Journal of Advances in Science and Technology

Vol. IV, No. VII, November-2012, ISSN 2230-9659

A BEHAVIORAL ANALYSIS OF CIRCULAR FOOTING FOR ITS BEARING CAPACITY

Journal of Advances in Science and Technology
Vol. IV, No. VII, November-2012, ISSN 2230-9659

A Behavioral Analysis of Circular Footing for Its Bearing Capacity

Sebok

Research Scholar, CMJ University, Shillong, Meghalaya, India

Abstract - Earth reinforcement is an effective and reliable technique for increasing the strength and stability of soils. The technique is used today in a variety of applications ranging from retaining structures and embankments to sub grade stabilization beneath footings and pavements. Reinforcement can vary greatly; either in form (strips, sheets, grids, bars, or fibers), texture (rough or smooth), and relative stiffness (high such as steel or low such as polymeric fabrics). In past practice reinforcements have typically consisted of long, flexible, galvanized steel strips with either a smooth or ribbed surface. Most field research to date on the mechanics of reinforced earth has tended to focus on high modulus, steel strips. (Wasti Y Butun MD [1997])However, randomly distributed fiber reinforced soils have recently attracted increasing attention in geotechnical engineering.

As developed during the past decades, the yield design theory provides an approach to the stability analysis of civil engineering structures under seismic conditions which has been often used, explicitly or implicitly. New results related to circular footings resting on a purely cohesive soil, taking into account the horizontal inertia forces, are presented in this paper for practical applications to the safety coefficient to be applied to the vertical load when designing seismic foundations.

---------------------------♦-----------------------------

INTRODUCTION

The lowest part of a structure is generally referred to as the foundation. Its function is to transfer the load of the structure to the soil on which it is resting. A properly designed foundation transfers the load throughout the soil without overstressing the soil. Overstressing the soil can result in either excessive settlement or shear failure of the soil, both of which cause damage to the structure. Thus, geotechnical and structural engineers who design foundations must evaluate the bearing capacity of soils.

The purpose of this study is to outline a work-hardening plasticity model that describes the behaviour of a circular foundation on un-cemented loose carbonate sand when subjected to drained combined loading. The model is based on the experimental data of Byrne & Houlsby (1998, 2001). An existing strain-hardening plasticity model for circular footings on dense silica sand forms the framework of this work. In this model, which is described in Houlsby & Cassidy (2002) and known as Model C, any combination of load or deformation path can be applied to the footing and the corresponding unknowns (deformations or loads) can be calculated. It has been found to be applicable to loose carbonate sands. In this study we outline the minor modifications necessary for Model C to be confidently applied to modelling circular foundations on carbonate sand. These include a new hardening expression, yield surface expansion due to horizontal and rotational plastic displacements (as well as vertical), and revised values of the existing Model C parameters for application in loose carbonate sand.

The analysis is carried out using an axisymmetric model. A prescribed displacement is applied at the top to simulate the penetration of the footing. Note that for an axisymmetric PLAXIS calculation, the mesh represents a wedge of an included angle 9 of one radian; the calculated reaction force must therefore be multiplied by 2w to obtain the load conesponding to a full circular footing. This is a typical situation where the 15-noded elements are preferable, since lower order elements will over-predict the failure load. A geometry line to be used in local refinement and controlling of the mesh is introduced at
the corner of the footing.

Further, the presence of fines in sand has an influence on the bearing capacity. The problem of bearing capacity of shallow foundations on granular soils has been studied for many years. However, an accurate solution capable of predicting peak load carrying capacity for a wide range of soil relative densities, effective stress conditions and foundation shapes within a practical context remains elusive owing to the presence of fines.

BEARING CAPACITY THEORIES

A number of equations based on theoretical analysis and experimental investigations are available to determine the ultimate bearing capacity equation.

1. TERZAGHI'S ANALYSIS: Main assumption made by Terzaghi was that the soil behaves like an ideally plastic material (This concept was initially developed by Prandtl). Terzaghi analysed the failure of a shallow continuous footing (L/B = ∞) and then suggested modifications for isolated square, rectangular and circular footings. The three cases considered by him are (1) smooth base of a footing resist on an ideal soil surface, (2) Rough base of a footing resting on an ideal soil surface and (3) Rough base of a footing resting at a level below the ground surface.

Terzaghi has further defined two types of failures. Before loading the soil is in a state of elastic equilibrium. When a load greater than critical load is applied, the soil gradually passes to a state of plastic equilibrium. For this transition from elastic to plastic state there may be either loacal shear failure or general shear failure.

2. MEYERHOF'S THEORY: Meyerhof extended Terzaghi's analysis of the plastic equilibrium of the surface footing to shallow and deep foundations, considering the shear strength of overburden.

CIRCULAR FOOTINGS ON NATURAL CLAY STABILIZED

The bearing capacity of shallow footings has been studied since Terzaghi's original observation during the 1940s. Although additional considerations to the governing criteria of bearing capacity have been proposed, the ultimate bearing-capacity calculation of a footing has changed very little since Terzaghi's first general equation for the ultimate bearing capacity, qult. The classic bearing-capacity formulation cannot be used directly in large-scaled footing design without a correlation.

Despite their operational and financial disadvantages, large and full-scale in-situ tests give more reasonable results in when simulating soil behavior. It is known from the literature that most of the experimental studies on soils have been conducted using small-scale laboratory tests and formulations have been derived from small-scale model footing tests. Small-scale model footing tests produce higher values for the bearing capacities than those of theoretical equations and therefore they should not be used for the design of full-scale footings without a reduction.

This study is focused directly on the scale-effect investigation in circular footings rested on natural clay deposits stabilized with compacted granular-fill layers. Numerical analyses were carried out using two-dimensional, finite-element formulations. Before conducting the analysis, the validity of the constitutive model was proved using field tests performed by the authors, with seven different footing diameters up to 0.90 m and three different compacted granular-fill layer thicknesses. After achieving a good consistency, the numerical analyses were continued by increasing the footing diameter up to 25 m. In this parametric study, the granular-fill layer thicknesses were selected as 0.17D; 0.33D; 0.67D; 1.00D; 1.33D; 1.67D and 2.00D according to the footing diameter. The results of this study showed that the partial replacement with compacted granular-fill layer had a considerable effect on the bearing capacity of the circular footings. It was found based on the numerical and field test results that the Bearing Capacity Ratio (BCR) of the stabilized natural clay deposits increased with an increase in the footing diameter and there was no significant scale effect of circular footing resting on natural clay deposits.

RESULTS AND DISCUSSION

Circular footing on clean sand and sand with increasing proportions of fines was tested to investigate the effect of confinement on bearing capacity. The pressure settlement responses show that there is no pronounced peak in the case of an unconfined soil bed, but slope of the pressure settlement curve tends to become steeper beyond a some level of settlement ratio i.e. S/D ratio. This indicated soil failure. With the provision of cell, clear failure is not noticed even at larger percentage of settlement.

In addition, when the footing is loaded, cellular support below the footing resists the lateral displacement of soil particles underneath the footing and confines the soil leading to a significant decrease in settlement and hence improving the bearing capacity. The improvement due to the soil confinement is represented using a non-dimensional factor, called improvement factor (If), which is defined as the ratio of the footing ultimate load with cellular support to the footing ultimate load in tests without cellular support.

CONCLUSION

Seismic actions must now often be taken into account when designing private or industrial buildings or structures such as bridges, dams, nuclear plants, etc. We have briefly outlined how such a problem can be thoroughly studied from the theoretical point of view through the yield design approach up to the writing of new international design codes. For this purpose it is necessary that the rationale of the yield design theory be thoroughly understood since most (not to say all) equations that are used in such codes are obtained through the external approach, either explicitly or implicitly. To this extent the yield design theory is a corner stone of ultimate limit state design (ULSD).

The assumption that the soil is a rigid perfectly plastic material is
not valid for footings resting on carbonate sand. Adequate experimented and field data for bearing capacity of footings on carbonate sand and subjected to inclined load is also not available. Thus the use of classical bearing capacity equations, with empirical reduction factors, for foundations resting on carbonate sands and subjected to inclined loads, is questionable.

Based on experimental study, the following conclusions are drawn -

1. Soil confinement has a significant influence on the behavior of circular footings leading to bearing capacity enhancement for systems supported on granular soils.

2. For small diameter of cells relative to footing size, the cell-soil-footing system acts as one unit i.e. the cell, soil, and footing settle all together.

3. For large diameter cells relative to footing size, the cell-soil-footing system behaves initially as one unit but as the failure approaches, the footing only settles while the cell remains unaffected.

4. The improvement in the ultimate bearing capacity depends on the d/D (cell diameter/footing diameter) and h/D ratio (cell height/footing diameter). The optimum ratio is 1.5 beyond which the improvement decreases as the h/D ratio increases from 0.5 to 1. Whereas if d/D = 2, the improvement factor (If) increases for all the values of h/D.

5. Increase in the height of the confining cell transfers footing loads to the deeper locations and increases the improvement factor due to an increase in the surface area of the cell-model footing.

6. The embedded depth of the footing relative to the top of confining cell has no significant effect on the response of footing-cell systems.

7. Bearing capacity of circular footings decreases on increase in proportions of fines for all ratios of d/D and h/D.

REFERENCES

- Hataf N., Rahimi M.M., [2005]. 'Experimental investigation of bearing capacity of sand reinforced with randomly distributed tire shreds'.
- Wasti Y., Butun M.D., [1996]. "Behaviour of Model Footings on Sand Reinforced with Discrete Inclusions".
- [Chatzigogos et al. 2007] C. T Chatzigogos, A. Pecker, and J. Salengon, "Seismic bearing capacity of a circular footing on a heterogeneous cohesive soil". Soils Found. 47:4 (2007), 783-787.
- [Fishman et al. 2003] K. L. Fishman, R. Richards Jr.. and D. Yao, "Inclination factors for seismic bearing capacity", J. Geotech. Geoenviron 129:9 (2003), 861-865.
- Gottardi, G. and Butterfield, R. (1993), On the bearing capacity of surface footings on sand under general planar loads. Soils and Foundations, Vol. 33, No, 3, pp. 68-79.
- Hansen, J.B. (1970), A revised and extended formula for bearing capacity. Danish Gcotechnical Institute, Copenhagen, Denmark, Bulletin 28, pp.5-11.
- Meyerhoff, C.G. (1963), Some reccnt research on the bearing capacity of foundations. Canadian Geotechnical Journal, 1, No. 1, pp. 16-26.
- Meyerhoff, C.G. (1953), The bearing capacity of footings under eccentric and inclined loads. Proceedings 3 rd ICSMFE, Zurich, pp. 440-445.
- eBeer, E.E., "Bearing Capacity and Settlement of Shallow Foundations on Sand", Symposium on Bearing Capacity and Settlement of Foundations, Duke University, Durham, NC , U.S.A., (1965), 15-33.
- Cerato, A. B. and Lutenegger, A. J. (2007). Scale effects of shallow foundation bearing capacity on granular material. *Journal of Geotechnical and Geoenvironmental Engineering*, ASCE, 133(10), 1192-1202.
- Dewaiker, D. M. and Mohapatro, B. G. (2003). Computation of bearing capacity factor Nγ-Terzaghi's mechanism. *International Journal of Geomechanics*, 3(1), 123-128.
- Das, B. M. and Omar, M. T. (1994). The effects of foundation width on model tests for the bearing capacity of sand with geogrid

reinforcement. *Geotechnical and Geological Engineering*, Technical Note (12), 133-141.

- Hettler, A. and Gudehus, G. (1988). Influence of the foundation width on the bearing capacity factor. *Soils Foundation*, 28(4), 81–92.

- Ueno, K., Miura, K. and Maeda, Y. (1998). Prediction of ultimate bearing capacity of surface footing with regard to size effects. *Soils Foundation*, 38 (3), 165–178.

- Zhu, F., Clark, J. I. and Phillips, R. (2001). Scale effect of strip and circular footings resting on dense sand. *Journal of Geotechnical and Geoenvironmental Engineerin*g, ASCE 127(7), 613-621.