Selected Papers from the Proceedings of the Fourth Geo–China International Conference

Geotechnical Special Publication No. 267

New Frontiers in Civil Infrastructure

Edited by

Hany Farouk Shehata, Ph.D.
David Yanez Santillan
Mohamed F. Shehata, Ph.D.

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Preface

Toward building sustainable and longer civil infrastructures, the civil engineering community around the globe continues undertaking research and development to improve existing design, modeling, and analytical capability. Such initiatives are also enhanced by the on-going research toward new frontiers in civil infrastructures. This Geotechnical Special Publication (GSP) "New Frontiers in Civil Infrastructures" is one of the several official proceedings of the GeoChina 2016 Conference and contains technical papers that address several of these issues. It includes the full-length, peer-reviewed papers accepted for this conference.

More than six hundred abstracts were received for this conference in response to the Call for Papers. The abstracts were reviewed by the Organizing and Scientific Committees. All papers were reviewed following the same procedure and at the same technical standards of practice of the Geo-Institute of the American Society of Civil Engineers. All papers received a minimum of two full reviews coordinated by various track chairs and supervised by the GSP editors. Standard editorial review forms and checklists were applied to maintain uniform technical standards of the papers. As a result, 23 papers were accepted and published in this GSP designated for the new frontiers in civil infrastructure's track. The authors of the accepted papers have addressed all the comments of the reviewers to the satisfaction of the session chairs. It is hoped that readers of this GSP will be stimulated and inspired by the wide range of papers written by a distinguished group of national and international authors. The papers (like all GSPs papers) are eligible for discussion in the Journal of Geotechnical and Geo-environmental Engineering and for ASCE award nominations.

Publication of this quality of technical papers would not have been possible without the dedication and professionalism of the paper reviewers. The names of these reviewers appear in the acknowledgment that follows. For any additional reviewers whose names were inadvertently missed, we offer our sincere apologies.

We are thankful to Professor Shucai Li, Chair and Professor Dar Hao Chen, Co-chair of the organizing committee of the GeoChina 2016 Conference. Appreciation is extended to the authors and track chairs for their significant contributions. Thanks are also extended to ASCE Geo-Institute staff, Board and meeting Specialist, for their coordination and enthusiastic support to this conference. All of the submission activities of the papers for this conference were managed online by Conference Manager and we thank Professor Khalid El-Zahaby and Professor Hesham K. Amin of the Housing and Building National Research Center, Egypt for their help with additional reviews and help with the final preparations of GSP. The editors also acknowledge the assistance of Ms. Donna Dickert at ASCE Geo-Institute in the final production of this Geotechnical Special Publication.

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Contents

New Trends in Foundation Design Using the Finite Element Analysis Method

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Abstract: This paper presents an advanced analysis of shallow foundations using both strip and isolated footings. Taylor (1948) assumed uniform distributions for the contact stresses under the concentrically loaded footings, and most references and standards have followed this assumption. They have also used this distribution in the calculation of the bending moment acting on footings that are resting on sand and clay. In the literature, many researchers have presented distributions that depart from the Taylor assumption. Approximately equal distributions of contact stress in sand and clay are presented here. The distribution is of higher stress near the edges and lower stress under the column. This paper also examines the problem of contact stress distribution under strip and isolated footings using PLAXIS 2D-AE and 3D-AE, respectively. Linear elastic and Mohr-Coulomb models are adopted to simulate the soils. The results showed that the Mohr-Coulomb soil model is more appropriate in the study of the contact stress distribution than the linear elastic model. The resulting contact stress distributions under the concentrically loaded strip and isolated footings are in good agreement with the previous research results. The contact stresses is highly concentrated near edges and lower under the column. These concentrations of stresses near edges have long arms in the calculation of the maximum bending moment under the footings. Therefore, the maximum bending moment estimated by this modern analysis is higher than the one calculated using the Taylor (1948) assumption. Accordingly, references and standards should be updated to include the real distributions of contact stress. Large scale models should be established to determine the real distributions of the contact stress under footings.

INTRODUCTION

In modern design, designers usually assume that there is uniform contact stress under the footings. Taylor (1948) wrote the seminal paper for this assumption and has been widely cited. He assumed that the distribution of contact stress under a footing on sand is high under the columns and low or zero at the edges. He also assumed that the distribution of contact stress under a footing on clay is high at the edges and slightly lower under the column. He stated that the general shape that combines sand and clay soils is a uniform distribution of the contact stress. This assumption was a reasonable early simplification of foundation analyses. However, references and standards still use this assumption as a real distribution. They also accept the assumption of uniform contact stress, i.e., the general shape between the footings on sand and clay. Figure (1) shows the distribution of contact stress under shallow foundations subjected to concentric vertical loads for cohesive and cohesion-less soils, after Donald P. Coduto (2001). It can be observed that the distribution of the contact stress under flexible footings in sand and clay is uniformly distributed, which is not compatible with the results presented in this paper. Instead, for rigid footings, the contact stresses under columns increases in sand and decreases in clay. Braja M. Das (2008) presented an illustration (Fig. 2) in his Handbook of the above mentioned distribution, as did Joseph E. Bowels (1997), in Figure (3) of his Handbook. These representations of the probable contact pressure under a rigid footing are not compatible with this paper's results or the real measurements.

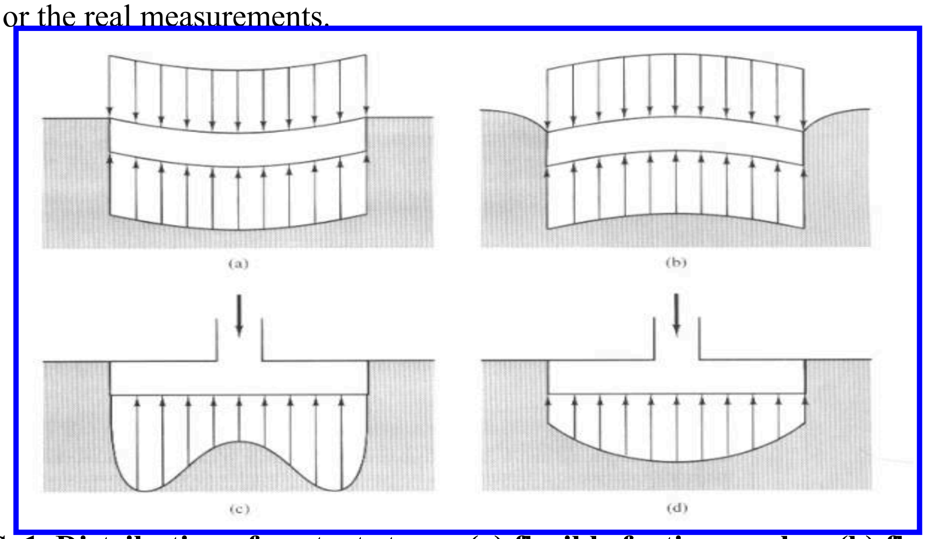
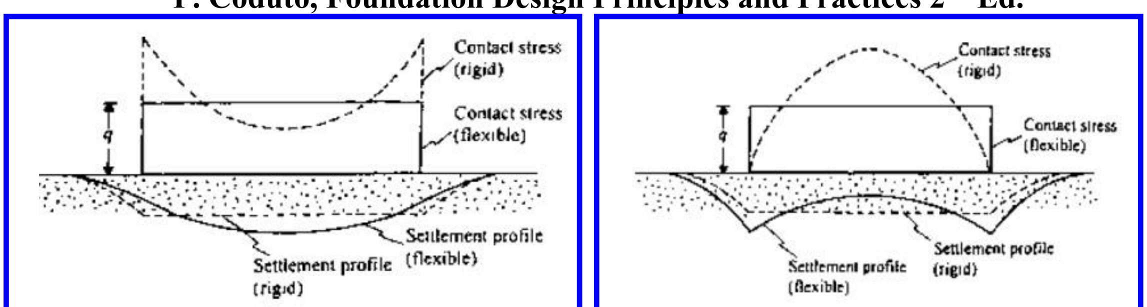


FIG. 1. Distribution of contact stress; (a) flexible footing on clay, (b) flexible footing on sand, (c) rigid footing on clay, (d) rigid footing on sand. P. 155, Donald P. Coduto, Foundation Design Principles and Practices 2nd Ed.



(a) (b)

FIG. 2. Contact pressures distribution and settlement profiles; (a) clay, (b) sand. Page 144, Braja M. Das, Advanced Soil Mechanics 3rd Ed.

The Committee of ACI 336 (1966) suggested an analysis and design procedure for combined footings and mats. In their report, they presented a suggested distribution of contact stress, as shown in Fig. 4. They stated that the assumption of a linear distribution is satisfactory.

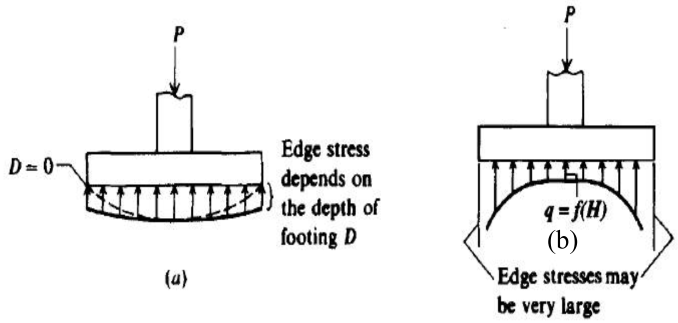


FIG. 3. Contact stress distribution under rigid footing; (a) clay, (b) sand. P. 406, Joseph E. Bowels, Handbook of Foundation Analysis and Design 5th Ed.

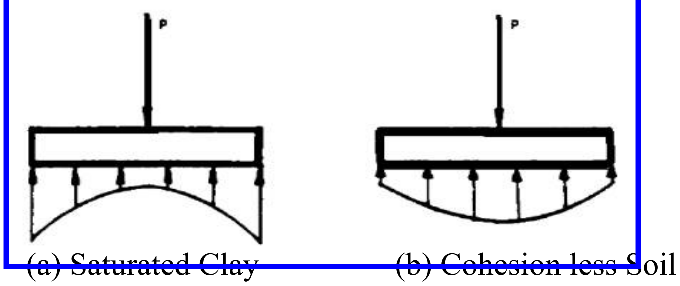


FIG. 4. Contact stress distribution under rigid footing; (a) Saturated clay, (b) sand. Page 6, ACI 336.2R 1966, reapproved 1980.

Several researchers, starting from the 18th century, have studied the problem of the distribution of the contact stress under footings. They have used the elastic soil model, the Boussinesq model, a subgrade model, and the Winkler model, to represent the soil. The exact representation of the footing with an accurate simulation of the surrounding soil is a very complex problem. These early researchers, working without the benefit of modern software, made great efforts to find a solution to this complex problem. They generally used models that did not take the type of soil into consideration. Some studies have used more advanced soil models, but the objective of these studies was not to investigate the shape of the contact stress under footings in sandy and clayey soils. Therefore, there is still need for more realistic soil models and full-scale measurements. The prediction of contact stress and settlement under foundations depends on the modelling superstructure, the foundation, the soil, and their simultaneous interaction. This complex problem can be addressed through various methods of calculating contact stress under foundations.

Subgrade Reaction Theory "Winkler Model"

This model assumes that the soil acts as a bed of evenly spaced, independent, linear springs. It also assumes that each spring deforms in response to the vertical stress applied directly to that spring and does not transmit any shear stress to the adjacent springs. However, in real soils the displacement distribution is continuous. The deflection under a load can occur beyond the edge of the footing, and the deflection diminishes at some finite distance. This is not considered to be a realistic model because it cannot take into account the effect of the shear transmission of stresses to the adjacent support elements. Consequently, the distributions of displacements are continuous. The deflection of a point in the soil occurs not just because of the stress