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COST COMPARISON BETWEEN THE CONSTRUCTION OF CONVENTIONAL METHOD AND INTERLOCKING BLOCK SYSTEM

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ABSTRACT

IBS cost usually has many factors to affect it and some of it are swing of market demand, transportation cost, storage cost and so on. However, from the previous study, it is proven through questionnaire survey that IBS system is more effective to use compared to conventional method. The objectives for this study are to determine the cost for single, 2-storey and 3-storey house by using the conventional method, to determine the cost for single, 2-storey and 3-storey house by using the interlocking block system and to determine the most economic construction between conventional and interlocking block system in term of material, manpower and time. For this study, the calculation is used to determine the cost for single, 2-storey and 3-storey house from IBS system and conventional method. From the calculation, it performs a Bill of Quantity (BQ) for houses. The BQ shows the different cost and it is possible to choose which house is more economical in term of price. The result of this study shows that the cost for 1 storey house of the interlock block system is 23% less than conventional method. For 2 storey and 3 storey house, it is less 16% and 22% compared to conventional method. So from this result indicate that it is more efficient to use to construct house compare to conventional method. This is because it more economical in term of price. It also takes less time to construct the house and need fewer workers.

ABSTRAK

Kos IBS biasanya mempunyai banyak faktor yang mempengaruhinya dan salah satu darinya adalah permintaan pasaran yang tidak menentu, kos pengangkutan, kos penyimpanan dan sebagainya. Walau bagaimanapun, daripada kajian yang lepas, ianya terbukti melalui kajian soal selidik yang sistem IBS adalah lebih berkesan untuk digunakan berbanding dengan kaedah konvensional. Objektif bagi kajian ini adalah untuk menentukan kos untuk rumah 1 tingkat, 2 tingkat dan rumah 3 tingkat dengan menggunakan kaedah konvensional, menentukan kos untuk rumah 1 tingkat, 2 tingkat dan rumah 3 tingkat dengan menggunakan sistem 'interlocking block' dan untuk menentukan kos yang paling ekonomi diantara kaedah konvensional dan sistem 'interlocking block' dari segi bahan, tenaga kerja dan masa. Untuk kajian ini, pengiraan adalah digunakan untuk menentukan kos bagi rumah 1 tingkat, 2 tingkat dan rumah 3 tingkat dari sistem IBS dan kaedah konvensional. Dari pengiraan, ia akan menghasilkan 'Bill of Quantity' (BQ) bagi rumah-rumah tersebut. BQ akan menunjukkan kos yang berbeza dan ia akan membantu dalam memilih rumah yang lebih menjimatkan dari segi harga. Hasil kajian ini menunjukkan bahawa kos untuk rumah 1 tingkat dari sistem 'interlocking block' berkurang sebanyak 23% daripada kaedah konvensional. Untuk rumah 2 tingkat dan 3 tingkat, ia kurang sebanyak 16% dan 22% berbanding kaedah konvensional. Jadi dari keputusan ini, ia menunjukkan bahawa adalah lebih berkesan untuk menggunakan kaedah 'interlocking block' untuk membina rumah berbanding dengan kaedah konvensional. Ini kerana ia lebih menjimatkan dari segi harga. Ia juga mengambil masa yang kurang untuk membina rumah dan memerlukan kurang tenaga pekerja.

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CHAPTER 1

INTRODUCTION

1.1 Introduction to IBS System

Not many among the people around are all except those who are in the midst of progressive development in the heart of the capital really understood the concepts and technologies lay behind the Industrialized Building System or simply known as IBS amongst the construction and build communities. Unrealised, the Government of Malaysia has put a lot of effort to start the implementation of IBS in their construction contract and roadmap for IBS toward 2010. Nevertheless, the industry stakeholders are indifferent about this idea and thus resist toward this change which, probably due to ignorance (lack of idea and awareness or lack of effort in understanding the concept) and cost in technology transfer due to the initial high cost in implementation (however these technologies enable to reuse of recurring processes).

IBS in Malaysia has begun in early 1960's when the Ministry of Housing and Local Government of Malaysia visited several European countries and evaluate their housing development program. After their successful visit in 1964, the government had started the first project on IBS aims to speed up the delivery time and built affordable and quality houses. About 22.7 acres of land along JalanPekeliling, Kuala Lumpur was dedicated to the project comprising seven blocks of 17 story flat there are 3000 units of low-cost flat and 40 shops lot. This project was awarded to Gammon & Larsen Nielsen using the Danish System of a large panel of pre-fabricated system.

1.2 Problem Statement

In a survey that has been conducted on 30 November 2012 to 9 January 2013, up to 75% of respondents agreed that house price is too expensive. This survey involved 924 respondents representing Malaysia's population across Klang Valley, northern, southern and East Malaysia. (Home Prices, URL)

There are five main IBS groups identified in Malaysia, there are Pre-cast Concrete Framing, Panel and Box Systems, Formwork Systems, Steel Framing Systems, Prefabricated Timber Framing Systems and Block Work Systems. With the advancement of technology and innovation, besides the five main types, various pre-fabricated materials have entered the market. It includes gypsum, wood wool, polymer, fibre glass, glass and aluminium based IBS components. (About IBS, URL)

IBS cost can be affected by swing of markets demands, delay in completion project, delay in payment, transportation cost, storage cost and assembly cost. (Maryam Qays, 2010). Factors that may influence IBS construction costs are project characteristics / IBS characteristics, factors related to contract procedures and procurement methods, factors related to consultant and design parameters, factors related to contractor attributes, factors related to economics and market conditions, factors related to external factor and factors related to government/authority requirements. (Nor Azmi, 2012).

IBS will save on labour, cost and time. It will also give better quality, durability for building life, better safety and security system and more cost effective. (Muhammad Adebi, 2011). From contractor perspective, construction costs increased by 10% to 20% due to increase in quality, suppliers and product customisation. From clients perspective, IBS is cheaper if can consider a whole life cycle cost of the building maintenance etc. and if want the building fast. (Kamarul Anuar M. K., 2008)

1.3 Objective

The objectives of this study are:

1. To determine the cost for single, 2-storey and 3-storey house by using the conventional method.
2. To determine the cost for single, 2-storey and 3-storey house by using the interlocking block system.
3. To determine the most economic construction between conventional and interlocking block system in term of material, manpower and time.

1.4 Scope of Study

The scope of study that being highlighted are:

1. Design of a single, 2-storey and 3-storey house of conventional method.
2. Scheduling the critical path method of a single, 2-storey and 3-storey house of conventional method.
3. Design of a single, 2-storey and 3-storey house of interlocking block system.
4. Scheduling the critical path method of a single, 2-storey and 3-storey house of interlocking block system.
5. Prepare the Taking off Quantity for 6 designed houses.
6. Compare the cost involved are the materials, manpower and time.

1.5 Significant of study

Study of IBS method of construction in Malaysia is very important because of the lack of understanding of this system compared to conventional method. The existence of this study will help the construction industry key players to understand the concepts of the various aspects in the IBS system and will help them to try to develop and widely used the system to construction in Malaysia. It also will help to reduce the use of conventional methods that we practice nowadays because it is proved that using the IBS system is more helping to the construction industry in term of reducing the cost, time and workers compared to conventional method.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter will discuss the IBS system. The first is that things should be known is the purpose of IBS itself. Then, it will discuss the types of IBS in Malaysia. IBS character will also be discussed. In addition, this chapter will also discuss the advantages, barriers to IBS and the cost comparison.

2.2 Conventional Method

Conventional method of constructing meaning that the construction are using the reinforced concrete frames and brick as infill, beam, column and roof that cast in-situ using timber formwork while steel reinforcement is fabricated on-site. (Mahayuddin & Zaharuddin, 2013)

Conventional construction usually problems are a huge number of workers, activities complicated, performs low quality output, contributes lots of non-value activities and always delay the construction. (Yahya & Shafie, 2012)

Conventional method usually has construction waste which is soil, rock, reinforced concrete, steel bar, wood, cement, sand, aggregate, brick, tiles, paint, lime, bituminous materials and timber. (Mahayuddin & Zaharuddin, 2013).

2.3 IBS System

IBS is a construction process, which utilizes techniques, products or components which manufacturing out or at the construction site where products are often produced in a factory, removed and subsequently installed to produce a perfect structure. (About IBS, URL).

IBS as a systematic process of integrated and coordinated elements enhancing the efficiency, productivity and effectiveness of the construction industry, whereas most of the prefabricated components are manufactured preferably off site, transported to the construction site and assembled on to the site with minimal site activities contributing to less wastage. (Mohammad Abedi, 2011)

IBS was off-site manufacturing where the building component was produced in factories and send to site to install to form a building structure and this can avoid the wastage and reduce the number of the manpower in the construction industry. (Kiong & Akasah, 2012).

IBS used in the Developer firm for timber framing system in average index is 3.35, steel framing system is 3.28, precast concrete system is 3.89, steel formwork system is 3.65, block work system is 3.37 and standard components is 3.43. (Chung, 2006)

2.4 Classifications of IBS

There are five main IBS groups identified in Malaysia:

1. Pre-cast Concrete Framing, Panel and Box Systems
    - Precast columns, beams, slabs, 3-D components (balconies, staircases, toilets, etc.)
2. Formwork Systems

- Tunnel forms, EPS-based forms, beams and columns moulding forms, permanent steel formwork, etc.

3. Steel Framing Systems
    - Steel beams and columns, portal frames, roof trusses, etc.
4. Prefabricated Timber Framing Systems
    - Timber frames, roof trusses, etc.
5. Block Work Systems.
    - Interlocking concrete masonry units (CMU), lightweight concrete blocks, etc.

With the advancement of technology and innovation, besides the five main types, various pre-fabricated materials have entered the market. It includes gypsum, wood wool, polymer, fibre glass, glass and aluminium based IBS components. (About IBS, URL).

Interlocking block is one of the IBS groups that identified in Malaysia. Interlocking blocks are like 2 adjoining pieces of a jigsaw puzzle. Each block has a projection at one end and a depression on the other. The projection of one block fits into the depression of the next so that they always align perfectly. (Dr.Nasly, 2012)

The interlock block system is a building with load bearing brick system. It is a structure that uses interlocking block as the wall and it is designed based on the International Code of Practice to carry loads of the structure. For this system, the walls are very important because it is the main element that carry load from upper to the foundation. By using this system, it is proven that it can be built up to 9-storey for the multi structure. (Mohd Redza Fahmi, 2007)

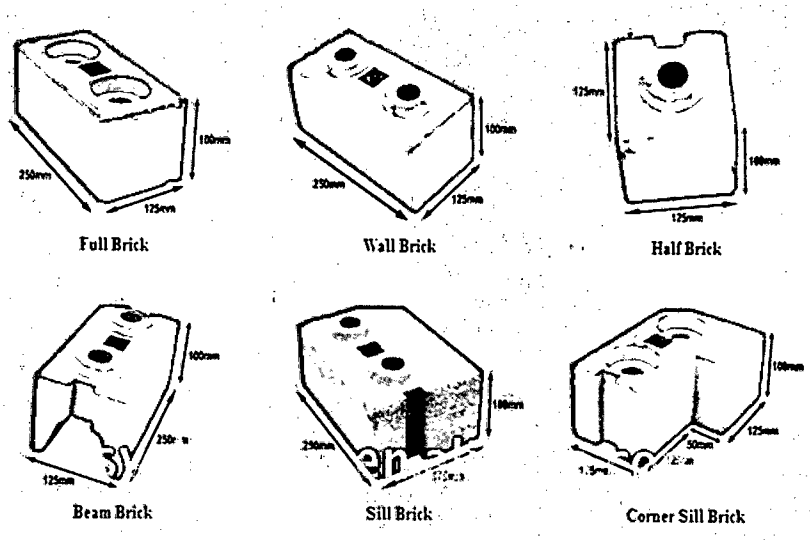

Figure 2.1: Type of interlock brick

Figure 2.2: Example of multi-structure using interlock block brick

2.5 Advantages of IBS

Factors in selection of using formworks are material cost in term of net price of the materials, delivery cost, storage cost and wastage, labour cost in term of skilled workers as carpenter, joiner and normally compared to general workers, semi skill workers as assistant to the carpenter, joiner are being lowered compared to skill workers but higher compared to general workers and general workers had no skill at all but only work as what had instructed by the supervisors and normally lowest paid workers at construction site, machineries usage cost in term of cost for the machinery operators salary, fuel cost, cost for maintenance and repairs and rental cost and salvage value for own machineries and lastly is fixed cost and profit in term of general expenditure as office rental, utilities, management expenditure and insurances, commercial taxes, salaries for office staff such secretary, clerks and so all, salaries for the site staff such as supervisors, drivers and so on, allowances and expenses for the directors, payment for shareholders and profit from the project. (Redzuan, 2006).

Benefits of applying the IBS are period shorter completion, reducing dependence on labour building construction site, produce construction site clean and orderly, reducing waste materials and construction materials wastages, can get a better quality of construction and result in better products, creating a special standard with every element dimensioning scale structures produce, components are easy to install, open and secure systems, reduce or eliminate the need for formwork or temporary props, improve safety on construction sites and reducing the cost of construction. (Eka Kusmawati, 2005).

Waste generation and composition normalized to $100m^2$ of floor space for fully prefabricated for soil and sand is 1.01, brick and blocks is 0.04, concrete and aggregate is 0.27, tiles is 0.02, scrap metal is 0.01 wood is 0.04, plastic materials is 0.01, packaging products are 0.07 an the total it are 1.47 and for the conventional for soil and sand is 14.700, brick and blocks is 0.6300, concrete and aggregate is 36.000, tiles is 2.7200, scrap metal is 0.4500, wood is 0.1100, plastic materials is 0.0300, packaging products is 0.0020 ant the totals of it are 54.642. (Begum, Satari, & Pereira, 2010)

Data that have been obtained from 100 residential projects through a questionnaire survey in 2005, it's shown that conventional building system and IBS system are different in term of 22 workers, 17 days per house and labour productivity 7.0 man-hours/m2 for conventional building system and 18 workers, 4 days per house and labour productivity 2.1 man-hours/m2 for IBS system. (Kadir., 2006).

The IBS system makes 2 times work faster than conventional method, reduces the need for skilled works, make system of construction more systematic, not need for the formwork user, more environmentally friendly, and make the surfaces of finishes smoother. (IBS, 2013).

57.89% had more than 10 years of working experience in IBS construction while 28.95% with the range of 5 to 9 years, the majority of the contractors had high experience in managing the construction and they said that managing IBS project enable contractor gain benefits in term of the rapid construction period, high quality factory product, standardized design and etc. (Ismail, Baharuddin, & Marhani, 2013)

Advantages of Industrialized Building System are achieving higher quality, faster construction time, high cost saving, reduction of unskilled workers and fewer site workers, enhancing the social benefits, increased environmental and construction site cleanliness and increasing the safety. (Abedi, Fathi, & Mirasa, 2011)

Labour productivity for the precast concrete system is 1.33 manhours/m^2, cast in situ half tunnel is 1.88 manhours/m^2, cast in situ table form, is 2.70 manhours/m^2 and conventional building system is 4.20 manhours/m^2 and the crew size for IBS is 22 peoples and conventional is 24 people. (Kadir, Lee, Jaafar, Sapuan, & Ali, 2005).

50% of respondents indicated that modifications to the design are commonly occurring in term of modification and 59.1% of respondents indicating an increase in the scope of work commonly occur in term of changes in scope of work. (Ahmad Firdaus, 2005)

IBS will save on labour, cost and time. It will also give better quality, durability for building life, better safety and security system and more cost effective. (Mohammad Abedi, 2011).

Compare to Conventional Method that need 912 days to construct 18 Stories High-Rise Residential Building, IBS system only need 529 days and it can be conclude those 383 days or 42% of saving if use the IBS system. (Ismail, Mohamad, & Yahya, 2010).

2.6 Barrier of IBS

Factors affecting the use of IBS in design innovation are standardization of building components, inadequate knowledge of the concept of modular coordination, insufficient research on IBS components and application, lack of proper planning of projects, poor management in construction firms, poor understanding of clients' needs, and poor organization of work schedule and lack of integration within the project team. (Onyeizu & Bakar, 2011).

Malaysian contractors consider IBS is the risk of financial failure any party, delayed payment and resolving contractual issues, changes in government regulation, contractor competence, quality of work, change in work and defective design, lack of special equipment and machinery, labour and equipment productivity and availability, poor quality product, site access or right of way, suppliers or manufacturers poor performance and safety. (Nur Adilah, 2010).

Causes of IBS failure are the high cost of using the system, lack of knowledge in alternative building techniques, no incentives to use the system, less emphasis and course about IBS system to local developers, failure of the major players to earn a full technology transfer from countries that skilfully uses the system IBS in the construction industry, authorities are not ready to change the law on local building and difficulty in changing the stance of engineers that only satisfied with conventional thinking and do not want to try new technology. (Siti Nur Zulaikha, 2008).

General safety of IBS, 75% of respondents stated the accident occurred between 1 to 5 times during the involvement, 75% of respondents state workers use protective equipment while 75% of respondents stated they do tool box meeting once weekly, safety at work lifting and placing components, 37% of respondents stated that there is a specific time for the installation of components between 9AM to 7PM, 87.5% of respondents agreed the work should be stopped if a strong wind or heavy rain hit, 87.5% of respondents stated that employees are given special protection such as safety harnesses while working at high place while 62.5% of respondents stated that using a walkie-talkie as a communication tool between the rigger and crane operator. (Ahmad Ikhwan, 2007).

Constraints to private sector projects using IBS are the use of conventional monitoring and payments to suppliers, the design process is still using conventional methods, there is no uniformity in the design, perceptions of state buyers IBS difficult project modified and the overall cost of using higher IBS that is the number of suppliers, resulting in demand exceeding supply, purchasing an expensive mould, cost of transportation and IBS component manufacturing requires high-tech equipment and expensive. (Kamarul Anuar, 2008).

Problems faced by the contractor during construction stage based on IBS are mechanization, limited modification, skilled workers, safety, state construction site, transportation, connection components, defect component, component installation, maintenance of buildings and storage. (Siti Fatimah, 2009).

Disadvantages of Industrialized Building Systems are higher initial investment cost, the industry is uncompetitive due to lack of open collaboration and specialized skills which require more time and investment. (Abedi, Fathi, & Mirasa, 2011).

2.7 Cost Comparison

From contractor perspective, construction costs increased by 10% to 20% due to increase in quality, suppliers and product customisation. From clients' perspective, IBS is cheaper if can consider a whole life cycle cost of the building maintenance, etc. and if the client wants the project finish faster and not delay. (Kamarul Anuar, 2008).

Factors that may influence IBS construction costs are projected characteristics / IBS characteristics, factors related to contract procedures and procurement methods, factors related to consulting and design parameters, factors related to contractor attributes, factors related to economics and market conditions, factors related to external factors and factors related to government/authority requirements. (Bari, 2012).

The cost required for maintenance is lesser than the cost required for repair or renovation because when the maintenance work is carried on, the specific structure can still be running and thus cost saving from the economic perspective. (Kiong & Akasah, 2012).

For the Conventional System, the total cost structure is RM 45,776.54 and the cost for each square foot is RM 52.02 and for the Interlocking Block System, the total cost structure is RM 42,401.84 and the cost for each square foot is RM 48.18. (Mohd Redza Fahmi, 2007)

It turns out that Conventional System cost is RM432 per square meter and the Formwork System is RM544 per square meter. (Haron, Hassim, Kadir, & Jaafar, 2005).

IBS cost can be affected by swing of markets demands, delay in completion project delay in payment, transportation cost, storage cost and assembly cost. (Qays, 2010).

2.8 Summary

From previous studies, they have done the survey and design method, they conclude that the IBS method is more effective to use. They also find lots of barriers from conventional method compared to IBS method. For this study, the design method is being done to determine which method is more effective to use in term of cost, time and workers.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

In conducting this study, several methods already been applied to obtain the required information. The following is the methods that applied are:

3.2 Literature Review

Literature methods are used to obtain information from the reading and analysis of resources such as:

1. Previous thesis
2. Research report
3. Reference books and journals
4. Website on the internet

For this study, the thing focus is the purpose and types of Industrialized Building System (IBS) along with its application in Malaysia. Particular emphasis is also given to the construction using conventional method and interlocking block system by looking at the way to design a structure and cost advantage of IBS. The results of this literature review are used to provide research report.

3.3 Design

The first step is to design of single storey, double storey and 3-storey houses using the conventional methods and the interlock block system. Methods that have been used to design these houses are through software and manual methods.

Software that's been used is Esteem. This software usually used to determine whether the building can carry the load of the building. It also determines the size and the quantity of the beams, columns, and etc. To make sure that the design didn't fail, the sizes have to choose wisely. The esteem design is being referred to Eurocode 2

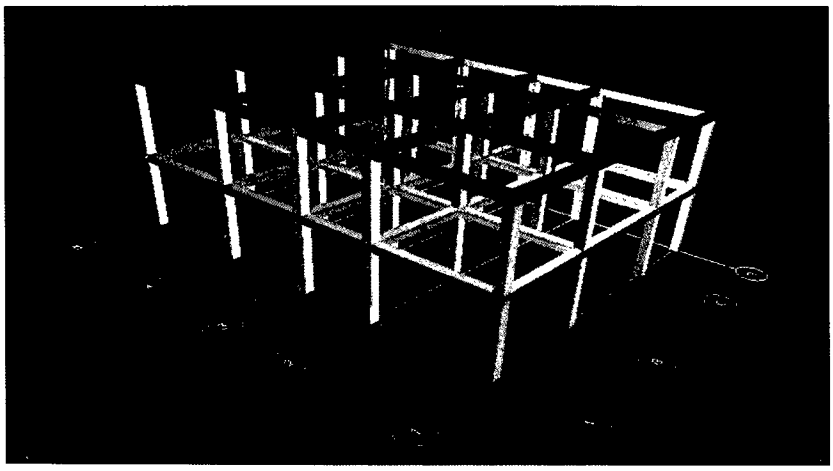

Figure 3.1: Example of 3D illustration design using Esteem software

For the manual method, it's been carried out to the some part that cannot be design through Esteem software such as staircases and raft foundation. The manual method is being referred to Eurocode 2. Reinforcement installation in the interlock block wall has been referred to previous thesis.