AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
STRUCTURAL ENGINEERING DEPARTMENT

Impacts of Deep Excavations in the Greater Cairo Area on the Nearby Structures

Thesis
Submitted in Partial Fulfillment of the
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In
CIVIL ENGINEERING
STRUCTURAL ENGINEERING DEPARTMENT

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STATEMENT

This thesis is submitted to Ain Shams University for the degree of M.Sc. in Civil Engineering.

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

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

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ABSTRACT

The deep braced excavation with the use of concrete diaphragm walls, as side supports, has been increasingly applied in the Greater Cairo for several purposes such as basements, underground garages, cut-and-cover tunnels, and subway stations. The most challenging task for geotechnical engineers is to estimate the settlement associated with the trenching process, especially if the diaphragm wall is constructed near existing structures.

The escalating needs for an acceptable estimate of the deformations associated with deep excavations in the Greater Cairo call for gaining more perception of the behavior of deep excavation including the combined actions of trenching, excavation, dewatering and their effect on buildings. Consequently, reliable estimates of ground movements in future projects that have similar conditions can be made using the semi-empirical relationships developed from the geotechnical dedicated studies.

The objectives of the current research are acquiring the knowledge for deep excavation process effects on the surrounding areas and buildings, especially under the different geotechnical conditions of the Greater Cairo area, also, to provide design aids and semi-empirical relationships of the retaining wall straining actions and the deformations associated with deep braced excavations considering the different lithological and groundwater prevailing in the Greater Cairo area. In addition, developing a reliable numerical modelling of deep excavation considering the construction sequence, the available lithological, geotechnical and groundwater data related to the Greater Cairo area is of a great importance in the current research. To verify this model, ground surface and lateral wall deformations were investigated and compared with field measurement of case studies. Simple deformations envelopes were deduced based on numerical modeling of various case studies to be utilized in the prediction of the induced deformations due to deep excavation.

Keywords: Deep braced excavation; diaphragm wall, trenching, excavation, settlement, lateral wall deformations.

SUMMARY

This research deals with the impact of deep excavations on buildings in the Greater Cairo area under different geotechnical conditions. Simple deformations envelopes were deduced based on numerical modeling of various case studies verified by measurements performed in each case during and after construction process of the deep braced excavation supporting system. The main case study was Al Rashdan, based on SPT test results soil parameters were computed considering the variation of the number of blows within each soil layer which represent the most optimistic and pessimistic conditions for this layer. This variety supports our analysis logic to depend on an envelope at which soil parameters have upper, lower bounds and the most probable condition which lie between the upper and lower bounds. The required soil properties were assessed for each layer using correlations developed to estimate soil characteristics presented by Mayne (2006), Brinkgreve & Vermeer (1998), Hatanaka & Uchida (1996) and Kulhawy & Mayne (1990).

A probabilistic approach was utilized in determining the soil parameters in which the mean value for a certain parameter (μ) is considered the most probable value, noting that the mean value has 50% chance to be lower than the actual value and 50% chance to be higher than the actual value. Finite element analysis program PLAXIS 2D was used to simulate the case studies. A comparison of the results of the conducted envelopes with the empirical work was made to estimate settlement caused by deep excavations. The deduced simple envelopes were compared to measurements performed in Al Rashdan, Rod El - Farag, Faisal Islamic Bank Tower, El-Dokki and El-Bohoos Stations and showed a good

agreement with the measured settlements and lateral wall deformations. Thus, the results of the research can be used to facilitate the initial prediction of the induced settlement and lateral deformations result due to deep braced excavation in the Greater Cairo area.

The thesis consists of six chapters

Chapter (1) is the introduction to this research; it discusses the importance, the scope, and the main objectives of the research.

Chapter (2) is a literature review for the previous related studies. It describes general trends of the induced ground deformations due to deep excavations. It also addresses the distresses of buildings located in the proximity of the excavations. The different criteria for assessing the building damages caused by deep excavations are highlighted.

Chapter (3) presents a description of the finite element method that is utilized in the analyses. The analysis sequence and different types of utilized elements are illustrated. A special highlight is given on utilized constitutive laws and their suitability for the analyses.

Chapter (4) comprises the deformations envelopes that are developed by the analyses for case studies in the Nile Alluviums. The selected cases comprise walls configurations as well as different support systems. The envelopes are utilized in the prediction of the induced settlement and lateral deformations result due to the deep excavation in the Nile alluvium.

Chapter (5) presents the effect of different parameters on the estimated envelopes from the analyses of the previous case studies; the effect of activating bracing systems, applying a pre-stressing force on it and the variations of axial stiffness effect. In addition, the effect of wall thickness, its embedded depth, changing the excavation depth, increasing the plug layer thickness, and using a value for the effective cohesion in each soil layer were all studied to gain more insight to their effects on the produced

envelopes of deformations also to clarify the parameters that have a major impact on induced deformations.

Chapter (6) presents the summary and the conclusions of the research. Suggestions for future studies relevant to the subject are also presented in this chapter.

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