Chapter-1

Introduction

Now these days soil plays very important and effective role in the life of civil engineer. The structure of all types i.e. buildings/bridges/highways etc. rest directly on the soil beneath them. The safety of these structures mainly depends upon the strength/ ultimate bearing capacity of the soil over which these are constructed. So for this a proper analysis of the soil properties and the design of their foundations become necessary to ensure that these structures remain stable and are safe against collapse or unequal settlements. In most of the cases the soil exploration reveals that the soil beneath the ground surface is anisotropic in nature. The foundation is very important part of any structure, which transfers the load from the super structure to the sub soil. All the theories which are developed for the estimation of ultimate load bearing capacity of shallow foundation. Assume that the soil is homogeneous, isotropic and semi infinite. However it is very difficult to get the site of construction with these assumptions. In practice soil is anisotropic in nature. Mostly it is quite possible to get the layered soils with different shear strength parameters and other geotechnical properties. In order to study the behavior of layered soils and thereby to estimate the bearing capacity. It is possible to perform the plate load test and to draw the load settlement curve of the soil foundation system for the proper dimension of the footing. The only problem which comes across is the scale effect. Many researchers have reported that the ultimate bearing capacity is governed by settlement criteria rather than the shear criteria.

Sometimes it is possible to get construction sites having the low bearing capacity beneath the foundation. Therefore such soils should be reinforced with geosynthetics to increase the bearing capacity. Now a days new technique is in practice is that to remove the existing weak soil to a shallow depth and either replace with the superior quality soil and same soil may be compacted at high density after placing geosynthetics in horizontal layer at the interface of the soil layer. The reinforcement can be made in multiple layers. In the present investigation a modeled plate load test with circular plate and without reinforced with geogrid. The bottom layer is coarse sand and upper layer is silty sand with various thickness in multiple diameter of plate. On the basis of the result obtained from the modeled plate load test the following problems may be analyzed:

- To study the behavior of load-settlement curve.
- To observe the effect of plate size on ultimate bearing capacity and settlement.
- To observe the effect of thickness of top layer soil. (silty sand)
- To observe the effect of reinforcing the layered soil at their interface on the bearing capacity and settlement.

Keeping the problem of anisotropy of the soil in mind following objectives may be made to carry out the project.

1.1 OBJECTIVES OF THE PROJECT:

The objectives of the present study are as follow:

- To determine geotechnical properties of coarse grained sand and silty sand.
- To manufacture the wooden box of size 1.5mX1.5m X1.0m (Length X Width X Depth).
- To perform the plate load test on coarse grained sand and silty sand alone.
- To perform the plate load test on layered soil as per detail given below:

Layer	**Types of soil in the layer**
Upper Layer	Silty sand
Lower Layer	Coarse sand

- To perform the plate load test on layered soils with geogrid at interface.
- The detail of model tests are as follows:

Name of parameter	**Variation**
No. of layer of reinforcement	One at the interface of soils
Thickness of top layer of soil (Z in mm)	D and 2D
Thickness of bottom layer(in mm)	900-Z

- Interpretation of the load settlement curves.
- Estimations of ultimate bearing capacity as per codal recommendation.
- Discussion of the results and conclusions.

  In order to achieve the objectives of the present study literature has been reviewed in the next chapter.

Chapter 2

Literature Review

In the present chapter literature has been reviewed with respect to plate load test carried out on various types of soils for the estimation of ultimate bearing capacity. The focus is mainly on the ultimate bearing capacity of the layered soil.

2.0 Literature Review

Many researchers have proposed various methods for the behavior of footings on reinforced soil that is homogeneous with low bearing capacity i.e. weak soil and various methods have been described for the ultimate load bearing capacity. The load bearing capacity of strip footing that is in two layered soils i.e. cohesive friction soil is taken while test performed for the determination of ultimate bearing capacity of such soils has been proposed by **Purushothamaraj P, Ramiah BK, Rao KNV (1973).**

Som and Sahu (1997) studied the effect of reinforced sand bed by using nonwoven and woven type of geo-textile at the compacted bed interface He concluded that there is no improvement in load bearing capacity with the geo-textile. He concluded that the rate of the rate of deformation for unreinforced bed is greater than the reinforced bed.

Consoli, et al. (1998) He describe a method of interpretation and comparison of measured load test with the numerical analysis and derived curves for shallow foundations on cemented soils beds. He used to determine the effects of footing shape and size on the settlement and the ultimate bearing capacity of vertically loaded shallow foundations which are resting on the uniform layers of cemented residual soil with basalt. He also describe a comparison between the load settlement behaviors by performing plate load tests on circular steel plates and square concrete footing. It is observed that the effect of size of the area which is loaded is used for measuring the settlement and ultimate bearing capacity of soil that was shown totally neglible.

Alawaji (2001) He has been determined the advantages of geogrid reinforced sand over collapsible soil for controlling the wet collapsible settlement by performing the plate load tests using a circular steel plate and geogrid. The parameters i.e. breadth and depth of the geogrid that may be varies. He has been concluded that there is increment in the load bearing capacity and decrement in the settlement of sand bed that is over the weak and collapsible soil.

Chakrabarti, et al. (2002) He conducting the test by adding natural jute textile. The biodegradable jute was placed on the soft bed of soil which is consolidated. It shows that the load bearing capacity of soil by adding biodegraded jute textile is improved. So there is reduction in the pavement thickness by improving the load bearing capacity of the soil.

Shukla (2002) He used bamboo sheets to improve the strength of soil. Unconfined compression tests are performed on the unreinforced and reinforced soil. The soil sample were prepared at maximum dry density corresponding to the optimum moisture content. On the basis of that the reading taken, it was concluded that the bearing capacity of the soil increases with increase in the number of reinforcing bamboo sheets which are placed in horizontal position. The ultimate bearing capacity of soil decreases if the reinforced bamboo sheets are taken in inclined plane, i.e.at an angle of 30º to 45º with the horizontal plane.

Teodoru and Toma (2009) They conducted plate load test on the soil to know the size effect on settlements. They also used the tests for the determination the values of geotechnical properties of soil that is used. It is concluded that the value of sub-grade reaction co-efficient is mainly dependent on the following parameters i.e. size area and load is applied.

Mohite and Admane (2015) He has been proposed that the test which is similar to the plate load test and the observed value compare with the results that are obtained. The Standard Penetration test also conduct and the results which are obtained. These values are compared with field results. He concluded that the results of field tests and model test in laboratory were comparable.The large model spread footings load tests on geosynthetics reinforced soil foundation has been proposed by **Adams MT, Collin JG (1997).**

Stability of loaded footings on reinforced and unreinforced soil has been analysed by **Akinmusuru JO, Akinbolade JA (1981)**.

The determination of bearing capacity by plate load test on reinforced earth slabs is carried by **Binquet J, Lee KL(1975a).**

The ultimate bearing capacity of footings by layered soils in which subsoil is cohesive has been proposed by **Button SJ (1993).**

The determination ultimate bearing capacity of two nearly or very closely spaced foundation(shallow foundation) on coarse grained sand is described by **Das BM , Larbi-Cherif S (1983).** He has been described that the bearing capacity in very closely spaced shallow foundation can be determined by adopting and using various bearing capacity equation by performing various load tests.

The determination of ultimate bearing capacity of geosynthetic reinforced soil in which geosynthetic is used to make weak soil as stronger or more load bearing by using variational methods in which layers are laid over each other in different thickness for the determination of bearing capacity by **Dixit RK, Mandal JN (1993).**

By using plate load test the determination of ultimate bearing capacity in two layered soil in which upper layer is weak and lower layer is strong has been described by **Hanna AM, Meyerhof GG (1982).**

The determination of ultimate bearing capacity in layered soils in which soil is laid in three different types by conducting plate load test with special references to the layered soils has been proposed by **Hanna AM, Meyerhof GG (1979).**

The design chart of the ultimate bearing capacity determined by plate load test for the determination of footing sand that is laid over soft clay has been described by **Hanna AM, Meyerhof GG (1980).**

By conducting plate load test the determination of bearing capacity of foundation in which layered soils is used that are sand and clay which are placed as that clay is overlain sand and at the interface geogrid is provided to determine the load resisting capacity that has been proposed by **Khing KH, Das BM, Puri YK, Yen SC, Cook EE (1993).**

The behavior of pressure settlement characteristics in shape of rectangular footing on reinforced soil that the behavior of pressure settlement has been determined in reinforced and unreinforced soil has been checked and give its description of its whole behavior has been proposed by **Kumar A, Walia BS, Saran S (2005).**

The determination of ultimate bearing capacity of foundation on layered soils in which load is applied on layered soils in inclined position and comparison of load applied in at right angle or direct load is applied has been proposed by **Hanna AM, Meyerhoff GG (1980).**

Analysis of reinforced and unreinforced soil layer and determination of their load bearing capacity by plate load and also analyzed the load settlement behavior has been proposed by **Murthy BRS, Sridharan A, Singh HR(1993)**.

On the basis of literature review on plate load test on layered soil with and without reinforced with geosynthetics and to fulfill the objectives of the project the detailed experimental study has been carried out in the succeeding chapters.

Chapter 3

Materials and Methods

In order to fulfill the objectives of the present project on plate load test on geogrid reinforced layered soils the materials and methodology are explained in the following paragraphs.

3.1 Materials used for the investigation

In the present study coarse gained sand and silty clay is used.

Sand: Sand is a naturally occurring material that is composed of finely grouped rock and minerals particles. Sand may also be defined as the soil which may pass through 4.75mm sieve and retained on 75micron sieve is called sand.

Silty sand: Silt is a granular material which size may be between the sand and clay i.e. the soil which may pass through 75micron sieve and coarser than 2micron size is known as silt. In the present work silt is taken as finer materials.

Geogrid:It is a polymer having a net like structure with large openings. Normally these are made of high densities polythene and polypropylene etc.

Water: Normally tap water is used which is available in laboratory.

Tank:In order to evaluate the load settlement behavior, model load tests were conducted in a Rectangular tank having internal sizes as 1.5 mX1.5m X1.0m consisting of mild steel plates having thickness 25.5 mm.

3.2 METHODOLOGY FOR THE INVESTIGATION:

In the present project, after finding out the index properties of the soil, following tests have been performed on the soil.

- Direct Shear Test.
- Proctor Compaction Test.
- Plate load test

3.3 TESTING PERFORM

3.3.1 Grain Size Analysis: The particle size distribution curve gives us detail of the various contents in soils are as silty sand and coarse sand from the soil sample which is taken for the particle analysis. Firstly the soil sample which is taken for analysis is allowed to pass through the IS. sieve size of 75 micron. The proportion of the given sample of the soil which pass through the sieve is used for the hydrometer analysis and the remaining sample which retained on sieve is used for sieve analysis.

Sieve Analysis

There are various ways by which the sieve analysis is performed are as:

1. Firstly the proportion of the soil sample that was retained on 75 micron IS sieve is used for the analysis as per IS-2720.
2. Then the sieve of standard size was select and these are arranged in the prescribed order for sieving the sample.
3. Then the sample was separated in to various fraction by the sieving through the sieves that are placed in prescribed order.
4. The weight of the soil was recorded which was retained in every sieve.
5. Then the plot between sieve size and the percentage finer is drawn on the semi Log graph paper with sieve size of Log axis.
6. After this the coefficient of curvature and coefficient of uniformity is determines from the value of $D_{10,}$ $D_{30,}$ D_{60} which was record from the plot.

3.3.2SPECIFIC GRAVITY(G)

Specific gravity of soil solids may be defined as the it is the ratio of weight ,in air of a given volume of dry soil solids to the weight of equal volume of the water is defined as per **IS-2720-Part-3-1980**. Generally specific gravity is used for the determination of the various properties of the soils i.e. Void Ratio, Porosity, Degree of Saturation, by knowing the water content and density. The value of specific gravity also helps us to differentiate the soil types. Following steps are followed for the determination of the specific gravity.

1. Firstly weight the empty clean and dry density bottle and record it as W_1.
2. About 150-200 grams of soil sample was placed in the pycnometer.
3. Then weight of the density bottle with given soil sample was recorded as W_2.
4. Then the density bottle was filled with water about 3/4 of the density bottle.
5. After that the sample was soaked for about 10 minutes and the mixture was stirred with a glass rod thoroughly for the removal of entrapped air.
6. Then the density bottle was filled with water up to the mark that is indicated on the density bottle and the outer surface of the pycnometer was cleaned properly with a clean and dry cloth. Then weight is as $W_{3.}$
7. The density bottle emptied and filled it clean water and weight it as W_4.
8. Calculation for the determination of the value of specific gravity was done by the following formula.
   $G=W_2 – W_1 / (W_2 – W_1) – (W_3 – W_4)$

3.3.3 LIQUID LIMIT

The liquid limit of soils may be determined with the help of the standard liquid limit apparatus which is defined as per **IS-2720-PART-5-(1985).** In the determination of liquid limit of the soil about 120g of the soil which may pass through 425µ sieve is taken and a groove is made in the prepared sample with the help of the groove tool. One brass cup raised and allowed to fall on the rubber base and the water content corresponding to 25 blows was taken as the liquid limit. There are various steps by which we can determine liquid limit are as;

1. The air dried soil sample which passed through the 425mm IS sieve which is thoroughly mixed.
2. A uniform paste is prepared by adding water in suitable proportion in evaporating dish.
3. Then prepared paste was placed in apparatus in which a cup is attached with it and the thickness of the sample was about 1cm.
4. Then with the help of grooving tool make a groove in the paste along the symmetrical axis of cup and holding the cup perpendicular.
5. Then give rotation at the rate of 2 revolution per second and rotate the handle till the both portion comes in contact with each other and record the no of blows.
6. Then a representative sample of the soil taken for the determination of the water content.
7. Again repeat the test with different moisture content at least 3 times and record the number of blows.

3.3.4 PLASTIC LIMIT

This test is perform for the determination of plastic limit of soil as per **IS- 2720-Part-5-1985**. The plastic limit of the soil is that in which soil is the water content below which soil ceases to be plastic. In the test soils starts crumbling when it is rolled in to 3mm diameter. The detailed procedure for the determination of Plastic limit is as;

1. The soil sample which is air dried and passed through the 425mm IS sieve which is thoroughly mixed.
2. A uniform plastic paste is prepared by adding water in suitable proportion that paste can be rolled in the form of ball with hand.
3. Then take soil sample and rolled it in form of ball and rolled it with the palm on glass plate and formed it in the shape of thread of about 3mm.
4. Again re rolled the thread in the form of ball.
5. Then the same processes repeats and collect the crumbled pieces of thread and keep them for the determination of moisture content.
6. The test repeated at least three times and record the average value of test performed.

Plasticity Index= Liquid limit – Plastic limit.

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3.3.5 PROCTOR COMPACTION TEST

Proctor compaction test is performed in laboratory for determine the relationship between the water content and the dry density of the soil at a specified comp active effect define as per **IS-2720-Part-7-1980.** The detailed procedure to determine Proctor compaction test is as below:

1) Soil is compacted in three layers at its optimum moisture content.
2) 25 blows are given after each layer to achieve the proper compaction.
3) Soil is weighted and divides its volume to determine the maximum dry density.

3.3.6 DIRECT SHEAR TEST

1. Direct shear test is performed for the determination of the shear strength parameter(c & ϕ).
2. A standard size 60mmx60mm Direct shear box was used for performing the test.
3. The test were conducted on three normal stresses i.e. 50, 100, 150KPa and the angle of internal friction (ϕ) and cohesion(c) values are obtained by plotting a straight line from the graph of shear stress v/s normal stresses.
4. This test performed as the direction given in **IS-2720:Part-13-1986.**

3.3.7 PLATE LOAD TEST

The plate load test consists of the plates and the hydraulic jack. The size of the tank is selected keeping in view the sizes of the test plates such that the size of the test tank should be at least five times the size of the largest test plate. The sizes of plate are 100mm, 150mm, 200mm of model test footing have been used. The size of the smallest plate is so selected such that it should be larger than four times the size of the largest soil particle. The load is applied through a manually operated hydraulic jack of 50KN capacity supported against a load reaction truss. The applied load was recorded using a pressure gauge mounted on the hydraulic jack. The settlement of the model test footing was observed using dial gauges mounted against the reference beams. The soils were filled in the tank in layers at the maximum dry density respectively by compacting with the help of rammer. The density of soils were verified by placing core cutter at different location in the tank and checked for the required density.

Figure 1: Set up of plate load test.

Chapter 4

Results & Discussion

4.1 Physical and Engineering Properties of Soil used in Plate Load Test.

Physical and Engineering properties of soil used for Plate Load Test were observed and calculated from the tests performed as per **IS-2720**

4.1.1 Gradation Analysis:

Sieve analysis of soil is performed for the determination of the type of soils. By performing sieve analysis it is observed that the soil is coarse sand and silty sand.

Table4.1: Grain size analysis soil sample.

	Wt. retained(gm)		% Retained(gm)		% Cum. Retained		%Passing	
Sieve size(mm)	Coarse sand	Silty sand	Coarse sand	Silty sand	Coarse sand	Silty sand	Coarse sand	Silty sand
4.75	53	40	5.3	4.0	5.3	4.0	94.7	96.0
2.36	461	26	46.1	2.6	51.4	6.6	48.6	93.4
1.18	381	94	38.1	9.4	89.5	16.0	15.8	84.0
.60	51	264	5.1	26.4	94.6	42.4	5.4	57.6
.30	19	215	1.9	21.5	96.5	63.9	3.5	36.1
.15	21	204	2.1	20.4	98.6	84.3	1.4	15.7
.075	10	210	1.0	21.0	99.6	95.3	0.4	4.7
Pan	4	47	0.4	4.7	100	100		
∑	1000	1000						

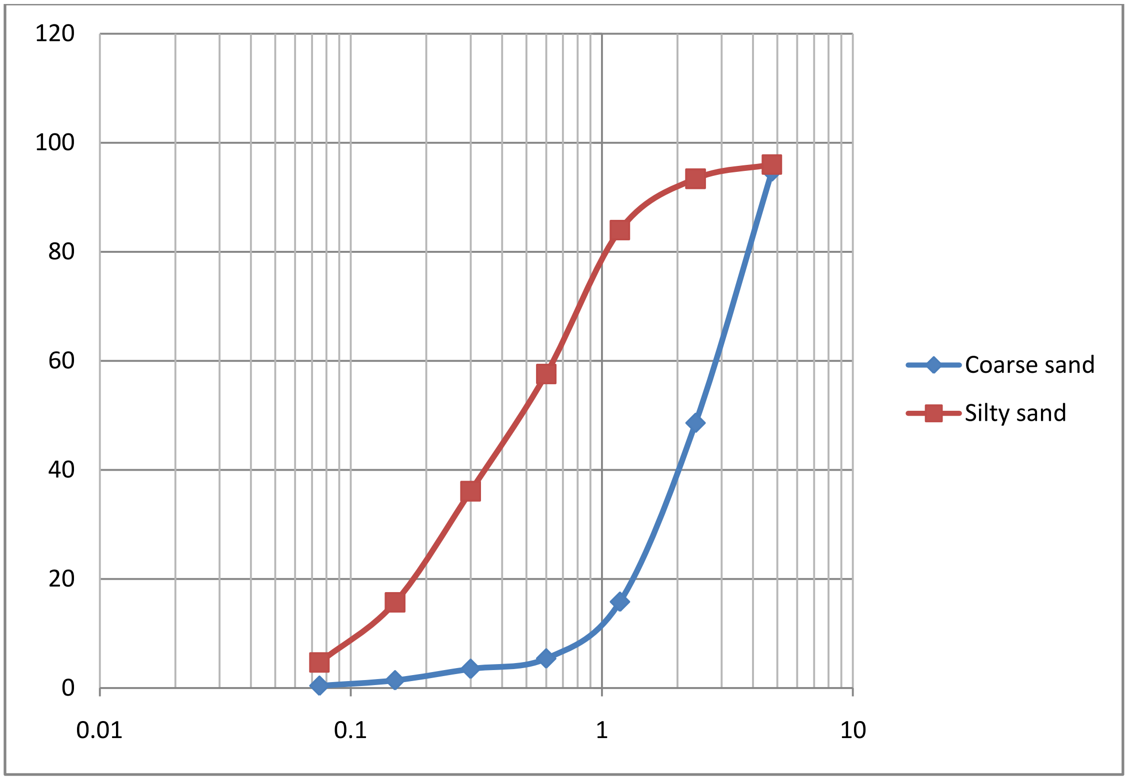

Fig.4.1 Classification of soils by sieve analysis.

Table 4.2 Grain Size Analysis Classification.

Results	Silty sand	Coarse sand
D_{10}	0.08	0.8
D_{30}	0.25	1.5
D_{60}	0.65	2.5
$C_u = D_{60}/D_{10}$	8.12	3.12
$C_c = D_{30}^2/D_{60} \times D_{10}$	1.20	0.031
Classification	SM	SP

4.1.2 Consistency Limits:

For the determination of consistency limits of soils tests were performed and following results are obtained for consistency limit i.e. Liquid Limit, Plastic Limit and Plasticity Index.

Table4.3 Consistency Limit of Soils.

Sr.No.	Sample Description	Liquid Limit(%)	Plastic Limit(%)	Plasticity Index(%)
1	Coarse Sand	NP	NP	**NP**
2	Silty Sand	28.2	23.5	4.7

4.1.3 PROCTOR COMPACTION TEST: This test is generally performed for determination the relationship between the water content and dry density of soil.

Table 4.4 Relationship between dry density and water content.

Silty sand		Coarse sand	
Water content (%)	Dry density (γ_d)(kN/m^3)	Water content (%)	Dry density (γ_d) (kN/m^3)
9.6	12.8	6.1	10.1
11.5	14.6	7.3	9.6
13.8	16.9	8.7	12.2
15.3	15.2	10.4	16.9
16.6	12.0	11.5	19.8
17.8	10.2	12.4	18.7
19.2	9.1	14.1	15.4

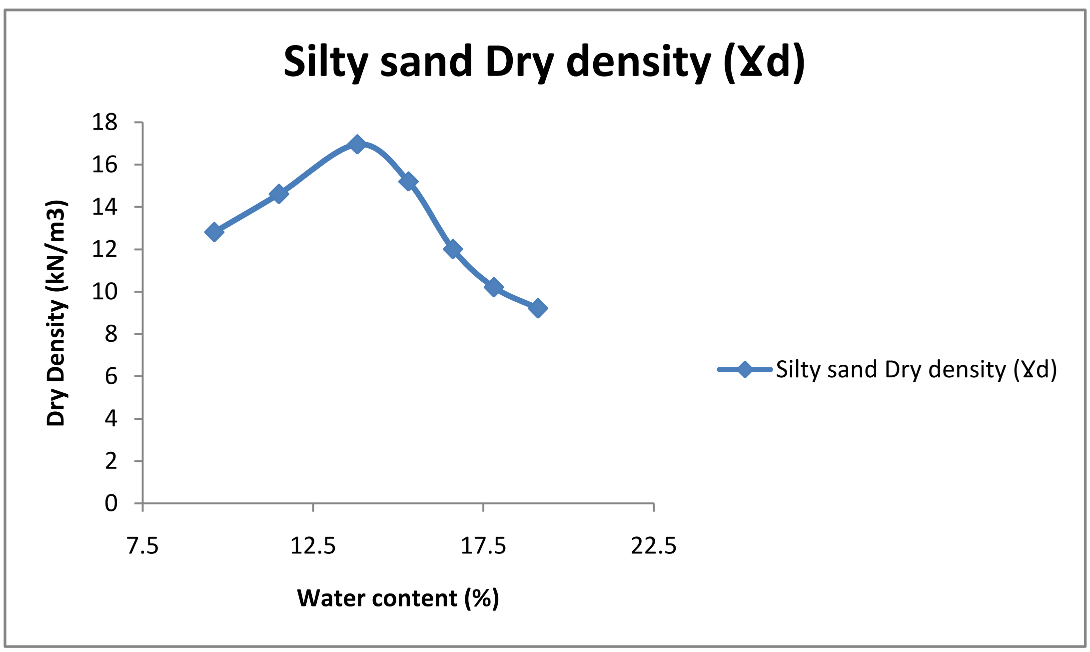

Fig.4.2 Dry density v/s water content for silty sand.

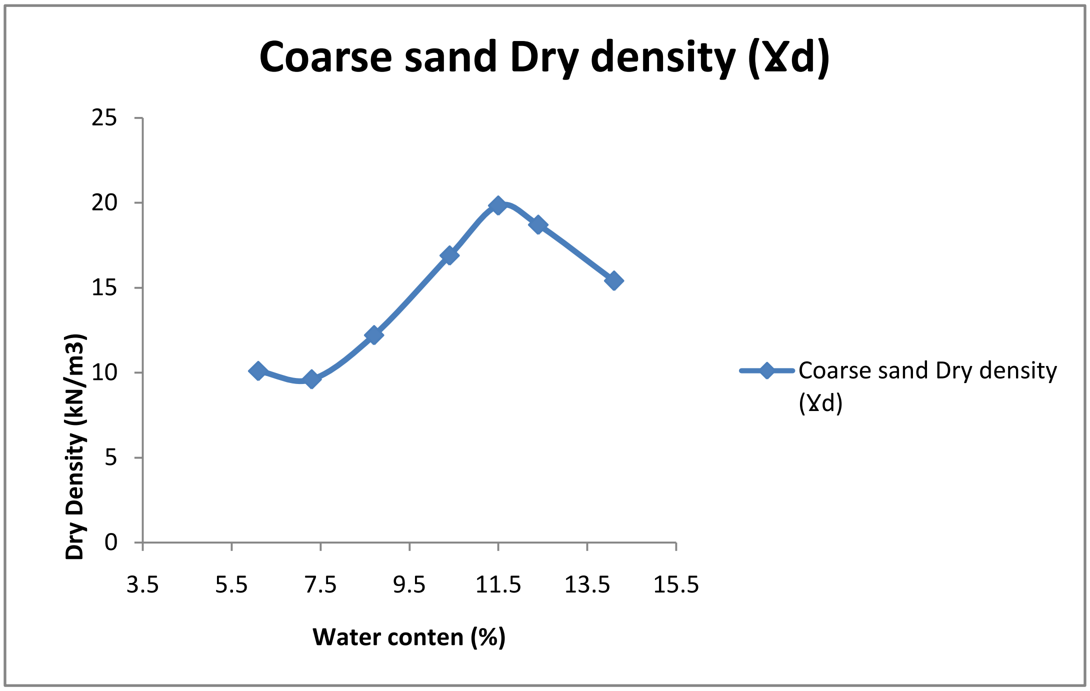

Fig.4.3 Dry density v/s water content for coarse sand.

<u>4.1.4 Shear characteristics of silt sand and coarse sand</u> :

Direct shear test was performed for the determination of cohesion and angle of internal friction on various loading condition. Which are as follows:

Table.4.5 shear stress with displacement readings for coarse sand.

H. displacement(mm)	$50KN/m^2$	$100KN/m^2$	$150KN/m^2$
0	0	0	0
0.2	19	50	66
0.4	45	110	110
0.6	65	139	158
0.8	88	169	190
1.0	100	188	213
1.2	116	201	234
1.4	124	210	250
1.6	136	226	267
1.8	143	235	281
2.0	151	246	297
2.2	158	257	311
2.4	163	261	325
3.0	178	286	358
3.2	181	292	364
3.6	186	301	375
4.0	189	308	384

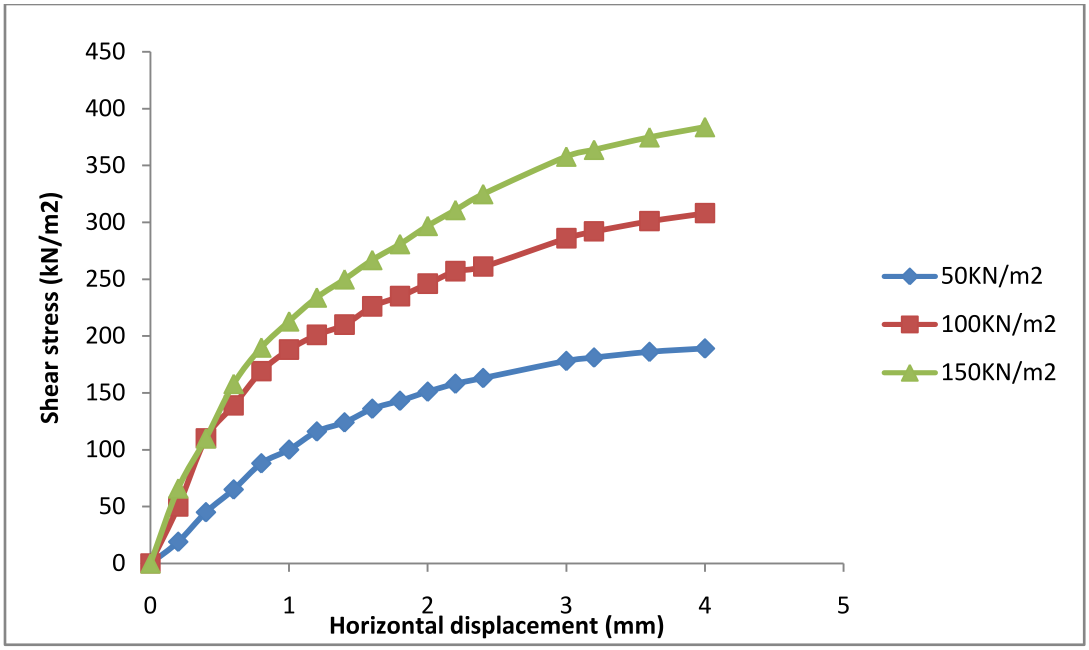

Fig.4.4 Shear stress with Displacement plot of coarse sand.

Table.4.6 shear stress with displacement readings for silty sand.

H. displacement(mm)	50KN/m^2	100KN/m^2	150KN/m^2
0	0	0	0
0.2	16	43	48
0.4	37	66	95
0.6	56	85	124
0.8	70	97	145
1.0	85	112	171
1.2	9	124	185
1.4	112	138	202
1.6	121	156	215
1.8	129	165	224
2.0	131	179	235
2.2	135	192	249
2.6	142	212	267
2.8	143	223	277
3.0	143	229	286
3.2		235	294
3.4		241	301
3.6		246	309
4.0		274	310

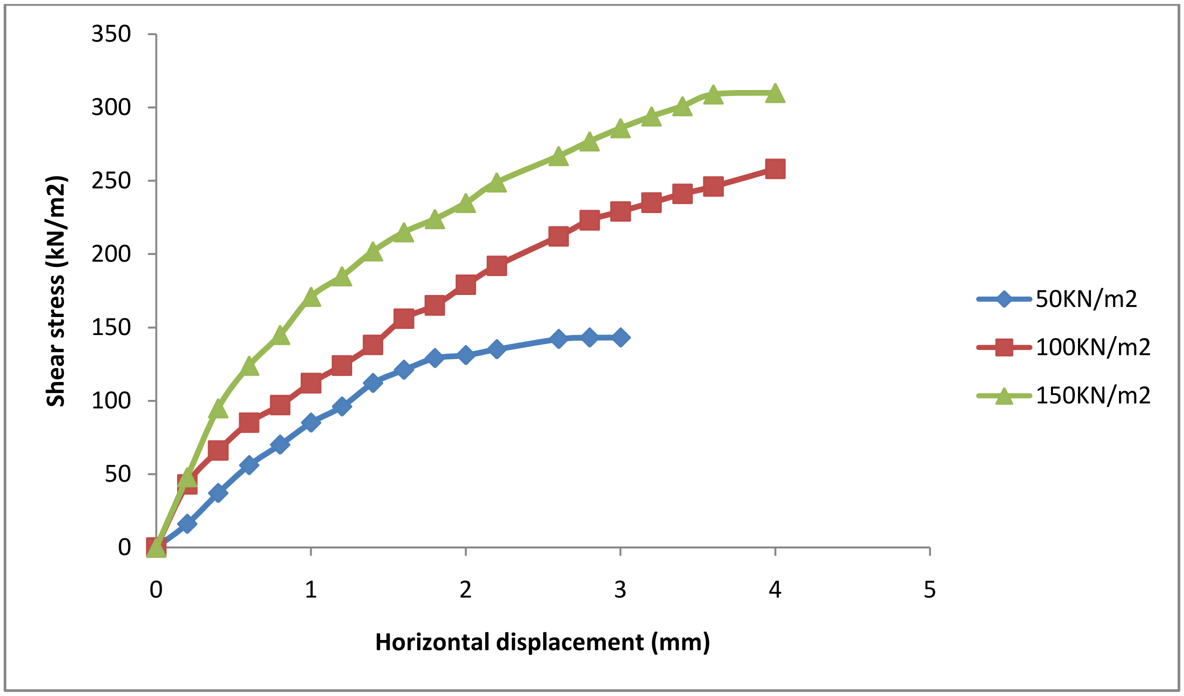

Fig.4.5 Shear stress with Displacement readings of silt sand.

Table 4.7 Properties of soils.

Properties	Silty sand	Coarse sand
Specific gravity	2.63	2.69
Liquid limit (%)	28.2	-
Plastic limit (%)	23.5	-
Plasticity index(%)	4.7	-
Maximum dry density(KN/m^3)	16.95	19.83
Optimum moisture content (%)	13.8	11.5
Cohesion (KN/m^2)	12.5	0
Angle of internal friction	24º	38º
Classification	SM	SP

4.1.5 Load settlement behavior of soil used in Plate Load Test.

Table 8. Load-Settlement of silty sand 100mm plate diameter.

Load (Kg)	Settlement(mm)
0	0
50	5
100	8
150	16
200	25
250	34
300	40
350	49

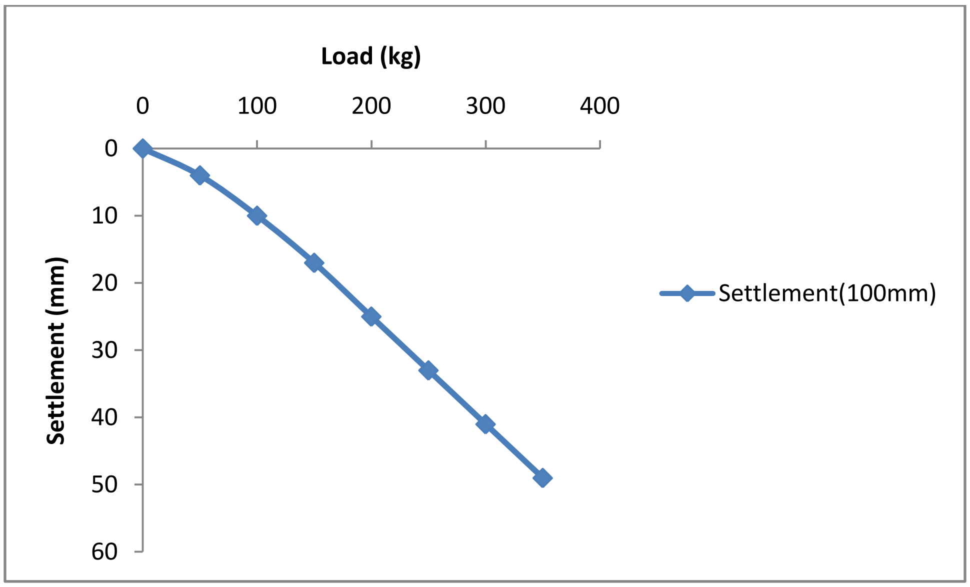

Fig.6 Load-Settlement of silty sand 100mm plate diameter.

Table 9. Load-Settlement of silty sand 150mm plate diameter

Load (Kg)	Settlement(mm)
0	0
50	2
100	5
150	7
200	9
250	11
300	13
350	16
400	19
600	27
800	43

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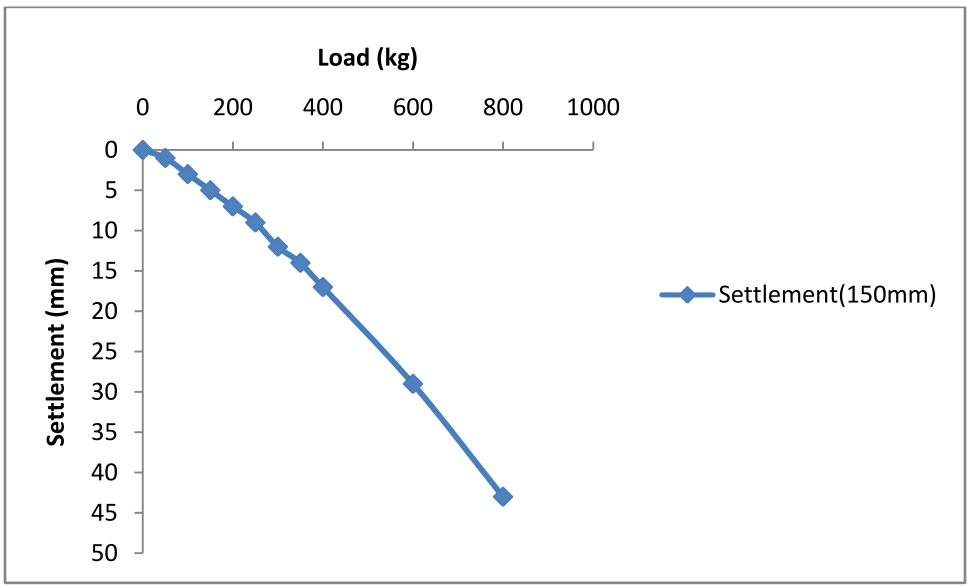

Fig.7 Load-Settlement of silty sand 150mm plate diameter.

Table 10. Load-Settlement of silty sand 200mm plate diameter.

Load (Kg)	Settlement(mm)
0	0
200	3
300	6
400	8
600	13
800	18
1000	23
1200	31
1400	40

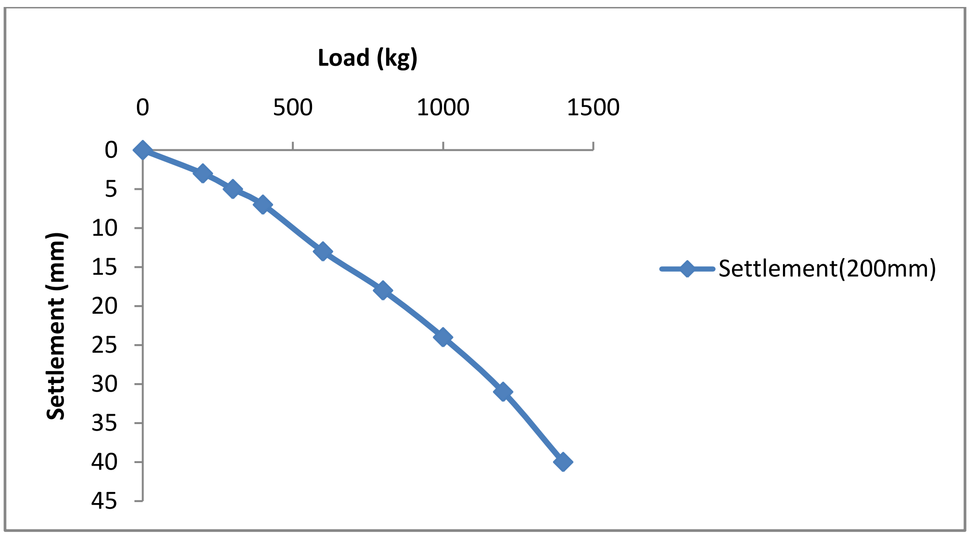

Fig.8 Load-Settlement of silty sand 200mm plate diameter.

Table 11. Load-Settlement of coarse sand 100mm plate diameter.

Load (Kg)	Settlement(mm)
0	0
50	3
100	6
150	10
200	13
250	25
300	30
350	34
400	41

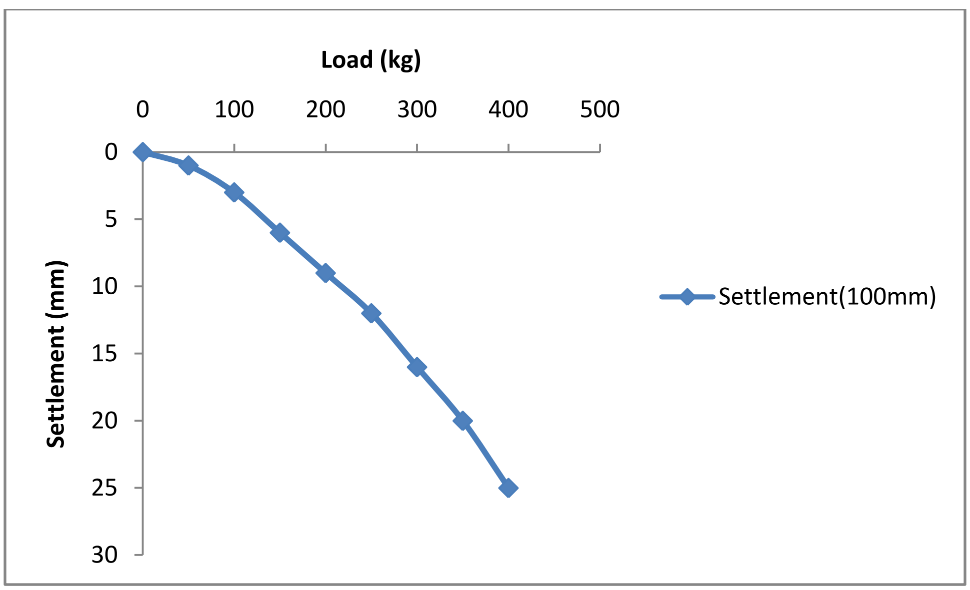

Fig.9 Load-Settlement of sand 100mm plate diameter.

Table 12. Load-Settlement of coarse sand 150mm plate diameter.

Load (Kg)	Settlement(mm)
0	0
100	3
200	6
300	8
400	11
600	18
800	25
1000	33
1200	42
1400	53
1600	66

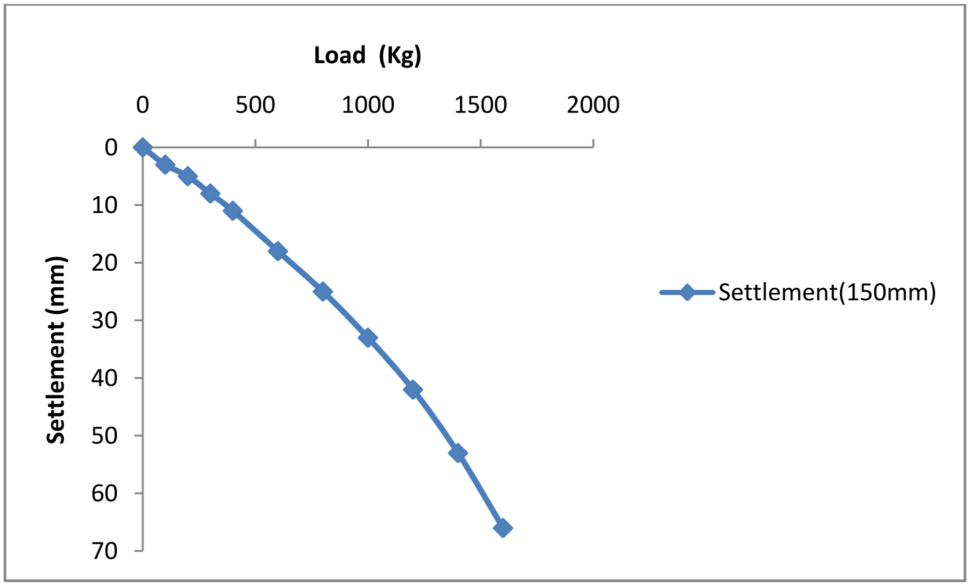

Fig.10 Load-Settlement of sand 150mm plate diameter.

Table 13. Load-Settlement of coarse sand 200mm plate diameter.

Load (Kg)	Settlement(mm)
0	0
200	1
400	5
600	8
800	10
1000	13
1200	16
1400	19
1600	23
1800	29
2000	37

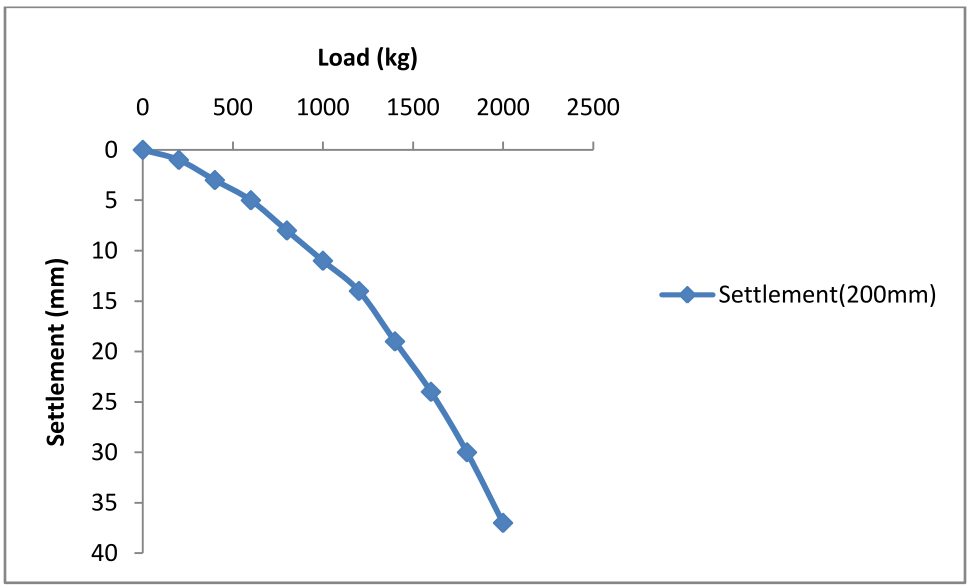

Fig.11 Load-Settlement of sand 200mm plate diameter.

Table 14. Load-Settlement of layered soil in which upper layer is silt sand 0n 100mm plate diameter without reinforced. [Z=D]

Load (Kg)	Settlement(mm)
0	0
50	4
100	10
150	16
200	21
250	25
300	28
350	34
400	37

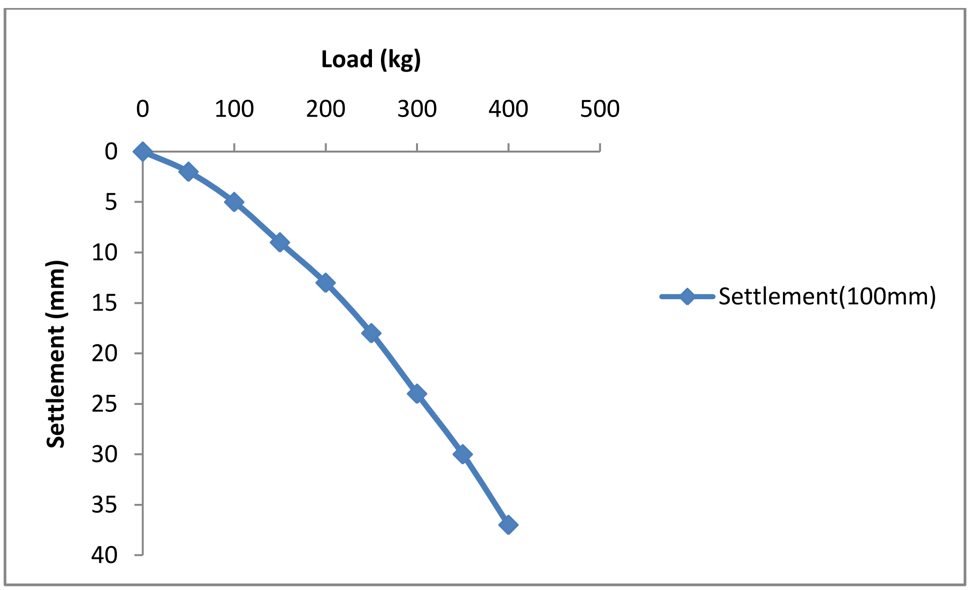

Fig.12 Load-Settlement of layered soil in which upper layer is silt sand 0n 100mm plate diameter without reinforced.[Z=D]

Table 15. Load-Settlement of layered soil in which upper layer is silt sand 0n 150mm plate diameter without reinforced. [Z=D]

Load (Kg)	Settlement(mm)
0	0
100	5
200	8
250	10
300	13
350	15
400	18
600	25
800	36
1000	49

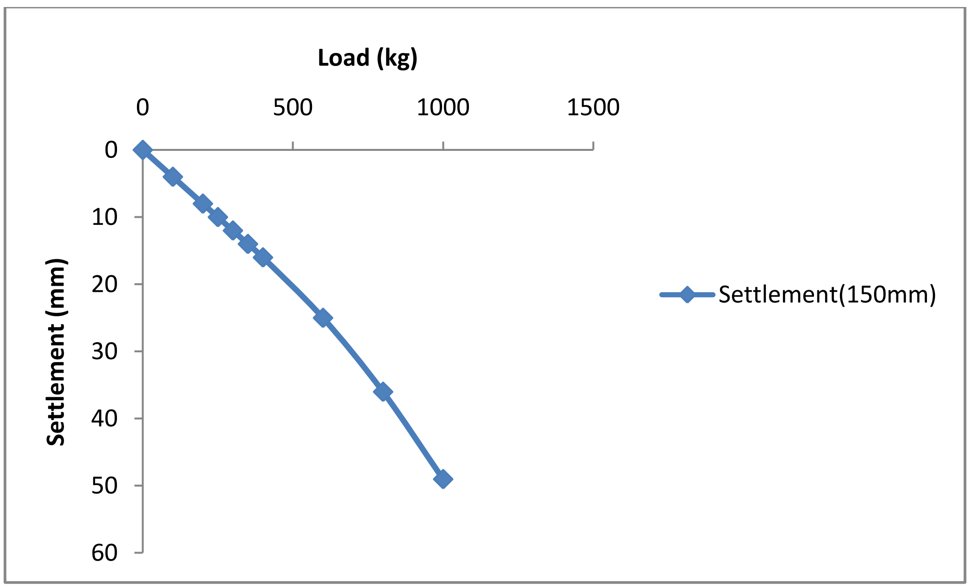

Fig.13 Load-Settlement of layered soil in which upper layer is silt sand 0n 150mm plate diameter without reinforced.[Z=D]

Table 16. Load-Settlement of layered soil in which upper layer is silt sand 0n 200mm plate diameter without reinforced.[Z=D]

Load (Kg)	Settlement(mm)
0	0
200	1
400	7
600	11
800	15
1000	19
1200	23
1400	28

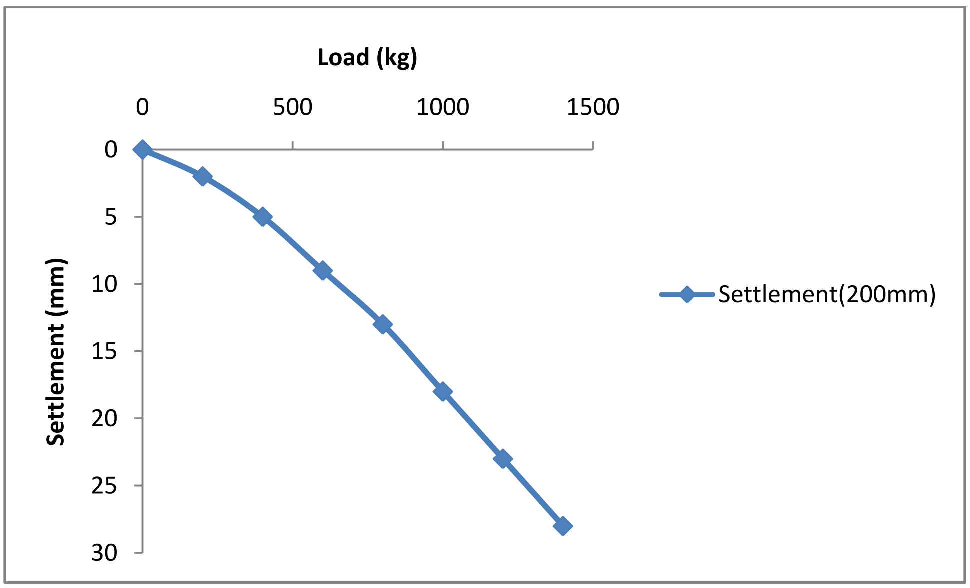

Fig 14. Load-Settlement of layered soil in which upper layer is silt sand 0n 200mm plate diameter without reinforced.[Z=D]

Table 17. Load-Settlement of layered soil in which upper layer is silt sand 0n 100mm plate diameter with reinforced.[Z=D]

Load (Kg)	Settlement(mm)
0	0
50	5
100	9
150	12
200	18
250	21
300	25
350	28
400	31
600	55

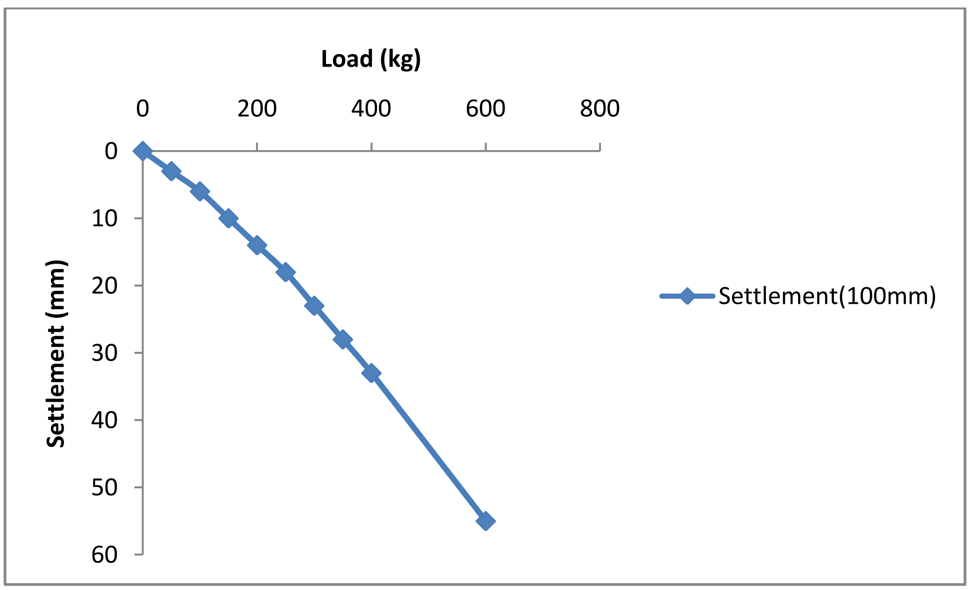

Fig 15. Load-Settlement of layered soil in which upper layer is silt sand 0n 100mm plate diameter with reinforced.[Z=D]

Table 18. Load-Settlement of layered soil in which upper layer is silt sand 0n 150mm plate diameter with reinforced.[Z=D]

Load (Kg)	Settlement(mm)
0	0
100	4
200	7
300	10
400	14
600	20
800	27
1000	34
1200	44
1400	53

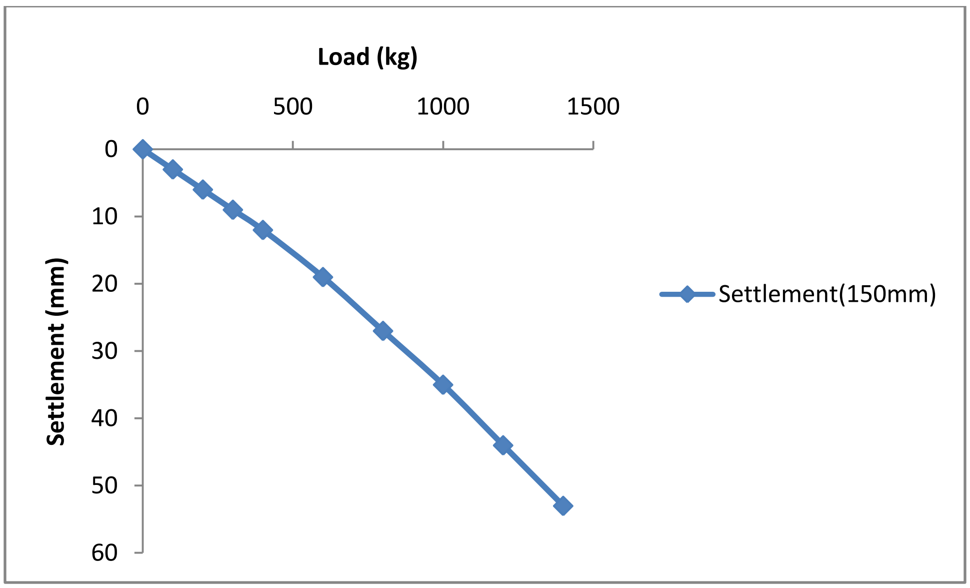

Fig.16 Load-Settlement of layered soil in which upper layer is silt sand 0n 150mm plate diameter with reinforced.[Z=D]

Table 19. Load-Settlement of layered soil in which upper layer is silt sand 0n 200mm plate diameter with reinforced.[Z=D]

Load (Kg)	Settlement(mm)
0	0
200	2
400	5
600	8
800	10
1000	12
1200	15
1400	19
1600	22
1800	27
2000	32

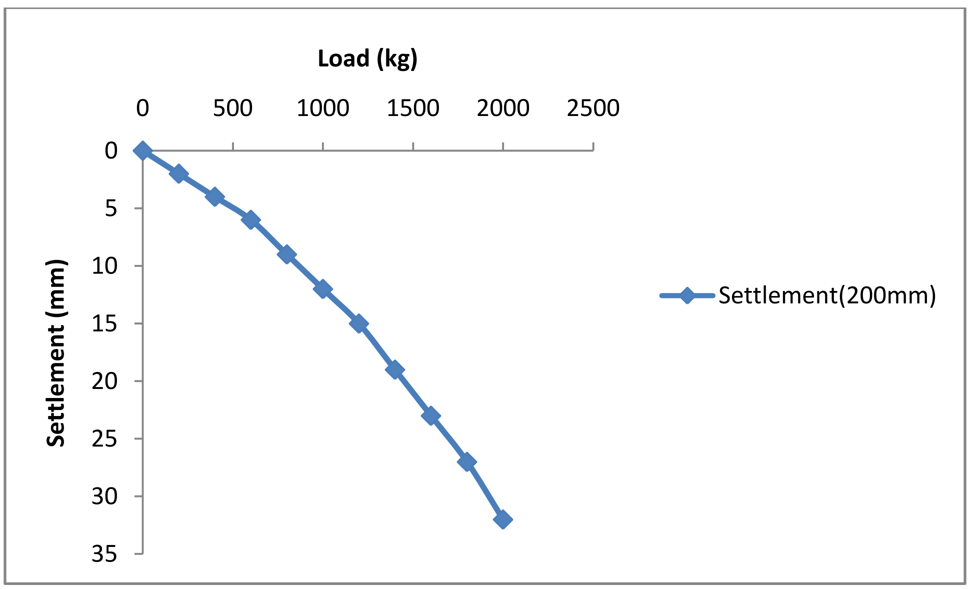

Fig.17 Load-Settlement of layered soil in which upper layer is silt sand 0n 200mm plate diameter with reinforced.[Z=D].

Table 20. Load-Settlement of layered soil in which upper layer is silt sand 0n 100mm plate diameter without reinforced. [Z=2D]

Load (Kg)	Settlement(mm)
0	0
50	5
100	8
150	12
200	16
250	20
300	25
350	29
400	35
600	50
800	70

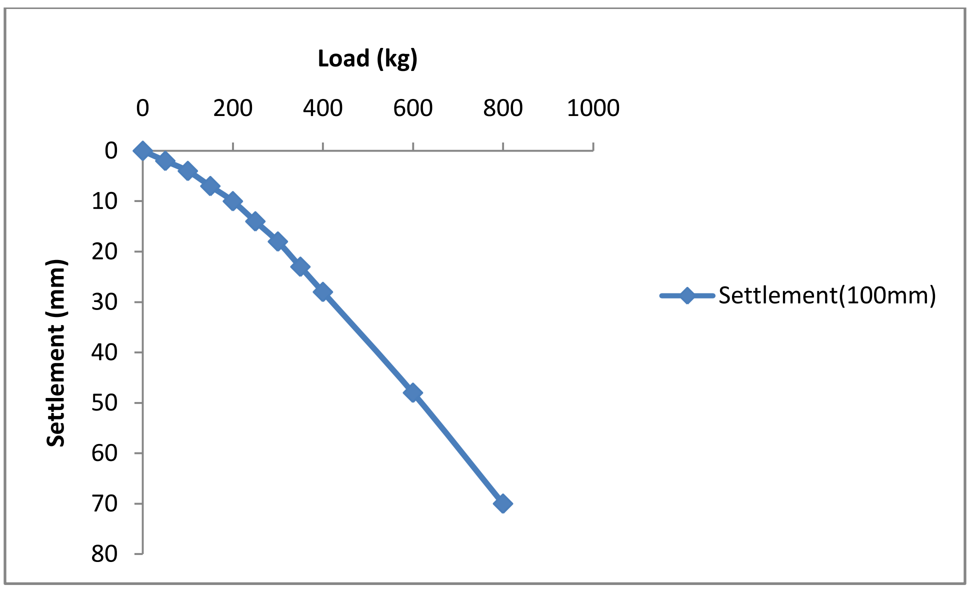

Fig.18 Load-Settlement of layered soil in which upper layer is silt sand 0n 100mm plate diameter without reinforced. [Z=2D].

Table 21. Load-Settlement of layered soil in which upper layer is silt sand 0n 150mm plate diameter without reinforced. [Z=2D]

Load (Kg)	Settlement(mm)
0	0
100	3
200	6
300	9
400	12
600	19
800	25
1000	33
1200	41
1400	51

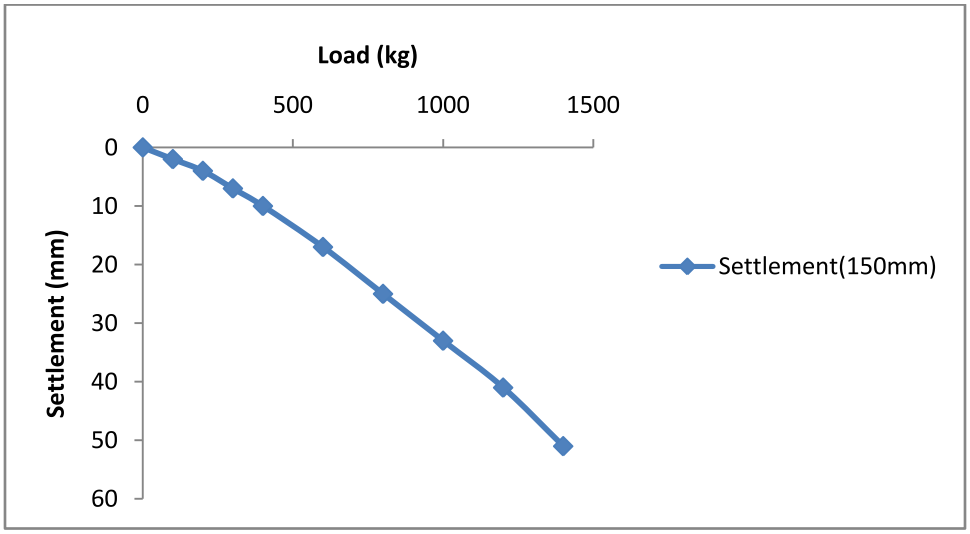

Fig.19 Load-Settlement of layered soil in which upper layer is silt sand 0n 150mm plate diameter without reinforced. [Z=2D].

Table 22. Load-Settlement of layered soil in which upper layer is silt sand 0n 200mm plate diameter without reinforced.[Z=2D]

Load (Kg)	Settlement(mm)
0	0
200	2
400	6
600	9
800	13
1000	16
1200	19
1400	24
1600	31
1800	42

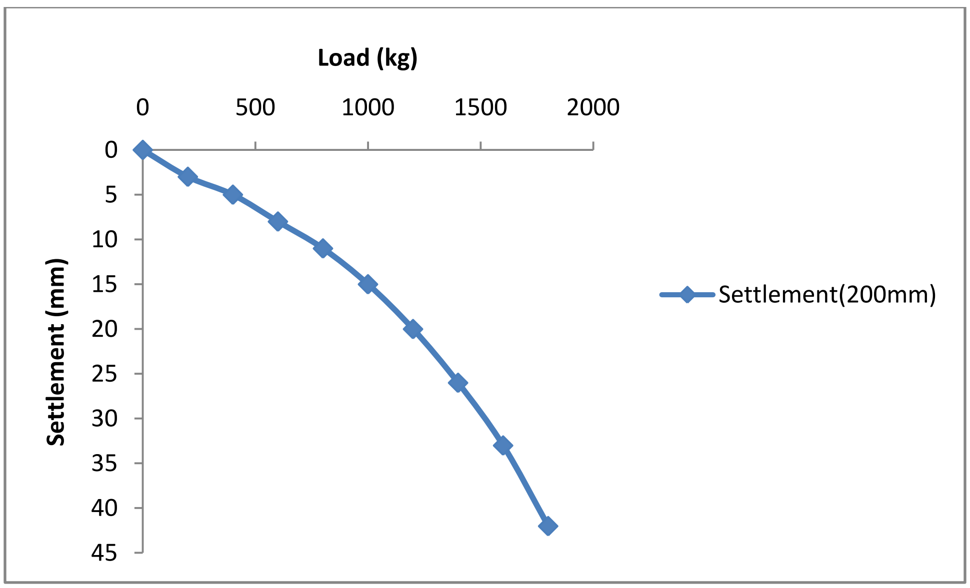

Fig.20 Load-Settlement of layered soil in which upper layer is silt sand 0n 200mm plate diameter without reinforced.[Z=2D].

Table 23. Load-Settlement of layered soil in which upper layer is silt sand 0n 100mm plate diameter with reinforced. [Z=2D]

Load (Kg)	Settlement(mm)
0	0
100	5
200	10
300	16
350	20
400	25
600	31
800	39

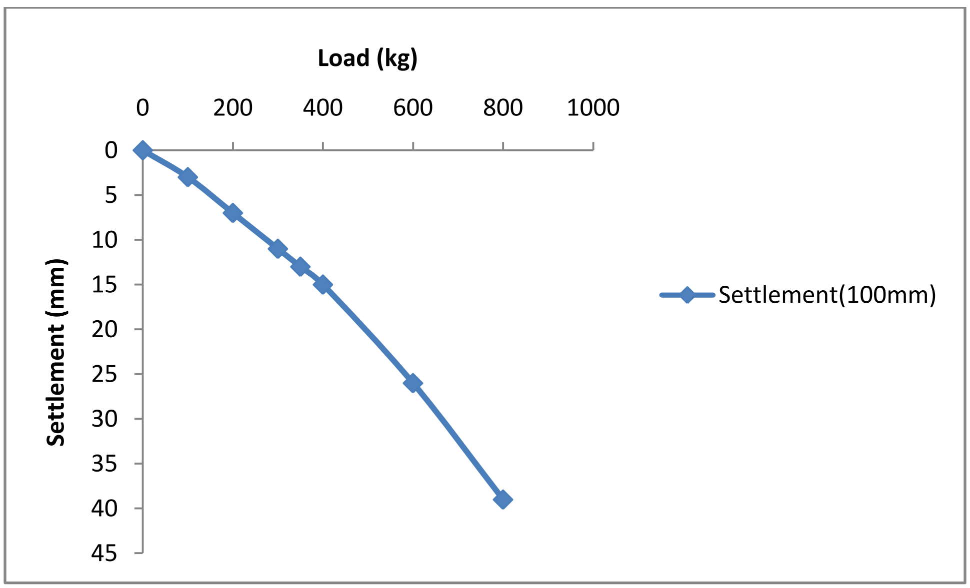

Fig.21 Load-Settlement of layered soil in which upper layer is silt sand 0n 100mm plate diameter with reinforced. [Z=2D]

Table 24. Load-Settlement of layered soil in which upper layer is silt sand 0n 150mm plate diameter with reinforced. [Z=2D]

Load (Kg)	Settlement(mm)
0	0
100	2
200	4
300	6
400	11
600	16
800	19
1000	21
1200	26
1400	36
1600	49
1800	65

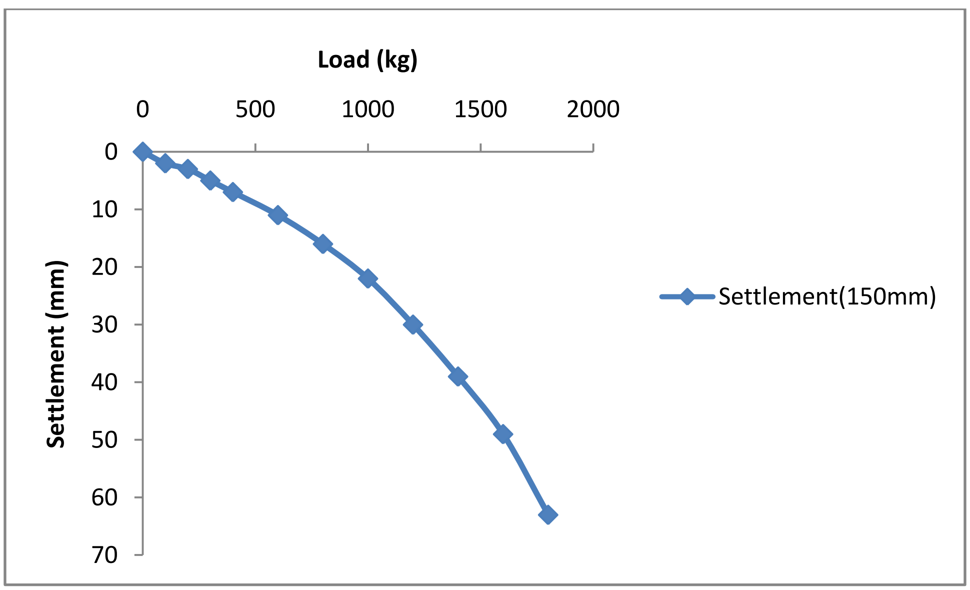

Fig.22 Load-Settlement of layered soil in which upper layer is silt sand 0n 150mm plate diameter with reinforced. [Z=2D]

Table25. Load-Settlement of layered soil in which upper layer is silt sand 0n 200mm plate diameter with reinforced.[Z=2D]

Load (Kg)	Settlement(mm)
0	0
200	2
400	3
600	7
800	8
1000	10
1200	11
1400	14
1600	16
1800	19
2000	21
2200	25

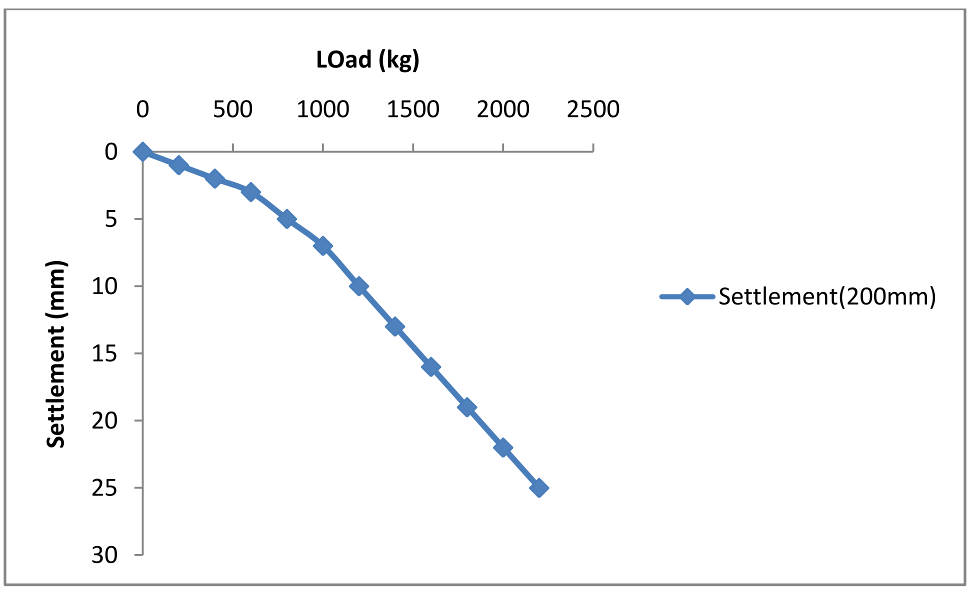

Fig.23 Load-Settlement of layered soil in which upper layer is silt sand 0n 200mm plate diameter with reinforced. [Z=2D]

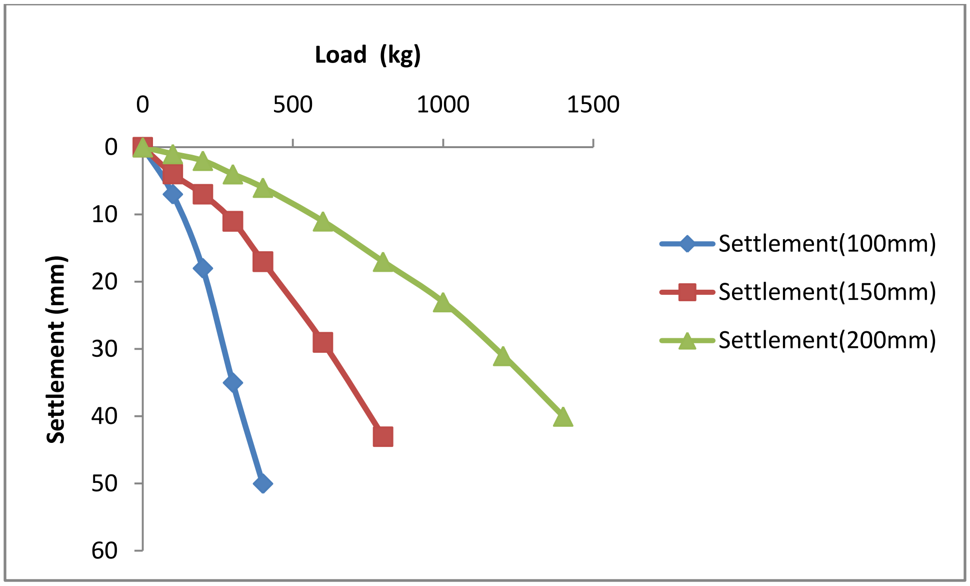

Fig.24 Load-Settlement of silt sand 0n 100mm, 150mm, 200mm plate diameter.

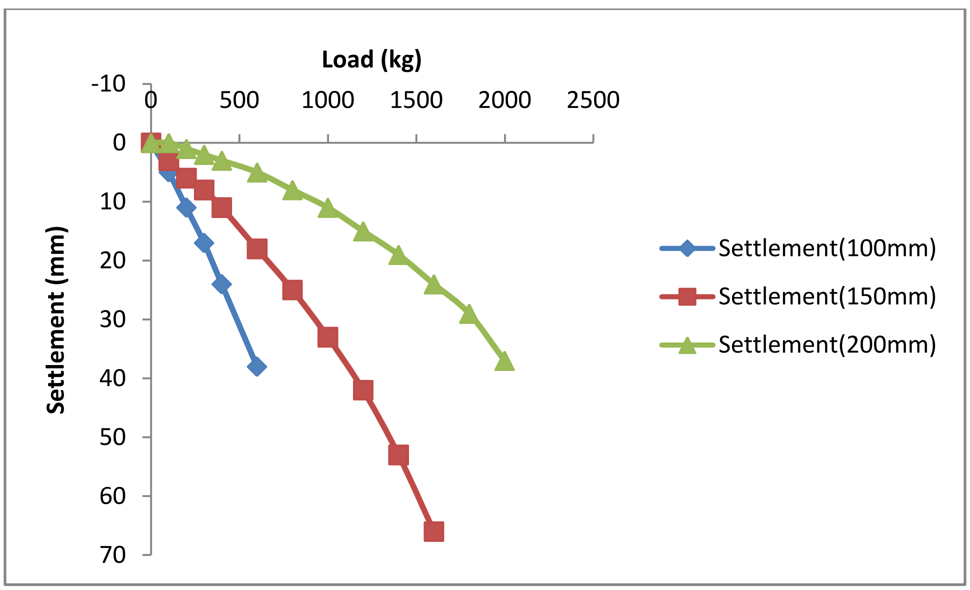

Fig.25 Load-Settlement of coarse sand 0n 100mm, 150mm, 200mm plate diameter.

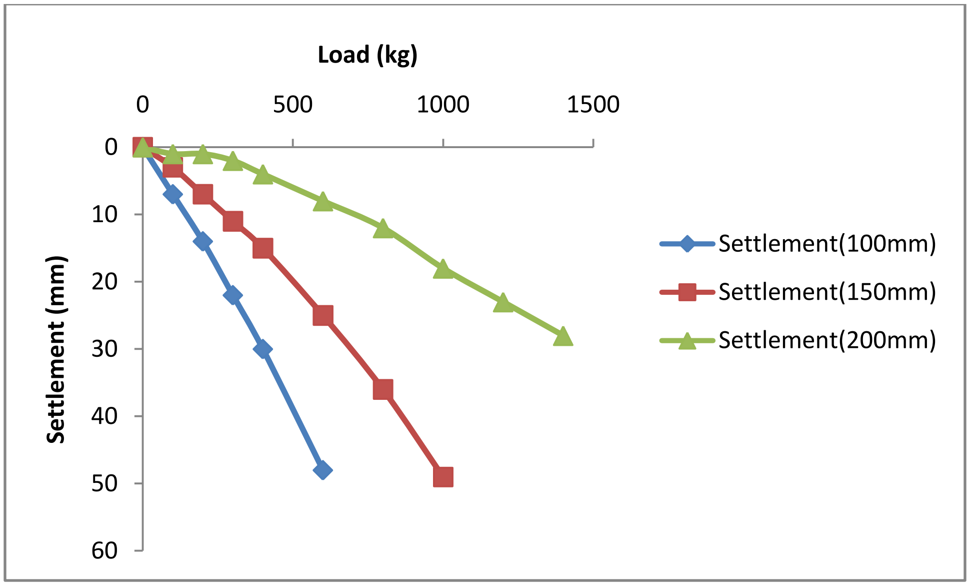

Fig.26 Load-Settlement of layered soil in which upper layer is silt sand 0n 100mm, 150mm, 200mm plate diameter without reinforced.[Z=D].

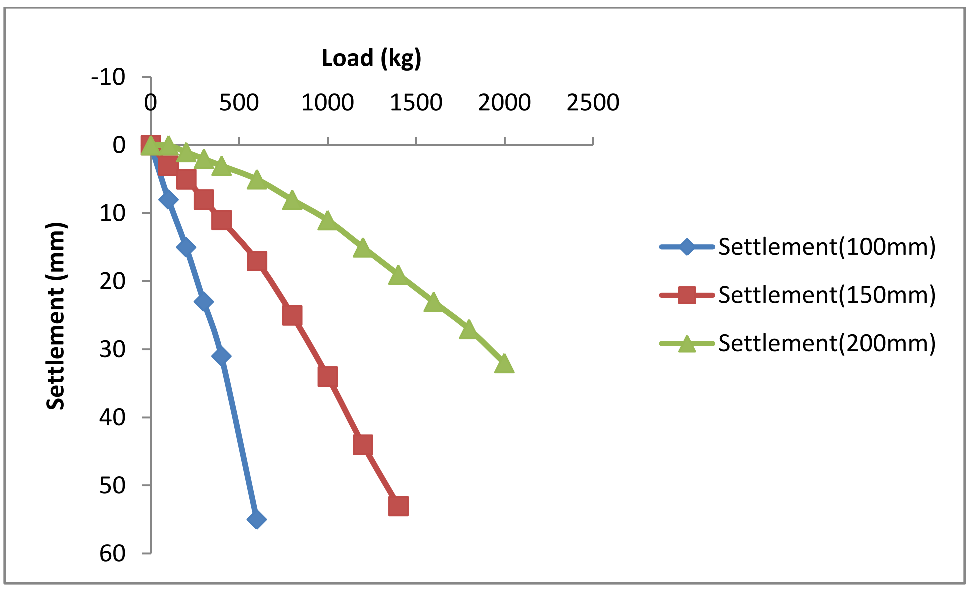

Fig.27 Load-Settlement of layered soil in which upper layer is silt sand 0n 100mm, 150mm, 200mm plate diameter with reinforced.[Z=D]

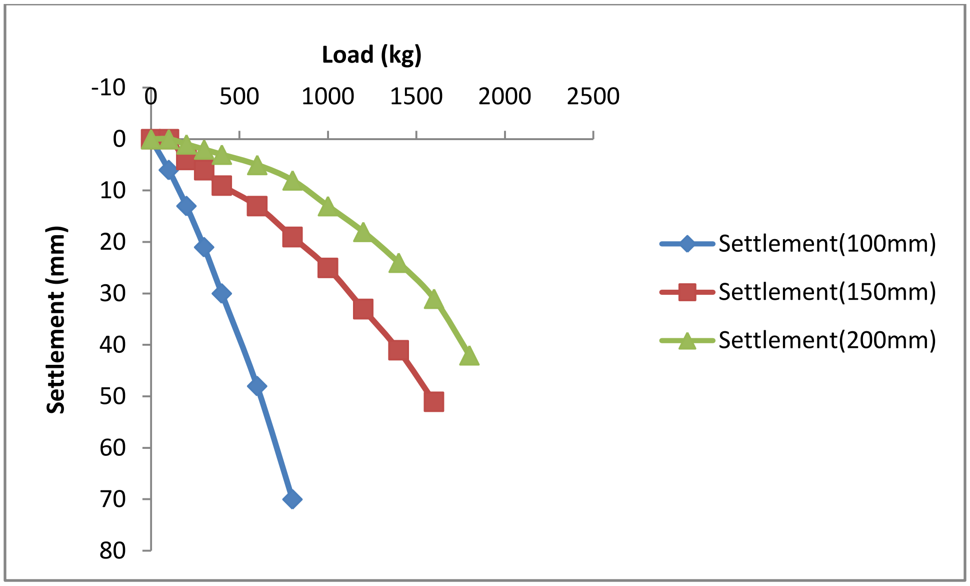

Fig.28 Load-Settlement of layered soil in which upper layer is silt sand 0n 100mm, 150mm, 200mm plate diameter without reinforced.[Z=2D]

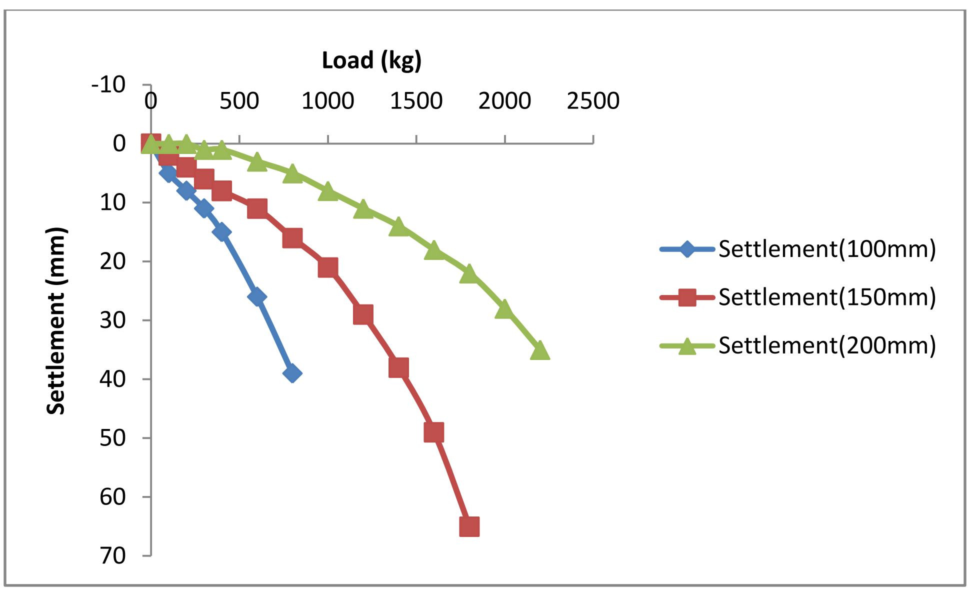

Fig.29 Load-Settlement of layered soil in which upper layer is silt sand 0n 100mm, 150mm, 200mm plate diameter with reinforced.[Z=2D].

4.1.6. Determination of %improvement.

1. Firstly the ultimate load was determined at 25mm settlement in each plate load test results.
2. Then the determination of area of each plate is calculated.
3. After this ultimate bearing capacity is calculated by using the formula;
   Ultimate bearing capacity= ultimate load / area of plate.
4. Then comparison of ultimate bearing capacity of silty sand coarse sand was done with each plate.
5. After this the comparison of ultimate bearing capacity of silty sand coarse sand was done with 100mm plate size.
6. Then comparison of ultimate bearing capacity of reinforced and unreinforced layered soil was done at Z=D and Z=2D.
7. Then the comparison of ultimate bearing capacity of silty sand was compared with unreinforced layered soil was done at the Z=D, Z=2D.

Table 26. % improvement between silty sand and coarse sand.

Plate size(mm)	Ultimate bearing capacity in (KN/m^2)		% improvement
	Silty sand	Coarse sand	
100	254.77	445.85	75.00
150	310.73	451.97	45.45
200	334.39	525.47	57.14

Table 27. % improvement between silty sand and coarse sand by plate size.

Plate size(mm)	Ultimate bearing capacity in(KN/m^2)		%improvement	
	Silty sand	Coarse sand	Silty sand	Coarse sand
100	254.77	445.85	-	-
150	310.73	451.97	21.96	1.37
200	334.39	525.47	31.25	17.85

Table28. % improvement between layered soils with reinforced and unreinforced at Z=D & Z=2D

Plate size(mm)	Ultimate bearing capacity in (KN/m^2)				% improvement	
	Reinforced		Unreinforced			
	Z=D	Z=2D	Z=D	Z=2D	Z=D	Z=2D
100	382.16	509.55	318.47	407.64	19.99	25.00
150	423.72	649.71	338.98	451.97	24.99	43.75
200	557.32	700.63	398.08	461.78	62.35	51.72

Table 29.% improvement between silty sand and layered soils at Z=D & Z=2D

Plate size(mm)	Ultimate bearing capacity in (KN/m^2)			%improvement	
	Silty sand	Z=D	Z=2D	Z=D	Z=2D
100	254.77	318.47	407.64	25.00	60.00
150	310.73	338.98	451.97	9.09	45.46
200	334.39	398.08	461.78	19.04	38.09

4.1.7 Discussion of the results.

On the basis of experimental study of plate load test on circular plates on reinforced layered soil the following points may be discussed.

- In each case of plate load test the deformation increase with the increase in load on the plates. This may be due to decrease in void ratio of the soil under lodal condition.
- The ultimate bearing capacity of the homogeneous soil bed (both made up of silt sand and coarse sand) increase with increase in the size of plates. This may be due to increase in the area of plate.
- It is observed that at a constant load the settlement of the plate increases with the increase in the size of plate. This may be due to the fact that on increase in plate size the size of pressure bulb increase.
- The ultimate bearing capacity of layered soil is more than that of homogeneous silty sand bed for a particular size of circular plate.
- The ultimate bearing capacity of layered soil is slightly less than the ultimate bearing capacity of coarse sand.
- In case of layered soil the ultimate bearing capacity increases with the increase in the thickness of top layer of silty sand.
- At the same level of load the settlement of plate (of a particular size) decrease with the increase in the thickness of the top layer of silty sand layer.
- The ultimate bearing capacity of reinforced layered soil is more than that of unreinforced layered soil. This may be due to the fact that the tensile stress developed on the soil is taken by reinforced geogrid.

Chapter 5

5.1Conclusion and Recommendations for the future work

On the basis of result and discussion the following points can be considered.

- It is beneficial to reinforced the soil at interface beneath the foundation on layered soil.
- There is 1.2 to 1.5 times increase in the ultimate bearing capacity of circular footing resting on double layer reinforced soil with unreinforced layered soil. Also at the same there is reduction in the settlement. The increase in ultimate bearing capacity exist at all levels of settlement.

5.2 Recommendation for the future work.

After the complete experimental study on plate load test on circular plate on unreinforced soil is scope for the future study may be as follows:

1. The similar study can be carried out on different types of soils with increase in number of layer of reinforcements.
2. If the poor quality soil is underlain by stiff soil than reinforcement at interface on reinforcement in layer in the top soil can be carried out after experimentation.
3. The same test can be repeated for the effect of water table.

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