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PROPERTIES OF COMPRESS STABILISED INTERLOCKING BLOCK USING LATERITE SOIL WITH DIFFERENT CEMENT - AGGREGATE RATIO.

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ABSTRACT

Interlocking block is one of method in Industrialized Building System (IBS) as classified by the Construction Industry Development Board Malaysia (CIDB). Compressed Earth Interlocking Block (CEIB) is one of the part of block system that will reduce the time and cost construction for housing because it do not required mortar in bricklaying work. The aim of this research is to determine the suitable curing method and the compressive strength of the laterite interlocking block using different ratio of cement content. The different ratios of cement were used in producing the interlocking block (1:5, 1:6, 1:7, 1:8 and 1:9). In this experimental, there are 4 different curing methods to be conducted. The result from the curing sets experimental shows that Set 3# which is dry in sun curing method that 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 different ratio of cement content experimental and different type of cement which is comparing between YTL cement and Lafarge cement. The result from the different ratio of cement content shows that interlocking block with ratio of 1:5 cement give highest compressive strength value which is 8.60 MPa meanwhile for interlocking block using Lafarge cement give value of 4.30 Mpa.

ABSTRAK

Batu saling mengunci adalah salah satu cabang dalam Sistem Binaan Berindustri (IBS) yang telah diklasifikasikan oleh Construction Industry Development Board Malaysia (CIDB). Batu tanah termampat saling mengunci (CEIB) adalah salah satu sistem yang boleh mengurangkan masa pembinaan dan kos pembinaan rumah kerana ia tidak memerlukan mortar dalam kerja-kerja pemasangan bata. Tujuan kajian ini adalah untuk menentukan kaedah pematangan yang sesuai dan untuk mengetahui kekuatan mampatan blok laterite saling mengunci yang menggunakan nisbah kandungan simen yang berbeza. Nisbah simen yang berbeza yang digunakan dalam menghasilkan blok saling mengunci (1:5, 1:6, 1:7, 1:8 dan 1:9). Di dalam kajian ini, terdapat 4 jenis kaedah pematangan yang berbeza. Keputusan yang diperolehi dari set eksperimen pematangan menunjukkan bahawa Set 3# iaitu kaedah pematangan keringkan di matahari memberi nilai kekuatan mampatan tertinggi iaitu (7.01 MPa) bagi pematangan selama 7 hari. Kaedah pematangan Set 3# akan digunakan didalam eksperimen nisbah simen yang berbeza dan eksperimen jenis simen yang berbeza iaitu perbandingan simen Lafarge dan YTL. Keputusan yang diperolehi daripada eksperimen nisbah simen yang berbeza menunjukkan dimana blok saling mengunci yang mengandungi nisbah simen 1:5 memberi nilai kekuatan mampatan tertinggi iaitu 8.60 MPa sementara blok menggunakan simen Lafarge ialah 4.30 MPa.

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INTRODUCTION

1.1 BACKGROUND OF STUDY

The provision of housing is a challenge faced by countries around the world, especially in developing countries including Malaysia. With the increase of construction materials costs such as cement, steel and timber, contractors are not enthusiastic to build house on tight budget. The alternative method has been explored in order to meet customer demand using low-cost building material to provide affordable and high quality housing.

Interlocking blocks is one of the new construction materials using prefabricated components that can interlock with one another. It is improvise from conventional method does not require mortar usage during bricklaying work. The amount of cement usage as stabilized agent mixed with laterite soil in order to increase strength of laterite interlocking blocks. Since they do not require mortar, the process of building walls is faster and requires less skilled labour as the blocks are laid dry and lock into place (Nasly et al, 2009).

According to (Aguwa, 2009), traditionally, lateritic soils, which are reddish brown in colour, have been used as blocks for buildings without any cement content. Recently, modern builders started introducing some percentage of cement to laterite for moulding stronger blocks, because of high cost of sandcrete blocks. 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 properties of the interlocking block using laterite soil as the main material with different cement content ratio consist of cement: soil: sand.

1.2 PROBLEM STATEMENT

According to the Construction Industry Development Board, costs of construction materials such as sand and cement have increased by about 10 percent on average in the past year. The Malaysian house price index had been increased in the last few years based on National Property Information Centre (NAPIC) in term of construction material such as cement. The use of cement as stabilizer playing an important role in creating bonding between soil-cement mixes and the function is to enhancing its strength and durability with right compressibility (Riza, Rahman & Zaidi, 2011).

Cement content in interlocking block had a potential in control the compressive strength of interlocking block but the optimum of mixed design is not determined yet. Optimum mixed proportions will give high quality mix with maximum strength. The problem is that there is not well documented guide as to how to produce laterite interlocking blocks and the best curing to give the optimum strength. Compressed Earth Interlocking Blocks (CEIB) is used only for buildings of single or second story buildings only which usually require compressive strength of 5.2MPa. For load bearing blocks, the strength should be 7.0 MPa according to Malaysia Standard MS 7.6:1972 / British Standard BS 3921:1985 for General Brick Specifications as Load Bearing Brick Class 1.

1.3 OBJECTIVE OF STUDY

The objectives of this research are:

i. To determine suitable curing process to be conducted
ii. To determine characteristic of interlocking block with using different type of cement and different cement content ratio mix proportion.
iii. To determine cement content ratio to achieve 7.0 MPa in terms of compressive strength

1.4 SCOPE OF STUDY

The scope of study is focus on:

i. Carry out soil tests for the determination the properties of the soil to be used with mineralogy test, hydrometer test, Atterberg limit test and sieve analysis.

ii. Determination of suitable curing process among wet in shade, wet expose to direct sunlight, dry in shade and dry expose to direct sunlight in terms of compressive strength.

iii. The findings of interlocking block using different type of cement and mix proportion in terms of compressive strength.

iv. The use of laterite as the main material in producing the interlocking laterite block that achieves the strength requirement of the block with different ratio of cement added (1:5, 1:6, 1:7, 1:8 and 1:9) on 3:7 soil-sand.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

Awareness to produce materials with improved energy efficiency is increasing and most countries are racing to find solutions to produce hollow block or brick, glazed wall in order to reduce the energy requirement for house. In Malaysia, interlocking blocks used in the construction of small low rise buildings. This technique is effective construction costs and also used to develop low-cost houses in which the proven techniques completion takes time less than conventional methods. Interlocking blocks is a molded rectangular block of raw material baked by the sun until hard and used as building materials. (Nasly, 2009) also said that interlocking block function well than normal block because it has lock to each of blocks to retain the load or stress without lay a mortar. The interlocking blocks are different from conventional sandcrete blocks since they do not require mortar to be laid during bricklaying work. The laterite will be less permeable when stabilised with ordinary Portland cement (OPC) or clay from termite heaps. The laterite is the main material that use in producing the interlocking laterite block. Its produce by using sand and cement, the different curing method and percentage of cement as stabilizer will show the different performance of the block. The testing that include in this research is based on the past research by the researcher, the test like compression strength, workability, and water absorption are commonly test to the block. This section writing will focus on the origin and definition of the laterite and also the mineral content composition of the laterite.

2.2 LATERITE SOIL

Laterite are the products of intensive and long lasting tropical rock weathering which is intensified by high rainfall and elevated temperatures. According to (Lemougna, Melo, Kamseu, & Tchamba, 2011), laterite soils are formed in the tropics weathering processes that favour the formation of iron, aluminium, manganese and titanium oxides. Laterites are widely distributed throughout the world in the regions with high rainfall, but especially in the inter-tropical regions of Africa, Australia, India, South-East Asia and South America. The interlocking block practically can be produced by using laterite soil which is widely spread in Malaysia.

Fresh laterite is generally redidish or orange in colour. Upon exposed to continuous weathering, changes of chemical compound of the laterite soil will then leads to colour changes. A colour change indicates the degree of maturity and is due to the various degree of iron, titanium and manganese hydration. As for the chemical compositions, the main content is to be ferum oxide (Fe_2O_3), and in some cases, aluminium oxide (Al_2O_3). These 2 type of chemical will normally exist in a bigger portion compare to other chemical composition like manganese (Mn), Titanium (Ti) and Vadadium (V) some of the most common lateritic soil with their hydrated iron oxides minerals is (Ponsjak and Mervin, 1919) are shown in table 2.1.

Table 2.1: Chemical composition and colour of some common lateritic soil

Name	Chemical Composition	Colour
Turgite	$Fe_2O_3 \cdot 1/2H_2O$	red to red brown
Goethite Lepidocrocite	$Fe_2O_3 \cdot H_2O$	brownish-black yellow and brown
Hydrogoethite Limonite Xanthosiderite Limnite	$Fe_2O_3 \cdot 4/3H_2O$ $Fe_2O_3 \cdot 3/2H_2O$ $Fe_2O_3 \cdot 2H_2O$ $Fe_2O_3 \cdot 3H_2O$	yellow and brown golden-yellow brown

Although estimation of colours can give only a rough idea of composition it does make it possible to estimate the level of evolution and the formation condition. Aluminous crust, on the other hand, become lighter in the course of time. From another point of view ferruginous crust are darken (brown) under condition of poor drainage than under conditions of oxidation (red).

Laterite can be easily found in countries having tropical or sub-tropical climate. According to Prescott and Pendleton (1952), distributions of the laterite are mainly at the four locations which include India and South-East Asia, Australia, Africa and America. Figure 2.1 illustrates the details of laterite distribution in the South-East Asian province. Malaysia, being in the Sunda sub province, the laterite is distributed throughout the country.

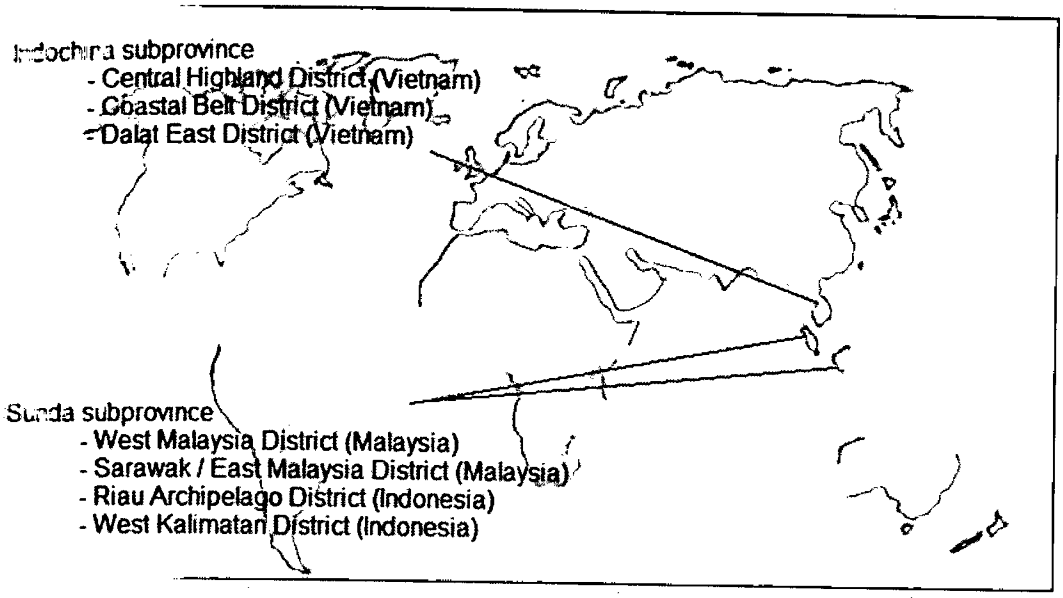

Figure 2.1: Details of laterite distribution in the South-East Asian province

2.3 IMPROVING LATERITIC SOILS BY CEMENT STABILIZATION FOR CONSTRUCTION PURPOSES

Stabilization processes are very complex because many parameters come into play. The knowledge of soil properties can help to better consider what changes, the economic studies (cost and time), as well as production and construction techniques to use. Ordinary Portland cement hydrates when water is added, the reaction produces a cementitious gel that is independent of the soil. The reaction in a soil-cement mixture comes from the hydration of the two anhydrous calcium silicates (3CaO. SiO2 (C3S) and 2CaO. SiO2 (C2S)), the major constituents of cement, which form two new compounds: calcium hydroxide (hydrated lime called portlandite) and calcium silicate hydrate (CSH), the main binder of concrete.

Unlike lime, the mineralogy and granulometry of cement treated soils have little influence on the reaction since the cement powder contains in itself everything it needs to react and form cementitious products. Cement will create physical links between particles, increasing the soil strength. Soil-cement mixes should be compacted immediately after mixing in order not to breakdown the newly created gel and therefore reduce strengthening. The basic function of cementation is to make the soil water-resistant by reducing swelling and increasing its compressive strength.

General processes of cementation, penetration and binding must be considered from many factor. Process may also vary between different types of soils. Cement is considered a good stabiliser for granular soils but unsatisfactory for clays. Generally cement can be used with any soil type, but with clays it is uneconomical because more cement is required. The range of cement content needed for good stabilisation is lies between 1:6 and 1:10 ratio of cement-soil, by weight depending on soil types and cement qualities, (Nasly, 2009).

2.4 INTERLOCKING BUILDING BLOCK

Compress Earth Interlocking Block (CSIB) are cement stabilized soil blocks that allow for dry stacked construction. It has the potential to bring durable and affordable homes to developing countries around the world. Nowadays, by using interlocking block construction method in walling system is becoming increasingly popular in developing countries. The bricks size are modular and rectangular (100mm high, 125mm to 150mm wide and 300mm length) in shape, the length of the brick is exactly twice from its width. So that, the right angle corner can be achieved without special corner bricks. Since the interlocking block not require mortar, it is automatically align the block in a wall by positive and negative element on top and at the bottom of the interlocking block. The holes on the block is to reduce weight and avoid seepages beside improve insulation. It also permit the vertical reinforcement embedded in concrete without the need for any formwork thus eliminating the use of wood as formwork. Reinforcement bar is use to make the building withstand earthquakes and heavy win loads. The grout holes are filled with a lean cement mixture to seal the wall and making permanent solid wall.

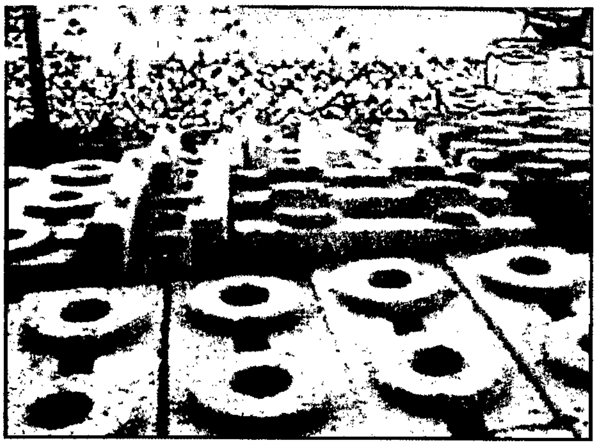

Figure 2.2: Shapes of interlocking block

2.5 THE BLOCK TEST

Previous study by the Nigerian Building and Road Research Institute (NBRRI) involved the production of laterite bricks that were used for the construction of a bungalow. In that study, the NBRRI proposed the following minimum specifications as requirements for laterite bricks: a bulk density of 1810 kg/m3, a water absorption of 12.5%, a compressive strength of 1.65 N/mm2 and a durability of 6.9% with a maximum cement content fixed at 5%. Compressive strength decreases because of increase of laterite content. Machine compacted hollow sandcrete blocks made from mix ratio 1:6 and with up to 10% laterite content is are suitable as well as recommended for building construction having attained a 28-day compressive strength of 2.07N/mm2 as required by the Nigerian Standards where the block were curing by sprinkling the water at morning and evening, (Olugbenga Ata et al, 2007).

According to (Raheem, Momoh, & Soyingbe, 2012), durability, water absorption and compressive strength tests were performed on the blocks. The durability of the blocks was determined through abrasion testing after the interlocking blocks attained the specified ages. Two blocks were selected at random and weighed in the laboratory; their weight was recorded. The blocks were placed on a smooth and firm surface, and then all the surfaces were wire-brushed in a back-and-forth motion 50 times, where one back and forth motion was considered a single stroke. After being brushed, the blocks were weighed again to determine the amount of material or particles abraded. This procedure was repeated for all the blocks produced with various cement contents and for blocks of various ages. According to (Riza et al., 2011), in previous study done by (Bahar, 2004) stated that the optimum water content range between 10 to 13% and for the durability is having 1.9% weight loss at the end of the abrasion test.

The compressive strength of compressed earth interlocking blocks (CEIB) depends on the soil type, type and amount of stabiliser, and the compaction pressure used to form the block. The maximum compressive strengths of the block are obtained by proper mixing of suitable materials and proper compacting and curing. The previous study carried out by Ahmad 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.

In terms to be used as a building material, the interlocking block must have high compressive strength. The minimum requirement form the Public Work Department (PWD) for internal walls bearing blocks is 2.8 MN/m^2 and for external walls bearing blocks is 5.2 MN/m^2 (Nasly et al., 2009). According to 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

CHAPTER 3

RESEARCH METHODOLOGY

3.1 GENERAL

Methodology can be defined as a systematic sequence of activities to solve a problem. There are some types of development methodologies that can be used to carry out a study and each approach chosen should be appropriate to the project developed. Methodology approach of the study is an important part in the study to achieve the objectives and goals. There is a variety of test to be carrying out in this project. These test ranges from the laterite soil testing like Mineralogy test, Atterberg limit test, and Sieve analysis. After the block cured for several weeks the block will be test for the compression strength, abrasion test and water absorption test.

The different of cement content, laterite soil and the mine sand will influence the result of the testing. The source of the laterite soil that collects at hill near Shah Putra University College will be testing before its will be used in Interlocking Block producing after the soil tested. The laterite soil must be dried first for at least one week before the soil can be used.

The blocks will be cover with plastic canvas and will be sprinkle with water in the morning and evening for a total of 14 days to prevent rapid drying of the blocks, which could lead to shrinkage cracking until they were ready for strength and durability tests. 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. There will be 4 type of curing process which consist of wet in shade, wet expose to direct sunlight, dry in shade and dry expose to direct sunlight. It is conduct to determine suitable curing process to be use. All of the blocks will be test for compressive strength, water absorption and durability after 28 days of aged.

There are all together 6 batches of the mix with different of cement content to be produced. These batches include laterite soil and mine sand (3:7) and cement as stabilizer with ratio of 1:5, 1:6, 1:7, 1:8, and 1:9. The test which will be carried out upon the completing of this project and the objective of the test is as below

i. Laterite Soil Test
   - Mineralogy test (Central Lab)
   - Atterberg limit test
   - Sieve Analysis

ii. Interlocking block test
   - Compression strength
   - Water absorption
   - Abrasion

Objective of test

- Mineralogy — Sample of soil tested on Central Lab to get mineral content and pH value of the laterite soil.

- Atterberg Limit - Basic index information about soil to estimate strength and settlement characteristic as Plasticity Index, Plastic Limit, Liquid Limit and Shrinkage Limit
- Sieve Analysis - To obtain finer percent of laterite soil from 5mm to pan
- Compression - To determine the load bearing capacities of the block
- Water Absorption - To determine the percentage of water absorb by the blocks
- Abrasion - To determine the durability of the blocks against the roughness especially when the blocks were exposed to the extreme environment at the construction site

3.2 PREPARATION MATERIAL

Raw material needed in producing interlocking block is such as laterite soil, mine sand and Ordinary Portland Cement. The total amount of the material is:-

- Laterite soil - 111.03 Kg
- Mine sand - 301.73 Kg
- Portland Cement - 55.24 Kg

3.2.1 Ordinary Portland Cement

There is variant type of cement in currently market. In this study, ordinary Portland cement is chosen in producing interlocking block. The cement is a stabilizer agent. This is because this kind of cement is widely used in construction. Cement is cohesive upon mixing with water. The several of cement content will be mixed with laterite soil and mine sand. This is to determine which proportion can give a better quality of block beside can achieve the requirement strength.

3.2.2 Laterite Soil

Laterites are the products of intensive and long lasting tropical rock weathering which is intensified by high rainfall and elevated temperatures. It has been used extensively for wall construction around the world, particularly in developing countries. Laterite has other advantages which make it potentially a very good and appropriate material for construction, especially for the construction of rural structures in the less developed countries. In this study, the laterite soil is obtained at hill in Indera Mahkota the near Shah Putra University College, Kuantan, Pahang (Latitude 3.824 longitude 103.284 sea level 34 m).. By using laterite soil, it becomes an alternative material in block producing that usually used sand and cement. Amount of cement usage will be decrease but the strength require in building construction also can achieve.