The International Journal Of Engineering And Science (IJES)
|| Volume || 4 || Issue || 1 || Pages || PP.22-26 || 2015 ||
ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805

Experimental Study of Load Bearing Capacity of Foundations with Different Vertical Cross-Sectional Shapes

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--ABSTRACT---
Results of experimental study of load bearing capacity and settlement of foundations with different vertical cross-sectional shapes are presented. Load-settlement relationships of three models of shallow foundations with different vertical cross-sectional shapes on three different modeled subsoil conditions were studied. Models of shallow foundations with rectangular, wedge and T shape vertical cross-sections were studied. The study shows that bulk of the load resistance of subsoil bases of shallow foundations with rectangular vertical cross-sectional shapes is mostly offered by the soil beneath the foundation base, while for those with wedge and T-shape vertical cross-sectional shape, both soils beneath the foundations bases and along their vertical stems, actively offers resistance to structural loads. This indicates that using foundations with wedge and T shape vertical cross-sections can help in the distribution of structural loads to less dipper soil strata, especially when stronger soil layers is underlain by weaker ones.

KEYWORDS*: Foundation shape; Load bearing capacity; Settlement; Soil base.*

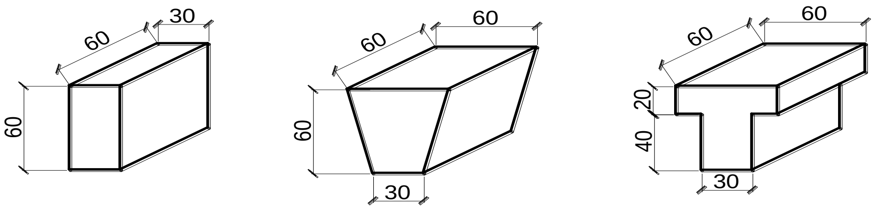
Date of Submission: 19 January 2015 Date of Accepted: 30 January 2015

I. INTRODUCTION

Load bearing capacity of foundation is a function of its dimension and shape, its embedment depth, physico-mechanical properties of the soil base and load geometry. Foundations are generally classified into shallow foundations and deep foundations. Shallow foundations are those types of foundations that transmit structural loads to the soil strata at a relatively small depth. Terzaghi [1] defines shallow foundation as that which is laid at a depth D_f not exceeding the width B of the foundation, that is $D_f/B\leq 1$. However, other research studies have shown that D_f/B can be as large as 3 to 4 for shallow foundations [2-4].Shallow foundations of various types/shapes are known, with strip, square, rectangular and circular shapes being the most widely used. These conventional shallow foundations types have different shapes which only vary from each other plan-wise or by horizontal cross-section. Their vertical cross-sectional shapes (depending on the design thickness) are basically the same. This makes the mode of their interaction with the soil bases vertically, basically the same. The interaction of foundations with soil bases is mostly studied using load-settlement relationship. Many studies [5-11], have been conducted on the effect of foundation shape on settlement and bearing capacity of soils. These past studies mostly considered the shape of the foundations plan-wise. The interaction of these shapes of foundations with the soil bases is such that the soil above their bases contributes to the resistance of the structural loads mostly by surcharging the soil below the base of the foundation. Therefore the study of other shallow foundations shapes, which can both partly distribute/resist structural loads vertically along their trunks and bases, is presented. V and T-shape foundations were considered along with the conventional rectangular shape foundations. This study is anchored on the fact that foundation supporting ground is usually a soil is, which is usually weaker than construction materials like wood, concrete, steel or masonry, and hence, compared to structural members made of these materials, a larger area or mass of soil is necessarily required in carrying the same load, and therefore foundations shape that will maximally achieve this are usually sort for.

II. EXPERIMENTAL METHODOLOGY

Three wooden models of shallow foundations, with the same base width but of different shapes vertically, were used for the study: the first model was a rectangular shaped block with dimension of *30x60x60* mm for width, length and height respectively; the second model was a wedge-shaped block of 60 mm height with width and length for top and lower sides as *60x60* mm and *30x60* mm respectively; and the third was a T-shape block of 60 mm height with width and length for top and lower parts as *60x60* mm and *30x60* mm respectively (fig. 1). The dimensions of the models were chosen so as to be within $D_f/B \leq 2$ (D_f and B are depth of foundation embedment and width respectively). Three subsoil conditions were modeled in a rectangular container with dimension *1100x600x250 mm* for length, height and width respectively.



a *b* *c*

a– rectangular shape; b– wedge-shape; c– T shape

Fig. 1: Foundation models

Clay soils were used in modeling the subsoil conditions as shown on figs2-4.The experimental stand was filled with the soils in layers of 25 and 50 mm, with each layer compacted to unit weight of 18 kN/m^3 and 17 kN/m^3 at moisture contents of 10 % and 20 % for the stiff and soft soil respectively. The foundation models were placed during placement and compaction of the last two upper layers as shown in fig. 2-4. Using 1:10 loading lever, loads were vertically, centrally and uniaxially applied to the foundations in an incremental manner, recording corresponding settlement for each load increment, using dial gauges of 1/100 mm division. Subsequent load increments were done when the rate of settlement from the previous loads becomes less than 0.02 mm/min. The results are presented graphically as load-settlement curves for the respective foundations under respective modeled subsoil conditions in figs 5-7.

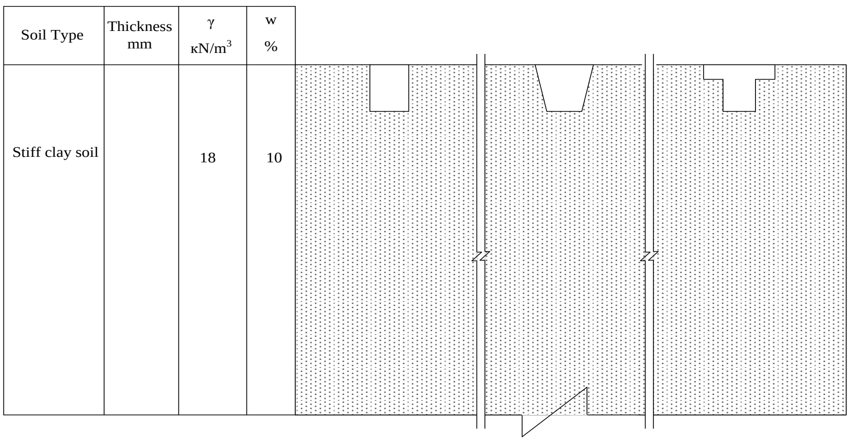


Fig. 2: First modeled soil condition

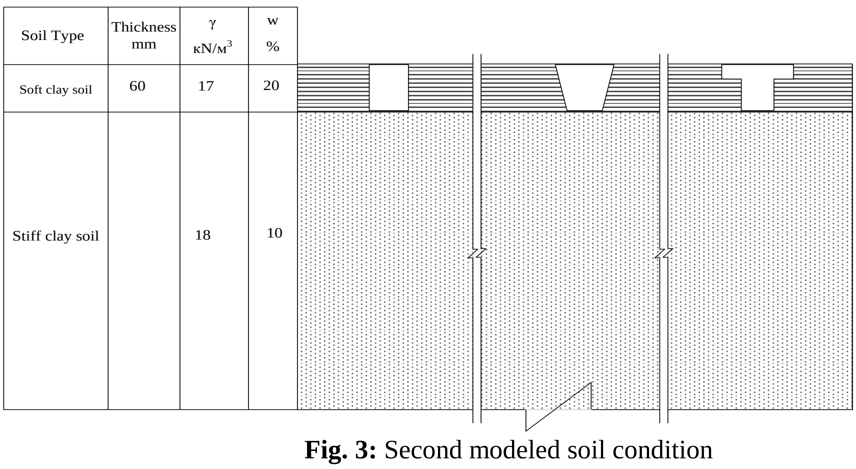


Fig. 3: Second modeled soil condition

Soil Type	Thickness mm	γ кN/м³	w %
Stiff clay soil	100	18	10
Soft clay soil	100	17	20
Stiff clay soil		18	10

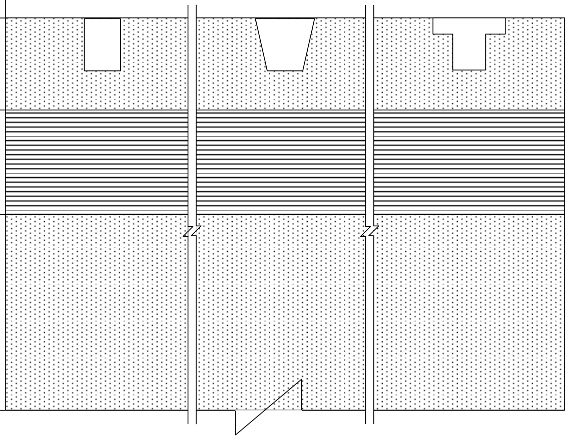


Fig. 4: Third modeled soil condition

III. EXPERIMENTAL RESULTS AND DISCUSSION

Results of load-settlement relationship for the foundations models on the first and second modeled subsoil conditions are shown in figs 5 and 6. From the figures, it is observed that the load bearing capacity of T-shape foundation is generally higher than those of rectangular wedge and shapes. The lowest load bearing capacity was observed with rectangular shape. The relatively higher load bearing capacity recorded with T and wedge shapes is attributed to additional resistance offered by the soil above their bases from the compression by their flanges. This additional resistance from the flanges is more pronounced with T-shape than with wedge shape, and hence the recorded highest load bearing capacity. Observation of results on the first (fig. 5) and second (fig. 6) modeled soil conditions, shows that no significant difference in load resistance in relation to settlement was recorded in the case of foundations with rectangular shape. But in the case of wedge and T shape foundations, higher settlement values were recorded at corresponding loads on the second model subsoil conditions (fig. 6) in comparison with the first condition. This is attributed to the presence of weaker (soft) soil above the foundation bases. This indicates that at the instance of wedge and T shape foundations, soil layer above their bases, i.e. along the vertical trunks, significantly contributes in load resistance. Observation of fig. 6shows the load-settlement curves of the three shapes taking relatively similar pattern. This can be explained by the presence of the soft soil layer above the bases of the foundations, which offers not much resistance to the flanges of wedge and T shapes, resulting to much of the resistance been offered by the stiff soil beneath the base of the foundations, and hence the observed pattern.

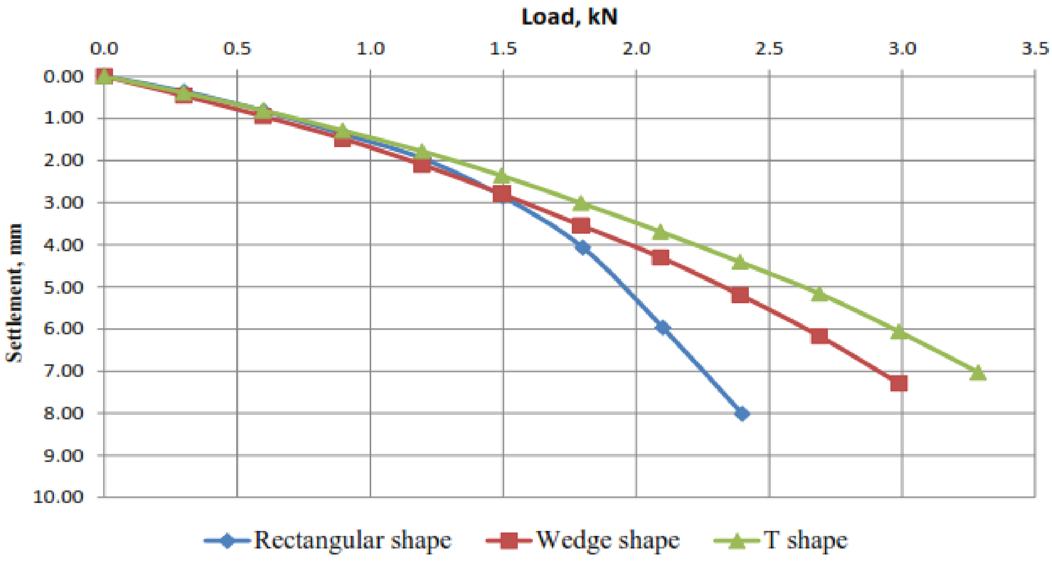


Fig. 5: Load-settlement curves on first modeled subsoil condition

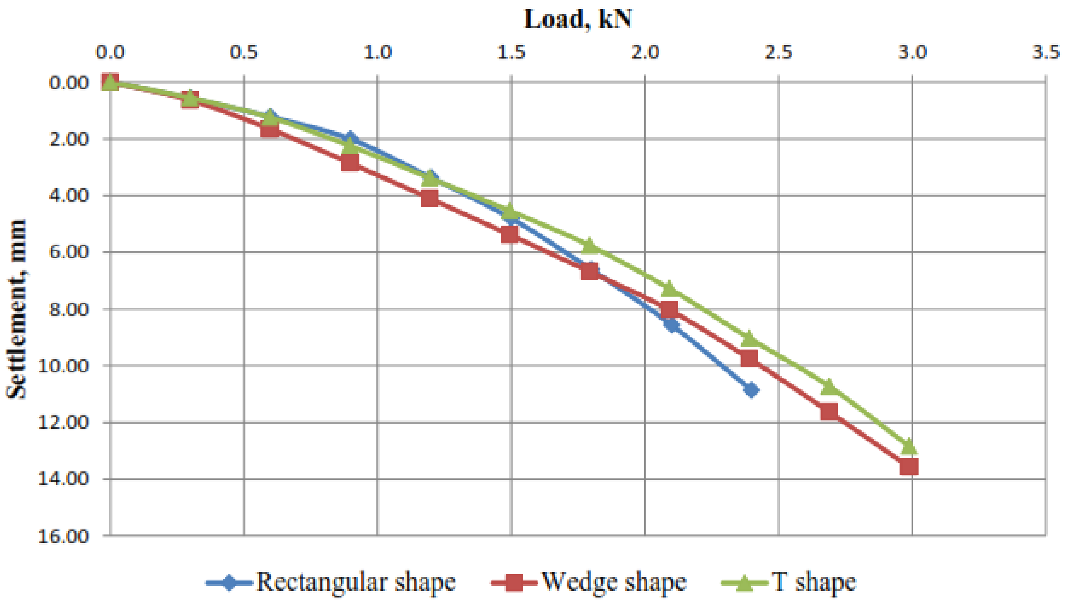


Fig. 6: Load-settlement curves on second modeled subsoil condition

Results of load-settlement relationship of the foundations models on the third modeled soil condition is shown in fig. 7. From the figure, it is observed that, while the rectangular shape foundation begins to losses it load bearing capacities, those of wedge and T shape foundations, continues to increase. This is as a result of the mobilization of the stiff soil along their vertical trunks in load resistance, in contrast with rectangular shape foundation.

A comparison of the test results shown in figures 5, 6 and 7 shows that the bearing capacity of foundations on the third modeled subsoil condition is generally lower than in the first and second modeled soil conditions.

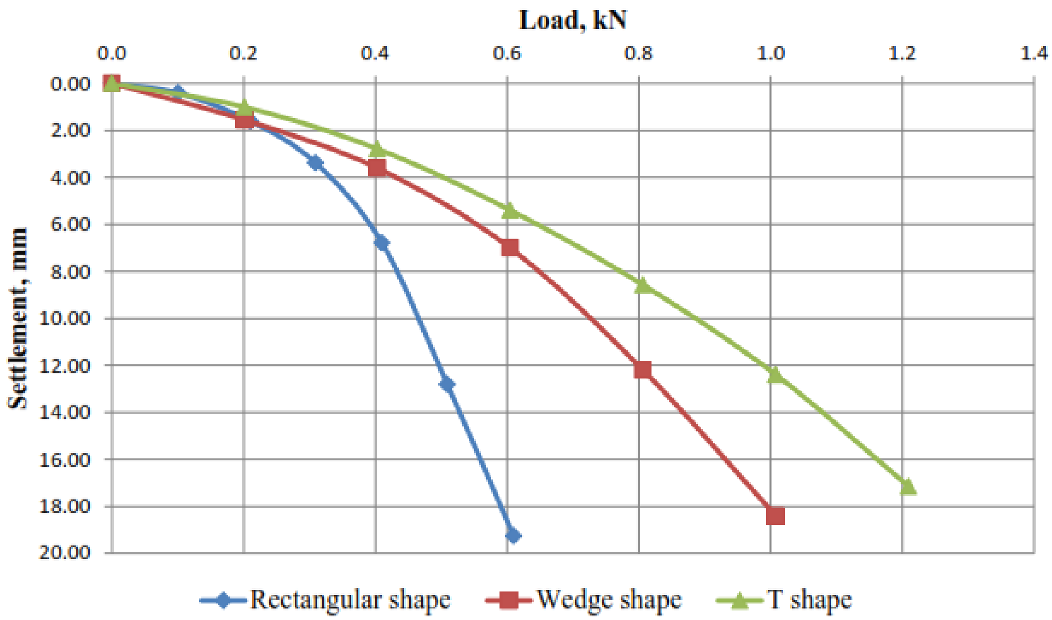


Fig. 7: Load-settlement curves on third modeled subsoil condition

IV. CONCLUSION

The study shows that bulk of the load resistance of subsoil bases of shallow foundations with rectangular vertical cross-sectional shapes is mostly offered by the soil beneath the foundation base, while for those with wedge and T-shape vertical cross-sectional shape, both soils beneath the foundations bases and along their vertical stems, actively offers resistance to structural loads. This indicates that using foundations with wedge and T-shape vertical cross-sections can help in the distribution of structural loads to less dipper soil strata, especially when stronger soil layers is underlain by weaker ones.

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