Experimental Study of Load Settlement behavior on Silt Clay Loam (Soft Murum) with or without Geogrid

Shripad S. Somvanshi[1] Prof. Dr. V. J. Sharma[2] Mr. Bhanudas Abhale[3]
[1]ME Student [2]PG Coordinator [3]Lecturer
[1,2]Department of Geotechnical Engineering [3]Department of Civil Engineering
[1,2]Matoshri College of Engineering and Research Centre, Nashik, Savitribai Phule Pune University, Nashik, (M.S.) India [3]Sandip Polytechnic, Nashik, 422213 (M.S.) India.

Abstract— Soil is all naturally occurring relatively unconsolidated earth material, organic or inorganic in character that lies above the bed rock includes different materials like silts, clays, gravels etc. It is universally available material of various types with different physical, chemical and organic properties. Foundation is a part of structure which transmits load of super structure to the sub soil. Geotechnical engineers face various problems while designing the foundations on highly compressible clayey soil due to poor bearing capacity and excessive settlement. Thus bearing capacity is one of the important aspects of soil engineering. The bearing capacity of the soil put forth by scientists like Prandtl (1921) Terzaghi (1943), Meyerhoff (1963), Hansen (1970), Vesic (1973), etc. In the project the bearing capacity of silt clay loam can be studied under static load in metallic tank. The prototype structure of working foundation is prepared and tested under cyclic load of various vertical load and eccentricities of a size of square and circular footing. The effect on bearing capacity of soil due to inclusion of reinforcement into the soil at various positions is also to be analyzed.

Key words: Load Settlement on Silt Clay Loam with Geogrid, Load Settlement on Silt Clay Loam without Geogrid

I. INTRODUCTION

A. General

Foundation is the lower most hidden but very important part of any structure whether it is onshore or offshore structure. It is the part which receive huge amount of load from superstructure and distribute it to ground. So the foundation should be strong enough to sustain the load of superstructure. The performance of a structure mostly depends on the performance of foundation. Since it is a very important part, so it should be designed properly. Design of foundation consists of two different parts: one is the ultimate bearing capacity of soil below foundation and second is the acceptable settlement that a footing can undergo without any adverse effect on superstructure. Ultimate bearing capacity means the load that the soil under the foundation can sustain before shear failure; while, settlement consideration involves estimation of the settlement caused by load from superstructure which should not exceed the limiting value for the stability and function of the super structure. Ultimate bearing capacity problem can be solved with the help of either analytical solution or experimental study. First one can be studied using theory of plasticity or finite element method, while the second is reached through performing laboratory model test. A literature survey on this subject shows that the majority of the bearing capacity theories involve centric vertical load on the rectangular footing. However in some of the cases, footing undergo eccentric loading due to the eccentrically located column on footing or due to the horizontal force along with vertical load acting on the structure. Footing located at property line, machine foundation, portal frame buildings are some examples where the foundations experience eccentric loading. A foundation under load will undergo settlement due to the horizontal and vertical movement of soil particle below foundation. In case of centric vertical load on the footing, stress distribution will be uniform below the footing and the footing will undergo equal settlement at both edges On the other hand if the load is eccentric, the stress distribution below the footing will be non-uniform causing unequal settlement at two edges which will result in the tilt of footing. The tilt will increase with the increasing eccentricity to width ratio (e/B). When eccentricity to width ratio (e/B) is greater than 1/6, the edge of the footing away from load will lose its contact with the soil which will result in the reduction of effective width of footing and hence reduction of ultimate bearing capacity of foundation. Researchers are introducing reinforcing material like metal strip, geofome, geotextile and geogrid to enhance the ultimate bearing capacity of foundation.

II. LITERATURE REVIEW

A. Background

After going through the literature, it has been found that several researchers worked on foundation problem. Some researchers worked on unreinforced sand bed while some worked on reinforce sand/soil bed. At the same time, some researchers based their study on the results of prototype laboratory model testing while some researchers used theories based on finite element and numerical analysis to develop formulas to predict ultimate bearing capacity. Results that are available is related to the enhancement of load bearing capacity of shallow foundation supported by sand/soil reinforced with metal strip, metal bar, rope fibers, geotextile and geogrid. Some of these tests were conducted using model square foundation while others using model strip foundation.

In this chapter, brief reviews of some literature are presented.

Ehsan Badakshan et.al (2015)[1] has studied eccentrically loaded circular footing, resting on a geogrid reinforced sand bed prepared prototype model footing of 120 mm in diameter,15mm thickness and sand relative density of 60%. The model prototype footing was rested on the sand foundation prepared in metallic square tank of size 600mm X 600mm X 600mm.Also, the effects of depth of first and second geogrid layer sand number of reinforcement layers (1-4) on the settlement-load response and tilt of footing under various load eccentricities (0 cm, 0.75 cm, 1.5 cm, 2.25 cm and 3 cm) were investigated. Test results indicate that ultimate bearing capacity increases in comparison with unreinforced condition. The test result also showed that when the reinforcements are placed in the optimum embedment depth (u/D =0.42 and h/D = 0.42), the bearing capacity ratio (BCR) increases with increasing load eccentricity to the core boundary (1.5cm) of footing, and that with further increase of load eccentricity, the BCR decreases, the tilt of footing increases linearly with increasing settlement. Finally, by reinforcing the sand bed, the tilt of footing decreases at 2 layers of reinforcement and then increases by increasing the number of reinforcement layers.

Prof. P.B Kulkarni et.al(2015)[1]has studied from their experiment conducted on square plate concluded that the bearing capacity of yellow soil was increased by 10% for yellow soil, sand and hydrated lime(YSL) 20% mix and 25% for YSL30% mix by increase in sand percentage and 3% lime in each combination which increased the gradation of yellow soil also the cementitious property was achieved by curing of YSL mix which increased the bearing capacity also it was found that no bearing capacity improvement was found for yellow soil, clay, sand and hydrated lime(YSCL) combination though 3% of lime was used; since percentage of fines increased which increased the moisture content and decreased the density of YSCL soil which results in decrease in bearing capacity of soil and this was influenced by parameters: increase in cohesion, decrease in angle of shearing resistance and tests also shown that the improvement of bearing capacity for YSCL20% and YSCL30% with geo-grid is found to be 30% and 59% respectively experiment also showed that a significant improvement in load carrying capacity was observed for YSL mix due to the provision of proposed sand-lime mix in yellow soil. The improvement in load carrying capacity was influenced by parameters: increase in angle of shearing resistance decrease in cohesion and inclusion of geo-grid as reinforcement.

Dhatrak A. I et.al (2014)[3]has studied the experimental study from a series of laboratory scale bearing capacity tests carried out on model square footings on single and double layer pre-stressed biaxial reinforcement. The dry sand were used as supporting soil and in the sand the biaxial geogrid were placed at B, B/2 and B/4 where B is the width of the footing. The sand was filled into tank by sand raining technique using hopper method. So it concluded that the beneficial effects of geotextile reinforcement without pre-stress were insignificant beyond a footing embedment depth of B/2 for low strains.

B. *Research Gap*

From above literature review most of research work were carried on the sandy soil but few of work on the clay, layered soil and silt clay loam and at eccentric load condition so this project mainly focuses on the effect of geo synthetic material on bearing capacity in silt clay loam at Centric and Eccentric loading condition

III. METHODOLOGY

In previous chapter the detail literature review is described, in this chapter the methodology of experimental behaviour of the model footing of various load eccentricities of silt clay loam are described.

A. *Preparation of Soil*

The test soil were prepared with following condition,

1) *Soft Murum*

The soft murum used as supporting foundation to model footings. In this project the behaviour of soft murum is tested with single model footing with or without geosynthetic material i.e. geogrid. The local soft murum used in this test program is extract from within 1m depth below the ground surface from the 02km pimplas in Rahata Tehsil District Ahmednagar. The physical properties of the sample, such as the compaction test and specific gravity have been determined in accordance with the relevant IS standard procedures. The Engineering properties of soil sample are listed which has been identified in table 1 for the present study soil samples of yellowish colored.

Sr. No.	Properties	Value
1)	Specific Gravity	2.7
2)	Compaction Test (Moisture Content39%)	16kN/sq.

Table 1: Engineering Properties of Soft Murum

2) *Equipment's and Materials*

The basic aim of this research is to discover the bearing capacity of reinforced silt clay loam so the silt clay loam is the basic material which is used in this research work. Geogrid is used to reinforcing the silt clay loam. Static loading machine is used to apply the concentrated load on the mild steel footing which is transferred to sand bed in form of distributed load. Test tank of dimension 1 X 0.504 X 0.655 m is used to prepare the sand bed.

3) *Experimental Set Up*

To study the load settlement characteristics of the footing under given parameters, the plate load test required to be conducted. The tests were conducted on the model footing similar to the prototype under the standard conditions. The various laboratory tests performed to decide the different geotechnical properties of soft murum and laboratory plate load test conducted on the model footing similar to the prototype under the standard conditions are as discuss below.

4) *Model Footing*

To study the effect of different load acting eccentricities on square and circular model footing of different area were used. Two metal prototype of shallow foundations were used for the study: the prototype was square and circular (marked square S and circular C as shown in photograph 3.1

Fig. 1: Model Prototype Footings

5) *Metallic Tank*

The loading tests were performed on soft murum prepared in mild steel model tank of size 750 x 1000 x750 mm and thickness of 8 mm Applied through model footings resting on the surface of soft murum. The metal box was made of four sides and rigid steel and concrete composite base to avoid the deformation due to loading.

6) *Laboratory Set-up*

Laboratory set-up consist of a tank, a reaction frame, a model footing, and hydraulic jack, pulleys, proving ring, dial gauges. Square frame fabricated in the laboratory with loading arrangement is show in fig. and photograph. The metal tank was kept in between the loading frame so that cyclic loading was given to the foundation with help of proving ring.

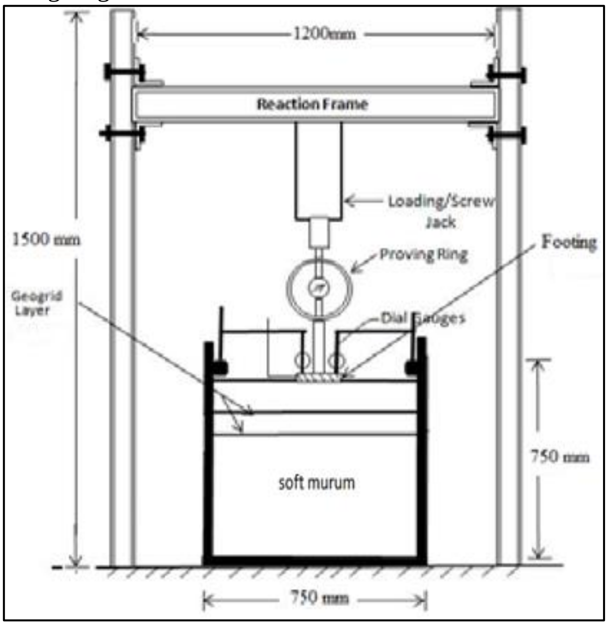

Fig. 2: Laboratory set-up

1) The soft murum is fill to the total depth of the metallic tank i.e. H=600mm, and the two model footing are tested
2) The soft murum is fill to the total depth of the metallic tank i.e. H=600mm, and geosynthetic material placed at position- 1 i.e. 40mm.
3) The soft murum is fill to the total depth of the metallic tank i.e. H=600mm, and geosynthetic material placed at position- 2 i.e. 67.2mm.
4) The soft murum is fill to the total depth of the metallic tank i.e. H=600mm, and geosynthetic material placed at position- 3 i.e. 92.8mm.

B. *Geogrid*

The geotextile is used in this study to reinforce the selected soil to study its effective use in construction of road and structure. Geo-grids are categorized by a relatively high tensile strength and a uniformly distributed group of large openings in between longitudinal and transverse rib. These openings are called aperture. The openings allow sand particle on either side of the mounted geogrid to come in direct contact which increases the interaction between the geogrid and murum.

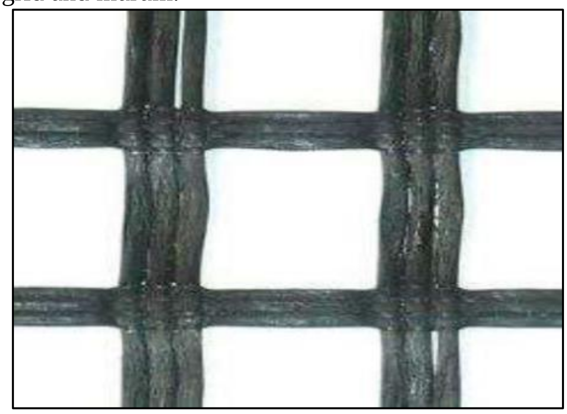

Fig. 3: Geogrid Material

Parameters	Value
Polymer Polypropylene	Pp
Tensile strength at 2% strain	7 *KN/m*
Tensile strength at 5% strain	14 *KN/m*
Aperture size (W)	39*39 mm
Aperture shape	Square
Rib width (w)	1.1 mm
Junction strength	95%

Table 2: Properties of the Geogrid

IV. RESULT& DISCUSSION

The Load settlement behaviour or the bearing capacity of the supporting soil depends on various factors, which are explained briefly in earlier chapters the shape of the footings and load eccentricities has great influence on the load settlement behaviour or bearing capacity of supporting soil, with or without reinforcement in case of soft murum. In order to examine whether the shape of the footings and load eccentricities has its influence on the load settlement behaviour or bearing capacity of the supporting soil, loading test were conducted using model footings resting on soft murum foundation contained in a model tank.

A. *Experimental Analysis*

1) *Soft Murum*

The soft murum is used as supporting soil without geogrid. The soft murum is filled up to the depth 600 mm and load test data were observed on square and circular model footing.

The test result shown in graphically the load settlement curve for both shape of footing is plotted also the load settlement curve for the change in different load eccentricities is plotted. For Square and circular type of the model footing it is observed that if load acted on different eccentricities of the footing there is decrease in load settlement behaviour. The Circular footing showing better performance than square of footing shown in graph.

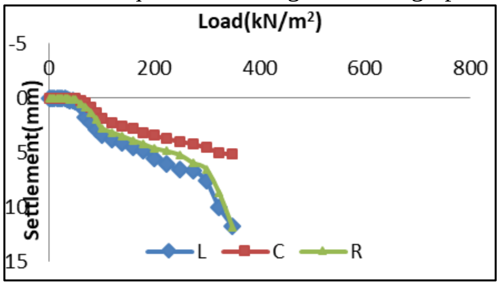

Fig. 4: Load settlement curve for square footing with eccentric loads at 2cm on L.H.S & R.H.S along with centric load

Sr. No.	Type of Footing	Type of Loading	Load (kN/sq.m)	Settlement (mm)
1	S	L	348.25	11.715
2	S	C	348.25	5.165
3	S	R	348.25	11.885

Table 3: Results

So it can observe that centre(C) having more bearing capacity as compared to other two eccentric loads it showing 5.165 mm settlement for the load 348.25 kN/m^2.

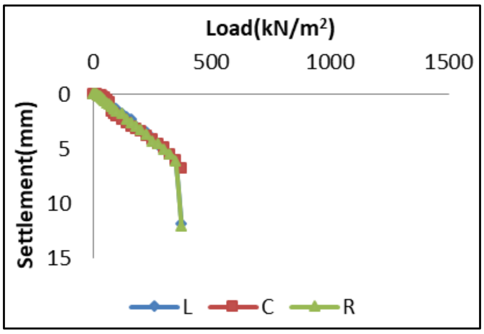

Fig. 5: Load settlement curve for square footing with eccentric loads at 3cm on L.H.S & R.H.S along with centric load

Sr. No.	Type of Footing	Type of Loading	Load (kN/sq.m)	Settlement (mm)
1	S	L	373.13	11.9
2	S	C	373.13	6.8
3	S	R	373.13	12.1

Table 4: Results

So it can observe that centre(C) having more bearing capacity as compared to other two eccentric loads it showing 6.8 mm settlement for the load 373.13 kN/m^2.

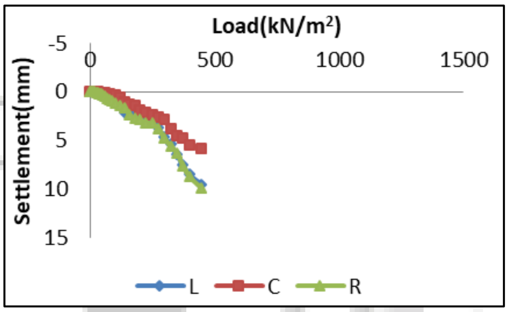

Fig. 6: Load settlement curve for circular footing with eccentric loads at 2cm on L.H.S & R.H.S along with centric load

Sr. No.	Type of Footing	Type of Loading	Load (kN/sq.m)	Settlement (mm)
1	C	L	447.76	9.5
2	C	C	447.76	5.9
3	c	R	447.76	9.9

Table 5: Results

So it can observe that centre(C) having more bearing capacity as compared to other two eccentric loads on left and right, it shows 5.9 mm settlement for the load 447.76 kN/m^2.

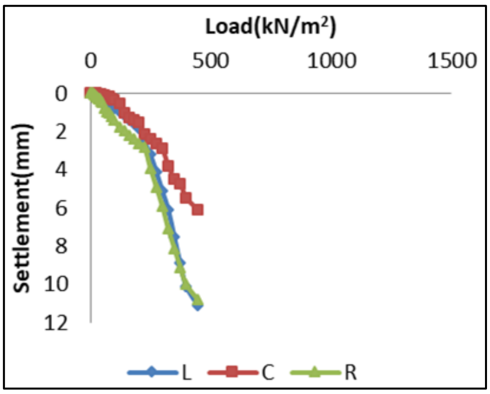

Fig. 7: Load settlement curve for circular footing with eccentric loads at 3cm on L.H.S & R.H.S along with centric load.

Sr. No.	Type of Footing	Type of Loading	Load (kN/sq.m)	Settlement (mm)
1	C	L	447.76	9.5
2	C	C	447.76	5.9
3	C	R	447.76	9.9

Table 6: Results

So it can observe that center (C) having more bearing capacity as compared to other two eccentric loads it showing 6.1 mm settlement for the load 447.76 kN/m^2.

V. CONCLUSION

In this experimental investigation it is seen that as the load eccentricity goes on increasing there is decrease in the load carrying capacity. In the both type of footing i.e. square and circular showing better load settlement behaviour for centric load. Circular footing show better result as compare to rectangular footing for sustaining load.

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