OPTIMIZATION OF RETAINING WALL IN DEEP EXCAVATION FOR BASEMENT WORK

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To my beloved wife Nurul Nadia bt Jaafar Zahri and my adorable son Adeeb Haikal, for their continuous support and tolerance during the writing of this thesis.

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ABSTRACT

Deep basement construction always anticipated in urban areas especially in Kuala Lumpur where the area is dense and limited. The design of basement retaining wall and its support system involves careful analysis, design and monitoring system. This is due to the sensitivity of ground movement that can cause damage to the adjacent buildings, roads, utilities and others. The focus in this paper is to model the actual cases on site by using Finite Element Software (Plaxis2D). The result will be compared to obtain the best option and worth to consider. An actual site in Kuala Lumpur has been chosen for this study. All the relevant data were obtained and re-analysed. The site is located in Kenny Hill formation which is basically a completely decomposed rock and generally has the consistency of a clayey SILT soil. The presence of ground water level at shallow depth requires a suitable wall to be adopted. Thus, diaphragm wall and contiguous bored pile has been adopted in the analysis. Bottom up construction sequence is found to be more suitable compared to cantilever construction due to depth of excavation. Both type of wall has been analysed in Plaxis2D as plain strain model. However, geometry conversion is needed for CBP so that it can be modelled as plain strain instead of asymmetry model. The Hardening soil model is found to be suitable for analysis after making comparison between Mohr Coulomb model which overestimate the shear strength of soil. Result of lateral wall deflection from both types of walls shows the relationship between system stiffness and deflection of wall. A higher stiffness wall will result in less deflection. Thus, the main factor to select the suitable wall is not the system stiffness. However it depends on working space for construction, cost, embedment length etc.

ABSTRAK

Pembinaan struktur bawah tanah seperti tempat letak kereta adalah satu kemestian bagi pembinaan dikawasan bandar terutamanya di Kuala Lumpur. Rekabentuk tembok penahan dan sistem yang lain memerlukan penelitian yang mendalam kerana tanah yang berhampiran dengan kerja pembinaan yang melibatkan pengorekan tanah yang dalam adalah amat sensitif. Ia juga boleh mengakibatkan kerosakan pada struktur bangunan yang terletak berhampirannya. Fokus utama bagi *thesis* ini adalah untuk menganalisa semula kes sebenar dengan menggunakan perisian komputer iaitu Plaxis2D. Perisian tersebut juga digunakan bagi mengkaji beberapa jenis model tanah dan juga tembok penahan terhadap pergerakan tanah berhampirannya. Hasil ujikaji akan dilihat tentang bagaimana untuk mengurangkan pergerakan tanah. Oleh yang demikian, tapak pembinaan sebenar yang terletak di Kuala Lumpur telah dipilih bagi menjalankan ujikaji tersebut. Segala data-data yang diperlukan telah diperolehi daripada syarikat jurutera perunding yang terlibat dengan projek tersebut. Analisa bagi dua jenis tembok penahan seperti *Diaphragm Wall* dan juga *Contiguous Bored Pile Wall* dipilih kerana ianya sesuai sebagai tembok penahan bagi kerja-kerja pengorekan yang sangat dalam. Melalui ujikaji, didapati bahawa model tanah iaitu *Soil Hardening* lebih sesuai digunakan untuk analisa yang melibatkan kerja-kerja pengorekan yang dalam. Selain itu keputusan penyelidikan menunjukkan kaitan saiz tembok penahan terhadap pesongan tembok penahan. Saiz tembok penahan yang besar tidak menyebabkan pesongan yang banyak. Manakala tembok penahan yang mempunyai saiz yang kecil mempunyai magnitud pesongan yang lebih besar. Pesongan tembok penahan juga bergantung kepada kedalaman tembok penahan.

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INTRODUCTION

1.1 Background of Study

Deep excavation is often necessary in Kuala Lumpur due to lack of space, very expensive and high level land costs as well as very dense traffic. Open excavation is not possible at all for a basement work. One challenging problem in deep excavation is the need to prevent damage to adjacent buildings. To achieve the goal of protecting adjacent buildings, it is necessary to eliminate or reduce excessive settlement caused by the wall deflection in excavation.

There are many types of retaining wall available in the industries nowadays. The cost of constructing a retaining wall is usually high compared with the cost of forming a battered slope. Therefore, the need for a retaining wall should be assessed carefully during design. Construction method should be fully considered at the design stage, since different construction methods may require different detailed design approaches. The selection of this method must base on several aspects, size of excavation, ground conditions, groundwater level, vertical and horizontal displacements of adjacent ground and limitations of various structures, availability of construction cost, speed of work and others. One of the main decisions is the water-tightness of wall.

1.2 Problem Statement

Normally deep excavation is anticipated when the need to utilize the underground space for car parks and other usage in expensive and congested urban area. In Malaysia deep excavation has been extensively constructed. Lately, there are some failures related to the retaining wall that are used for deep excavation and basement work. The failures of the retaining wall can be catastrophic affecting the serviceability of adjacent structures. Thus, the selection of the wall must be carefully considered during design and construction stages for deep excavation.

1.3 Case Study

In year 2008, Kuala Lumpur City Hall (DBKL) has stated a Kuala Lumpur vision to be a world class city in year 2020. In order to achieve the vision for A World Class City by 2020, Kuala Lumpur needs an optimum population that can support the City's global and economic role as a leading centre of the new economy. As such Kuala Lumpur will have a population of 2.2 million and employment of 1.4 million.

With a sustainable growth rate, where its population density far exceeds other urbanised areas, Kuala Lumpur's regional role and being the epicentre of the nation's national growth conurbation provides it with the opportunity and advantage to achieve its targets. Thus, intensification development of the city must be planned carefully. Most importantly, Kuala Lumpur must be liveable in order to encourage people to live in the City comfortably and through the plan allows for an additional 600,000 people in the next coming years.

There are going to be rapid development in Kuala Lumpur to achieve the KL City Draft Plan. However, the area for construction is very limited and the cost of the land is very expensive. As pressure for development in Kuala Lumpur become more intense, the need to utilize underground spaces become greater. Thus, the trend towards the development of high rise building with deep multi-level basement is often the best option to choose. In order to construct the basement, deep excavation is always anticipated. One important thing that needs to be considered when carrying out deep excavation work is the ground movement. There is certain limit of ground

movement so that the adjacent building or road will not get affected and caused damaged.

For this research purpose, a site in Kuala Lumpur has been chosen to investigate and analyzed several types of retaining wall and method of construction through a comparative study in order to find the best option that can be adopted so that the ground movement can be minimized. The site is a service apartment consisting of four level of basement car park and thirty six level of service apartment located adjacent to the other luxury residential apartments surrounding it. For this study, the actual ground profile re-analyzed using a finite element geotechnical software PLAXIS 2D to carry out comparative study.

1.4 Aims and Objectives

The objectives of this project report are to identify the effect and performance of different types of permanent retaining wall for basement work in terms of wall deflections, ground movements during stages excavation. Besides that, to determine the appropriate wall type for basement based on economical aspect.

1.5 Study Limitation

The scope of this study will focus on one case study which is Residential Development at Lot 103, Persiaran KLCC, Kuala Lumpur. Client intended to build a service apartment consisting of a 4-level basement car park and 36-level service apartment. The proposed project site encompasses an area of approximately 4792m^2.

A subsurface investigation (S.I.) programme has been initiated by SI Contractor for the proposed residential development to obtain information about subsoil stratigraphy, soil condition and geotechnical parameters of the proposed development area for foundation and substructure design. Thus, for this study purpose, site and laboratory test will not be carried out due to time constraint.

The site is a relatively small area and flat (man-made platform level) and is an abandoned bungalow. The site is generally at +36mRL to +37mRL. The geological map of the region as shown in Appendix 1 indicates that the site is underlain by Kenny Hill Formation. The Kenny Hill Formation which is a sequence of clastic sedimentary rocks consisting of interbedded shales, mudstone and sandstones of the Upper Palaeozoic period extends significantly over part of Kuala Lumpur City and Klang Valley. The Kenny Hill material is basically a completely decomposed rock and generally has the consistency of a clayey SILT soil, overlain by a layer of alluvium as evident from the latest soil investigation works.

During the soil investigation field works, water level was monitored daily in order to examine the groundwater profile. Based on the groundwater level observations during site investigation works, it is reasonably inferred that the groundwater lies at about +32.5m RL to +34.5m RL. For design purpose, water level may be adopted as +34.0mRL.

There are various types of wall for basement work such as sheet pile, soldier pile, secant pile, contiguous bored pile and diaphragm wall. However, a review of the available system and the selection process adopted has eliminated several methods as either being not practical or economically not viable for this project. Accordingly, the following methods are considered:-

1. Contiguous bored pile walls
2. Diaphragm walls.

The analysis of the wall and support system will be carried out using Plaxis2D geotechnical finite element software. In order to carry out a comparative study, there are some limitations in the analysis of the wall and support system. The result will be compared to find the best method so that economic design can be achieved.

1.6 Significant of Research

Deep excavation in urban areas has increasingly become a necessity in different projects from high-rise buildings to subway systems. One challenging problem in deep excavation is the need to prevent damage to adjacent buildings. To achieve the goal of protecting adjacent buildings, it is necessary to eliminate or reduce excessive settlement caused by the wall deflection in excavation. Hence, the selection of the appropriate method, sequence of construction, wall type and support system is important to minimise the ground movement and to achieve economic design and construction. A design which minimise wall dimensions and material use but one which increases construction duration because it is difficult to build may not result in overall economy.