THE WATER RESISTANCE OF INTERLOCKING BLOCK WALL

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ABSTRACT

Water that absorbed by block will make the strength of the block decreased. When external walls are exposed to water from different sources such as rain and flood water will enter the building, travelling from outer walls into internal walls. The water may lead to cracks in bricks and lead the the building collapse. If the weather conditions did not change, it may just mean that the walls stay damp without getting the opportunity to dry out. The objectives of this proposed topic are to test compressive strength of the blocks, to study the porosity of interlocking block and most importantly, to test the water resistance of the interlocking block wall with three different conditions that is normal block wall, block wall with mortar as infill and block wall added with grout around the block. The method for porosity test,is by using vacuum saturation method. The test for block wall is by pouring the interlocking block wall with water. The porosity for normal block is with 16.03 % while for the block with mortar as infill, 10.98 %. The block wall with assemble grout around the block is the best water resistance among the three interlocking block wall. This grouted wall take 39 minutes for the water to pass through all the blocks. The poorest water resistance is normal block wall that take only 17 minutes for the water to pass through the wall. This research can conclude that the type of assemble on the interlocking block wall affected the time for the water to went through the wall.

ABSTRAK

Air yang diserap oleh blok akan membuat kekuatan blok berkurangan. Apabila dinding luar terdedah kepada air dari sumber-sumber yang berbeza seperti hujan dan banjir air akan memasuki bangunan itu, dalam perjalanan dari dinding luar ke dalam dinding dalaman. Air boleh membawa kepada keretakan dalam batu-bata dan menyebabkan keruntuhan bangunan. Jika keadaan cuaca tidak berubah , ia hanya boleh bermakna bahawa dinding kekal lembap tanpa mendapat peluang untuk kering. Objektif topik yang dicadangkan ini adalah untuk menguji kekuatan mampatan blok, untuk mengkaji keliangan saling blok dan yang paling penting, untuk menguji rintangan air blok dinding saling dengan tiga keadaan yang berbeza iaitu dinding blok biasa, blok dinding dengan mortar sebagai isian dan blok dinding ditambah dengan grout di sekitar blok. Kaedah untuk ujian keliangan, adalah dengan menggunakan kaedah tepu vakum. Ujian bagi blok dinding adalah dengan menuang blok dinding saling dengan air. Keliangan bagi blok normal adalah dengan 16.03% manakala bagi blok dengan mortar sebagai isian, 10,98%. Dinding blok dengan memasang grout sekitar blok adalah rintangan air terbaik di antara ketiga-tiga saling blok dinding. Ini dinding diturap mengambil 39 minit untuk air untuk melalui semua blok. Rintangan air paling lemah adalah dinding blok biasa yang hanya mengambil masa 17 minit untuk air untuk melalui dinding. Kajian ini boleh membuat kesimpulan bahawa jenis berkumpul di blok dinding saling terjejas masa untuk air untuk pergi melalui dinding

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

For past 60 year, technology to development and improve had been done by the researcher to seek the convenience way due to the technique of manufacturing and constructing this interlocking block. Interlocking blocks system is an alternative way to replace the conventional building material that can be used as a structural member like column and wall and no formworks are needed. Interlocking Blocks comes in various shape along with various dimension. This was depending on the manufacturer of the blocks. There are full blocks dimensions of 300x 150x 100 mm for all standard walls (single or double brick thick). For bricklaying purposes, half blocks that with dimension of 150 x 150 x 100 mm was also being used. For masonry method, interlocking block beam is alternative to solve the problem to replace the conventional method using the formwork

1.2 PROBLEM STATEMENT

When external walls are exposed to water from different sources such as rain, water can enter building, with some cases travelling laterally from outer walls to internal walls.

The water may be cracks in bricks or pointing are letting the water flow in, or weather conditions may just mean that walls stay damp without getting the opportunity to dry out any cracks in pointing and brickwork can cause a difference in the water absorbency of different areas of the walls, some areas of the wall will absorb more water than others part. In order to overcome this, the way of how to assemble the wall will be studied. This is important so that we can determine which type assemble is the best water resistance and hence, can save may cost by using interlocking block with good water resistance.

1.3 OBJECTIVE OF STUDY

The objectives of this proposed topic are as follows:

I. To test compressive strength of the blocks
II. To study the porosity of interlocking block
III. To test the water resistance of the interlocking block wall with three different conditions:
    1. Block wall with normal assemble and with mortar pointing
    2. Block wall with assemble that add mortar as infill with mortar pointing
    3. Block wall with assemble added with grout around the block
IV. To examine the effect of different assemble on the water resistance of interlocking block wall

1.4 SCOPE OF STUDY

The scope of this study are as follows :

1. Produce 100 interlocking Compress Stabilized Earth Blocks (CSEB).
2. The determine sieve analysis test.
3. To test the compressive strength of the interlocking block.

4. To determine the porosity of interlocking block using vacuum saturation method. The first brick be not added with anything. The second brick will be added with mortar as infill.
5. To design and build small room with 1m x 1m x 1m dimension using interlocking block with each assemble each 1m wall
6. To determine the water resistance of the block wall by pouring the interlocking block wall with water. Time will be recorded for the water to pass through the interlocking block wall.

1.5 SIGNIFICANCE OF STUDY

The research study could provide information on the issues of water resistance in interlocking block wall. Furthermore, this study would also be a review on the development of interlocking block especially in Malaysia because in Malaysia, the construction using interlocking method is still new. Besides that, this study would also be beneficial to the constructor in Malaysia particularly as this study enhance the knowledge of effect of different type of assemble of block wall towards water resistance. The research will also helps to have a deeper understanding about the problem statement and objectives of the research This would expectedly heighten the awareness about the important of interlocking block towards water because it can reduce the strength of the interlocking block. For the future researchers, this study definitely can provide information so that improvement can be added in the future

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, the outcomes of research from the previous researchers are discussed. The results between them are discussed and compared to each other so that it can be a guide for this study. In the technology of construction industry nowadays, there are so many brilliant people come out with an interesting idea on how to improve the construction industry, how to save cost in structure construction or maybe to shorten the time of construction for any particular building but some ideas are acceptable and some of them are cannot be realized, especially in Malaysia.

2.2 WATER RESISTANCE

This property is closely related to the quality of the outer few centimetres of concrete. Water resistance is a durability indicator, for it quantifies concrete resistance to penetration by external agents. The importance of ascertaining this parameter lies in the fact that water is one of the main carriers of aggressive substances and is also directly related to freeze–thaw cycle-induced damage. Penetration depends primarily on concrete pore structure, aggregate characteristics and moisture content. In the absence of codes and specifications on the subject, the water resistance of structural concrete made with ceramic or fired clay materials as coarse aggregate is an innovative line of research of international interest (Medina,2013)

2.3 POROSITY

Porosity can be as one of the major parameters which influence the strength and durability of concrete. The porosity of a material, such as cement paste, mortar, concrete and also other porous material can be determined by measuring any of two quantities; bulk volume, pore volume or solid volume. (Khan, 2011) Porosity is a measure of the void spaces in a porous medium, it is defined as the fraction of the volume of voids over the total volume. The porosity is an important parameter in the models enabling the estimation of the density and of the thermal capacity and conductivity.(Harouna, 2011) The porosity is the fraction of the bulk volume of the material occupied by voids. Besides, there are numerous techniques being employed for the measurement of porosity in the laboratory test.

2.4 INTERLOCKING BLOCK

The interlocking block configurations were first developed from compressed mixtures of Portland cement, dust from and water (Etherington ,1985). The interlocking blocks also follow the same pattern to have tongues and grooves on the top and bottom surfaces of the blocks respectively to restrain horizontal movement when laying interlocking block on top of one another without the use of mortar joints. Installing some reinforcement and grouting mortar in the grout holes increases the strength of the wall. Thus, the wall will be made strong enough to carry upper floor loads similar to conventional load-bearing walls. Construction is simple enough for unskilled labour to build walls without mortar bedding which is great advantage of the interlocking block wall. The axial load resistance of interlocking block walls has not been clearly specified in any standard codes.

Interlocking compressed block is a cost effective and sustainable construction material . Interlocking compressed block originally created to encounter problem such as the price of constructions 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. 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). The interlocking block is different from normal block. They do not require layering process. Thus, reduce the usage of cement as mortar is not used as any layering process is not involved and require less skilled worker. The blocks were produced using a special compression machine. This machine uses high pressure to create compression force in forming each block. The product from this machine was well sized rectangular interlocking block. The dimensions for the block are 300mm in length, 150mm breadth, and also 100mm in height. The self-aligning (automatic stacking) of bricks will reduce the need for skilled labour, and enhance construction productivity.

Production of blocks used for wall construction have different techniques adopted which could be in form of hollow or solid blocks produced in varying shapes covered with mortar. The improved form of mortar-less blocks which also is an innovative structural component for masonry building construction called interlocking block which can be produced mechanically or manually using interlocking block production machine, that is specially an improved interlocking block machine with dual mould. This brings about save economical production, with reduced cost of labour and most importantly appreciation of available local materials for construction of structures for both rural and urban development in world today, therefore eliminating the use of mortar in laying of blocks (Chukwudi, 2014)

2.4.1 Cement

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. In this study, Ordinary Portland Cement is chosen in producing interlocking block. The selection based on the common practice as this type of cement is widely used in construction process. Water-cement ratio has strong influence to the quality of certain concrete. Water-cement ratio is the proportion percentage of the volume between water and cement, a lower water cement-ratio will increase the strength of a concrete and durability. Unfortunately the process of deciding the water cement-ratio not only includes the strength and durability of concrete, the workability of concrete also should be considered.

Workability of fresh or plastic concrete requires more water than is needed for hydration. The excess water, beyond hydration requirements, is detrimental to all desirable properties of hardened concrete. This is shown; water-cement ratio will affected the workability of concrete and the strength of concrete, especially at the early stage of the concrete and harden concrete

Portland cement is the most widely used stabilizer for earth stabilization. Besides that, cement also has the ability to the reduce liquid limit (LL) and then increase plasticity index (PI) and hence higher the workability of the soil. The addition of chemical stabilizers like cement and lime has twofold effects of acceleration of flocculation and promotion of chemical bind. The chemical binding particularly depends upon the type of stabilizers employed. The study of revealed that soils with Plasticity Index (PI) less than 15% are suitable for cement stabilization

2.4.2 Block Wall

An accurately aligned masonry wall should be vertical to plumb, with truly straight and horizontal (level) courses. The vertical joints (perpends) at alternating courses should be in line and truly vertical throughout the wall height (Kintingu , 2009). Wall is one of the main structures need to be erected during a construction process. It has many functions other than bearing load of the upper floor and later transfers it to the foundation below the ground.

Wall is important to protect the occupants from the weather such as heat, rain, or storms. Features required for self-aligning interlocking blocks includes:

· Fitting into each other without adjustments (cutting, shaving or shimming).

· Having distinct orientation features, so that if wrongly placed they will not fit and therefore require either reversing or replacement for rectification.

· Fulfilling modular coordination requirements

· Having tight tolerances

· Having few elements, each with its simple and unique overall shape, to simplify the management during production and construction The interlocking blocks produce to build the wall is by ratio 1:2:6 of cement, laterite soil, and sand mixture.(Jasim, 2014). Estimated weight for each normal block is 6 kg and 6.75 kg for corner block

2.4.3 Laterite Soils

Laterite is a red tropical soil that is rich in iron oxide and is usually derived from rock weathering under strongly oxidising and leaching condition. Bishopp defined laterite as the end or apical product of process of rock degradation which may stop short at the formation of the hydrated silicates, clays or lithomarge or continue right on to hydrate according to chemical and physical environment and nature of the parent rock(Ismail 2013). Fresh laterites are generally reddish or orange in colour .soil generally considered as heavy and has low strength. But by the additional of stabilizer and compressed, the soil can have a high strength in compressive. The stabilizers that usually used for soil in improvement of soil strength are cement and lime (Raheem et al., 2012).

Soil is a natural aggregate of mineral particles, that it sometimes including organic constituents; it has solid, liquid and gaseous phases. Soil itself is defined as uncemented aggregates of minerals grains and decayed organic matter with liquid and gaseous occupying the void spaces between the solid particles. Soil is used as uncemented materials in various civil engineering projects and it support the foundation of structures. Soil has been used for building in a many variety of ways, which differs according to climate and type of soil available. The properties and use of soil as a building material must therefore be studied by anyone concerned with building materials. In recent times, the potential of soil as a building material has been considerably underestimated. There seems to be two main reasons for this to occur. Firstly, the enormous variety of the naturally occurring soils has made specification for any particular set of property difficulty, and engineers should have therefore tend to choose the more predictable manufactured material and secondly, many types of soils in their untreated states lack strength and dimensional stability, this has led to the believe that soil is a generally inferior material of short life and requiring high maintenance. The development of science of soil mechanics and other related testing and classification of soil types has made possible the selection and specification of soil for building purposes with some precision; and the techniques of stabilization, that first developed for use in roads, airfields and also dams, can now be used to convert the soil into a building material whose properties are entirely adequate for most building purposes, and are often fully comparable with other available building materials. If the soil to be used successfully, it is very important, as with other building materials, that lead engineering properties should be clearly understood. These derived from the origin and condition of formation of soils

2.5 GROUT

Grout mixtures for construction must be workable enough to pour into the small holes of the block. Therefore, a grout mixture with fine sands and a very high slump was used. An effort was also made to create a grout that would closely match the compressive strength of the ICEBs.

Previous testing had shown that brittle failure occurs in prisms where the grout has a significantly higher compressive strength than the ICEBs (Bales et al., 2009). The grout mixture chosen consisted of approximately 1:0.4:2.6:4.2 parts of Portland cement to lime to water to sand; all measured by dry volume. Preparation of the grout consisted of dry mixing the ingredients in 15 liter batches. The dry mixture was then added slowly to a portion of the water and mixed until a homogeneous mixture was obtained. Grout samples were tested for each batch of grout poured. Due to the ICEB's inherent water absorbing properties, it was decided to test grout samples that had been poured into the blocks.

2.6 VACUUM SATURATION METHOD

The aim of the development of pressure saturation apparatus was to achieve total absorption or full saturation of dense mortar and concrete to enable the estimation of porosity (Mee E E, 2005). In this research, the test to porosity is conducted using vacuum saturation method. Samples of the size 50 x 50 x 50 mm were used. They were cut from a cube size of 100 x 100 x 100 mm with a cutter**.** The test conducted shows that concrete mix of P10- 046 and P20-046 have higher porosity than concrete mix P10-S and P20-S.

2.7 TYPE OF INTERLOCKING BLOCK

The Thai interlocking brick with dimensions 300 x 150 x 100mm, was developed in the early 1980s, by the Human Settlement Division of the Asian Institute of Technology (HSD-AIT), Bangkok. This is an interlocking brick as defined in Section 2.2.1 (BS 6073-1:1981), although the developer calls it a block. The Thai interlocking brick is produced using a modified CINVA-Ram manual press developed in Colombia in 1956 a wall with vertical grooves run through the full height that provide good keys for render. Vertical holes also run through the full height of a wall, serving the following purposes:

· They reduce weight

· They can house reinforcement or mortar to increase wall stability at chosen locations

· They may be used for electrical and communication conduits

Figure 2.1 : The Thai interlocking block (Kintingu , 2009)

The type of interlocking brick from India is Auram system that has some similarities with Bamba and Thai types, but of a simpler shape with size 295 x 145 x 95mm. The family of bricks (intermediate, three quarter bat, half bat and channel) makes it relate more closely to the Thai system but with no grooves and reduced perforations.

The Auram system reduces the number of three quarter bats required to just one due to shape similarity, compared to the two required with Bamba interlocking brick. In this type of interlock a three-quarter bat is used as a corner brick; this has flat ends, to avoid a semi-circle notch appearing at the external surface of the wall

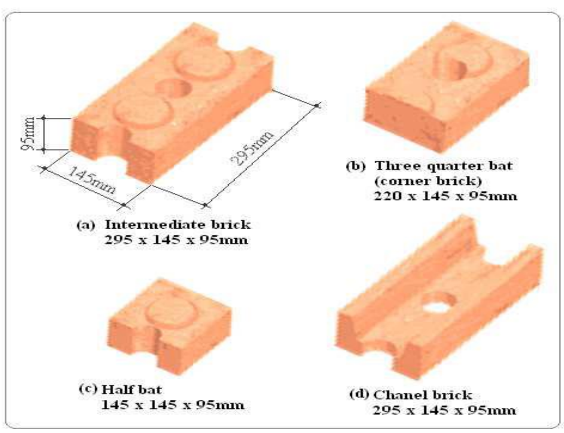

Figure 2.2 : Auram interlocking block (Kintingu , 2009)

A variety of interlocking blocks have been developed during the past years, differing in material composition, shape and size, depending on the required strengths and uses:

Different materials

- Soil-cement blocks depending on the soil and cement qualities, the cement-to-soil ratio usually lies between 1: 6 and 1: 10, by volume. (Laboratory tests are essential).
- Rice husk ash (RHA) cement blocks The cement-to-RHA ratio is generally 1: 4, by volume. Two types of blocks can be produced: white blocks, with a compressive strength of 4 N/mm, using ash (amorphous silica) from field kilns, burnt below 900C; black blocks, with a compressive strength of 1.4 N/mm, using boiler ash (crystalline silica), burnt up to 1200C;
- concrete blocks A typical mix proportion of cement-to-sand-to-gravel is 1: 5: 3.

Different shapes and sizes

- Full blocks (300x 150x 100 mm) for all standard walls (single or double brick thick)
- Half blocks (150 x 150 x 100 mm), which can be moulded to size, or made by cutting freshly moulded full blocks in half.
- Channel blocks, same sizes as full and half blocks, but with a channel along the long axis, into which reinforcing steel and concrete can be placed to form lintels or ring beams.
- The vertical sides of the blocks can be flat or have recesses, and the vertical grout holes can be square or round

The concept of interlocking blocks is based on the following principles:

- The blocks are shaped with projecting parts, which fit exactly into depressions in the blocks placed above, such that they are automatically aligned horizontally and vertically - thus bricklaying is possible without special masonry skills.
- Since the bricks can be laid dry, no mortar is required and a considerable amount of cement is saved.
- Each block has vertical holes, which serve two purposes: 1. to reduce the weight of the block, and 2. to insert steel rods or bamboo for reinforcement, and/or to pour liquid

mortar (grout) into the holes, which run through the full height of the wall, thus increasing its stability.

- The length of each block is exactly double its width, in order to achieve accurate alignment of bricks placed at right angles.

2.8 COMPOSITION OF INTERLOCKING BLOCK

The composition of block depends on the availability of materials and its use. The major components of interlocking block include :

Cement: Cement has the property of setting and solidifying upon mixture with water. Cements are widely used in construction firms in design of the structures, and having many varieties, with Portland cement as the most common type of cement in the general usage. It is also a basic component of concrete, block, plaster or mortar. Besides, Cement consists of a mixture of oxide of calcium silicon together with aluminium. Portland cement is made up by heating limestone (a source of calcium) with clay and grinding this product (called clinker) with a source of a sulphate that most commonly called gypsum (Niel, 1998).

Water: Water combines with cement and aggregates to begin the process of hydration, and adequate water-cement ratio that provides a good consistency. The cement paste glues the aggregate to bind together, fills voids within it and also allows it to flow more smoothly. More importantly, The use of clean pure water is always recommended for the use in block production to prevent adverse any harmful effect of salt and turbidity and any other impurities. Impure water used to make block can cause problem when setting or in causing premature failure of interlocking block walls.

Aggregates: Fine and coarse aggregates made up the bulk of interlocking block mixture. Various types were explained above under of the properties and the types of soil. The process can occur naturally or made artificially in industries (whether uncrushed or crushed). Furthermore, The size of aggregate affects the strength and load bearing capacity of interlocking block.

2.9 CONSTRUCTION OF WALL

Before placing the first course in a mortar bed, the blocks must be laid dry on the foundation around the entire building, in order to ensure that they fit exactly next to each other (leaving no gaps), and that an exact number of full blocks are used, otherwise the system will not function.

When laying the first course in the mortar bed, care must be taken that the blocks are perfectly horizontal, and in a straight line, or at right angles at corners. Once the base course is properly hardened, the blocks are stacked dry, with the help of a wooden or rubber hammer to knock the blocks gently into place. Up to 10 layers can be placed at a time, before the grout holes are filled with a liquid mortar - 1 part cement to 3 parts sand (or soil or rice husk ash) to 1 part water.

It is advisable to place channel blocks around the building, at window sill height, to install a ring beam. Besides, they should also be placed directly above doors and windows to install lintels, and directly below the roof to finish the walls with a ring beam. For increased structural stability, especially in earthquake regions, steel rods or bamboo should be inserted in the vertical grout holes, especially at corners, wall junctions and on either sides of openings.

Interlocking blocks are ideally suited for load-bearing wall constructions, even for two or more storeyed buildings, provided that the height of the wall does not exceed 20 times its thickness, and wall sections without butresses or cross walls do not exceed 4.5 m length (to prevent buckling). Though less economic, non-loadbearing constructions are more common. The walls are constructed in the same way as load- bearing walls, but merely serve as infills between the reinforced concrete frame (post and beam) structure, which supports the roof. Care must be taken to achieve a good bond between the walls and frame-work

Almost any type of building can be constructed with interlocking blocks, the main design constraints being that the plan should be rectangular and all wall dimensions and openings mustbe multiples of the width of the block type used. All other principles of design and 38 construction, such as dimensioning of foundations, protection against rain and ground moisture, construction of ceilings and roofs, and the like, are the same as for other standard building types