EFFECT OF CEMENT – AGGREGATE RATIO AND ALKALINE ADDITION ON THE MECHANICAL PROPERTIES OF COMPRESSED STABILISED EARTH INTERLOCKING BLOCKS

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ABSTRACT

In construction field there are a lot of complex works that require time and skilled worker to handle the work. Interlocking blocks is a new method of construction where it gives a lot of 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. The aims of the research are to determine the compressive strength, abrasion and water absorption of the interlocking block by different proportion of cement added to the aggregate. Secondly to determine the effect of alkaline solution to the compressive strength. This research was also to determine the best curing method to the interlocking blocks. Six different sets of blocks were carried out in this study. Interlocking blocks can be tested with various types of tests regarding the block's characteristic such as compression test, abrasion test and water absorption test. However the optimum mix proportion between cement, sand and laterite for compressive strength 7.0 N/mm2 load bearing wall is not determined yet. From previous research that had been done, various type of curing had been applied to the blocks but the results are uncertain. This leads to best way of curing is still unknown. The result for this research is divided into 3 category which are curing set, different ratio trial set and lastly the alkaline solution set. For the curing set, the variables were curing under sun and curing under shade. For curing under sun, the result of compressive strength was 3.96 Mpa and under the shade was 2.12 Mpa. The next is different ratio trial set where the variables are 1:1:6 and 1:0.5:6. For ratio 1:1:6 the compressive strength was 5.63 Mpa and for 1:0.5:6 was 3.19 Mpa. Lastly is the alkaline solution set where the variables were 1 molarity and 2 molarity alkaline solution. For 1 molarity alkaline solution the compressive strength was 5.31 Mpa and for the 2 molarity alkaline solution was 5.40. The variables recorded that had the strongest compressive strength was the ratio of 1:1:6.

ABSTRAK

Dalam bidang pembinaan terdapat banyak kerja-kerja yang kompleks yang memerlukan masa dan pekerja mahir untuk mengendalikan kerja. Saling blok adalah kaedah baru pembinaan di mana ia memberi banyak kelebihan seperti penggunaan pekerja yang sedikit, kurang pembaziran, penjimatan bahan-bahan binaan, peningkatan kebersihan alam sekitar dan tapak pembinaan dan kawalan yang lebih berkualiti. Tujuan kajian ini adalah untuk menentukan kekuatan, lelasan dan penyerapan air kepada blok saling dengan mengunnakan pemboleh ubah simen dan agregat. Kajian ini juga mengkaji kesan penggunaan alkali kepada blok. Dalam kajian ini juga akan menkaji kaedah awetan yang terbaik kepada blok. Enam set blok telah dijalankan dalam kajian ini. Blok saling boleh diuji dengan pelbagai jenis ujian iaitu ujian mampatan, ujian mampatan basah, ujian lelasan, ujian penyerapan air dan ujian kubu warna. Kekuatan mampatan yang diperlukan untuk blok saling ialah 2.8 N/mm2 untuk dinding yang tidak menaggung beban, 5.2 N/mm2 untuk dinding yang menaggung beban dan 7.0 N/mm2 untuk beban dinding galas dinyatakan untuk dinding luar. Walau bagaimanapun kadar campuran optimum antara simen, pasir dan tanah laterit untuk kekuatan mampatan 7.0 N/mm2 bagi dinding menanggung beban tidak ditetapkan lagi. Kajian ini mempunyai 3 jenis kategori blok dimana kategori nya adalah set pengawetan, set nisbah yang berbeza dan set pengunaan alkali. Bagi set pengawetan, pemboleh ubah nye adalah kuring di bawah matahari dan kuring di bawah teduh. Keputusan ujian mampatan bagi kuring di bawah matahari adalah 3.96 Mpa dan kuring di bawah teduh adalah 2.12 Mpa. Bagi set nisbah yang berbeza pula pemboleh ubah nya ada 1:1:6 dan 1:0.5:6. Kepututsan ujian kekuatan mampatan bagi nisbah 1:1:6 adalah 5.63 Mpa dan bagi nisbah 1:0.5:6 adah 3.19 Mpa. Akhir sekali adalah set pengunaan alkali kepada blok. Keputusan ujian kekuatan mampatan bagi 1 mol asdalah 5.31 Mpa dan bagi 2 mol pula adalah 5.40 Mpa. Kekuatan mampatan yang terkuat adalah kepada pemboleh ubah set nisbah 1:1:6 dimana kekuatan mampatannya adalah 5.63 Mpa.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure No. **Title** **Page**

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

The price of real estate in developing countries like Malaysia keeps on rising regarding of the inflation of the economy causing the price of the house and buildings rise. The inflation in the economy not just affecting the materials such as cement, steel and timber that needed for construction thus also the man power and extra cost for the development of housing. With the increase of construction materials costs such as cement, steel, sand and timber, contractors keep having problems on building a house regarding the price. 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 compressed block is a cost effective and sustainable construction material. Interlocking compressed block construction has the potential to bring durable and affordable homes to developing countries around the world such as Malaysia. Today, interlocking block construction is becoming increasingly popular in developing countries including Malaysia. Compressed earth blocks are energy efficient and cost

efficient they require anywhere from 1/5 to 1/15 of the energy to make when compared to fired bricks and concrete masonry units (Maini 2010)

Interlocking compressed block originally created to encounter problem such as the price of construction's material increased, manpower and machinery because the characteristics of the interlocking compressed block itself gives an advantage like the block itself can become column, wall and beam where it need less steel and timber. Interlocking compressed block also does not need skilled worker and heavy machineries to conduct the construction.

Earth that is soil and sand as a construction material has been used worldwide since thousands of years so as compressed earth stabilized with cement can be produced by special high compacting pressure machines. The block's sizes usually (100 mm high, 125mm to150 mm wide and 300 mm long) in shape. The block's properties can be modified by adding another material to improve its compression strength, wet compression, water absorption and durability. The minimum British Standard requirements of 2.8MN/m2 for precast concrete masonry units (size 4.5 x 9 x 3 ins). The Public Works Department (JKR) recommends values of 2.8 MN/ m2 for non-load bearing block and 5.2 MN/m2 for load bearing block. The strength of the block depends on the type of soil as well as the amount of stabilizer and the proportion of sand and soil added to the mix. Laterite soil has the potential to be used as a compressed stabilized soil load bearing block.

Each block has vertical holes, the purposes of the holes are to reduce the weight of the block, to insert steel rods or treated kenaf bar for reinforcement, to act as conduit for electrical and water piping and lastly to pour liquid mortar (grout) into the holes, which run through the full height of the wall, thus increasing its stability and providing barrier to seepages. The length of each block is exactly double its width, in order to achieve accurate alignment of blocks placed at right angles, else, a junction block is required. The holes of the interlocking blocks permit the introduction of vertical reinforcement embedded in concrete without the need for any formwork thus

eliminating the use of wood in form work. The cement-to-soil ratio usually lies between 1: 6 and 1: 10,by weight depending on soil types and cement qualities.

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).

1.2 PROBLEM STATEMENT

Cement content and clay content in interlocking block had a potential in control the compressive strength of interlocking block. Clay content in interlocking blocks will help the workability of the blocks in term of production purposes when lifting the block from the casting machine, however the clay content can reduce the compressive strength of the block. The optimum mixed design is not determined yet for load bearing wall that is (5.2 N/mm2) and also for (7.0 N/mm2) at exterior part. Optimum mixed proportions will give high quality mix with maximum strength. From previous research that had been done (Zulkarnain , 2013) various type of curing had been applied to the blocks but the results are uncertain. This leads to best way of curing is still unknown. The effect of alkaline solution in interlocking block production is still uncertain in interlocking blocks production.

1.3 OBJECTIVE OF STUDY

1. To determine the properties of interlocking blocks in term of

- compressive,
- abrasion,
- water absorption

2. To determine the optimum mix of cement ratio between sand and laterite soil for a stronger blocks.

3. To determine the effect of alkaline on compressive strength.

4. To determine the best curing method between curing under sun and curing under shade.

1.4 SCOPE OF STUDY

This scope of study is focus on:

I. Carry out soil tests for the determination of the properties of the soil, soil test including sieve analysis.

II. Carry out block tests for the determination of the properties of the block, the block tests consist of compression test, abrasion and water absorption.

III. The use of different materials such as laterite soil and sand as the main material in producing the interlocking laterite block that achieves the strength requirement of the block with different ratio of cement , laterite soil and sand. The ratio used are 1:2:6 , 1:1:6 , 1: 0.5 : 6 and the add of alkaline solution 1 molarity and 2 molarity.

1.5 SIGNIFICANCE OF STUDY

This study is to determine the optimum mix design of interlocking blocks for better mechanical properties regarding compressive strength, durability and water absorption. The best curing method for interlocking blocks is still unknown, thus this study also will study on curing method. And also this study consist of research about the effect of alkaline to the interlocking blocks regarding compressive strength, durability and water absorption. This study can helps by determining the best optimum mix design and understanding the benefit of alkaline addition to the interlocking blocks. At the end of the research, the optimum mix design will be determined, the effect of alkaline solution to the interlocking blocks will be determined and the best curing method can be obtained.

Compressed stabilised interlocking blocks properties can be modified by adding another material to improve its compressive strength. Regarding modifying it's compressive strength, this study had focusing on the add of alkaline solution that were 1 molarity and 2 molarity to the blocks. The Public Works Department (JKR) recommends values of 2.8 MN/ m2 for non-load bearing block and 5.2 MN/m2 for load bearing block. The strength of the block depends on the type of soil as well as the amount of stabilizer and the proportion of sand and soil added to the mix.

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).

2.2 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.

2.3 LATERITE SOIL

Laterite is a red tropical soil that is rich in iron oxide and is usually derived from rock weathering under strongly oxidising and leaching conditions. It forms in tropical and sub-tropical regions where the climate is humid. The amount of cement need to stabilized soil in range 3 to 16% by dry weight of soil. Ordinary Portland Cement is mostly used as stabilizer. The laterite soil was air-dried for seven days in cool and dry place before grinding and sieving of the soil. Grinding carried out using hammer to break the lumps in the soil. Sieve is done using a wire mesh screen about 6mm in diameter. Fine materials passing through the sieve were collected for use.

2.4 WATER

Water is necessary in soil cement to help obtain maximum compaction and for hydration of the portland cement. Moisture contents of soil cement are usually in the range of 10 to 13 percent by weight of oven-dry soil cement. Potable water or other relatively clean water, free from harmful amounts of alkalies, acids, or organic matter, may be used.

2.5 COMPRESSIVE STRENGTH

Compressive strength test was carried out to determine the load bearing capacity of the blocks. The weight of each blocks are taken before place on the compression machine. The top and bottom line lie horizontally on a flat metal plate to prevent sheaving of blocks during test. The blocks then crushed and corresponding failure load were recorded. The block will be tested for 7, 14 and 28 days of ages. The crushing force was divided by the sectional area of the block to arrive at the compressive strength. The minimum requirement from the Ministry of Work for non-load bearing blocks is 2.8 MN/m^2 and for load 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.

f=F/Ac [MPa]

Where:

f = compression strength [MPa]

F = ultimate crushing force [N]

Ac = sectional area [mm2]

2.6 DISCUSSION

From the previous research, the optimum mixed design is not determined yet for load bearing wall that is (5.2 N/mm2) and also for (7.0 N/mm2) at exterior part. Optimum mixed proportions will give high quality mix with maximum strength. From previous research that had been done (Zulkarnain , 2013) various type of curing had been applied to the blocks but the results are uncertain. This leads to best way of curing is still unknown. The addition of alkaline solution will be conducted and the result should effect the compressive strength. The ratio of the interlocking blocks will be change for determining the optimum mix design in term of a better mechanical properties that is compressive strength, water absorption and durability.

CHAPTER 3

METHODOLOGY

3.1 GENERAL

Methodology is the systematic, theoretical analysis of the methods applied to a field of study, or the theoretical analysis of the body of methods and principles associated with a branch of knowledge. For this research, there are 2 kinds of test that had been made, that is for the laterite soil itself and for the interlocking block.

i. Laterite Soil Test

- Atterberg limit test
- Sieve Analysis

ii. Interlocking block test

- Water absorption
- Abrasion
- Compression

Objective of test

- Sieve Analysis - To obtain finer percent of laterite soil and river sand, the laterite soil and river sand must pass 1.18 mm sieve
- Water Absorption - Determine moisture absorption percentage
- Abrasion - Determine durability of the laterite block
- Compression - To determine the load bearing capacities of the Block.

3.2 MATERIALS PREPARATION AND TESTING

The raw materials in producing interlocking blocks are Ordinary Portland Cement (OPC), laterite soil, river sand, water and alkaline.

3.2.1 Ordinary Portland cement

Ordinary Portland cement were used in producing interlocking blocks. This is because this type of cement is widely used in most construction project.

3.2.2 Laterite Soil

The laterite soils were obtained from nearby site location at University Malaysia Pahang, Gambang, Kuantan.

Figure 3.1 : Laterite soil

3.2.3 Alkaline solution admixture

Alkaline was the admixture in the interlocking blocks. The controlled molarity that had been used is 1 molarity for 1 set of interlocking block and 2 molarity for 1 set of interlocking block.

3.2.4 Sand

River sand was used in interlocking blocks as the material to be put in the controlled ratio. River sand must first go trough sieve process. The sieve was 1.18 mm.

3.2.5 Water

The water is also needed in the mixing process. Specified water content used in the mix proportion is 10% from the weight of sand.