DEFLECTION ANALYSIS OF UNDERPINNED SECANT PILE WALL

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ABSTRACT

Underpinned retaining wall commonly been used for the construction of underground basement or any other open cut excavation projects, especially in urban areas. The excavation process at a different ground level induced the deflection of the retaining wall. Factors that influence the deformations of retaining wall are the excavation length, excavation depth, wall penetration depth, stiffness of the wall, stiffness of struts, struts spacing, struts preloaded and time dependent. The project focuses on the horizontal movement of the braced retaining wall due to lateral load. The analyses of horizontal deflection are by the beam on elastic foundation (BEF) method (manual calculation) and by the finite-element method (Plaxis v7.2 software). Mohr-Coulomb model is applied in the analysis using Plaxis v7.2. Comparisons are being made on both methods with the secant pile wall field measurement.

ABSTRAK

Dinding penahan jenis bertupang kebiasaannya digunakan dalam pembinaan tingkat bawah tanah atau mana-mana pembinaan yang melibatkan pengorekan tanah terutamanya di kawasan bandar. Proses pengorekan pada kedalaman yang berlainan akan menyebabkan pemesongan pada dinding penahan itu. Faktor yang mempengaruhi pemesongan dinding penahan ialah lebar pengorekan, kedalaman pengorekan, kedalaman penusukan dinding, kekuatan dinding, kekuatan penahan, jarak di antara penahan, pra beban penahan dan masa. Projek ini memfokuskan kepada pergerakan mendatar oleh dinding penahan jenis bertupang disebabkan beban mendatar. Analisis pergerakan mendatar ini menggunakan kaedah rasuk pada asas elastik (pengiraan manual) dan kaedah unsur terhingga (perisian Plaxis v7.2). Model Mohr-Coulomb telah digunapakai dalam analisis perisian Plaxis v7.2. Perbandingan dibuat di antara kedua-dua kaedah dengan bacaan pengukuran tapak dinding penahan 'secant pile'.

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LIST OF SYMBOLS

a_{ii}	-	Constant of integration
A_x, B_x, E_x	-	Coefficient of deflection for laterally loaded piles
A_ϕ, B_ϕ, E_ϕ	-	Coefficient of slope for laterally loaded piles
BEF	-	Beam on elastic foundation
c	-	Soil cohesion
c'	-	Effective soil cohesion
c_u , S_u	-	Undrained shear strength
E	-	Young's Modulus
EI	-	Wall/pile stiffness
H, He	-	Soil depth
h_i	-	Length of sections
K	-	Earth pressure coefficient
K_a	-	Coefficient of active earth pressure
K_i	-	Stiffness of supports (struts)
K_o	-	Coefficient of earth pressure at restt
K_p	-	Coefficient of passive earth pressure
k	-	Strut stiffness
k	-	Permeability of soil
M	-	Moment
M_0	-	Moment at excavation level
m, n_h	-	Constant of modulus of horizontal subgrade reaction
pl	-	Lateral pressure caused by self weight of soil above excavation level
p , q	-	Uniformly distributed load
Q_0	-	Shear force at excavation level
$Q_i(x_i)$, $R_i(x_i)$, $S_i(x_i)$, $T_i(x_i)$	-	Load function at length of integration (x_i) at sections

u	-	Pore water pressure
v	-	Poisson's Ratio
x_i	-	Length of integration at sections
y	-	Displacement
y_i , δ_i	-	Displacement at excavation level
α	-	Deformation coefficient of pile
$\sigma_a{}'$	-	Active effective stress/earth pressure
σ_a , P_a	-	Active stress/earth pressure
$\sigma_p{}'$	-	Passive effective stress/earth pressure
σ_p , P_p	-	Passive stress/earth pressure
σ'_h	-	Horizontal effective stress/earth pressure
σ'_v	-	Vertical effective stress/earth pressure
σ_v	-	Vertical stress/earth pressure
ϕ'	-	Soil friction angle
ϕ	-	Effective soil friction angle
γ	-	Soil unit weight
ψ	-	Dilatancy angle

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Underpinned retaining wall commonly been used in the construction of underground basement, road and rail tunnel or any other open cut excavation projects. The retaining wall is prevented from moving to avoid failure of adjacent properties, i.e. buildings, utilities, etc. The excavation process will then induce the wall deflection because of the unbalance forces acting on the retaining wall. Many previous studies have been conducted on the excavation induced deflection of embedded retaining wall due to excavation process. The studies conducted will then be as a reference in designing of retaining wall in the future.

Embedded retaining walls can be in terms of soldier piles, sheet piles, secant piles and diaphragm walls. Each of the types of retaining wall has their own characteristics and the selection of the retaining wall depending on various situations.

One of the analyses involved in design the underpinned retaining wall is the deformation and stress analysis. The deformation analysis is conducted to predict the wall deflection due to the excavation process while stress analysis is done in conjunction with the structural retaining wall design. These analyses may be conducted using simplified method, beam on elastic foundation method and finite-element method. The deflection of underpinned retaining wall is dependable on the stiffness of the wall structure, soil characteristics and struts.

1.2 Problem Statement

Studies have been conducted to evaluate the performances of excavation induced wall deflections and some empirical or semi-empirical approaches have been developed. Prediction of the wall deflection is important to avoid failure from happens and to control surrounding properties from damage. Analysis with different methods will give different results of predicted deflection thus a comparison is done to validate the effectiveness and preciseness of the analysis.

Beam on elastic foundation (BEF) method is one of the methods that has been used in understanding the excavation induced stress and deformation analysis. In this method, certain assumptions are made for the ease of the analysis. Another method in stress and deformation analysis is by using the finite-element method. The method is capable to simulate various factors of instability forces acting on retaining wall thus it is more accurate than the beam on elastic foundation method. However, limited studies have been done for comparison of these two methods, therefore this project will be focusing on the analysis of the wall deflection using beam on elastic foundation (BEF) method and finite-element method. The analysis that will be discussed is on the horizontal deformation and the moment of the wall structure.

During construction, a set of monitoring instrumentation will be installed on the underpinned retaining wall to evaluate the design performance of the constructed wall. The instrumentation reading will then be used as a back analysis of the predicted wall deflection. In this project, inclinometer readings from a field case study will be discussed. The inclinometer readings measure the horizontal displacement of the underpinned retaining wall on different levels of excavation.

1.3 Objectives

The objectives of the study are as follows:

i. To analyze the horizontal deflection of underpinned secant pile wall due to lateral load on a given type of soil using beam on elastic foundation method (manual calculation).

ii. To analyze the horizontal wall deflection under different excavation level of a given type of soil using finite-element software; Plaxis version 7.2.

iii. To make a comparison between the predicted retaining wall deflection and field measurement (inclinometer).

1.4 Scope and Limitation

A case study for this project is Project Lateral, Belgravia, London. An inclinometer reading from the case study will be taken for back analysis using beam on elastic foundation (BEF) method and finite-element method. The type of wall, geometry and soil parameters in the analysis will be conducted using the data from the case study. For this project, only the lateral loading was considered in the deflection analysis of the retaining wall.

The procedure of analysis of the horizontal deflection using beam on elastic foundation method was referring to the paper on 'Analysis of Multi-Braced Earth Retaining Structures' by H.B. Xiao, J. Tang, Q.S. Li and Q.Z Luo (2003).

Software Plaxis version 7.2 is selected in the analysis using the finite-element method. The Mohr-Coulomb soil constitutive model was chosen for the deflection analysis in the software.

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