PROPERTIES OF COMPRESS STABILISED LATERITE INTERLOCKING BLOCK USING RECYCLED FINE AGGREGATE

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Thesis submitted in partial fulfilment of the requirements for the award of the degree of Bachelor of Civil Engineering

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JANUARY 2014

ABSTRACT

Construction waste is becoming a serious environmental problem in many large cities in the world including Malaysia. Thus, the minimisation of construction wastes has become a pressing issue. Compressed earth interlocking block (CEIB) is a part of Block Work Systems in Industrialised Building Systems (IBS). Using the CEIB will reduce the construction time and cost in houses construction as it does not required mortal in bricklaying work. The aim of this study is to determine the suitable curing method and to determine the characteristic of the interlocking block using recycled fine aggregate in terms of compressive strength, durability and water absorption. The different percentages of natural fine aggregate and recycled fine aggregate were used in producing the interlocking block (50:50%, and 33.33:66.67%). The curing sets experimental have 4 different type of curing method. The results from the curing sets experimental shows that Set 3# give the highest compressive strength value (7.01 MPa) for 7 days of curing. The curing method of Set 3# will be used in the recycled set experimental. The test result for the interlocking block using recycled fine aggregate show a lower value of compressive strength than interlocking block in curing set 3# (3.78 MPa from interlocking block with 50% replacement of recycled fine aggregate) with 13.33% of water absorption percentage.

ABSTRAK

Sisa pembinaan menjadi satu masalah besar yang serius kepada alam sekitar di kebanyakkan bandar-bandar besar di dunia termasuk Malaysia. Oleh itu, cara untuk mengurangkan sisa pembinaan telah menjadi satu isu yang tidak boleh diabaikan. Blok Termampat Saling Mengunci (CEIB) adalah sebahagian daripada Sistem Kerja Blok dalam Sistem Binaan Berindustri (IBS). Penggunaan CEIB akan dapat mengurangkan masa pembinaan dan kos pembinaan rumah kerana ia tidak memerlukan mortar dalam kerja-kerja melepa bata. Tujuan kajian ini adalah untuk menentukan kaedah pengawetan blok yang sesuai dan untuk menentukan ciri-ciri blok saling mengunci yang diperbuat dengan menggunakan agregat halus yang dikitar semula dari segi kekuatan mampatan, ketahanan dan penyerapan air. Peratusan yang berbeza antara agregat halus semula jadi dan agregat halus yang kitar semula digunakan dalam penghasilan blok saling mengunci (50:50 %, dan 33.33:66.67 %). Set eksperimen pengawetan mempunyai 4 jenis kaedah pengawetan yang berlainan jenis. Keputusan dari set eksperimen pengawetan menunjukkan kaedah Set 3# memberikan nilai kekuatan mampatan tertinggi dengan nilai kekuatan (7.01 MPa) selama 7 hari usia pengawetan . Kaedah pengawetan Set 3# akan digunakan dalam pengawetan blok set eksperimen kitar semula. Keputusan ujian bagi blok saling mengunci yang menggunakan agregat halus yang dikitar semula menunjukkan nilai kekuatan mampatan yang lebih rendah daripada blok saling mengunci yang dihasilkan set eksperimen pengawetan kaedah 3# (3.78 MPa dari blok saling mengunci dengan penggantian 50% agregat halus yang dikitar semula) dengan 13.33 % nilai peratusan penyerapan air..

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

The use of Industrialised Building System (IBS) offers valuable advantages such as the reduction of unskilled workers, less wastage, less volume of building materials, increased environmental and construction site cleanliness and better quality control, among others. The conventional building materials such as sandcrete block and fired clay brick are mainly been used by contractors in Malaysia. These conventional building materials are proven to be costly and messy in the construction process. The increases of conventional materials costs allowed the contractors to finding an alternative building materials and construction methods.

Interlocking blocks are known to be an alternative building material used as a structural member like column and wall that can replace the use of the conventional building materials. Interlocking block can be categorised as Type 5: Block work systems in IBS that will replace the conventional material. The practical use of interlocking block technique in construction will save cost and time as there will be no mortar involve in bricklaying work and also does not require skilled labour (Nasly & Yassin, 2009).The usage of laterite interlocking block is a possible solution that overall will reduce the materials and construction cost (Adeyeye, 2012).

Laterite soil are rich in iron and aluminium which available in most tropical and sub-tropical countries. Regarding the definition based on hardening property, the term laterite was first introduced by Buchanan (1807) to describe ferruginous, vesicular, unstratified and porous material with yellow ochre's due to high iron content occurring in Malabar, India. This material is soft enough to be cut by trowel and will harden upon in contact with air, It was locally used by the native as brick for building and hence Gidigasu named it laterite from a Latin word "later" meaning brick. The laterite has a potential as the alternative building material that will achieve the requirement strength when added with the sand and cement as stabiliser in producing interlocking block.

This study will investigate the engineering properties of the interlocking block using different percentage of fresh and recycled laterite soil as the main material and the mix proportion consist of cement: soil: sand.

1.2 PROBLEM STATEMENT

Housing is the basic human requirement that needs to be met on priority basis. In effort for restructuring a society and eradicating poverty, housing has been recognized as an important development tool (Goh & Ahmad, 2009). Malaysian government only carried out official planning and implementation of the low-cost housing schemes for the poor but failed to address the issues related to habitability, suitability, defects and shoddy workmanship, lack of maintenance and physical safety of the occupants. It has been a major concern among the government, political leaders and town planners issues related to home ownership over the past few years.

The Malaysian government has committed billions of Ringgit Malaysia in residential sector but Construction Industry Development Board Malaysia (CIDB) stated that the future development of Malaysia is not in line with the state of the local construction industry with its current level of quality, productivity, safety, and excessive reliance on unskilled foreign workers. CIDB had done IBS Survey in 2003; it shows that the usage level of IBS in the local construction industry stands at only 15%.

Construction waste is becoming a serious environmental problem in many large cities in the world. In Malaysia, the construction industry generates lots of construction waste which caused significant impacts on the environment and aroused growing public concern in the local community. Thus, the minimisation of construction wastes has become a pressing issue.

In term of environmental preservation and effective usage of natural resources, there is an advantage in using the recycled laterite soil to produce interlocking block as the alternative building materials to construct houses, can further reduce the overall cost thus, will achieve the government target to provide its citizen with adequate, affordable and quality housing.

1.3 OBJECTIVE OF STUDY

The objectives of this research are:

i. To determine a suitable curing method for the interlocking block in terms of compressive strength.

ii. To determine the characteristic of the interlocking block using recycled fine aggregate in terms of compressive strength, durability and water absorption.

1.4 SCOPE OF STUDY

This scope of study is focus on:

i. Silt test are to be conducted to determine the silt content in laterite soil, river sand and recycled fine aggregate

ii. Preparation of fresh sample using cement soil sand to be used as the stabilisation control agent.

iii. Several types of curing processes will be conducted to find the best curing method for the laterite interlocking block

iv. The use of the crushed laterite interlocking block as the sand replacement material to produce the interlocking block.

v. Carry out tests on the interlocking blocks using recycled fine aggregate workability using various laboratory testing such as compression test, wet compression test, abrasion test, water absorption test.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Interlocking block or IBS is now being widely used around the world. In Malaysia, interlocking block is used to construct the small building for the benefits of time save consumption and cost effective term. With this factor, this system was used to develop low-cost houses which proven to be better than conventional method in term of time and cost. By using the laterite soil and recycled laterite soil as material to produce the block, it will reduce the cost of building materials. It also can be used to build many type of building, the main design principle is that the plan should be rectangular and all wall dimension openings must be more width. All the other principle of design and construction are the same as other standard building conventional.

2.2 LATERITE SOIL

Laterite is a red tropical soil that is rich in iron oxide and usually derived from rock weathering under strongly oxidizing and leaching conditions. It forms in tropical and sub-tropical regions where the climate is humid (Mahalinga Iyer & Williams, 1997). The interlocking block practically can be produced by using laterite soil which is widely spread in Malaysia.

Although it is believed that laterite are formed from the changes of weathering effect in the tropical and sub-tropical region, this however can hardly reached to the satisfaction of many geologists that have always interested in the origin of the laterite. Some researchers claimed that genesis of laterite are from igneous rock while Maignien (1996) believes laterite is formed from all parents rock available as long as sources of sesquioxides are available. In fact, different researchers carry different points of views, thus is still yet to reach to a conclusion on the genesis and hardening of laterite.

Environment does have important role for the formation of laterite soil. This includes changes due to climatic conditions, temperature conditions, and rainfall conditions. When being exposed to the environment, the soil will harden over a certain period of time. The amount of rainfall and temperature changes will have a big impact on the laterite formed.

Laterite possesses many good qualities which can hardly be found in most of other types of soil. Laterite is a material that does not swell with water, making it to perform well in packing material especially when there is no sandy condition (Maignien, 1996). Laterite is most desirable in the form of well jointed, small, globular cuirasses when been used as a building material in small structures like headwalls, culverts, canal or simple dams. The laterite is also used in the application of road and airfield sub grade construction, base courses as well as wearing surfaces.

2.3 INTERLOCKING BUILDING BLOCK

The size of the block are modular and rectangular (100 mm high, 125mm to150 mm wide and 300 mm long) in shape like in figure 2.1. These dimensions allow multi-dimensional walls making configuration such as buttresses, lintels or columns possible. Corner or junction block are required to maintain the right angled corner or a proper T junction. The interlocking blocks are different from normal bricks because they do not require mortar to be laid during bricklaying work. By this characteristic, the process of building walls become faster and requires less skilled labour where the blocks are laid dry and lock into place. Compressed earth interlocking blocks produced with hollow centres to reduce the weight and avoid seepages or improve insulation. The holes inside the blocks will allow rebar then concreting (creating reinforced concrete) to run vertically through the block to compensate for the lack of the tensile strength. The type of rebar that used can be of mild steel instead of the usual higher grade steel. When a section of wall is built, the grout holes are filling with a lean cement mixture to seal the wall and making a solid wall. The amount of grout used to be less than 7.5% of the mortar used in conventional masonry (Nasly M.A, 2009).

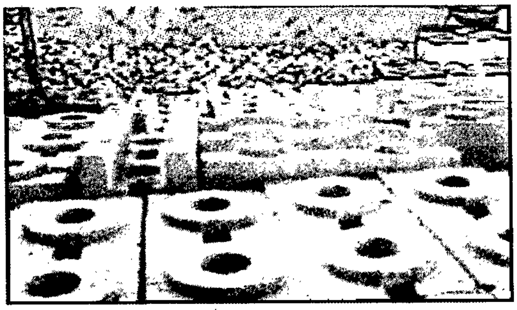

Figure 2.1 : Shape of interlocking block

2.4 BENEFITS AND LATERITIC MATERIAL IMPLEMENTATION

The use of local building material will give environmental benefit. By reducing the amount of cement used in building will decrease the amount of CO2 emitted and energy used for construction. The large carbon emissions come from electricity generation, transport, industries and building operations (Radhi, 2009). Ordinary Portland cement results from the calcinations of limestone (calcium carbonate) and silico-aluminous materials. The production process of 1 ton of cement will generates 0.55 tons of CO2 to the air and its needs the combustion of carbon-fuel into 0.40 tons of CO2 (Davidovits, 1991). The amount of world's cement-carbon-dioxide was evaluated at 1 and 1.8 billion tons in 1988 and 2000. By considering the trend observed in the cement market and industry production, these CO2 emissions are expected will reach 3.5 billion tons by the year 2015 (Davidovits, 2008).

The reduction of cement needs through the use of ecologically-friendly building materials like earthen products (CEB, adobe or cut laterites) is the best ideal way to protect our environment by the reduction of energy consumption and CO2 emissions to the air. The reduction of CO2 is of every importance as this harmful gas contributes to global warming through greenhouse effect. The thermal insulation and thermal mass properties of building materials have been proven to significantly affect the amount of energy required for heating or cooling and affect the total amount of electricity used in residential houses (Radhi, 2009). By the high density and valuable thermal inertia qualities, earth walls that create will allow the storage of solar heat during the day and its slowing release to atmosphere during the night then make indoor comfort and reducing electricity usage. Earth walls also can control the moisture of indoor air because of their permeability to water vapor. The production of earth wall process do not need of emission greenhouse gases and without using of a high amount of energy.

Figures2.2 below show photos of the contrast that exists in the realization of building structures depend on how the materials are produced and use. Its availability, like other local building materials, may also influence the socio-economic development of country when these materials are used the amount of exported materials for building will be reduce (Patrick N, 2011)

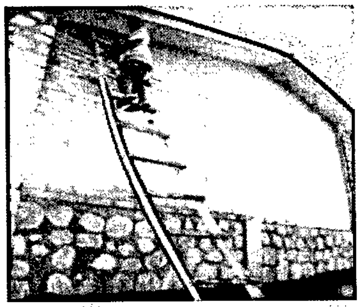

Figure 2.2 : Classrooms that build from Compressed Earth Blocks (CEB).

2.5 PRODUCTION OF INTERLOCKING BLOCK

Interlocking block production depends on the block type, material used, quality grade, and resources availabilities. The blocks were produced in special fabricated steel moulds which need the batching, mixing, casting and compaction that can be done manually by hand or using machinery.

The mixing process need to be done on an impermeable surface made free from all harmful materials that could alter the properties of the mix (Raheem, Falola, & Adeyeye, 2012). The laterite interlocking block require tamping or better steel vibration for proper compaction, thus manually press by hand compaction tend to be unsuitable in terms of quality and strength.

2.6 COMPRESSIVE STRENGTH

The purpose of performing the compressive strength test is to determine the load-bearing capacities of the blocks. The interlocking block compressive strength depends on various factors such as materials used, moisture content, curing type process, days of curing and the percentage of recycled fine aggregate as the sand replacement.

In the research conducted by Raja Mohamad Hanis in 2012, is to find the strength of the compressed concrete using recycled concrete waste as a partial aggregate substitute, the results shows that 50% of recycled concrete waste (RCW) as a replacement shows the highest value of compressive strength compares to the 0%, 25%, 75% and 100% of RCW at age of 28 days. The amount of recycled aggregate can influence the compressive strength value.

The mix proportion of the cement-laterite-sand also influences the compressive strength of the interlocking block. The previous study carried out by Ahmed Redzuan and Mohamad Hasren on the interlocking block using orange and red laterite soil shows that the mix proportion that give the highest value of compressive strength is the 1:2:6 mix proportion of cement-laterite-sand.

The blocks with high compressive strength can be used as a building material. The minimum requirement from the Ministry of Work for internal walls bearing blocks is 2.8 MN/m^2 and for external walls bearing blocks is 5.2 MN/m^2 (Nasly M.A, 2009). According to the Malaysia Standard MS 7.6: 1972 / British Standard BS 3921: 1985, for General Brick Specifications, the average compressive strength for Load Bearing Brick Class 1 is 7.0 MPa.

Dimensions & Tolerances

Specified Dimensions	Overall Measurement of 24 Bricks
Height: 65 + 1.875 mm	1560 + 45 mm
Width: 102.5 + 1.875 mm	2460 + 45 mm
Length: 215 + 3 mm	5160 + 75

Strength & Water Absorption

Designation	Class	Ave. Compressive Strength, MN/m^2 (min)	Ave. Water Absorption, % (max)
Engineering Brick	A	69.0	4.5
	B	48.5	7.0
Load bearing Brick	15	103.5	No Specific Requirements
	10	69.0	
	7	48.5	
	5	34.5	
	4	27.5	
	3	20.5	
	2	14.0	
	1	7.0	
Brick for Damp-proof Courses	DPC	As required	4.5

Figure 2.3 : General brick specification according to MS 7.6:1972

2.7 DISCUSSION

From the analysis of the previous studies related to this topic of study, the optimum mix proportion to produce the interlocking block will be the 1:2:6 mix proportion. This mix proportion will used to carry out the curing sets experimental and the recycled sets experimental.

The replacement of natural sand by recycled fine aggregates at the levels of 50% and 75% has good effects on the compressive strength of the bricks (Ismail & Yaacob, 2010). The study on the strength of compressed concrete using recycled concrete waste also shows that the replacement between 50 % - 100% show an increment in compressive strength value.

CHAPTER 3

METHODOLOGY

3.1 GENERAL

This chapter will discuss in detail works and procedures to achieve the objective of this study. It will discuss on how to produce samples of interlocking block using recycled fine aggregate and variety of tests procedure to be carried out on the interlocking blocks. There will be sand and recycled fine aggregate to be used as the main material to produce the interlocking block. To determine that the soil use is laterite soil, various tests will be carried out such as Mineralogy test, Atterberg limit test and sieve analysis. Testing such as wet compression test, compression test, and abrasion test will be carried out after the blocks have been produced and cured for several weeks. The mix proportion 1:2:6 of cement-soil-sand with different percentage of sand and recycled fine aggregate to be used will influence the testing results.

3.2 MATERIALS PREPARATION AND TESTING

This section will mainly focus on the preparation of raw materials needed to produce the interlocking block. These raw materials include Ordinary Portland Cement (OPC), Fresh Laterite Soil, Recycled Fine Aggregate and River Sand.

3.2.1 Ordinary Portland Cement

There are varieties of Portland cement available in the market. In this study, Ordinary Portland Cement is chosen to be used in producing the interlocking block. This selected type of cement is widely been used and applied in most construction environment.

3.2.2 Laterite Soil

The laterite soils were obtained at hill in Indera Makhota near the Shah Putra University College, Kuantan, Pahang. (Latitude 3.824 longitude 103.284 sea level 34 m.

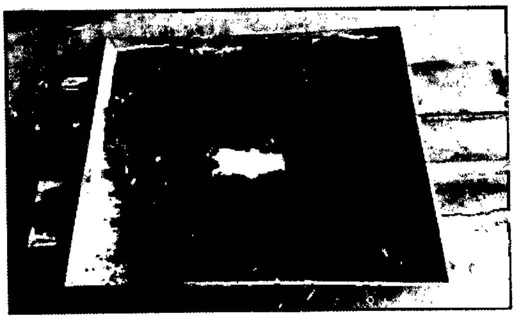

Figure 3.1 : Laterite soils