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Ultimate Bearing Strength on Rectangular Footing Resting Over Geogrid Reinforced Sand Under Eccentric Load

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ABSTRACT
There is number of works has been carried out for the evaluation of an ultimate bearing strength of shallow foundation, supported over geogrid reinforced sand and subjected to load on center. Some experimental has been study for calculation of the bearing strength of shallow foundation on geogrid reinforced sand under eccentric loading. However that the studies for strip footings. The main purpose of the research work is to conduct model tests under the laboratory with utilizing rectangular surface foundation rest over the reinforced sand. The true bearing capacity of eccentrically loaded rectangular footing resting over geogrid reinforced sand can be determined by knowing the ultimate bearing strength of rectangular footing resting over reinforced sand bed and subjected to central vertical load with using reduction factor (R kR). An equation for reduction factor for rectangular footing resting over geogrid reinforced sand is developed on based of the laboratory model test results

KEY WORDS: *Ultimate Bearing Strength, Eccentric Load, Reinforced Sand Bed.*

INTRODUCTION
Foundation is the lower part of any structure, but very important part of any structure whether it is onshore or offshore structure. That part which receive very big amount of load from superstructure and transmitted the load on the foundation. Therefore the foundation should be strong enough to sustain the load of superstructure. The work of the structure is usually depends on the work of the foundation. Since it is very important part, so it should be designed well. The main problem of True bearing capacity is solved with help of both analytical experimental work. The first one can be calculate using theory of plasticity or finite element method, and the second is reached by performing laboratory test model, the literature survey of the subject shows that the majority of the ultimate bearing capacity theories involve centric vertical load of the rectangular footing. On the other hand if the load is eccentric, the stress distribution below the footing will be no uniform causing unequal settlement at two edges which will result in the tilt of footing. The title will rise with rise eccentricity to width ratio (e/B). The ratio of eccentricity to width (e/B) is greater than 1/6, the edge of the footing away from load is lose its contact with the soil which will result on the reduction of the effective width of footing and hence reduction of true bearing strength of foundation. Researchers are introducing reinforcing material like metal strip, geophone, geotextile and geogrid to enhance the true bearing strength on foundation.

EQUIMENTS AND MATERIALS
The basic purpose of this research is to discover the bearing capacity of reinforced sand bed. Tenser Biaxial geogrid is used to reinforce the sand. Test tank of dimension 1 X 0.504 X 0.655 m is used to prepare for sand bed.

MATERIAL
SAND
1. Sample Collection: It is sand used for the research work is collected from near by jammu (Tavi River). That sand is wash and it use for free from of soil, grass roots, and another organic materials and then the wash specimen is dried in oven.
2. Characteristics of Sand: All the practically work are conducted at same relative density of 69%.

The overall average unit weight of sand on the relative density is 1.46g/cc and internal friction angle is find out to be 40.9^0 by shear direct test of the relative density.

Table.1: Geotechnical Property of Sand

Property	Value
Specific gravity (G)	2.64
Effective particle size (D_{10})	0.33mm
Mean particle size (D_{50})	0.455mm
(D_{60})	0.47mm
(D_{30})	0.42mm
Coefficient of uniformity (C_u)	1.424
Coefficient of curvature (C_c)	1.137
Maximum unit weight	14.87 kN/m^3
Minimum unit weight	13.42kN/m^3
Angle of internal friction (□degree)	40.9^0
Maximum void ratio (e_{max})	0.929
Minimum void ratio (e_{min})	0.741

GEOGRID

The shap of geogrids is the separate type of geosynthetics designed for reinforcement. Geogrids is the categorized by a relatively high tensile strength and a same distributed group of big openings in between longitudinal and transverse rib. The openings are known aperture. That openings allow sand particle on both side of the mounted geogrid to come on the direct contact which rise the interaction between the geogrid and sand.. On the base of strength direction, geogrids is classified like Uniaxial and Biaxial while classified like Rigid and Flexible basis on rigidity. In present studyg geogrid is used to model test is biaxial flexible geogrid whose physical characteristics is shown in Table 3.2.

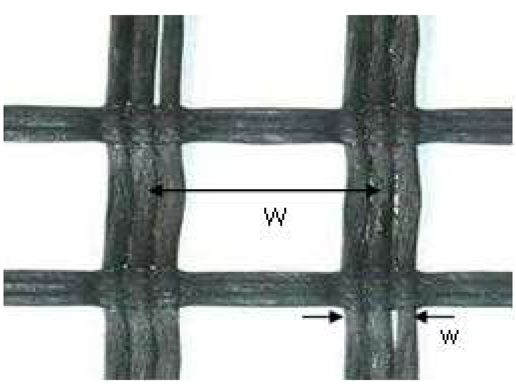

Figure 1 Flexible Geogrid

Table2. Properties of the geogrid

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%

TEST TANK

The size of the tank is made up on the base of IS code and from the result of some literature. IS 1888-1962 said that lowest size shell be at least 5 times the wide of test plate to develop the full failure zone without any interference to side. Due to the tank size, there is some scale effect which will influence the ultimate bearing strength of footing resting over geogrid reinforced bed sand. factor (*RKR*) is reduction factor is defined as:

$$\left(1-\frac{quR\ (e)}{quR(e=0)}\right)$$

Where *q uR(e)* and *q uR(e=0)* are the ultimate bearing strength of reinforced bed sand under eccentric and centric loading respectively.

EQUIPMENT USED

STATIC LOADING UNIT

A hydraulically operated static loading unit is used to apply the load over the foundation during test. The shaft is supported with horizontal beam which supply the reaction on the shaft during application of load.

PROVING RING

Proving ring of 20kN, 25kN, 50kN & 100kN are use during practically work to measure the actual applied load over the foundation during the practicallyt work. The top of proving ring is connected with the movable shaft of static loading unit on the other hand the bottom is in connected with the metallic ball which is resting over the footing

DIAL GAUGE

Two number of dial gauge which is east to measure settlement up to 50mm with least count of 0.01mm is used during the practically work. Needle of the dial gauge is placed over the two diagonally at adjacent corner of the footing. Magnetic basis which is supported with test tank is used to support the dial gauge.

MODEL FOOTING

The thickness of Model test footing 3cm made up of mild steel are used for experimental work. A 1cm deep circular grove is made to hold the metallic ball on one face of the footing at center and an eccentricity of 0.05B, 0.1B & 0.15B from the centre of the alone footings. Sand is use while the side of footing with the helped of epoxy glue to make it rough therefore that friction in between foundation and foot of soil can developed on application ofload

MODEL TEST AND METHODOLOGY

To study the bearing strength of eccentrically loaded foundation, laboratory model test are performed over rectangular footing resting on bed sand reinforced with numbers of layers geogrid. Model test has performed over sand remolde on one density, foot and aneccentricity varied from 0 to 0.15B and number of reinforcement varied as 0, 2, 3 & 4

PLACEMENT OF GEOGRID

On the case of reinforced sand bed, it is an essential to decide the magnitude of u/B and b/B to take the more benefit in the bearing strength of reinforced sand. After then through many 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 foot respectively and *(h/B)cr* lies between 0.25 to 0.4.

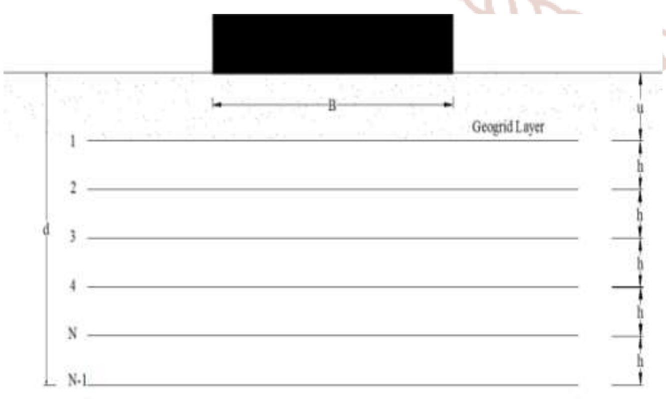

Figure 4.1 Cross-section showing sand bed and multiple number of reinforcement

Figure 4.2 Placement of geogrid during experiment.

RESULTS AND ANALYSIS

Load tests have been completely on model rectangular of size footings like 10cmx18cm and 9cmx28cm resting over unreinforced as well as reinforced sand bed with eccentricity varying from 0.0 to 0.15B. The true bearing capacity for each test is determined from load settlement curve using tangent intersection method.

BEARING STRENGTH OF UNREINFORCED SAND

MODEL TEST RESULT

Results of load test have been draw in term of load settlement curve as shown in Figure 5.1 and 5.2 for footing size 10x18 cm (B/L=0.55) and 9x28 cm (B/L=0.32 respectively. From graph, it is observed that true bearing capacity less like eccentricity width ratio (e/B)and also increases in the total settlement at failure load decreases as eccentricity width ratio (e/B) increases. By compare the graph shown in Figure 5.1 and 5.2, it can also be concluded that the Ratio of width to length (B/L) decreases, load carrying capacity of footing increases

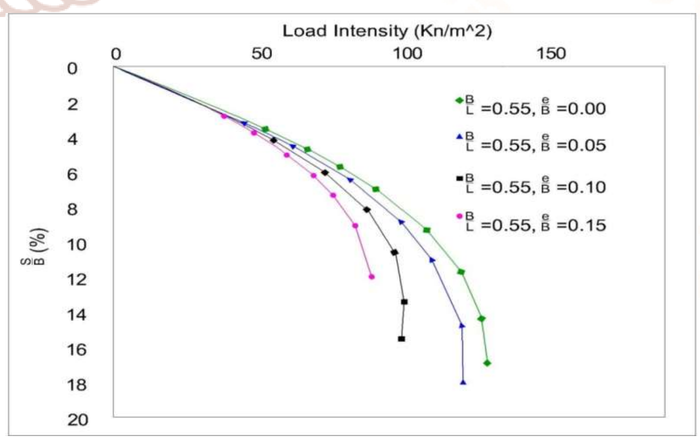

Figure4. Load-settlement curve of bed unreinforced sand bed (B/L=0.55)

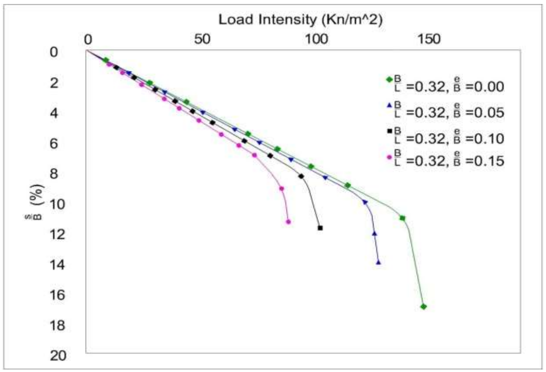

Figure5 Load-settlement curve of unreinforced sand bed (B/L=0.32)

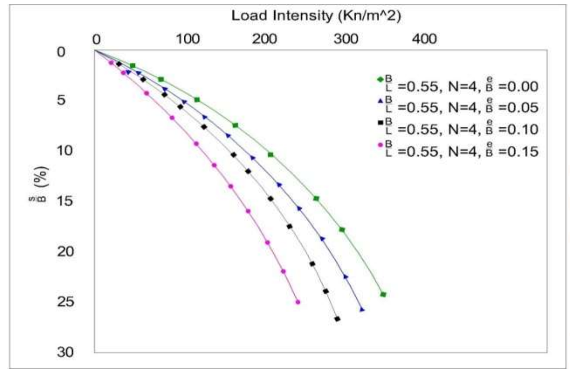

Figure 8 Load-settlement curve for B/L=0.55 & N=4 and different e/B ratio

BEARING STRENGTH OF GEOGRID REINFORCED SAND

MODEL TEST RESULT

The Laboratory model tests have been preform with using rectangular foot with B/L=0.55 & 0.32 resting over the geogrid reinforced sand. This sand is reinforced by place multilayer (N=2, 3, 4) geogrids with *df/B* ratio equals to 0.6, 0.85 & 1.1, where *df*is the depth of lower most geogrid layer from bottom of footing and *B* is the width of footing. Thae load is applied centrally as well as eccentrically on the model foot use static loading machine. The Settlement corresponding to each load increment have been write down and load settlement curve have been plotted.

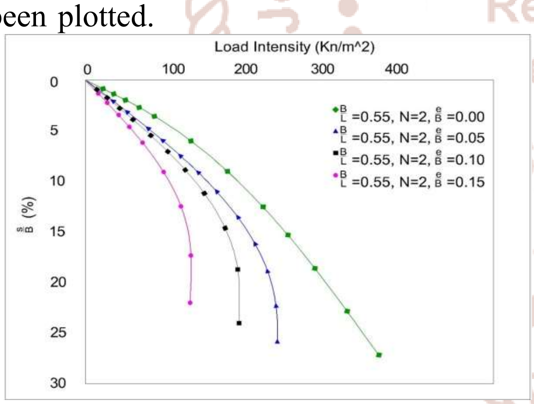

Figure6. Load-settlement curve for B/L=0.55 & N=2 and different e/B ratio

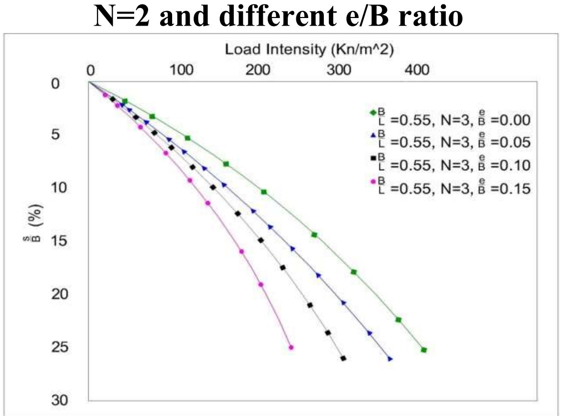

Figure7. Load-settlement curve for B/L=0.55 & N=3 and different e/B ratio

SUMMARIZED RESULTS AND SCOPE OF FUTURE WORK

There is a number of laboratory model tests has been conducted to find the ultimate load bearing capacity of rectangular model footings resting on geogrid reinforced sand and subjected to vertical an eccentric load. All the tests has been conducted for footing resting over the surface.

Following is the summarized results of present research work.

- An ultimate bearing strength of the foundation for un-reinforced and reinforced soil decreases with the increase in eccentricity ratio i.e. *e/*B.
- An ultimate bearing strength of the foundation increases with the increase in number of reinforcement layer.

Reduction factor for the footing with B/L=0.55 & 0.32 has been derived alonely and then combined toget a simple general equation to reduction factor for rectangular footing as shown in Equation 5.11.

SCOPE OF FUTURE WORK

On the present study the research work is related to ultimate bearing strength of eccentrically loaded rectangular footing with B/L = 0.55 & 0.32 resting on reinforced sand bed. During time constraint, another aspects similar to shallow foundations can not be studied. The work for should consider the below mentioned points:

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