A Review Paper on analysis of Biangle Shaped Footing Subjected To Two Way Eccentric Loading By Finite Element Analysis

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Abstract- *A common field issue is footing that is subjected to eccentric loading along two axes that are mutually perpendicular. As a result, bearing capacity is significantly lowered and the effective size is significantly decreased. Numerous factors can cause a footing to exhibit one- or two-way eccentricity. It is standard practise to align the centres of gravity of column loads and footing areas when a footing is subject to one-way eccentricity. When the footing is subjected to a two-way eccentric stress, strap footings are also frequently used. These footings boost bearing capacity while also resisting eccentric stress with very little tilt. Another novel concept has been developed using the angle-shaped footing and bi-angle-shaped footing ideas that came from the study of partial confinement. These footings are shaped as a vertical downward projection that faces one neighbouring edge's eccentric side.In the present paper the study was performed on rectangular footings subjected to eccentric loadings by taking into account various points of eccentricity, as well as variable projections and footing sizes. Analysis has been done on a diagonal footing under a point load with one vertically downward footing projection along one adjacent side in the direction of the eccentricity.*

Keywords- Bi-angle shaped footing, eccentric loading, tilt, settlement, ANSYS software.

I. INTRODUCTION

It becomes crucial to comprehend both the foundation design element and the behaviour of the surrounding soil when an object, such as a foundation, is subjected to eccentric inclined loads. It is crucial to bear in mind that the foundation design must have adequate protection against failure and settling, as well as the need to keep in mind the tolerance limit. The bearing capacity and compressibility play the biggest roles in determining the above-mentioned parameters. It may be argued that when designing shallow foundations, settlement criteria are more important than bearing capacity.Limiting the total and differential settlements can help to ensure a structure's safety. The settlement standards for pad or strip foundations are typically restricted to 25mm. The requirements of less than footing width (e<B/6) should be adhered to in order to prevent tension between soil and foundation and to have a safe design. The footing tends to tilt in the direction of the eccentric load as a result of the eccentric load, but the pressure beneath the footing does not change. The eccentric width ratio determines how much the footing tilts.

Any of the following factors could cause an eccentric loading on a footing:

1) The column's and the footing's centres of gravity are not congruent.
2) Axial loads and certain moments are coming onto the footing.
3) One or more of the footing's adjacent sides are in close proximity to the boundary of the property.
4) A building experiences an earthquake or a strong wind.

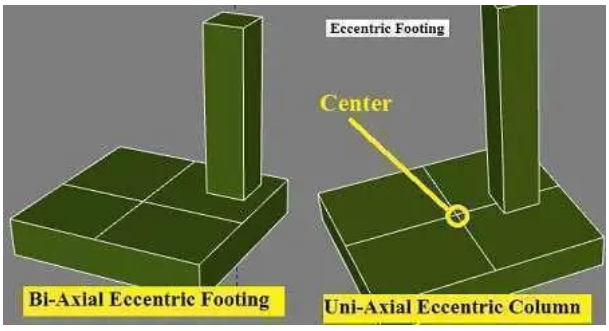

Figure 1. Eccentrically loaded footing

II. OBJECTIVES OF THE STUDY

The objective is to verify the eccentricity width ratio (e/L) for zero tilt condition for the real size footing of size 1.5m x 1 m, 2.0m x lm, 2.5m x lm, 3.0m x 1.0m using the

parameters-Length of projection (D/L) = 0.2m, 0.4m, 0.6m, 0.8m. e„/L values = 0 , 0.05, 0.1, 0.15 , 0.2 By using the combinations of above parameters in form of different cases, the objective is clear to determine the following-

- To determine and check the tilt of the footing which should be within permissible limits.
- To determine and check the settlement of footing which should be within permissible limits.
- To compare the results with the work done previously, both experimentally as well as on finite element modeling software.

III. LITERATURE REVIEW

S. NAZEER , R.K. DUTTA (2021)

Purpose: The purpose of this study is to estimate the ultimate bearing capacity of the E-shaped footing resting on two layered sand using finite element method. The solution was implemented using ABACUS software. Design/methodology/approach: The numerical study of the ultimate bearing capacity of the E-shaped footing resting on layered sand and subjected to vertical load was carried out using finite element analysis. The layered sand was having an upper layer of loose sand of thickness H and lower layer was considered as dense sand of infinite depth. The various parameters varied were the friction angle of the upper (30° to 34°) and lower (42° to 46°) layer of sand as well as the thickness (0.5B, 2B and 4B) of the upper sand layer.

SANDEEP NIGHOJKAR, BHAGYASHREE NAIK, DR.U.PENDHARKAR (2020)

Global rise in temperature and lowering of ground water table, significantly affects the behaviour and strength characteristics of foundation soil. It possesses a critical problem of differential settlement of foundations in structures. It is a major concern for foundation designer. Bi-Angle shape skirted footing can be a better alternative to reduce the differential settlement. Skirts, i.e. vertical walls at the base of footing, which helps in confining the under lying soil, generates a soil resistance on skirt sides that helps the footing to resist settlement. Bi-angle shaped skirts are the skirts in which vertical walls are provided under the footing on two adjacent sides. A finite element model is being prepared to study and investigate the behaviour and effectiveness of Bi-angle shape skirted footing resting on clayey soil; using finite element software SAP 2000 VS18.The study has been carried out for two types of soils and footing model are analyzed to find the effectiveness of skirts and their depths in arresting differential settlement of footing. Encouraging results obtained from finite element modelling and analysis shows that the settlement of footing decreases with the increase in skirt depth.

KOUSHIK HALDER,DEBARGHYA CHAKRABORTY (2020)

The present study considers the influence of inclined and eccentric loading on the bearing capacity of a strip footing placed on the reinforced cohesion less soil slope by using lower bound finite element limit analysis technique. The effects of other parameters such as soil friction angle, embedment depth of reinforcement layer below the footing, interface friction angle between soil and reinforcement, and vertical spacing between two reinforcement layers are also investigated. Results are presented as the variation between reinforcing efficiency and various combinations of above-mentioned parameters. The bearing capacity of strip footing reduces under combined effects of inclined and eccentric loading. However, with the inclusion of reinforcement layers at the optimum depth, the bearing capacity enhances significantly. The reinforcing efficacy increases with the increasing value of load inclination. The reinforcing efficiency reduces with the consideration of partial roughness between soil and reinforcement layer. Stress contours are also plotted in the two-dimensional object space to understand the failure mechanism of slopes.

ZAINAB TALIB JAFAAR , ZINAH WALEED ABASS , SHAIMAA HASAN FADHIL (2020)

Punching shear failure is one of the most common problems in shallow foundations (pad footings). Therefore, this investigation is conducted to study the effect of increasing of the flexural reinforcement ratios as (0.0036, 0.0047, and 0.0057) and using funnel-shaped punching shear preventers (FSPSP)on the punching shear failure of self-compacting concrete(SCC) pad footing. Four footing specimens were supported on a bed of steel(car)springs and loaded by vertical force till failure. The results show that the first crack load, the ultimate load, the ductility and the punching shear strength were improved by using the FSPSP. The results showed that the first crack load and ultimate load increased with increasing of the flexural reinforcement ratio while the ductility and the deflection are decreased. In contract, the using of the FSPSP showed an improve of the first crack load, the ultimate load, the ductility and the punching shear strength.

TAREK MANSOURI, KHELIFA ABBECHE (2019)

Based on the response of small-scale model square footing, the present paper shows the results of an experimental

bearing capacity of eccentrically loaded square footing, near a slope sand bed. To reach this aim, a steel model square footing of (150 mm × 150 mm) and a varied sand relative density of 30%, 50% and 70% are used. The bearing capacity-settlement relationship of footing located at the edge of a slope and the effect of various parameters such as eccentricity (e) and dimensions report (b/B) were studied. Test results indicate that ultimate bearing capacity decreases with increasing load eccentricity to the core boundary of footing and that as far as the footing is distant from the crest, the bearing capacity increases. Furthermore, the results also prove. that there is a clear proportional relation between relative densities –bearing capacity. The model test provides qualitative information on parameters influencing the bearing capacity of square footing. These tests can be used to check the bearing capacity estimated by the conventional methods.

SHARAD CHAURASIA, DR. RAKESH KUMAR (2018)

Footing subjected to eccentric loading along two mutually perpendicular axes is quite a common field problem. Due to this bearing capacity is reduced considerably as the effective size is drastically reduced. A footing may be subjected to one way or two-way eccentricity due to many reasons. In the case of footing subjected to one-way eccentricity the common practice is to match the centre of gravity of column loads to centre of gravity of footing area. Strap footings are also commonly used when the footing is subjected to two-way eccentric load. These footings not only resist the eccentric loading without (negligible) tilt but increase the bearing capacity also. Using the idea of angle-shaped footings and bi-angle shaped footing which was a result from the study of partial confinement, another new idea, has been developed. These footings have shape in the form of one vertically downward projection towards the eccentric side of one adjacent edge. In the present paper Square Angle shaped footing which was the experimental work ofDr. H. K Mahiyar has been analysed and then verified by Finite Element Technique using ANSYS software. Secondly rectangular footings subjected to eccentric loadings have been considered and an analysis has been done by taking different points of eccentricity along with varying projection and sizes of footing. Footing under a point load at some eccentricity along diagonal with one vertically downward footing projections of equal length along one adjacent side towards the eccentricity have been analysed. To get the zero-tilt condition of the footing for the eccentric load, the projection has been given certain ratios with respect to the size of the footing. It has been observed that the equation given by Dr. H K Mahiyar was verified and the position of the zero tilt of rectangular angle shaped footing could be achieved successfully.

PANCHAM KUMAR, HEMANT MAHIYAR (2015)

The bases of all the civil engineering structures rest on soil/rock. The size of open foundation depends upon the bearing capacity and compressibility of soil/rock. The footings are often subjected to eccentric and inclined loading. The experimental and finite element analysis of Angle Shaped Footings has proved their acceptability under eccentric vertical or eccentric inclined static loading. In Angle Shaped Footings a vertical projection which is an integral part of footing and remains embedded in soil is there if the footing is subjected to eccentric vertical load while the projection is inclined in case the footings are subjected to eccentric inclined loading. However, the quadrant of eccentricity has to be known well before providing such footings as the footing projection is always provided towards the eccentricity. The earthquake is a natural phenomenon the occurrence of which is not in the hand of human being, and the civil engineers have to design the substructure taking care of earthquake force since the effect shall be ultimately transferred to foundation. Thus the study of foundation under dynamic loading is conducted to assess the behaviour of Angle Shaped Footings under variable parameters of experimental studies. After conducting exhaustive experimental studies on Angle Shaped Footings it has been found that Angle Shaped Footings displaced less in the direction parallel and perpendicular to direction of shaking but the tilt is more as compared to normal footing.

IV. PROBLEM FORMULATION

- To use the angle shaped footing in foundations of building subjected to eccentric loading.
- The parameters to be considered are depth-width ratio, depth-length ratio and size of footing. The edge on which projection to be provided i.e. on longer side or shorter side.
- Its analysis has been carried out using finite element method.
- The programming has been done using the finite element modeling software's ANSYS.
- The soil is considered dry and assumed to behave linearly. Failure criteria are based on Mohr Coulomb's theory.
- For the solution of the given problem a number of numerical methods are available: Matrix method Finite difference method. Etc.
- In the modern days the finite technique which is the most versatile tool for the analysis of a given problem has been extensively used due to its Superiorities over the other methods and hence the finite element technique has been adopted. The readymade software i.e. ANSYS 12 which is based upon the FEM has been employed. The soil, footing projections and footing have been discertized and

the input required for the solution are also chosen and the program is rum for a given condition mentioned in the objectives. The output of the analysis is noted in the form of displacements and the analysis has been performed.

V. PROPOSED METHODOLOGY

- The concept of Angle Shaped Footing has been introduced to optimize the geometry of structural element i.e. foundation, so that it becomes more useful and economical in comparison to the other types of footing which may be of no use or highly uneconomical. The capability of angle shaped footing to support the structure depends on various factors.
- These factors are loading intensity, footing size and depth of projection. The free body diagram of angle shaped footing shows various forces developed and their nature on it.
- The use of angle shaped footing for the structures can be the solution for many civil engineering problems. But to make it safe for using in structure, it is necessary to know about the various forces developed in it
- The software ANSYS which is based on Finite Element Technique is used for the purpose of analysis. The Graphic User Interface of any software makes good use of the features available for the development of the computerized model of the actual problem. The three dimensional model of angle shaped footing and two dimensional model gives the same results because the forces in the Z direction is negligible, and the problem can be considered as the plane stress problem.

VI. CONCLUSIONS

The no of cases of square and rectangular footing will be considered. The equations will be derived for zero tilt condition for biangle shaped square footing using the simulation software ANSYS, so that the research can be utilized on field for the benefit of the common people. Based upon the output of ANSYS and following conclusions will be made for rectangular as we as square footing.

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REFERENCES

[1] "Angle shaped footing under eccentric vertical load" Indian Geo-technical Journal Vol.40 No.2 pp-129-134
[2] "Analysis of angle shaped footing under eccentric vertical load"journal of geotechnical and geo-environmental engineering Vol 126. No.1, p 1151-1156 December 2000
[3] "Analysis of angle shaped square footings resting on soil under eccentric inclined load- —published in emerging journal on engineering science and technology. Vol 1. No.1, nov 08-jan09 pp-8-15.
[4] "Performance of angle shape footing resting on soil under eccentric inclined load- —published in emerging journal on geotechnical engineering, Vol 14, Band.Fpp 1-10.
[5] "Angle shaped rectangular footing with variable angle of footing projection under eccentric vertical load--published in emerging journal on geotechnical engineering. Vol 14, Bandpp 1-9.
[6] "Effectiveness of angle shaped footings resting on soil under eccentric inclined load-published in international journal of theoretical and applied mechanics ISSN 0973-6085 Vol 4 no.1 pp. 95-105.
[7] "Application of finite element techniques analysis angle shaped footing.--Published in international journal of theoretical and applied mechanics ISSN 0973-4562 Vol 4 no.6 pp. 1071-1084.
[8] "Moment tilt characteristics of angle shaped footing under eccentric inclined loading"-published in international journal of theoretical and applied mechanics ISSN 0973-4562 Vol 4 no.1 pp. 1085-1092.
[9] National conference on "behavior of horizontal displacement in an angle shape footing under eccentric inclined loading"-published in the proceedings of Indian geotechnical conference on geo-techniques in infrastructure development held at Guntur during 17° -19° Dec 09.
[10] "Experimental studies on angle shaped rectangular footing under uni-axial eccentric loading", M.E. thesis submitted to D.A.V.V., Indore.
[11] "Experimental studies on angle shaped square footing under uni-axial eccentric loading", M.E. thesis submitted to D.A.V.V., Indore.
[12] "Effect of shear parameters on bearing capacity of angle shaped footing", Communicated for India geotechnical conference, Warangal.
[13] Bi-angle shaped model footing subjected to two way eccentric load under mixed soil condition", M.E. thesis submitted to R.G.P.V. Bhopal.

[14] Abel, F., J. and Desai, S., C. (1972), "Introduction to the Finite Element Method", Litton Educational Publishing, Inc., New York.
[15] Atulkar, K., Narendra (2005), "Optimization of angle shaped footing", M.E. thesis submitted to R.G.P.V.. Bhopal.
[16] Czap, Z. (1994), "Finite element analysis of cutting resistance in foundation design", Periodical Polytechnic: Civil Engineering, 38(1), pp 21-28.
[17] Duwasa, Anand (2007), "Experimental study of bi-angle shaped footing subjected to two way eccentric loading with pile under sand-, M.E. thesis submitted to R.G.P.V., Bhopal.
[18] Kanungo, A. (2004), "Experimental study of angle shaped square footing on cohesive and cohesion less soil under eccentric loading", M.E. thesis submitted to R.G.P.V., Indore.
[19] Paice, G., M., Griffiths, D., V., Fenton, G., A. (1996), "Finite Element Modeling of Settlements on Spatially Random Soil", Journal of Geotechnical Engineering, 122 (9), 777-779.
[20] Rajput, D. (2006), "Bi-angle shaped model footing subjected to one way eccentric load under mixed soil condition", M.E. thesis submitted to R.G.P.V. Bhopal
[21] IS:456-2000, “Plain and Reinforced Concrete - Code of Practice “Bureau of Indian Standards.
[22] IS:456-2000, “Plain and Reinforced Concrete - Code of Practice “Bureau of Indian Standards.

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