International Journal of Scientific Progress and Research(IJSPR) e-ISSN: 2349-4689
Issue 196, Volume 80, Number 06, June 2022

Research Result

Analysis of Angle Shaped Footing with Inclined Projection by using Eccentric Loading

Vaibhav Singh Kourav[1] and Kamlesh Kumar Choudhary[2]

[1]M.Tech. Scholar, SIET, Jabalpur (M.P.), INDIA
[2]Assistant Professor, SIET, Jabalpur (M.P.), INDIA

ABSTRACT

Footing subjected to eccentric loading on two reciprocally perpendicular axes is kind of a standard field downside. for the reason that of this bearing capability is reduced significantly because the effective size is drastically reduced. a foothold could also be subjected to 1 means or two-way eccentricity because of several reasons. within the case of footing subjected to unidirectional eccentricity, the common observation is to match the middle of gravity of column masses to the center of gravity of footing space. Strap footings also are ordinarily used once the footing is subjected to a two-way eccentric load. These footings do not solely resist the eccentric loading while not (negligible) tilt however increase the bearing capability additionally. victimization of the concept of angle-shaped footings, which was a result of the study of partial confinement, another new plan, has been developed. These footings have a form within the type of one vertically downward projection towards the eccentric facet of one adjacent edge. Within the gift paper Angle formed footings are analyzed by the Finite component Technique victimization ANSYS code. Footing below a degree load at some eccentricity on diagonal with one vertically downward footing projections of equal length on one adjacent facet towards the eccentricity has been analyzed. The footing has additionally been analyzed for a tilt within the load just in case the building is subjected to wind or earthquake load. to induce the zero-tilt condition of the footing for the atilt load, the projection has been given bound angles with reference to its original position. it's been determined that footings subjected to unidirectional eccentricity may well be designed for no tilt by victimization Angle formed footings. The depths of two footing projections of equal length can rely upon the eccentricity on the diagonal.

KEYWORDS

Static Load, Angle Shaped Footing, Dynamic Load, ANSYS Software, One Way or Two-Way Eccentricity, Eccentric Loading

1. INTRODUCTION

The conception of footing during which the footing projection is at right Associate into footing and such footings subjected to eccentric vertical load was extended to footings beneath eccentric and inclined loading by rotating the footing projection at an angle β with vertical in clockwise direction termed as changed sq. angle formed footing. Inclined projection additionally provides the horizontal reaction to the laterally moving soil thanks to the rotating impact of footing thus the inclined projection additionally to vertical reaction to axial masses is additionally resisting the horizontal forces. additionally, to the current triangular wedge fashioned beneath the inclined projection additionally enhances the planet pressure to a lower place the footing and additional resistive force or reaction is developed that is advantageous compared to vertical projection.

The forces acting on square angle shaped footing under such condition will be: -

Vertical forces are: -

- Downward load and self-weight of footing.
- Upward pressure, bearing pressure, frictional force between sand and projection.
- Pressure below the projection (very small so neglect).

Horizontal force: -

- Frictional force between under laying sand and footing.
- Earth pressure at rest condition due to uniform surcharge.
- Since these conditions should be satisfied:

$$\Sigma V=0$$

$$\Sigma H=0$$

$$\Sigma M=0$$

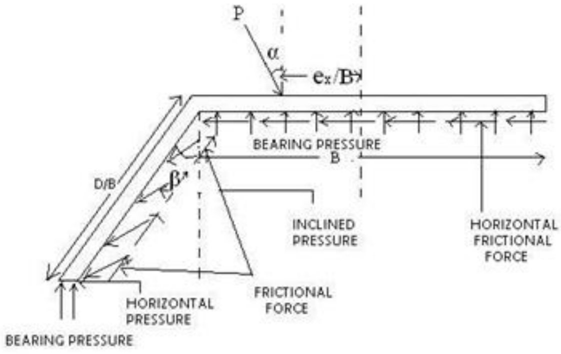
$$\mathbf{D/B = 85.77(e_x/B)^3 - 8.95(e_x/B)^2 + 3.42(e_x/B) - 0.0012}$$

Where,

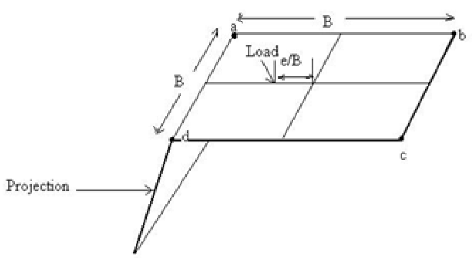
B = width of footing;

D = depth of footing projection;

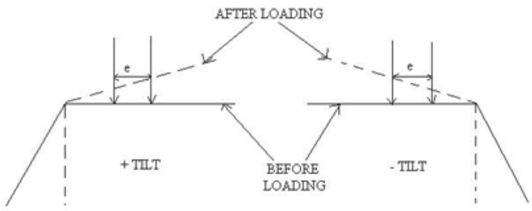
e_x = eccentricity along x-axis;



FRONT VIEW OF SQUARE ANGLE SHAPED FOOTING



ISOMETRIC VIEW OF SQUARE ANGLE SHAPED FOOTING



(SIGN CONVENTIONS FOR TILT)

2. CRITIQUES

From then on top of studies it will be seen that the work has been done by experimentation still as by modelling package on model footing except.

- The foundations are subjected to eccentric loads which create the non-uniform pressure beneath the footing; bearing capacity for normal footing is done by many researchers.
- Minimization of the rotation or tilt for uniaxial loading is to be done by introducing the projection of required length and inclination.
- The concept of square angle shaped footing has been extended by varying angle of projection (β) & angle of eccentric loading (α). The charts were developed for zero tilt condition for different α, β and D/B values by conducting experiments on model footing plate of size 220mm x220mm.
- The earlier studies were the experimental studies on model footings & software modelling on the study had also been done. To use the angle shaped footing in foundations of building subjected to eccentric inclined loading, and to make it possible to design it by engineer, it is needed to analyze it.

3. PROPOSED METHODOLOGY

The concept of square 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 square 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 square angle shaped footing shows various forces developed and their nature on it. The use of square angle shaped footing for the structures can be the solution for many civil engineering problems. But to make it safe for using it 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 square 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.

Modeling in ANSYS –

Geometry -

The model of square angle shaped footing and the soil is made by assuming that the effect of foundation on soil is felt up to five times the width of footing as compare to soil mass of infinite extent. Similarly, the extent of soil is taken as five times the width of footing.

Material Properties -

For the material properties the entire model is divided into two parts first model being the footing and second model being the soil or the medium in which the footing is kept. The model 1 (footing) is considered as a concrete footing of M25 grade of linear isotropic model having a modulus of elasticity Ex=2.2E10, Poisson ratio PRXY = 0.15 and density=25000. Model 2 (sand) the medium in which the footing is engraved is an isotropic material have in the modulus of elasticity Ex=2.25E7, Poisson ratio PRXY=0.25 and density 17000.

Meshing -

The meshing of concrete as well as soil in the model is done with element PLANE42. It is a 2-Dimentional structural solid element without mid-side node. This element was chosen because of the reason that the reactions in form of nodal loads on the mid-side node of the higher order element will always give unrealistic values. So the use of element having mid-node will give such a pressure distribution on soil, which cannot be explained or understood practically. However, the reactions will be unrealistic even then the results in the form of total force would be found accurate. The meshing and modeling of contact surface is done using 'Contact Manager' which is available in ANSYS. The elements used automatically are CONTACT172 and TARGET169. These elements are used in pair to define the behavior of contact surface. It is important to properly choose which surface should be assigned as contact surface and which should be target surface. A target surface should be chosen such that it should penetrate the contact surface, if a penetration occurs in the analysis. Therefore, the surface of concrete is assigned to be target

Surface and the soil surface is assigned as contact surface. Meshing of the concrete and soil mass is done by free meshing. The mapped meshing cannot be done because the topology of geometrical model of square angle shaped footing is not satisfying the requirements for orientation of direction of elements.

Boundary Conditions -

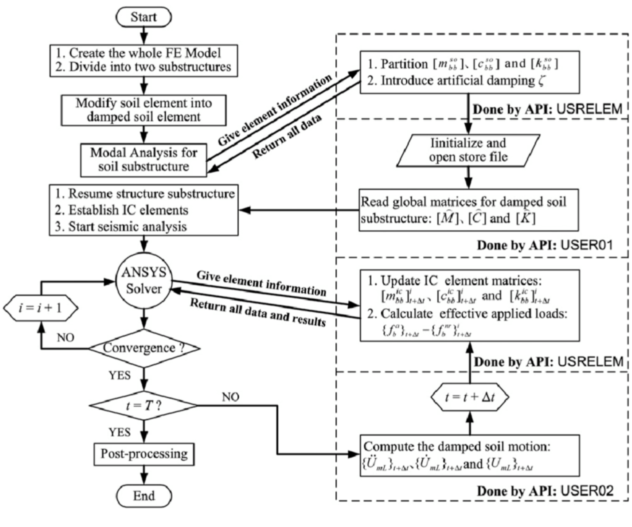
The displacement of soil surface in their individual perpendicular direction is set to be zero except the top surface. The static intensity of 150 & 250KN is applied at a point (i.e. ex/B) so that the no tilt occurs (the position of vertical load for no tilt occur has been taken from literature) by creating a pilot node in the model using 'Contact Manager' and defining its contact with the top surface of footing.

Solution Options -

The number of sub steps is chosen 100 in this analysis. However, 20 numbers of sub steps also give results equally accurate, which was discovered after the analysis was done. Type of analysis is 'Large Displacement static' with the automatic time stepping is turned off.

Calculation of Results -

The results in the form of nodal displacement of corner nodes in all directions are obtained. Displacements at sections are not found directly in case of 3-D and 2-D structural solids. So, the results are taken in Microsoft office Excel sheets. This calculation is done only for the nodes which are on the surfaces. In order to verify the results to be accurate, the sample problem of isolated square footing is modelled and analyzed in ANSYS with the rest of parameters kept same. The results for this sample problem are found to be very accurate, which verify that our methodology is correct.



4. OBJECTIVE OF THE STUDY

The objective is to verify the eccentricity width ratio (e_x/B) for zero tilt condition for the real size footing of size 1m x1m, using the parameters-

1. Inclination of load (α) = 0^0, 3^0, 6^0, 9^0, 12^0
2. Inclination of length of projection (β) = 0^0, 15^0, 30^0, 45^0.
3. Length of projection = 0.2m, 0.4m, 0.6m.

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 th 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 of the work done previously on finite element modelling software.

5. RESULTS

The verification of the charts by the considered parameters for the real size footing of 1m x1m using the simulation software ANSYS has been done and results are found to be satisfactory. Following conclusions can be made from the above tabulated results-

1. The graphs plotted show that the eccentricity increases with the increase in the angle of inclination.
2. With the increase in the angle of projection the eccentricity decreases.
3. Settlements found are within permissible limits as per N.B.C.
4. The angle shaped footing thus has proved to be much better even subjected to eccentric and inclined loading.
5. The finite element analysis is done for real size footing of 1mx1m subjected to eccentric and inclined load of 150 KN, the angular distortion (tilt) and footing's settlement are within the permissible limit.

Table-1 β=0^0, D/B=0.2and (α) = 0^0, 3^0, 6^0, 9^0, 12^0

for Avg. Settlement (in mm) &Angular Distortion

β=0^0, D/B=0.2						
Angle	Node				Avg. Settlement (in mm)	Angular Distor-tion (in mm)
α	a	b	c	d	(a+b+c+d)/4	
0^0	5.3	5.6	5.6	5.4	5.48	$1x10^{-4}$
3^0	5.1	5.8	5.7	5.2	5.45	$1x10^{-4}$
6^0	5.4	5.5	5.4	5.5	5.45	$2x10^{-4}$
9^0	5.4	5.4	5.4	5.5	5.43	$2x10^{-4}$
12^0	5.2	5.4	5.4	5.3	5.33	$3x10^{-4}$

Case I - Loading intensity of 150 KN/m^2

Permissible downward settlement=50 mm,

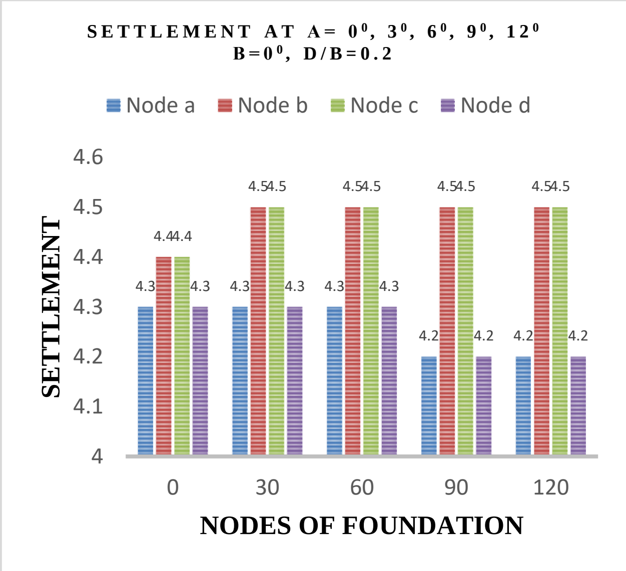
Permissible tilt=$1.5x10^{-3}$

Footing of size 1m x1m, using the parameters-

Inclination of load (a) = 0^0, 3^0, 6^0, 9^0, 12^0

Inclination of length of projection (β) = 0^0

Length of projection = 0.2m,



Graph -1 β=0^0, D/B=0.2 for Avg. Settlement (in mm) &Angular Distortion

FIGURES-1 β=0^0, D/B=0.2

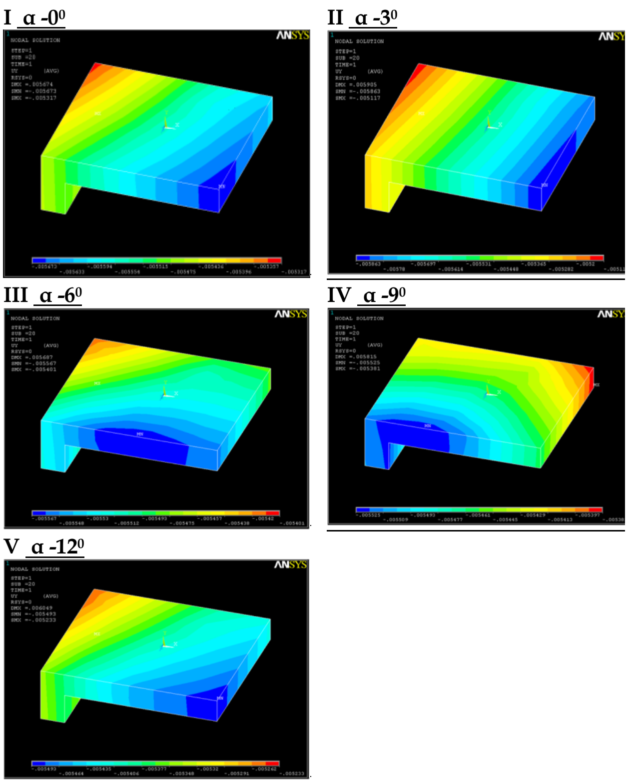


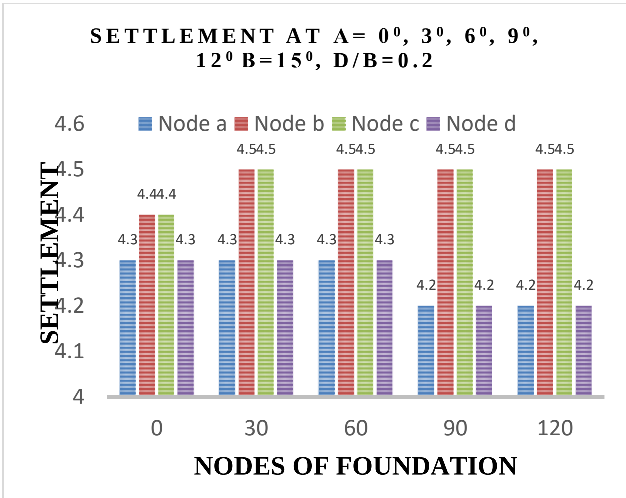
Fig-3 β=0^0, D/B=0.2and (α) = 0^0, 3^0, 6^0, 9^0, 12^0

for Avg. Settlement (in mm) &Angular Distortion

Table-2 β=15^0, D/B=0.2and (α) = 0^0, 3^0, 6^0, 9^0, 12^0

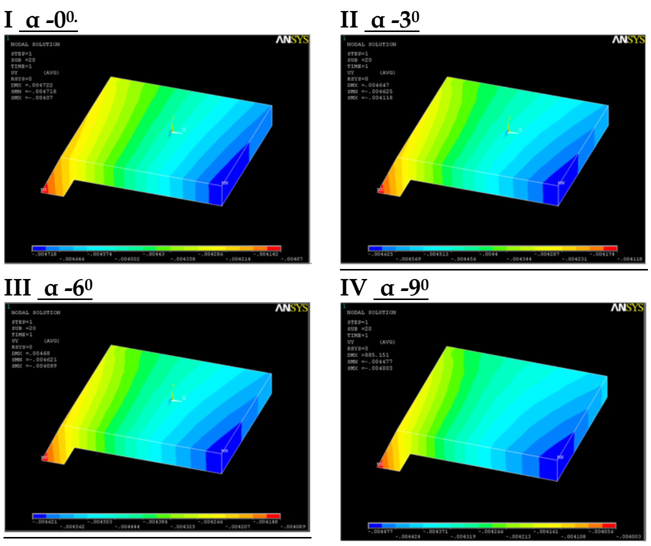
for Avg. Settlement (in mm) &Angular Distortion

β=15^0, D/B=0.2						
Angle	Node				Avg. Settle-ment (in mm)	Angular Distor-tion (in mm)
α	a	b	c	d	a+b+c+d) /4	
0^0	4.20	4.90	5.00	4.20	4.58	$2x10^{-4}$
3^0	4.20	4.80	4.90	4.20	4.53	$2x10^{-4}$
6^0	4.30	4.80	4.90	4.20	4.55	$3x10^{-4}$
9^0	4.20	4.80	4.90	4.20	4.53	$4x10^{-4}$
12^0	4.20	4.70	4.80	4.20	4.48	$4x10^{-4}$



Graph -2 β=15^0, D/B=0.2 for Avg. Settlement (in mm) &Angular Distortion

FIGURES-2 β=15^0, D/B=0.2



V α -12⁰

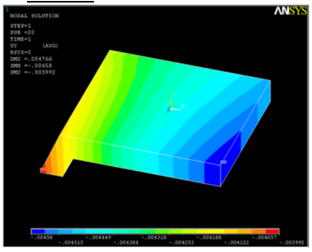
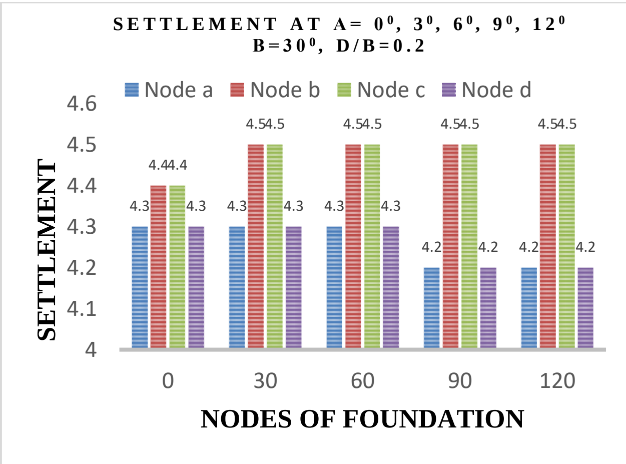


Table-3 β=30⁰, D/B=0.2and (α) = 0⁰, 3⁰, 6⁰, 9⁰, 12⁰

for Avg. Settlement (in mm) &Angular Distortion

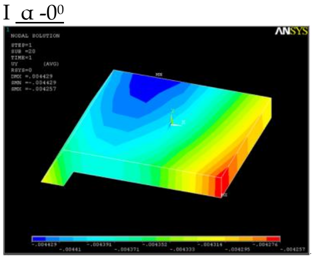
β=30⁰, D/B=0.2						
Angle	Node				Avg. Settlement (in mm)	Angular Distor-tion (in mm)
α	a	b	c	d	(a+b+c+d) /4	
0⁰	4.20	4.90	5.00	4.20	4.58	$2x10^{-4}$
3⁰	4.20	4.80	4.90	4.20	4.53	$2x10^{-4}$
6⁰	4.30	4.80	4.90	4.20	4.55	$3x10^{-4}$
9⁰	4.20	4.80	4.90	4.20	4.53	$4x10^{-4}$
12⁰	4.20	4.70	4.80	4.20	4.48	$4x10^{-4}$



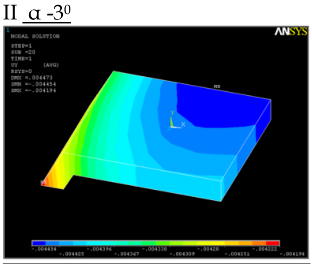
Graph -3 β=30⁰, D/B=0.2 for Avg. Settlement (in mm) &Angular Distortion

FIGURES-3 β=30⁰, D/B=0.2

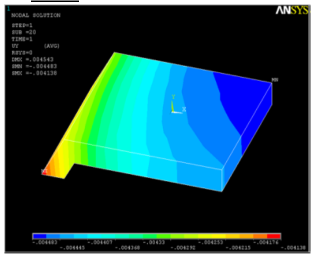
I α -0⁰



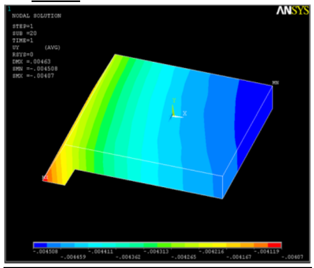
II α -3⁰



III α -6⁰



IV α -9⁰



V α -12⁰

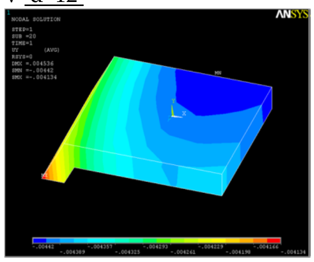
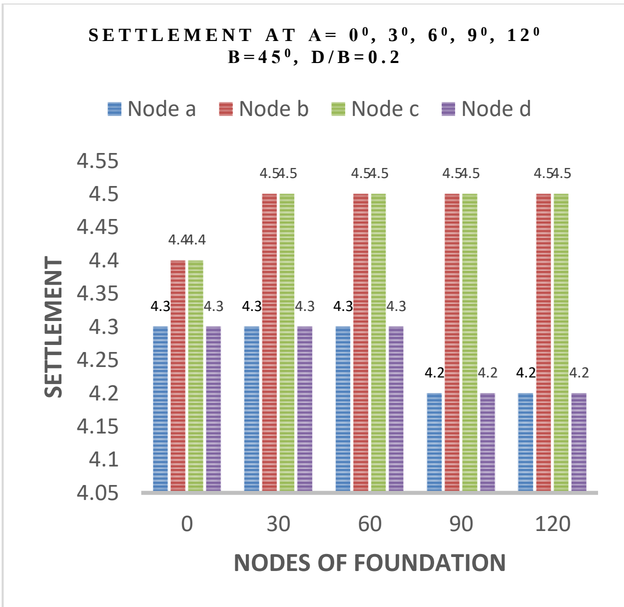


Table-4 β=45⁰, D/B=0.2and (α) = 0⁰, 3⁰, 6⁰, 9⁰, 12⁰

for Avg. Settlement (in mm) &Angular Distortion

β=45⁰, D/B=0.2						
Angle	Node				Avg. Settlement (in mm)	Angular Distor-tion (in mm)
α	a	b	c	d	(a+b+c+d) /4	
0⁰	4.30	4.40	4.40	4.30	4.35	$3x10^{-4}$
3⁰	4.30	4.50	4.50	4.30	4.40	$4x10^{-4}$
6⁰	4.30	4.50	4.50	4.30	4.40	$5x10^{-4}$
9⁰	4.20	4.50	4.50	4.20	4.35	$5x10^{-4}$
12⁰	4.20	4.50	4.50	4.20	4.35	$6x10^{-4}$

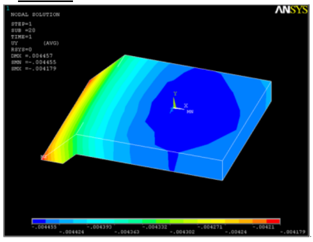


Graph -4 β=45⁰, D/B=0.2 for Avg. Settlement (in mm)

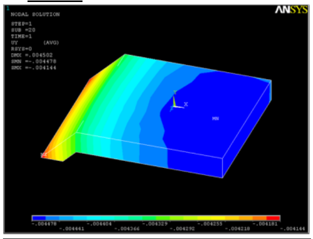
&Angular Distortion

FIGURES-4 β=45^0, D/B=0.2

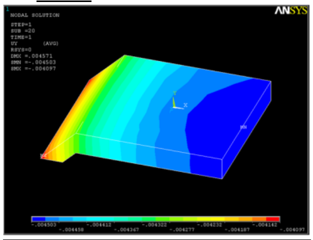
I α -0^0



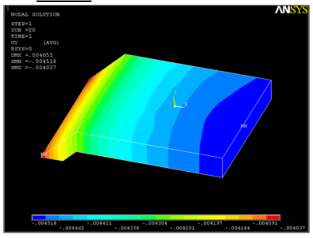
II α -3^0



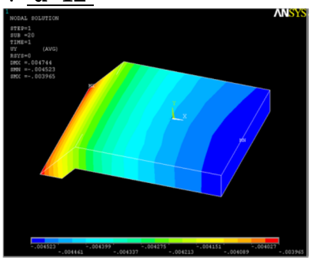
III α -6^0



IV α -9^0



V α -12^0



6. CONCLUSIONS

The verification of the charts by the considered parameters for the real size footing of 1m x1m using the simulation software ANSYS has been done and the results are found to be satisfactory. Following conclusions can be made from the above tabulated results-

1. The eccentricity-width ratio (ex/B) taken from the previously developed charts for the different cases of α, β & D/B ratio were verified using the simulation software Ansys.
2. The eccentricity-width ratio (ex/B) remains same on the application of 150 KN/m2.
3. Settlements found are within permissible limits as per N.B.C.
4. The square angle shaped footing thus has proved to be much better even subjected to eccentric and inclined loading.
5. 5The finite element analysis has been done for real size footing of 1mx1m subjected to eccentric and inclined load of 150 KN/m2, the angular distortion (tilt) and settlement of the footing are within the permissible limit.

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.