Analysis and Design of Shallow Foundations on Different Soils

Prepared by: Ibrahim Al-Muqbil, Ayman Al-Awwad, Khalid Al-Harbi, Rashed Al-Jaloud

Supervised by: Dr. Mounir Ltifi

ABSTRACT

The main objectives in the implementation of a foundation project are the factors of stability and economy. Therefore, design of foundation must satisfy at least, two limit states: bearing capacity and excessive settlement requirements. This project treats the analysis and design of shallow foundation. In the first part of this study a literature review related to the general aspects (such as performances requirements, uncertainties and the factors of safety with regards to the adopted codes and standards); and the various methods for estimating the ultimate bearing capacity and the settlement of shallow foundations under various types of loading and subsoil conditions. In the second part, an Excel sheet application is developed to calculate the bearing capacity and estimate the settlement of a shallow foundation. The bearing capacity is determined by two different methods: Terzaghi and Vesic's methods. However, the settlement is estimated by the 'Classical Method' basing on the consolidometer tests results and by 'Schmertmann Method' basing on the in-situ tests (SPT: Standard Penetration Test and CPT: Cone Penetration Test). The validity of the developed Excel sheet application is checked by numerical examples. In addition, a parametric study of the different parameters such as the geometry of the foundation, the properties of the soil and the loading conditions is carried out to underline the most influential parameters on the bearing capacity and the settlement of a shallow foundation.

OBJECTIVES

This project focuses on the analysis and design of shallow foundations of different buildings. It mainly focuses on the shallow foundation design of the buildings. The foundations transmit all the combined loads of a structure to the soils or rocks. Their main objective is to prevent the structure from any compressive, lateral or torsional movement.

The main objectives of this project for are listed below:

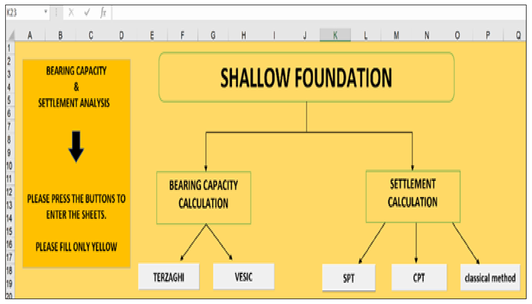
- Understand the general aspects of the interaction soil-structure.
- Analysis of the different methods to evaluate the bearing capacity and the ultimate bearing capacity.
- Analysis of the different methods used to calculate the settlement from the laboratory and in-situ tests.
- Design an Excel sheet application to optimize the analysis of the foundation.
- Analysis of the results and underline the most influential parameters through a parametric study.

METHODOLOGY

- Analysis and design of shallow foundation on different soil by determining the ultimate bearing capacity by using Terzaghi's and Vesic's methods.
- Investigating the effect of the shape of footing on the ultimate bearing capacity.
- Analysis of the bearing capacity of shallow foundations on different soil by considering different parameters: width of the footing, depth of the footing, depth of the ground water table, cohesion of the soil and friction angle of the soil.
- Analysis and design of shallow foundation on different soil by determining the settlement by using cone penetration test results, standard penetration test results and classical method.
- Investigating the effect of the shape of footing on the settlement.
- Analysis of the settlement of shallow foundations on different soil by considering different parameters: width of the footing, depth of the footing, depth of the ground water table and the applied column loads.

DEVELOPMENT OF EXCEL SHEETS & ANLYSIS OF BEARING CAPACITY AND SETTLEMENT

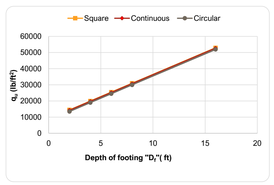
An excel has been made to design and analyze the ultimate bearing capacity and settlement of shallow foundations. Following are the main window of that sheet.



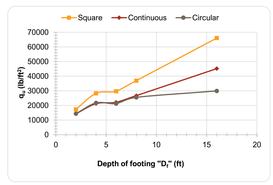
Bearing Capacity

❖ **Geometry Effects**

➢ Footing embedment depth effects



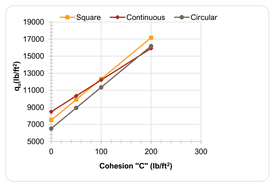
Effect of depth of foundation on BC using Terzaghi.



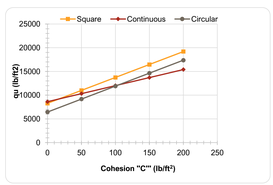
Effect of depth of foundation on BC using Vesic.

❖ **Soil Condition Effects**

➢ Effects of cohesions of the soil

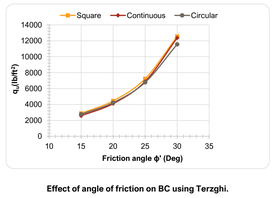


Effect of cohesion of soil on BC using Terzaghi

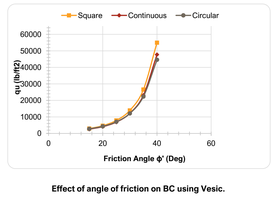


Effect of cohesion of the soil on BC using Vesic

➢ Effects of friction angle



Effect of angle of friction on BC using Terzghi.

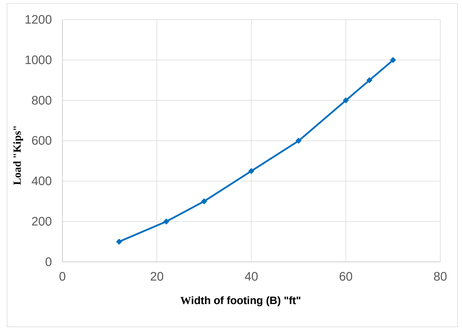


Effect of angle of friction on BC using Vesic.

Settlement

A proposed building has the following data. By using excel sheet a plot of allowable column load vs the width of the footing

Type of foundation	Spread footing	**C_c / (1+ e_o)**	0.12
Depth of footing	36 in	**C_r / (1+ e_o)**	0.03
Type of soil	Silty clay	**GWT**	10 ft
Depth of soil strata	∞	**Allowable settlement**	1 in

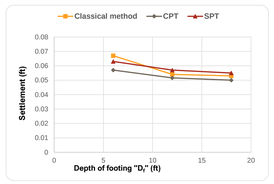


Effect of width of foundation and load on settlement "Square and circular"

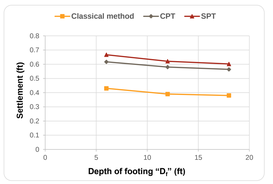
After that we introduce B the width of the foundation (square) and the vertical load. The settlement estimated should be less than the allowable settlement 1in. This procedure is repeated for many times by changing B and P, with respecting to allowable settlement.

❖ **Geometry Effects**

➢ Footing embedment depth effects



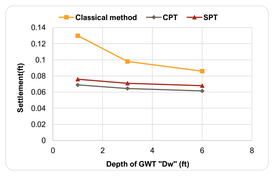
Effect of depth of foundation on settlement "Square "



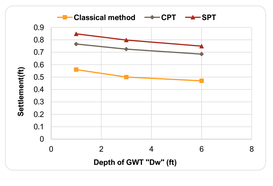
Effect of depth of foundation on settlement "Continuous"

❖ **Soil Condition Effects**

➢ Ground water table depth effects



Effect of depth of water on settlement "Square"



Effect of depth of water on settlement "Continuous"

RESULTS

- ❑ In case of bearing capacity when the friction angle is high then the bearing capacity will be high.
- ❑ The bearing capacity will increase with the increase of cohesion of soil, this is true for both Terzaghi and Vesic methods.
- ❑ By using Terzaghi method, with increasing the depth of footing, the bearing capacity will increase for all footing shapes as the same amount.
- ❑ By using Vesic method, since there is a depth factor for each shape then the increase in the bearing capacity will not be the same for all shapes.
- ❑ The settlement of shallow foundations will reduce with the increase of the depth of footing.
- ❑ In case of settlement in soil with different area values, it is found that when the area increases, settlement will decrease.
- ❑ The settlement will increase with the presence of water within the range of influence.

CONCLUSIONS

This project has been very useful for understanding the aspects of design and analysis of shallow foundations.

The main conclusions can be summarized as following:

- ❑ The understanding of the theory of bearing capacity as well as its practical and empirical aspects. Particularly the Terzaghi and Vesic's methods which are discussed in this study.
- ❑ The Control of the computation methods of settlement by using laboratory test (consolidometer tests) and in situ tests (SPT and CPT tests).
- ❑ The validation of the Excel sheet developed in this study by studying many numerical cases with different conditions of loading, foundation geometry and soil properties.
- ❑ Highlighting the main parameters that affect the bearing capacity and the settlement through the analysis of the results of the parametric study.

Some recommendations can be made at the end of this project concerning the extension of the Excel sheet application for more specific cases such as combined footing and mat foundation with different conditions of loading as lateral earth pressure.

REFERENCE

- Foundation Design Principles and Practice, Donald P. Coduto, 1999 Second edition.
- Shallow Foundation Bearing Capacity and Settlement, Braja M. Dos, 1999.
- Geotechnical Engineering Principles and Practice, Donald P. Coduto, 2010 Man-chu Ronald Yeung and William A.Kitch, Second edition.

ACKNOWLEDGEMENTS

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