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ECONOMIC ASPECTS OF INTERLOCKING HOLLOW BRICK SYSTEM DESIGNED FOR INDUSTRIALIZED BUILDING SYSTEM

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Abstract. Construction industry has moved forward into a technology driven where a transition is in progress from conventional method to a more advanced and mechanised system known as the Industrialised Building System (IBS). However, the need to implement the IBS should be well understood by all construction players such as designer, architect, contraction, erectors and construction workers. Therefore, there is a need to educate all these construction players which should be spearheaded by authorities such as Construction Industrial Development Board where enforcement trough building by laws as well as initiative to those that adopt the IBS in their construction. This paper reports on economic aspects of using interlocking hollow brick system in construction as an alternative method offered for Industrialized Building System. The main objective is to address the economic aspects of using interlocking block system in terms of time, costs, and utilization of manpower and to present some of the experimental tests results related to Interlocking Hollow Brick System (IHBS). Example of savings from the use of IHBS is presented in this paper by comparing the construction of two storey terrace house with build-up area of about 200 square meter with conventional construction method of typical reinforced concrete construction (RCC) compared to IHBS. The comparison shows that the implementation of IHBS can reduce construction time, cost, and utilization of man power up to 26.6% compared to the conventional method. Moreover, the construction time using IHBS can also be reduced by up to 50% as compared to the conventional construction.

INTRODUCTION

One of the main problems facing in construction industry is related to shortage of manpower. The influx of foreign works in our society could further aggravate the social problems such as crime and health problems. Therefore, the introduction of Industrialized Building System (IBS) can be considered as good alternative to reduce the dependency on foreign workers. However, set-back was reported by Trikha [1] where the use of IBS as an alternative to the conventional system (reinforced concrete) has not widely accepted by construction industry players. Some of negative perceptions given by construction industry players on the use of IBS are listed as not ready towards new concept, insufficient information and lack of knowledge to understand changes in IBS. Hervas [2] revealed that construction sector is identified as traditional sector that is not willing to accept changes or even resist changing. This chapter discusses on the current implementation of IBS, its shortcomings and the way forward to introduce IBS in the construction industry. It also elaborates the current issues by focusing on stability, build-ability and cost efficiency and research done in IBS.

Traditional construction method is very common and well known by the contractor as compared to IBS. However, in these few years, as the population is increasing and generating great demands on infrastructure and building

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construction, the needs of fast, cost effective, and quality construction are desperately critical. These phenomena have led to the shortage of building structures in South East Asia as the demand is higher than the supply. The conventional construction method is time consuming and could not be able to meet the schedule of construction given to contractors Agus, [3]. Therefore, the need to implement the use of IBS in residential and commercial buildings is getting popular. The main objective of this paper is to present and compare the economic aspects of IHBS in terms of time, cost, and utilization of manpower.

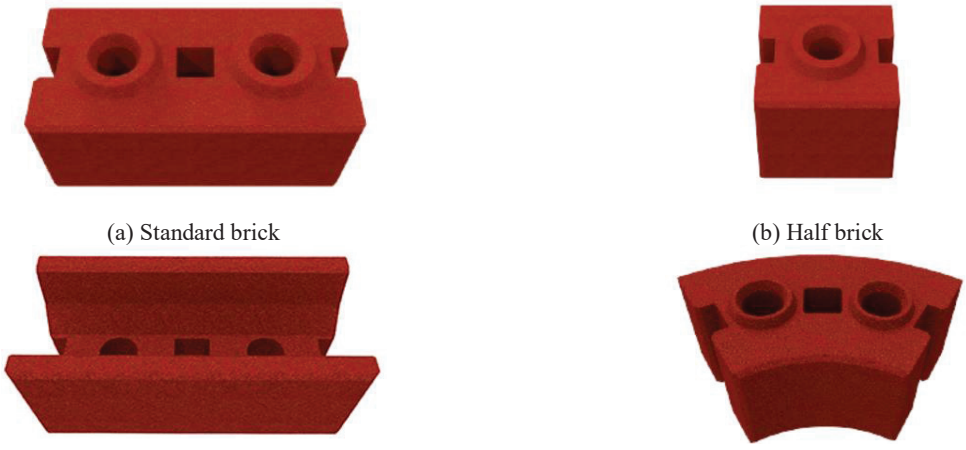
ASPECTS OF INDUSTRIALIZED BUILDING SYSTEM (IBS)

IBS is defined as a construction system which components are manufactured in a factory, delivered to site, and assembled into structure with minimum additional site work, CIDB, Malaysia, 2003 [4]. Dietz [5] defined IBS as total integration of all construction activities and production of construction components into overall process of construction by fully utilizing industrialized production, transportation and assembly techniques. According to [6], IBS is a system where the intensive use of industrialized production technique either in the production of component or in the assembly of the buildings or both. Lessing et al [7] defined IBS as an integration of construction component and construction process with well-planned organization for efficient management, preparation and control over resources used, activities and results supported by the used of highly developed component in factory. Industrialized Building System is usually associated with sustainable construction which is described as the ability of the construction system to consider the environmental impact of a building over its entire lifetime, while optimizing its economic advantages and the comfort and safety of its occupants [8]. Typical standard building practices are based on short term economic considerations where profit is the main goal. The concept of IBS usually associates with the preservation of the environment which also related to issues such as the efficient use of resource, continual social progress, promising economic growth, and improve standard of living.

The main aims of IBS construction are to provide the needs for housing, good working environments and easy to assess infrastructure but not to compromise the ability of future generations to develop and prosper. As the construction time decreases, the overall cost of construction is also reduced. Two important factors that contribute to the cost of construction are construction materials and labor. The use of quality material and production of building component in mass could significantly reduce the cost of construction. The use of state-of-the art machines, installation and erection on site could reduce significantly the need to use extensive labor. As a result, significant contribution to cost saving from labor dependent can be achieved. A lot of research have been done to improve the performance of structural elements and make the structures more sustainable [9-13].

ASPECTS OF INTERLOCKING HOLLOW BRICK SYSTEM (IHBS)

Interlocking bricks (see Fig. 1) and mortar are usually associated with mortar less technology [14]. The use of IHBS should take into consideration on observing proper bonding in building construction rules. Bonding can be defined as bricks arrangement in an interlocking design, generate a stable wall. The main features of IHBS are the elimination of mortar layers and plastering on both sides of the bricks which can lead to cost effective construction due to reduction of number of skilled and unskilled workers. The connected parts of the bricks resisted the stresses developed in the wall due to the applied loads. The IHBS are like two adjoining pieces of jigsaw puzzle that used to replace conventional bricks and mortar in construction. Interlocking bricks are used in the Interlocking Building System as a replacement for the typical column and beam with Load Bearing Wall System. These interlocking bricks are formed from a mixture of clay, fine soil, cement, and water. All these materials are mixed together before transferred to a compression machine. A compression forces up to 2500 pound per square inch are applied by hydraulic jack to the mixture to form into an IHBS. The brick is then proceeded to the next stage of curing process. The curing process is done within a period of 14 days where the bricks are watered for every day within a period of 7 days. On the 8 to 14 days the brick is moved to an open space for it to be dried naturally.



(a) Standard brick (b) Half brick

(c) U brick (d) Curve brick

FIGURE 1. Typical size and shape of Interlocking Hollow Brick System

Interlocking Hollow Block system is different from the conventional wall brick method, where in this system no need of mortar to be laid on the block. The concept of the IHBS is similar to the modular concept, where the brick is stack one of each other, then each block is locked into place by filled in with mortar. The outcomes of this characteristic, less use of skilled labor and fastest wall can be developed. The first layer of blocks need to be laid on the mortar to ensure the blocks is perfectly horizontal and in a straight line or at the right corner. Reinforcement bars of size T10mm (460 N/mm2) is placed at 1m spacing both in vertical and horizontal directions. As soon as the base is appropriately laid, wooden rubber hammer is use to knocks the block one by one gently in place [15].

IHBS VERSUS REINFORCED CONCRETE CONSTRUCTION (RCC)

A comparative study between IHBS construction and conventional method of reinforced concrete construction (RCC) was carried out based on savings due to time, cost, and utilization of manpower. The difference in analysis and design also been considered between the two construction methods. A double storey terrace house of 200 square meter was designed using both IHBS and conventional RCC methods. A comparison between these two systems has been referred to Kontraktor Selatan & Enterprise [16] for the information on cost, time of construction, number of labour needed and overall completion time taken. The overall cost of saving can reach up to 26.6% and reduced the time of construction by up to 50% for the double storey terrace house. Details of cost and time to construct are given by Kontraktor Selatan & Enterprise [16] based on year 2016 as shown in Table 1.

DISCUSSION AND CONCLUSIONS

In this study, it can be concluded that the cost associated with the process of constructing a wall with the interlocking block is far lower compared to using the conventional block. A case study presented in this thesis has shown that about 26.6% of the construction cost is due to the erection of the wall using the conventional brick wall which can be reduced significantly if the interlocking block is used. Despite the fact that a relatively lower cost of labour played a role as the use of IHBS did not require the construction of formwork for beam, column, and slab. The design concept of IHBS as load bearing has significantly reduce the need of labor as the wall can be functioned as column and beam.

Main factors affecting the use of IHBS can be concluded as the need of know-how on the installation, the need of quality brick with prefect size, the need on the concept of design and the need to understand the strength and performance of the IHBS. All these factors need to be addressed first before using IHBS for housing construction. However, the study also revealed that a number of non-value added steps like spreading of base mortar for various courses, vertical mortar jointing and levelling, which are associated with the use of conventional block, could be eliminated when the interlocking block is used for wall construction. Such various forms of waste as over-production, unnecessary movement, unnecessary processing, inventories and waiting, seen to be associated with the use of the conventional blocks, are minimized to a large extent when the interlocking block is in use.

The elimination of the various non-value added steps associated with the conventional block wall construction can also be identified through the use of the interlocking block system by reducing the cycle time of block bonding thus increasing the speed of wall construction. There is also a significant reduction in the material requirement for the interlocking block wall construction process due to the absence of mortar jointing. Reduction in the labor and material requirements in the interlocking block wall construction process makes the cost associated with the process of building walls using the interlocking blocks far less. It can be concluded that the use of IHBS can achieve the cost of construction up to 26.6% and the time of construction up to 50% as compared with the conventional construction of typical reinforced concrete construction. However, the overall cost of savings can be further increased if the availability of the IHBS is very close to the site as the cost of transportation can be further reduced. The type of construction such as single storey or double storey could also influence the cost of construction. A single storey house could reduce further the cost as there is no slab system for first floor system that need to be constructed. Most of the savings came from the saving due to a lesser dependency of labor and saving from material cost. It can also be concluded that the use of IBS such as IHBS can be a very good solution to solve the problem of need on both quantity and quality of the housing construction.

Table 1. Cost comparison of construction using IHSB vs RCC

Construction activities	**Cost in Malaysian Ringgit (MYR)**
Conventional Construction Cost calculated based on the following construction activities: - • External Works – Earthwork, site clearance, mobilization, setting grid lines • Sub-structures – Excavation and fill, concreting, preparing formwork, layout on re-bars. • Beams, columns and slabs – Concreting, preparing formwork, layout on re-bars • Brickworks and plastering – Plaster on both sides, skin coating. • Transportation and machineries • Roof trusses, windows, doors, plumbing and accessories • Drainage and sewerage. • Wiring, painting, and site clearance • Design and endorsement	485605.00
Interlocking brick system Cost calculated based on the following construction activities: - • External Works – Earthwork, site clearance, mobilization, setting grid lines • Sub-structures – Excavation and fill, concreting, preparing formwork, layout on re-bars. • Ground Beams and slabs – Concreting, preparing formwork, layout on re-bars • Brickworks and mortaring – Lay the IHBS and filled with mortar. • Transportation and machineries • Roof trusses, windows, doors, plumbing and accessories • Drainage and sewerage. • Wiring, painting, and site clearance • Design and endorsement	377515.00
Saving in labor = (6 workers x 6 months(conventional) – 6 workers x 3 months (interlocking brick)) 26days x 3 x RM100 x 6	46,800
Saving in labor by 50%	
Saving in construction material	61,290
Total direct saving = 485,605.00 – 377515 = 108,090.00	
Saving due to 3-month completion which can be converted to renting (2,000 x 3 month)	6,000
Saving on crane for concreting column and roof beam	2,000
Saving due to site clearance and dumping of construction waste	3,000
Saving due to defect and maintenance	10,000
Total indirect saving	21,000
Total direct and indirect saving % difference = [(485605 - 377515) + 21000/ 485,605] x 100% = 26.6%	

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