UNIVERSITI SAINS MALAYSIA

SCHOOL OF CIVIL ENGINEERING
ENGINEERING CAMPUS

COST EFFECTIVENESS IN THE CONSTRUCTION OF TERRACE HOUSES BY USING RAFT FOUNDATION & CONCRETE MASONRY UNIT

CHUA CHUN HOW

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6.	Choong Sai Sun	Seri Barat Mixed Sdn. Bhd., K.B.	Project Manager
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8.	Lee Kok Choy	Syarikat Aziz & Din, K.B.	Contractor
9.	Mr. Foo	Intergrated Brickworks Sdn. Bhd., K.L.	Contractor

and the suppliers who had provided valuable information to me.

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LIST OF SYMBOLS

f_k	Compressive Strength
G_k	Dead Load
Q_k	Imposed Load
$\rho_{concrete}$	Concrete Density
A_{st}	Areas of steel bars required at tension
A_{sc}	Areas of steel bars required at compression
h_{ef}	Effective height
t_{ef}	Effective thickness
e_x	Eccentricity
β	Capacity reduction factor
γ_m	Partial safety factor for material

ABSTRACT

A research done by the Construction Cost Engineering Research Group of University of Liverpool had shown that the type of foundation has achieved an important index of 71% which indicates a high effect on cost and duration of construction projects. Conventionally, local construction of terrace houses will use pad footing as the foundation. However, raft foundation gradually has gained popularity among the local contractors nowadays in their construction of terrace houses. Even the qualified engineers seem to agree on the statement that the raft foundation is able to bring cost effectiveness compare to pad foundation. Nonetheless, there is no such a survey carried out locally to show the results of both the alternatives in the construction of foundation. Thus, the case studies from this final year project are hopefully able to bring an answer to the question above with a standard design and reliable figure.

Concrete masonry unit or in this case, concrete hollow block is an alternative in the construction of walls. It is believed that the material is sooner going to replace the conventional clay brick in wall design. Basically, the concrete hollow block seems to be able to reduce the usage of steel bars and concrete while the formwork and plaster are eliminated in the construction. Concrete hollow block is expected to reduce the cost of a housing project by 30% if compare to brick wall. However, this figure is provided by the contractor from the manufacturer of concrete masonry itself. There is no survey done by either local suppliers or engineers as well as to prove the positive outcome in the context of cost effectiveness by using concrete masonry unit in wall design.

ABSTRAK

Penyelidikan yang dibuat Kejuruteraan Kos Pembinaan daripada Universiti Liverpool telah menunjukkan bahawa jenis asas bangunan mempunyai index kepentingan sebanyak 71% yang mana ini menandakan asas bangunan mempunyai kesan yang ketara terhadap kos pembinaan keseluruhan projek. Secara konvension, asas pad digunakan dalam pembinaan rumah teres tempatan. Namun, asas rakit menjadi semakin popular di kalangan kontraktor dalam pembinaan rumah teres sehingga kebanyakan jurutera bertauliah juga bersetuju degan kenyataan bahawa asas rakit akan menjimatkan kos pembinaan berbanding asas pad. Walau bagaimanapun, tiada sebarang penyelidikan dibuat untuk menjustifikasikan kedua-dua alternatif dalam pembinaan asas bangunan. Lantaran, projek tahun akhir ini harap dapat memberikan penjelasan yang sepenuhnya kepada persoalan di atas dngan contoh rekabentuk dan pengiraan yang konkrit. Konkrit bata ataupun dalam konteks ini konkrit bata berlubang adalah suat alternatif dalam pembinaan dinding bangunan. Ia dijangka akan menggantikan penggunaan bata lempung dalam rekabentuk dinding. Secara amnya, konkrit bata berlubang tampaknya akan menurunkan kos pembinaan dengan pengurangan dalam penggunaan bar keluli dan konkrit serta ketidakperluan langsung dalam penggunaan rangka struktur dan plaster. Konkrit bata dijangka akan menurunkan kos pembinaan sebanyak 30% berbanding bata lempung. Namun, angka ini adalah daripada kontraktor pengilang konkrit bata tersebut dan tiada sebarang penyelidikan dibuat oleh jurutera mahupun pengusaha pembinaan tempatan.

CHAPTER 1: INTRODUCTION

1.1 Problem Definition

Most of the contractors nowadays choose to use raft foundation rather than pad foundation in the construction of terrace houses in large scale. The contractor judgement in this context simply lies within their knowledge and experiences. Even most of the qualified engineers agreed with the statement that raft foundation might be cost effective compare to pad foundation. However, there is no such a study being carried out locally to justify the statement in details with concrete figures. Thus, this report is made for references to the above matter and as an answer to the question aroused by Ir. Khor P.C from Jurutera Teknik Dan Rakan-Rakan, a civil and structural consulting firm in Kota Bharu, Kelantan.

The usage of concrete masonry unit in the local construction is no longer a new thing. There are a lot of houses used concrete masonry unit to replace the conventional brick in setting up walls. However, the usage of it mostly happened to be in the construction of single storey houses and is done in a very small scale, mostly by the owner themselves – without standard. The usage of masonry unit to replace the brick wall in a large scale has been done as well but the quantity of it is small. The problem lies in the fact that not much contractors are experienced in it and not many manufacturers that produced the standard concrete masonry unit.

Concrete masonry unit is believed to reduce the cost of a housing project. It is also expected to shorten the construction period by eliminating the tedious and time consumed of labour works.

1.2 Objectives

1.2.1 To determine whether the cost of foundation for terrace houses can be reduced by using raft foundation rather than pad foundation.

1.2.2 To determine whether the cost of walls for a residential house can be reduced by using concrete masonry unit rather than conventional clay brick.

1.2.3 To show the mentioned cost effectiveness with a justified figure and standard design

1.2.4 To serve as a reference to contractors, developers and engineers in the similar housing projects.

1.3 Location and Scopes

1.3.1 Major Scope

Basically, the scope of this project involved Case 1 and Case 2. Case 1 is a project of 65 single storey terrace houses situated at Rantau Panjang, Kota Bharu, Kelantan. It is divided into 6 rows of terrace houses and each row consists of 11 lots of houses. The Studies for Case 1 cover these 11 lots of houses because it will be laid on the same raft foundation which is going to be designed. Case 2 involved Phase B of 90 double storey shop lots situated at Kuala Terengganu, Terengganu. It is divided into 6 rows as well and each row consists of the case studies scope of 15 lots of terrace shops.

1.3.2 Minor Scope

The scope for comparison for the case of foundation lies between the excavation levels to ground slab. This is to produce a fair comparison for pad and raft foundation. For the scope of the case of concrete masonry unit, the comparison is made from the bottom to the top of the walls (height of wall) which included the columns.

CHAPTER 2: LITERATURE REVIEW

2.1 Overview

Cost estimation is heavily experience-based process, which involves evaluations of unknown circumstances and complex relationships of cost-influencing factors. A wide range of cost forecasting methods has been exploited in the construction industry. It is found that these techniques do not take into account most of the significant factors affecting project costs, such as site conditions, procurement systems, design feasibility, ground condition, project duration etc. this report however is narrowed down to the factor of structural design and labour productivity in local construction cost effectiveness.

Practical experience shows that structural design has different effects on the final cost of projects. This might be attributed to several variables like different type of materials, formwork and plants required, and also the time required for the erection of different type's frames. A survey amongst QS shows that structural design has gained an important index of 68%, which indicates a high effect on cost and duration of construction projects (Thomas et al., 1999). Improper design will also lead to the waste of materials that eventually will affect the construction cost (Bossink and Brouwers, 1996). Decisions made during design have a significant impact upon the future running and maintenance costs of buildings as well.

The importance of structural design to the construction cost is primarily due to the materials used, namely steel and concrete. In the research done by the Construction Cost Research Engineering Group, University of Liverpool (1998) on 13 office buildings comprises 2 load bearing structures, 8 steel structures and 3 reinforced concrete structures, the results showed that the reinforced concrete structures are the most expensive. It is obvious that concrete has significant effect on the construction cost and this impact certainly also implies to the local construction environment. However, the research is mainly on office buildings whereby it cannot be fully represent the whole construction type of buildings. The units of buildings are to be built also have the impact toward the construction cost. However, the main factor affecting a construction cost lies within the credibility and experiences of the contractor himself (Rosenfeld et al., 1998).

Labour productivity plays a vital part to the construction cost. The importance of labour forces simply lies in the activities involving structural implementation such as erection of formwork, concrete batching, plastering etc. Among the activities that commonly will involve the hugest number of labour forces is the concreting. Thus, an economically design structure will not meet the objective of cost effective until the control of labour forces is properly managed.

There are several factors affecting labour productivity. One of the factors is the inability to provide materials, tools, equipment and information at an accelerated rate (Thomas and Raynar, 1997). The delay in providing materials to the construction site will not only prolong the duration of the whole project as the idle and waiting times of the construction machineries will increase the cost day to day significantly. With reference to the article ‘Quantitative Effects of Construction Changes On Labour Productivity’ published in the Journal of Construction Engineering and Management on Sept/Oct 1995, a threefold increase in the number of materials availability problems was the most obvious disruption associated with change work. The average effect of all changes was a 30% of loss efficiency. Thus, the provision of materials and construction-related tools and equipments if not properly managed will lead to the decrease in labour productivity and hence will increase the cost of construction.

Delivery method and weather are also the factors affecting the labour productivity (Thomas et al., 1999). The effects of weather are quantified. Significant losses of productivity occur because snow (41%) and cold temperatures (32%). Result of the survey obviously cannot reflect on local construction environment. However, the weather is traditionally still a major factor affecting the labour productivity in many of the construction projects available today.

2.2 Cost Effectiveness by Using Raft Foundation

According to the 'Fundamental of Geotechnical Engineering' by Braja M.Das (2000), raft foundation is a combined footing that may cover the entire area under a structure supporting several columns and walls. 'Reinforced Concrete Design' by W.H.Mosley and J.H.Bungey (1998) defined raft footing as a foundation that transmit the loads from structures to the ground through a continuous reinforced concrete slab on the structure foundation. Nonetheless, raft foundations are used when columns loads or other structural loads are close together and individual pad foundations would interact. A raft foundation normally consists of a concrete slab that extends over the entire loaded area. It may be stiffened by ribs or beams incorporated into the foundation. Raft foundations have the advantage of reducing differential settlements as the concrete slab resists differential movements between loadings positions. They are often needed on soft or loose soils with low bearing capacity as they can spread the loads over a larger area.

Type of foundation has different effects on the final costs of the projects. There was a research done by the Construction Cost Engineering Research Group of University of Liverpool to show the degree of influence of the foundation factor incurs in tender price estimation. A survey amongst QS shows that the type of foundation has achieved an importance index of 71% which indicates a high effect on cost and duration of construction projects. The survey concluded that the most expensive type of foundation is found to be the piles followed by strip footings and at the bottom of the list comes the pad footings. There is no raft footing among the 13 projects in the scope of the survey. However, it is obviously that the pad foundation found to be the cheapest solution the the type of foundation used.

The conclusion made by the Construction Cost Engineering Research Group cannot exactly reflect the local construction situation. There are some important points that need to be highlighted here. The survey is done on office buildings only. Therefore, it is insufficient to show that the survey really can implies on the other type of buildings, such as residential terrace houses, bungalows, shop lots etc. Moreover, the survey is done in UK whereby the structural design and the guideline of developments are slightly differing from the local condition. In fact, the parameters that should be taken into account are the structural design and the experience of the contractor.

In the local construction practices, foundation for small buildings is rarely ‘designed’ in the engineering sense, usually being based on the experiences of the contractor. Simple calculation will show that the loads to be carried by the foundation bed beneath a single family dwelling, for example, are small indeed. However, there are some cases whereby the foundation for small buildings needs to be properly designed. For example, in some part of western Canada, is the existence at ground surface of clay soil having well developed properties of swelling and shrinking with changes in water content. In such areas special measures are called for to avoid serious trouble with movements' of the superstructure. It is a fact that the foundation should be well designed by considering the subsoil condition and importantly it should be economically build-up. Long accepted practices in local construction, such as the pad footings for small buildings, should be questioned. Thus, the possibility of the potential for economy in building provided by the use of raft footing for house foundation should be highlighted.

2.3 Cost Effectiveness by Using Concrete Masonry Unit

Concrete masonry unit is no longer a new material to the local construction nowadays. It has been widely used especially at the rural areas at the East Peninsular – without standard. Of course, only high-strength hollow concrete blocks manufactured to approve specifications and standards can safely be used.

The usage of concrete masonry unit in the design of walls not only serves as enclosures, but are designed and constructed to act together with the floors or roof trusses to support both vertical and lateral loads. The floors or roof trusses transmit lateral forces by diaphragm action to the walls and down to the foundation.

Concrete masonry unit or concrete hollow blocks, reinforced for load-bearing applications, consists of the same materials as reinforced concrete and have similar physical and structural properties. The advantages of the system are it combines into one simple operation, the several complicated procedures of R.C construction, it saves materials and labour: formwork for columns, and beams is eliminated; no plastering is required (the even surfaces of the blocks can be painted straight on); less steel is needed., it saves time: structural work, enclosure and finishing are carried out in a one-step process and it requires fewer trades on the jobs, simplifying scheduling of construction and ensuring faster completion.

It is believed that the concrete masonry unit will slowly replace the conventional clay bricks wall for load bearing walls construction. It is getting its popularity among the structural engineers and local contractors as it is belief able to bring cost effectiveness to local building construction. However, a detail survey should be done locally to clarify the effectiveness of the system in the context of economical design.

Application of technologies in construction has become an important subject to the contractors nowadays. There is a paper regarding the method to prioritize cost-effective construction technologies that had been published in the Journal of Construction Engineering and Management, May/June 1998. The study was carried out with the objective to identify opportunities for shortening the duration of construction project by the adoption of innovative construction technologies. Furthermore, the Massachusetts Institute of Technology (MIT) has done a research on the implications of increased panel used in building and the paper was published in the Journal of Construction Engineering and Management on June 1995. It shows that panelized system for roofs, walls and floors system are able to improve the construction performance and achieve a lower cost.

CHAPTER 3: METHODOLOGY

Below shows the sequences of work from start until the end of this final year project.

3.1 Work Flow

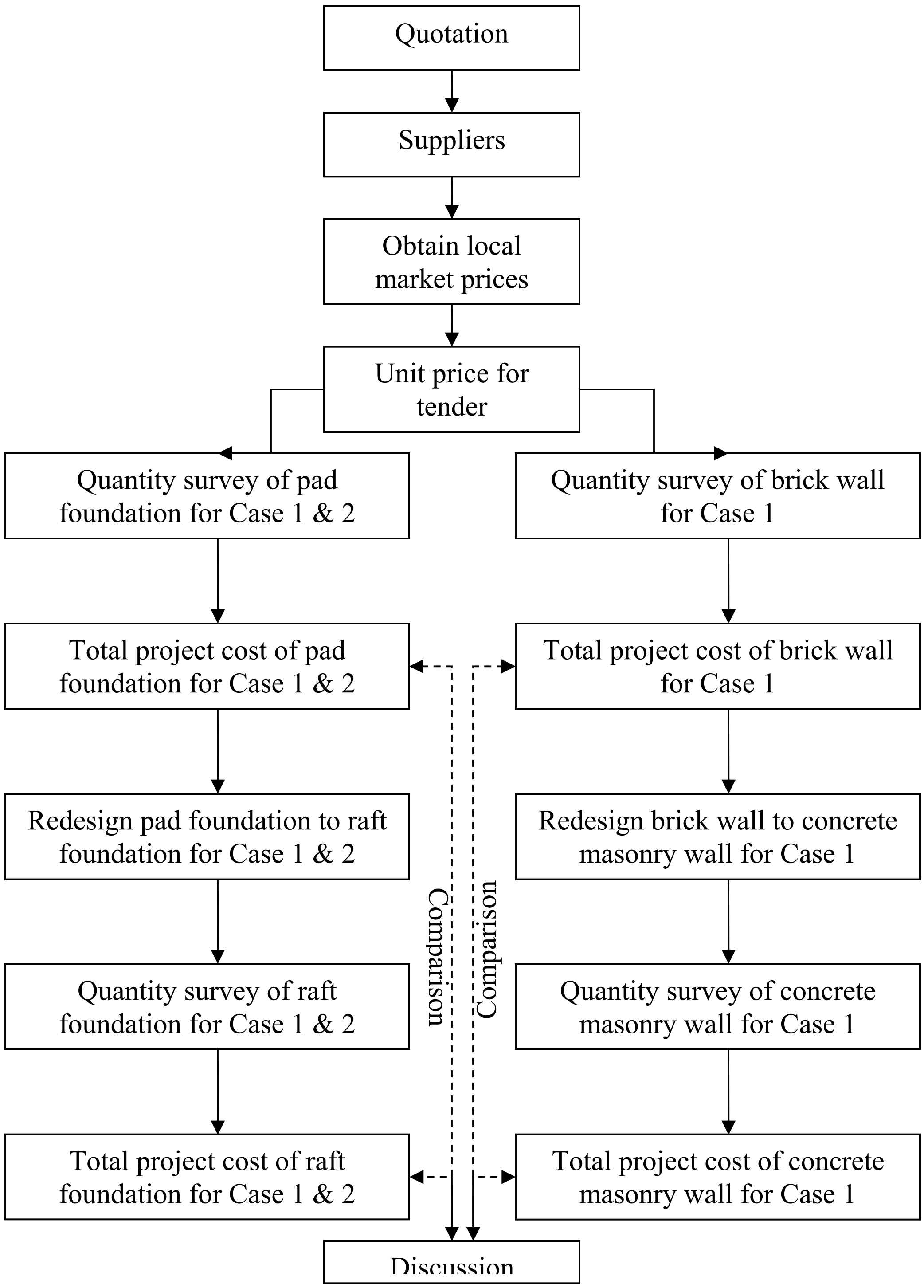


Figure 3.1: Work Flow

The project is divided into two parts; foundation and wall. Both are the alternative to cost effectiveness in construction of terrace houses. The activities involved basically identical to the real construction procedures. Quotation for construction materials is first to send to the local supplier in Kelantan and outstation suppliers in Kuala Lumpur (please refer to the attachment). A visit to manufacturer has been done as well for details understanding. Construction materials required are cement, sand, aggregate, timber, steel bar, clay brick and concrete masonry unit. The price offered by all the suppliers is then processed to obtain the reasonable market prices for each of the materials. The unit prices of the construction materials are used in the computation of the total project cost later.

The first portion of the work is to determine the pad foundation cost for case 1 (11 lots of single storey terrace houses) and case 2 (15 lots of double storey shops). Quantity survey is carried out with reference to the actual drawings provided by the project consultant and aided by the analysis from Esteem Structural Design software. However, the actual work at site is partially dependent on the judgments of the qualified engineer. Subsequently, with the quantities known from the computation, total cost of the pad foundation is sorted out by multiplying the quantities with the unit prices which was calculated earlier.

Pad foundation of case1 and case 2 are then redesigned to raft foundation with the help from project consultant. The drawings are produced by Computer Aided Design software while the computation for the materials used in raft foundation is done manually. With the quantities to be used in raft foundation is known, the total cost of it is once again calculated. The bill of quantities for comparison of the different foundation type is prepared. Hence, the economical design of foundation can be clearly seen from the summation of the bill of quantity.

The second portion of the work is to determine the clay bricks wall cost for case 1. The quantities of clay bricks is computed manually with the reference from the architectural drawings. Total cost of wall per lot of house is calculated based on the unit price which has included the cost for mortar and plastering.

The clay bricks wall for case 1 is then redesigned to concrete masonry wall with reference from BS5628: Part 1 & Part 2. The design of the masonry wall is done with the help of the project consultant and the corresponding manufacturer of the concrete masonry unit. The quantity for the materials used in concrete masonry wall is calculated manually. The total cost of the masonry wall is then computed by multiplying the quantities and the unit prices which were calculated earlier. Finally, the bill of quantities for comparison is prepared and the summation of the total cost for different type of wall is clearly stated.

The discussion is done by referring to the bill of quantities for comparison. A survey to the unpredictable problems which might occur during the construction for the design is done with the help from experienced contractors, qualified engineers and manufacturer. The outcome of the survey is being discussed and final decision or solution is outlined in the discussion.

CHAPTER 4: RESULTS

4.1 Bill of Quantity (Case 1: Foundation Studies)

	Pad Footing					Raft Foundation				
No.	Particular	Units	Qty	Rate (RM)	Price (RM)	Particular	Units	Qty	Rate (RM)	Price (RM)
1	Excavation	m^3	203.18	12	2438	Excavation	m^3	310.58	12	1376
2	Lean concrete G20	m^3	6.77	80	542	Lean concrete G20	m^3	9.77	80	782
3	Formwork	m^2	598.99	25	14975	Formwork	m^2	424.77	25	10619
4	BRC	m^2	1273.27	8	10738	BRC	m^2	1734.63	8	14429
5	Steel bars	kg	1738.20	3.50	6084	Concrete G25	m^3	161.37	160	25819
6	Concrete G25	m^3	149.49	160	23918	Hardcore	m^3	116.47	33	3844
7	Hardcore	m^3	116.47	33	3844	Sand	m^3	116.47	15	1564
8	Sand	m^3	116.47	15	1564					
					RM64,103					**RM58,433**

**The above calculation is encountered for 11 lots of houses.*

4.2 Bill of Quantity (Case 2: Foundation Studies)

	Pad Footing					Raft Foundation				
No.	Particular	Units	Qty	Rate (RM)	Price (RM)	Particular	Units	Qty	Rate (RM)	Price (RM)
1	Excavation	m^3	494.90	12	5939	Excavation	m^3	188.47	12	2262
2	Lean concrete G20	m^3	16.50	80	1320	Lean concrete G20	m^3	12.19	80	975
3	Formwork	m^2	1286.91	25	32173	Formwork	m^2	552.95	25	13824
4	BRC	m^2	1978.50	8	15828	BRC	m^2	2474.40	8	19795
5	Steel bars	kg	5222.70	3.50	18279	Concrete G25	m^3	269.34	160	43094
6	Concrete G25	m^3	241.33	160	38613	Hardcore	m^3	138.53	33	4571
7	Hardcore	m^3	138.53	33	4571	Sand	m^3	138.53	15	2078
8	Sand	m^3	138.53	15	2078					
					RM118,801					**RM86,599**

**The above calculation is encountered for 15 lots of shop houses.*

4.3 Bill of Quantity (Case 1: Wall Studies)

	Brick Wall					Concrete Masonry Wall				
No.	Particular	Units	Qty	Rate (RM)	Price (RM)	Particular	Units	Qty	Rate (RM)	Price (RM)
1	Brick (115mm)	m^2	110.55	42	4643	Concrete Masonry Unit	m^2	181.14	39	7064
2	Brick (225mm)	m^2	70.59	87	6141	Concrete G25	m^3	3.60	160	576
3	Formwork	m^2	38.77	25	969	Steel Bar	kg	96.49	3.50	338
4	Concrete G25	m^3	1.86	160	300					
5	Steel Bar	kg	237.42	3.50	831					
					RM12,884					**RM7,978**

**The above calculation is encountered for 1 lot of house.*

Bill of quantity is a document containing a detailed schedule of all items of work and the quantities required for a building or other project. The above bill of quantity is to show a clearer picture of comparison in total materials cost for different type of foundation and walls.

4.4 References for Calculation

The calculation to determine the quantity and rate of cost for construction materials are located as below:

Case 1: Pad Foundation

Excavation

Quantity (m^3): Please refer to A.2.1

Rate (RM) : Please refer to A.1.1, the rate is provided by Ir. Khor P.C. from Jurutera Teknik Dan Rakan-Rakan, K.B.

Lean Concrete G20

Quantity (m^3): Please refer to A.2.4

Rate (RM) : The rate is provided by Ir Khor P.C from Jurutera Teknik Dan Rakan-Rakan, K.B.

Formwork

Quantity (m^2): Please refer to A.2.2

Rate (RM) : Please refer to A.1.2, the rate is provided by Ms. Lim from Sunlin KB Enterprise, K.B and other local suppliers in K.B.

BRC

Quantity (m^2): Please refer to A.2.3

Rate (RM) : Please refer to A.1.3, the rate is provided by Mr. Gan Yew Hock from Cheang Zie (M) Sdn. Bhd, K.B.

Steel Bar

Quantity (kg): Please refer to A.2.3

Rate (RM) : Please refer to A.1.3, the rate is provided by Ir. Khor P.C from Jurutera Teknik Dan Rakan Dan Rakan and other local suppliers in K.B.

Concrete G25

Quantity (m^3): Please refer to A.2.5

Rate (RM) : Please refer to A.1.4, the rate is provided by Ir. Khor P.C. and other local suppliers in K.B.

Aggregate

Quantity (m^3): Manually calculated

Rate (RM) : Please refer to A.1.5, the rate is provided by Ir. Khor P.C. and other suppliers in K.B

Sand

Quantity (m^3): Manually calculated.

Rate (RM) : Please refer to A.1.5, the rate is provided by Ir. Khor P.C. and other suppliers in K.B.

Case 1: Raft Foundation

Excavation

Quantity (m^3): Please refer to A.4.1

Rate (RM) : Please refer to A.1.1, the rate is provided by Ir. Khor P.C. from Jurutera Teknik Dan Rakan-Rakan, K.B.

Lean Concrete G20

Quantity (m^3): Please refer to A.4.4

Rate (RM) : The rate is provided by Ir Khor P.C from Jurutera Teknik Dan Rakan-Rakan, K.B.

Formwork

Quantity (m^2): Please refer to A.4.2

Rate (RM) : Please refer to A.1.2, the rate is provided by Ms. Lim from Sunlin KB Enterprise, K.B and other local suppliers in K.B.

BRC

Quantity (m^2): Please refer to A.4.3

Rate (RM) : Please refer to A.1.3, the rate is provided by Mr. Gan Yew Hock from Cheang Zie (M) Sdn. Bhd, K.B.

Concrete G25

Quantity (m^3): Please refer to A.4.5

Rate (RM) : Please refer to A.1.4, the rate is provided by Ir. Khor P.C. and other local suppliers in K.B.

Aggregate

Quantity (m^3): Manually calculated

Rate (RM) : Please refer to A.1.5, the rate is provided by Ir. Khor P.C. and other suppliers in K.B

Sand

Quantity (m^3): Manually calculated.

Rate (RM) : Please refer to A.1.5, the rate is provided by Ir. Khor P.C. and other suppliers in K.B.

Case 2: Pad Foundation

Excavation

Quantity (m^3): Please refer to A.5.1

Rate (RM) : Please refer to A.1.1, the rate is provided by Ir. Khor P.C. from Jurutera Teknik Dan Rakan-Rakan, K.B.

Lean Concrete G20

Quantity (m^3): Please refer to A.5.4

Rate (RM) : The rate is provided by Ir Khor P.C from Jurutera Teknik Dan Rakan-Rakan, K.B.

Formwork

Quantity (m^2): Please refer to A.5.2

Rate (RM) : Please refer to A.1.2, the rate is provided by Ms. Lim from Sunlin KB Enterprise, K.B and other local suppliers in K.B.

<u>BRC</u>

Quantity (m^2): Please refer to A.5.3

Rate (RM) : Please refer to A.1.3, the rate is provided by Mr. Gan Yew Hock from Cheang Zie (M) Sdn. Bhd, K.B.

<u>Steel Bar</u>

Quantity (kg): Please refer to A.5.3

Rate (RM) : Please refer to A.1.3, the rate is provided by Ir. Khor P.C from Jurutera Teknik Dan Rakan Dan Rakan and other local suppliers in K.B.

<u>Concrete G25</u>

Quantity (m^3): Please refer to A.5.5

Rate (RM) : Please refer to A.1.4, the rate is provided by Ir. Khor P.C. and other local suppliers in K.B.

<u>Aggregate</u>

Quantity (m^3): Manually calculated

Rate (RM) : Please refer to A.1.5, the rate is provided by Ir. Khor P.C. and other suppliers in K.B

<u>Sand</u>

Quantity (m^3): Manually calculated.

Rate (RM) : Please refer to A.1.5, the rate is provided by Ir. Khor P.C. and other suppliers in K.B.

Case 2: Raft Foundation

Excavation

Quantity (m^3): Please refer to A.7.1

Rate (RM) : Please refer to A.1.1, the rate is provided by Ir. Khor P.C. from Jurutera Teknik Dan Rakan-Rakan, K.B.

Lean Concrete G20

Quantity (m^3): Please refer to A.7.4

Rate (RM) : The rate is provided by Ir Khor P.C from Jurutera Teknik Dan Rakan-Rakan, K.B.

Formwork

Quantity (m^2): Please refer to A.7.2

Rate (RM) : Please refer to A.1.2, the rate is provided by Ms. Lim from Sunlin KB Enterprise, K.B and other local suppliers in K.B.

BRC

Quantity (m^2): Please refer to A.7.3

Rate (RM) : Please refer to A.1.3, the rate is provided by Mr. Gan Yew Hock from Cheang Zie (M) Sdn. Bhd, K.B.

Concrete G25

Quantity (m^3): Please refer to A.7.5

Rate (RM) : Please refer to A.1.4, the rate is provided by Ir. Khor P.C. and other local suppliers in K.B.

Aggregate

Quantity (m^3): Manually calculated

Rate (RM) : Please refer to A.1.5, the rate is provided by Ir. Khor P.C. and other suppliers in K.B

Sand

Quantity (m^3): Manually calculated.

Rate (RM) : Please refer to A.1.5, the rate is provided by Ir. Khor P.C. and other suppliers in K.B.

Case 1: Brick Wall

Brick (115mm)

Quantity (m^2): Please refer to A.9.1

Rate (RM) : Please refer to A.1.6, the rate is provided by Ir. Khor P.C. from Jurutera Teknik Dan Rakan-Rakan, K.B. and other local suppliers.

Brick (225)

Quantity (m^2): Please refer to A.9.2

Rate (RM) : Please refer to A.1.6, the rate is provided by Ir. Khor P.C. from Jurutera Teknik Dan Rakan-Rakan, K.B. and other local suppliers.

Formwork

Quantity (m^2): Please refer to A.9.3

Rate (RM) : Please refer to A.1.2, the rate is provided by Ms. Lim from Sunlin KB Enterprise, K.B and other local suppliers in K.B.

Concrete G25

Quantity (m^3): Please refer to A.9.4

Rate (RM) : Please refer to A.1.4, the rate is provided by Ir. Khor P.C. and other local suppliers in K.B.

Steel Bar

Quantity (kg): Please refer to A.9.5

Rate (RM) : Please refer to A.1.3, the rate is provided by Ir. Khor P.C. and other local suppliers in K.B.

Case 1: Concrete Masonry Wall

Concrete Masonry Unit

Quantity (m^2): Please refer to A.9.6

Rate (RM) : Please refer to A.1.8, the rate is provided by Mr. Yeap H.T. from KB Concrete Products, K.B. and other local suppliers.

Concrete G25

Quantity (m^3): Please refer to A.9.7

Rate (RM) : Please refer to A.1.4, the rate is provided by Ir. Khor P.C. and other local suppliers in K.B.

Steel Bar

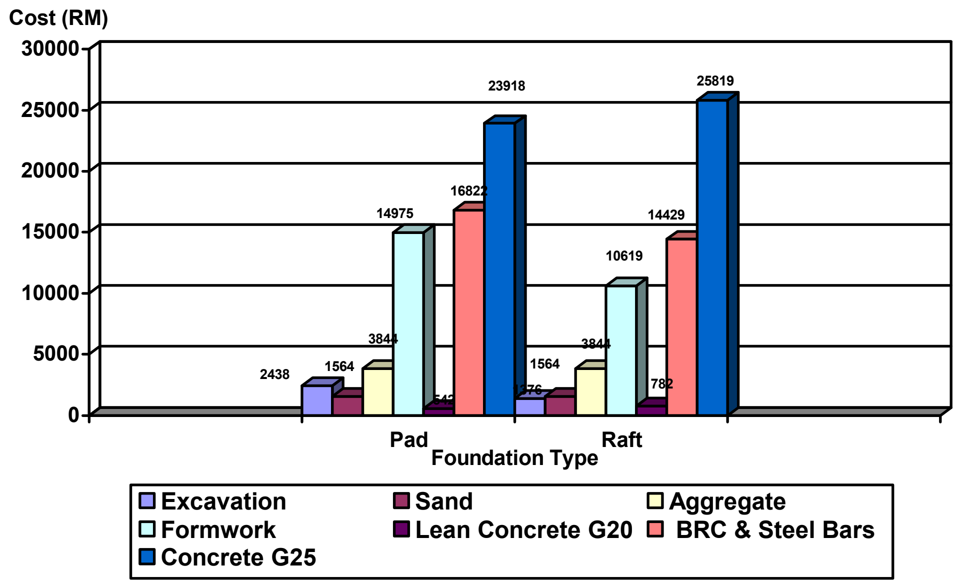
Quantity (kg): Please refer to A.9.8

Rate (RM) : Please refer to A.1.3, the rate is provided by Ir. Khor P.C. and other local suppliers in K.B.

CHAPTER 5: DISCUSSION

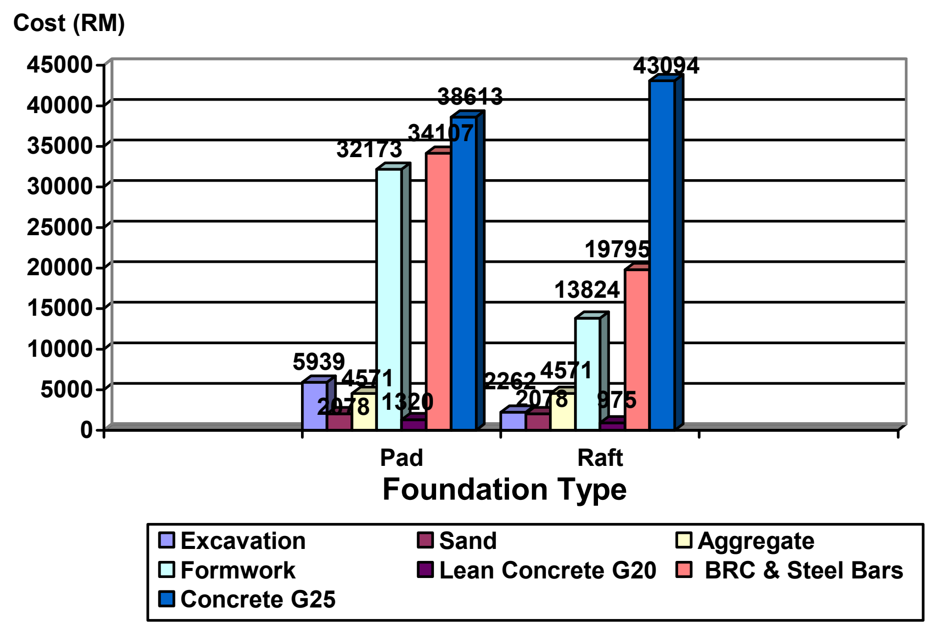
5.1 Pad & Raft Foundation

Figure 5.1: Cost (RM) vs. Foundation Type (case 1)



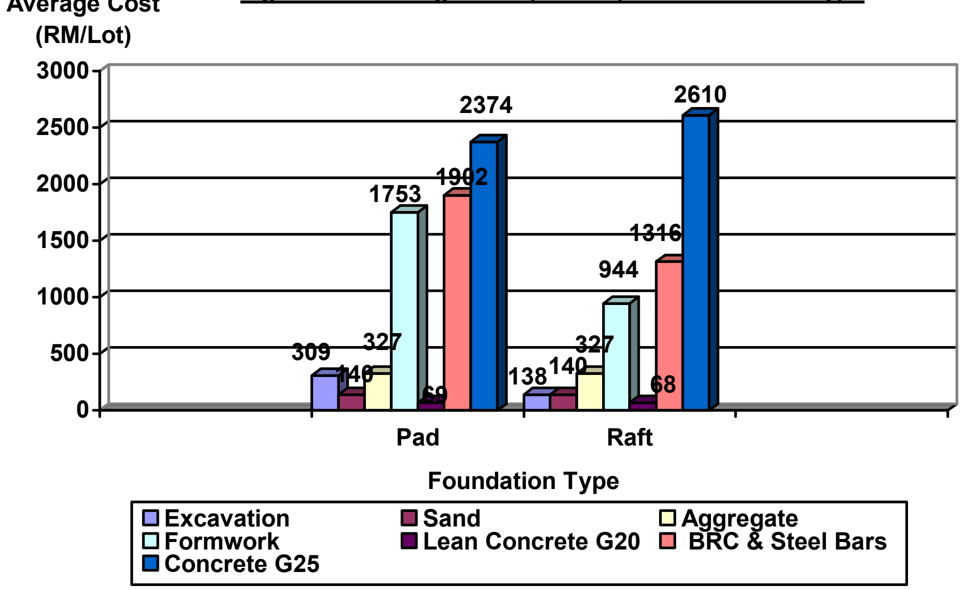
From Figure 5.1, it is obvious that concrete G25 encountered for the highest cost in foundation construction for Case 1, RM23,918 and RM25,819 respectively for pad and raft foundation. A nearly 8% of increased in cost in the usage of concrete is due to the structural design of both foundation. BRC and steel bars are the second materials which contributed a higher volume in cost. About 14% in cost of reinforcement has been reduced by raft foundation. Reduction in the cost for formwork by raft foundation has achieved 29%, which indicated the highest percentage of reduction among the other construction materials. There is 43.5% of reduction in cost for the excavation work. However, this huge amount of percentage does not affect so much on the total cost of the project. It is only RM97 of cost reduction per house. There is no change in the usage of sand and aggregate and the percentage falls in the usage of lean concrete is negligible. The application of sand and aggregate as foundation enhancement is most likely subjected to the judgment of qualified engineers.

Figure 5.2: Cost (RM) vs. Foundation Type (case 2)



From Figure 5.2, the cost of concrete G25 is also the highest for Case 2. The same situation happened here whereby raft foundation has increased the usage of concrete from RM38,613 to RM43,094 for 15 shop lots. However, there is a tremendous decreased in the cost of formwork, BRC and steel bars. Raft foundation is able to save up over 50% the cost of formwork. About 40% in cost is reduced in context of steel bars usage. This is due to the BRC replacement as the reinforcement for ground slab. Excavation is once again achieved a high amount of cost reduction in Case 2; from RM5939 to RM2262. However, this amount is just encountered for about 3% from the total cost of foundation. The sand, aggregate and lean concrete usage is subjected to the judgment of qualified engineer and is mostly do not differ so much for the both alternatives in foundation construction.

Figure 5.3: Average Cost (RM/Lot) vs. Foundation Type



The Figure 5.3 is an average summation of Case 1 and Case 2. It is hoped to produce a clearer picture on how the construction materials cost differ for both the pad and raft foundation per house. This average summation has concluded that the only materials cost raised are concrete for raft foundation. The cost in concrete for foundation is also high. The cost of concrete averagely stands at about RM2500 for both alternatives. However, there is just an amount of RM266 differ per house. Thus, the effect is not much to the total foundation cost. The average cost for formwork is reduced from RM1753 to RM944 per house. For steel bars and excavation works, the cost is reduced by about RM586 and RM171 respectively. It should be highlighted here that the increased or decreased in cost of foundation is not a direct proportional function to the unit of houses. There are other factors influencing the materials cost in foundation and the most prominent is the design of the foundation itself.