DESIGN OF A RAFT FOUNDATION FOR A 5 STOREY FLAT

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DESIGN OF A RAFT FOUNDATION FOR A 5 STOREY FLAT

by

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APPROVAL SHEET

This project report attached here to, entitled "Design of a Raft Foundation for a 5-storey flat," prepared and submitted by Lee Wei Ming in partial fulfillment of the requirement for the degree of Bachelor of Engineering (Civil) is hereby accepted.

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ABSTRACT

This project is to design a mat foundation for a 5-storey flat, the project was design as a piled foundation. The objective of this project is redesign from pile foundation to a raft or mat foundation.

In the key plan of the project, the base surface is not a proper square or rectangular shape. But it is a combination of multiple rectangular pieces of base surface shape. In order to make the design more economical, the base is dividing into 6 small rectangular bases. For the large individual rectangular bases cover whole building structure and the area is 584.6 m^2 (6292.63 ft^2). The total area of the 6 small bases is 384.05 m^2 (4134.27 ft^2) Therefore, division of the base is more economical in the sense of materials in used.

The 6 small individual pieces of raft foundations were designed separately. In the design, there would be six different designs from the individual pieces of raft foundation. There six different designs would be combined to become a complete design.

During division task, there were some columns seating across two different individual pieces of raft foundation design. When the raft foundation was divided into two individual pieces, the column load would be divided into two, each with half of the load for the design.

The design of the mat foundation is carry out by computer software, but the designs are checking by manual calculation.

ABSTRAK

Projek ini ialah rekabentuk asas rakit bagi satu bangunan rumah pangsa 5 tingkat, projek ini telah direkabentuk dengan menggunakan asas cerucuk. Objektif projek in ialal merekabentuk semula asas cerucuk kepada asas rakit.

Dalam key plan bagi projek ini, permukaan asas bukan bentuk segiempat tepat sempurna, tetapi daripada gabungan beberapa asas permukaan segiempat. Untuk menjadikan rekabentuk ini lebih ekonomi, asas ini telah dibahagikan kepada 6 asas berbentuk segiempat yang kecil. Bagi asas besar yang berbentuk segiempat secara individu dan menutupi keseluruhan asas yang berbentuk segiemapat, ia telah menutupi luas sebanyak 584.6 m^2 (6292.63 ft^2). Hasil tambah luas bagi 6 asas kecil ialah 284.05 m^2 (4134.27 ft^2). Oleh itu, pembahagian asas adalah lebih ekonomi dalam bentuk meterial ynag digunakan.

Enam individu asas rakit direkabentuk secara berasingan. Maka dalam rekabentuk ia menpunyai enam rekabentuk yang berbeza bagi setiap satu asas rakit. Enam rekabentuk asas rakit yang berbeza itu akan dicantumkan menjadi satu rekabentuk yang lengkap bagi keseluruhan asas bagi struktur bangunan ini.

Semasa kerja pembahagian, sesetengah tiang duduk ditengah antara dua individu asas rakit. Bila asas rakit itu dibahagi pada dua individu asas, maka beban daripada tiang juga dibahagi dengan dua, setiap satu mengambil setengah daripada beban untuk menrekabentuk.

Rekabentuk bagi asas rakit ini dihasilkan dengan menggunakan program komputer, tetapi rekabentuk ini disemak dengan mengguanakan kiraan secara tangan.

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d = Effective depth of tension reinforcement

b = Width of the cross section

f_{cu} = Characteristic strength of concrete [BS 8110 (1985)]

f_y = Characteristic strength of reinforcement

M = Ultimate moment of resistance

z = Lever arm

A_s = Area of tension reinforcement

V_c = Design concrete shear stress

γm = Partial safety factor for steel reinforcement

CHAPTER 1

INTRODUCTION

1.1 Objectives

The foundation of the 5-storey flat for Sepangar Bay project was design as a piled foundation. The objective of this project was to redesign from piled foundation to a raft foundation for a 5-storey flat. From the final design, some comparison works would be carried out, such as:

- Adequacy of the foundation for the building structure.

1.2 Project Significance

Raft foundation is diaphanous use in Kuching, Sarawak especially for high-rise building. But, raft foundation is customary design for high-rise building in West Malaysia especially in Selangor for example Petronas Twin Tower, Kuala Lumpur Tower, etc. Raft foundation is a very useful and important for high-rise building nowadays and also for the future.

CHAPTER 2

PROJECT REVIEW

2.1 Background

Foundation of a structural building is defined as the part of the structure in direct contact with the ground and which transmit the load of the structure to the ground. It is evident on the basic of this definition of a foundation that it is the most important part of the engineering system.

All engineering construction resting on the earth must be carried by a foundation. The foundation is the part of an engineered system which transmits to, and into the underlying soil or rock the loads supported by the foundation and it its selfweight. The resulting soil stress except the groundwater are in addition to those presently existing in the earth mass from the material selfweight and geological history.

Foundation may be classified based on where the load is carried by the ground, that is,

Shallow foundation – term bases, footings, spread footing, or mats. The depth is generally D / B ≤ 1 but may be what more. (Figure 1.1a)

Deep foundation – pile, drilled pier, or drilled caissons D / B ≥ 4 with a pile illustrated. (Figure 1.1b)

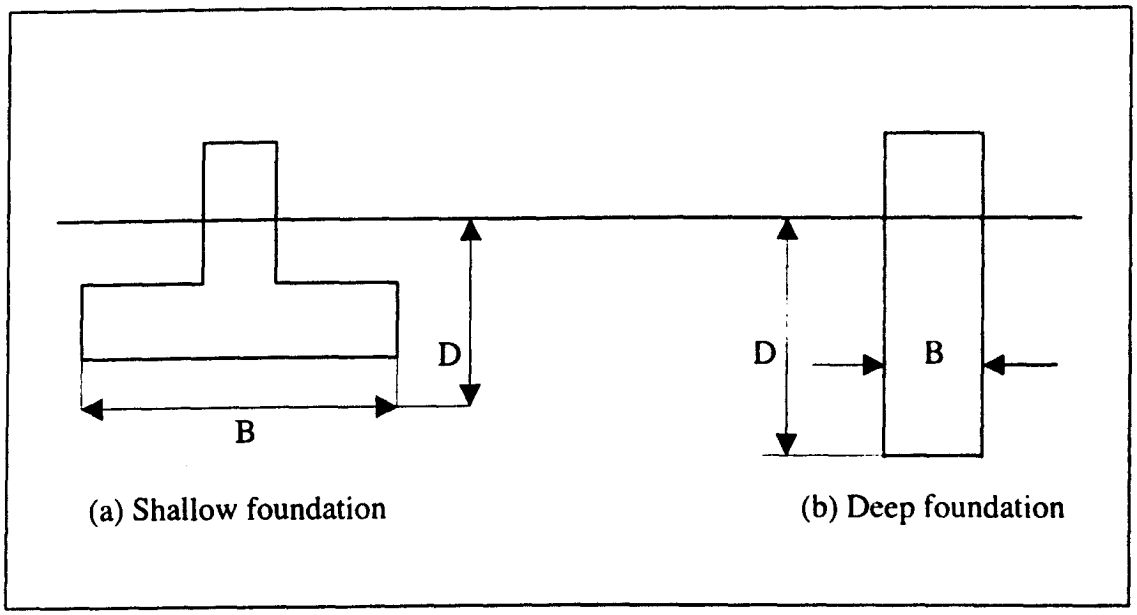

Figure 2.1 Two type of foundation

2.2 Foundation Types

Basically there are four major groups of foundation types; strip and pad foundations, surface spread foundations, piled foundations, and miscellaneous element and forms. There are a number of grades within each group and there are combinations of types. The choice determined by the

structural load, ground conditions, economics of design, economics of scale of the contract and construction costs, build ability, durability.

2.2.1 Pad and Strip

- shallow mass concrete pads
- shallow reinforces concrete pads
- deep mass concrete pads
- deep reinforced concrete pads
- balanced pad foundations
- rectangular balanced pad foundations
- trapezoidal balanced pad foundations
- holed balanced pad foundations
- cantilever balanced pad foundations
- strip footing
- masonry strips
- concrete strip (plan/reinforce)
- stone trench fill
- rectangular beam strips
- inverted T beam strips

2.2.2 Surface Spread

- nominal crust raft
- crust raft
- blanket raft
- slip-plane raft

- cellular raft
- lidded cellular raft
- beam strip raft
- jacking raft
- buoyancy (or 'floating') raft

2.2.3 Pile

- stone/gravel piles
- concrete pile
  - driven precast piles
  - driven cast in situ piles
  - bores piles
  - augered piles
- timber piles
- steel piles
- anchor piles
- anchor blocks
- pile cape and ground beams

2.2.4 Miscellaneous Elements and Forms

- suspended ground floor slabs
- floating ground floor slabs
- pier and beam foundations
- retaining walls
- grillage foundations

2.3 Raft / Mat Foundation Design

Raft or Mat foundation is a large concrete slab used to interface one or more columns in several lines with the base soil. It may encompass the entire foundation area or only a portion. Mat foundation may be supported by piles in situations such as high groundwater (to control buoyancy) or where the base soil is susceptible to large settlements.

Raft foundations are required on soils of low bearing capacity, or where structure column or other loaded areas are as close in both directions that individual pad foundation would nearly touch each other. Raft foundation is useful in reducing differential settlement on variable soils or where there is a wide variation in loading between adjacent column or other applied loads.

The function of a raft foundation is to spread the load over as wide an area as possible, and to give a measure of rigidity to the sub-structure to enable it to bridge over local areas of weaker or more compressible soil. The degree of rigidity given to the raft also reduces differential settlement.

In this project, the raft foundation was designed by using computer software. Which is*Mat3D* (3.1.0 version) developed by Dimensional Solutions, Inc. This software is obtained from Website, which is a demo or trial version. This demo or trial version is allows only design in accordance to ACI 318 Code (1985)

2.4 Project Review

In this project, the 5-storey building is located at Sepangar Bay, Kota Kinabalu, Sabah. It is one of the buildings in Royal Malaysia Naval base.

The project is a 5-storey residential flat for the Royal Malaysia Navy. This 5-storey flat consists 3 units of apartments on each floor. Each apartment was designed with 3 bedrooms, 2 toilets, 1 kitchen, 1 living room, 1 dining room and 1 balcony.

The foundation design is for a 5-storey flat, and the whole flat is a reinforced concrete structure. The total height of the building is 17.5 m from ground level. The flat was designed to build on 323.33 m^2 base surface area. Within this area, there are 32 columns in the building structure supported by the ground. This 32 columns and the 323.33 m^2 of ground surface area are the major figures to design the raft foundation (refer to Figure 2.2)

CHAPTER 3

METHODOLOGY

3.1 Software Used for Design

Today, with the rapid development resulted from the era of information technology and globalisation, there are a lot of software developers in the world developing structural design software. The way software penetrates to the global market is through Website. Within the Website, there are many software companies publishing their products. Most of the companies allow user to download the software in demo, trial or shareware version.

During the software search in the World Wide Web, it was found that some software are specifically for raft foundation design. The software being chosen is *Mat3D* (3.1.0 version), developed by Dimensional Solutions, Inc. The reason *Mat3D* (3.1.0 version) was chosen is because the software provide a trial version and it can carry out a full design for the raft foundation. However some of the features are disabled for the trial version such as:

a. All printing is disabled.

b. Only US customary units and ACI Code are enabled.

c. At the present time, the CAD interface is disabled.

c. The trial version will only work for 30 days.

Dimensional Solutions *Mat3D* is an advanced single program solution that analyses and designs soil and pile supported mat foundations .It interfaces with popular CAD programs such as Microstation, AutoCAD and SmartSketch to produce a detailed construction drawing.

Some of the features in the *Mat3D* 3.1.0 full version are as follows:

a. Foundation analysis/design
b. Multiple pier design and footing/pile cap design
c. Soil and pile supported
d. Customisation of rebar and formwork sizes
e. Multiple pier and column shapes
f. Multiple input and output units
g. In accordance with ACI 318 and BS 8110
h. Material quantities
i. Direct CAD interface with Autocad, Microstation and SmartSketch
j. Square, and rectangular footings
k. Ability to generate detail sketches
l. A summarized and detailed hard copy report.

3.2 Initial Step for Design

In the key plan of as shown in Figure 2.1 the project, the base surface is not a proper square or rectangular shape. But it is a combination of multiple rectangular pieces of base surface shape. In order to make the design more economical, then the base was divided into small individual pieces of rectangular base. Through this method, the total area of the base would be less compared to the total area of the full rectangular base covered by the whole building structure.

The foundation design was divided into 6 small rectangular bases (refer to Figure 3.1). If the foundation were to be designed as a single rectangular base, it would cover an area of 584.6 m^2 or 6292.63 ft^2 for the design. When the foundation was designed as 6 smaller rectangular bases; they covered only 384.05 m^2 or 4134.27 ft^2. Refer to Figure 3.2 to Figure 3.7 for details illustration. Therefore, this is more economical in the sense of materials in used.

The 6 small individual pieces of raft foundations were designed separately. In the design, there would be six different designs from the individual pieces of raft foundation. There six different designs would be combined to become a complete design.

During division task, there were some columns seating across two different individual pieces of raft foundation design. When the raft foundation

was divided into two individual pieces, the column load would be divided into two, each with half of the load for the design. For example 100kN of load would be divided into 50kN for each piece of raft foundation interfacing at the column location.

Since some of the values are not in details such as live and dead loads. So total load from each column are separated into live and dead load. In this design, some assumptions were made including the total loads were divided into live and dead loads equally. The reason why the live and dead loads were divided equally was that the live load on the roof is very small as compared to the live load on the ground floor, since ground floor is for car parking usage.

3.3 Assumptions made by the software

Footing design is in accordance to ultimate limit state. The critical sections for wide beam shear stress and two-way or punching shear stress in a square or rectangular footing are determined based on ACI Code recommendations. The following are the assumptions made:

- Concrete tensile strength is ignored for footing design.
- For load combinations, where the sum of the applied external loads and the weight of the pier produces tension or uplift, a soil-supported foundation is designed such that the sum of the footing selfweight and the weight of the soil above the footing is at least 1.5 times the tension or uplift load.