INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume3, Issue3)
Available online at www.ijariit.com

Performance of Equal Skirted Strip Footing Resting On Sand Slope Subjected To Lateral Load

Pratieksha S. Deshmukh
Government College of Engineering, Amravati, Maharashtra, India
pratiekshadeshmukh@gmail.com

Thakare S. W
Government College of Engineering, Amravati, Maharashtra, India
sanjay.thakare1964@gmail.com

Dhatrak A. I
Government College of Engineering, Amravati, Maharashtra, India
anantdhatrak@rediffmail.com

Abstract**: Skirted foundations are considered a viable foundation type for a variety of offshore applications, facilities for the oil gas industry and structures where scour is a major concern. In offshore structures, power transmitting cables and earth retaining structures, the lateral forces acting on the footings may be dominant. Thus there is need to study the performance of skirted strip footings subjected to lateral loads. In the present study, static lateral load tests were performed to shed some lights on the performance of equal skirted strip footings. Different parameters were the effect of the ratio of the depth of skirt to the width of footing (d/B), the ratio of the distance of footing from crest to the width of footing (b/B). From the results of laboratory tests, it was found that as the depth of skirt increases and as the distance from the crest to the width of footing increases, the ultimate lateral load carrying capacity of footings increases significantly.

***Keywords:** Equal Skirted Footing, Strip Footing, Sand Slope, Lateral Load, Ultimate Lateral Load Capacity.*

I. INTRODUCTION

Skirted foundations are an alternative to pile foundations in offshore structures. The term skirted foundations are used to identify shallow foundations with vertical/ inclined thin either equal/unequal in depth structural elements fixed along its periphery, "called skirt". The skirts form an enclosure in which soil is confined and works as a unit with the overlain foundation to transfer superstructure load to soil essentially at the level of skirt tip. Peripheral skirts can be used with new and existing shallow foundations of square, rectangular, strip and circular shape. Shallow Footings are subjected to lateral forces induced by earthquake movements, wind loads, water wave pressure, lateral earth pressure and transmitting power cables. In offshore structures, power transmitting cables and earth retaining structures, the lateral forces acting on the footings may be dominant. The present study aims at exploring the performance of equal skirted strip footing subjected to lateral load under different parameters on a sand slope.

II. LITERATURE REVIEW

A review of previous studies on skirted foundations in terms of behaviour, performance, analysis approaches by the numerical and analytical study is carried out. The objective of this review is to identify the contributions established by researchers on skirted foundations and identify the gap in research for the present study.

Saleh *et al*. (2010) studied "Performance of Skirted Strip Footing Subjected to Eccentric Inclined Load" using PLAXIS version 7.1. Parameters selected for study were various load inclination angles, load eccentricities, and skirt length. The study concluded that inserting a skirt under the footing edge reduces the lateral movement of soil.

Pusadkar and Bhatkar (2013) carried out investigations to study "Behaviour of raft foundation with inclined skirt" using PLAXIS 2D. On the basis of a study carried out, it was concluded that there was an increase in B.C. with a decrease in settlement for two-sided skirted raft.

Joshi and Mahiyar (2000) conducted an experimental study to find the effectiveness of angle shaped footing under eccentric loading. They concluded that in the angle shaped rectangular footing, at any angle of footing projection with vertical, projection along the longer side of the footing becomes more effective as compared with footing projection along the shorter side.

Amr Z El Wakil (2010) carried experimental investigation to determine the horizontal capacity of skirted shallow footings on sand. It was concluded that as the length of the skirt to footing diameter ratio increases up to 1.5, the ability of[4] skirted footings of resisting lateral load increases.

Joshi and Mahiyar (2009) conducted series of loading tests on a square angle shaped footing on the sand. They concluded that failure load for an angle shaped footing depends on angle and depth of footing projection.

Ashraf Kamal Nazir and Wasim R. Azzam (2010) conducted experimental analysis to improve B.C on soft clay with and without skirts. There was an improvement in the load bearing capacity using both partially replaced sand piles with and without confinement.

Pusadkar and Dhygude (2016) carried out an investigation to study “Performance of Vertical Skirted Strip Footing on Slope Using PLAXIS 2D”. From the study, it was concluded that skirted strip foundation had a significant effect in improving the bearing capacity with an increase in skirt depth. The skirted strip footing at crest shows significant improvement in bearing capacity.

Thakare and Shukla (2016) carried out investigation to study “Performance of rectangular skirted footing resting on sand bed subjected to lateral load” and from the experimental investigation, it was concluded that increase in the number of skirts and depth of skirt increases the ultimate lateral load carrying capacity of footings. Load carrying capacity of footing increases with increase in inclination of the load in the plan.

III. METHODOLOGY

The main objective of experimental investigation in the present study was to study the response of equal skirted strip footing resting on sand slope subjected to a lateral load.

A. *Test Sand*

For the model tests, cohesion-less, dry, clean and washed Kanhan sand was used as the foundation material. This sand is available in Nagpur region of Vidharabha, Maharashtra. The geotechnical and engineering properties of the sand were determined as per relevant I.S codes.

B. Model Footing

The model footings of skirted strip footings were fabricated by using mild steel plates having dimensions 420 mm x 80 mm and 10 mm thickness. Footing was provided with skirts welded along their periphery. The skirts were made of M.S plates of thickness 5 mm. The depth of the skirts was corresponding to different width ratio of footing as detailed in the program. The photographs of equal skirted strip footing with skirts used for experimental investigation are shown in Fig 1 (a) to (c).

(a) *(b)* *(c)*

Fig. 1: Model skirted footing used in the experimental investigation. (a) Front View (b) Top View (c) Equal skirted Strip Footing

C. Test Setup

The test tank was made of 3 mm thick M.S. sheets having dimensions 1050 mm × 450 mm in plan and 600 mm high. Sufficient horizontal and vertical bracings were provided to prevent it from bulging. One of the sides of the tank was made of thick glass, to observe the mode of failure of footing. The loading frame used for applying lateral loads on the skirted strip footing consisted of a rectangular horizontal base frame of channel section. Two vertical threaded rods made of mild steel were fixed to this base frame. The horizontal bar was connected to these threaded rods using nuts. This bar was having an arrangement for supporting pulleys. The pulley arrangements were fabricated such that the lateral loads could be applied in the forward direction (toward sloping ground).The static lateral loads were applied to the footing by means of dead weights placed on a loading hanger connected to a non-extensible steel rope, passing over the pulleys.

D. Test Procedure

A series of tests were conducted in steel tank 1.05 m x 0.45 m and 0.60 m in depth. The skirted strip footing was then placed on the top of the sand slope and pushed into the sand by displacement method till the skirts were inserted in the sand bed for its full height. After skirts were pushed in the sand slope, the surface was levelled using sharpened straight steel plate. After driving the footing, it was left undisturbed for 12 hours. One dial gauge was placed against the brace welded to the footing to measure the lateral displacement, and two dial gauges supported on the top surface to measure vertical displacement and rotation of footing. The static lateral load test was conducted on footing as per the procedure recommended by Amr Z El Wakil[4] on skirted footing resting on sand bed for a lateral load test. The static lateral loads were applied on the footing using a frictionless pulley and a rope connected to the footing at one end and to the hanger at the other end, in increments by adding dead weights through the loading arrangement. Standard weights were used for loading. Each increment was kept constant for ½ hour. The load was applied laterally at 10 mm above the levelled sand surface. The lateral displacement, vertical displacement and rotation of the skirted footing was measured within an accuracy of 0.01 mm using three dial gauges. The load was applied till failure of footing which was indicated by sudden upliftment of footing from the sand bed slope. Different load displacement curves versus lateral load were plotted for the tests. The detail of test program is shown in Table I.

TABLE I

DETAILED PARAMETERS

Sr. No	Parameters	Details of Parameters
01	Type of footing	Both Side Equal Skirt
02	The ratio of distance of footing from crest to the width of footing (b/B)	1.0, 2.0, 3.0
03	The ratio of depth of skirt to width of footing (d/B)	0.0 , 0.25, 0.5, 1

IV. EXPERIMENTAL RESULT AND DISCUSSION

The lateral load displacement and vertical displacement behaviour of skirted strip footings were determined by conducting model tests. Rotation of footing edge was also calculated as the difference between vertical displacement at load edge and rear edge divided by distance between two edges of footing. The ultimate lateral load was determined from the load-displacement curve.

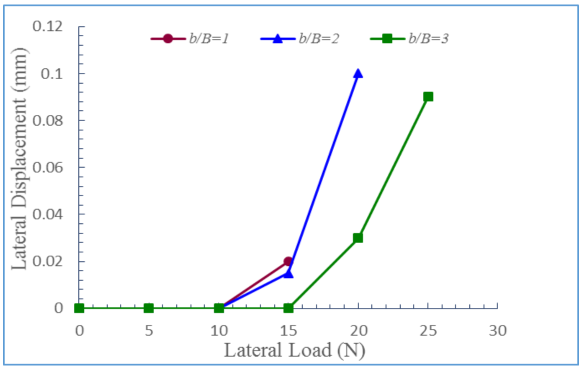
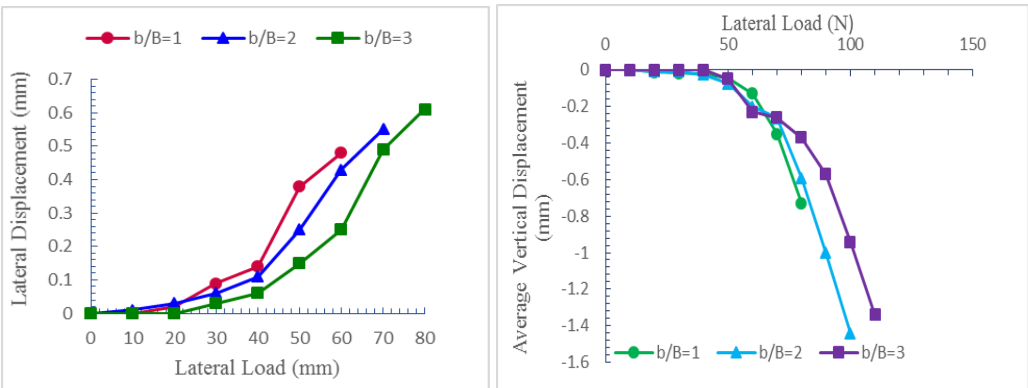
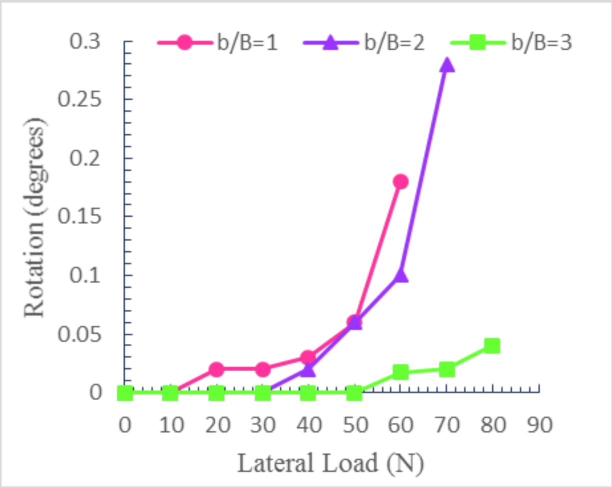


Fig. 2: Lateral Load versus Displacement Curves for Different b/B Ratios (for d/B=0.0)

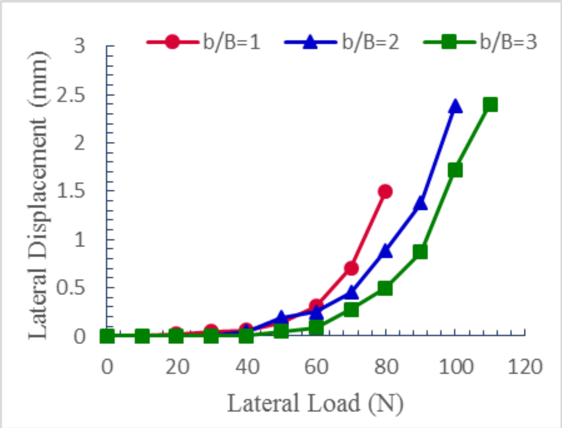


(a) (b)

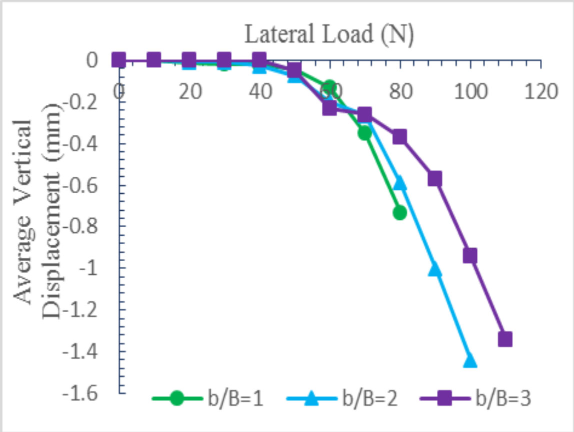


(c)

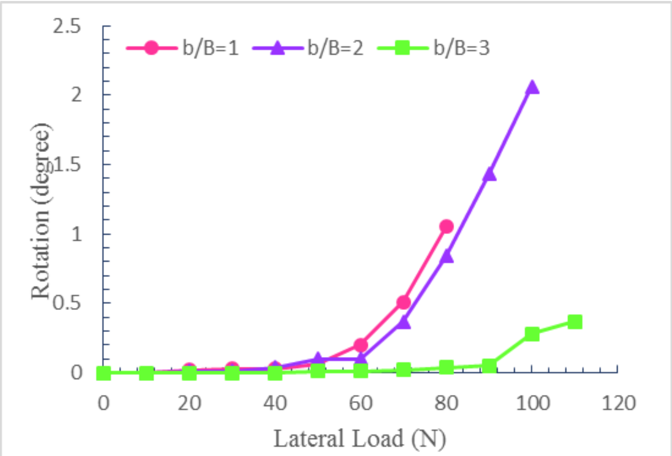
Fig. 3: Lateral Load versus Displacement Curves for Different b/B Ratios (for d/B= 0.25) (a) Lateral Displacement (b) Avg. Vertical Displacement (c) Rotation



(a)

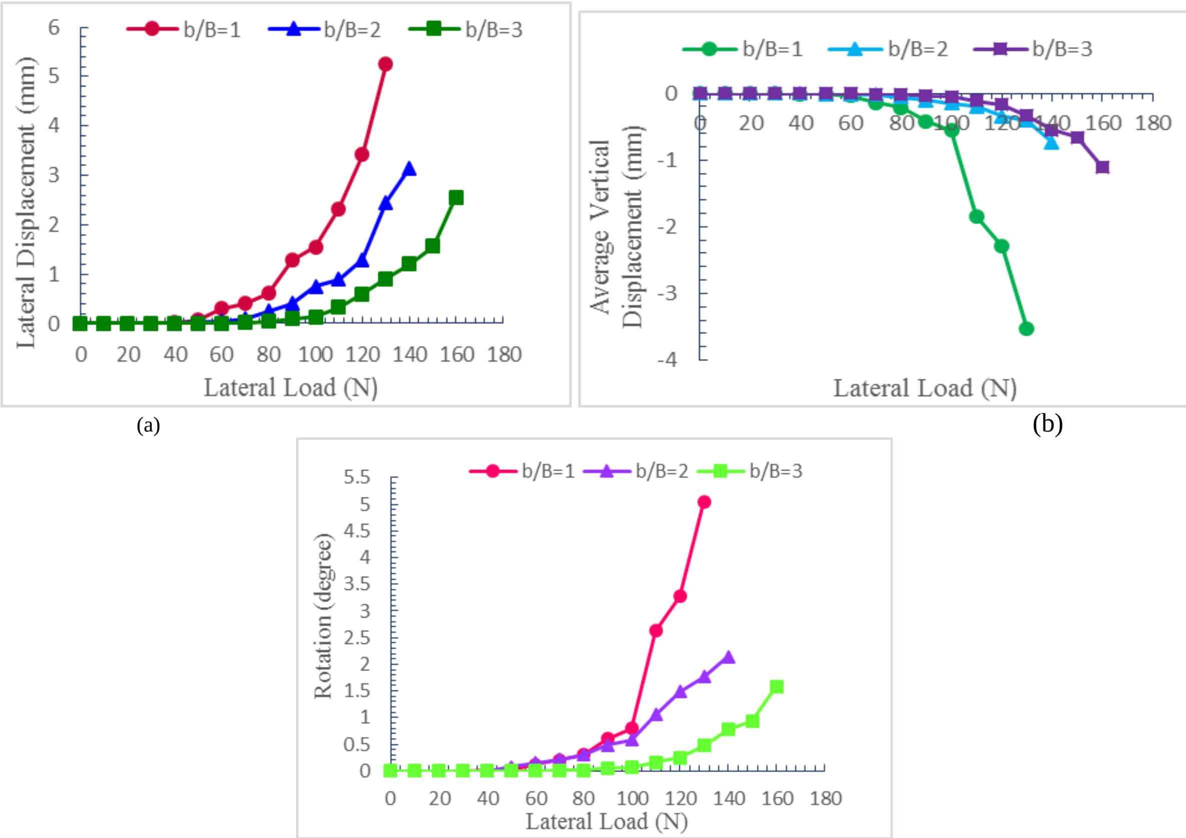


(b)



(c)

Fig. 4: Lateral Load versus Displacement Curves for Different b/B Ratios (for d/B= 0.5) (a) Lateral Displacement (b) Avg. Vertical Displacement (c) Rotation



(a) (b)

(c)

Fig. 5: Lateral Load versus Displacement Curves for Different b/B Ratios (for d/B= 1.0) (a) Lateral Displacement (b) Avg. Vertical Displacement (c) Rotation

TABLE II

ULTIMATE LATERAL LOAD CAPACITY OF EQUAL SKIRTED STRIP FOOTING

Sr. No.	**Depth of skirt to the width of footing ratio *(d/B)***	**Ultimate Lateral Load Capacity of Equal Skirted Strip Footing for different *b/B* Ratios (N)**		
		1	**2**	**3**
1.	0.0	20	25	30
2.	0.25	70	80	90
3.	0.5	90	110	120
4.	1.0	135	150	170

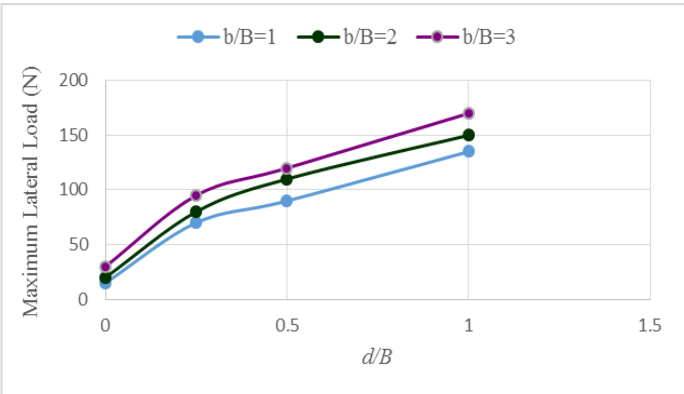


Fig 6: Variation of ultimate lateral load capacity of equal skirted strip footing for various d/B ratios

From the Figure 6, it is observed that the ultimate lateral load capacity of skirted strip footing increases rapidly with the increase of skirt depth to width of footing ratio (d/B). The increase in lateral load carrying capacity may be due to the contribution of the larger surface area for resisting the lateral load.

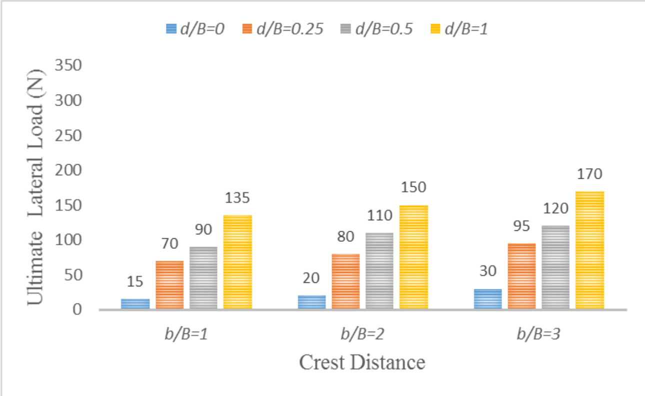


Fig. 7: Ultimate Lateral Load Capacities of Equal Skirted Strip Footing for various Crest Distances

From the Figure 7, it is observed that the lateral load carrying capacity of equal skirted strip footing increases rapidly with increase in crest distance. The increase of lateral load carrying capacity may be due to the increase in confinement which was provided by the surrounding soil.

CONCLUSIONS

From the experimental study of equal skirted strip footing, following conclusions are made:

1. The lateral load capacity of skirted strip footing is much higher, as higher as 7 times, than that of strip footing.
2. The lateral load capacity of equal skirted strip footing increases with increase in the depth of structural skirt; maximum up to 250%.
3. The lateral load capacity of equal skirted strip footing increases with increase in crest to the width of footing ratio; maximum up to 50 %.

ACKNOWLEDGMENT

The tests were performed in Soil Mechanics Laboratory of Government College of Engineering, (An Autonomous Institute of Government of Maharashtra), Amravati, which is appreciated.

REFERENCES

[1] Amr Z El Wakil, "Horizontal capacity of skirted shallow footings on sand". *Alexandria Engineering Journal.*, Vol.49, pp 379–385, 2010.

[2] Joshi D. and Mahiyar H., "Angle Shaped Rectangular Footing with Variable Angle of Footing Projection under Eccentric Vertical Load" *EJGE.*, Vol.14, 2000.

[3] Joshi D. and Mahiyar H., "Angle Shaped Rectangular Footing with Variable Angle of Footing Projection under Eccentric Vertical Load" *EJGE.*, Vol.14, 2009.

[4] Prof. Thakare S.W. and Shukla A.N. "Performance of skirted Rectangular footing resting on Sand bed subjected to Lateral Load" *International Journal of Innovative Research In Science, Engineering, and Technology* (IJIRSET), ISSN (print): 2347-6710, Volume 5, Issue 6, June 2016.

[5] Pusadkar S. S. and Bhatkar T., "Behaviour of raft foundation with inclined skirt using PLAXIS 2D" *Indian Geotechnical Conference.*, Vol-3, No 6, 2013.

[6] Pusadkar S. S. and Dhaygude P. S.,(2016),"Performance of Vertical Skirted Strip Footing on Slope Using PLAXIS 2D", *IOSR Journal of Mechanical and Civil Engineering (IOSR--JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X,* Volume 13, Issue 3Ver. IV 2016.

[7] Nazir A. K., Wasim R. A, "Improving the B.C of Footing on soft clay with sand pile with and without Skirts". *Alexandria Engineering Journal Elsevier.* Vol.49, pp 371-377, 2010.

[8] Saleh M. N, Alsaied E. Ahmed and Azza M. Elleboud, "Performance of Skirted Strip Footing subjected to eccentric Inclined Load" *EJGE.*, Vol. 13. 2010.

[9] Indian Standards- IS: 2720 (Part 3)-1980 "*Methods of a test of soils, determination of specific gravity, fine, medium and coarse grained soils",* New Delhi.

[10] Indian Standards- IS: 2720 (Part 4) -1985 "*Methods of a test of soils, grain size analysis- mechanical method",* New Delhi.

[11] Indian Standards- IS: 2911 (Part 4) -1985 "*Part for lateral load test on piles"* Indian Standard Code of Practice for Design and Construction of Pile Foundations, New Delhi.

