

IMPROVING THE LOAD CARRYING CAPACITY OF SQUARE FOOTING RESTING ON GEOGRID REINFORCED SAND

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Abstract- The foundations of assorted structures area unit subjected to serious loading. This project presents the results of laboratory model tests on square footings supported on geogrid strengthened sand bed below loading conditions for various densities of sand bed and U/B ratio. The load applied on the footing to judge the response of a sq. footing against load. The impact of sand for the density 1.445 g/cc, 1.490 g/cc, and 1.496 g/cc and for various U/B ratio of 0.2, 0.4, and 0.6 were investigated on ultimate bearing capacity that is increased by increasing the density of sand and with the rise of U/B ratio up to 0.4 The results of ultimate bearing capacity for reinforced sand is more than unreinforced sand bed.

Key Words: Sand, Ultimate load, Settlement, Geogrid reinforcement, U/B ratio.

1. INTRODUCTION

The lowest a part of a structure is mostly cited because the foundation. It Is perform is to transfer the load of the structure to the soil on that it's resting. A properly designed foundation transfers the load throughout the soil while not overstressing the soil. Overstressing the soil may end up in either excessive settlement or shear failure of the soil, each of that cause harm to the structure. Thus, geotechnical and structural engineers who design foundations should judge the bearing capability of soils. Foundation is that a part of the structure that is in direct contact with the soil and transmits load on to the soil. Before the appliance of load, the soil at a lower place the bottom of the footing is in elastic equilibrium. Because the load is applied settlement occurs that is proportional to the load. With the rise in loading, settlement progressively will increase, and also the soil transforms from the state of elastic equilibrium to plastic equilibrium and so the distribution of soil reaction changes and failure of soil happens. There are three principal modes of shear failure i.e. general shear failure, local shear failure and punching shear failure relying upon the relative squeezability and characteristics of soil. General shear failure happens in comparatively incompressible soil with finite cut strength. The failure is amid wide bulging of on the soil surface. local

shear failure happens in comparatively compressible soil. The failure is amid visible sheared zone when bulging has taken place. Punching shear failure takes place because of the comparatively nice squeezability of soil and will be evaluated by decisive the rigidity index of the soil.

1.1 Mechanism of reinforcement

Randomly directed distinct inclusions added into soil improve its load-deformation behavior by interacting with the soil particles automatically through surface friction and additionally by interlocking. The performance of the bond is to transfer the stress from the soil to the distinct inclusions by mobilizing the strength of separate fibers. Thus, fiber-reinforcement works as resistance and tension resistant part.

1.2 Types of Fibres

Fibers will be classified in 2 main categories synthetic fiber and natural fiber. Varied forms of artificial fibers are nylon, plastic, polypropylene, glass, asbestos, etc. These are typically most well-liked than the natural fibers due to their higher strength and resistance. The assorted forms of natural fiber accessible in India are coir, sisal, jute, hemp, bhabar, munja, bamboo, and banana. So as to reduce the value of the strengthened soil, regionally accessible fibers are thought-about in design. Because of its low strength and lack of sturdiness, natural fibers aren't used wide for reinforcements however are most popular for erosion control as they're eco-friendly.

2. EQUIPMENTS AND METHODOLOGY

2.1 General

The basic aim of this research is to discover the bearing capacity of reinforced sand bed. So the sand is the basic material which is used in this research work. Tensar Biaxial geogrid is used to reinforcing the sand. Hydraulic 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 60 X 60 X 30 cm is used to prepare the sand bed.

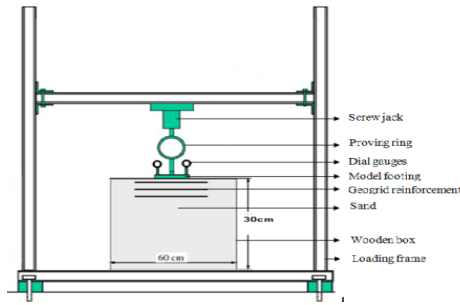


Fig 1 Line diagram of experimental setup

2.2 Materials

2.2.1 Sand

The sand used in research work is collected from nearby Krishna River Raichur. The sand is washed to make it free from silt & clay, grass roots, and other organic materials and then the washed sample is dried in oven. The oven dried sample is first sieved on 4.75mm IS sieve and then the sand passing through 4.75 IS sieve is again sieved on 75µ IS sieve. The sand sample retained by 75µ IS sieve is used for research work

Table -1 Properties of sand

Description	Value
Gravel (%)	0.2
Coarse grained sand (%)	0.4
Medium coarse grained sand (%)	76.8
Fine grained sand (%)	22.4
Fines (%)	0.2
D ₁₀	0.35mm
D ₃₀	0.49mm
D ₆₀	0.61mm
C _u	1.74
C _c	1.124
Sand type	Uniformly graded
Specific gravity	2.65
Maximum Density (kN/m ³)	14.96
Minimum Density (kN/m ³)	14.45
Angle of internal friction ($\gamma_d = 1.445$ g/cc)	30°
Angle of internal friction ($\gamma_d = 1.496$ g/cc)	34°

2.2.2 Geogrid

Geogrids forms a separate type of geosynthetics designed for reinforcement. Geogrids 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 sand.

2.2.3 Test tank

For cohesion less soil, the maximum extension of failure zone will be 2.5 times of the footing width along the side and 3 times the width of footing below the footing. Keeping the above criteria in mind the tank dimension 60cmx60cmx30cm as shown in fig 3.2 has been used for 10cmx10cmx10mm footing during experimental work. The tank is made up of 12mm thick wooden plate, horizontal bracings of 6mm thick flat are provided on the all four sides of tank to prevent bulging of side during experimental work.

2.3 EQUIPMENTS USED

2.3.1 Hydraulic jack

A hydraulic jack uses hydraulic power. Jacks are usually rated for a maximum lifting capacity (1.5 tons or 3 tons).



Fig 2 Hydraulic jack

2.3.2 Proving ring

Proving ring of 50kN is used during experiment to measure the applied load on the foundation during the experimental work. Top of proving ring is attached with the movable shaft of static loading unit while the bottom is in contact with the metallic ball which is resting on the footing. When load is applied, the load is transmitted from proving ring to the footing via this metallic ball.

2.3.3 Dial guage

Two number of dial gauge which can measure settlement up to 25mm with least count of 0.01mm is used during the experimental work. Needle of the dial gauge is placed on the two diagonally opposite corner of the footing.

2.3.4 Model footing

Model footing of thickness 10mm made up of mild steel is used for experimental work. A 1cm deep circular groove is made to hold the metallic ball on one face of the footing at centre.



Fig 3 Mild steel model footing

3. METHODOLOGY

3.1 Placement of sand

Internal dimension of the test tank is measured and weight of sand to fill the tank up to a specified height is calculated using working density of 1.46gm/cc. Now sever trials are made to discover the height of fall of sand by allowing the sand to fall from different height to filling the tank up to desired height. After filling the tank up to desired height using raining technique, density of sand filled in tank for different trials is calculated. Height of fall for which the density is same as working density is taken for sample preparation. After finding out the height of fall, weight of sand require for 2.5cm thick layer to maintain the working density is taken and poured into the tank from specified height of fall using sand raining technique. Each layer is levelled using level plate to check whether the density is maintained properly or not. For the preparation of reinforced sand sample, geogrid is placed at desired depth from bottom of footing after levelling the surface to make it horizontal.

3.2 Placement of Geogrid

In case of reinforced sand bed, it is very essential to decide the magnitude of u / B and b / B to take the maximum advantage in bearing capacity of reinforced sand. After

going through several literature, it has been found that $(u/B)_{cr}$ for strip foundations vary between 0.25 and 0.5, $(b/B)_{cr}$ is 8 and 4.5 for strip footing and square footing respectively and $(h/B)_{cr}$ lies between 0.25 to 0.4. By keeping the above factor in mind, for this test these factors are fixed as $(u/B) = 0.35$, $(b/B) = 4.5$ & $(h/B) = 0.25$.

Since in this test, width of footing B is 10cm so width of geogrid b is taken as 4.5cm. The depth of first layer u from bottom of footing is taken as 3.5cm and distance between each consecutive layer h is taken as 2.5cm. During the sample preparation, square shaped geogrid of size 4.5cm has been taken and placed below the footing with first layer at the depth of 3.5cm and other layers with 2.5cm distance between two consecutive geogrid layer.



Fig 4 Placement of geogrid

3.3 Equipment Setup

After preparation of reinforced or unreinforced sample, footing is placed over the top of sand bed in such a way so that footing is parallel to the wall of test tank. Proving ring of desired capacity is attached with the cylindrical shaft of static loading unit and brought into contact with footing through metallic ball in between shaft and footing. Before making contact between shaft and footing, ensure that shaft is vertical. Two dial gauge of same specification is placed at the diagonally opposite corner of the footing.

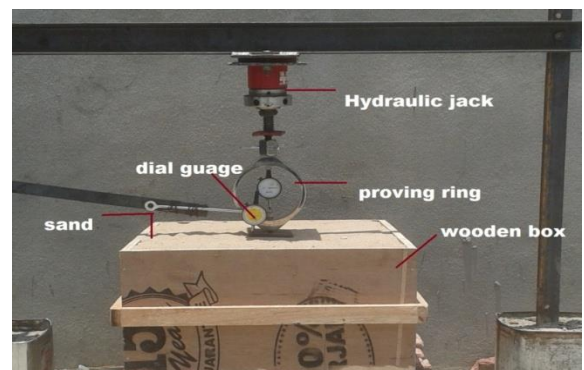


Fig 5 Equipment of setup

3.4 Model Test Procedure

The test is stress controlled, the load calculated in one step is applied on the footing and corresponding settlement is measured by taking reading of dial gauge fitted at corner of footing. After taking the reading on proving ring and dial gauge, load applied is calculated by multiplying the number of division on proving ring by its least count and corresponding settlement is calculated by multiplying the dial gauge reading by its least count i.e. 0.01. Now the load-settlement curve is drawn and using double tangent method, experimental bearing capacity is extracted.

4. RESULTS AND DISCUSSIONS

Curve of pressure versus settlement is plotted and q_u is found by back tangent method as shown in below graph.

4.1 Without reinforcement

Density 14.45kN/m³

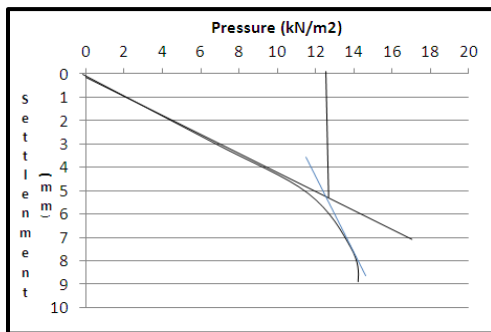


Chart 1 Pressure vs Settlement for density 14.45 kN/m³

The ultimate load bearing capacity is 12.2 kN/m² with settlement 5.2 mm. The ultimate load bearing capacity obtained from Terzaghi equation is 11.42 kN/m², the variation is 8%. Hence the load bearing capacity can be calculated in laboratory.

Density 14.96 kN/m³

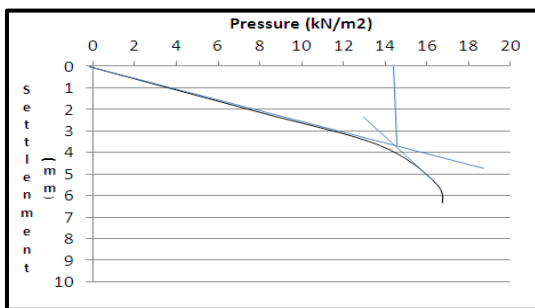


Chart 2 Pressure vs Settlement for density 14.96kN/m³

The ultimate load bearing capacity is 14.1 kN/m² with settlement 3.8mm. The ultimate load bearing capacity obtained from Terzaghi equation is 14.96 kN/m², the variation is 6%, and the bearing capacity increases with increase in density and reduces settlement.

4.2 With reinforcement

Density 14.45kN/m³ and u/b=0.2

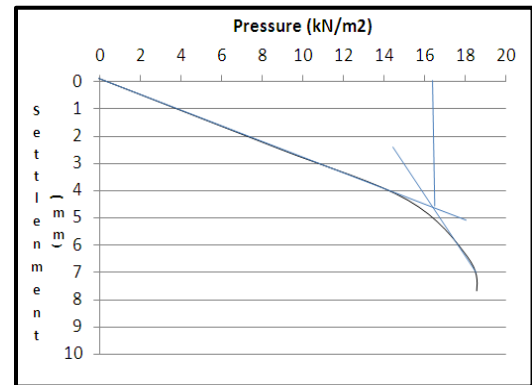


Chart 3 Pressure vs Settlement for density 14.45 kN/m³ with u/b=0.2

The ultimate load bearing capacity is 16.2 kN/m² with settlement 4.5 mm. The bearing capacity increased by 32% when compared to unreinforced sand.

Density 14.45kN/m³ and u/b=0.4

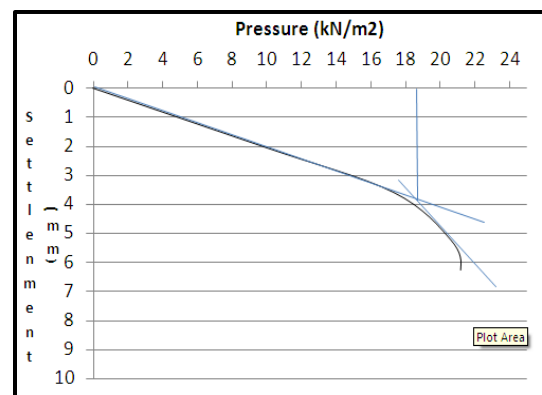


Chart 4 Pressure vs Settlement for density 14.45 kN/m³ with u/b=0.4

The ultimate load bearing capacity is 18.45 kN/m² with settlement 3.8 mm. The bearing capacity increased by 51% when compared to unreinforced sand.

Density 14.45kN/m³ and u/b=0.6

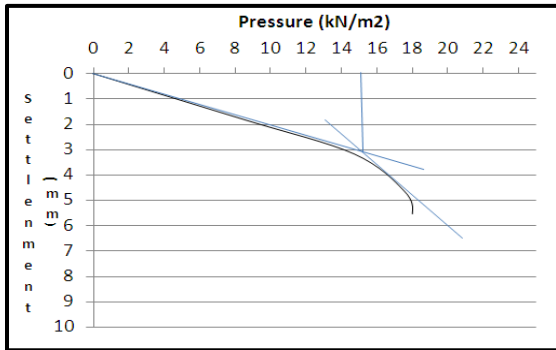


Chart 5 Pressure vs Settlement for density 14.45 kN/m³ with u/b=0.6

The ultimate load bearing capacity is 15 kN/m² with settlement 3 mm. The bearing capacity increased by 22% when compared to unreinforced sand. But the value is less than u/b=0.4.

Density 14.96 kN/m³ and U/b=0.2

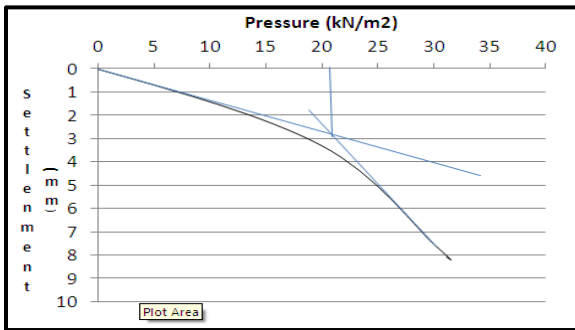


Chart 6 Pressure vs Settlement for density 14.96kN/m³ with u/b=0.2

The ultimate load bearing capacity is 21 kN/m² with settlement 2.8mm. The bearing capacity increased by 49% when compared to unreinforced sand.

Density 14.96 kN/m³ and U/b=0.4

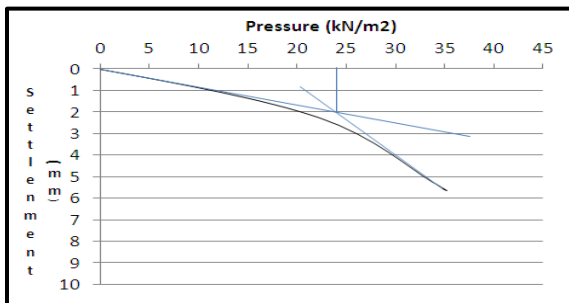


Chart 7 Pressure vs Settlement for density 14.96kN/m³ with u/b=0.4

The ultimate load bearing capacity is 24 kN/m² with settlement 2 mm. The bearing capacity increased by 70% when compared to unreinforced sand.

Density 14.96 kN/m³ and U/b=0.6

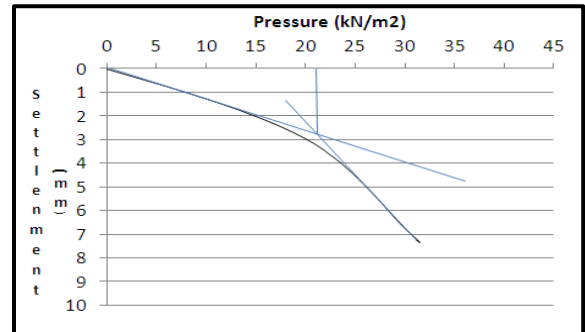


Chart 8 Pressure vs Settlement for density 14.96kN/m³ with u/b=0.6

The ultimate load bearing capacity is 22kN/m² with settlement 2.8 mm. The bearing capacity increased by 56% when compared to unreinforced sand. But the value is less than u/b=0.4. Hence concluded that optimum u/b value is 0.4

5. CONCLUSION

- The ultimate load bearing capacity can be calculated in the laboratory.
- The load carrying capacity (q_u) of the square footing in case of un reinforced sand increases with the increase in the density of the soil medium, it further increases with the inclusion of geo-grid reinforcement.
- The values of load carrying capacity q_u are increases up to U/B ratio 0.4 and afterwards decreases.
- Use of the geo-grid reinforcement leads to better performance from the point of view of q_u improvement as well as settlement reduction.
- The result of ultimate bearing capacity for reinforced sand is greater than unreinforced sand bed.

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