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Experimental and Numerical Analysis of Load Carrying Capacity of Ring Footing on Sand Reinforced with Geonet

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ABSTRACT

Ring footings are usually used for symmetrical buildings such as bridge piers, transmission towers, water storage tanks, chimneys, television antennas, silos. Compared with other footings less studies are done related to ring footings. The use of ring footing decrease the amount of material, less self weight and is more economical. This paper deals with experimental and numerical investigation of load carrying capacity of ring footing resting on geonet reinforced sand. Model ring were made and test were done on both reinforced and unreinforced sand. The parameters considered in the study are depth and number of layers of geonet. Both experimental and numerical study showed that the inclusion of geonet in sand causes significant increase in the load carrying capacity. The increase in load carrying capacity and reduction in settlement depends upon the depth and the number of layers of reinforcement. The numerical analysis is done in Plaxis3D.

***Keywords*—** Ring footing, geonet, sand, Plaxis3D

I. INTRODUCTION

Ring footings are used to support axisymmetrical structures such as bridge piers, transmission towers, water storage tanks, chimneys, television antennas, silos. In axisymmetric structures, ring footing supports the columns or walls, they are normally circular in plan. The load carrying capacity of strip footing has been extensively studied for many decades. However less studies have been done related to the ring footing. A few experiments have also been performed to determine the load carrying capacity of ring footing. The use of ring footing decrease the amount of material, less self weight and is more economical. Previous studies showed that ring footing with inner to outer diameter ratio 0.4 gives high load carrying capacity. For improving the properties of soil variety of materials are used for reinforcement. The technique of using reinforcement in soil is one of the most important economical solutions compairing to the deep foundations. In this study geonet is used for reinforcing the soil.

This paper deals with the effect of geonet reinforcement on the load carrying capacity of ring footing under axial concentric load. Both experimental and numerical analysis were done on footing. The numerical analysis were done in Plaxis 3D.

II. MATERIALS

Laboratory model test were carried out to determine the load carrying capacity of ring footing on unreinforced and reinforced sand using geonet. Various materials used are given below.

1. SAND

Locally available river sand were used for the test from kottayam.

TABLE I
PROPERTIES OF SAND

SAND PROPERTIES	VALUES
Specific Gravity	2.67
Cu	6.67
Cc	2.96
Direct Shear	Φ=36
Relative Density	50%
Height of Fall	32cm

2. GEOTEXTILE

Inorder to provide reinforcement material for model test, geonet is used. it has good tensile strength and it is easy to handle.

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Fig. 1. Geonet

III. EXPERIMENTAL SETUP

TEST SET UP

The test set up mainly consist of a test box to which steel channel frame, loading frame, shaft, proving ring , dial gauges are attached. According to IS 1888-1982 Method of load test on soils, lateral dimension of tank should be 5 to 9 times of the width of the footing The rectangular steel test box is of size 600mmx600mmx550mm.After the preparation of sand bed and model footing is placed, vertical load is applied. The vertical load is applied by rotating the shaft attached to the loading frame. The load was applied using a manually operated loading device that gives an axial concentric load. The load was measured using a calibrated proving ring. The calibrated proving ring had a load capacity of 2 KN. The corresponding displacement of footing is measured using two dial gauges which had a least count of 0.01mm.

Fig. 2. Model test tank

MODEL FOOTINGS

Model ring footing made of mild steel with an outer diameter 80mm, inner diameter 32mm,thickness 12mm have been considered. Since the outer to inner diameter ratio was 0.4.To simulate the overhead structures on footing, four steel columns of height 80mm is welded to a circular plate of 12mm thickness and is placed over the footing.

Fig. 3. Model ring footing

WORK PLAN

In this study after placing footing on the sand bed, reinforcement is placed at different depths and at various number of layers. The axial concentric load is applied on ring footing on unreinforced and reinforced condition. Load is applied and corresponding failure load is noted. Failure load corresponding to 25mm settlement is noted. Corresponding load settlement graph is plotted. Then the experimental result is verified by numerical analysis. The numerical analysis is done by Plaxis 3D.

IV. EXPERIMENTAL RESULTS

For the experimental analysis, test tank is modelled, sand is filled in the tank and footing is placed and reinforcement is placed, reinforcement is placed on the basis of depth and number of layers. Based on various studies, reinforcement is placed at a depth of 0.25 to 0.5 times the width of the footing and width of the reinforcement should be 2.5 to 5 times the width of footing. In this study the depth chosen is 0.45 times the width of the footing and width of reinforcement chosen is 4.5 times the width of the footing. Then load is applied and corresponding failure load is noted corresponding to 25mm settlement. Then load settlement graph is plotted.

TABLE II
EXPERIMENTAL RESULTS OF RING FOOTING

	RING FOOTING
Unreinforced	0.47
Reinforcement in 3.6cm	0.67

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depth	
Reinforcement in 7.2cm depth	0.62
Reinforcement in 10.8cm depth	0.6
Reinforcement in 14.4cm depth	0.58
reinforcement in 3.6cm and 7.2cm depth	0.97
Reinforcement in 7.2cm and 10.8cm depth	0.9
Reinforcement in 10.8cm and 14.4cm depth	0.78
Reinforcement in 3.6cm, 7.2cm, 10.8cm	1.21
Reinforcement in 3.6cm, 7.2cm, 10.8cm, 14.4cm	1.17

The above table shows the experimental results of ring footing. From the above table, it is clear that there is increase in the load carrying capacity with the inclusion of reinforcement than unreinforced condition in case of ring footing.

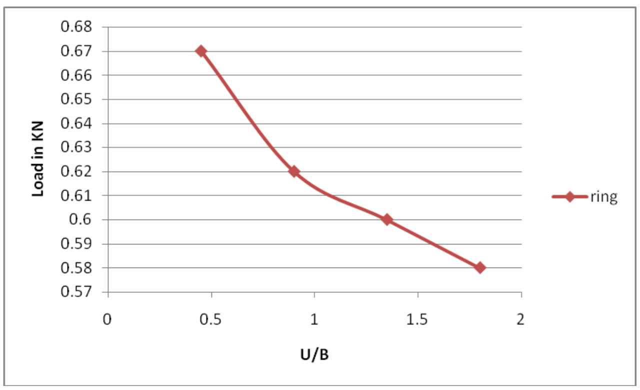

Fig. 4. Load vs U/B for single layer

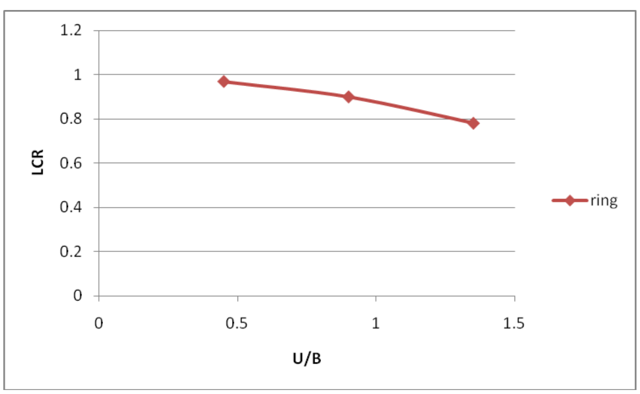

Fig. 5. Load vs U/B for double layer

The above graphs are plotted with load vs U/B, in case of single and double layer of reinforcement and it is clear that, as the depth increases the load carrying capacity decreases. The load is more for the footing with reinforcement near to the footing .The increase in the load carrying capacity with the inclusion of reinforcement is because the reinforcing material interact with the particles present in the soil through the function of interlocking. Due to this interlocking the load carrying capacity is increasing.

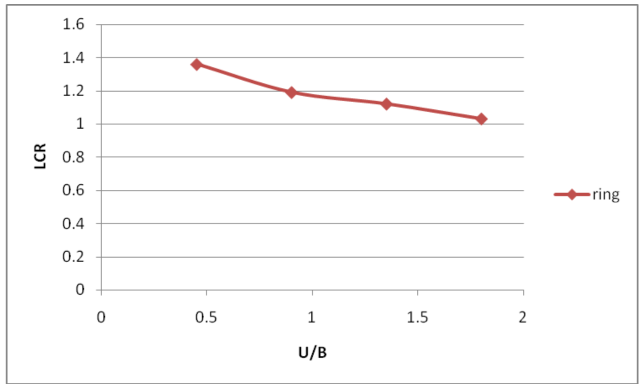

Fig. 6. LCR vs U/B for single layer

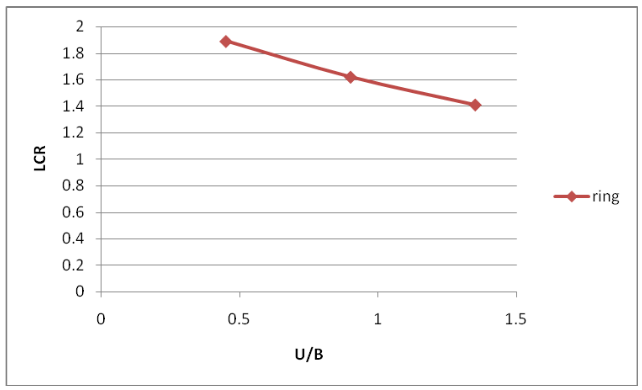

Fig. 7. LCR vs U/B for double layer

Load carrying capacity ratio (LCR) is defined as the ratio of load carrying capacity of reinforced sand bed and unreinforced sand bed. From the above graphs it is clear that, for single and double layer of reinforcement the BCR decrease with increase in U/B ratio as in case of the footing.

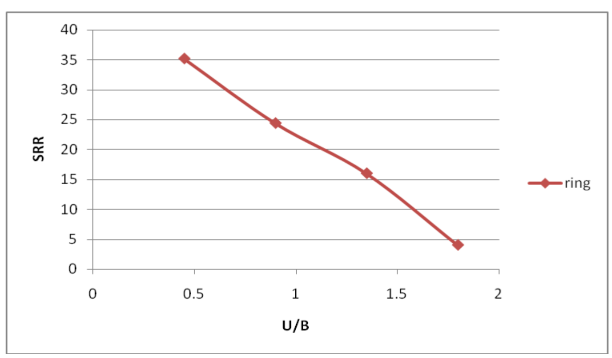

Fig. 8. SRR vs U/B for single layer

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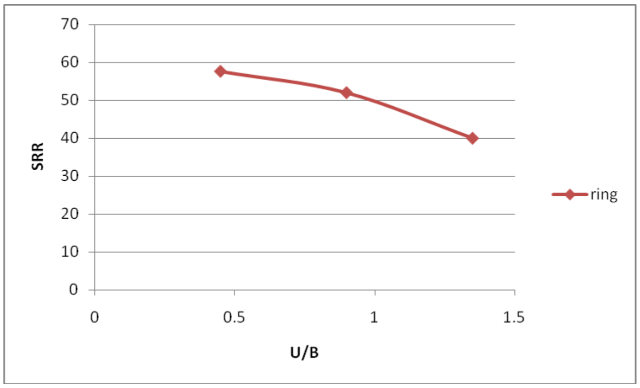

Fig. 9. SRR vs U/B for double layer

Settlement reduction ratio (SRR) is defined as the ratio of unreinforced load minus reinforced load divided by unreinforced load. SRR also decreases with increase in U/B ratio in case of the footing.

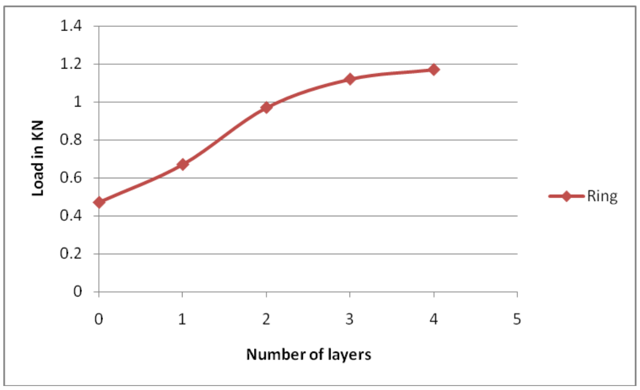

Fig. 10. Load vs Number of layers

Number of layers plays important role in the load carrying capacity. The load carrying capacity increases with increase in number of layers, this is due to the high stiffness and confinement for the reinforced region.

V. NUMERICAL ANALYSIS

The experimental results is verified by numerical analysis. In this study the numerical analysis is done in Plaxis 3D.

Ring and circular footing is analysed in Plaxis 3D. The ring footing is analysed in unreinforced condition and also in reinforced condition by varying reinforcement at different depth and in number of layers. The model ,mesh figures are given below in both reinforced and unreinforced condition.

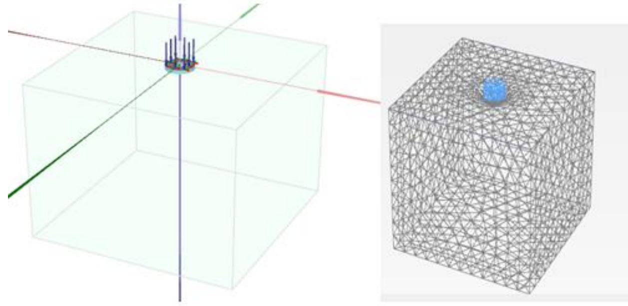

Fig. 11. Ring footing unreinforced model and deformation

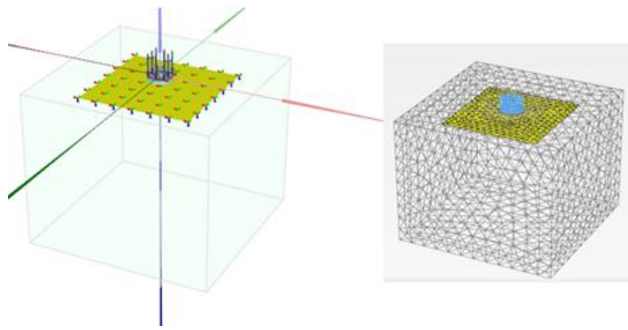

Fig.12. Ring footing reinforced single layer model(3.6cm) and deformation

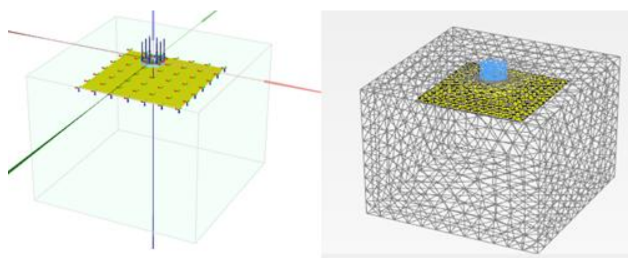

Fig.13. Ring footing reinforced single layer model(7.2cm) and deformation

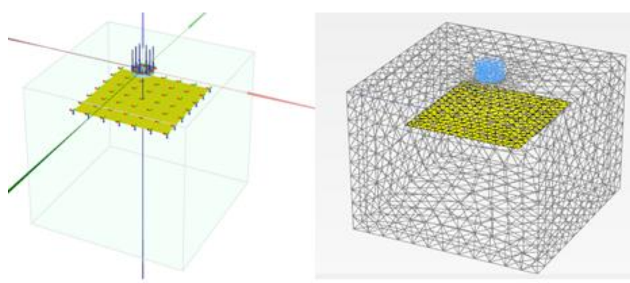

Fig.14. Ring footing reinforced single layer model(10.8cm) and deformation

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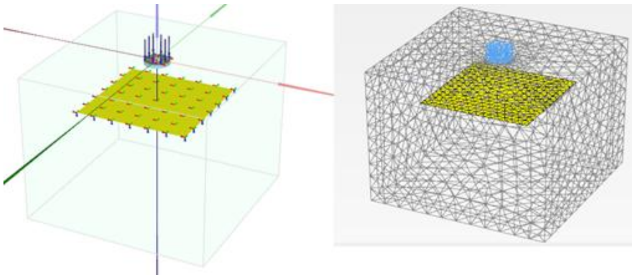

Fig.15. Ring footing reinforced single layer model(14.4cm) and deformation

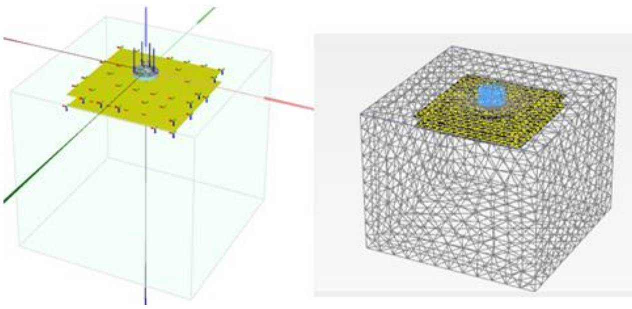

Fig.16. Ring footing reinforced double layer model (3.6cm,7.2cm) and deformation

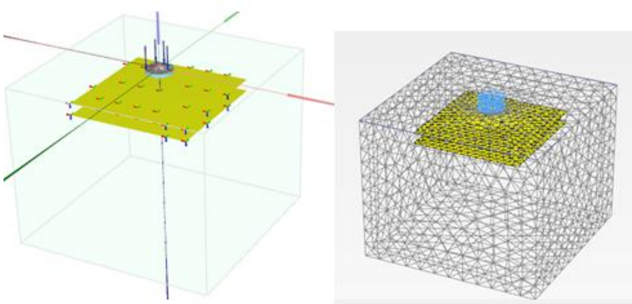

Fig.17. Ring footing reinforced double layer model (7.2cm,10.8cm) and deformation

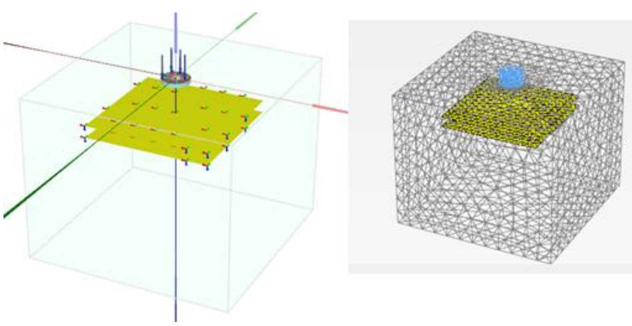

Fig.18. Ring footing reinforced double layer model (10.8cm,14.4cm) and deformation

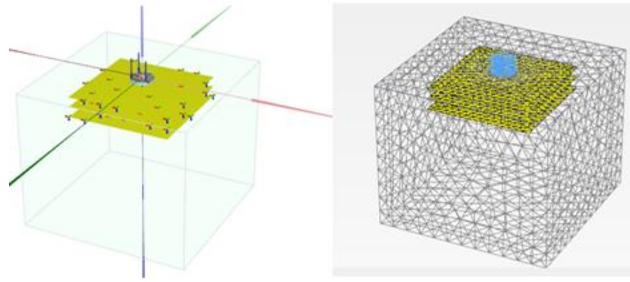

Fig.19. Ring footing reinforced three layer model(3.6cm,7.2cm,10.8cm) and deformation

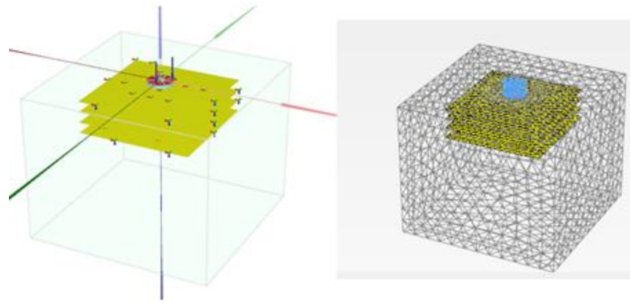

Fig.20. Ring footing reinforced four layer model(3.6cm,7.2cm,10.8cm,14.4cm) and deformation

Table III
EXPERIMENTAL AND NUMERICAL RESULTS OF RING FOOTING

	Experimental	Numerical
Unreinforced	0.47	0.42
Reinforcement in 3.6cm depth	0.67	0.6
Reinforcement in 7.2cm depth	0.62	0.58
Reinforcement in 10.8cm depth	0.6	0.58
Reinforcement in 14.4cm depth	0.58	0.53
reinforcement in 3.6cm and 7.2cm depth	0.97	0.92
Reinforcement in 7.2cm and 10.8cm depth	0.9	0.86
Reinforcement in 10.8cm and 14.4cm depth	0.78	0.72
Reinforcement in 3.6cm, 7.2cm, 10.8cm	1.21	1.03
Reinforcement in 3.6cm, 7.2cm, 10.8cm, 14.4cm	1.17	1.1

VI. CONCLUSION

Ring footing is analysed experimentally and numerically. In the analysis, As the number of reinforcement increases the load carrying capacity also

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increases. As the depth increases, the load carrying capacity decreases. In case of single or double layer of reinforcement, as the U/B ratio increases the load decreases. In case of single or double layer of reinforcement, as the U/B ratio increases the Load carrying capacity ratio (LCR) decreases. In the case of single or double layer of reinforcement as the U/B ratio increases the settlement reduction ratio (SRR) decreases. Experimental results is verified using numerical analysis and from the above table it is clear that numerical and experimental results showed almost near values of load carrying capacity. As the ring footing have good load carrying capacity, its use is nowadays increasing is more economical, since less material is needed and has less self weight. Also it is clear that inclusion of reinforcement increases the load carrying capacity.

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