Behavior of Ring Footing Over Reinforced Sand

1.THANGAMANI K, 2. SYED IRFAN AHMED
Department of Geotechnical Engineering,
Lords Institute Of Engineering And Technology, HimayathSagar, Hyderabad, TS

Abstract :The main objective of the study is to investigate the use of geo-synthetics in geotechnical characteristics of sand and to evaluate the effects of geo-synthetics on shear strength of sand by carrying out direct shear tests and to evaluate the increase in the bearing capacity of sand by the application of footing load tests over sand at different relative densities. The experiments performed to evaluate the change in bearing capacity of sand after reinforcement show that there is an increase in bearing capacity of sand on reinforcement .This increase in bearing capacity increases with reinforcement provided up to a depth of B from the top layer of sand and then the increase gradually reduces at a depth of 1.5B and 2B from the top layer of the sand.

Key words: Ring footing, sand reinforcement.

I.INTRODUCTION

For any land-based structure, the foundation is very important and has to be strong to support the entire structure. For the foundation to be strong, the soil around it plays a very critical role. We need to have a proper knowledge about their general properties like it's' specific gravity, maximum and minimum void ratio and dry density.

From the beginning of construction work, the necessity of enhancing soil properties has come to the light. Ancient civilizations of the Chinese, Romans and Incas utilized various methods to improve soil strength etc., some of these methods were so effective that their buildings and roads still exist.

An appropriate method to prevent sand failure or excessive settlement under loads is reinforcing the sand with geosynthetics, geotextiles, etc. The bearing capacity of foundations besides the parameters and conditions of the sand below the foundation depends on the shape of the foundation. Ring footings are usually used for symmetrical buildings like silos, chimneys and oil storages. This study presents a series of laboratory studies on behavior of ring footings over sand reinforced with geosynthetics. Sand reinforcement is the process of altering some sand properties by different methods, mechanical or chemical in order to produce an improved sand material which has all the desired engineering properties.

Sands are generally stabilized to increase their strength and bearing capacity to resist failure due to excessive loading. The main aim is the creation of a sand material or system that will hold under the design use conditions and for the designed life of the engineering project. The properties of sand can be improved through compaction and reinforcement of sand layers at different depths. Various methods are employed to reinforce sand and the method should be verified in the lab with the sand material before applying it on the field.

Principles of Sand Reinforcement

1. Evaluating the sand properties of the area under consideration.
2. Deciding the property of sand which needs to be altered or improved in order to achieve Improved sand with improved bearing capacity so as to be able to resist greater shear stress over it and choose the effective and economical method for reinforcement.
3. Designing the reinforced sand sample and testing it in the lab for intended Values of bearing capacity.

Construction of structures depends a lot on the bearing capacity of the sand hence; we need to reinforce the sand with geosynthetics to improve the load bearing capacity. Reinforced sand is a very cost-effective technique compared to other construction techniques. The major benefits of reinforced sand are:

• The inclusion of reinforcement in sand improves the shear resistance of the sand thereby improving its structural capability.

• The inclusion of reinforcement enables the use of poorer quality sands to be used as structural components.

• Land acquisition can be kept to a minimum because reinforced structures can be made steeper than would otherwise be possible.

• Construction time can be reduced when reinforced sand techniques are used.

II.EXPERIMENTAL INVESTIGATIONS

2.1 Brief steps involved in the experiments

2.1.1 Specific gravity of the sand

The specific gravity of soil is the ratio between the weight of the soil solids and weight of equal volume of water.

The soil sample (200g) should if necessary be ground to pass through a 4.75mm IS Sieve. A 400to 600g sub-sample should be obtained by riffling and oven-dried at a temperature of 105 to 110

1. Dry the pycnometer and weigh it with its cap(W_1)
2. Take about 200 g to 300 g of oven dried soil passing through 4.75mm sieve into the pycnometer and weigh again(W_2)
3. Add water to cover the soil and screw on the cap.
4. Shake the pycnometer well and connect it to the vacuum pump to remove entrapped air for about 10 to 20 minutes
5. After the air has been removed, fill the pycnometer with water and weigh it (W_3).
6. Clean the pycnometer by washing thoroughly

7. Fill the cleaned pycnometer completely with water up to its top with cap screw on.
8. Weigh the pycnometer after drying it on the outside thoroughly (W_4).

2.2 Procedure for the determination of minimum dry density of sand

Sand containing particles smaller than 9.50 mm should be placed as loosely as possible in the mould by pouring the sand through the spout in a steady stream. The spout should be adjusted so that the height of free fall of the sand is always 25 mm. While pouring the sand the pouring device should be moved in a spiral motion from the outside towards the centre to form a sand layer of uniform thickness without segregation.

The mould should be filled approximately 25 mm above the top and leveled with top by. Making one continuous pass with the steel straight edge. If all excess matter is not removed, an additional continuous pass should be made. Great care shall be exercised to avoid jarring the mould during the entire pouring and trimming operation. The mould and the sand should be weighed and the mass recorded.

2.3 Procedure of finding the maximum dry density of sand

The guide sleeve should be assembled on top of the mould and the clamp assemblies tightened so that the inner surfaces of the walls of the mould and the sleeve are in line. The lock nuts on the two set screws equipped with them should be tightened. The third clamp should be loosened, the guide sleeve removed, the empty mould weighed and its mass recorded. The mould should then be filled with the thoroughly mixed.

The mould filled for the determination of minimum density may also be used for this test. The guide sleeves should be attached to the mould and the surcharge base plate should be placed on the sand surface. The surcharge weight should then be lowered on the base-plate using the hoist in the case of the 15 000 cm* mould. The mould should be fixed to the vibrator deck (see Fig. 1D) for assembly.

The vibrator control should be set at maximum amplitude and the loaded sand specimen should be vibrated for 8 minutes. Footing load test was performed to determine the ultimate bearing capacity of the sand sample. A cylindrical vessel with 40 depth and 44.2 cm diameter is used. The sand samples were prepared at different maximum dry densities. Then the samples were placed.

2.4 Direct shear test

This test is used to find out the cohesion (c) and the angle of internal friction (φ) of the sand, these are the soil shear strength parameters. The shear strength is one of the most important soil properties and it is required whenever any structure depends on the soil shearing resistance. The test is conducted by putting the sand inside the shear box which is made up of two independent parts. A constant normal load (ς) is applied to obtain one value of c and φ.

Horizontal load (shearing load) is increased at a constant rate and is applied till the failure point is reached. This load when divided with the area gives the shear strength 'τ' for that particular normal load. The equation goes as follows:

$$\tau = c + \sigma * \tan(\varphi)$$

After repeating the experiment for different normal loads (ς) we obtain a plot which is a straight line with slope equal to angle of internal friction (φ) and intercept equal to the cohesion (c). Direct shear test is the easiest and the quickest way to determine the shear strength parameters of a soil sample. The preparation of the sample is also very easy in this experiment.

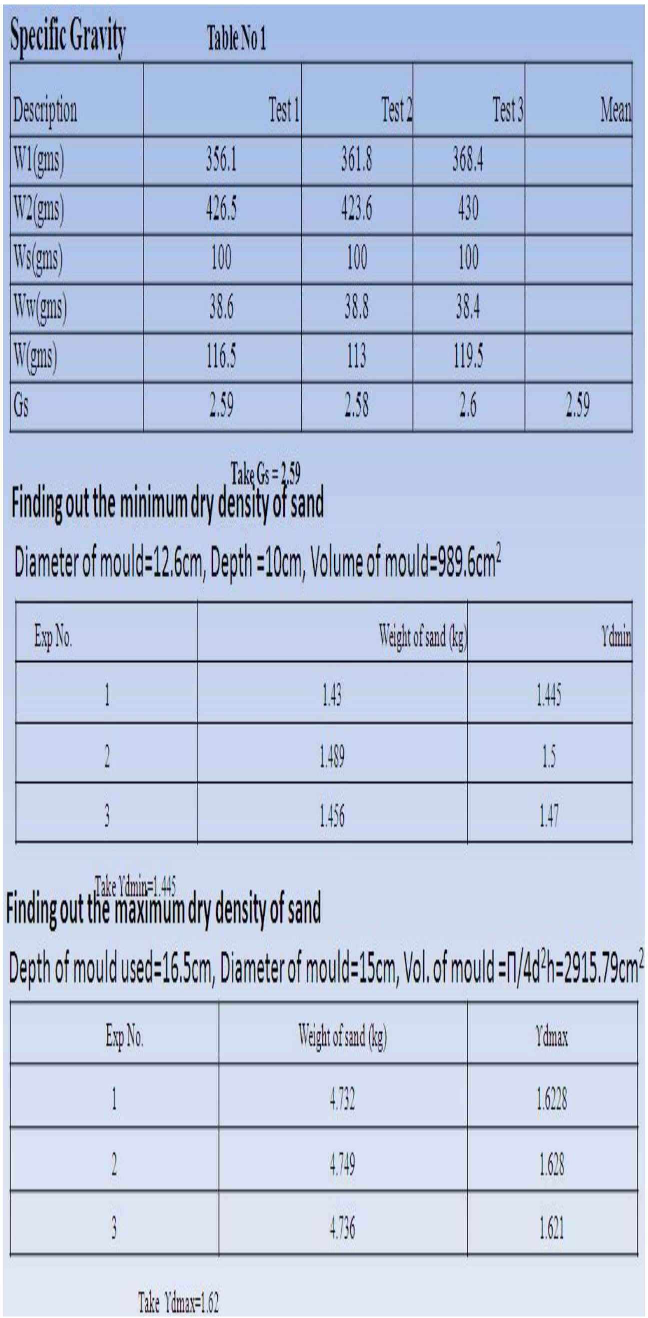
Fig 1. The Vibrating Table Along With The Hammer

2.5 Determination of bearing capacity of sand using footing load test machine

Footing load test was performed to determine the ultimate bearing capacity of the sand sample. A cylindrical vessel with 40 depth and 44.2 cm diameter is used. The sand samples were prepared at different maximum dry densities. Then the samples were placed. Over the testing machine and the dial gauge and proving ring reading were noted down. From the above data graph was plotted between bearing pressure and settlement. The proving ring constant was found out to be 6.66N whereas the least Count of the dial gauge for measuring the settlement was 0.01 mm. The proving ring had a loading capacity of 5kN and the rate of loading was 1.25mm/min.

Fig .2. The Footing Load Test Machine

III.RESULTS



Specific Gravity Table No 1

Description	Test 1	Test 2	Test 3	Mean
W1(gms)	356.1	361.8	368.4	
W2(gms)	426.5	423.6	430	
Ws(gms)	100	100	100	
Ww(gms)	38.6	38.8	38.4	
W(gms)	116.5	113	119.5	
Gs	2.59	2.58	2.6	2.59

Take Gs = 2.59

Finding out the minimum dry density of sand

Diameter of mould=12.6cm, Depth =10cm, Volume of mould=989.6cm^2

Exp No.	Weight of sand (kg)	Ydmin
1	1.43	1.445
2	1.489	1.5
3	1.456	1.47

Take Ydmin=1.445

Finding out the maximum dry density of sand

Depth of mould used=16.5cm, Diameter of mould=15cm, Vol. of mould =Π/4d^{2}h=2915.79cm^2

Exp No.	Weight of sand (kg)	Ydmax
1	4.732	1.6228
2	4.749	1.628
3	4.736	1.621

Take Ydmax=1.62

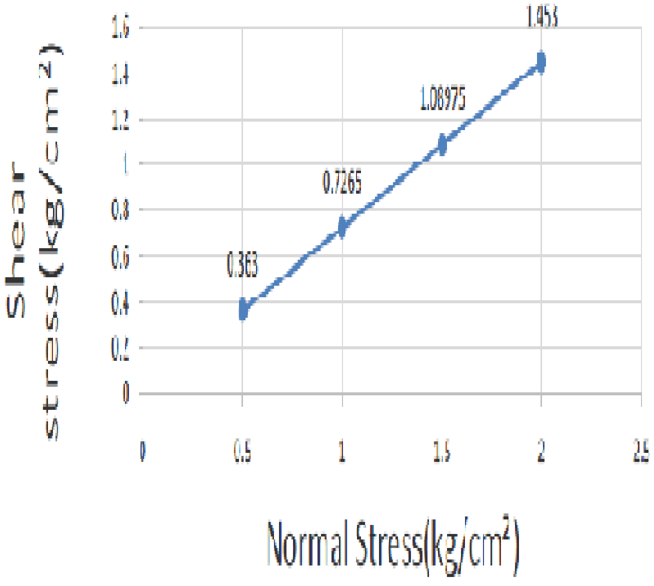
Fig.3.Comparison of minimum dry density of sand

Direct Shear Test

For sand of relative density 0.3

Table No 4

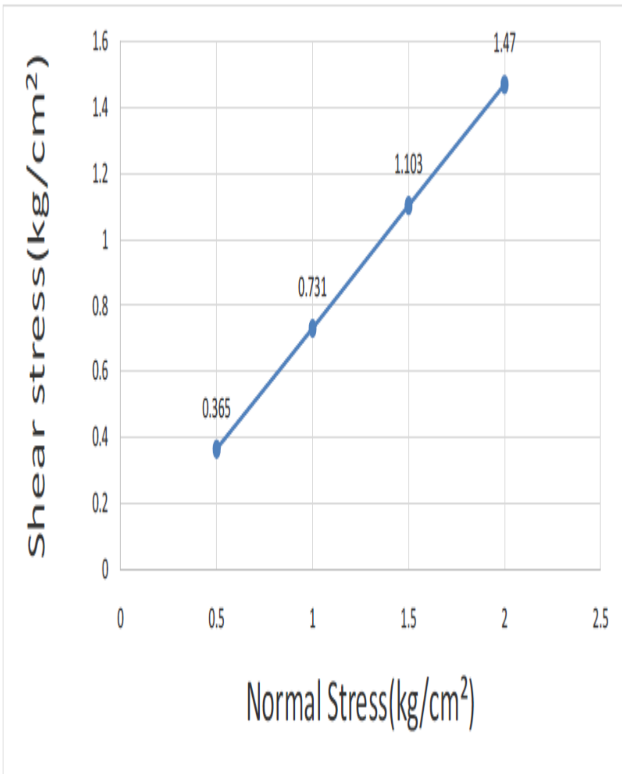
Exp No.	Normal Stress (kg/cm²)	Shear Stress (kg/cm^2)
1	0.5	0.363
2	1	0.7625
3	1.5	1.089
4	2	1.453



For sand of relative density 0.6

Table No 5

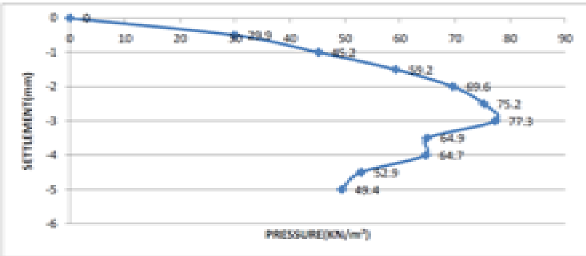
Exp No.	Normal Stress (kg/cm²)	Shear Stress (kg/cm^2)
1	0.5	0.365
2	1	0.731
3	1.5	1.103
4	2	1.47



Bearing capacity of sand at different relative densities

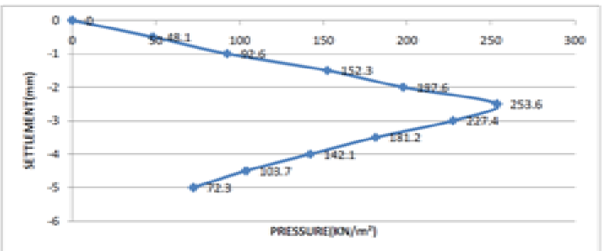
For sand of relative density of0.3

SETTLEMENT(mm)	PRESSURE(KN/m²)
0	0
0.5	29.9
1	45.2
1.5	59.2
2	69.6
2.5	75.2
3	77.3
3.5	64.9
4	64.7
4.5	52.9
5	49.4



For sand of relative density 0.6

SETTLEMENT(mm)	PRESSURE(KN/m²)
0	0
0.5	37.6
1	71.7
1.5	104.4
2	130.2
2.5	142.7
3	135.0
3.5	111.4
4	89.1
4.5	72.4
5	62.6
5.5	52.4



IV.CONCLUSION

On the basis of present experimental study, the following conclusions are drawn, The maximum and minimum dry density of sand was found out to be 1.62kg/m3 and 1.445 kg/m3 respectively based on which the maximum and minimum void ratio of the unreinforced sand sample was found out to be 0.89 and 0.59 respectively. The specific gravity of the sand sample was found out to be 2.59. On the results of the Direct test conducted over the sand sample the values of cohesion © was found out to be zero. Thus concluding that sand is cohesion less in Nature.

The angle of internal friction (Φ) for sand samples of relative densities 0.3, 0.6, 0.75, 0.9 was found out to be 36°, 36.16°, 37°, and 38° s respectively. Thus concluding that the value the angle of internal friction increases with the increase in the relative density of sand. The maximum bearing capacity of the unreinforced sand sample for a relative density of 0.3, 0.6 and 0.75 was found out is 77.3kN/M2, 135.0kN/M2, and 253.6kN/M2 respectively. Thus concluding from the above results that the maximum bearing capacity of sand increases with the increase in its relative density. After reinforcement with the use of geosynthetics the maximum bearing capacity of sand for a relative density of 0.75 was found to increase considerably up to a depth of B, where B is the outer diameter of the ring footing. On the other hand its value decreased when reinforcement was provided below a depth of B from the top of the sand layer at a depth of 1.5B and 2B respectively. The value of maximum bearing capacity of sand for a relative density of 0.75 increased at a depth of 0.5B and B by 18.10% i.e. by 45.92kN/M2 and by 23.02% i.e. by 54.8kN/M2 respectively .This increase in bearing capacity decreased to 7.4% i.e. to 18.77kN/M2 and 3.2% i.e. to 8.2kN/M2 at a depth of 1.5B and 2B respectively.

REFERENCES

[1].Boushehrian, J. H., and Hataf,N.(2003)‘‘Experimental and numerical investigation of the bearing capacity of model circular and ring footings on reinforced sand..”

[2].El Sawwaf, M. (2009).‘‘Experimental and numerical study of eccentrically loaded strip ootings resting on reinforced sand.’’

[3].Hataf, N., and Razavi, M. (2003).‘‘Behaviorof ring footing on sand.’’

[4].Karaulov, A. M. (2006). “Experimental and theoretical research on the bearing capacity of ring foundation beds.’’

[5].Ackerley, S. K., Hellings, J. E. & Jardine, R. J. (1987).Discussion on `A new device for measuring local axial strains on triaxial specimens' by C. R. Clayton and S. A. Khatrush, 1987, GeÂotechnique 37, No. 3,

[6]ASTM D1194 (1989). Bearing Capacity of Soil for Static Load and Spread Footings. Annual Book of ASTM Standards

[7]ASTM D2487 (1989). Classi®cation of Soils for Engineering Purposes. Annual Book of ASTM Standards.

[7]IS: 2720(Part 2), 1973 Methods of Test for Sands, Determination of water content.

[8] IS 2720(III/SEC-I): 1980 Methods of Test for Sands, Determination of specific gravity.

[9] IS 2720(VII):1980 Methods of Test for Sands, Determination of water content dry density relation using light compaction.

[10]IS 2720(XIII):1986 Methods of Test for Sands, direct shear test Punmia B.C. 2007, “Soil Mechanics & Foundations” Laxmi Publication.