"SOIL TESTING AND SOIL STABILIZATION"

Submitted in partial fulfillment of the requirements for the award of the degree
of
BACHELOR OF TECHNOLOGY
IN
CIVIL ENGINEERING

Under the supervision of

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By

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to

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CERTIFICATE

This is to certify that project report entitled "**SOIL TESTING AND SOIL STABILIZATION**", submitted by **SUMEER SHARMA** in partial fulfillment for the award of degree of Bachelor of Technology in Civil Engineering to Jaypee University of Information Technology, Waknaghat, Solan has been carried out under my supervision.

This work has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

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SUMEER SHARMA (101665)

CIVIL ENGINEERING

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

As the basic structural foundation for almost all construction, soil materials play an important role in the ultimate success of a project. Whether you're working in clay, silt, sand, gravel, peat, or loam, understanding the soil properties of your site help you make good construction decisions.

1.2 TYPES OF SOIL

The most common engineering classification system for soils is the Unified Soil Classification System (USCS). The USCS has three major classification groups: (1) coarse-grained soils (e.g. sands and gravels); (2) fine-grained soils (e.g. silts and clays)

1.2.1 Coarse –grained soils

1. Coarse grained soils are identified primarily on the basis of particle size or grain size. Individual particles are visible by naked eye.
2. Coarse grained soils are divided into two groups, Sand & Gravel. Particles having diameter larger than 4.75 mm is called **Gravel** and particles having diameter in between 4.75 mm to 75 micron is called **Sand.**
3. Verbal description of coarse grained soil is done on the basis of its gradation (well or poor), particle shape (angular, sub-angular, rounded or sub-rounded) & mineralogical components.
4. Coarse grained soil exhibit a good load bearing capacity.
5. Coarse grained soil posse's good drainage qualities.
6. There is no volume change with change in moisture condition.
7. There is no appreciable amount of change in strength characteristic by change in moisture condition.
8. Vibration accentuates volume change in loose state, by arranging the soil fabric.
9. Engineering properties are controlled by the grain size of the particles and their structural arrangement.

10. When touched by hand it feels gritty.

1.2.2 Fine-grained soils

1. Fine grained soils are identified on the basis of its plasticity. Individual particles are not visible by naked eye.
2. Fine grained soils are also divided in two groups, Silt & Clay. Particles having diameter in between 75 micron to 2 micron are called **Silt** and particles having diameter smaller than 2 micron is called **Clay**.
3. Verbal description of fine grained soil is done on the basis of its dry strength, dilatancy, dispersion and plasticity.
4. Fine grained soil exhibit a poor load bearing capacity.
5. Fine grained soil is practically impermeable in nature because of its small particles size.
6. Volume change occurs with change in moisture content.
7. Strength changes with change in moisture condition.
8. Fine grained soil is susceptible to frost action.
9. Engineering properties are controlled by mineralogical factors.
10. When touched by hand it feels smooth, greasy and sticky.

Soil stabilization refers to the process of changing soil properties to improve strength and durability. There are many techniques for soil stabilization, including compacting, dewatering and by adding materials to the soil.

For the process of stabilization, soil testing is mandatory.

1.3 PROPERTIES OF SOIL

Soil testing helps us to know about the properties of soil.

Soil properties can broadly be divided into two major categories depending upon their properties achieved during soil formation process.

- The physical properties of soil
- The chemical properties of soil

1.3.1 Physical Properties of Soil

Soil Texture

The texture of soil is based on the size distribution of the constituent particles. In simple terms, the relative percentage of clay, sand, and silt in a soil mass determines its texture. Furthermore, the soil texture determines the water retention capacity of a soil sample. Sand particles have the largest diameter, whereas clay particles have smallest diameter, among the three soil constituent particles.

Soil Structure

Soil structure refers to the arrangement of sand, silt, and clay particles within a soil mass. Air and water movement through a soil mass directly depends upon the structure of soil mass. Symmetry leads to stability, so if a soil mass has symmetrical or good structure, water and air movement through it will be smooth.

Permeability and Porosity of Soil

The ease with which soil will allow water to pass through it is called **permeability**, which is a very useful value for civil engineers. Constructing a building on highly permeable soil means that water proofing techniques have to be put in place before digging a foundation or raising columns. On the other hand, the **porosity** of a soil mass means the pore space or void space in a soil mass. It affects the strength of a soil mass and it depends upon other physical properties of the soil like texture, structure, and presence of organic matter in soil.

1.3.2 Chemical Properties of Soil

Acidity of Soil (pH)

Determination of the pH of the soil mass is essential for construction works, highly acidic soil will affect the bitumen stability of roads and have adverse effects on concrete strength.

Silicate Clay Presence

The presence of silicate clay materials affects the chemical properties of soil mass. Clay particles have a large surface area and are the finest materials present in a soil mass. Clay particle increase the reactivity of a soil mass and affect the stability of the soil mass by forming compounds with external materials. Determination of silicate clay presence is important to find out the reactivity of the soil mass and its compatibility with admixtures and construction materials used with concrete.

2. TESTS CONDUCTED ON SOIL SAMPLE

2.1 Particle size distribution of soils (Grain-size analysis) by sieve analysis for coarse-grained soil.

This test is done to determine the particle size distribution of soil as per IS: 2720.

A sieve analysis test is performed on a sample of aggregate in a laboratory. A typical sieve analysis involves a nested column of sieves with wire mesh cloth (screen).

A representative weighed sample is poured into the top sieve which has the largest screen openings. Each lower sieve in the column has smaller openings than the one above. At the base is a round pan, called the receiver.

The column is typically placed in a mechanical shaker. The shaker shakes the column, usually for some fixed amount of time. After the shaking is complete the material on each sieve is weighed. The weight of the sample of each sieve is then divided by the total weight to give a percentage retained on each sieve.

The appratus required to do this test :-

1. A set of fine sieves of sizes – 2mm, 1mm, 600 microns, 425 microns, 300 microns, 212 microns, 150 microns, 75 microns.

2. A set of coarse sieves of sizes – 10mm, 4.75mm.
3. Sieve shaker.
4. Soil sample (1000g air dried)

RESULTS

SIEVE SIZE	SAMPLE RETAINED
10mm	42.5g
4.75mm	148.5g
2mm	166g
1mm	188g
600 microns	111.5g
425 microns	92g
300 microns	40.5g
212 microns	77.5g
150 microns	24g
75 microns	39.5g
Pan	69g
Total	999g

(1 gram of soil sample lost during shaking of soil in sieve shaker).

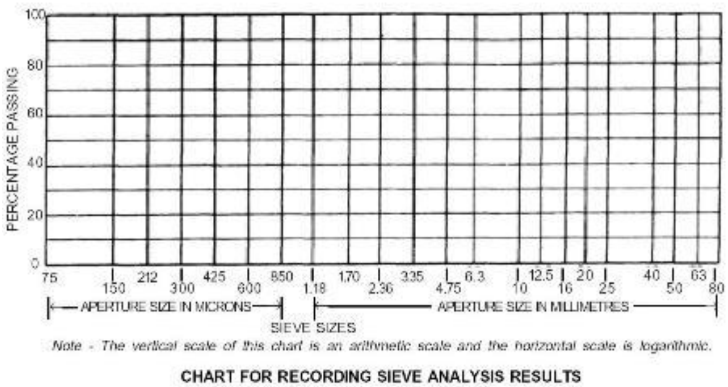

Figure 1

Figure 2

Sieve shaker appratus

2.2 Determination of moisture content in the soil sample with drying duration.

This test is done to determine the water content in soil by oven drying method as per IS: 2720 (Part II) – 1973. The water content (w) of a soil sample is equal to the mass of water divided by the mass of solids.

Apparatus required :-

i) Thermostatically controlled oven maintained at a temperature of 110 ± 5^{o}C

ii) Soil sample

iii) Container

RESULTS

Weight of empty container (w1) = 20g

Weight of container + wet soil (w2) = 173g

Weight of container + dry soil (w3) = 160g

So, weight of dry soil (w3-w1) = 140g

Mass of moisture (w3-w2) = 13g

Water content (W) = (w2-w3)/(w3-w1)*100%

= 1300/140 = 9.29%

2.3 Determination of Atterberg's limits(consistency limit) for non swelling type soils. i.e Liquid limit

This test is done to determine the liquid limit of soil as per IS: 2720 (Part 5) – 1985. The liquid limit of fine-grained soil is the water content at which soil behaves practically like a liquid, but has small shear
strength. It's flow closes the groove in just 25 blows in Casagrande's liquid limit device.
The value of liquid limit helps in classification of fine grain soil.
The values of liquid limit are required to calculate flow index, toughness index etc.

The apparatus used :-
i) Casagrande's liquid limit device.

ii) Soil sample (200gm).

iii) 425 micron sieve.

RESULTS

Soil sample	Water added(ml)	No. of blows	Moisture Content(%)
1.	40ml	10	27.73%
2.	20ml	18	23.43%
3.	15ml	28	23.80%

Figure 3

⟷ Cassagrande's apparatus is used to determine the no. of blows when sample is kept on it as shown.

The liquid limit test gives a graph between moisture content and no. of blows

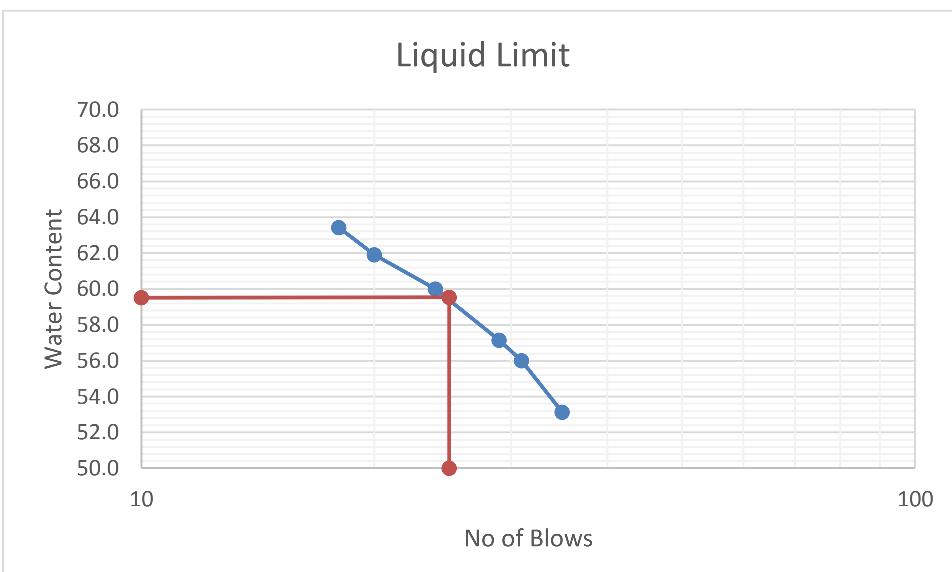

Figure 4

2.4 Determination of Atterberg's limits(consistency limit) for non swelling type soils. i.e Plastic limit

Use 425 microns sieve to sieve 100 g sample. We add some water to the sample and try to roll it into threads of about 5 cm length and 3 mm dia. Until the soil tends to crumble below that dia. The set of changes that occurs in a soil between plastic and liquid limit is called as plasticity of the soil. The sample we have here is very sandy and contains near about 80% sand and very less clay. Thus we may conclude that the plasticity of this sample is very close to zero.

Image of sample when it was made to roll into threads:

Figure 5

It is seen here that the soil sample can not be rolled into threads of 3mm very precisely and that they crumble very easily when heated in the oven at a temp. between 100-110 degrees.

2.5 Standard Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils

This test method covers determination of the strength and stress-strain relationships of a cylindrical specimen of either undisturbed or remolded cohesive soil. Specimens are subjected to a confining fluid pressure in a triaxial chamber. No drainage of the specimen is permitted during the test. The specimen is sheared in compression without drainage at a constant rate of axial deformation (straincontrolled)In a triaxial shear test, stress is applied to a sample of the material being tested in a way which results in stresses along one axis being different from the stresses in perpendicular directions. This is typically achieved by placing the sample between two parallel platens which apply stress in one direction, and applying fluid pressure to the specimen to apply stress in the perpendiculardirections.During the test, the surrounding fluid is pressurized, and the stress on the platens is increased until the material in the cylinder fails and forms sliding regions within itself, known as **shear bands**. The geometry of the shearing in a triaxial test typically causes the sample to become shorter while bulging out along the sides. The stress on the platen is then reduced and the water pressure pushes the sides back in, causing the sample to grow taller again. This cycle is usually repeated several times while collecting stress and strain data about the soil

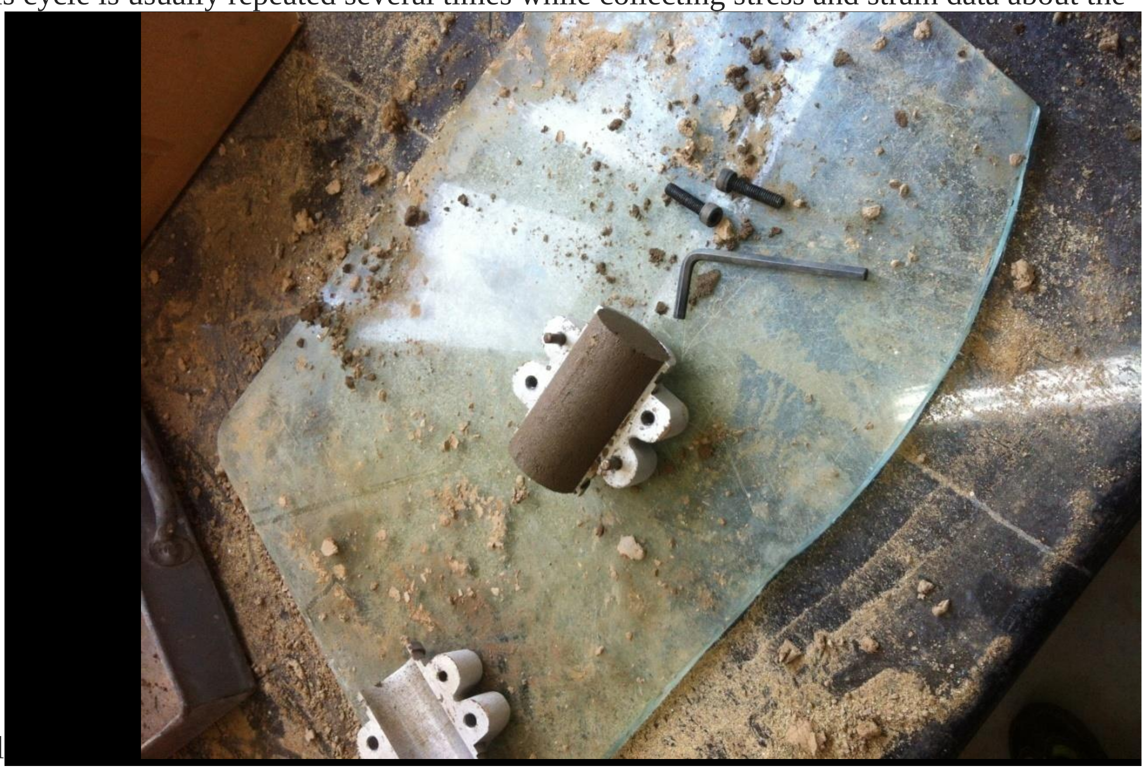

Figure 6

Figure 7

Figure 7

RESULTS

Load = 0.2kn
Pressure = 6.38kg/cm^2
Displacement = 1.33mm

Figure 9

2.6 Determination of specific gravity of soil using pycnometer.

The specific gravity of a soil solids is used in calculating the phase relationships of soils, such as void ratio and degree of saturation.

Appratus Required:-

1. Pycnometer
2. Soil sample

RESULTS

Mass of empty, clean pycnometer(W1) = 465.3gm

Mass of empty pycnometer + dry soil + flyash(W2) = 537.3gm

Mass of pycnometer + dry soil + water(W3) = 1235.6gm

Mass of pycnometer + water(W4) = 1190gm

Therefore,

Specific Gravity of soil = (W2-W1)/(W2-W1)-(W3-W4)

Specific Gravity of soil = 2.72

FUTURE WORK

The previous tests are to be repeated for soil stabilization by adding an admixture-Fly ash to the soil sample.

3.1 The following tests are now repeated by adding an admixture fly ash to the soil sample.

The effectiveness of fly ash use in the stabilization of organic soils and the factors that are likely to affect the degree of stabilization were studied. Unconfined compression and resilient modulus tests were conducted on organic soil–fly ash mixtures and untreated soil specimens.
The unconfined compressive strength of organic soils can be increased using fly ash, but the amount of increase depends on the type of soil and characteristics of the fly ash. Resilient moduli of the slightly organic and organic soils can also be significantly improved. The increases in strength and stiffness are attributed primarily to cementing caused by pozzolanic reactions, although the reduction in watercontent resulting from the addition of dry fly ash solid also contributes to strength gain.

The significant characteristics of fly ash that affect the increase in unconfined compressive strength and resilient modulus include CaO content and CaO=SiO2 ratio [or CaO=ðSiO2 þ Al2O3Þ ratio].

Fly ash has been used successfully in many projects to improve the strength characteristics of soils. Fly ash can be used to stabilize bases or subgrades, to stabilize backfill to reduce lateral earth pressures and to stabilize embankments to improve slope stability. Typical stabilized soil depths are 15 to 46 centimeters (6 to 18 inches). The primary reason fly ash is used in soil stabilization applications is to improve the compressive and shearing strength of soils.

3.1.1 Determination of moisture content in the soil sample with drying duration.

This test is done to determine the water content in soil by oven drying method as per IS: 2720 (Part II) – 1973.

APPRATUS REQUIRED:

- i) Thermostatically controlled oven maintained at 110-105C.
- ii) Soil sample.
- iii) Container.
- iv) Fly ash.

1. Adding 5% Flyash (admixture) by weight to the soil sample.

Weight of soil = 47.5 g , Weight of Flyash = 2.5 g

Weight of empty container (W1) = 20gm

Weight of container + wet soil + Flyash (W2) = 68.0 gm

Weight of container + dry soil (W3) = 63.1 gm

Weight of dry soil (W3-W1) = 43.1gm

Mass of moisture (W2-W3) = 4.9 gm

Water content (W) = (W2-W3)/(W3-W1)*100% = 11.36%

2. Adding 10% Flyash (admixture) by weight to the soil sample.

Weight of soil = 45 g , Weight of Flyash = 5 g

Weight of empty container (W1) = 20gm

Weight of container + wet soil + Flyash(W2) = 69.1 gm

Weight of container + dry soil (W3) = 64 gm

Weight of dry soil (W3-W1) = 44 gm

Mass of moisture (W2-W3) =5.1gm

Water content (W) = (W2-W3)/(W3-W1)*100% = 11.59%

3. Adding 15% Flyash (admixture) by weight to the soil sample.

   Weight of soil = 42.5 g , Weight of Flyash = 7.5 g

   Weight of empty container (W1) = 20gm

   Weight of container + wet soil + Flyash(W2) = 69.6 gm

   Weight of container + dry soil (W3) = 66.3 gm

   Weight of dry soil (W3-W1) = 46.3 gm

   Mass of moisture (W2-W3) = 3.3 gm

Water content (W) = (W2-W3)/(W3-W1)*100% = 7.12%

3.1.2 Determination of atterberg's limits (consistency limit) for non swelling type soils. i.e. Liquid limit.

This test is done to determine the liquid limit of soil as per IS: 2720 (Part 5) – 1985. The liquid limit of fine-grained soil is the water content at which soil behaves practically like a liquid, but has small shear
strength. It's flow closes the groove in just 25 blows in Casagrande's liquid limit device.
The value of liquid limit helps in classification of fine grain soil.
The values of liquid limit are required to calculate flow index, toughness index etc.

Apparatus used :-

i) Casagrande's liquid limit device.

ii) Soil sample (200gm).

iii)425 micron sieve.

1. 5% Fly ash by weight added.

Weight of soil sample = 190gm

Weight of Flyash (admixture) = 10gm

Use 425 micron sieve to sieve 200 gm sample.

RESULTS

Soil sample	Water added(ml)	No. of blows	Moisture Content(%)
1.	40ml	12	12.53%
2.	20ml	23	12.27%
3.	15ml	31	11.36%

Figure 8

Cassagrande's apparatus is used to determine the no. of blows when sample is kept on it as shown.

2. 10% Fly ash by weight added.

Weight of soil sample = 180 gm

Weight of Flyash (admixture) = 20gm

Use 425 micron sieve to sieve 200 gm sample.

Soil sample	**Water added(ml)**	**No. of blows**	**Moisture Content(%)**
1.	40ml	19	12.87%
2.	20ml	26	12.40%
3.	15ml	32	11.59%

3. 15% Fly ash by weight added.

Weight of soil sample = 170gm

Weight of Flyash (admixture) = 30gm

Use 425 micron sieve to sieve 200 mg sample.

Soil sample	**Water added(ml)**	**No. of blows**	**Moisture Content(%)**
1.	40ml	15	12.16%
2.	20ml	25	11.89%
3.	15ml	28	11.25%

3.1.3 Particle size distribution of soils (Grain-size analysis) by sieve analysis for coarse-grained soil.

This test is done to determine the particle size distribution of soil as per IS: 2720.

A sieve analysis test is performed on a sample of aggregate in a laboratory. A typical sieve analysis involves a nested column of sieves with wire mesh cloth (screen).

A representative weighed sample is poured into the top sieve which has the largest screen openings. Each lower sieve in the column has smaller openings than the one above. At the base is a round pan, called the receiver.

The column is typically placed in a mechanical shaker. The shaker shakes the column, usually for some fixed amount of time. After the shaking is complete the material on each sieve is weighed. The weight of the sample of each sieve is then divided by the total weight to give a percentage retained on each sieve

The appratus required to do this test :-

1. A set of fine sieves of sizes – 2mm, 1mm, 600 microns, 425 microns, 300 microns, 212 microns, 150 microns, 75 microns.
2. A set of coarse sieves of sizes – 10mm, 4.75mm.
3. Sieve shaker.
4. Soil sample (1000g air dried)
5. Fly-ash (admixture).

RESULTS

1. 5% fly-ash added to 1000gms of sample.

Weight of soil sample = 950gm

Weight of fly-ash = 50gm

Figure 9

SIEVE SIZE	SAMPLE RETAINED
10mm	34.5g
4.75mm	126g
2mm	159g
1mm	194g
600 microns	117.5g
425 microns	86.4g
300 microns	44.2g
212 microns	73.6g
150 microns	28.3g
75 microns	52g
Pan	83g
Total	998.5g

1.5 gram of sample lost during shaking of sample in sieve shaker.)

2. 10% fly-ash added to 1000gms of sample.

Weight of soil sample = 900gm

Weight of fly-ash = 100gm

SIEVE SIZE	SAMPLE RETAINED
10mm	43g
4.75mm	138.5g
2mm	124.3g
1mm	177.8g
600 microns	93.6g
425 microns	85g
300 microns	57.2g
212 microns	76.5g
150 microns	33.2g
75 microns	78g
Pan	83.5g
Total	998g

(2 gram of sample lost during shaking of sample in sieve shaker.)

3. 15% fly-ash added to 1000gms of sample.

Weight of soil sample = 850gm

Weight of fly-ash = 150gm

SIEVE SIZE	SAMPLE RETAINED
10mm	47.7g
4.75mm	150.6g
2mm	133g
1mm	168.3g
600 microns	106g
425 microns	63g
300 microns	51.3g
212 microns	79.1g
150 microns	41.5g
75 microns	69g
Pan	87.5g
Total	997g

(3 gram of sample lost during shaking of sample in sieve shaker)

Figure 10

3.1.4 Determination of specific gravity of soil using pycnometer.

Appratus Required:-

1. Pycnometer
2. Soil sample
3. Fly-ash(admixture)

RESULTS

Mass of empty, clean pycnometer(W1) = 465.3gm

Mass of empty pycnometer + dry soil + flyash(W2) = 537.3gm

Mass of pycnometer + dry soil + water(W3) = 1235.6gm

Mass of pycnometer + water(W4) = 1190gm

Therefore,

Specific Gravity of soil = (W2-W1)/(W2-W1)-(W3-W4)

Specific Gravity of soil = 2.72

3.1.5 Standard Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils.

Appratus required:-

1. Soil sample
2. Sample extractor
3. Fly-ash
4. Triaxial shear test apparatus

This test method covers determination of the strength and stress-strain relationships of a cylindrical specimen of either undisturbed or remolded cohesive soil. Specimens are subjected to a confining fluid pressure in a triaxial chamber. No drainage of the specimen is permitted during the test. The specimen is sheared in compression without drainage at a constant rate of axial deformation (straincontrolled).In a triaxial shear test, stress is applied to a sample of the material being tested in a way which results in stresses along one axis being different from the stresses in perpendicular directions. This is typically achieved by placing the sample between two parallel platens which apply stress in one direction, and applying fluid pressure to the specimen to apply stress in the perpendicular directions. During the test, the surrounding fluid is pressurized, and the stress on the platens is increased until the material in the cylinder fails and forms sliding regions within itself, known as shear bands. The geometry of the shearing in a triaxial test typically causes the sample to become shorter while bulging out along the sides. The stress on the platen is then reduced and the water pressure pushes the sides back in, causing the sample to grow taller again. This cycle is usually repeated several times while collecting stress and strain data about the sample.

Figure 11

Figure 12

Figure 13

RESULTS

Load = 0.2kn
Pressure = 6.38kg/cm^2
Displacement = 1.39mm

3.1.6 Determination of Atterberg's limits(consistency limit) for non swelling type soils. i.e Plastic limit

Use 425 microns sieve to sieve 100 g sample.

1. By adding 5% fly ash to the sample.

   Weight of soil sample = 95gm

   Weight of fly ash = 5gm

   We add some water to the sample and try to roll it into threads of about 5 cm length and 3 mm dia. Until the soil tends to crumble below that dia. The set of changes that occurs in a soil between plastic and liquid limit is called as plasticity of the soil. The sample we have here is very sandy and contains near about 80% sand and very less clay. Thus we may conclude that the plasticity of this sample is very close to zero.

   Image of sample when it was made to roll into threads:

Figure 14

It is seen here that the soil sample can not be rolled into threads of 3mm very precisely and that they crumble very easily when heated in the oven at a temp. between 100-110 degrees.

REFERENCES

1. GEOTECHNICAL LAB MANUAL
2. BASIC AND APPLIED SOIL MECHANICS – GOPAL RANJAN & RAO