EXPERIMENTAL INVESTIGATION ON THE PERFORMANCE OF INTERLOCKING BRICK WALL WITH OPENING-DOOR

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A THESIS IS SUBMITTED TO FACULTY OF ENGINEERING, UNIVERSITY MALAYSIA SABAH IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR REWARD OF THE DEGREE OF BACHELOR OF ENGINEERING WITH HONOURS

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بِسْمِ ٱللَّهِ ٱلرَّحْمَٰنِ ٱلرَّحِيمِ

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ABSTRACT

This study focuses primarily on experimentally comparing the performance of an interlocking brick wall with and without an opening door. In addition to this, an investigation of the features of the interlocking bricks that were utilised in the construction of the interlocking brick wall was carried out. The major building ingredients for interlocking brick in this procedure are soil, sand, cement, and water. In addition, physical and mechanical evaluations of each individual brick were conducted in relation to the water curing method at 7, 14, and 28 days following curing.

The characteristics of the hardened concrete were evaluated after 7, 14, and 28 days of curing respectively. The ratio of water to cementitious materials was set at 0.5. Next, compression tests for the brick and water absorption tests for the interlocking brick were conducted to measure the brick's compressive strength and water absorption. According to the results of the experiment, all of the mixtures were classed as workable pastes. The interlocking brick walls with and without door openings were put to the test in the laboratory until they failed. The findings of this study demonstrated that a wall with no openings has a higher compressive strength than a wall with openings, and that it fails only after a significant amount of time has passed.

ABSTRAK

PENYIASATAN EKSPERIMEN TERHADAP PRESTASI DINDING BATA SALING MENGUNCI DENGAN BUKAAN PINTU

Kajian ini tertumpu terutamanya pada eksperimen membandingkan prestasi dinding bata yang saling mengunci dan dinding yang mempunyai pembukaan pintu. Di samping itu, penyiasatan tentang ciri-ciri bata saling mengunci yang digunakan dalam pembinaan dinding bata saling mengunci telah dijalankan. Bahan binaan utama untuk saling mengunci dalam prosedur ini ialah tanah, pasir, simen, dan air. Seterusnya, penilaian fizikal dan mekanikal bagi setiap bata individu telah dijalankan berhubung dengan kaedah pengawetan air pada 7, 14, dan 28 hari selepas pengawetan.

Ciri-ciri konkrit yang dikeraskan telah dinilai selepas 7, 14, dan 28 hari pengawetan masing-masing. Nisbah air kepada bahan bersimen ditetapkan pada 0.5. Seterusnya, ujian mampatan untuk bata dan ujian penyerapan air untuk bata saling mengunci dijalankan untuk mengukur kekuatan mampatan bata dan penyerapan air. Mengikut keputusan eksperimen, semua campuran dikelaskan sebagai pes yang boleh digunakan. Dinding bata yang saling berkunci dan bukaan pintu telah diuji di makmal sehingga ia gagal. Penemuan kajian ini menunjukkan bahawa dinding tanpa bukaan mempunyai kekuatan mampatan yang lebih tinggi daripada dinding dengan bukaan, dan ia gagal hanya selepas masa yang ketara berlalu.

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LIST OF ABBREVIATIONS

ASTM	-	American Society for Testing and Materials
BS	-	British Standard
MS	-	Malaysian Standard
IBS	-	Industrialized Building System

CHAPTER 1

INTRODUCTION

1.1 Project Overview

One of the world's most essential building materials, brick masonry has been around for thousands of years and is still in use today. Traditional brick-making methods have been shown to have serious flaws. Previously, bricks were made by mixing raw materials, forming the bricks, drying and fire them until they reached a particular level of strength, according to historical and conventional techniques (Allen E and Thallon R, 2011).

As a result of the inadequacies of previous methods of brick-making, which have become obsolete, the brick-making process has evolved in the last two decades, away from conventional methods of brick-making. Due to the current trend, bricks have been created in two classifications during the last two decades: solid brick and interlocking brick. Solid brick is the most common type of brick used in construction.

Mortarless brick construction has led to a considerable rise in field profitability and efficiency, as well as a reduction of the construction industry's need for highly-specialized work teams. Furthermore, the use of interlocking blocks work has gained rapid popularity in a variety of foreign countries as a viable alternative to traditional blocks for the construction of stable and long-lasting structures.

In contrast to typical blocks, interlocking blocks do not necessitate the placement of mortar between the layers of blocks during building. This trait makes the process of constructing walls and partitions more efficient, requiring fewer experienced employees, because the blocks are constructed dry and stacked on top of one another during the construction process. Although bricks have many advantages, they also have certain drawbacks, including low strength, increased water absorption, low fire resistance, and large porosity.

The increased demand for building construction provides justification for finding new and better ways to meet and resolve the challenges associated with construction. Interlocking bricks are an alternate system that is similar to "LEGO blocks" in that it uses little or no mortar to hold the bricks together. Interlocking bricks can be used in a variety of applications. Interlocking bricks were developed to eliminate the need for human labour and, as a result, to meet the requirements of the Industrialized Building System (IBS). In building, the interlocking brick system is a quick and cost-effective construction technology that provides a good solution for many problems.

As there is no formal standard for the usage of interlocking bricks in Malaysia, the use of this system is not extensively used in the country. Furthermore, the little research that has been done in the fabrication and installation of the system for local requirements has all contributed to the inability to employ this system in the building. In order to measure the efficacy of the interlocking brick construction technique, it is necessary to expedite the effort.

1.2 Objective of Study

1. To study the properties of materials for interlocking brick.
2. To determine the physical and mechanical properties of a single unit interlocking brick.
3. To analyze and compare the performance of interlocking brick wall with and without door opening.

1.3 Problem statement

More alternative approaches have been developed to replace conventional building materials that are less concerned with the elements of sustainability, particularly human, economic, and environmental sustainability, in order to achieve sustainable and green technology in construction. Due to the employment of the flame process in the manufacturing process, traditional bricks utilize and emit a lot of energy. Furthermore, significant carbon emissions from combustion might add to the greenhouse impact.

Previous research has demonstrated that conventional masonry constructions typically have poor structural performance, especially when subjected to intense loading situations such as earthquake, impact, and blast loads. Therefore, it is important to conduct studies to study the performance of interlocking brick wall.

1.4 Scope and limitation of study

To achieve the objectives of this project, the study will be concentrated on the strength development of single unit brick also the performance of the interlocking brick wall. The main scope for this study is:

1. A thesis study focuses on the strength development of the manufactured interlocking brick. The strength will be checked after 7 days, 14 days, and 28 days of water curing.
2. The interlocking brick wall will be tested it performance with and without door opening.

1.5 Thesis structure

The project is divided into the following five sections. The scope of the study, the study goals, and the project overview are all discussed in detail in this first chapter. An extensive literature study will be included in the second chapter of this paper. Chapter 3 will go through the approach, which includes the utilisation of equipment and materials, mixing design, processes, and the experimental programme. The fourth chapter will go over the results and data analysis from the experiment. Chapter 5 will give the project's conclusions and recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The use of interlocking bricks dates back to the early 1900s, when they were first used in the creation of children's toys (McKusick (1997), Love and Gamble (1985)). The following were among the first creators of toy systems who made significant contributions to mortarless technology (the arrangement of elements that allows for the construction of ideal structures):

- (1863 – 1936) - The Englishman Frank Hornby of Liverpool with Meccano sets.
- (1884 – 1962) - A.C Gilbert of Salem, Oregon with Erector sets.
- In 1913 - Charles Pajeau who invented Tinker Toy construction sets. He was a stonemason from Evanston, Illinois, USA.
- In 1920 - John Lloyd Wright who invented Lincoln Logs.
- (1891 – 1958) - Ole Kirk Christiansen who invented Lego.

Toy mechanisms were meant from the beginning to teach the concepts of creativity and to be a tool for learning scientific, engineering, and architectural ideas as well as to entertain children (Kintingu, 2009).

2.2 Types of Interlocking Brick

2.2.1 Interlocking Hollow Blocks

In terms of quality, strength, and affordability, interlocking hollow-blocks made of sand and cement are capable of competing with current technologies. This figure illustrates several interlocking hollow-blocks from Canada, each with typical measurements of 16"x 8" (400 x 200mm) and representing more than thirty different varieties, all of which were described by (Thanoon et al, 2004 and Ramamurthy & Nambiar, 2004). The vast majority of interlocking hollow blocks are utilised in the construction of reinforced concrete structures to eliminate the need for formwork.

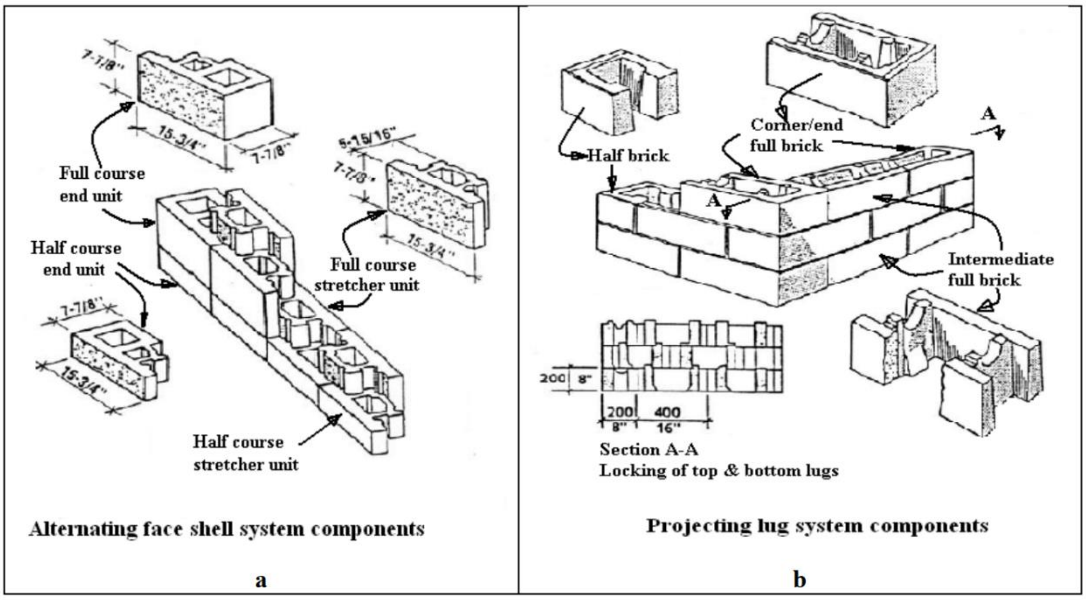


Figure 2.1: interlocking hollow blocks (Kintingu, 2009)

The figure 2.1a shows alternative face-shell components, sometimes known as the Sparlock system (Hines, 1993). The Sparlock system allows for only vertical reinforcements to be installed, whereas Projecting lug system components figure 2.1b, known as Haener system (Gallegos,1988) and (Harris et al., 1992). The Haener system allows for the installation of horizontal and vertical reinforcements in the same structure. Because of the high strength requirements of thin block webs and the pressure transferred during the process of laying concrete grout in hollow block construction, material mix ratios (cement to sand/aggregates) for hollow block production are frequently greater than 1:10 in order to achieve satisfactory results. The schematics (Figure 2.1) show how to assemble block units and how they should be placed together to construct a wall or formwork for a wall.

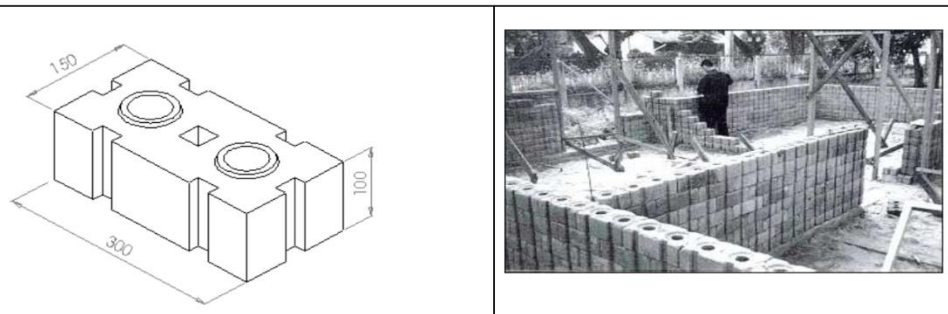
Most of the interlocking brick/block kinds that are frequently utilised in Africa and Asia are made from stabilised soil and are intended for use in low-cost house construction projects. Thai interlocking brick, South African Solbric, Hydraform, and Bamba Systems, Indian Auram system, and Tanzanian type are all examples of interlocking brick designs that are available on the market today.

It was invented by different people at different times to reduce mortar costs, boost building productivity, and improve the characteristics of walls. All of the interlocking bricks described above were invented by different persons at different times (accuracy, stability, and strength). Using the appropriate manufacturing method and wall construction technology, as well as the appropriate locking mechanism, this was accomplished.

2.2.2 Thai Interlocking Bricks

The Thai interlocking brick (Figure 2.2), which was developed in the early 1980s by the Human Settlement Division of the Asian Institute of Technology (HSD-AIT), Bangkok, in collaboration with the Thai Institute of Scientific and Technical Research, has dimensions of 300 x 150 x 100mm and is made of concrete (TISTR). Despite the fact that the developer refers to it as a block, this is an interlocking brick according to Section 2.2.1 (BS 6073-1:1981) of the British Standard. An improved CINVA-Ram manual press, which was designed in Colombia in 1956 and imported to Thailand, is used to manufacture the Thai interlocking brick (VITA 1975). Figure 2.2b depicts a wall with vertical grooves that span the entire height of the wall and serve as excellent keys for rendering. Vertical holes can also be seen running the full height of a wall, and they are used for the following purposes:

I. They reduce weight
II. They can use reinforcement or mortar to increase wall stability at chosen locations
III. They may be used for electrical and communication conduits.



a) Brick length = 300mm, width = 150mm and height = 100mm

b) Wall thickness = 150mm, course height = 100mm

Figure 2.2: Thai interlocking brick

Sources: Kintingu (2009)

The grooves, on the other hand, may increase the amount of render required during the internal plastering process. When paired with the grooves, the perforations have the ability to reduce the entire strength of a brick, and consequently the overall strength of a wall made of these bricks. The locking mechanism is not effectively secured because the knobs and depressions are too small (approximately 5mm). The strength of such interlocks is decided by the surface render that is applied to them, or by the grout that is placed in vertical holes with additional reinforcements if necessary.

2.2.3 SOLBRIC System from South Africa

Figure 2.3a, The SOLBRIC method uses solid interlocking bricks (the compacting stroke is parallel to the longer side of the bricks) and is guided or regulated in height and width. SOLBRICs are used in bricklaying by laying them on top of the regular bed surface of the bricks (Figure 2.3c). The following are the measurements of a SOLBRIC: Dimensions: 250 x 200 x 100 mm. Conduits and pipelines can be installed in between the courses, as well as reinforcements in specified sections to strengthen the wall in those regions. (Figure 2.3b) (cill and lintel levels).

In the SOLBRIC wall, the chamfered edges of the bricks on one side and the pointed edges on the other create an outwardly pointed joint surface (Figure 2.3b). In addition, because of SOLBRIC's smooth interior surface and outer pointed joint, the thickness of plaster mortar required is reduced. The contrast between bricks and other materials means that they cannot be reversed (front to back).

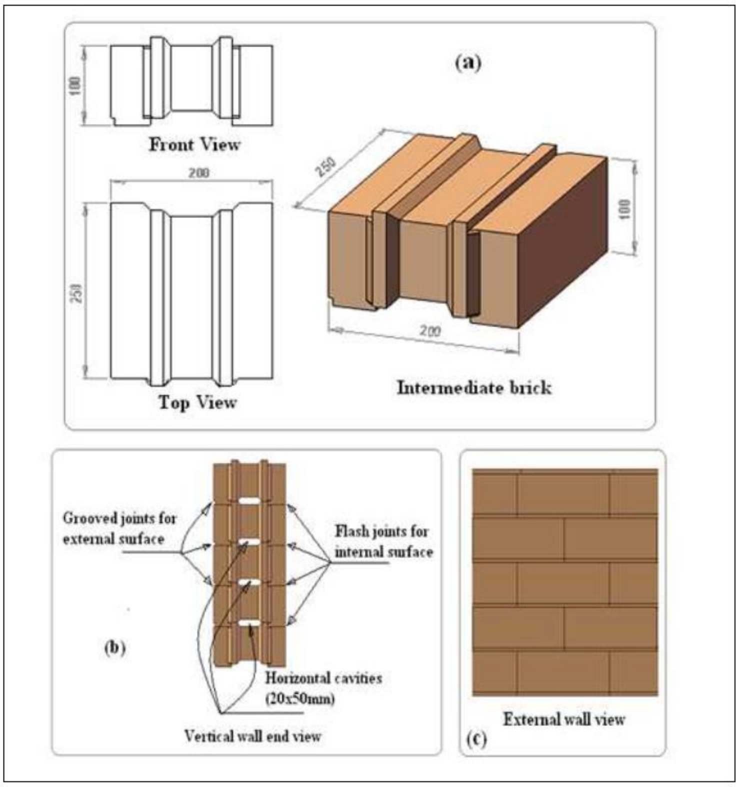


Figure 2.3: SOLBRIC interlock brick

sources: Kintingu (2009)

In spite of the apparent ease of use, the SOLBRIC interlocking brick system can only be used to build external walls since it cannot link partitions, i.e. form tee or cross joints, between them due to the shape of the bricks and parts created by the machine. Due to the obvious material used, the tiny thicknesses (15mm) of the vertical and horizontal tongues that allow interlocking are problematic (soil stabilised with cement that is brittle in nature).

2.2.4 Bamba system from South Africa

Perforated with protrusions and depressions, the Bamba interlocking brick (Figure 2.4) is perforated. The top and bottom faces of Bamba bricks feature negative symmetry, allowing them to fit together (lock).

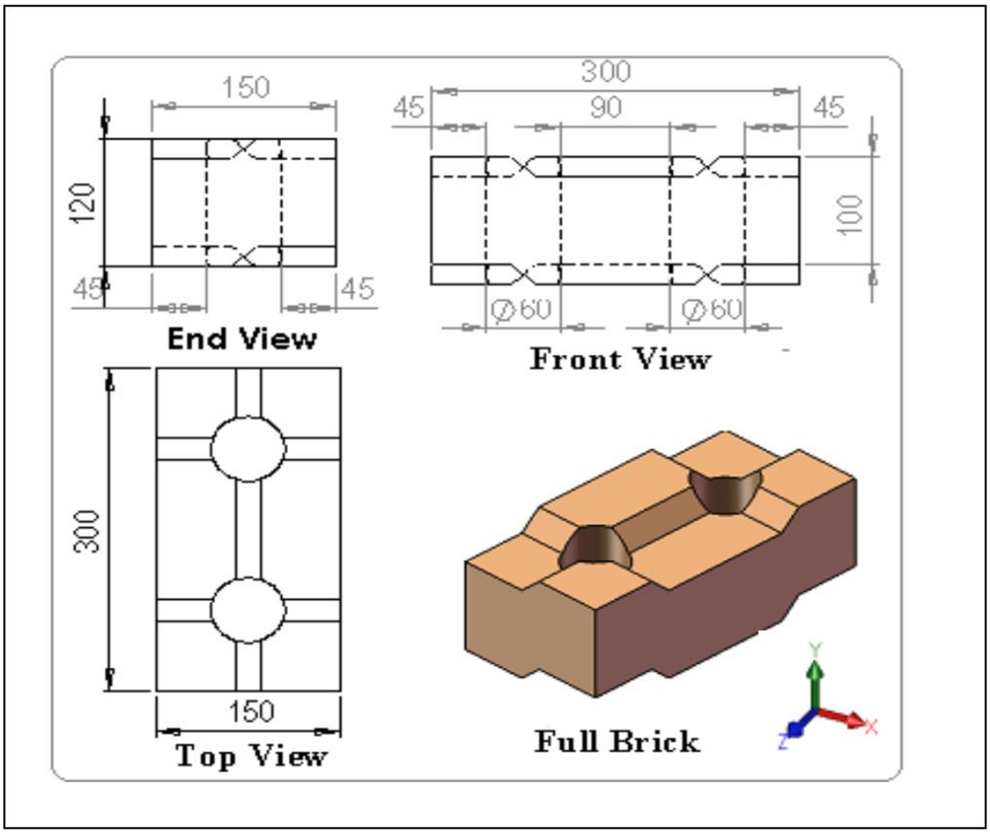


Figure 2.4: Bamba Interlocking brick

sources: Kintingu (2009)

When the brick is rotated 180 degrees around its Z-axis, the bottom view becomes the top view, as seen in Figure 2.4; this allows for reversal to find a better orientation or position during brick-laying.