

STATIC BEHAVIOUR OF GEO-CELL CONFINED WITH REINFORCED SOFT CLAY SOIL

A project report submitted in partial fulfillment of the requirements For
the degree of Bachelor In Technology

Submitted by

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CERTIFICATE

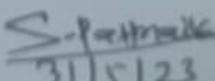
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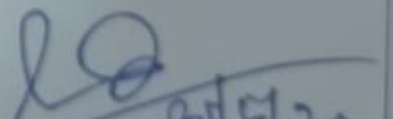
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DECLARATION

I hereby certify that the work which is being presented in the report entitle "**STATIC BEHAVIOUR OF GEO-CELL CONFINED WITH REINFORCD SOFT CLAY SOIL**" in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in GANDHI INSTITUTE FOR TECHNOLOGY, Bhubaneswar is an authentic record of our own work carried out during the period from 2022 to 2023 under the supervision of Asst. Prof Sanam Sarita Tripathy.

The matter embodied in this thesis has not been submitted by me for the award of any other degree of this or any other University/Institute.

This is to certify that above statement made by the student is correct to the best of our knowledge.

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ABSTRACTS

Soft clay is normally avoided during construction due to its low bearing capacity and high susceptibility of consolidation. The safe bearing capacity of soft clay is considerably increased with insertion of geo-cells at suitable depth from the foundation. Although it is known that geo-cell reinforced soft clay behaves differently in confined and unconfined conditions, but a detailed study is not reported yet. Moreover, the behavior of geo-cell reinforced soft clay under dynamic loading is also not properly studied. Extant of increase in bearing capacity of soft clay due to insertion of geo-cells is also not known. Present research is intended to study a series of static tri-axial tests to understand the effect of geo-cells on modification of strength parameters and

dynamic properties of soft clay. Both confined and unconfined tests have been done considering actual site condition.

It is observed that under unconfined conditions, the geo-cells will compress resulting in increase in strain, whereas, under confined condition, the geo-cells will stiffen the soil resulting in increase in stress. It is also observed that maximum improvement in axial stress is achieved when the geo-cells are placed at a depth of one fourth of the loading diameter. However, position of geo-cells does not have a significant effect on stress strain curve in unconfined condition. It is observed that the shear modulus increases and the damping ratio decreases due to insertion of geo-cells.

A study has also been conducted to obtain the effect of geo-cells on modification of residual strength after cyclic loading. It is observed that reduction of strength due to cyclic loading is much less due to insertion of geo-cells.

CHAPTER -1

1. INTRODUCTION

1.1 GENERAL

During the last three decades geo-synthetics are being extensively used to improve the properties of poor soil, like to increase the drainage property, to reduce the compressibility, to improve the shear strength, etc. In order to increase the bearing capacity of soft clay, use of geo-cells is also being extensively used and so on. Dash et al. (2003) reported that provision of geo-cell reinforcement improves the load carrying capacity of foundation soil. Normally a geo-cell is a three-dimensional, honey-comb like structure made of geo-synthetics interconnected by joints. Geo-grids are normally used to make the cage and geotextiles or geo-membranes are put inside the cage for retaining the Filling material like sand, gravel or boulder. The geo-cells may be triangular, square, rectangular or hexagonal in plan depending upon the nature of utility.

Geo-cells have been found to be useful for base reinforcement of embankments and subgrade soil, reinforcement below shallow foundations and steep slopes and in other applications where the soil should withstand the high tensile stresses. Flexural rigidity of the geo-cells plays an important role in increasing the strength of soil against bending. In the present study, effects of geocells in modifying the shear strength of soft clay under static and dynamic loading have been under taken. A series of triaxial compression tests have been carried out on 75 mm diameter clayey soil samples reinforced with four interconnected geocells placed at different depths from the top of the sample. Cyclic tri-axial tests have also been conducted on the samples to find out the improvement on dynamic properties of soft clay, due to insertion of geocells. A considerable improvement in the static and dynamic properties has been observed. Geo-synthetic – a planar product manufactured from polymeric material used with soil, rock, earth or other geotechnical engineering related material as an integral part of a human made project, structure, or system.

1.2 The specific objectives of the present study are as below

1. To carry out literature review for detail understanding of Geo-cell reinforcement.
2. The behaviour of Geo-cell can be understood better, when a relative study is made. To facilitate this, Geo-cell specimens were tested under the same conditions of original soil specimens.
3. To study the influence of shear strength parameters of different Geo-cell layer reinforced soil.

1.3 ORGANISATION OF THE REPORT

- The present work has been organised into six chapters. Following is a brief outline of the report.
- In the second chapter, general overview of literatures from various journals and publication are overviewed and discussed.
- The third chapter presents the general overviews of various materials used in this study, the experimental program like mixing procedure, specification, detail of various tests and their procedure are discussed.
- The fourth chapter presents the various results and discussions of the study.
- The fifth chapter deals with the result of the study carried out, overall conclusions, and contribution are presented in the last chapter to bring out the outcome of the present work.
- The last chapter deals with the different References.

CHAPTER -2

2 LITERATURE REVIEW

Thakur [1] (2012) have studied the effect of geo-cell reinforced recycled asphalt pavement (RAP) bases over weak subgrade under cyclic plate loading and found that geo-cell has improved the performance of RAP bases over weak subgrade as compared with the unreinforced base section and geo-cell significantly increased the percentage of resilient deformation of the RAP base. The geocell reinforcement reduced the vertical stresses transferred to the subgrade by distributing the load over a wider area.

Emersleben [2] (2008) have studied about the bearing capacity improvement of gravel base layers in road constructions using geocell and concluded that geocell layer placed within the gravel base layer of an asphalt paved construction reduced the vertical stresses on subgrade during vehicle crossing about 30 per cent and increased the layer modulus of the gravel base layers compared to an unreinforced layer. As a result the measured deflections on the asphalt surface were also reduced.

Sireesh [3] (2009) have performed experiments on circular footing on geocell–sand mattress overlying clay bed with void to study the increase in the bearing capacity of circular footing. A series of model load tests have been conducted to evaluate the potential benefits of providing geocell reinforced sand mattress over clay bed with a continuous circular void. The test results clearly demonstrate that geocell mattress can substantially increase the bearing capacity and reduce settlement of the clay subgrade with void.

Dash [4] (2003) conducted experiments on circular footing supported on geocell reinforced sand underlain by soft clay and concluded that Provision of geocell reinforcement in the overlying sand layer improves the load carrying capacity and reduces the surface heaving of the foundation bed substantially. The performance improvement increases with increase in the width of the geocell layer up to $b=D$ of 5 beyond which it is negligible. Good improvement in the load carrying capacity of the foundation bed can be obtained even with geocell mattress of width almost equal to the diameter of the footing.

Leshchinsky [5] (2012) studied about the numerical modeling of behavior of railway ballasted structure with geocell confinement. In the end of his he concluded that the confinement of the ballast using geocell was quite effective in reducing vertical deformations, especially when low-quality material was used. Higher shear strength of the ballast reduces the need for reinforcement, reducing the need for sub structure improves.

Mehdipour [6] (2013) investigate a numerical study on stability analysis of geo-cell reinforced slopes by considering the bending effect and they concluded that geo-cell reinforcements were found to be advantageous in increasing the factor of safety and reducing the lateral deformations of slopes due to the tensile strength and bending moment of geo-cell reinforcement. Also geo-cell reinforcement acts like a wide slab and it can restrain the failure surface from developing and redistribute the loads over a much wider area.

CHAPTER -3

3. MATERIALS & METHODS OF EXPERENTS

3.1 MATERIALS

3.1.1 SOIL

Locally available silty clay soil which was used for this project. This soil was collected from Mayurbhanj District.

The soil contains 83% particles finer than 75 micron. Fig 1 depicts the particle size distribution of this soil. The basic properties of soil or soil parameters obtained on conducting appropriate tests are as per IS: 2720 have been formulated in various parts. This part covers method of preparation of samples for the various laboratory tests covered in the standard.

The parameters of the soil obtained on conducting appropriate tests are given in the Table 3.1 & Table 3.2

3.1.2 GEO-CELL

Geocell are combination of geogrid and geomembrane for this project. One geocells, each of size 25 x 25 x 25 mm were prepared with geo-grid. A layer of geomembrane was put inside the geogrid. Coarse sand was poured into each cell. Fig. 2 shows the picture of the geocells used in the present study. The geocells were placed at different depths inside the soil sample as shown in Figs. 3 and 4. Table 1 shows the properties of the geogrid.

3.1.2.1 Geo-grid

Geo-grid of 18mm x 20mm Aperture size is used as geocell block. The aperture opening shape is rectangle. The Properties of geogrid are given in the Table 1.

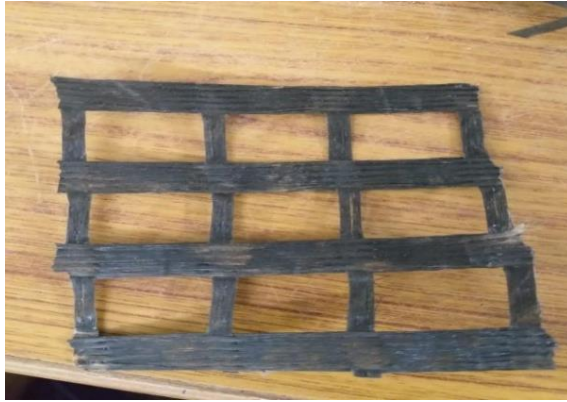


Fig3.1 Geogrid

3.1.2 .2 Geo-membrane and Coarse sand

Geomembrane of locally available plastic sheet, 0.09 mm thick was put inside the geogrid. Coarse sand is used to fill the geocell. The sand has a uniformity coefficient (Cu) of 2.28, coefficient of curvature (Cc) of 1.11 and specific gravity of 2.6.



Fig 3.2 Geocell Block (18mmX20mm)

3.1.3 WATER

Clean potable water as obtained from laboratory of Civil Engineering Department of GIFT Autonomous College was used for mixing and curing of soil specimen.

Table 3.1 Physical Properties of the Geogrid

SL.NO	PARAMETER	QANTITY
1	Polymer	Polypropylene
2	Aperture size	18 x 20 mm
3	Peak tensile strength	4.8kN/m*5.5kN/m
4	Yield point strain	23%*20%
5	Aperture opening shape	Rectangle

Table 3.2 Physical Properties of coarse aggregate

SL.NO	PARTICULARS	TEST RESULTS
1	Specific Gravity	2.6
2	Uniformity co-efficient	2.28
3	Coefficient curvature	1.11

3.2 EXPERIMENT PROGRAMME

3.2.(A) PREPARATION OF SOIL SPECIMENS

Different mix of Soil + Geocell & original soil sample obtained to conduct specific gravity test, coarse and fine grained analysis of soil, Liquid and Plastic limit of soil , Modified Proctor test of soil ,UCS test on standard mould of sample size 38mm diameter and 76mm height , Tri-axial test of soil sample of size 75 mm(diameter) & 150mm (height).

3.2. (B) GEO-CELL INSERTION PROCEDURE

Insertion of perfect depth of Geocell should be ensured to get correct test results of the soil specimen strength. For original soil sample initially the oven dried soil is weighed for required quantity and poured into another mixing tray or mould which is completely dry.

Later water is added with the dry soil according to its O.M.C for (UCS and Triaxial test only). For Geocell Reinforced soil, the above-explained procedure is followed. Then the Geocell is insert at different height of different trial at $h/2$, $h/3$, $h/4$ distance of soil specimen (Triaxial test) .

3.2. TESTING OF SOIL SAMPLE

Various tests conducted on soil sample in order and briefly described.

3.2.1 SPECIFIC GRAVITY OF SOIL

Specific gravity of soil particle (G) is the ratio of a unit volume of soil solids to the mass of the same volume of gas-free distilled water at a stated temperature (27°C). It is an important parameter and is also used for determination of void ratio and particle size. The standardized detailed procedure for the determination of the specific gravity of soil solids is contained in Indian standard specification.

Standard Reference:

IS 2720 (Part III) – 1980 is the standard recommended to determine specific gravity of fine grained soils.

The specific gravity of solid particle can be determined in the laboratory using many methods that is pycnometer method, density bottle method, jar method etc.

Pycnometer method is used for coarse grained soil while density bottle method is used for fine grained soil. Density bottle method is used for present study.

Equation for specific gravity, G:

$$G = \frac{W_2 - W_1}{(W_2 - W_1) - (W_3 - W_4)}$$

Where, W1= weight of empty bottle

W2= weight of bottle + dry soil

W3= weight of bottle + soil + water

W4= weight of bottle + water

Specific gravity for different soil is not same, generally the general range in which the specific gravity of soil can be categorized as given in table:

Table 3.3 Specific gravity of different soil

Sand	2.63-2.67
Silt	2.65-2.7
Clay and Silt	2.67-2.9
Organic soil	<2

3.2.2 PARTICLE SIZE DISTRIBUTION

3.2.2 A) Sieve analysis of coarse grained soil

The soil contains 83% particles finer than 75 micron. Rest 184 gram of oven dried soil are taken for Sieve analysis by the help of sieve shaker machine. The different sieve size are 4.75mm, 2.36mm, 1.18mm, 0.600mm, 0.450mm, 0.212mm, 0.150mm, .075mm.

Standard Reference:

IS: 2720 (Part 4): 1985. Scope: To determine grain size of soil fraction passing through 4.75 mm IS sieve and retained on 75 micron IS Sieve.



Fig 3.3 Sieve shaker machine

3.2.2 (B) Grain size distribution of fine grained soil by hydrometer analysis

Hydrometer method is used to determine the particle size distribution of fine-grained soils passing 75 μ sieves. The hydrometer measures the specific gravity of the soil suspension at the centre of its bulb. The specific gravity depends upon the mass of solids present, which in turn depends upon the particle size. Hydrometer analysis is an indirect method of assessing the size of soil particle based on Stokes law which relates the velocity with which a spherical particle settles in a still liquid to the diameter of the particle. Hence the size of particle determined in this method is known as equivalent diameter. Hydrometer at any instant measures the relative density of soil suspension.

The amount of soil taken 50 gms of oven dried which is passing through 0.075mm.

Standard Reference:

IS: 2720 (Part 4): 1985. IS: 2720 (Part 4): 1985. Scope: To determine grain size of soils.

3.2.3 LIQUID LIMIT TEST

The liquid limit is the moisture content at which a soil ceases to be plastic. After receiving the soil sample it is dried in air or in oven. The soil passing 425 micron sieve is used in this test. It becomes semi-fluid and tends to flow like a liquid under an applied pressure. This limit is used for classification of soils for engineering purpose. The apparatus used for determining the liquid limit is *liquid limit device* i.e. Casagrande apparatus.

Standard Reference:

IS: 2720(Part 5)-1985-Methods of test for soils of determination of liquid and plastic limit.

Consistency of fine-grained soils may be defined as the relative ease with which a soil can be remolded. Consistency limits may be categorized into three limits called Atterberg limits. They are 1) Liquid limit 2) Plastic limit.

3.2.4 PLASTIC LIMIT TEST

The plastic limit is the lowest moisture content at which a soil can be deformed without cracking. It is the upper limit of moisture content for tillage operation for most crops, except rice. Tillage operations in soil at moisture content above the plastic limit result in smearing and puddling of the soil.

Standard Reference:

IS: 2720(Part 5)-1985 - Methods of test for soils of determination of liquid and plastic limit.

3.2.5 SWELLING INDEX TEST

The swell index test procedure is used to determine the general swelling characteristics of betonies clay. The Swell Index test has not been demonstrated to have a proportional correlation to hydraulic properties, a high swell is considered by most to be a good indicator of betonies quality.

Free Swell Index is the increase in volume of a soil, without any external constraints, on submergence in water.

Standard Reference:

IS 2720 (Part-40): 1977 “Method of test for soils Determination of Free swell Index of soils”.

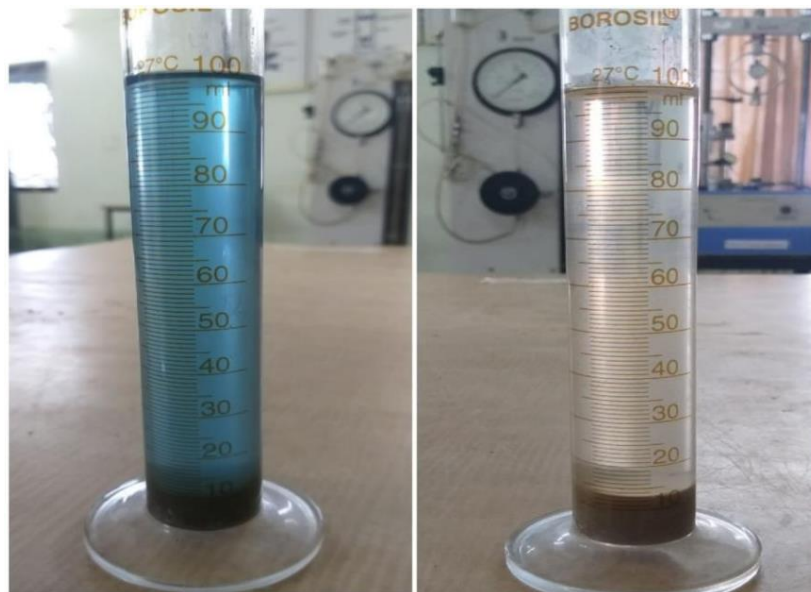
REPORTING OF RESULTS

Free swell index

$$= [V_d - V_k] / V_k \times 100\%$$

Where, V_d = volume of soil specimen read from the graduated cylinder containing distilled water.

V_k = volume of soil specimen read from the graduated cylinder containing kerosene.



Soil with kerosene

Soil with water

Fig 3.4 Swelling index test

3.2.6 MODIFIED PROCTOR TEST

Soil compaction is the process of increasing bulk density and reducing pore volume as a result of the applied pressure. It leads to destruction of larger pores, re-arrangement of solid particles and compression of air within the pore spaces in the soil.

In this modified proctor test generally preferred as the road construction work and easily determine the O.M.C and M.D.D of soil.

Standard Reference:

IS: 2720 (PART 8): 1983, to determine the water content-dry density relation of soil using heavy compaction.



Fig 3.5 Modified proctor test (Heavy compaction)



Fig 3.6 Thermostatically Controlled Ovens



Fig 3.7 Weighing machine

3.2.7 UNCONFINED COMPRESSION TEST

The Unconfined Compression Test is a laboratory test used to derive the Unconfined Compressive Strength (UCS) of a soil specimen. Unconfined Compressive Strength (UCS) stands for the maximum axial compressive stress that a specimen can bear under zero confining stress.

Standard Reference:

IS 2720(Part 10): 1991, determination of unconfined compression test.

3.2.7 A) Preparation of soil sample

The mould size of the USC test is 38mm diameter and 76mm long. The amount or the weight of soil which is passing through the 425 μm sieve, required to prepare one soil sample.

$$= Y_d \times \text{vol. of mould}$$

$$= 1.685 \times \pi/4 \times d^2 \times h$$

$$= 1.685 \times \pi/4 \times 3.8^2 \times 7.6 = 146 \text{ gram}$$

The amount of water required to add the soil sample = Weight of soil sample \times O.M.C

$$= 146 \times 15.50 \%$$

$$= 21.9 \text{ gm. or } 21.9 \text{ ml}$$

3.2.7 B) CALCULATIONS

Stress-strain values shall be follows:

- a) The axial strain, e , shall from the following relationship:

$$\epsilon = \frac{\Delta L}{L}$$

Where dL = the change in the specimen length as read from the strain dial indicator, and L = the initial length of the specimen.

- b) The average cross-sectional area, A , at a particular strain shall be determined from the following relationship:

$$A = \frac{A_0}{1 - e}$$

Where A_0 = the initial average cross-sectional are of the specimen.

- c) Compressive stress, shall be determined from the relationship:

$$\sigma_c = \frac{P}{A}$$

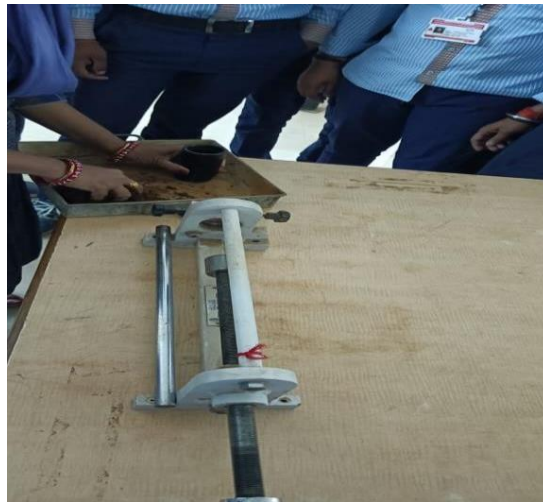


Fig 3.8 UCS Sample preparation



Fig 3.9 UCS Soil sample weight



Fig 3.10 UCS sample extractor



Fig 3.11 UCS Testing machine set up



Fig 3.12 UCS SAMPLE



1



2



3



4) Geocell failure pattern

Fig 3.13 UCS SAMPLE FAILURE PATTERN

3.2.8 TRIAXIAL TEST

Triaxial testing is a type of shear test for solid materials performed while the specimen is under confining pressures on all sides. The confining pressures are generated in a fluid chamber to simulate stresses from surrounding soil materials. It then can give a clearer picture of the behavior of materials in place.

The tri-axial shear test is most versatile of all the shear test testing methods for getting shear strength of soil i.e. Cohesion (C) and Angle of Internal Friction (ϕ), though it is bit complicated. This test can measure the total as well as effective stress parameters both. These two parameters are required for design of slopes, calculation of bearing capacity of any strata, calculation of consolidation parameters and in many other analyses. This test can be conducted on any type of soil, drainage conditions can be controlled, pore water pressure measurements can be made accurately and volume changes can be measured. In this test, the failure plane is not forced, the stress distribution of failure plane is fairly uniform and specimen can fail on any weak plane or can simply bulge.

Standard specification:

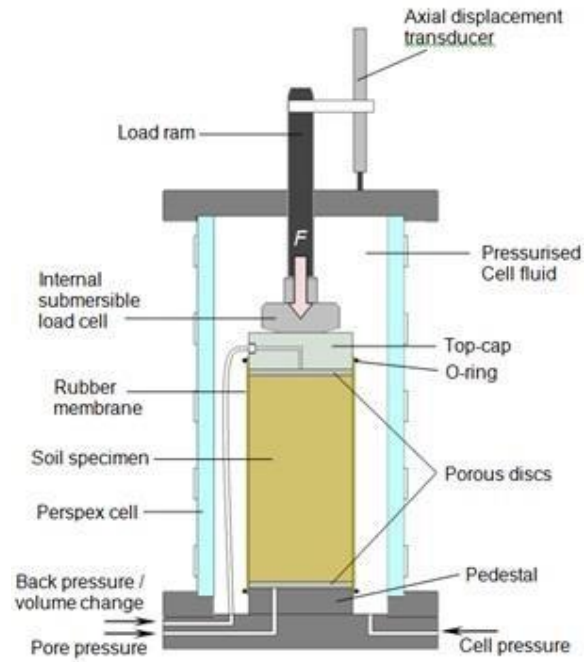
IS 2720(Part 12):1981 Determination of Shear Strength parameters of Soil from consolidated undrained triaxial compression test with measurement of pore water pressure.

Sample preparation:

Prepare the soil sample as per adding the O.M.C and IS code.

Fig 3.14 Triaxial sample preparation





Source: www.compression.com

Fig 3.15 Triaxial machine set up



Fig 3.16 Soil sample for Triaxial test

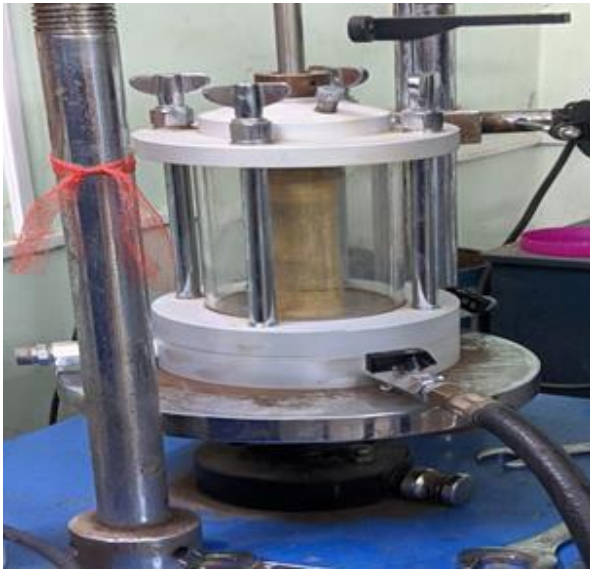


Fig 3.17 Triaxial test under load



Fig 3.18 Triaxial test

CHAPTER – 4

RESULT AND DISSCUSION

This chapter deals with the presentation of test result, and discussion on shear strength, dry density and Triaxial test shear parameter development of original soil sample over reinforced soil.

4.1 SPECIFIC GRAVITY OF SOIL

The test result of specific gravity is shown in table 4.1

Table-4.1 Specific gravity of soil

S.I No	Description	Trail-1	Trail-2	Trail-3
1	Wt. of dry Density bottle (W1)	33.33	33.33	33.33
2	wt. of dry Density bottle+ soil(W2)	43.30	43.20	43.00
3	Weight of dry soil taken $W_d = (w2 - w1)$ g.	10.00	9.95	10.00
4	Weight of density bottle + soil + water (W3)	89.00	88.56	88.93
5	Weight of pycnometer + water (W4)	82.70	82.29	82.56
6	Specific gravity corresponding to test temprature(G_s)	2.70	2.70	2.75
7	Specific gravity corresponding to 27p c (G).	2.70	2.80	2.80
8	Average specific gravity	2.76		

Specific gravity of soil is-2.76

4.2 PARTICLE SIZE DISTRIBUTION

4.2.1 Sieve analysis

The soil contains 83% particles finer than 75 micron. Rest 184 gram of oven dried soil are taken for Sieve analysis by the help of sieve shaker machine.

Table-4.2 Result of sieve analysis

Sl.No.	Sieve size (mm)	Weight of soil retained (gm.)	% weight retained	Cumulative % retained	% Finer
1	4.75	0	0	0	100
2	2.36	0	0	0	100
3	1.18	0	0	0	100
4	0.6	33	17.93	17.93	82.07
5	0.45	38.7	21.03	38.97	61.03
6	0.21	49.2	26.74	65.71	34.29
7	0.15	22.6	12.28	77.99	22.01
8	0.075	40.5	22.01	100	0

4.2.2 Hydrometer analysis

The test result of hydrometer analysis is shown in the following table 4.4

4.2.1 TABLE 4.3 Hydrometer analysis

Calculation of hydrometer											
	Time(min)	Temp.	Ct	Cd	Rh'	$Rh = Rh' + C_m - C_d + C_t$	He	Viscosity	Sp. Gravity	Diameter	%of finer
Observation-1	0.5	29	0.0004	1.003	1.004	1.0024	18.7	8.18	0.996	0.0729	6.19
Observation-2	1	29	0.0004	1.003	1.003	1.0014	19.1	8.18	0.996	0.0521	3.61
Observation-3	2	29	0.0004	1.003	1.021	1.0184	12.6	8.18	0.996	0.0299	47.46
Observation-4	4	29	0.0004	1.003	1.023	1.0214	11.5	8.18	0.996	0.0202	55.2
Observation-5	8	29	0.0004	1.003	1.021	1.0194	12.3	8.18	0.996	0.0148	50.04
Observation-6	15	29	0.0004	1.003	1.018	1.0164	13.4	8.18	0.996	0.0113	42.3
Observation-7	30	29	0.0004	1.003	1.016	1.0144	14.1	8.18	0.996	0.0082	37.15
Observation-8	60	29	0.0004	1.003	1.013	1.0109	15.5	8.18	0.996	0.0061	28.12
Observation-9	120	29	0.0004	1.003	1.012	1.0099	15.8	8.18	0.996	0.0043	25.54
Observation-10	240	29	0.0004	1.003	1.009	1.0074	16.8	8.18	0.996	0.0032	19.09
Observation-11	480	29	0.0004	1.003	1.008	1.0064	17.2	8.18	0.996	0.0023	16.51
Observation-12	720	29	0.0004	1.003	1.007	1.0054	17.6	8.18	0.996	0.0019	13.93
Observation-13	9	29	0.0004	1.003	1.006	1.0044	17.9	8.18	0.996	0.0168	11.35

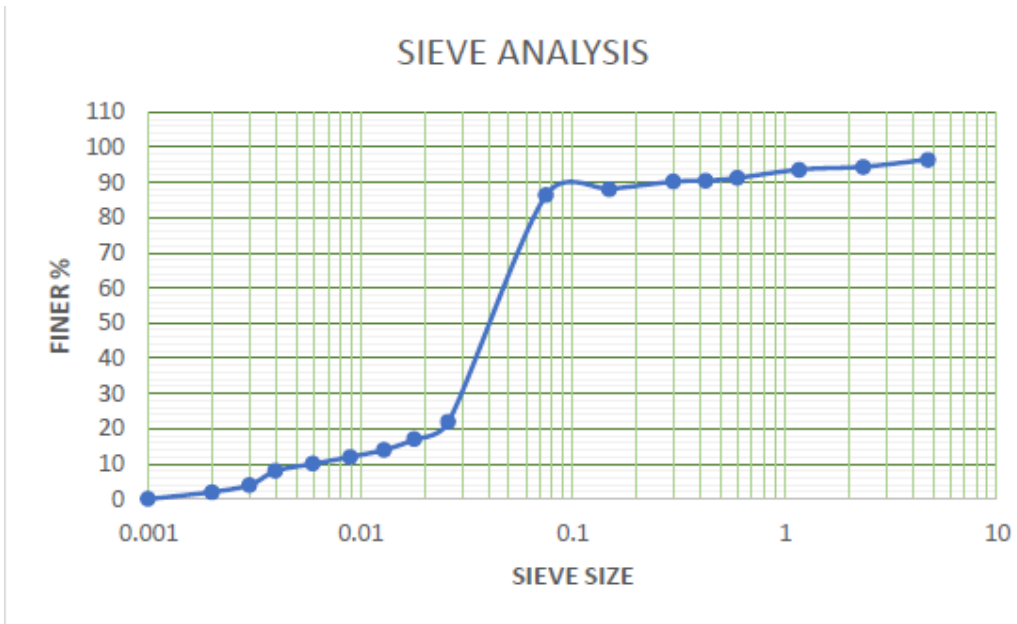


Fig 4.0.1 Grain size distribution

4.3 LIQUID LIMIT TEST

The test result of hydrometer analysis is shown in the following table 4.5

Table 4.3 liquid limit test

LIQUID LIMIT OF SOIL				
Sl no	Description	Trial - 1	Trial - 2	Trial- 3
1	No of observation	1	2	3
2	No of blows	33	21	18
3	Moisture tin number	12	18	15
4	Wt. of moisture tin (gm.)	20	20	20
4	Wt. of wet soil+ moisture tin (gm.)	38	34	27
5	Wt. of dry soil + moisture tin (gm.)	32	29	24.7
7	Weight of dry soil (gm.)	12	9	4
8	Weight of water	6	5	2.3
9	moisture content in %	50	55.56	57.5

4.4 PLASTIC LIMIT TEST

The test result of hydrometer analysis is shown in the following table 4.6

Table 4.4 plastic limit test

PLASTIC LIMIT TEST					
Sl. No.	Determination No.	1	2	3	4
1	Watch glass No.	24	6	40	49
2	Wt. of watch glass+wet soil (gm.)	15	15	15	15
3	Wt. of watch glass+ dry soil (gm.)	13.75	13.95	14.02	14.03
4	Wt. of water (gm.)	1.25	1.05	0.98	0.97
5	Wt. of container (gm.)	10	10	10	10
6	Wt. of dry soil (gm.)	3.75	3.95	4.02	4.03
7	Moisture content %	33.3333	26.5823	24.3781	24.0695
8	Average	27			

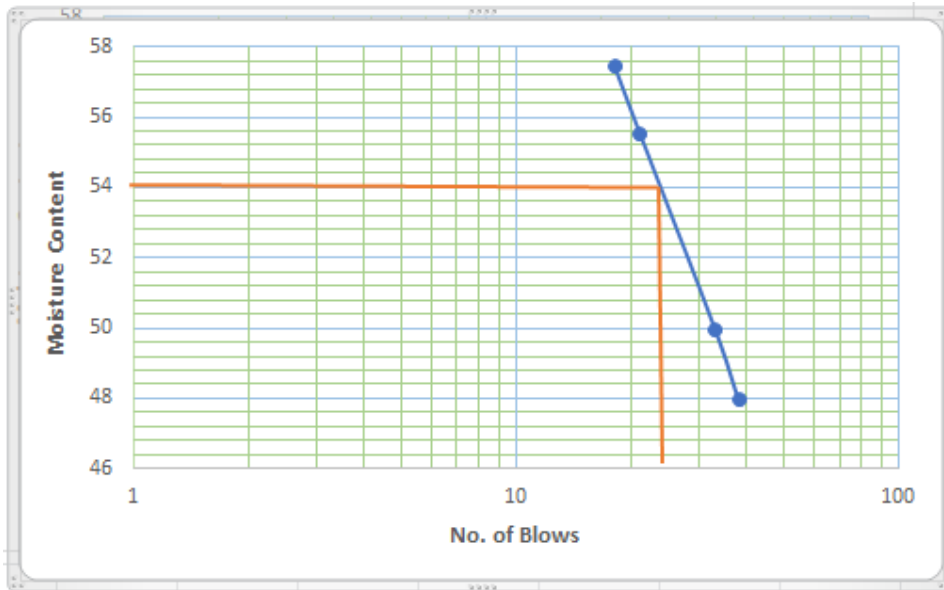


Fig 4.0.2 liquid limit graph

4.5 SWELLING INDEX TEST

REPORTING OF RESULTS

Free swell index

$$= [V_d - V_k] / V_k \times 100\%$$

$$= [13 - 10] / 10 \times 100\%$$

$$= 30\%$$

Where, V_d = volume of soil specimen read from the graduated cylinder containing distilled water.

V_k = volume of soil specimen read from the graduated cylinder containing kerosene.

4.6 MODIFIED PROCTOR TEST (COMPACTION TEST)

Modified compaction test is required due to heavy load is required in road construction. The table 4.5 is shown the result of compaction test or M.D.D and O.M.C of original soil sample.

4.6.1 Original soil test result

Table 4.5 compaction test result for original soil

Modified Proctor test											
WEIGHT OF EMPTY MOULD = 4595gm											
SL.	Water % added	Wt. f mould +soil gms	Wt. of soil gms	Wt density gm./cc	MOISTURE DETERMINATION					Moisture content %	Dry density kN/m ³
					Container No.	Wt. of Container gms	Wt. of container + wet soil in gms	Wt. of container + dry soil gms	Wt. of water gms.		
1	6	6340	1745	1.745	5	15.39	50	47.03	2.97	9.39	15.95
2	8	6416	1821	1.821	6	15.53	50	46.42	3.58	11.6	16.32
3	10	6513	1918	1.918	7	16.33	50	45.81	4.19	14.2	16.79
4	12	6557	1962	1.962	8	15.84	50	45.18	4.82	16.4	16.85
5	14	6558	1963	1.963	9	16.04	50	44.74	5.26	18.3	16.59
6	16	6551	1956	1.956	10	15.79	50	44.17	5.83	20.5	16.23

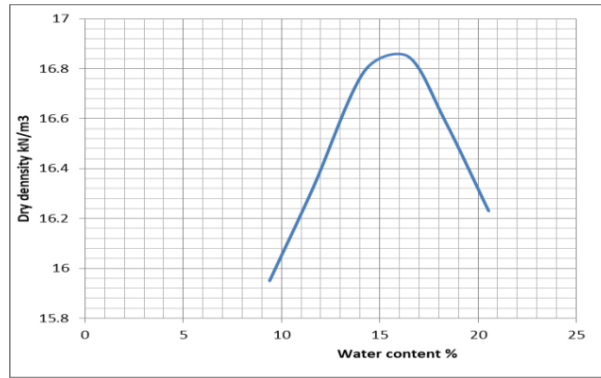


Fig 4.1 Water content and Dry Density relationship of original soil

Optimum Moisture Content (OMC) 15.50%

Maximum Dry Density (MDD) 16.52 kN/m³

4.7 UNCONFINED COMPRESSION TEST

4.7.1 UCS test for original soil sample

The unified compression test of original soil sample are tested below the table

Table 4.7.1 UCS test for original soil sample

USC TEST VALUE						
Disp. Dial gauge	Shear Disp (cm)	Corrected area	Proving ring	Shear (kg)	Shear stress (kg/sq cm)	Axial strain (%)
0	0	11.3411	0	0	0	0
50	0.05	11.4163	1.3	1.3	0.1139	0.658
100	0.1	11.4924	2.2	2.2	0.1914	1.316
150	0.15	11.5695	3	3	0.2593	1.974
200	0.2	11.6477	5.3	5.3	0.455	2.632
250	0.25	11.7269	6.8	6.8	0.5799	3.289
300	0.3	11.8072	8.4	8.4	0.7114	3.947
350	0.35	11.8887	10.2	10.302	0.8665	4.605
400	0.4	11.9712	11.8	11.918	0.9956	5.263
450	0.45	12.0549	12.6	12.726	1.0557	5.921
500	0.5	12.1398	13.4	13.534	1.1148	6.579
550	0.55	12.2259	14	14.14	1.1566	7.237
600	0.6	12.3132	13	13.13	1.0663	7.895

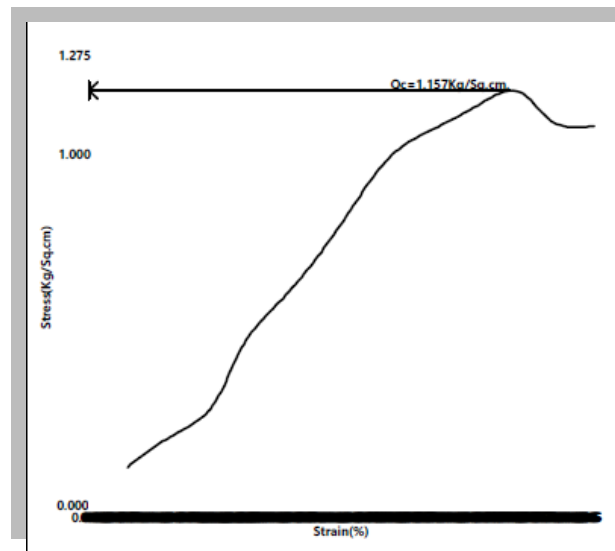


Fig 4.2(a) Stress strain relationship of original soil sample

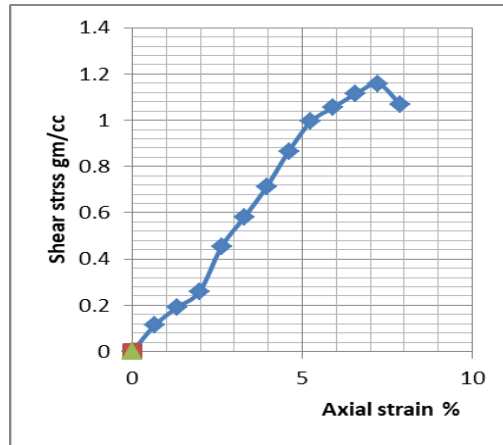


Fig 4.2(b) Stress strain relationship of original soil sample

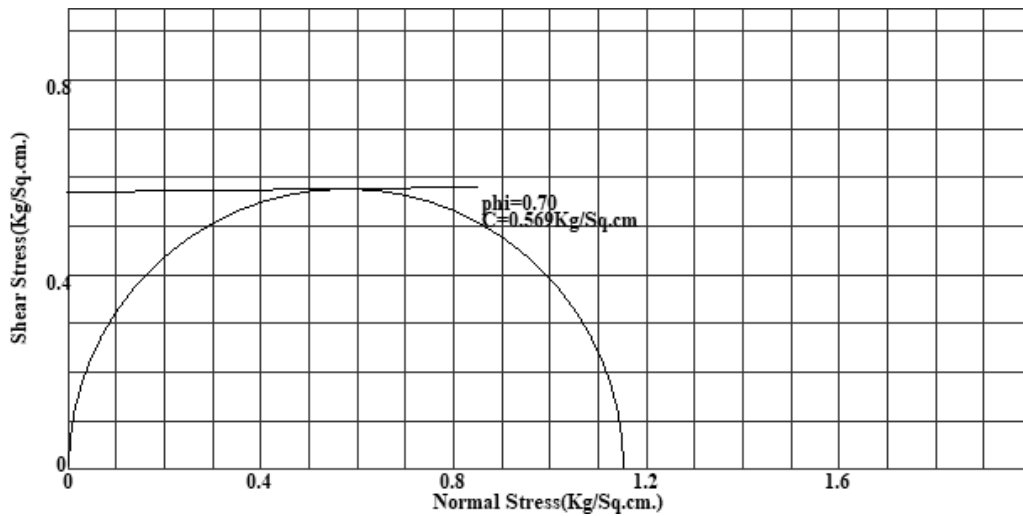
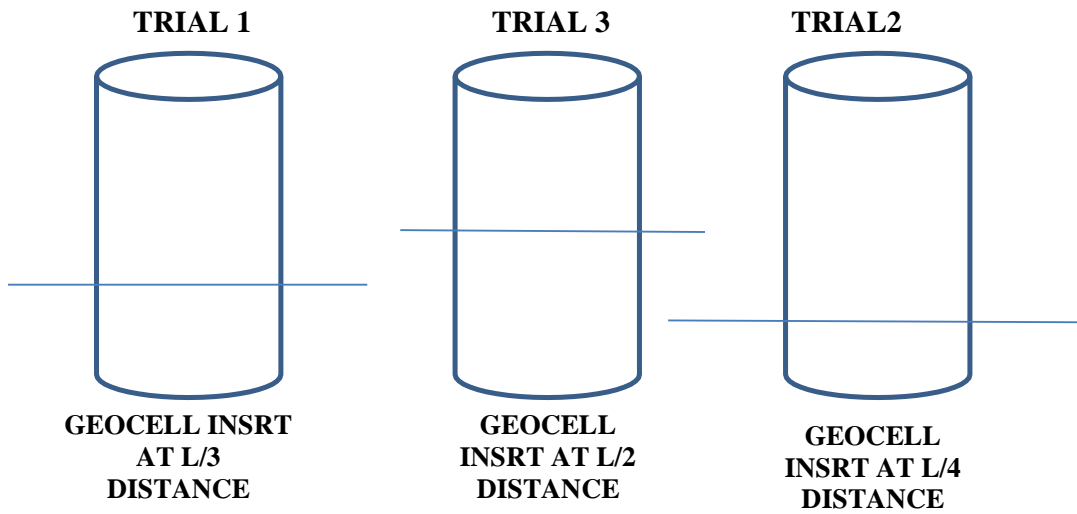


Fig 4.3 Mohr's circle

Original soil sample $\phi=0.70$ $C=.569 \text{ Kg/sq. cm}$

Maximum stress = 1.157 Kg/sq. cm

Fig no: 4.4 GEOCELL INSERT AT DIFFERENT DEPTH



4.6.13 UCS GEOCELL INSERT AT L/2 DEAPTH (3.8 cm)

Table 4.8.2 UCS GEOCELL INSERT AT L/2 DEAPTH

Disp. Dial gauge	shear Disp cm	corrected area	proving ring	shear (kg)	shear stress (kg/sq cm)	Axial strain (%)
0	0	11.3411	0	0	0	0
50	0.05	11.4163	2	2	0.1752	0.658
100	0.1	11.4924	3	3	0.261	1.316
150	0.15	11.5695	3.5	3.5	0.3025	1.974
200	0.2	11.6477	4	4	0.3434	2.632
250	0.25	11.7269	5	5	0.4264	3.289
300	0.3	11.8072	6.4	6.4	0.542	3.947
350	0.35	11.8887	8.2	8.2	0.6897	4.605
400	0.4	11.9712	11	11.11	0.9281	5.263
450	0.45	12.0549	13	13.13	1.0892	5.921
500	0.5	12.1398	16.2	16.362	1.3478	6.579
550	0.55	12.2259	18.6	18.786	1.5366	7.237
600	0.60	12.3132	20.8	21.216	1.7230	7.895
650	0.65	12.4018	21.4	21.828	1.7601	8.553
700	0.70	12.4917	20.0	20.200	1.6171	9.211

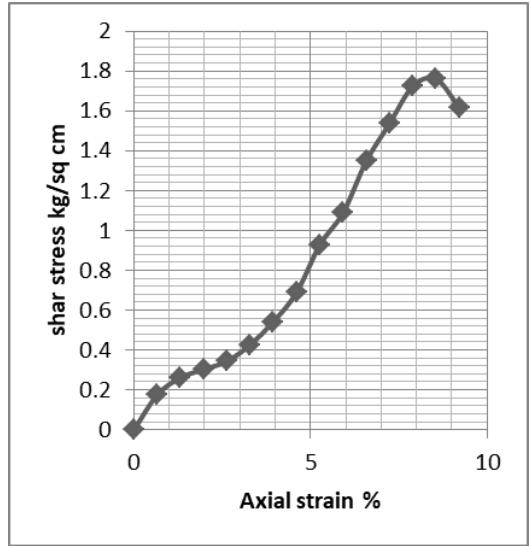


Fig 4.4 (a) UCS GEOCELL INSERT AT L/2 DEAPTH).

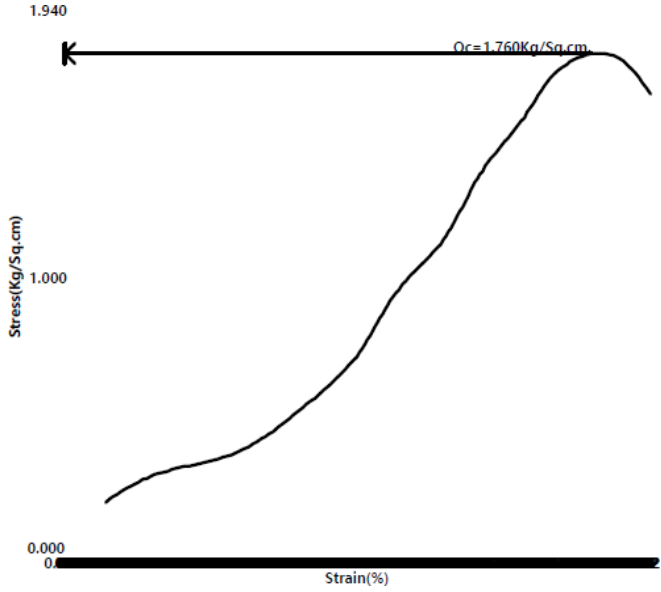


Fig 4.4 (b) UCS GEOCELL INSERT AT L/2 DEAPTH).

4.6.14 UCS GEOCELL INSERT AT L/4 DEAPTH (3.8 cm)

Table 4.8.3 UCS GEOCELL INSERT AT L/4 DEAPTH

Disp. Dial gauge	shear Disp cm	corrected area	proving ring	shear (kg)	shear stress (kg/sq cm)	Axial strain (%)
0	0	11.3411	0	0	0	0
50	0.05	11.4163	2	2	0.1752	0.658
100	0.1	11.4924	3	3	0.2610	1.316
150	0.15	11.5695	3.5	3.5	0.3025	1.974
200	0.2	11.6477	4	4	0.3434	2.632
250	0.25	11.7269	5.8	5.8	0.4946	3.289
300	0.3	11.8072	6.8	6.8	0.5759	3.947
350	0.35	11.8887	8	8	0.6729	4.605
400	0.4	11.9712	8.2	8.20	0.6850	5.263
450	0.45	12.0549	11	11.11	0.9216	5.921
500	0.5	12.1398	13	13.13	1.0816	6.579
550	0.55	12.2259	16	16.16	1.3218	7.237
600	0.6	12.3132	18	18.18	1.4765	7.895
650	0.65	12.4018	20	20.2	1.6288	8.553
700	0.7	12.4917	22	22.44	1.7964	9.211
800	0.8	12.67	21	21.42	1.6700	10.526

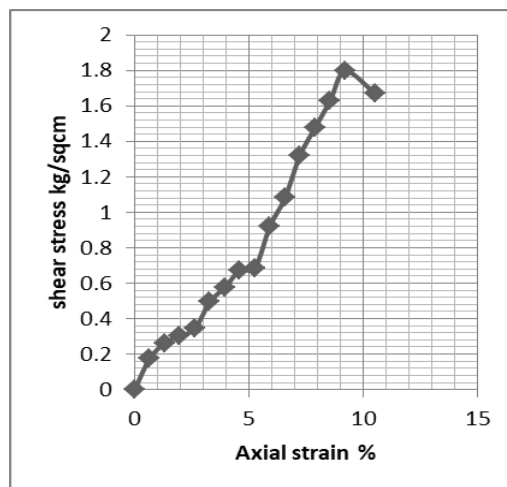


Fig 4.5 (a) UCS GEOCELL INSERT AT L/4 DEAPTH

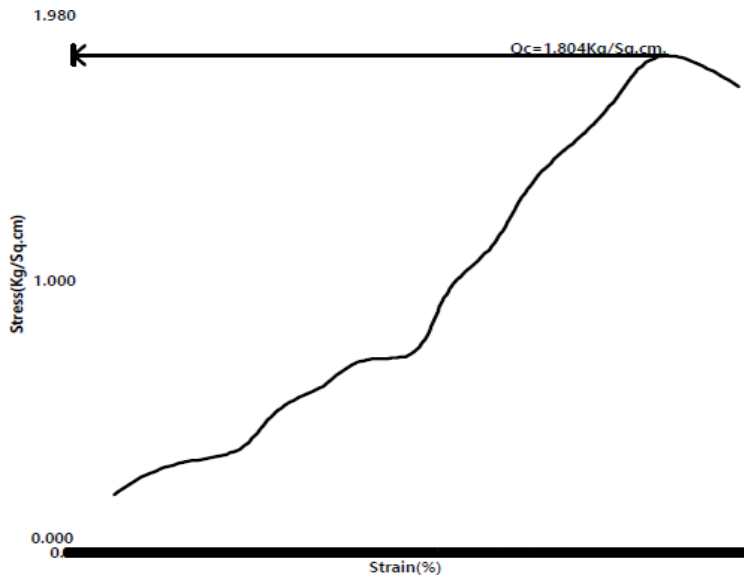


Fig 4.5 (b) UCS GEOCELL INSERT AT L/4 DEAPTH

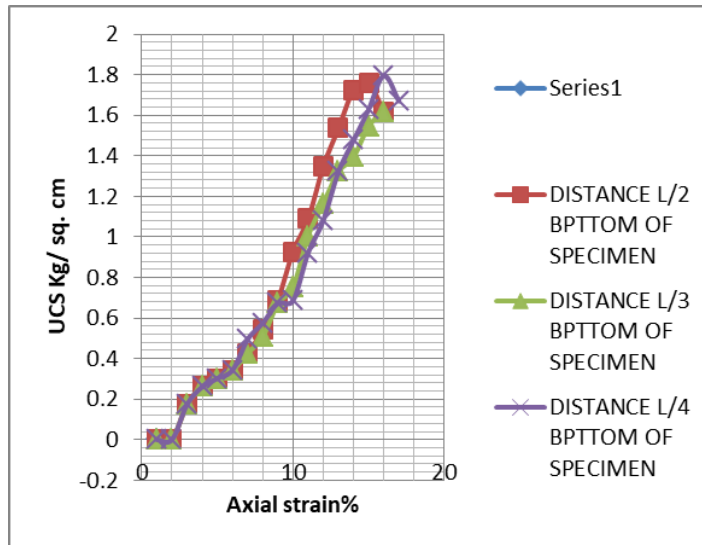


Fig 4.6 Comparison graph of geocell insert at different depth

4.6.15 Comparison of UCS between stress and Different height of Geo-cell.

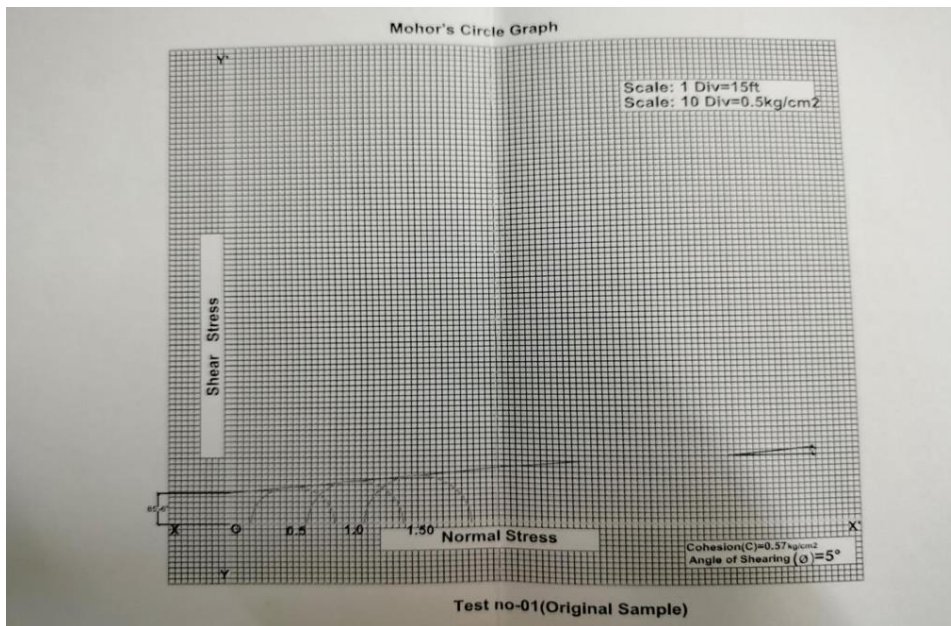
- The peak value of stress was obtained from the stress-strain curve which is called as unconfined compressive strength.
- The UCS test GEO-CELL insert at different place different trial at h/2, h/3, h/4 distance of soil specimen, but more strength can be achieved by insert of L/2 distance of the total sample height.

3.9 TRIAXIAL TEST

4.9.1 Triaxial test for original soil sample

The Triaxial test of original soil sample are tested below the graph

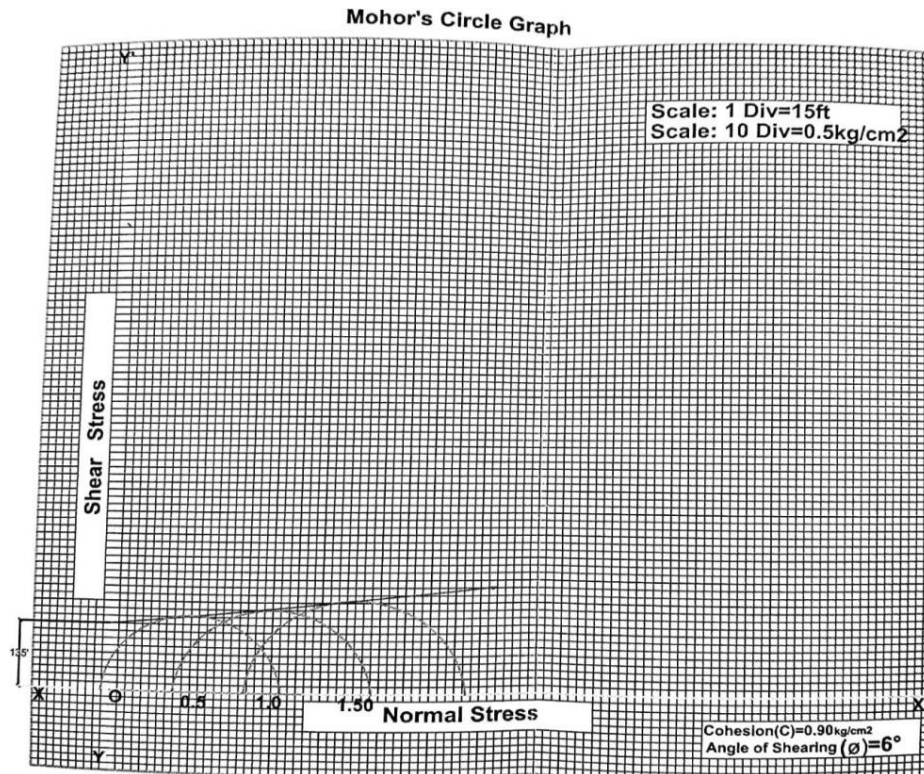
Fig 4.7 Triaxial test Original soil sample



Angle of shearing = 5° Cohesion (C) = $.57\text{kg/cm}^2$

4.9.2 Triaxial test for insert geocell at L/2 distance of geocell

Fig 4.8 Triaxial test Original soil sample + Geocell



Angle of shearing= 0.9 kg/cm²
Cohession (C) =0 .90kg/cm²

In this Triaxial test, after adding the geocell block at L/2 distance of soil sample.

CHAPTER -5

5. CONCLUSION AND FUTURE SCOPE

5.1 CONCLUSION

In this present study an effort has been taken to enlighten the use of Geocell as a reinforcing material and physical properties with original clay soil. Based on the experimental observation in current study following conclusions can be made.

- I. The induced apparent excessive strength depends on the position of the geocells from the top of the sample. It is observed that when the geocells are placed at half of the diameter /width of the loading area, maximum benefit in strength is achieved.
- II. Geocell reinforced soil does not show any failure stress under unconfined condition.
- III. There is a degradation of strength of soil after some loading cycles, however, the degradation is marginally less once geo-cells are inserted into the soil.
- IV. Lesser damping ratio and higher secant shear modulus are obtained if the soil is reinforced with Geo-cell.
- V. The secant shear modulus shows a maximum increase in its value under confined condition when geo-cells are placed at one-fourth of the sample diameter.

CHAPTER -6

6. REFERENCES

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