COMPARATIVE OF FLAT SLAB TYPE RAFT FOUNDATION TAKING INTO ACCOUNT OF DIFFERENCE BUILDING CODE AND DESIGN METHODOLOGY

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DEDICATION

I want to dedicate this Master's Degree

To my dear parents, Shamsir Alam & Azizah, who gave me a lot of support and prayers.

To my beloved husband, Muhammad Basysyar Zahar, thank you for your endless support, sacrifice, and prayers.

To the beloved children, Muhammad Hazim Amsyar and Muhammad Adib Absyar. You are my strength to keep going to succeed.

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"In the name of Allah, the Most Gracious and Merciful"

Praise be to Allah, The Almighty God for His Blessings, and Merciful for showering me with this successful journey. I am grateful to Allah for His Grace and Bounties that I can continually explore, seek knowledge, and gain invaluable experiences in my life.

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ABSTRACT

This project report was carry out the existing project of one storey of the warehouse at Meru, Klang. This warehouse was built in 1991 and the superstructure of this warehouse with size area 150 m x 25 m is a steel structure with the ground slab. Unfortunately, four of this warehouse is not fully usable due to severe damage to the ground floor. Forensic engineering has been done and found that the ground slab had settled up to 400 mm depth. The foundation failure is the main cause of slab settlement. Soil investigation was done and found that hard layer at ±23 meters depth with SPT 50. The upgrading of the functionality of the warehouse to the hotel laundry will apply new loading based on new equipment. This study will present the comparative analysis of flat slab type raft foundation design using computer software STAAD-Pro and analytical calculation according to Eurocode 2 and BS 8110. The result of the numerical method by using STAAD-Pro show that the differences of BS 8110 are 5.09% slightly higher than Eurocode 2. While the analytical solution the result is 5.16% BS 8110 higher than Eurocode 2. The percentage of comparison for process analysis between STAAD-Pro and analytical solution is 18% due to the result of the bending moment. While for the reaction shown that 10% of differences where the STAAD-Pro result is higher than the analytical solution. Besides that, in term of deflection, the differences of allowable limit is 39.39% where the Eurocode 2 is much higher than BS 8110. The total result between Eurocode 2 and BS 8110 not much different. This report shows that the reinforcement design according to BS 8110 is lower than Eurocode 2 because of the coefficients of BS 8110 used are lower than Eurocode 2 and the technical considerations are more conservative.

ABSTRAK

Kajian ini menjalankan projek gudang satu tingkat yang terletak di Meru, Klang. Gudang ini dibina pada tahun 1991 dan struktur atas gudang ini dengan ukuran kawasan gudang 150 m x 25 m adalah struktur keluli dengan papak tanah. Malangnya, ke empat-empat gudang ini tidak dapat digunakan sepenuhnya kerana kerosakan teruk di papak. Kejuruteraan forensik telah dilakukan dan mendapati bahawa permukaan tanah telah mengalami pemendapan dengan kedalaman sehingga 400 mm. Kegagalan asas tanah adalah penyebab utama permasalahan ini. Penyiasatan tanah dilakukan dan mendapati bahawa lapisan keras adalah pada kedalaman ±23 meter dengan SPT 50. Gudang ini akan diperbaharui dan dinaik taraf sebagai dobi hotel dan tempat simpanan berkapasiti tinggi. Kajian ini akan mengemukakan analisis perbandingan reka bentuk asas rakit jenis papak rata menggunakan perisian komputer STAAD-Pro dan pengiraan analitik berdasarkan Eurocode 2 dan BS 8110. Hasil analisis dengan menggunakan perisian komputer STAAD-Pro menunjukkan bahawa perbezaan BS 8110 adalah 5.09% lebih tinggi daripada Eurocode 2. Manakala penyelesaian analisis melalui kaedah analitik adalah 5.16% di mana BS 8110 lebih tinggi daripada Eurocode 2. Peratusan perbandingan kaedah analisis antara perisian komputer STAAD-Pro dan penyelesaian analitik bagi keputusan hasil momen lentur adalah 18% di mana STAAD-Pro lebih tingggi hasilnya berbanding penyelesaian analitik. Sementara itu, beban tindak balas telah menunjukkan bahawa 10% perbezaan di mana hasil STAAD-Pro lebih tinggi daripada penyelesaian analitik. Selain itu, dari segi pesongan papak, perbezaan had yang dibenarkan adalah 39.39% di mana Eurocode 2 jauh lebih tinggi daripada BS 8110. Keputusan analisis mendapati bahawa perbezaan antara Eurocode 2 dan BS 8110 tidak jauh berbeza. Momen lenturan BS 8110 lebih tinggi daripada Eurocode 2. Dalam kajian ini menunjukkan reka bentuk tetulang bagi BS 8110 lebih rendah berbanding dengan Eurocode 2 kerana pekali yang digunakan lebih rendah dan pertimbangan teknikal lebih konservatif.

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LIST OF ABBREVIATIONS

EC 2	-	Eurocode 2
BS	-	British Standards
EN	-	European Standards
MS	-	Malaysian Standards
NA	-	National Annex
NA	-	Neutral Axis
UDL	-	Uniform Distributed Load
DL	-	Dead Load
LL	-	Live Load
SLS	-	Service load state
ULS	-	Ultimate load state
L_x	-	The shortest length
L_y	-	The longest length
SW	-	Self-weight
RC	-	Reinforcement Concrete

LIST OF SYMBOLS

b	-	Width of section
d	-	Effective depth of the tension reinforcement
h	-	Overall depth of section
x	-	Depth to neutral axis
z	-	Lever arm
l_{eff}	-	Effective span of beams and slab
C_{nom}	-	C_{nom} nominal cover to reinforcement
g_k, G_k	-	Characteristic permanent action
qk, Q_k	-	Characteristic variable action
f_{ck}	-	Characteristic compressive cylinder strength of concrete at 28 days
f_{yk}	-	Characteristic yield strength of reinforcement
f_{cd}	-	Design compressive strength of concrete
f_{yd}	-	Design yield strength of reinforcement
F_d	-	Design action
A_{s1}	-	Area of tension reinforcement
A_{s2}	-	Area of compression reinforcement
α	-	Angle of shear reinforcement to the longitudinal axis
θ	-	Angle of the compression strut to the longitudinal axis
ρ_1	-	Reinforcement ratio corresponding tp A_{s1}
V_{Ed}	-	Design value of the applied shear force
$V_{Rd,c}$	-	Shear resistance of member without shear reinforcement
$V_{Rd,max}$	-	Maximum shear force, limited by crushing resistance of compression
strut	-	strut
A_{sw}	-	Cross-sectional area of the shear reinforcement.
A_c	-	Cross-sectional area of the concrete.
A_s	-	Area of longitudinal reinforcement.
γ_{con}	-	Density of concrete

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The comparison of the method was done because most engineers more prefer to use software compare to manual design. Nowadays, the software very important in building analysis because the design needs to be completed in a short time. Architecture design also as a factor of software is used. A comparison of these two design solution needs to be done to verify the calculation.

Besides that, the design codes are important as the guideline to make sure the building is safe. The structural building in Malaysia uses BS 8110 as the main guideline. However, starting in 2010 Malaysia try to implement Eurocode 2 as the main guideline. Besides that, the economical design is most important regarding the cost limited. This project report will further show the advantages and disadvantages of the two codes.

This project report was carried out the existing project of a warehouse at Meru, Klang, Selangor. The warehouse was built in 1991 for storage purposes. and has been used for timber, old hotel furniture, documents, and construction materials. The superstructure of this warehouse with a build-up size area 150 m (length) x 25 m (width) is using a steel structure with reinforced concrete (RC) ground slab. Unfortunately, four of this warehouse is not fully usable due to severe damage to the floor as shown in Figure 1.1.

Figure 1.1 View in one of warehouse

During the rainy season, this warehouse will be flooded because the outside level of warehouse is higher than inside. In the addition, the uneven floor condition makes it difficult to organize storage items. So, this warehouse space is not fully utilized.

In 2018, the client was decided to use the existing warehouse as a high capacity warehouses and hotel laundry. In order to succeed, this warehouse need to be repair and upgrade to ensure that the space can be used as much as possible.

So, forensic engineering has been done and found that the ground slab had settled up to 400 mm depth. While the steel structure is still in good condition. Only slight damage to the end-wall of warehouse. The foundation failure is the main cause of slab settlement. Existing design were used 150 mm thickness of RC pile raft foundation with pile spacing 7.5 m centre to centre. While the size of reinforcement concrete pile is 300 mm square were used with 4 m length embedded. Figure 1.2 were shown the section of existing slab.

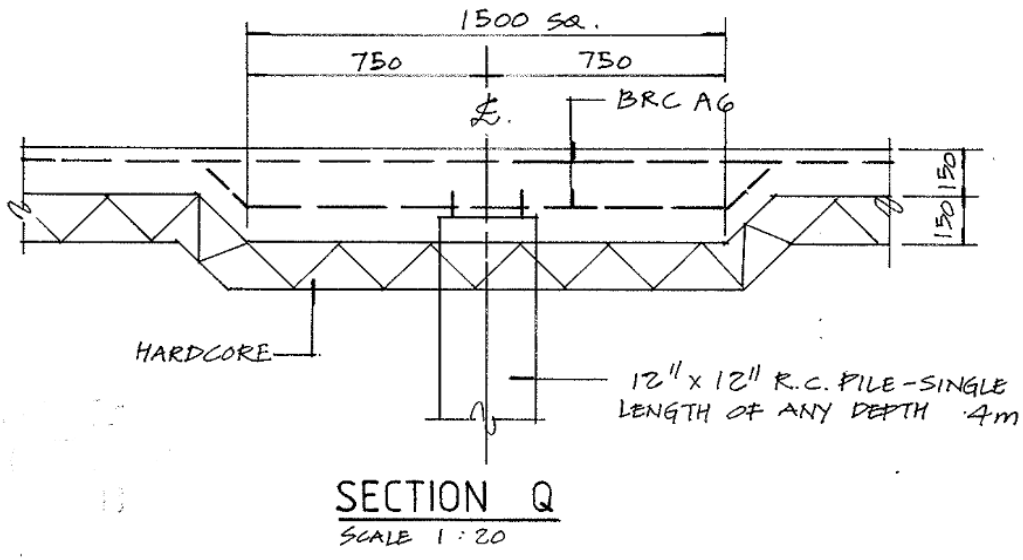

Figure 1.2 Section of existing slab

The substructure for the steel structure is normal pile length design according to soil condition. Therefore, the different settlement of ground slab and pile cap for steel structure were shown in Figure 1.4 (a) and (b). The amount of settlement for shallow foundation is depend of type of soil.

The most facilities on sand, the total of settlement is limited to 50 mm. While for structure on clay, the total settlement is 75 mm is acceptable because the foundation on clay settle much more slowly than foundation on sand. According to investigation on existing structure found that the maximum settlement is 400 mm. This is much higher than allowable limitation. Figure 1.3 is the layout of the location for maximum settlement.

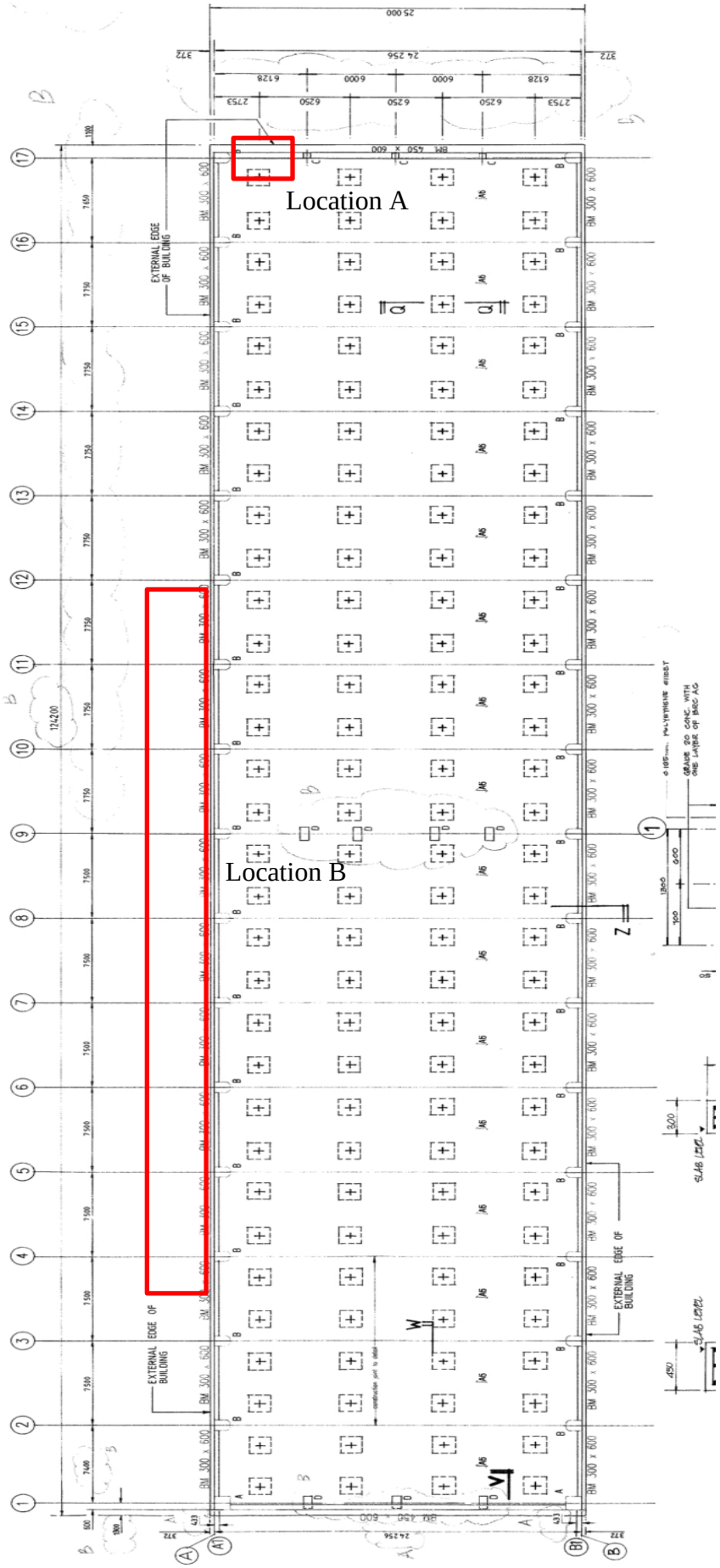

Figure 1.3 Location of maximum settlement

(a) (b)

Figure 1.4 (a) 400 mm settlement at Location A (b) 100 mm to 300 mm settlement at Location B

This project report will carry out the slab design for hotel laundry only. Since soil conditions at Meru, Klang is marine clay, so here are not suitable for shallow foundation design. Redesign the slab foundation with revised the loadings is necessary.

1.2 Statement of The Problem

Nowadays, the time frame is the most problem to the engineers. Sometimes, the time given does not make sense to finish the design in a short time. In construction field a lot of industries are competed each other to make sure all projects can be owned. Due to the advancing technology, a lot of things created for

engineers that can choose to make life easier. One of them is software, where it can save a lot of time for engineers. This make almost all the engineer now use software compare to manual design.

Besides that, manual calculation is very limit to do analysis where only simple load can apply. For example, analysis of steel structure, in manual calculation they can do analysis the structure due to vertical load. When to apply horizontal load, they will have the problem which are cannot calculate one typical bracing member. Wall in building must have windows and doors. They cannot simply put the bracing at they prefer to make sure the structure is stable. So, 3D analysis by software very important the find the exactly of design based on the environment and condition.

Other than that, the great idea of architectural also is one of factor the engineer need use the software. For example, the architect wants a beam with 'S' shape. So how the structure engineer fulfils that request. So, the software is the answer to solve it. Since the software is very helpful to engineers, they will use it in designing even though for simple design. Software analysis, can used to verified the valid output of analysis. We cannot just rely on software. Limitation the use of software is needed to improve the skill of design. At least we know how the result of software were come out. Therefore, a comparison between numerical and analytical is very important to make sure the design is correct.

The design codes are important as the guide line to make sure the building is safe. The structural building in Malaysia use BS 8110 as the main guideline. However, in 2004, The Institution of Engineers, Malaysia has published a position paper on concrete codes of practice in Malaysia after 2010 and recommended that Eurocodes shall be adopted after the withdrawal of structural British Standards. Therefore, this research is to develop comparison analysis between BS 8110 and Eurocode 2 is required to get the optimum design and safe to used.

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