 1: Liquid limits apparatus

1.20.3 Plastic Limit

The plastic limit tes ... the test of plastic limit is classified under Att ... low the threads are made by adding water content up to optimum moisture content. The material is used for making threads is passed through sieve no 40 as shown in Figure 4.2.

Figure 42: Plastic limit apparatus

1.20.4 Permeability Test

The permeability test is performed to find out how much permeable soil is, for this purpose the soil is powdered to fine and pass through sieve no 40. Before crushing and sieving the soil it is kept in oven for 24 hours so that its entire moisture can eradicated. Now by following standard procedure the soil is subjected to test if the soil is highly permeable no water could percolate through it. Explicitly shown in Figure 4.3 below

Figure STYLEREF 1 \s 4 SEQ Figure_ * ARABIC \s 1 3**:** Apparatus Permeability Test

1.20.5 Moisture Dry Density

The moisture dry density test is carried out to find out the dry density and optimum moisture content of the soil. This test enables us to find out the relation between dry density and moisture content. Elaborated in Figure 4.4 below

Figure STYLEREF 1 \s 4 SEQ Figure_ * ARABIC \s 1 4: MDD apparatus

1.20.6 Direct Shear Test

The direct shear test is performed to find out the shear strength parameters known as ‘angle of internal friction’ and ‘cohesion’. Apart from that it also gives the lateral deformation subjected to specimen. The peak shear stress and the ultimate shear stress are the indicative of specimen endurance against the lateral loading.

The test is performed in a shear box test machine that is a digital display unit and a lateral deformation and dial reading gauges. Picture of machine is given in Figure 4.5 below

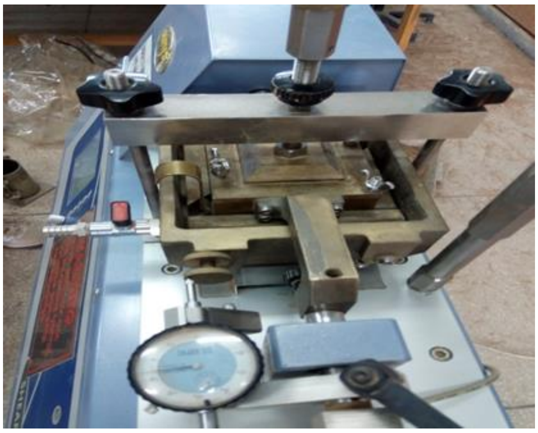


Figure STYLEREF 1 \s 4 SEQ Figure_ * ARABIC \s 1 5: Direct shear test apparatus

1.20.7 Unconfined Compression Test

The unconfined compression test is used to find out the shear strength of the soil. The unconfined compressive strength 'qu' is well indicator of the durability of soil. This test is limited to cohesive soil only because the specimen is cylindrical in shape and is place without any lateral support as shown in Figure 4.6 below.

Figure STYLEREF 1 \s 4 SEQ Figure_ * ARABIC \s 1 6: UCS Test apparatus

Test specimen & Procedure

1.21 Introduction

In this chapter we are going to discuss about our specimen on which, we performed different experiment's, the cohesive/fill soil is taken from OPF block 5 society near japan road Islamabad. The brick debris is taken from a brick kiln near Naval Anchorage Islamabad. Both the brick debris and fill soil is oven dried and crushed thereafter. Also both the material is passed through sieve 40 and samples are prepared from it.

1.22 Test setup and procedure

1.22.1 Determination of Liquidity Limit

This test is standardized as (AASHTO T89-96),(ASTM D 4318)

For Liquid limit:

Sample taken = 100g

Apparatus:

- Porcelain dish
- Spatula

- o Grooving tool
- o Balance
- o Drying oven
- o Containers

Sample preparation:

During this test, the sample taken was tested in five different proportions i-e total sample 100g containing 0%, 5%, 10%, 15% and 20% Bhatta waste at OMC.

Samples criteria taken as follows:

1. 100g soil with 0% Bhatta waste
2. 100g sample containing 5% Bhatta waste i-e 95g soil and 5% Bhatta waste.
3. 100g sample containing 10% Bhatta waste I-e 90g soil and 10g Bhatta waste.
4. 100g sample i-e 85g soil and 15g Bhatta waste.
5. 100g sample I-e 80g soil and 20g Bhatta waste.

Details are described in Figure 5.1below

Figure 51: liquid limit sample preparation

Determination of Liquidity Limit at 5, 10, 15, 20%

Procedure:

Following procedure was adopted during the performance of this test

- First of all we need to check the height of drop of cup of cassagrande apparatus and adjust it equal to 10mm with 0.2mm relaxation.
- 100g of sample was taken which was thoroughly mixed different proportions of soil and Bhatta waste as mentioned above passing through sieve no 40 i-e 0.425mm.
- Further water was added in increments of 1 to 3ml.
- After water addition, sample was thoroughly mixed to form a uniform paste of stiff consistency, and then sufficient amount of it was placed in the cup and spread with spatula in such a way that depth in middle of the cup is equal to 10mm.
- Sample paste in the cup was divided by firm strokes of grooving tool along the diameter so that a clean sharp groove is formed.
- The cup containing sample was subjected to blows by turning the lever almost at a rate of two revolutions per sec until two sides of the sample came in contact at the bottom of groove along a distance of 13mm.
- Numbers of blow were noted down.

- The sample was taken to determine the moisture content.

After every trial when the groove was closed the number of blows were noted down and sample was taken to determine the moisture content.

1.22.2 Determination of Plastic limit & Plasticity index

This test is standardized as (AASHTO T 90-96),(ASTM D 4318)

For plastic limit:

Sample taken = 20g

Apparatus:

- o Porcelain dish
- o Spatula
- o Glass surface for rolling
- o Balance
- o Drying oven & containers

Sample preparation:

1. During this test, the sample taken was tested in five different proportions i-e 20g soil with 0%, 5%, 10%, 15% and 20% Bhatta waste.
2. Sample proportions are as follows.
3. 20g soil
4. 20g sample with 5% Bhatta waste i-e 19g soil & 1g Bhatta waste
5. 20g sample with 10% Bhatta waste i-e 18g soil & 2g Bhatta waste.
6. 17g soil & 3g Bhatta waste.
7. 16g soil & 4g Bhatta waste.

Picture of sample are shown in Figure 5.2 below

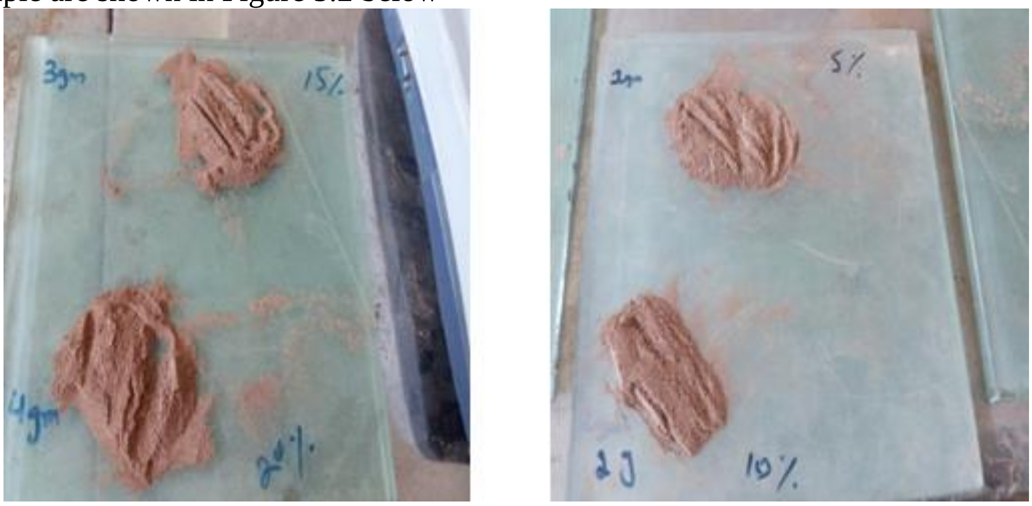


Figure 52: plastic limit sample

Procedure:

- Following procedure was adopted during the performance of this test.
- 8g of sample was deformed in to an ellipsoidal shape mass.
- This mass was rolled between the fingers on a glass plate until a thread was formed of uniform diameter throughout its length.
- When diameter of thread became less than 3mm, thread became non-uniform near to be broken so re-gathering and re rolling was done until a thread of uniform diameter was formed which couldn’t be further rolled.
- Threads of uniform diameter slightly greater than 3mm was made on different samples and placed in a container that was meant to be placed in the drying oven for the determination of moisture content.

Plasticity index= liquid limit - plastic limit

Particle size sieve analysis by wash sand method

This test is standardized as (ASTM D 1140)

Sieve analysis:

Sieve analysis can be defined as a procedure that is used in civil engineering for the particle size distribution of a material by allowing it to pass through a series of
Arranged sieves according to the standard.

Apparatus:

- Balance
- Set of sieves

For Sieve Analysis:

Sample taken = 500g

Sample taken:

1. For 5% =25g debris + 475g soil
2. For 10%= 50g debris + 450g soil
3. For 15%= 75g debris + 475g soil
4. For 20%= 100gdebris + 400g soil

Procedure:

- First prepare the sample after passing it through the sieve of no 40.
- Now place sieves in order of no 40, 100 & 200.
- After that put sample in sieves and place it on sieve shaker for about 60 seconds minimum.
- Now note the amount retained on each sieve and wash the soil retained on sieve no 200 using water.
- After that collect the soil wash by water note down its weight and put in cup of known height.
- Draw graph of particle size distribution.

Sample preparation is shown in Figure 5.3 below

Figure 53: sieve analysis sample

1.22.3 Determination of moisture density relationship

This test is standardized as (AASHTO T 99-97),(ASTM D 698-70)

For MDD:

Sample taken = 2kg

Apparatus:

- Mold with detachable color and base plate
- Rammer with mass of 2.5kg
- Balance
- Drying oven
- Straightedge for trimming soil
- Sieve no 4
- Containers

Sample Taken:

Sample taken was tested in five different proportions i-e 2kg sample containing 0%, 5%, 10%, 15%, and 20% Bhatta waste.

- Samples taken are as follows.
- 2000g soil
- 2000g sample with 5% Bhatta waste i-e 1900g soil & 100g Bhatta waste.

- 2000g sample containing 10% Bhatta waste i-e 1800g soil & 200g Bhatta waste.
- 2000g sample containing 15% Bhatta waste i-e 1700g soil & 300g Bhatta waste.
- 2000g sample containing 20% Bhatta waste i-e 1600g soil & 400g Bhatta waste.

Procedure:

- Following procedure was adopted during the performance of this test.
- First of all sample selected was thoroughly mixed with sufficient water to dampen it to approximately 4% below the expected optimum moisture content.
- Then sample was compacted in the mold with collar attached to it in three equal layers to a depth of approximately 125mm or 5in.
- Each layer was compacted by 25 uniformly distributed blows of the rammer dropping free from a height of 12in above the soil surface.
- After that, the collar was removed and the excessive soil even at top of the mold was trimmed and weight of mold and soil was determined.
- Then, material from the mold was removed and from that sample moisture content was determined.
- After that the specimen was broken down in to pieces and mixed with remaining testing sample
- Further water was added in more quantity than previous one to increase the moisture content of the sample and procedure was repeated on each increment of water added.
- We continued this series of determination until there was a decrease or no change in the wet density of the compacted soil.
- Then, moisture content and dry density of the compacted soil for each trial was calculated from which we could draw moisture density relationship.

1.22.4 Determination of shear strength parameters by unconsolidated-un drained shear box test

This test is standardized as (ASTM D 3080-90)

Shear box test is basically used to determine the shear strength of soil & also to predict the failure strength of a surface.

For Shear box test:

Sample taken = 2.5kg

Apparatus:

- Shear box test machine
- Mold
- Spatula
- Specimen box
- rammer

Sample Taken:

Sample details

Both soil & Bhatta waste was passed through sieve no 40.

2.5kg of sample was tested in five different proportions and on 3 different weights i-e 1, 2 and 4kg.

1. 2.5 kg soil with 0% Bhatta waste i-e 2500g soil
2. 2.5kg sample with 5% Bhatta waste i-e 2375g soil & 125g Bhatta waste.
3. 2.5kg sample with 10% Bhatta waste i-e 2250g soil & 250g Bhatta waste.
4. 2.5 kg sample consists of 2175g soil & 375g Bhatta waste.
5. 2.5kg sample comprising of 2000g soil & 500 Bhatta waste.

Pictures of sample are shown below in Figure 5.4

Figure 54: shear box sample

Procedure:
Following procedure was adopted during the performance of this test.

- First of all sample comprising of particular percentage of soil & Bhatta waste was thoroughly mixed in a pan.
- Water added was 15.66% of the total sample (2500g) i-e OMC value.
- Thoroughly mixed the sample until all the bubbles appearing in the sample were disappeared.
- Then sample prepared was filled in the mold and 75 to 80 blows were given to each sample.
- Soil specimen was then taken from that mold with the help of spatula & placed in the shear box which was square.
- A normal load of specific and constant magnitude was applied.
- The particular normal load and the shear load that produced shear failure were recorded through dial gauges i-e load gauge and deflection gauge of the shear box machine.
- The soil specimen was then removed from the shear box and discarded.

Process was repeated for other samples

1.22.5 Determination of Shear Strength Parameter by Unconfined Compression Test

This test is standardized as (ASTM D 2166), (AASHTO T-208)

For UCS:
Sample taken = 2kg
Sample taken:
Sample details are as follows
Both soil and Bhatta waste were passed through sieve no 40.
2kg of sample taken was tested in 5 different proportions i-e

1. 2kg sample containing 0% Bhatta waste i-e 2000g soil
2. 2kg sample containing 5% Bhatta waste i-e 1900g soil & 100g Bhatta waste.
3. 2kg sample containing 10% Bhatta waste i-e 1800g soil & 200g Bhatta waste.
4. 2kg sample containing 15% Bhatta waste i-e 1700g soil and 300g Bhatta waste.
5. 2kg sample conataing 20% Bhatta waste i-e 1600g soil and 400g Bhatta waste.

Apparatus:

- Compression machine

- Load & deformation gauges
- Sample trimming equipment
- Balance
- Moisture can

Procedure:

Following procedure was adopted during the performance of this test.

- First of all sample comprising of soil and Bhatta waste of particular percentage was thoroughly mixed in pan.
- Then water was added in increments according to the OMC i-e 25%
- Again thoroughly mixed the sample until all the bubbles appearing in the sample were disappeared.
- Sample prepared was then filled in the mold and subjected to 15 blows.
- Sample was then extruded from the mold through Shelby tube sampler.
- Sample was then placed in the compression testing machine & centered that from all sides on the bottom of the plate.
- Device was adjusted in such a way that upper plate makes contact with specimen.
- Load and dial gauges were settling down to zero.

Load was then applied through machine at a rate of 0.6mm/min and then load and deformation dial gauges were recorded throughout the process of load application until the sample tends to cracks as shown in Figure 5.5 below

Figure 55: UCS sample

1.22.6 Determination of permeability

This test is standardized as (Not been standardized by ASTM or AASHTO)

For Permeability:

Sample taken = 1750g

Apparatus:

a. Cutting edge compaction parameter: 4in

b. Measuring panel:

Consisting of 3 glass standpipe tubes with different diameters, placed vertically on the wooden panel that is used to apply and measure the hydraulic falling head.

Glass tubes of different diameter are used to make permeability measurement for different types of soil the smallest cross section tube is used for low permeability soils.

Sample preparation:

This test was performed on total sample 1750g containing 0%, 10% and 20% Bhatta waste.

Sample details are as follows.

1. 1750g A-4 soil.
2. 1575g A-4 soil & 175g Bhatta waste.
3. 1400g A-4 soil & 350g Bhatta waste.

Sample picture are shown in Figure 5.6 below

Figure 56: permeability sample

Graph and Reading of Tests

In this chapter we will discuss about results obtained from different experiments

1.23 Introduction

Following are the list of experiments of which results are discussed in this chapter

1) Atterberg limits
2) Sieve analysis
3) Permeability
4) UCS
5) Direct Shear
6) MDD

1.24 Atterberg limits

1.24.1 For 0% Debris

Table 61: liquid & plastic limit Determination 0% debris

ASTM D-2487, Unified Soils Classification System

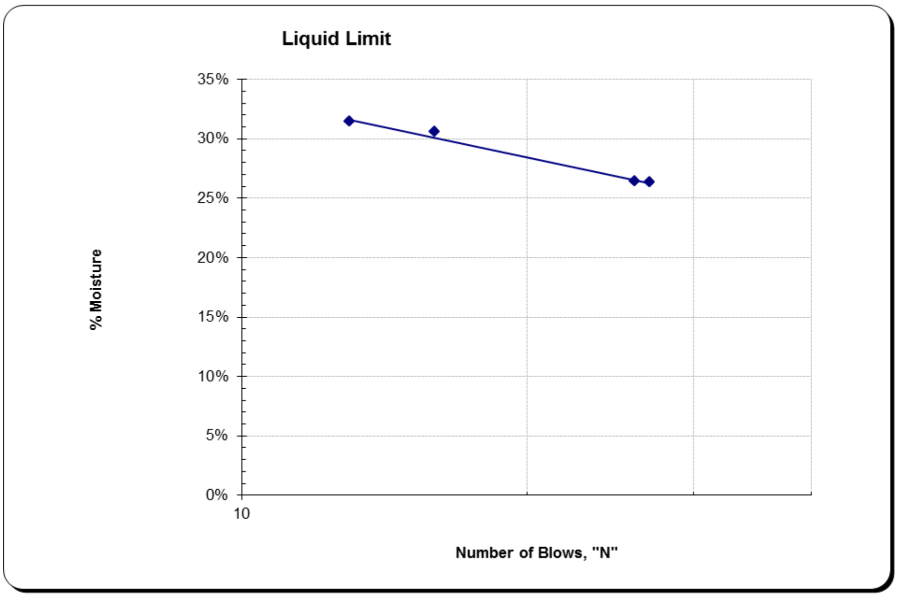
Liquid Limit Determination

	#1	#2	#3	#4	#5	#6
Weight of Wet Soils + Pan:	26.55	19.31	19.34	16.66		
Weight of Dry Soils + Pan:	23.29	17.53	17.73	15.59		
Weight of Pan:	12.63	11.88	11.64	11.53		
Weight of Dry Soils:	10.66	5.65	6.09	4.06		
Weight of Moisture:	3.26	1.78	1.61	1.07		
% Moisture:	30.6 %	31.5 %	26.4 %	26.4 %		
N:	16	13	26	27		

Liquid Limit @ 25 Blows:	27.0 %
Plastic Limit:	15.7 %
Plasticity Index, I_P:	11.3 %

Plastic Limit Determination

	#1	#2	#3	#4	#5	#6
Weight of Wet Soils + Pan:	17.32	15.74				
Weight of Dry Soils + Pan:	16.84	14.94				
Weight of Pan:	11.57	11.36				
Weight of Dry Soils:	5.27	3.58				
Weight of Moisture:	0.48	0.80				
% Moisture:	9.1 %	22.4 %				



Graph 61: liquid limit determination 0% debris

1.24.2 For 5% Debris

Table 62: liquid & plastic limit Determination 5% debris

ASTM D-2487, Unified Soils Classification System

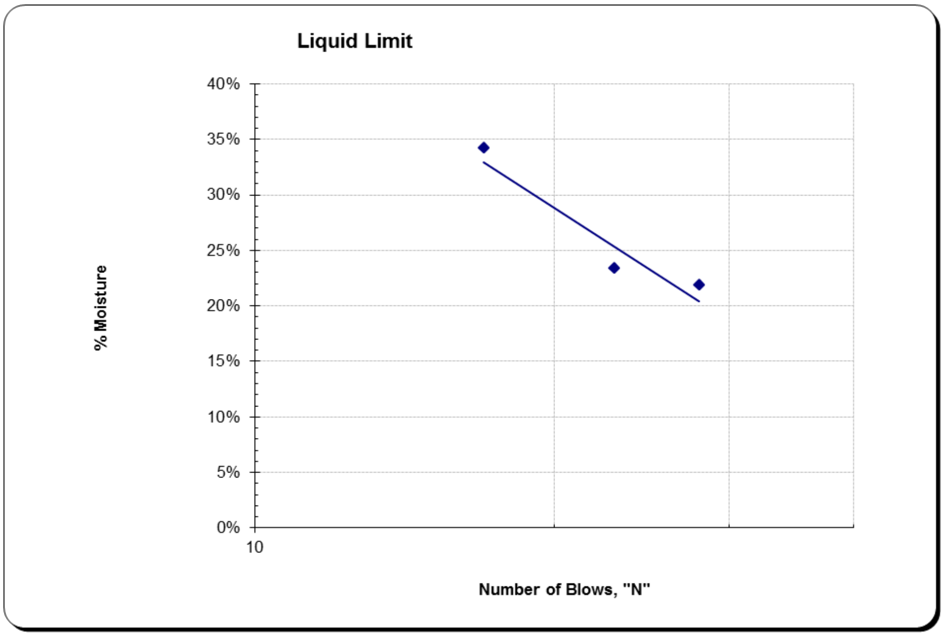
Liquid Limit Determination

	#1	#2	#3	#4	#5	#6
Weight of Wet Soils + Pan:	23.49	23.94	17.85			
Weight of Dry Soils + Pan:	21.44	21.22	16.62			
Weight of Pan:	12.07	13.27	11.36			
Weight of Dry Soils:	9.37	7.95	5.26			
Weight of Moisture:	2.05	2.72	1.23			
% Moisture:	21.9 %	34.2 %	23.4 %			
N:	28	17	23			

Liquid Limit @ 25 Blows:	23.8 %
Plastic Limit:	12.7 %
Plasticity Index, I_P:	11.1 %

Plastic Limit Determination

	#1	#2	#3	#4	#5	#6
Weight of Wet Soils + Pan:	20.90	21.44				
Weight of Dry Soils + Pan:	19.84	20.34				
Weight of Pan:	11.65	11.49				
Weight of Dry Soils:	8.19	8.85				
Weight of Moisture:	1.06	1.10				
% Moisture:	12.9 %	12.4 %				



Graph 62: liquid limit determination 5% debris

1.24.3 For 10% Debris

Table 63: liquid & plastic limit Determination 10% debris

ASTM D-2487, Unified Soils Classification System

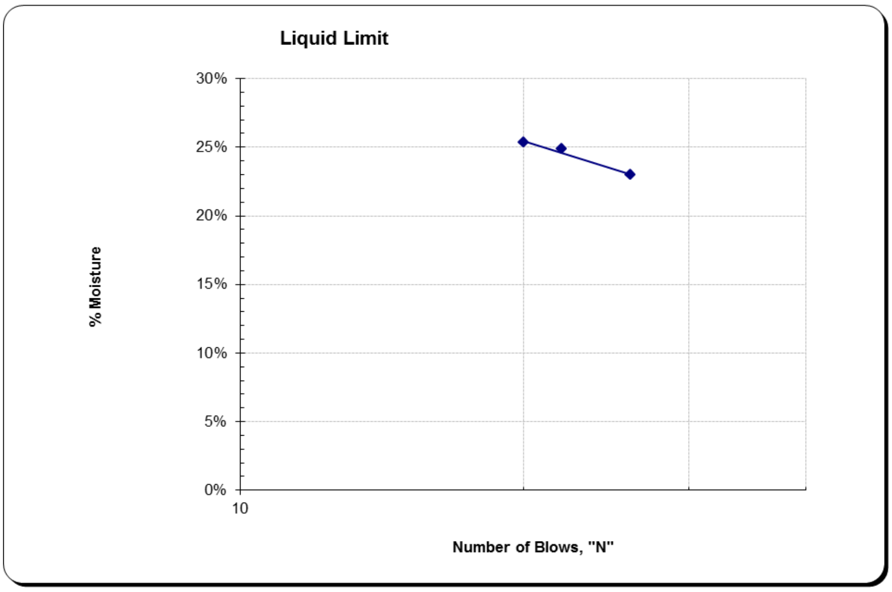
Liquid Limit Determination

	#1	#2	#3	#4	#5	#6
Weight of Wet Soils + Pan:	19.93	20.69	19.44			
Weight of Dry Soils + Pan:	18.41	18.87	17.89			
Weight of Pan:	11.80	11.55	11.78			
Weight of Dry Soils:	6.61	7.32	6.11			
Weight of Moisture:	1.52	1.82	1.55			
% Moisture:	23.0 %	24.9 %	25.4 %			
N:	26	22	20			

Liquid Limit @ 25 Blows:	23.5 %
Plastic Limit:	12.7 %
Plasticity Index, I_P:	10.7 %

Plastic Limit Determination

	#1	#2	#3	#4	#5	#6
Weight of Wet Soils + Pan:	18.93	20.21				
Weight of Dry Soils + Pan:	18.17	19.15				
Weight of Pan:	11.50	11.62				
Weight of Dry Soils:	6.67	7.53				
Weight of Moisture:	0.76	1.06				
% Moisture:	11.4 %	14.1 %				



Graph 63: liquid limit determination 10% debris

1.24.4 For 15% Debris

Table 64: liquid & plastic limit Determination 15% debris

ASTM D-2487, Unified Soils Classification System

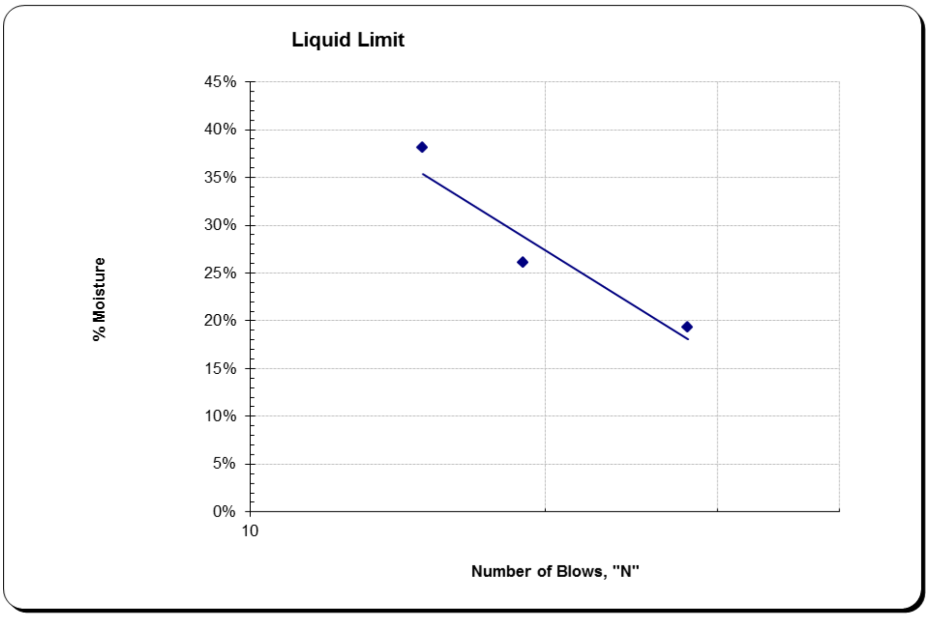
Liquid Limit Determination

	#1	#2	#3	#4	#5	#6
Weight of Wet Soils + Pan:	30.38	22.50	27.73			
Weight of Dry Soils + Pan:	26.49	20.72	23.52			
Weight of Pan:	11.59	11.51	12.47			
Weight of Dry Soils:	14.90	9.21	11.05			
Weight of Moisture:	3.89	1.78	4.21			
% Moisture:	26.1 %	19.3 %	38.1 %			
N:	19	28	15			

Liquid Limit @ 25 Blows:	22.1 %
Plastic Limit:	12.2 %
Plasticity Index, I_P:	9.9 %

Plastic Limit Determination

	#1	#2	#3	#4	#5	#6
Weight of Wet Soils + Pan:	25.75	24.59				
Weight of Dry Soils + Pan:	24.59	23.14				
Weight of Pan:	13.35	12.78				
Weight of Dry Soils:	11.24	10.36				
Weight of Moisture:	1.16	1.45				
% Moisture:	10.3 %	14.0 %				



Graph 64: liquid limit determination 15% debris

1.24.5 For 20% Debris

Table 65: liquid & plastic limit Determination 20% debris

ASTM D-2487, Unified Soils Classification System

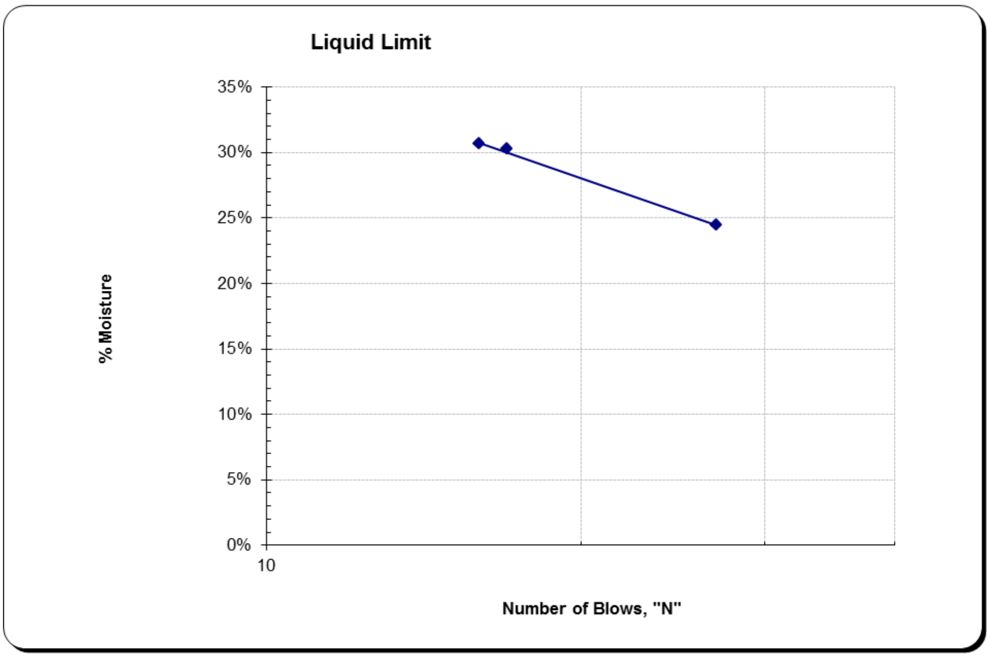
Liquid Limit Determination

	#1	#2	#3	#4	#5	#6
Weight of Wet Soils + Pan:	16.92	18.94	19.78			
Weight of Dry Soils + Pan:	15.66	17.53	18.07			
Weight of Pan:	11.50	11.76	12.49			
Weight of Dry Soils:	4.16	5.77	5.58			
Weight of Moisture:	1.26	1.41	1.71			
% Moisture:	30.3 %	24.4 %	30.7 %			
N:	17	27	16			

Liquid Limit @ 25 Blows:	25.6 %
Plastic Limit:	16.0 %
Plasticity Index, I_P:	9.6 %

Plastic Limit Determination

	#1	#2	#3	#4	#5	#6
Weight of Wet Soils + Pan:	19.84	17.91				
Weight of Dry Soils + Pan:	18.56	17.36				
Weight of Pan:	12.89	11.56				
Weight of Dry Soils:	5.67	5.80				
Weight of Moisture:	1.28	0.55				
% Moisture:	22.6 %	9.5 %				



Graph 65: liquid limit determination 20% debris

1.25 **Permeability**

1.25.1 Result

The condition for starting test is drainage of water through the soil specimen which never occurred in any of following test. The sample is placed for 48 hrs. So it is concluded that soil is highly impermeable.

1.26 **Moisture Dry Density**

1.26.1 For 0% debris

Table 66: Density Determination 0% debris

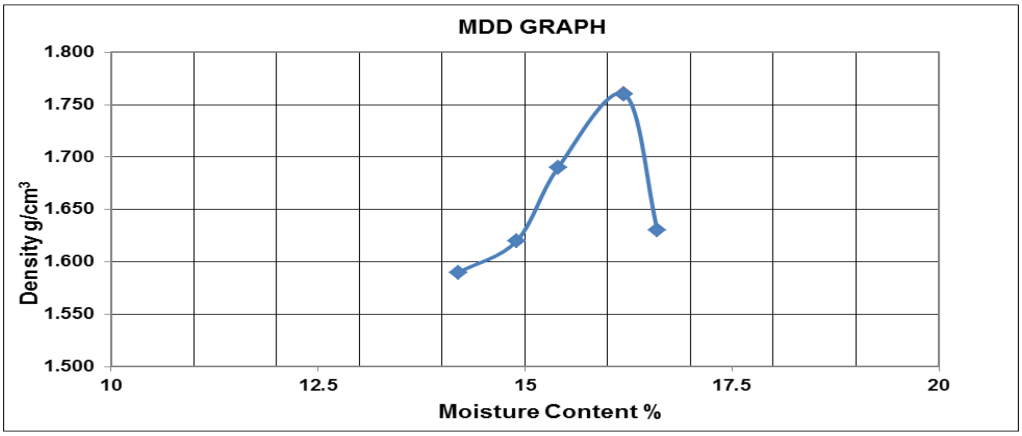
Density Determination							
Test No		**1**	**2**	**3**	**4**	**5**	
Wt of Mould (g)	A	2765.0	2765.0	2765.0	2765.0	2765.0	
Volume of Mould (cm^3)	V	944.0	944.0	944.0	944.0	944.0	
Wt of Mould + Wet Soil (g)	C	4407.6	4473.6	4511.4	4530.3	4549.2	
Weight of Wet Soil (g)	C-A	1642.6	1708.6	1746.4	1765.3	1784.2	
Wet Density of Soil (g/cm^3)	D = (C-A)/V	1.740	1.810	1.850	1.870	1.890	

Table 67: Water Content Determination 0% debris

Water Content Determination of Soil:							
Cane No.		**A-1**	**A-2**	**A-3**	**A-4**	**A-5**	
Wt. of Container (grm)	B	55.3	52.1	66.3	50.4	53.1	
Wt. of Container + Wet Soil (grm)	E	295.3	259.6	245.6	219.5	228.3	
Wt. of Container + Dry Soil (grm)	F	265.5	232.7	221.7	195.9	203.4	
Weight of Water (grm)	G = E - F	29.8	26.9	23.9	23.6	24.9	
Weight of Dry Soil (grm)	F - B	210.2	180.6	155.4	145.5	150.3	
Water Content %	G/(F -B)100	14.2	14.9	15.4	16.2	16.6	
Dry Density of Soil (g/cm^3)	D/(100+w)	1.670	1.710	1.730	1.760	1.792	

Table 68: Omc and Mdd 0%

MDD	**OMC**
1.760 g/cm^3	**16.20 %**



Graph 66: moisture dry density 0% debris

1.26.2 For 20% debris

Table 69: Density Determination 20% debris

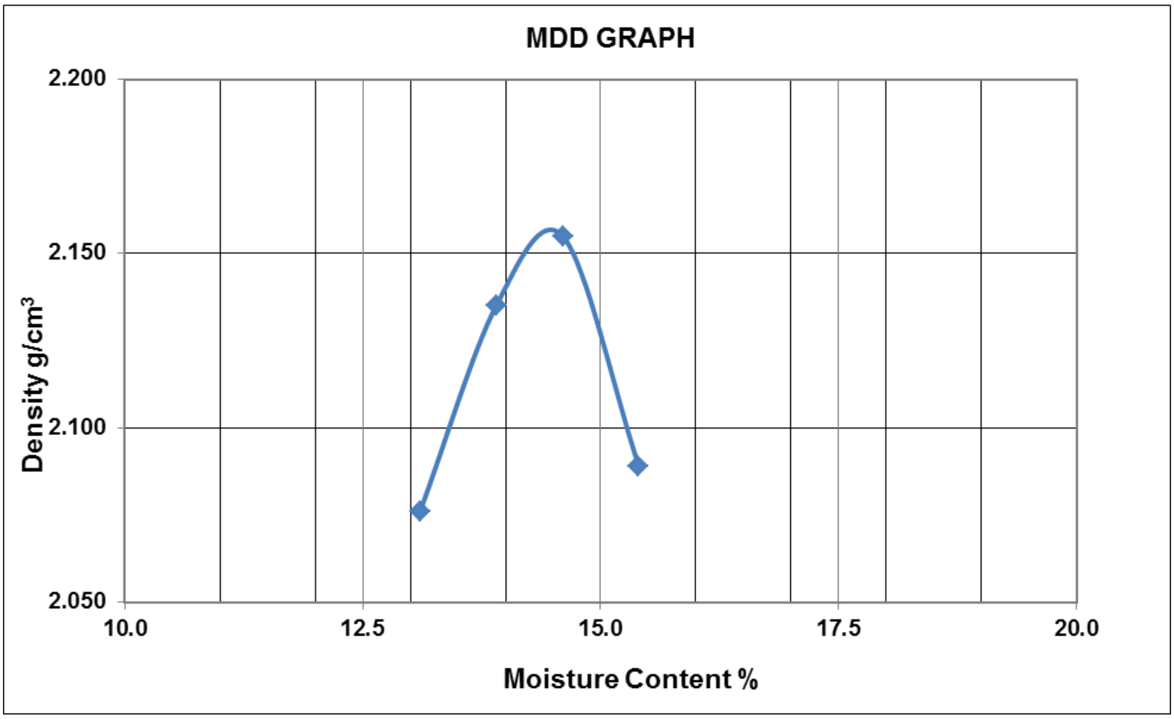
Density Determination							
Test No		1	2	3	4	5	
Wt of Mould (g)	A	2765.0	2765.0	2765.0	2765.0	2765.0	
Volume of Mould (cm^3)	V	944.0	944.0	944.0	944.0	944.0	
Wt of Mould + Wet Soil (g)	C	4813.5	4853.1	4955.1	5053.3	4949.4	
Weight of Wet Soil (g)	C-A	2048.5	2088.1	2190.1	2288.3	2184.4	
Wet Density of Soil (g/cm^3)	D = (C-A)/V	2.170	2.212	2.320	2.424	2.314	

Table 610: Water Content Determination 20% debris

Water Content Determination of Soil:							
Cane No.		A-1	A-2	A-3	A-4	A-5	
Wt. of Container (grm)	B	55.3	52.1	66.3	50.4	53.1	
Wt. of Container + Wet Soil (grm)	E	290.7	256.4	243.3	217.1	226.5	
Wt. of Container + Dry Soil (grm)	F	265.5	232.7	221.7	195.9	203.4	
Weight of Water (grm)	G = E - F	25.2	23.7	21.6	21.2	23.1	
Weight of Dry Soil (grm)	F - B	210.2	180.6	155.4	145.5	150.3	
Water Content %	G/(F -B)100	12.0	13.1	13.9	14.6	15.4	
Dry Density of Soil (g/cm^3)	D/(100+w)	2.049	2.076	2.135	2.155	2.089	

Table 611: omc and mdd 20%

MDD	OMC
2.155 g/cm^3	14.60 %



Graph 67: moisture dry density 20% debris

1.27 Sieve analysis

1.27.1 For 0% Debris

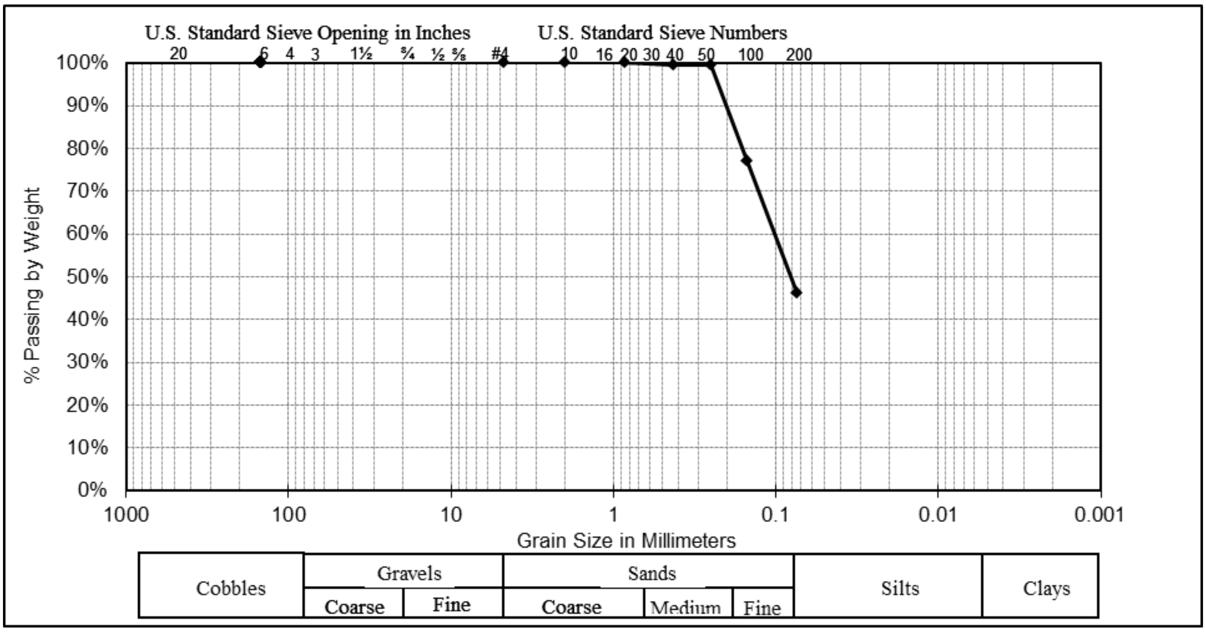
Table 612: Sieve Analysis 0% debris

Fines Section

	Weights are Cumulative:	x			Fineness Modulus:	0.23	
	Before Wash Weight:	500.0	« Enter Total Sample Weight Here!				
	After Wash Weight:	500.0	Accuracy:	53.80%	$D_{(10)}$=	0.016	mm
	After Sieving Weight:	231.0			$D_{(30)}$=	0.049	mm
					$D_{(60)}$=	0.108	mm

Sieve Size US	mm	Cumulative Retained Weight	Cumulative Percent Retained	Cumulative Percent Passing	Interpolated Percent Passing
#4	4.75	0.00		100.0 %	100.0%
#10	2.00	0.00		100.0 %	100.0%
#16	1.18				100.0%
#20	0.85	0.00		100.0 %	100.0%
#30	0.600				99.8%
#40	0.425	2.10	0.4 %	99.6 %	99.6%
#50	0.300				99.6%
#60	0.250	2.10	0.4 %	99.6 %	99.6%
#80	0.180				83.9%
#100	0.150	114.00	22.8 %	77.2 %	77.2%
#140	0.106				59.0%
#170	0.090				52.4%
#200	0.075	269.00	53.8 %	46.2 %	46.2%
Pan		231.00			

Coeff. of Curvature, C_C =	1.35
Coeff. of Uniformity, C_U =	6.68
% Gravel =	0.0 %
% Sand =	53.8 %
% Silt & Clay =	46.2 %
% Silt:	N/A, Run Hydromet
% Clay:	N/A, Run Hydromet
% Moisture:	15.0%



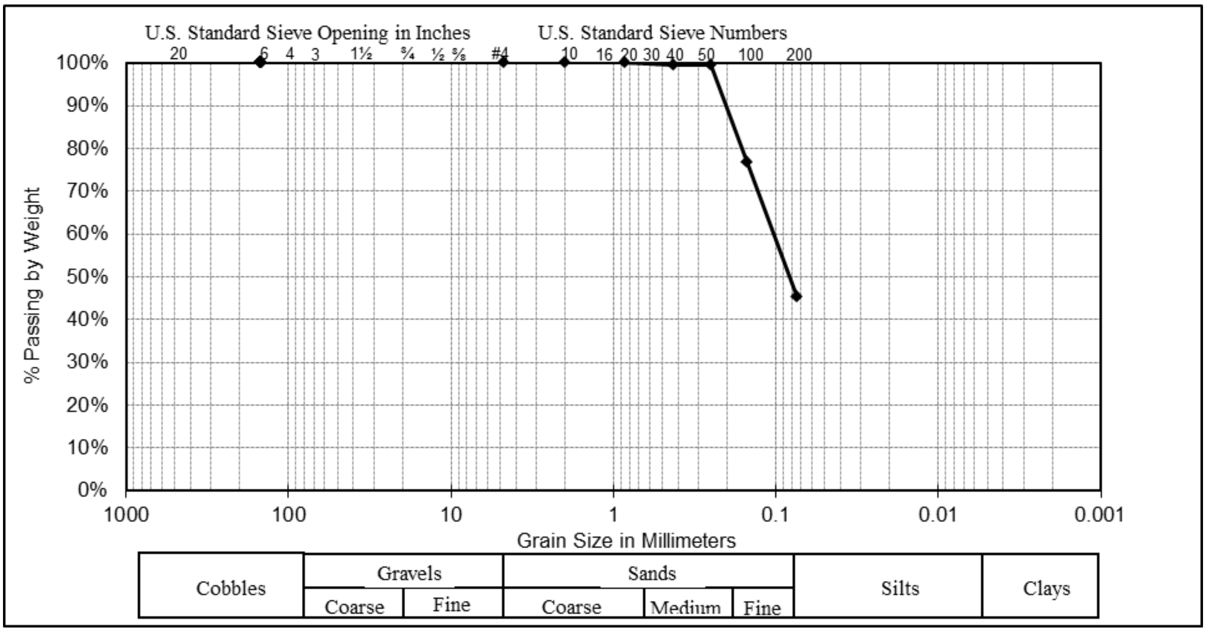
Graph 68: sieve analysis 0% debris

1.27.2 For 5% Debris

Table 613: Sieve Analysis 5% debris

Fines Section

		Weights are Cumulative:	x			**Fineness Modulus:**	**0.24**	
		Before Wash Weight:	**500.0**	« Enter Total Sample Weight Here!				
		After Wash Weight:	**500.0**	Accuracy:	54.80%	$D_{(10)}$=	0.017	mm
		After Sieving Weight:	226.0		Invalid, Repeat Test	$D_{(30)}$=	0.050	mm
		Cumulative	Cumulative	Cumulative	Interpolated	$D_{(60)}$=	0.110	mm
Sieve Size		**Retained**	**Percent**	**Percent**	**Percent**	Coeff. of Curvature, C_C =	**1.36**	
US	**mm**	**Weight**	**Retained**	**Passing**	**Passing**	Coeff. of Uniformity, C_U =	**6.64**	
#4	4.75	**0.00**		100.0 %	100.0%			
#10	2.00	**0.00**		100.0 %	100.0%	% Gravel =	0.0 %	
#16	1.18				100.0%	% Sand =	54.8 %	
#20	0.85	**0.00**		100.0 %	100.0%	% Silt & Clay =	45.2 %	
#30	0.600				99.7%	% Silt:	N/A, Run Hydromet	
#40	0.425	**2.40**	0.5 %	99.5 %	99.5%	% Clay:	N/A, Run Hydromet	
#50	0.300				99.5%			
#60	0.250	**2.40**	0.5 %	99.5 %	99.5%	% Moisture:	15.0%	
#80	0.180				83.6%			
#100	0.150	**116.00**	23.2 %	76.8 %	76.8%			
#140	0.106				58.3%			
#170	0.090				51.5%			
#200	0.075	**274.00**	54.8 %	45.2 %	45.2%			
Pan		**226.00**						



Graph 69: sieve analysis 5% debris

1.27.3 For 10% Debris

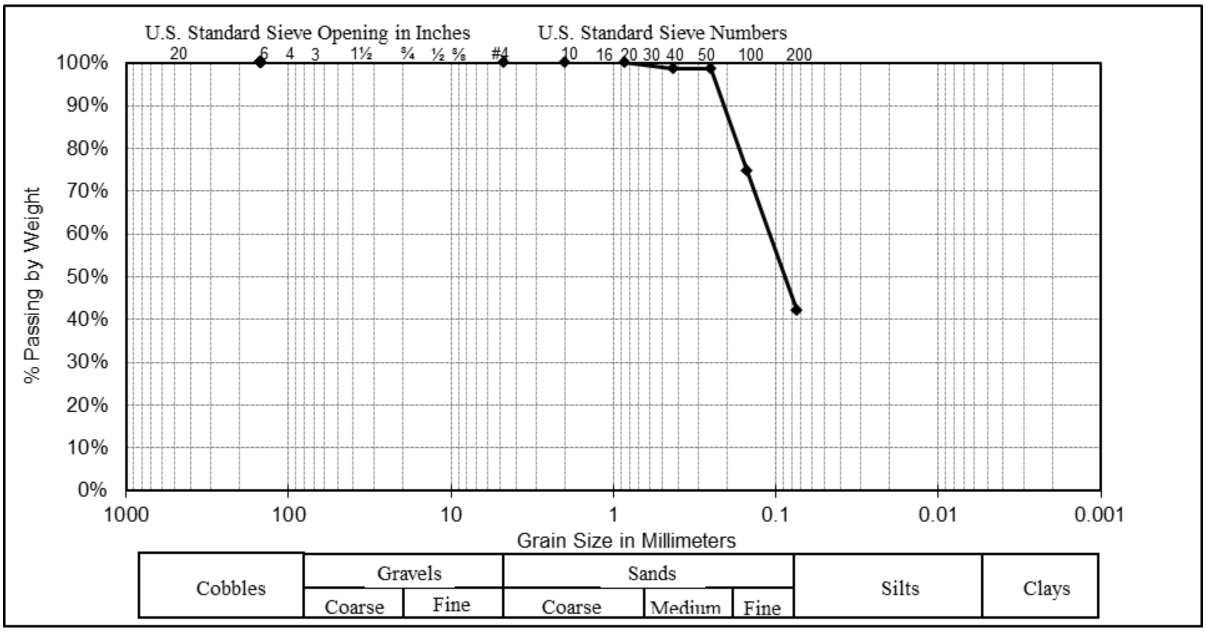
Table 614: Sieve Analysis 10% debris

Fines Section

Weights are Cumulative:	x		Fineness Modulus:	0.28
Before Wash Weight:	500.0	« Enter Total Sample Weight Here!		
After Wash Weight:	500.0	Accuracy: 58.00%	$D_{(10)}$=	0.018 mm
After Sieving Weight:	210.0		$D_{(30)}$=	0.054 mm
			$D_{(60)}$=	0.116 mm
			Coeff. of Curvature, C_C =	1.38
			Coeff. of Uniformity, C_U =	6.52

Sieve Size US	mm	Cumulative Retained Weight	Cumulative Percent Retained	Cumulative Percent Passing	Interpolated Percent Passing
#4	4.75	0.00		100.0 %	100.0%
#10	2.00	0.00		100.0 %	100.0%
#16	1.18				100.0%
#20	0.85	0.00		100.0 %	100.0%
#30	0.600				99.2%
#40	0.425	6.80	1.4 %	98.6 %	98.6%
#50	0.300				98.6%
#60	0.250	6.80	1.4 %	98.6 %	98.6%
#80	0.180				81.8%
#100	0.150	127.00	25.4 %	74.6 %	74.6%
#140	0.106				55.5%
#170	0.090				48.5%
#200	0.075	290.00	58.0 %	42.0 %	42.0%
Pan		210.00			

% Gravel =	0.0 %
% Sand =	58.0 %
% Silt & Clay =	42.0 %
% Silt:	N/A, Run Hydromet
% Clay:	N/A, Run Hydromet
% Moisture:	15.0%



Graph 610: sieve analysis 10% debris

1.27.4 For 15% Debris

Table 615: Sieve Analysis 15% debris

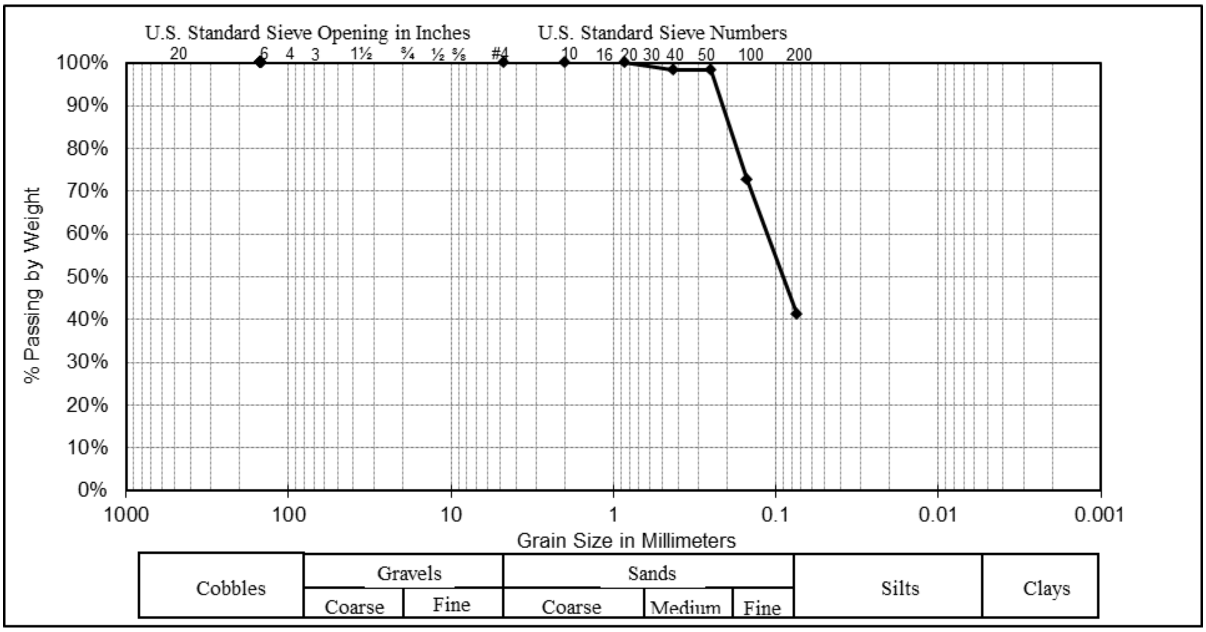
Fines Section

Weights are Cumulative:		x				Fineness Modulus:	0.30
Before Wash Weight:		500.0	« Enter Total Sample Weight Here!				
After Wash Weight:		500.0	Accuracy:	58.66%		$D_{(10)}$=	0.018 mm
After Sieving Weight:		206.7				$D_{(30)}$=	0.054 mm
						$D_{(60)}$=	0.119 mm

Sieve Size US	mm	Cumulative Retained Weight	Cumulative Percent Retained	Cumulative Percent Passing	Interpolated Percent Passing
#4	4.75	0.00		100.0 %	100.0%
#10	2.00	0.00		100.0 %	100.0%
#16	1.18				100.0%
#20	0.85	0.00		100.0 %	100.0%
#30	0.600				98.9%
#40	0.425	9.00	1.8 %	98.2 %	98.2%
#50	0.300				98.2%
#60	0.250	9.00	1.8 %	98.2 %	98.2%
#80	0.180				80.4%
#100	0.150	135.90	27.2 %	72.8 %	72.8%
#140	0.106				54.4%
#170	0.090				47.6%
#200	0.075	293.30	58.7 %	41.3 %	41.3%
Pan		206.70			

Coeff. of Curvature, C_C = 1.37
Coeff. of Uniformity, C_U = 6.58

% Gravel = 0.0 %
% Sand = 58.7 %
% Silt & Clay = 41.3 %
% Silt: N/A, Run Hydromet
% Clay: N/A, Run Hydromet
% Moisture: 15.0%



Graph 611: sieve analysis 15% debris

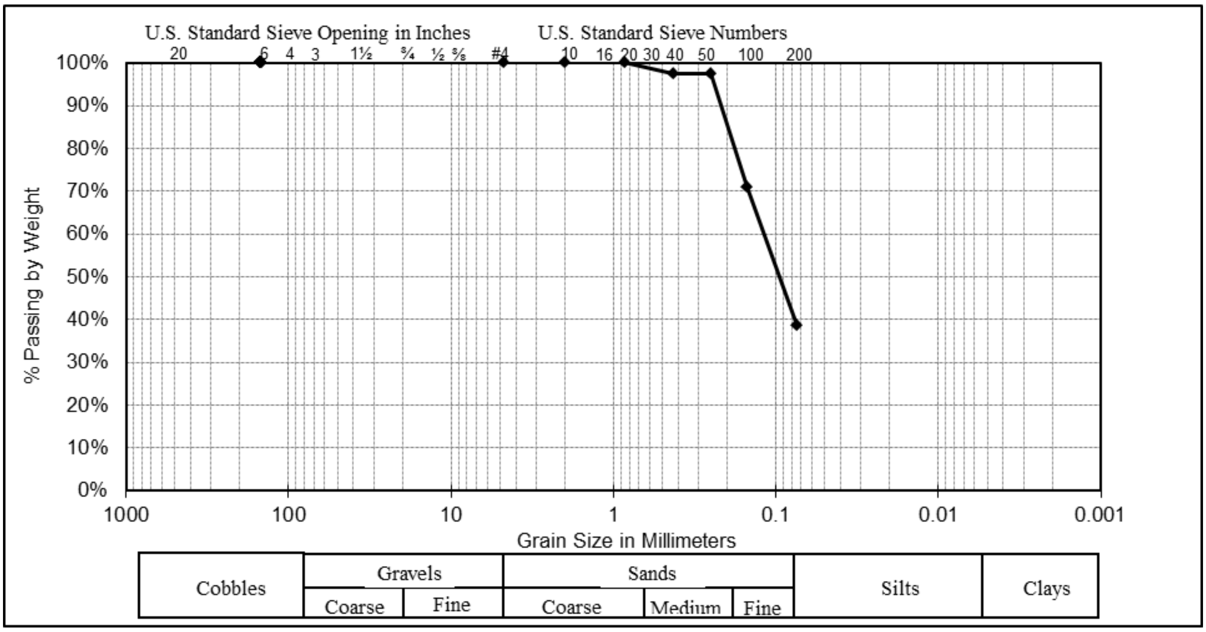
1.27.5 For 20% Debris

Table 616: Sieve Analysis 20% debris

Fines Section

Weights are Cumulative:	x				Fineness Modulus:	0.33	
Before Wash Weight:	500.0	« Enter Total Sample Weight Here!					
After Wash Weight:	500.0	Accuracy:	61.40%		$D_{(10)}$=	0.019 mm	
After Sieving Weight:	193.0				$D_{(30)}$=	0.058 mm	
					$D_{(60)}$=	0.124 mm	

Sieve Size US	mm	Cumulative Retained Weight	Cumulative Percent Retained	Cumulative Percent Passing	Interpolated Percent Passing		
						Coeff. of Curvature, C_C =	1.41
						Coeff. of Uniformity, C_U =	6.40
#4	4.75	0.00		100.0 %	100.0%		
#10	2.00	0.00		100.0 %	100.0%	% Gravel =	0.0 %
#16	1.18				100.0%	% Sand =	61.4 %
#20	0.85	0.00		100.0 %	100.0%	% Silt & Clay =	38.6 %
#30	0.600				98.4%	% Silt:	N/A, Run Hydromet
#40	0.425	13.20	2.6 %	97.4 %	97.4%	% Clay:	N/A, Run Hydromet
#50	0.300				97.4%		
#60	0.250	13.20	2.6 %	97.4 %	97.4%	% Moisture:	15.0%
#80	0.180				79.0%		
#100	0.150	144.70	28.9 %	71.1 %	71.1%		
#140	0.106				52.0%		
#170	0.090				45.1%		
#200	0.075	307.00	61.4 %	38.6 %	38.6%		
Pan		193.00					



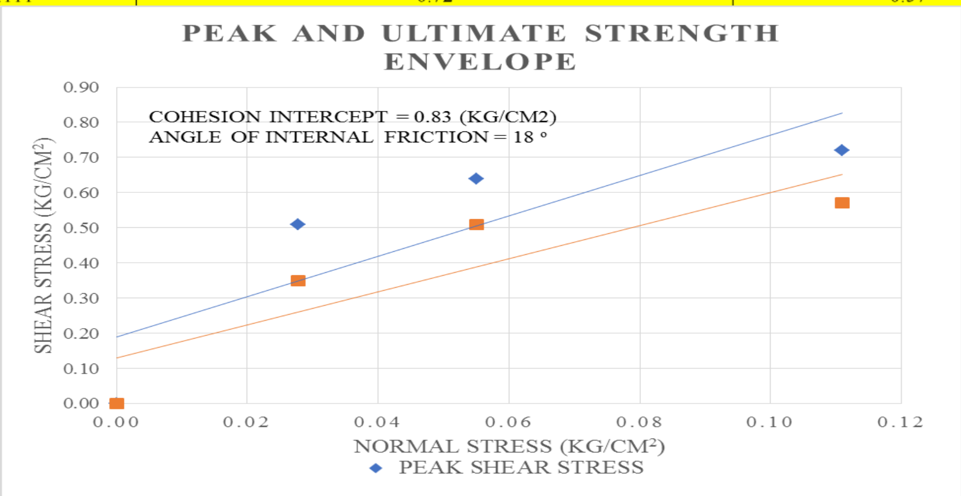
Graph 612: sieve analysis 20% debris

1.28 **Direct Shear Test**

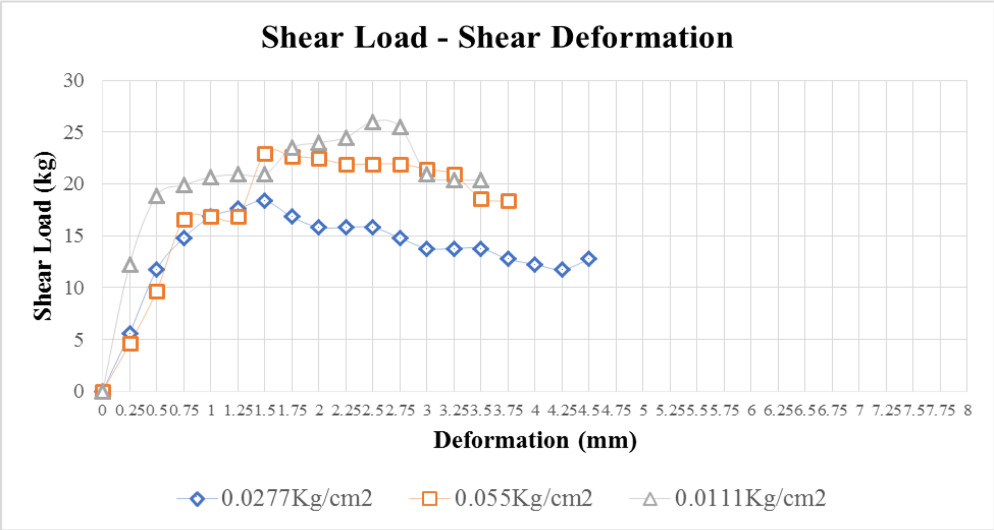
1.28.1 For 0% Debris

Table 617: Direct Shear Test 0% debris

NORMAL STRESS	PEAK SHEAR STRESS	ULITMATE SHEAR STRESS
0	0	0
0.0277	0.51	0.35
0.0555	0.64	0.51
0.111	0.72	0.57



Graph 613: shear box-peak load 0% debris

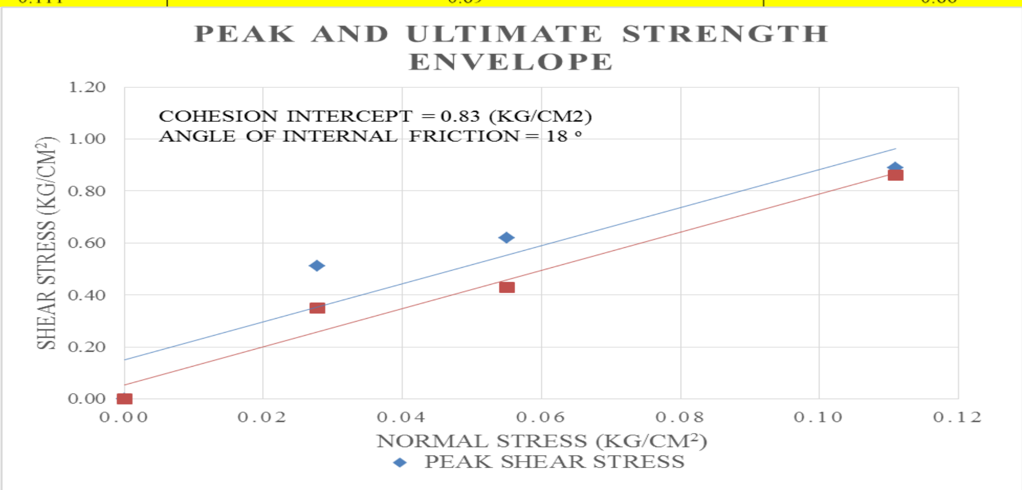


Graph 614: shear box-peak stress 0% debris

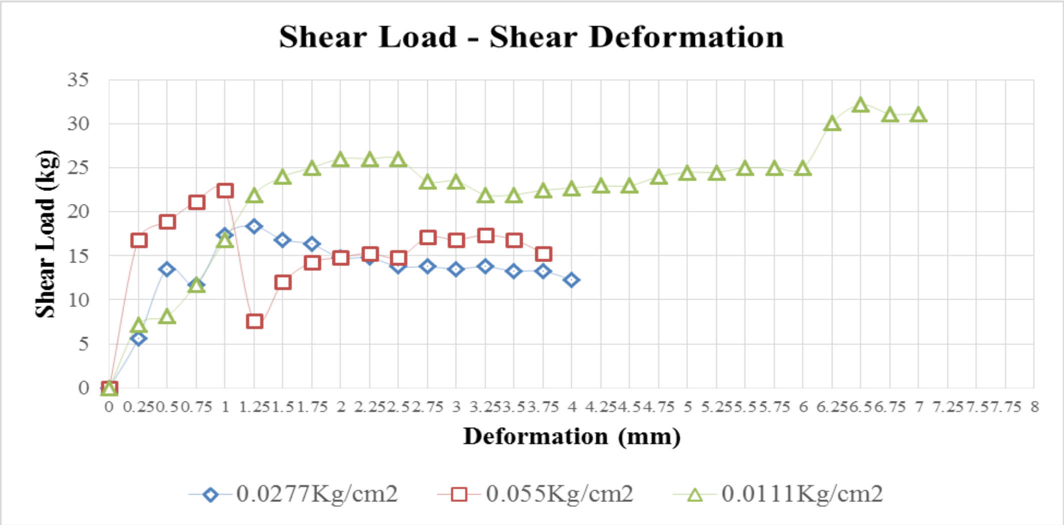
1.28.2 For 5% Debris

Table 618: Direct Shear Test 5% debris

NORMAL STRESS	PEAK SHEAR STRESS	ULITMATE SHEAR STRESS
0	0	0
0.0277	0.51	0.34
0.0555	0.62	0.43
0.111	0.89	0.86



Graph 615: shear box-peak load 5% debris

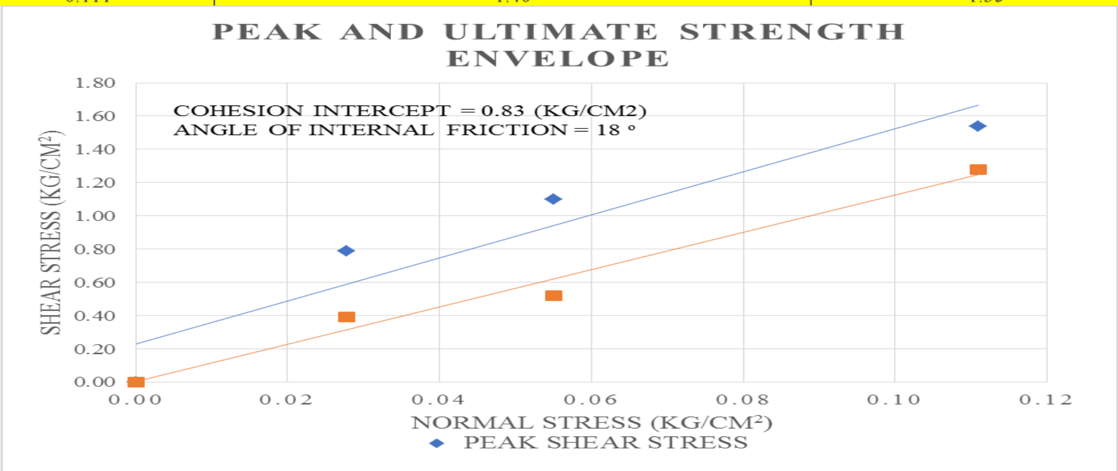


Graph 616: shear box-peak stress 5% debris

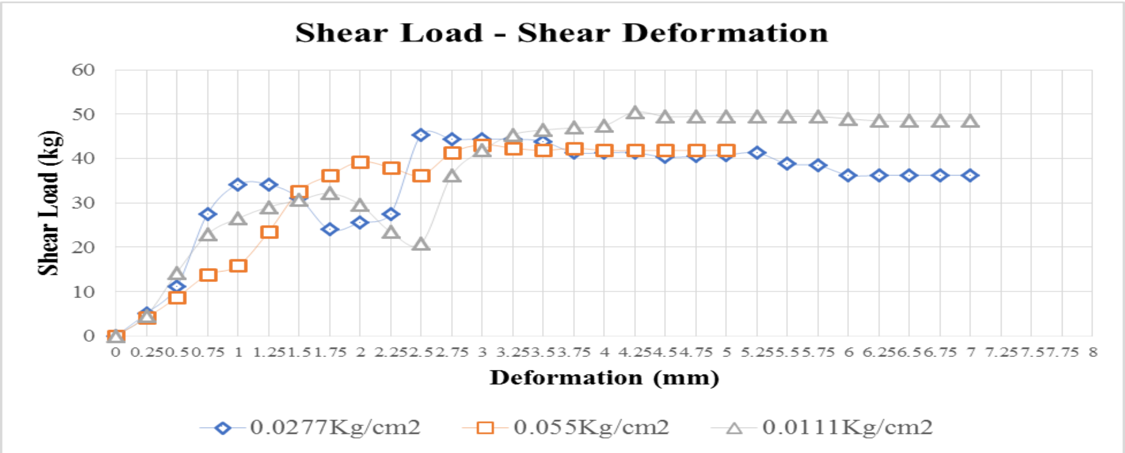
1.28.3 For 10% debris

Table 619: Direct Shear Test 10% debris

NORMAL STRESS	PEAK SHEAR STRESS	ULITMATE SHEAR STRESS
0	0	0
0.0277	1.26	1.01
0.0555	1.20	1.16
0.111	1.40	1.35



Graph 617: shear box-peak load 10% debris

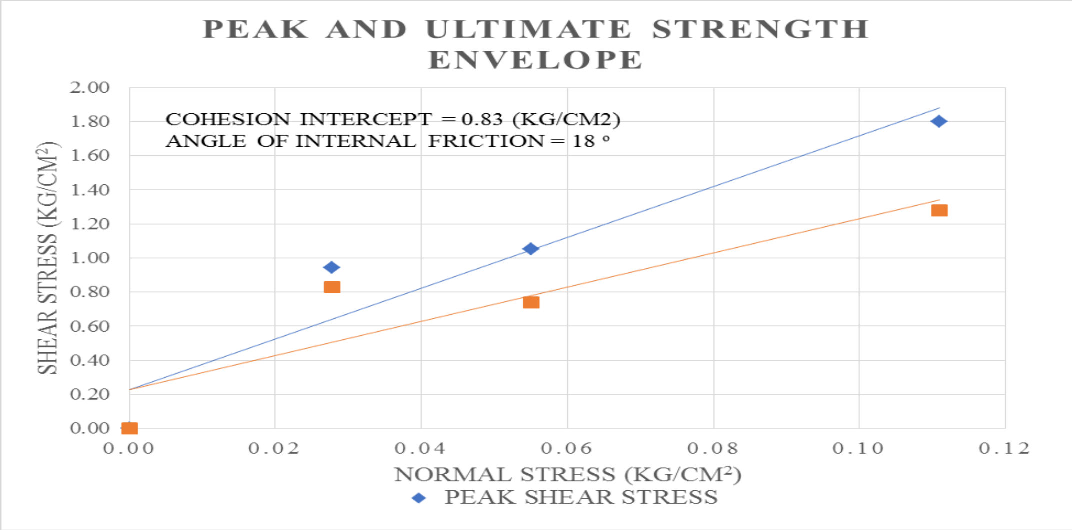


Graph 618: shear box-peak stress 10% debris

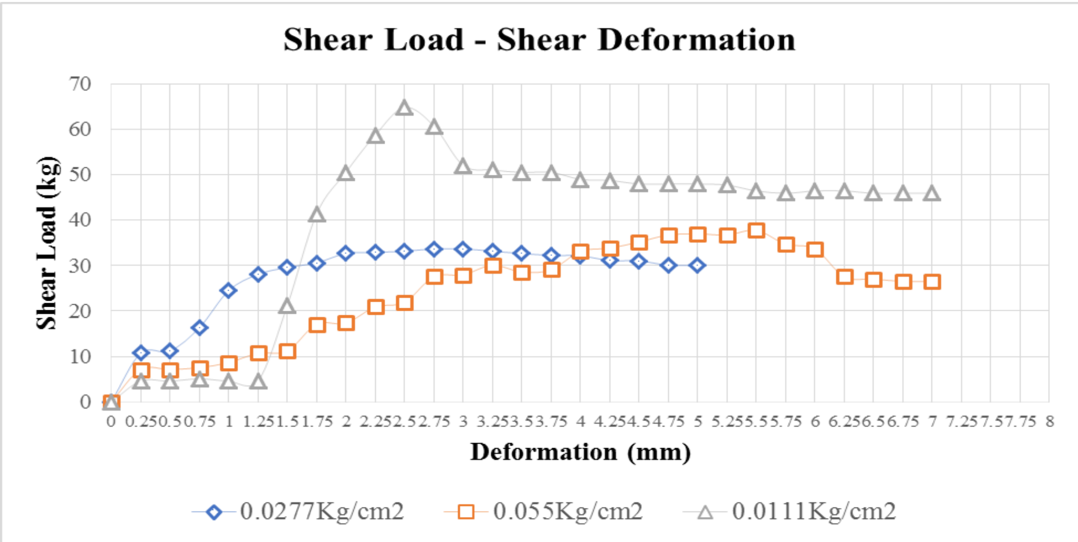
1.28.4 For 15% Debris

Table 620: Direct Shear Test 15% debris

NORMAL STRESS	PEAK SHEAR STRESS	ULITMATE SHEAR STRESS
0	0	0
0.0277	0.94	0.84
0.0555	1.05	0.74
0.111	1.80	1.28



Graph 619: shear box-peak load 15% debris

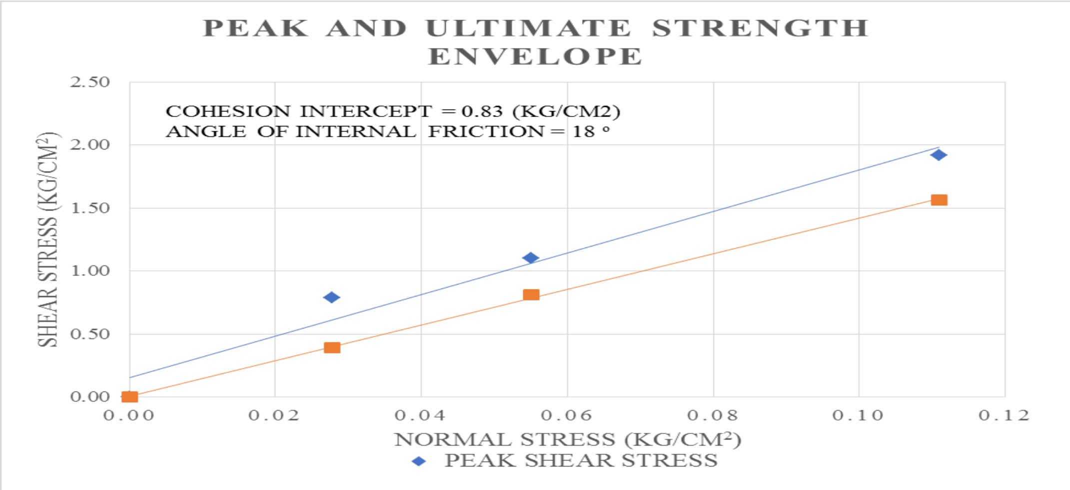


Graph 620: shear box-peak stress 15% debris

1.28.5 For 20%

Table 621: Direct Shear Test 20% debris

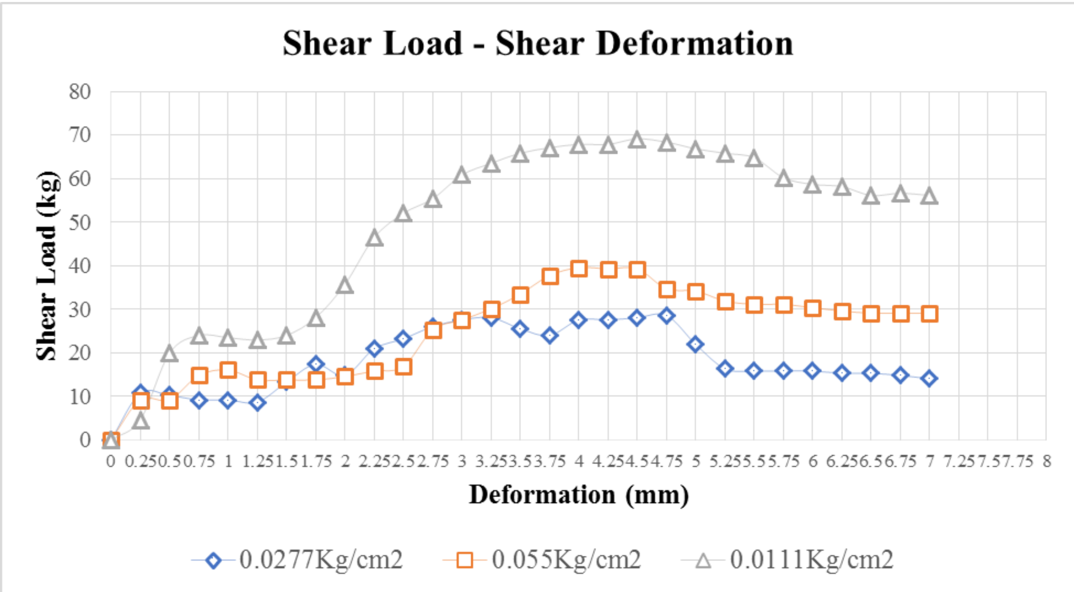
NORMAL STRESS	PEAK SHEAR STRESS	ULITMATE SHEAR STRESS
0	0	0
0.0277	0.79	0.39
0.0555	1.10	0.81
0.111	1.92	1.56



Graph 621: shear box-peak load 20% debris

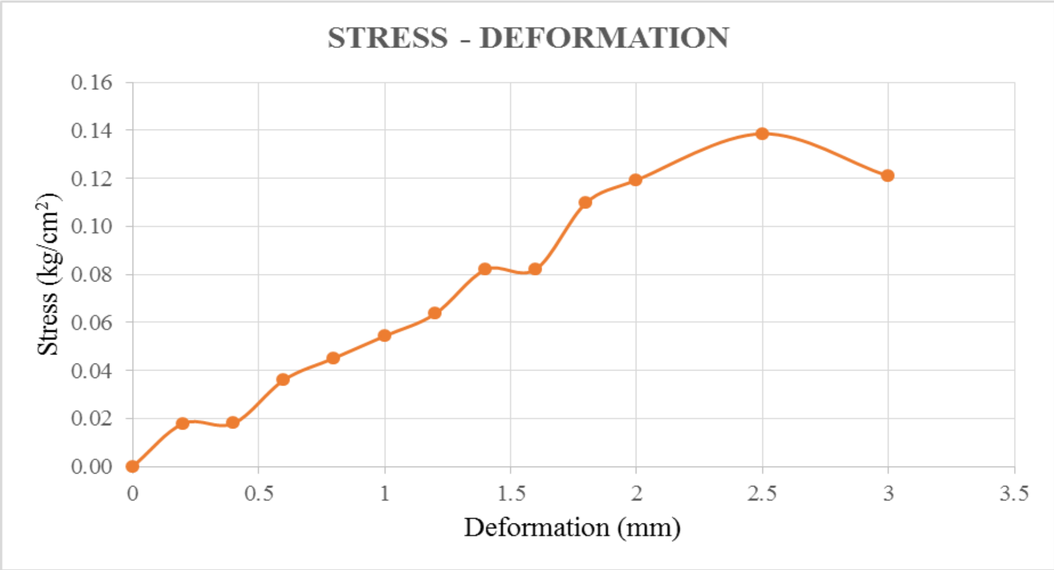
1.29 **Unconfi**

1.29.1 For 0%



Graph STYLEREF 1 \s 6 SEQ Graph * ARABIC \s 1 22: shear box-peak stress 20% debris

									11.4
									11.4
									11.4
180	1.2	1.8	0.024	2.37	11.14	1.22	0.11	1.02	11.4
200	1.3	2	0.026	2.63	11.11	1.33	0.12	1.02	11.4
250	1.5	2.5	0.033	3.29	11.04	1.53	0.14	1.02	11.4
300	1.3	3	0.039	3.95	10.97	1.33	0.12	1.02	11.4

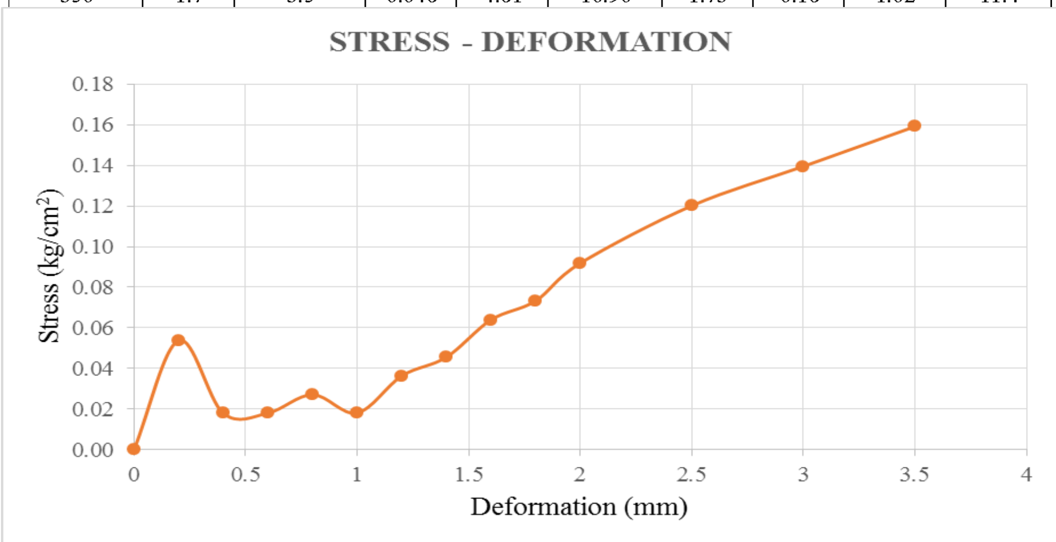


Graph 623: peak stress UCS 0% debris

1.29.2 For 5% Debris

Table 623: For 5% Debris Unconfined Compression Test

5% UCS									
Deformation dial reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain (ε)	% Strain	Corrected Area (A)	Load (kg)	Stress (kg/cm2)	Ring Constant	Area of Specimen
0	0	0	0.000	0.00	11.40	0.00	0.00	1.02	11.4
20	0.6	0.2	0.003	0.26	11.37	0.61	0.05	1.02	11.4
40	0.2	0.4	0.005	0.53	11.34	0.20	0.02	1.02	11.4
60	0.2	0.6	0.008	0.79	11.31	0.20	0.02	1.02	11.4
80	0.3	0.8	0.011	1.05	11.28	0.31	0.03	1.02	11.4
100	0.2	1	0.013	1.32	11.25	0.20	0.02	1.02	11.4
120	0.4	1.2	0.016	1.58	11.22	0.41	0.04	1.02	11.4
140	0.5	1.4	0.018	1.84	11.19	0.51	0.05	1.02	11.4
160	0.7	1.6	0.021	2.11	11.16	0.71	0.06	1.02	11.4
180	0.8	1.8	0.024	2.37	11.14	0.82	0.07	1.02	11.4
200	1	2	0.026	2.63	11.11	1.02	0.09	1.02	11.4
250	1.3	2.5	0.033	3.29	11.04	1.33	0.12	1.02	11.4
300	1.5	3	0.039	3.95	10.97	1.53	0.14	1.02	11.4
350	1.7	3.5	0.046	4.61	10.90	1.73	0.16	1.02	11.4

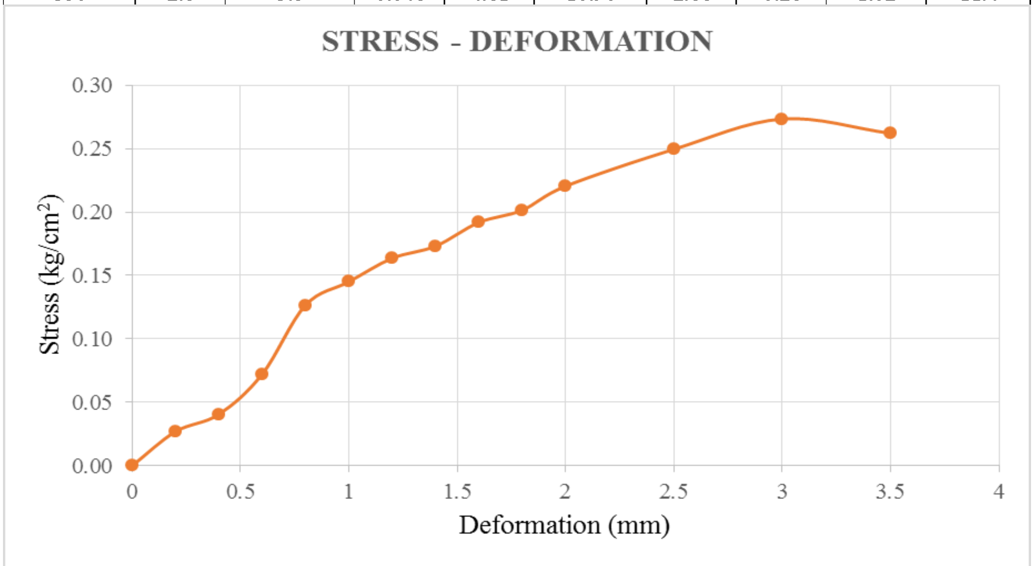


Graph 624: peak stress UCS 5% debris

1.29.3 For 10 % Debris

Table 624: For 10% Debris Unconfined Compression Test

10% UCS									
Deformation dial reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain (ε)	% Strain	Corrected Area (A)	Load (kg)	Stress (kg/cm2)	Ring Constant	Area of Specimen
0	0	0	0.000	0.00	11.40	0.00	0.00	1.02	11.4
20	0.3	0.2	0.003	0.26	11.37	0.31	0.03	1.02	11.4
40	0.45	0.4	0.005	0.53	11.34	0.46	0.04	1.02	11.4
60	0.8	0.6	0.008	0.79	11.31	0.82	0.07	1.02	11.4
80	1.4	0.8	0.011	1.05	11.28	1.43	0.13	1.02	11.4
100	1.6	1	0.013	1.32	11.25	1.63	0.15	1.02	11.4
120	1.8	1.2	0.016	1.58	11.22	1.84	0.16	1.02	11.4
140	1.9	1.4	0.018	1.84	11.19	1.94	0.17	1.02	11.4
160	2.1	1.6	0.021	2.11	11.16	2.14	0.19	1.02	11.4
180	2.2	1.8	0.024	2.37	11.14	2.24	0.20	1.02	11.4
200	2.4	2	0.026	2.63	11.11	2.45	0.22	1.02	11.4
250	2.7	2.5	0.033	3.29	11.04	2.75	0.25	1.02	11.4
300	2.94	3	0.039	3.95	10.97	3.00	0.27	1.02	11.4
350	2.8	3.5	0.046	4.61	10.90	2.86	0.26	1.02	11.4

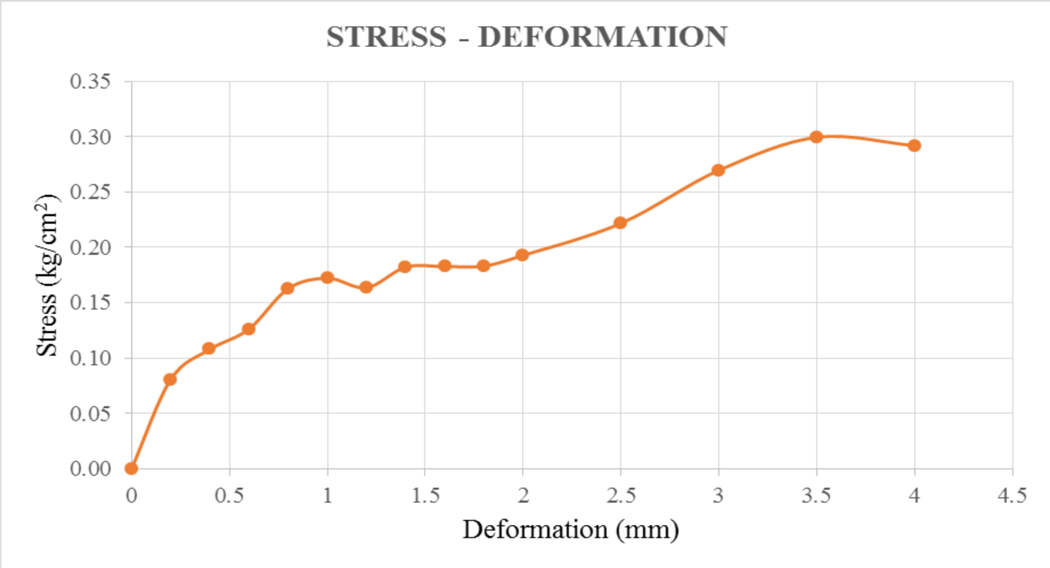


Graph 625: peak stress UCS 10% debris

1.29.4 For 15% Debris

Table 625: For 15% Debris Unconfined Compression Test

15% UCS									
Deformation dial reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain (ε)	% Strain	Corrected Area (A)	Load (kg)	Stress (kg/cm2)	Ring Constant	Area of Specimen
0	0	0	0.000	0.00	11.40	0.00	0.00	1.02	11.4
20	0.9	0.2	0.003	0.26	11.37	0.92	0.08	1.02	11.4
40	1.2	0.4	0.005	0.53	11.34	1.22	0.11	1.02	11.4
60	1.4	0.6	0.008	0.79	11.31	1.43	0.13	1.02	11.4
80	1.8	0.8	0.011	1.05	11.28	1.84	0.16	1.02	11.4
100	1.9	1	0.013	1.32	11.25	1.94	0.17	1.02	11.4
120	1.8	1.2	0.016	1.58	11.22	1.84	0.16	1.02	11.4
140	2	1.4	0.018	1.84	11.19	2.04	0.18	1.02	11.4
160	2	1.6	0.021	2.11	11.16	2.04	0.18	1.02	11.4
180	2	1.8	0.024	2.37	11.14	2.04	0.18	1.02	11.4
200	2.1	2	0.026	2.63	11.11	2.14	0.19	1.02	11.4
250	2.4	2.5	0.033	3.29	11.04	2.45	0.22	1.02	11.4
300	2.9	3	0.039	3.95	10.97	2.96	0.27	1.02	11.4
350	3.2	3.5	0.046	4.61	10.90	3.26	0.30	1.02	11.4
400	3.1	4	0.053	5.26	10.83	3.16	0.29	1.02	11.4

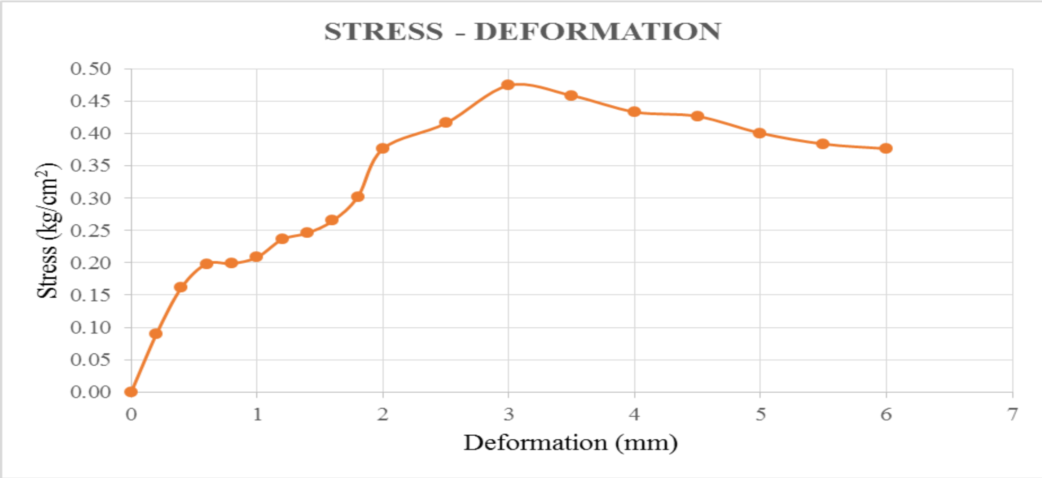


Graph 626: peak stress UCS 15% debris

1.29.5 For 20 % Debris

Table 626: For 20% Debris Unconfined Compression Test

UCS 20%									
Deformation dial reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain (ε)	% Strain	Corrected Area (A)	Load (kg)	Stress (kg/cm2)	Ring Constant	Area of Specimen
0	0	0	0.000	0.00	11.40	0.00	0.00	1.02	11.4
20	1	0.2	0.003	0.26	11.37	1.02	0.09	1.02	11.4
40	1.8	0.4	0.005	0.53	11.34	1.84	0.16	1.02	11.4
60	2.2	0.6	0.008	0.79	11.31	2.24	0.20	1.02	11.4
80	2.2	0.8	0.011	1.05	11.28	2.24	0.20	1.02	11.4
100	2.3	1	0.013	1.32	11.25	2.35	0.21	1.02	11.4
120	2.6	1.2	0.016	1.58	11.22	2.65	0.24	1.02	11.4
140	2.7	1.4	0.018	1.84	11.19	2.75	0.25	1.02	11.4
160	2.9	1.6	0.021	2.11	11.16	2.96	0.26	1.02	11.4
180	3.3	1.8	0.024	2.37	11.14	3.37	0.30	1.02	11.4
200	4.1	2	0.026	2.63	11.11	4.18	0.38	1.02	11.4
250	4.5	2.5	0.033	3.29	11.04	4.59	0.42	1.02	11.4
300	5.1	3	0.039	3.95	10.97	5.20	0.47	1.02	11.4
350	4.9	3.5	0.046	4.61	10.90	5.00	0.46	1.02	11.4
400	4.6	4	0.053	5.26	10.83	4.69	0.43	1.02	11.4
450	4.5	4.5	0.059	5.92	10.76	4.59	0.43	1.02	11.4
500	4.2	5	0.066	6.58	10.70	4.284	0.40	1.02	11.4
550	4	5.5	0.072	7.24	10.63	4.08	0.38	1.02	11.4
600	3.9	6	0.079	7.89	10.57	3.978	0.38	1.02	11.4



Graph 627: peak stress UCS 20% debris

Conclusions and Recommendations

1.30 **Results**

1. For Atterberg limits: the value of liquid limit and plasticity index for percentages of 0% is 27 & 11.while the value of liquid limit and plasticity index for percentages of 20% is 26 & 10 respectively.
2. For sieve analysis: the percentage passing through sieve no 200 has decreased from 46.2 to 38.6%, as we move gradually towards higher percentages of brick debris. The coefficient of uniformity 'cu' decreased from 6.68 to 6.40, and the coefficient of curvature 'cc' increased from 1.35 to 1.41 for the percentages of 0 to 20%.
3. For Unconfined Compression Test: the peak stress increased from 0.14 to 0.47 kg/cm^2 as we move towards higher percentages of brick debris.
4. For Direct Shear Test: the peak stress at 4kg load applied ranges from 0.72 to 1.92 kg/cm^2 for percentages of 0-20% debris respectively.
5. For Permeability Test: no water drained through samples of 0, 10 & 20%.
6. For Moisture Dry Density Test: increase in dry density from 1.76 to 2.15 g/cm^3 for test of 0&20%, and decrease in optimum moisture content from 16.2 to 14.6%.

1.31 **Conclusions**

- Atterberg limits data shown marginal effect on plasticity after 10% and soil is classified as A-4 from A-6. The A-4 soil is strength wise improved soil as compared to A-6.
- Sieve analysis results indicated the replacement of fines occurred.it means that the smaller particles are replaced with bigger particles as we move on to higher percentages of 20%. It also results in more amount of material retained on sieve no 200.

- Unconfined Compression Test results shows a pattern in which the peak stress is increased as we move to higher percentages. Also the moisture content is increased for this test because the brick debris absorbed water, as result of which sample were broken previously and increase of moisture became obligatory.
- Direct shear test on percentages up to 15 % showed that the peak shear stress increased, which indicates that on higher percentages the sample took more load as compared to small percentages.
- During Permeability test no drainage of water occurred through the sample indicating it as highly impermeable. Although at the higher percentages, small quantity of water drained but it's not sufficient for test conduction.
- Moisture Dry Density relationship provides a clear indication of increase in density of soil as moved to higher percentages and decrease in OMC which suggest that, clay absorbs more water content as compared to brick debris.

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