Missouri University of Science and Technology
Scholars' Mine

International Conference on Case Histories in Geotechnical Engineering

(1988) - Second International Conference on Case Histories in Geotechnical Engineering

03 Jun 1988, 10:30 am - 5:30 pm

Distribution of Contact Pressure and Stresses under Skirted Footings

M. L. Ohri
University of Jodhpur, Jodhpur, India

A. Singh
University of Jodhpur, Jodhpur, India

G. R. Chowdhary
University of Jodhpur, Jodhpur, India

Follow this and additional works at: https://scholarsmine.mst.edu/icchge

Part of the Geotechnical Engineering Commons

Recommended Citation

Ohri, M. L.; Singh, A.; and Chowdhary, G. R., "Distribution of Contact Pressure and Stresses under Skirted Footings" (1988). *International Conference on Case Histories in Geotechnical Engineering*. 12.
https://scholarsmine.mst.edu/icchge/2icchge/icchge-session5/12

This work is licensed under a Creative Commons Attribution-Noncommercial-No Derivative Works 4.0 License.

This Article - Conference proceedings is brought to you for free and open access by Scholars' Mine. It has been accepted for inclusion in International Conference on Case Histories in Geotechnical Engineering by an authorized administrator of Scholars' Mine. This work is protected by U. S. Copyright Law. Unauthorized use including reproduction for redistribution requires the permission of the copyright holder. For more information, please contact scholarsmine@mst.edu.

Proceedings: Second International Conference on Case Histories in Geotechnical Engineering, June 1-5, 1988, St. Louis, Mo., Paper No. 5.53

Distribution of Contact Pressure and Stresses under Skirted Footings

M.L. Ohri
M.B.M. Engineering College, University of Jodhpur, Jodhpur, India

A. Singh
M.B.M. Engineering College, University of Jodhpur, Jodhpur, India

G.R. Chowdhary
M.B.M. Engineering College, University of Jodhpur, Jodhpur, India

SYNOPSIS : Skirted footings posses many novel characteristics which render them eminently suitable for construction of structures in situations involving heavy loads and poor soil conditions with promise of economy. The results of the present investigations will help considerably to understand a detailed picture of the complex phenomenon of contact pressure distribution and vertical stress distribution in soil under skirted footings.

INTRODUCTION

A skirt may be constructed as an integral part of the footing along its periphery or independently adjacent to it. These footings have staged their entry into foundation engineering in the early eighties by their use in some important projects located in the Thar desert of India (Singh, Punmia and Ohri, 1981). They may be found efficien t for strengthening the buildings under distress due to excessive total or differential settlement. A model skirted footing provided with integral skirt at 45° with vertical and having skirt depth equal to 0.5 times the top width is capable to take 30% more pressure intensity than its equivalent flat footing in dune sand. Rao and Sharma (1980) have brought out the beneficial effects of non-integral vertical skirts around a footing in increasing bearin g capacity and reducing settlement characteristics. Skirted granular piles also improved the load carrying capacity significantly (Rao and Bhandari, 1979).

For the realistic design of a skirted footing, the nature of pressure distribution at the footing-soil interace and also within the soil mass should be known. Regardless the hypothesis by which these may be calculated the desirability of their determination by actual measurements is always keenly felt. Apart from the present experimental studies, the attempts to measure contact pressures and stress distribution in soil under skirted footings are non-existent. These were investigated under the perfect case of rigidity, using cast iron skirted footing models which settle uniformly at all points on the footing. It ensured not only perfect rigidity but also retention of shape at all stages of loadings.

SOIL

The uniformly graded dune sand used in the test programme had fine sand fraction (425 micron to 75 micron)=98%, coefficient of uniformity = 1.28, coefficient of curvature = 0.94, mean diameter = 0.11 mm, effective size =0.084 mm, specific gravity = 2.66, maximum dry density = 1.43 g/cc, ultimate friction angle is 29° under all conditions of moisture and loading. The peak angle of internal friction in dry state lies in the range of 32° to 35° at the rate of 3° per 10% change in voids ratio.

DESCRIPTION OF MODEL PROGRAMME

Footings

The model footings used in the investigations were made as strip footings of 80 mm x 500 mm provided with skirt at 0°, 20°, 30°, 40°, 45°, 50°, 60° and 90° with the vertical (θ). The depth of the skirt was kept as 0.7 B (B=width of footing), for contact pressure measurements and that of 0.5 B for vertical stress measurements studies. All the footings of each set had the same contact area. Twenty four grooves of 20 mm diameter and 4 mm deep were machined in the footings to receive the boundary earth pressure cells. They were snug fitted and set flush with the base of the footing.

Placement of Sand and Test Equipment

A tank measuring 1.25 m x 0.50 m in plan and 0.90 m in depth was used in the test programme. The sand was allowed to fall freely from a sieve having perforations of 2mm diameter at 25.4 mm c/c from a height of 0.60 m in lifts of 50 mm to achieve a density of 1.60 g/cm^3 The sand was vibrated to achieve a density of 1.65 g/cm^3 Dead load system with a lever arrangement was used to apply the load to the footing. It ensured the constant application and transfer of the applied load from the footing to the soil in each test observations. The dead load system is especially suitable when such sensitive observations as contact pressure and pressure distribution measurements are made. Density measurements were made in each test and probe penetrometer soundings were also performed for density control.

Experimental Procedure

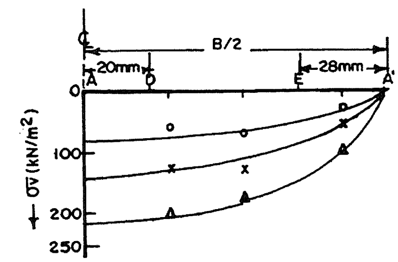
Correct positioning and placement of a model skirted footing required considerable care and effort. The method of its placement on dune sand was perfected after several trials. The stainless steel pressure cells of 20 mm and 30 mm diameter (D) with integral diaphragm, designed and fabricated with considerable care and effort were used for contact pressure and stress distribution measurements respectively.

Second International Conference on Case Histories in Geotechnical Engineering
Missouri University of Science and Technology
http://ICCHGE1984-2013.mst.edu

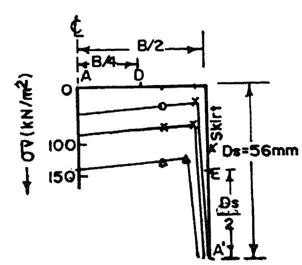
TABLE 1. Charateristics of Pressure Cells

Cell	Capacity (kN/m^2)	Inner dia.(d) mm	Outer dia.(D) (mm)	$\left(\frac{d^2}{D^2}\right)$	Aspect ratio	Thickness of Cell (mm)	Thickness of Diaphragm(mm)
Contact pressure Cell	0-300	14	20	0.49	0.20	4.0	0.40 + 0.03
Embedded Pressure Cell	0-100	20	30	0.45	0.20	6.0	0.45 + 0.03

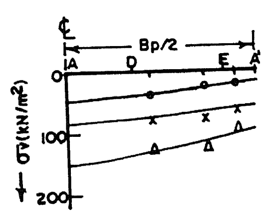
The characteristics of the cells are given in Table 1. The pressure cells were calibrated by using compressed air in triaxial cell and also by applying pressure from a column of mercury manometer designed for purpose. Both the methods gave parallel results. An integral skirted footing containing 24 pressure cells was placed in its position on the sand bed. For the determination of stresses inside the sand medium, twenty four pressure cells were embedded at a time. To have large number of stress points,the position of pressure cells were changed in the second stage of the test on the same footing. Two dial gauges of 0.01 mm least count were set on the footing. A seating pressure of 100 g/cm^2 was applied and released before the start of the test. The wire leads of each pressure cell were connected to the multi-channel input. The output terminal was then connected to the digital strain indicator. By operating the multichannel selector switch, the desired pressure cell was connected to the strain indicator and its initial reading was recorded. The loads corresponding to 20%, 33% and 50% of the ultimate load were applied in steps to the footing (soil deposited at 1.65 g/cm^3) for contact pressure measurements and tat of 30 kN/m^2 (soil deposited at 1.60 g/cm^3) for stress distribution studies. The reading of the strain indicator of each pressure cell was recorded when the settlement of the footing had ceased. The difference between the initial and final readings of the strain indicator gave the magnitude of the strain that each pressure cell had undergone. Each test was repeated atleast three times to check the reproducibility of the test results. The defective cells, if any, were replaced in the subsequent observations.



1 (a).



1 (b).

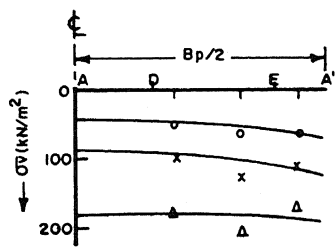


1 (c).

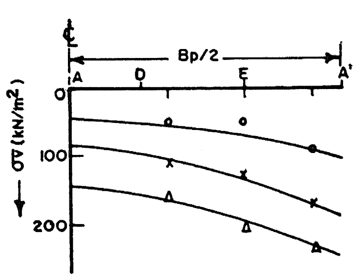
TEST RESULTS AND DISCUSSIONS

Contact Pressure under Footings.

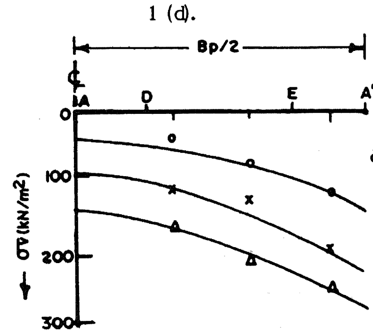
Fig 1(a) shows that the contact pressure distribution under a flat footing which is maximum at the centre and minimum near the edges. The contact pressure increases with the increase of the applied pressure. The observed contact pressure for the footings having skirts at 20°, 30°, 40°, 45° 50° and 60° are plotted on the projected plan width (Bp) of each footing and that of 0° on the geometry of the footing (Fig 1(b) to 1 (h)). The contact pressure below the skirt tends to reduce significantly when the angle of skirt (θ)is more than 45°. The contact pressure distribution is nearly constant when the angle of skirt is 60°. When the skirt of a footing is at 0° with the vertical, the contact pressure is maximum at the centre and relatively non-existent along the length of the skirt. With the increase of angle of skirt from 0° to 50°, there is but a gradual decrease in the cotact pressure at the centre of the footing and significant increase in it along the depth of the skirt. When the angle of skirt is 40°, the contact pressure at the centre of the footing is very nearly the same as that of the skirted footing having the same as that of the skirted footing having θ=45°. However, the same at the edge of the skirt for θ = 45° is 14.5% more than that of θ=40° The concentration of stresses in general is less at centre and more at edges of the skirted footings when $\theta \geq 30$. This trend is reversed for footings having $\theta \leq 20$. The



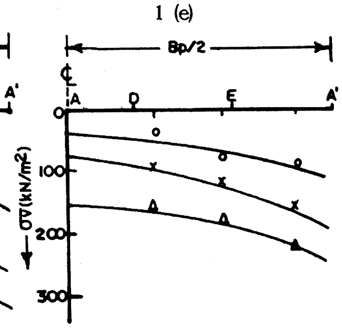
1 (d).



1 (e)

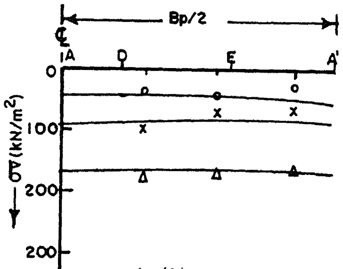


1 (f)



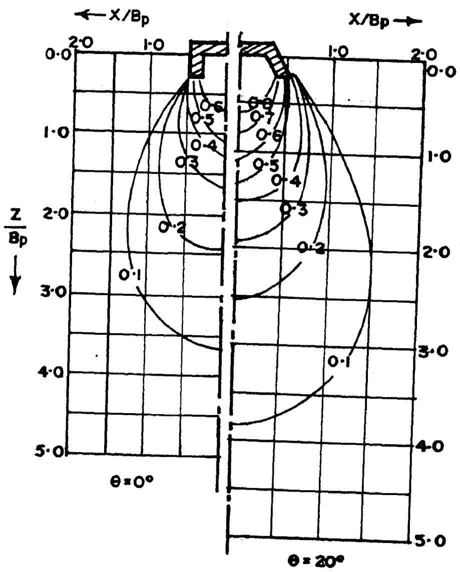
1(g)

Second International Conference on Case Histories in Geotechnical Engineering
Missouri University of Science and Technology
http://ICCHGE1984-2013.mst.edu

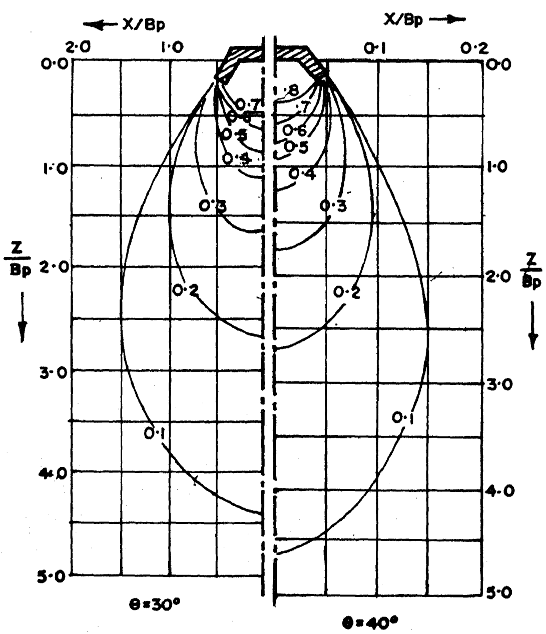


1 (h)

Fig.1. Contact Pressure Distribution under Skirted Footings.



2 (a)

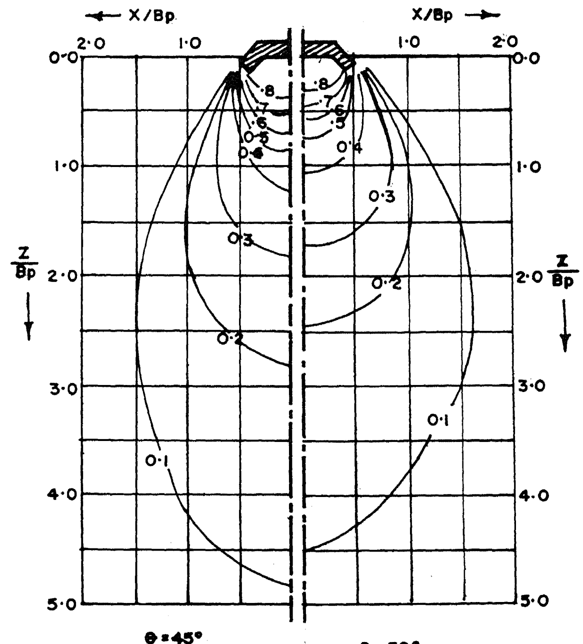


2 (b)

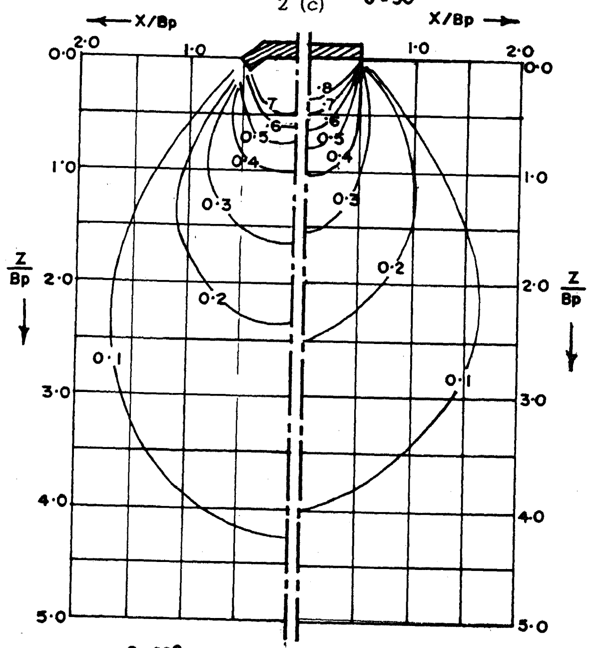
maximum amount of contact pressure at a given pressure intensity at the bottom edge of the skirt has been observed when the angle of skirt (θ) is 45° with the vertical.

Vertical Stress Contours under Skirted Footings.

Fig.2 (a) to 2(d) show the vertical stress contours for skirted footings provided with skirt at 0°, 20°, 30°, 40°, 45°, 50°, 60° and 90° with vertical at the pressure intensity of 30 kN/m². The depth Z/Bp (Z= Depth of soil, Bp = plan width of footing



2 (c)



2(d)

Fig.2. Vertical Pressure Distribution under Skirted Footings.

Second International Conference on Case Histories in Geotechnical Engineering
Missouri University of Science and Technology
http://ICCHGE1984-2013.mst.edu

at the centre of skirted footingof the stress contour of 0.1q intensity due to the applied pressure on a skirted footing having θ = 0°, 20°, 30°, 40°, 45°, 50°, 60° and 90° is 3.65, 3.80, 4.4, 4.5, 4.8, 4.4, 4.25 and 4.25 times the plan width of footing respectively. It may be observed from the figures that region of distribution of a vertical stress of a given pressure intensity increases laterally with increase of angle of skirt from 0° to 60°. The actual stress measured at a given depth below the flat strip footing (θ=90°) is lower than that obtained by Boussinesq. This may be due to the non-linear behaviour of soil. The more the confinement of sand in the skirt zone, the higher is the magnitude of vertical stress at a given depth. The confinement of sand is maximum when angle of skirt is 45°.

CONCLUSIONS

On the basis of a series of laboratory tests on rigid skirted footings bearing on dune sand the nature of contact pressure distribution as well as vertical pressure distribution in soil have been studied and found to be mainly dependent on the angle of skirt. A perfect picture regarding the distribution of contact pressure emerges from the tests. The contact pressure show a definite tendency for edge concentration for $30° \leq \theta \leq 50°$. The contact pressures also exhibit a tendency to shift of concentration towards the central regions of these foundations when the applied load is at a factor of safelty of 2. The pressure bulbs of vertical pressure distribution under skirted footings have been developed and presented which were not so far available in literature. The reported study comprehensively attempts to present the behaviour of skirted footings on dune sand and throws light into the manner in which the loads are transferred from the footings to the soil.

REFERENCES

Barden, L. 1962. An approximate solution for finite beams resting on elastic soils, Civil Eng.Pub.Works, Rev.Vol.57

Boussinesq, J. 1885. Application Des potentiels a L'Etude de L' Equilibre et du Mouvement Des Solids Elastiques, Gauthier Villars, Paris, France.

Chowdhary,G.R. 1987. Behaviour of skirted footings on Dune sand. Ph.D. thesis, Univ. of Jodhpur,India.

Ohri,M.L., A.Singh and G.R.Chowdhary, 1987. Bearing capacity of skirted footings in sand. Proc. International Conference on foundations and tunnels, London.

Rao,B.G. and A.K.Sharma, 1980. Skirted granular pile foundations for seismic and flood-prone zones. ICEPND, Asian Instt. ofTech. Bangkok.

Rao, B.G. and R.K.Bhandari, 1980. Skirting - a new concept in the design of heavy storage tank foundation. Proc. 6th SEACSE, Taipei.

Singh,A. B.C.Punmia and M.L.Ohri.1985. Regional Deposits Desert soils. A state of the art report, Indian Commemorate Volume released by IGS on XI ICSMFE,44-53.

Vardarajan,A. 1983. FEM and its use in soil-structure-inter action studies, International Workshop on soil structure Interaction, Roorkee, India.

Second International Conference on Case Histories in Geotechnical Engineering
Missouri University of Science and Technology
http://ICCHGE1984-2013.mst.edu