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Analysis of Different Shaped Footing Under Soft Soil Condition : A Review

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ABSTRACT

Soil Structure interaction is very important part of a building-load distribution. As the total load of a building is directly transmitted to the soil beneath footing. Shape of footing plays a vital role in distributing load to the soil, thus shape of footing should be ideal to distribute maximum load to the soil. Foundations provide support for structures, transferring their load to layers of soil or rock that have sufficient bearing capacity and suitable settlement characteristics. The term footing or footings is an ambiguous one that can be interpreted in a number of ways. In some cases 'footings' is used as a synonym for shallow foundations. Shallow foundations are typically used where the loads imposed by a structure are low relative to the bearing capacity of the surface soils. Here, the most commonly used term is strip footing (or footings), referring to a strip foundations, used to provide a continuous strip of support to a linear structure such as a wall. Approved Document A of building regulations defines minimum widths for strip footings based on the load of load-bearing walling they support. A brief review on footing flexibility and code provision of previous studies is presented here. This literature review focuses on sloping ground, lateral forces in reinforced concrete structures, soil data implementation in a building foundation and some code provisions will be addressed by area.

Keywords: Footing, Different Shape, Structural Analysis, Finite Element Analysis.

I. INTRODUCTION

Foundation structures undergo soil-structure interaction. Therefore, the behaviour of foundation structures depends on the properties of structural materials and soil. Determination of properties of soil of different types itself is a specialized topic of geotechnical engineering. Understanding the interacting behaviour is also difficult.

Footings are structural elements, which transfer loads to the soil from columns, walls or lateral loads from earth retaining structures. In order to transfer these loads properly to the soil.

To provide a detailed review of the literature related to Tall structure, footing geometry, dynamic analysis and soil properties in its entirety would be difficult to address here. although there has been a lot of work modeled on sloping ground - none provide in-depth understanding of the seismic response (dynamic analysis) of reinforced concrete (rc) buildings contributions related with soil data and footing geometry also related to tall structures and past efforts most closely related to the needs of the present work. A brief review on footing flexibility and code provision of previous studies is presented here. This literature review focuses on sloping ground, lateral forces in reinforced concrete structures, soil data implementation in a building foundation and some code provisions will be addressed by area.

II. LITERATURE SURVEY

Meyerhof (1974) (Meyerhof equation for soil bearing capacity) the study was based on the ultimate bearing capacity of circular and strip footing resting on sub-soils having two layers of different cases of dense sand on soft clay and loose sand on stiff clay. Bearing capacity ratio of clay to sand, friction angle, shape and depth of foundation are the main factors which have an influence over sand layer thickness below the footing. For circular footing upper limits of $S\gamma = 0.6$ and $Sq = 1$.

Rahaman (1981) (Investigation of soil strength under different coefficient) study was carried out for understanding the problem of the bearing capacity and settlement by using Circular footing on sand bed. Shear strength, Frictional angle, relative density (Dr) of sand, and surcharge effect on bearing capacity and settlement are investigated. Maximum vertical strain occurs at 0.5 to0.6 times the diameter of footing, depth increase with decrease in density of sand. Radial deformation increase from center of the footing to a maximum value at a distance of 0.75 time the diameter and then started decreasing.

Taiebat and Carter (2002) (Designing of footing using finite element method for homogeneous soil) this paper described Finite element modeling of the problem of the bearing capacity of strip and circular footings under vertical load and moment. The footings rest on the uniform and homogeneous soil surface which undergoes deformation under undrained condition. The soil has a uniform undrained Young's modulus and a uniform undrained shear strength (Su), Eu = 300Su .A Poisson's ratio of μ=0.5. The Young's modulus for the foundations was set as Ef =1000Eu that is, the foundations are much stiffer than the soil, and therefore they can be considered as effectively rigid. The contact between the footings and the soil is unable to sustain tension.

Boushehrian and Hataf (2003) (Study of single layer footing bed for soft soil) study was performed on circular and ring footing. Here, the effects of vertical spacing, number of reinforcement layers on bearing capacity of footing and the depth of first layer of reinforcement were considered for investigation. Both the experimental and numerical studies showed that, with the use of a single layer of reinforcement, there is an optimum reinforcement embedment depth for which the bearing capacity is greatest. They also found out that, for multi-layer reinforced sand, it requires an optimum vertical spacing of reinforcing layer. It was also found that, with the increase in number of reinforcement layers, the bearing capacity also increased, provided the reinforcements were placed within a range of effective depths. Further, the analysis indicated that, bearing capacity does not increase beyond a threshold value of reinforcement stiffness.

Dash et al. (2003) (Investigation of geocell reinforcement for granular soil) by conducting small-scale model tests, the effectiveness of geocell reinforcement placed in the granular fill overlying soft clay beds has been studied. The test beds were applied with uniform loading by a rigid circular footing. The overall performance of the system depends on the factors such as width and height of geocell mattress and presence of a planar geogrid layer at the base of geocell mattress. The performance of the system can be improved substantially by providing geocell reinforcement in the sand layer lying above. With the addition of another geogrid layer at the base of the geocell mattress, load carrying capacity and stiffness of foundation bed increases considerably. With increase in the height of geocell mattress, this beneficial effect decreases.

Sitharam and Sireesh (2004) (design of circular footing for multi layer geogrid sand beds) this paper contains the model test conducted to determine the bearing capacity of an embedded circular footing supported by multi-layer geogrid sand beds. Besides load settlement data, strain in geogrid layer, pressure distribution on soil subgrade and deformations on fill surface were measured. The results obtained from test shows that, the ultimate bearing capacity increases with embedment depth ratio of the foundation. A considerable improvement in performance in terms of increase in bearing capacity and reduction in surface deformation can be obtained by providing multi-layer geogrid reinforcement in the sand bed. It also causes uniform redistribution of footing pressure over a wide area of subgrade soil.

Cerato and Lutenegger (2006) (Determination of bearing capacity of well graded soil) investigation carried out on model circular and square footing test performed on well-graded sand with 3 different relative density and 5 different sand layer thickness. The foundation will have an influence over the unit load supported by the soil of the hard layer present at a certain depth. Therefore original equation of bearing capacity modified for this condition. Footing shape factor γ S should account for both shape and final layering. To predict bearing capacity on finite layer first appropriate shape factor (Square S^{γ}= 0.8,CircularS^{γ}=0.6) should be chosen.

Basudhar et al. (2007) (Determination of footing sizes for relative densed soil) investigated on the Effect of the footing size, number of reinforcing layers, reinforcement placement pattern and bond length and the relative density of the soil on the load- settlement characteristics of the circular footing over sand bed with geotextile. By the increase in number of reinforcement layers settlement value decreases. There is substantially increment of BCR values for each increment in the number of reinforcement layers.

Sireesh et al. (2009) (Analyzing of soil with layer of sand above clay bed) the paper based on various parameters such as, thickness of unreinforced sand layer above clay bed, width and height of geocell mattress, influence of an additional layer of planar geogrid placed at the base of the geocell mattress, relative density of the sand fill in the geocell varies in the model test. The test results shows that, by providing adequate size of geocell over the clay performance can be improved. If the height of geocell mattress is greater than 1.8 times the diameter of footing, effect of voids over the performance of footing reduces. With geocells filled with dense soil better improvement in performance can be achieved.

Nagaraj and Ullagaddi (2010) (Investigation of foundation capacity under sand) in this paper investigation carried out to study the effect of shape and size of footing on load settlement behavior of sand foundation. In case of sand foundation the increase in size of footing will improve the bearing capacity or load – settlement behavior of the supporting soil and also the shape of the footing has influence on the bearing capacity or load - settlement behavior of the supporting soil. Square footing has shown better load-settlement behavior as compared to circular and rectangular shapes.

Lovisa et al. (2010) (Numerical simulation for soil domain in shaking table model test) paper studied for circular footing to find out the behaviour of prestressed geotextile-reinforced over sand bed. A significant improvement to the load bearing capacity and settlement can be achieved by addition of prestress reinforcement. The load-carrying capacity at 5 mm settlement in the prestressed case (with prestress equal to 2% of the allowable tensile strength of the geotextile) is approximately double that of the geotextile reinforced sand without prestress for surface footing.

Dewaikar et al. (2011) (Principle and numerical method of finite element method) observed on the model circular footing with reinforced soil to study the load settlement behaviour. The study showed that provision of a single layer reinforcement, ultimate bearing capacity increases and settlement decreases. Further, in case of BCR and SRF rubber grid performed better than the Geo-grid.

Elsaied et al. (2014) (soil-structure dynamic interaction." Englewood Cliffs: Prentice-Hall) three dimensional physical laboratory models were examined to investigate the influence of soil confinement on circular footing behavior resting on granular soil. Observed that on increasing the number of geogrid layers more than one layer had a small significant effect on the footing behavior. Moreover, placing geogrid layers underneath the cylinders improves the bearing capacity up to 7.5 times that of the non-confined case. The load-settlement behavior depends on the diameter and height of the confinement cylinder relative to the footing diameter.

Gupta et al. (2014) (Comparative Analysis of RCC and Steel-Concrete-Composite (B+G+ 11 Storey) Building) investigation has been done on the influence of three dimensional confinement of dense sand on the behavior of a model circular footing resting over dense sand. The load bearing capacity was studied for a circular footing supported on a three-dimensional confined sand bed. The results indicate that, by confining soil the bearing capacity of circular footing can be increased appreciably. As compared to the unconfined case the bearing capacity was found to increase by a factor of 36.18

Joao T. et. al. (2015) (Comparative Study on Dynamic Analysis of Composite, RCC & Steel Structure) Illustrated that Isolated footings are reinforced concrete elements whose flexural and punching shear strengths are usually governing for their design. In this work, both failure modes and their interaction are investigated by means of the kinematical theorem of limit analysis. Previous works in this domain have traditionally considered failure mechanisms based on a vertical penetration of a punching cone. In this work, two enhanced failure mechanisms are investigated considering not only a vertical penetration of the punching cone, but also a rotation of the outer part of the footing, allowing to consider the role of both bottom and top reinforcements on the failure load. A rigid-plastic behavior with a Mohr–Coulomb yield criterion is considered for the concrete and a uniaxial rigid-plastic behavior is assumed for the reinforcement bars. The analysis shows that a smooth transition between flexural and punching shear failure occurs, corresponding to a flexural-shear regime. With respect to the punching shear failure regime, it is shown that the top reinforcement might play an important role (a fact usually neglected by previous investigations). Simplified formulations, allowing easy calculation of the load carrying capacity of footings, are derived and compared to the solutions according to limit analysis. Both theoretical and approximated solutions are finally compared with experimental results, showing consistent agreement

Jaroslaw et. al. (2016) (Comparative Study of RCC and Composite Multi-storeyed Building) studied the analysis of the behaviour of the foundations of historic buildings. Some basic aspects of foundation engineering are discussed, with an emphasis placed on its development, applied techniques, and materials. Several different approaches and methods for the analysis of foundations of historical buildings are presented. A particular analysis has been focused on an example of a typical stone foundation from the sixteenth century. First, the calculations have been performed using the finite element method, then the bearing capacity and the settlement analysis has been determined according to EC-7. Next, the bearing capacity has been evaluated using simplified analysis. A settlement of the foundation has been also estimated using Kerisel's proposal. The information should allow for a better understanding of the behaviour of foundations discussed in this research, and especially of methods of their analysis. A comparison analysis has been performed and possible directions for further research in this field have been indicated.

noorzad & badakshak (2016) (analysis of g+15 rcc and composite structure having a soft storey at ground level by response spectrum and equivalent static methods using etabs 2013) This study presents the results from a laboratory modeling tests and numerical studies carried out on circular and square footings assuming the same plan area that rests on geosynthetic reinforced sand bed. The effects of the depth of the first and second layers of reinforcement, number of reinforcement layers on bearing capacity of the footings in central and eccentral loadings are investigated. The results indicated that in unreinforced condition, the ultimate bearing capacity is almost equal for both of the footings; but with reinforcing and increasing the number of reinforcement layers the ultimate bearing capacity of circular footing increased in a higher rate compared to square footing in both central and eccentrial loadings. The beneficial effect of a geosynthetic inclusion is largely dependent on the shape of footings. Also, by increasing the number of reinforcement layers, the tilt of circular footing decreased more than square footing. The SR (settlement reduction) of the reinforced condition shows that settlement at ultimate bearing capacity is heavily dependent on load eccentricity and is not significantly different from that for the unreinforced one. Also, close match between the experimental and numerical load-settlement curves and trend lines shown that the modeling approach utilized in this study can be reasonably adapted for reinforced soil applications.

III.CONCLUSION

The literature review has suggested that use of a Soil bearing capacity to justify the depth of footing. Here the soil interaction with soil is justified on the basis of type of soil, thus here we will justify its load distribution on shapes of footing. Staad.pro software is utilized for analysis purpose, with the help of this software study of soil-footing interaction and building structure has been done. STAAD.Pro also helps in Finite Element Modeling in view of that different type of forces can apply to get the actual results. In this literature review it is revealed that soil interaction is really necessary for high rise building under dynamic loading conditions.

1 In all of the previous general soil testing and assumptions for footing type is considered.
2 In previous studies no comparison was done on the effects of different footing shapes.
3 In this study comparing three different shapes of footing is considered to determine the most suitable shape and distribution of loading in it.

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