FINITE ELEMENT MODELING of BI-ANGLE SHAPE SKIRTED FOOTING RESTING ON CLAYEY SOIL USING SAP2000 Vs. 18

Sandeep Nighojkar[1], Bhagyashree Naik[2], Dr.U.Pendharkar[3]

[1]Associate Prof. SKITM Indore, R.G.P.V., Bhopal
[2]Research Scholar Ujjain Engineering College, Ujjain, R.G.P.V., Bhopal
[3]Prof. Civil Engineering Department, Ujjain Engineering College, Ujjain

---***---

Abstract- *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 behavior 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 modeling and analysis shows that the settlement of footing decreases with the increase in skirt depth.*

Key words: Bi-angle shape Skirts1, Bearing capacity2, clayey soil3, skirt depth4, Settlement5.

1. INTRODUCTION

For poor ground conditions i.e. soil having general weakness or high degree of variability or a combination of two; the design Engineer has to work for the improvement either on soil or on the foundation, to overcome the effects of adverse soil conditions. In present work a foundation performance improvement technique known as Bi-Angle shaped skirted footing is discussed.

Vertical projection below the footing base; known as skirt which is commonly used technique in offshore structures for improving ground conditions can be an innovative concept to reduce displacement of footing; in the region of soil having low or inadequate bearing capacity. When an isolated column footing is subjected to load higher than actual load carrying capacity of the footing from safe soil bearing capacity consideration; it results in failure of the foundation. Main objective of the present study is to evaluate the effect of skirt on settlement of such types of isolated footings.

Bi-angle shaped skirt in which vertical walls surrounds two adjacent sides of the footing is a special case of skirted footing. A series of finite element base numerical models of Isolated Bi-angle shaped skirted footings are prepared based on results by the previous researchers. The numerical model study has been carried out considering different parameters such as loads, bearing capacity of soil, footing sizes and skirt depth to evaluate behaviour and effective equivalent settlement of Bi-angle shaped skirted footing models using SAP 2000 Vs18.

SAP2000 Vs18 is a FEM based software for structural and foundation analysis. This programme includes verity of national and international design codes. It has unlimited analysis capabilities, time history, a complete range of finite element analysis options and static linear and non linear analysis. It has a capability of export and import for other drafting and design programmes.

The research that conducted by S. Nighojkar et.al (2020) on performance study of skirt depth on settlement and net upward pressure characteristics of single skirted Isolated square footing and concluded that at near side on which skirt is provided, the average settlement is reduces by 40 to 60% of skirt depth 250 mm and by almost 60 to 70% for skirt depth of 1500 mm.

B. Naik et. al (2020) studied the settlement of single skirt Isolated square footing for different skirt parameters and found that the effectiveness of skirted foundation be very significant when skirt is provided symmetrically or coaxial to the footing side. Whereas the effect of size of footing and value of net upward soil pressure does not affect the settlement of single skirted footing much as compared to the depth of skirt. Mohammed Y. Al-Aghbari and A. Mohamedzeim (2018) investigate the use of skirts to improve the bearing capacity and to reduce the settlement of circular footing resting dune sand. The improvement in bearing capacity is upto about 470% for a surface footing with skirt of depth 1.25Band settlement reduces by 17%.

Thakare Et al (2016) studied the performance of rectangular skirted footing resting on sand bed subjected to lateral loads and concluded that as the D/B ratio increases from 0.5 to 2.0, the ability of skirted footing for resisting lateral load increases up to 300%.

Performance of vertical skirted strip footing on slope using finite element software PLAXIS 2D by Dr. S. PUSADKAR et.al (2016). A series of various numerical model were analyzed using PLAXIS 2D to evaluate the bearing capacity of strip footing with and without structural skirts resting on sand slopes. EI WAKIL(2013) using 18 laboratory test of skirted circular footing that machined from steel, with the sand as the media of testing and concluded that the use of skirted footing is very effective on increasing the value of footing bearing capacity.

Experimental study on the Performance of skirted strip footing subjected to eccentric inclined load was performed by Nasser M. saleh et.al (2008). Nighojkar S. and Mahiyar H.K. (2006) had studied experimentally Bi-angle shaped skirted footing subjected to two way eccentric load under mixed soil condition. Al-Aghbari and Zein (2004, 2006) was performed tests on strip and circular footing models resting on sand. Gourvenec (2002, 2003) applied two and three dimensional finite element analysis to assess the behaviour of strip and circular skirted foundations subjected to combined vertical, moment, and horizontal loading. Ortiz (2001) inserted a discontinuous vertical skirt dowels around existing foundation. A marked increase 20 % in the bearing capacity and a reduction of settlement were observed.

In this paper; the Bi-angle angle shaped isolated square footing models with variable depth of vertical skirt subjected to different axial loads are investigated and analyzed to get effectiveness of skirt and skirt depth in reducing settlement of footing, using finite element software SAP 2000 vs.18.

2. NUMERICAL MODELLING

In present work, the dimensions of the finite element model of Bi-angle skirted footings in SAP 2000 Vs.18 are prepared to have constant permissible Net upward Soil Pressure around 150KN/m^2.For linear static analysis of footing models, thick shell element is considered. Allowable maximum permissible settlement of Isolated Square model footing assumed as 25mm; is used to calculate the spring stiffness K to assign the soil properties to the model footing through area spring. Two extreme values of soil bearing capacities are taken to assign the soil pressure to the model footing say 80KN/m^2 and 200KN/m^2. The modulus of subgrade reaction is a conceptual relationship between soil pressure and deflection that is widely used in the structural analysis of foundation members. It is used for continuous footing, mat, and various types of pilings, this ratio is defined as $Ks=q/\delta$.

In this study various sizes of footing models at different loads was carried out. The footing model was loaded by axial load through column (comprising of DL and LL). The load combination was used according to BIS codes. The footing model was analyzed to check the settlement of the footing without skirt and with variable depth of skirts.

Various skirt depths at the two adjacent sides of the footing considered areas $(Ds)_1$=0.0, $(Ds)_2$=250,$(Ds)_3$=500,$(Ds)_4$=750,$(Ds)_5$=1000,

$(Ds)_6$=1250 &$(Ds)_7$=1500mm for multiple combinations.

Table 1: Model Footing parameters

S. No.	Load in KN	Size of Footing Model in m
1.	W1=600	F1=2.0x2.0x0.5
2.	W2=750	F2=2.2x2.2x0.5
3.	W3=900	F3=2.4x2.4x0.55
4.	W4=1000	F4=2.6x2.6x0.6
5.	W5=1200	F5=2.8x2.8x0.65
6.	W6=1400	F6=3.0x3.0x0.7
7.	W7=1600	F7=3.2x3.2x0.75
8.	W8=1760	F8=3.4x3.4x0.8
9.	W9=1950	F9=3.6x3.6x0.85

Table 2: Material properties for Model Footings

S. No.	Parameter	Value
1.	Material Name	M20
2.	Material type	Concrete
3.	Weight per unit volume	24.9926
4.	Mass per volume	2.5485
5.	Modulus of elasticity	22360680
6.	Poisson ratio	0.2
7.	Coefficient of thermal expansion A	5.500E-6
8.	Shear modulus G	9316950
9.	fck	20000

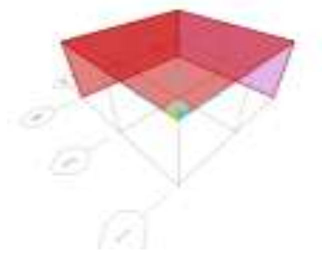

Fig-1: Geometry of model footing

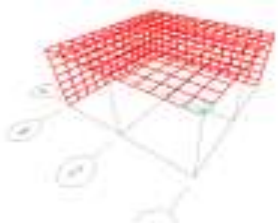

Fig-2: Generated mesh for model footing

Fig-3: Deformed shape of model footing

3. RESULTS and Discussion

On the basis of numerical modelling of Isolated Bi-angle Shaped Skirted footing (IBSSF) for different skirt depths (Ds) due to Concentric load from column and the figures shown below, the various interpretation regarding settlement of footing are mentioned below. For the study nine different sizes of footing and two soil types have been considered. To study the effect of skirt depth seven skirt depths ranging from 0 to 1500mm have been considered. The thickness of the skirt has been considered as 200mm. The footing and skirts have been considered to be made up of same material.

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 06 | June 2020 www.irjet.net p-ISSN: 2395-0072

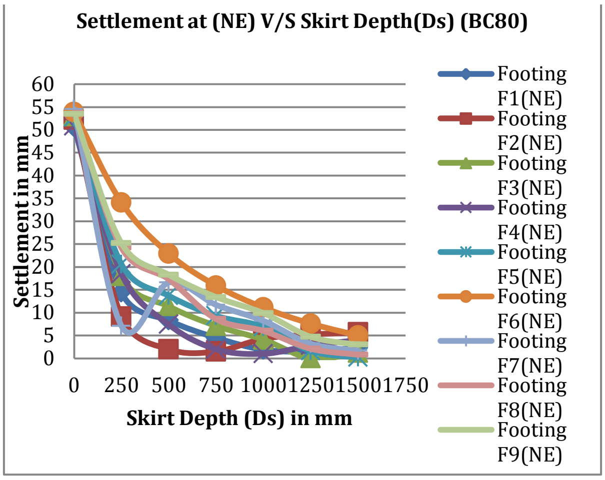

Chart-1: Variation of Settlement at (NE) with Skirt Depth for BC 80 KN/m²

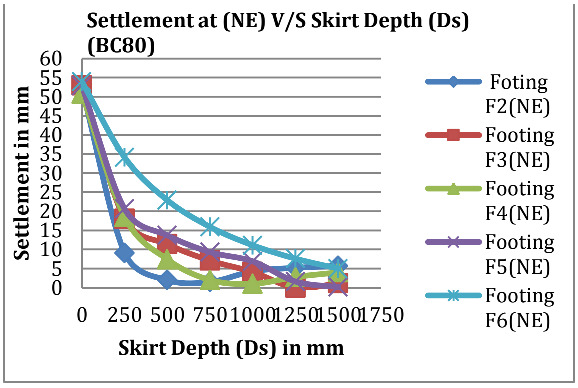

Chart-2: Variation of Settlement at (NE) with Skirt Depth for BC 80 KN/m²

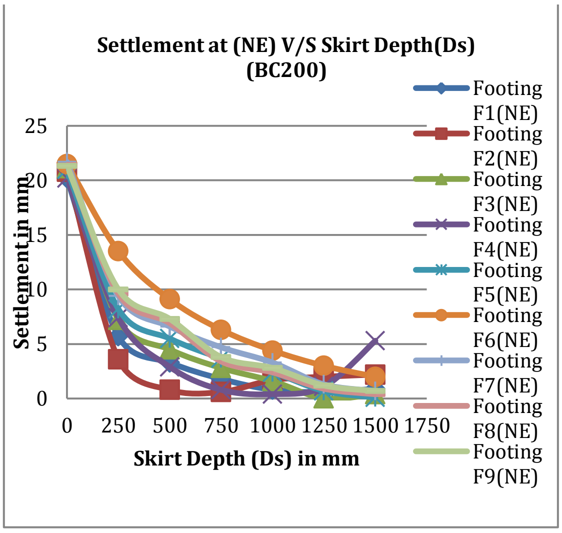

Chart-3: Variation of Settlement at (NE) with Skirt Depth for BC 200 KN/m²

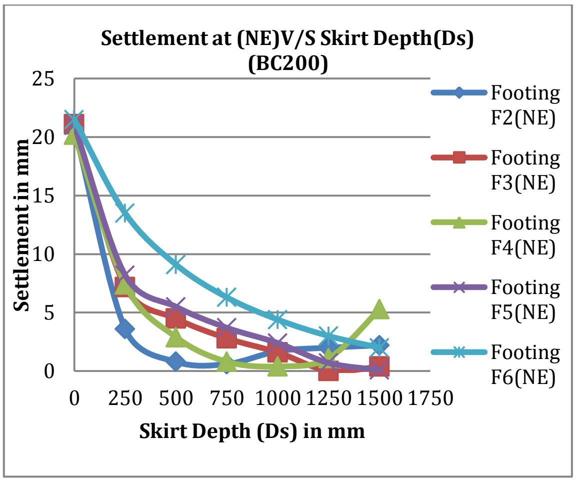

Chart-4: Variation of Settlement at (NE) with Skirt Depth for BC 200 KN/m^2

3.1Discussion:

When an isolated column footing is subjected to load higher than actual load carrying capacity of the footing from safe soil bearing capacity consideration; it results in failure of the foundation. The failure is mainly due to excessive settlement in subsoil under the footing. The present study is being carried out assuming that the footing in itself is structurally safe to carry the load coming over it. Main objective of the present study is to evaluate the effect of skirt on settlement of such types of isolated footings.

For the study nine different sizes of the footings have been considered. These nine different footing are considered to be resting on two different types of soil strata. The two types of soils considered have the safe bearing capacity of 80KN/m^2 and 200KN/m^2.

For bearing capacity 80KN/m^2; the effectiveness of skirt and skirt depth found to be very good for the footing size ranging from F3 to F8. An ideal case for almost zero settlement is obtained for F3 at load W3 with skirt depth $(Ds)_6$ & $(Ds)_7$.

For higher load W8 footing size F8 with the skirt depths $(Ds)_6$ & $(Ds)_7$ is performing very good. Showing minimum settlement i.e. 2.1 mm and 0.08 mm respectively.

For bearing capacity 200KN/m^2 the effectiveness of skirt and skirt depth is found to be very good for footing size ranging from F2 to F6. As the skirt depth increases from $(Ds)_1$ to $(Ds)_7$. The resulting settlement of footing decreases remarkably. For skirt depth $(Ds)_6$ and footing size F3 the settlement is almost zero. Whereas the skirt depth $(Ds)_6$ and $(Ds)_7$ the footing size F5 is having zero settlement. Thus F4 and F5 footings are performing very good for comparatively higher bearing capacity of 200KN/m^2.

For skirt depth $(Ds)_6$ and $(Ds)_7$ Footing sizes F3, F4 & F5 are found very effective for both the values of bearing capacity of soil and hence can be recommended.

Footing sizes having settlement value of footing exceeding the assumed maximum allowable settlement of 25 mm, requires resizing of footing dimensions to improve effectiveness of skirt.

4. CONCLUSION

From the Chart-1 it is clear that skirt depth of 250mm is effective in introducing the settlement within permissible limit for footing size (2.8x2.8x0.65) m. From Chart-1 again it is clear that if skirt depth of 500mm is provided to any size of footing, it reduces the settlement within assume permissible limit and it could be concluded that for higher size of footing minimum depth of skirt should not be less than 500mm.

From Chart-1 again it is clear that the skirt depth higher than 500mm does not have significant effect on settlement of the footing. Hence could be concluded that for all practical cases skirt depth of 500mm is provided, it serves the purpose to make footing safe.

From Chart-3, the settlement patterns of the footings resting on soil having higher bearing capacity of 200KN/m^2 has been observed to be the same. Though the initial settlement of the footings was already within the permissible limit.

Skirted footing resting on clayey soil having bearing capacity 80kN/m^2 is taking load which belongs to 1.87 times higher upward pressure of the soil. For various skirt depths, settlements on all the points along the footing comes within the assumed permissible limit of 25 mm.

For bearing capacity 80KN/m^2 footing size F6 at load W6 with skirt depth $(Ds)_2$ settles by 34.1 mm where as footing size F9 at load W9 with skirt depth$(Ds)_2$ shows the settlement of 25.2 mm, which is greater than maximum allowable settlement value. This shows failure of footing on settlement criteria and hence required resizing of footing.

For bearing capacity of 80KN/m^2, remaining all sizes of footing shows settlement values within permissible limit of 25 mm for all skirt depths. Effectiveness of skirt is found to be very high for footings resting on soil having low bearing capacity of 80KN/m^2 and carrying loads higher than maximum allowable load.

References

[1] S.Nighojkar, B. Naik & Dr. U. Pendharkar (2020) " Performance study of skirt depth on settlement and net upward pressure distribution characteristics of a single skirted Isolated square footing" International Journal of Science and Research, Vol.9, Issue 5 May2020.

[2] B. Naik, S.Nighojkar, & Dr. U. Pendharkar (2020) " Settlement studies of single skirt Isolated square footing for different skirt parameters" International Journal for Research in Applied Science & Engineering Technology, Vol.8, Issue IV April2020.

[3] M. Y. Al-Aghbari & A. Mohamadzem (2018) " The use of skirts to improve the performance of a footing in sand" International Journal of Geotechnical Engineering,2018.

[4] Chandni Seth, Dr. S.J. Shukla, Dr. A.K. Desai(2017) "Dynamic Analisis of piled block foundation using SAP:2000Vs18" published in the International journal of innovative research in science,Engg. & Tech.(IJIRSET), Vol.-6, Issue 6 June 2017, PP 77-83.

[5] Dr. Sunil S. Puusadkar, Priyanka S. Dhaygude (2016)"Performance of vertical skirted strip footing on slope using PLAXIS 2D.

[6] Prof. S.W.Thakare, A.N. Shukla (2016) "Perforamance of rectangular skirted footing resting on sand bed subjected to lateral load" IJIRSET, Vol.-5, Issue-6.

[7] Joseph E. Bowles, Foundation Analysis and Design, V Edition, Mc. Graw Hill Education.

[8] Entidhar Al-Taie, Nadhir Al- Ansari, Tarek Edrees Saaed and Sven Knutsson (2014) "Bearing capacity affecting the design of shallow foundation in various regions of Iraq using SAP2000 & SAFE softwares" Journal of Earth Sciences and Geotechnical Engineering, Vol. 4, 2014, 35-52.

[9] Computers and Structures, Inc., CSI Analysis Reference Manual, Berkley, California, 2013.https://docs.csiamerica.com.

[10] Amr Z. EL Wakil (2013) "Bearing capacity of skirt circular footing on sand" Alexandria Engineering Journal.

[11] Nighojkar S., Naik B., and Dr.Pendharkar (2013) " Analysis for No-Tilt condition of Bi-angle shape skirted footing in B.C. soil subjected to Eccentric Load" International Journal of Latest Trends in Engineering and Technology(IJLTET).

[12] Nighojkar S.,Naik B., Dr. Pendharkar U. and Dr.Mahiyar H. (2012) "Performance study for No-Tilt Condition of Bi-angle shape skirted footing in clayey soil subjected to eccentric load," International Journal of Engineering Research and Development, Vol.2, Issue 8(August2012), PP.14-20.

[13] Nighojkar S., Naik B., Dr. Pendharkar U. and Dr. Mahiyar H. (2011) "Performance study of Bi-angle shape skirted footing in yallow soil subjected to Two-way eccentric load" ACEE In. J. on Civil and Environmental Engineering, Vol.01,No.01, Feb2011.

[14] Saleh Naseser M., Alsaied A. and Elleboudy A., (2008), "Performance of Skirted Strip Footing Subjected to Eccentric Inclined Load," Electronic Journal of Geotechnical Engineering, Volume 13, Page No.1-13.

[15] Nighojkar S. and Mahiyar H.K. (2006) had studied experimentally Bi-angle shaped skirted footing subjected to two way eccentric load under mixed soil condition.

[16]Al-Aghbari, M.Y. and Zein, Y.E. (2006) "Improving the Performance of Circular Foundations Using Structural Skirts," Journal of Ground Improvement, Vol. 10, No.3, pp. 125-132. Vol. 13, Bund. F 13

[17] Gourvenec, S. (2002) “Combined Loading of Skirted Foundations,” Proc. 5th ANZYGPC Rotorua, New Zealand, pp.105- 110.

[18] Mahiyar, H. and Patel, A.N. (2000) “Analysis of Angle Shaped Footing Under Eccentric Loading,” ASCE Journal of Geotechnical and Geoenvironmental Engineering, Vol. 126, No. 12, pp.1151- 1156.

[19] Mahiyar Hemant and Patel A. N. (2001) Moment- Tilt characteristics of angle shaped footingunder eccentric loading-proceedings of Indian geotechnical Conference at Indore Dec (2001).

[20] Mahiyar Hemant and Patel A. N. (2003) Rectangular footing coffined on two opposite sides- proceedings of Indian geotechnical conference at Roorkee Dec. (2003).

[21] Ortiz, J.M.R. (2001) "Strengthening of Foundations through Peripheral Confinement," Proc. 15th International Conference on Soil Mechanics and Geotechnical Engineering, Netherlands, Vol. 1, pp. 779-782.