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Experimental investigation of Triangular Shell Foundation by varying Edge Beam dimension and Embeddment Ratio

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***Abstract:*-- Shell foundations derive their strength from their geometry rather than mass. This characteristic enables them to obtain maximum structural integrity with minimum consumption of materials. The shell footings are capable of supporting higher vertical loads, better load settlement characteristics and are economical in terms of material compared with the conventional footings. Here in this project a study on the load settlement behavior of triangular shell footing by varying edge beam dimensions and embedment ratio is carried out. An edge beam of dimensions 35mm, 45mm and 50 mm are used. The behavior of the same is analyzed by placing geotextile at different depths of 0cm, 25cm and 50 cm . Then the result obtained are compared with conventional flat slab footing. Plate load test is the important test used in this project. This study strengthen the case of triangular footings by confirming its superiority in the aspect of lower settlement characteristics.**

Index Terms:- Triangular shell footing, Embedment ratio , Edge beam dimension, Plate load test, Geotextile.

I. INTRODUCTION

Shell footings are those structure that derive their strength from it's geometry rather than mass. It provides three dimensional manifestation of the arch action. In case of structures resting on deep layers of soft clay, changing the bottom of foundation shape into shell shaped footing is a solution to avoid using deep foundation or other costly soil improvement techniques. Shell footings provide three dimensional manifestation of the arch action. There are different types of shell footings namely Triangular, Conical, Spherical, Hemispherical, Parabolic, Hyperbolic Paraboloid etc. Shell footings are broadly classified in to two types as Curved and Folded plate. Curved is further classified as singly curved and doubly curved and folded plates as upright and inverted(Fig 1)

Shells in modern foundation engineering are relatively new. Different types of shapes are employed in shell foundation eg Adel A Azzawi(2013),Bujang.B.K.Huat(2006). Earlier studies have established that the bearing capacity of shell foundations increases with increase in interface roughness and under shell,the bearing capacity increases with increase in cohesion and angle of interface values eg Nainan P Kurian(2005) . Pusadkar Sunil Shaligram(2011) stated that the geotextile layer shows increase in ultimate bearing capacity and decrease in settlement. The effect of embedment depth on the shallow foundation is found out by M Ashtiani(2012) and stated that the rupture mechanism of shallow foundation without embedment depth is different when the shallow foundation is embedded in ground.

Triangular shell footing is used in this project. The inverted triangular shell footing had higher load carrying capacity compared with other strip footing and it exhibit higher stress concentration in the edge part of shell footing eg B B K Huat(2007). Half shell angle influence much in the load carrying capacity of Conical shell footing eg Dr R Madheswaran(2017), J E Colmenares et al(2013)

From previous studies it have been stated the influence of peak angle on the load settlement characteristics. The smaller the peak angle , the higher will be the bearing capacity and lower the measured settlement eg Adel Hanna(1990). The effect of increasing the edge beam width as opposed to depth greatly improves the load bearing and settlement characteristics in Hyperbolic Paraboloid shell footing(HYPAR) eg Krishnan A V(2017)

This research was carried out to investigate load settlement behavior of triangular shell footing with and without edge beam at different embedment ratio by placing geotextile. The experiments are repeated in plane footing.

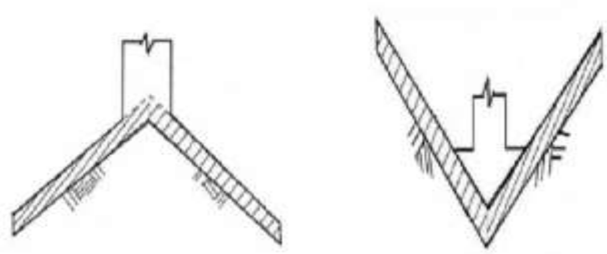

Fig. 1 Upright and inverted triangular shell footing

II. MATERIALS USED

Locally collected clean river sand was used in all the experiments as a soil medium (Fig 2). A triangular shell footing of size 160mm x 160mm x 120mm with thickness 30mm and angle 1000 was used in this study (Fig 3a). This represents the behavior of triangular shell footing as shallow footing. The model footings were triangular solid footing being solid mild steel stem having 40mm thickness.

Fig. 2 Sand

Sand is used in loose condition(Fig 3). Woven Geotextile of thickness 2mm (Fig 4) is used to provide reinforcement. Here the function is only to provide reinforcement. Hence woven geotextile is used. It is collected from local work site.

(a) **(b)**

Fig. 3 (a)Triangular shell footing with edge beam (b) Flat footing

Fig. 4 Woven Geotextile

Properties of Sand

Table. I Index properties of sands

Parameters	Value
Specific Gravity	2.60
Effective size, D10 (mm)	0.24
D30 (mm)	0.465
D60 (mm)	0.700
Uniformity coefficient, Cu	2.96
Coefficient of curvature, Cc	1.287
Gradation of sand	SP
Maximum density (g/cc)	1.698
Minimum density (g/cc)	1.440
Sand density (30% RD) (g/cc)	1.508
Sand density (50% RD) (g/cc)	1.558
Angle of internal friction (30% RD) (degree)	39
Angle of internal friction (30% RD) (degree)	45

III. EXPERIMENTAL PROGRAMME

The load settlement behavior of triangular shell footing of size 160mm x 160mm x 120mm is investigated using a laboratory model experiments. Experiments were done in a test tank of size 800 mm x800 mm x 900 mm, made up of steel sheet of thickness 5mm (Fig 5) Sand is filled in the tank in layers. Predetermined quantity of soil is filled in layers with a spacing of 50mm. Each layer was compacted to achieve the desired density. Triangular shell footing is placed in desired embedment depth and continue the filling of sand till it reaches the top of the footing and level the top surface of sand bed.

The axial The load was applied by means of a hydraulic jack which was clamped to the reaction frame and its hose was connected to the lever system. The load was applied to the top of triangular shell footing by using reaction frame through the hydraulic jack and proving ring. A calibrated proving ring of capacity 100 kN and dial guage of 25 mm capacity with sensitivity of 0.01 mm are used for measuring loads and displacement respectively. over which proving ring is connected in order to measure the applied load. A dial gauge is provided for the measurement of corresponding settlements. The test was started by applying load using hand operated hydraulic jack. The footing was loaded at a constant loading rate until an ultimate bearing state was reached. Triangular shell footing were fabricated with different edge beam of size 35mm,45mm,50mm.

The test is repeated for different embedment ratios and edge beam dimensions with or with out geotextile below footing at a depth of ocm,25cm and 50 cm. Same sets of experiments are repeated in the case of square footing of size 160mm x 160mm x120 mm(Fig 3b)

Fig. 5 Axial loading set up

IV. RESULTS AND DISCUSSIONS

A. Effect of Edge Beam Configurations on Load Settlement Characteristics

Axial load is applied at the top of the triangular shell footing for obtaining vertical behavior of triangular shell footing in sand. Then to evaluate the effect of edge beam dimensions, the edge beam dimension change as 35mm, 45mm, and 50 mm. The effect of modifying the edge beam has been shown to reduce the soil pressure and increase bearing capacity with increasing width of the edge beam in triangular shell footings (Fig. 6)

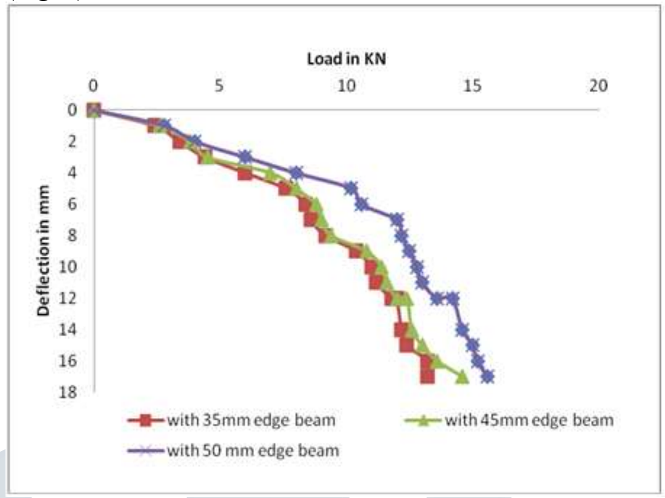

Fig. 6 Axial load-displacement graph of triangular shell footing with various edge beam dimensions

B. Effect of Varying Embedment Ratio on Load Settlement and Characteristics

It was observed that the load-settlement characteristics improved with increasing embedment ratio of both triangular shell footing (Fig.7) and plane footing (Fig.8). Embedment ratio of footing was changed as 0,0.5, and 1 to obtain the effect of embedment ratio on vertical load capacity. The values of triangular and plane footing is compared in Fig.9.

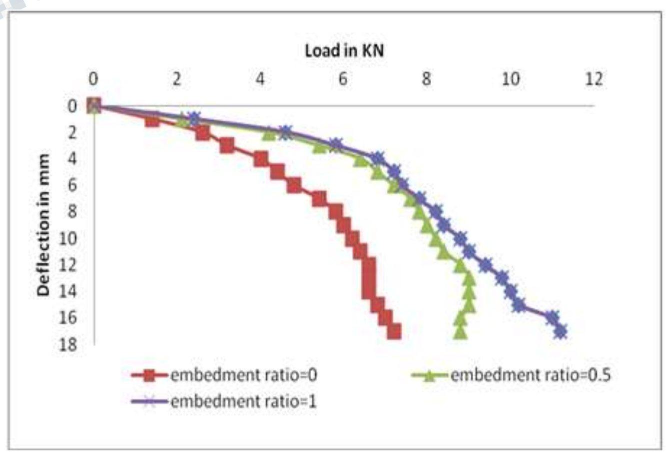

Fig. 7 Axial load-displacement graph of triangular shell footing with various embedment ratio

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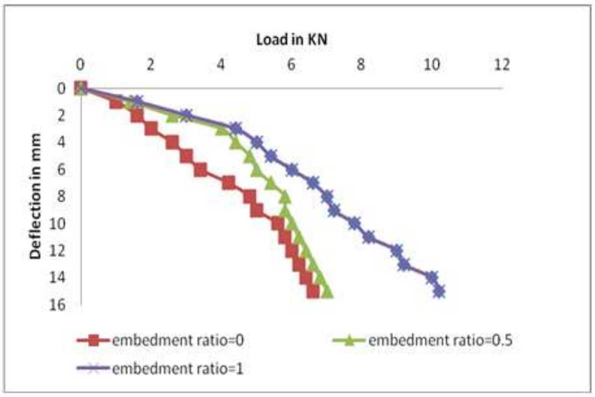

Fig. 8 Axial load-displacement graph of plane footing with various embedment ratio

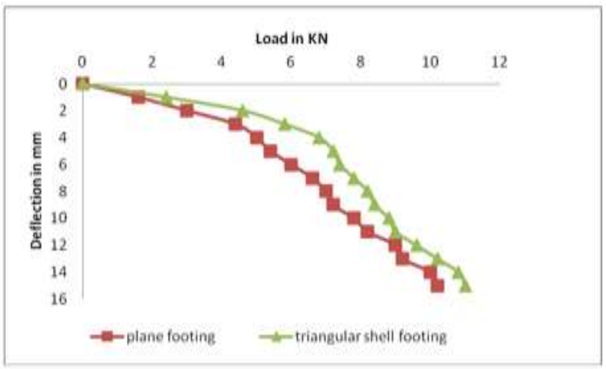

Fig. 9 Axial load-displacement graph of plane footing and triangular shell footing with embedment ratio=1

C. Effect of Varying depth of Geotextile

It was observed that the load-settlement characteristics improved by placing geotextile below the footing (Fig.10). At the position when geotextile is immediately below footing shows the best value. For all the five cases including plane footing the load settlement characteristic improved while placing geotextile.

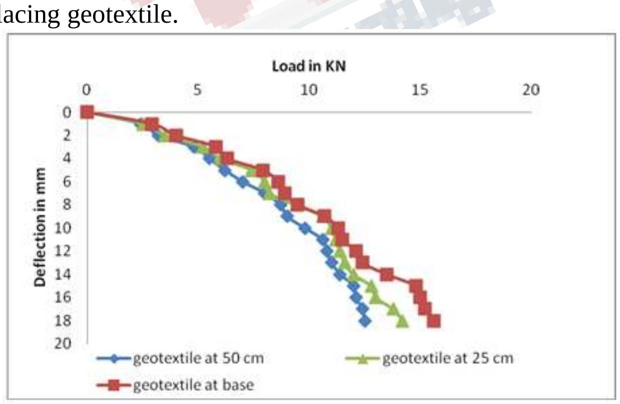

Fig. 10 Axial load-displacement graph of triangular shell footing with 35mm edge beam and embedment ratio=1,with geotextile

CONCLUSION

- Triangular shell footing has better load settlement characteristics than conventional flat footing in loose sand.
- Ultimate vertical load capacity is greater in case of triangular shell footing with edge beam than triangular shell footing without edge beam. Among them footing with edge beam size 50mm have more load carrying capacity.
- The load carrying capacity of triangular shell footing is maximum at an embedment ratio of 1.
- The condition at which geotextile is immediately below the footing shows higher load carrying capacity with lower settlement.

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