Ain Shams University
Faculty of Engineering
Department of Structural Engineering

Limit State Design in Geotechnical Engineering and its Applications for Deep Foundations in Egypt

A THESIS
Submitted in Partial Fulfillment for the Requirements of the Degree of
MASTER OF SCIENCE IN CIVIL ENGINEERING

Submitted by

Muhammad Ahmed El Sayed Zayed
B.Sc. in Civil Engineering - Structural Engineering- June 2010
Ain Shams University – Faculty of Engineering

Supervised by

Prof. Yasser M. El- Mossallamy
Professor of Geotechnical Engineering
Structural Engineering Department
Faculty of Engineering
Ain Shams University

Dr. Mohamed Maher Tawfik
Assistant Professor of Geotechnical Engineering
Structural Engineering Department
Faculty of Engineering
Ain Shams University

June 2014

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EXAMINERS COMMITTEE

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Prof. Dr. Yasser M. El-Mossallamy Professor of Geotechnical Engineering Faculty of Engineering Ain Shams University	

Date: 23 / 6 / 2014

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SUPERVISORS COMMITTEE

Name and Affiliation	**Signature**
Prof. Dr. Yasser M. El-Mossallamy Professor of Geotechnical Engineering Faculty of Engineering Ain Shams University **Dr. Mohamed Maher Tawfik** Assistant Professor of Geotechnical Engineering Faculty of Engineering Ain Shams University	

Date: 23 / 6 / 2014

Postgraduate Studies
Authorization stamp: The thesis is authorized at / / 2014

College Board approval
/ / 2014

University Board approval
/ / 2014

CURRICULUM VITAE

Name:	Muhammad Ahmed El Sayed Zayed
Date of Birth:	08, March, 1989
Place of Birth:	Kingdom of Saudi Arabia
Nationality:	Egyptian
University Degree:	B.Sc.in Civil Engineering, Faculty of Engineering, Ain Shams University, 2010.
Current Job:	Teaching Assistant at Structural Engineering Department, Faculty of Engineering, Ain Shams University

STATEMENT

This dissertation is submitted to Ain Shams University for the degree of Master of Science in Civil Engineering (Structural Eng.)

The work included in this thesis was carried out by the author in the Structural Engineering Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt.

No part of this thesis has been submitted for a degree or qualification at any other university or institution.

Name: Muhammad Ahmed El Sayed Zayed

Signature:

Date:

ACKNOWLEDGMENT

I would like to express my gratitude and respect to my supervisor and advisor, Prof. Yasser El-Mossallamy, for his support and help throughout this research. I am also thankful to my co-supervisor, Dr. Mohamed Maher, for his great efforts and precious advices throughout this research. Working with Prof. El-Mossallamy and Dr. Maher has been a great experience.

I also would like to thank my colleagues and the technical staff of the Soil Mechanics and Foundation Engineering Laboratory, Ain Shams University, for their support.

I deeply thank my mother, father, sister and brother for their continuous support and effort.

ABSTRACT

Muhammad Ahmed El Sayed Zayed- Limit State Design in Geotechnical Engineering and its Applications for Deep Foundations in Egypt- MSc Thesis- Faculty of Engineering- Ain Shams University

Supervisors:

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The philosophy of Working Stress Design (WSD) has been widely used for several areas of geotechnical design in Egypt. In accordance, the Egyptian Code of Practice for Soil Mechanics and Foundations Design and Construction (ECP-202, 2001) employs the WSD concept by means of global safety factors. On the other hand, for the design of structural elements, the Egyptian Code of Practice for Design and Construction of Reinforced Concrete Structures (ECP-203, 2007) uses the Limit State Design (LSD) philosophy with the concept of partial safety factors. Design incompatibility normally arises when applying two different design philosophies for the superstructure and its foundations, which may lead to confusions and design misleading. Therefore, the implementation of the LSD concept for geotechnical designs in Egyptian practices has become mandatory.

In this study, the feasibility of applying the LSD concept for geotechnical design of pile foundations in Egypt was examined. It was proposed that gradual transition is highly required to smoothly transfer from the commonly used WSD concept to the LSD concept. Hence, calibrated

partial safety factors were needed to be exploited in the LSD. The calibration-by-fitting technique was utilized to find out calibrated partial safety factors that can result in similar design values to that acquired from the WSD. The proposed calibration methodology was applied on a number of design methods that are currently in-use in the ECP-202 (2001) for the design of axially loaded single piles. The major two approaches of the LSD, i.e., the factored resistance approach and the factored strength approach, were examined through the calibration process.

Calibrated reduction factors for the pile total, side and base resistances were obtained from the factored resistance approach, i.e., Load and Resistance Factor Design (LRFD). Furthermore, calibrated partial safety factors for the soil shear strength parameters were ascertained from the factored strength approach. The results of calibrated reduction factors in this study were found in adequate agreement with that adopted in most international codes for geotechnical limit state design.

Keywords: *Limit state design, working stress design, global safety factor, partial safety factors, piles, calibration*

SUMMARY

Muhammad Ahmed El Sayed Zayed- Limit State Design in Geotechnical Engineering and its Applications for Deep Foundations in Egypt- MSc Thesis- Faculty of Engineering- Ain Shams University

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Implementation of limit state design in the geotechnical design in Egypt has become mandatory and essential due to the inconsistency and the confusion that may arise from the incompatible design philosophies for substructures and superstructures in the Egyptian practice. Rational calibration procedures to calibrate reduction factors and partial safety factors were investigated to be used with limit state design of axially loaded single piles. The calibration process was conducted via applying calibration-by-fitting technique aiming to obtain design estimates from limit state design quite close to that obtained from traditional philosophy of working stress design. Both factored resistance approach, i.e., Load and Resistance Factor Design (LRFD), and factored strength approach were utilized throughout the calibration of the reduction factors and the partial safety factors, respectively.

This thesis is organized in five chapters. The contents of each chapter can be summarized as follows:

Chapter (1): This chapter provides a brief description of the problem, objectives of the study and thesis organization.

Chapter (2): The second chapter of this thesis provides main differences between the two design philosophies of working stress design and limit state design regarding the geotechnical engineering design problems. A review of literature relevant to the limit state design in geotechnical engineering is also provided in Chapter (2), and different approaches that can be employed for geotechnical limit state designs are also illustrated.

Chapter (3): This chapter provides a rational procedure to calibrate reduction factors for total pile resistance and pile side and base resistances to be used in the LSD, focusing on application to design axially loaded single piles. The calibration of the resistance reduction factors is achieved via applying calibration-by-fitting technique. In this chapter, reduction factors for pile resistances are calibrated using the factored strength approach, i.e., Load and Resistance Factor Design (LRFD).

Chapter (4): In this chapter, a rational procedure is provided to calibrate partial safety factors for soil strength parameters to be used with the static equation for limit state design of axially loaded single piles. The partial safety factors for soil strength parameter are calibrated via applying calibration-by-fitting technique and using the factored strength approach.

Chapter (5): This chapter presents the summary, conclusions of this research and recommendations for future researches concerning this topic.

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