A STUDY ON HOLLOW BLOCK CONCRETE BRICK

Submitted to the department of Civil Engineering

Of Sonargaon University (SU), DHAKA in partial fulfilment of the requirement

for the degree of B.Sc. in CIVIL Engineering

Submitted By

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January 31,2020

To

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Subject: Submission of Project Report.

Dear Sir.

This is our great pleasure that we are submitting here with the project report on **"Hollow Block Concrete Brick"** It is an important tropic. The project report has been done according to the requirement and guidelines of the Sonargaon University (SU).

We hope that this report will certainly help you in evaluating our project report on **"Hollow Block Concrete Brick".** We would be very glad to provide any assistance in interpreting any part of the paper, whenever necessary.

Thanking You

Sincerely your's

Nahiyan Alsad Galib

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DECLARATION

This is to declare that the work and material presented in the report has been carried out by us and has not previously been submitted to any University College/Organization for any Academic qualification. We hereby ensure that the work that has been presented does not breach existing copyright. We undertake to indemnify the university against any loss or damage arising from breach of the foregoing obligation.

Thanking You

Sincerely your's

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Authors

ABSTRACT

Economy and stability are the prime requisites of any structure. Best designer is one who comes out with a design which gives the stable and economic structure. ”Hollow Block Concrete Brick” have become a regular or frequent choice today in construction activities as these blocks offer various benefits, simplicities in their use as building elements, strength comparable with the conventional blocks like bricks, facilities to get reinforced thereby increasing the strength of constructed units, facility for better finish, adoptability for getting desired architectural shapes and beauty and above all rendering economy in construction. The strength of hollow concrete block masonry wall is grater than brick masonry wall but cost of construction of former wall is very less. With these aspect under study the authors concentrated upon some case studies indicating the uses of Hollow block concrete brick in the construction of beam, walls etc. Hollow block concrete brick masonry is carried out and a comparative study is executed with respect to brick masonry construction and strength parameter, economy, light weight character and insulation property are studied and compared, to study the outcomes of these studies and have, then based on the investigations of these case studies reviewed the various aspect related to the uses of Hollow block concrete brick. The paper briefly reviews all the above points referred.

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CHAPTER 1

INTRODUCTION

1.1 Nature of study:

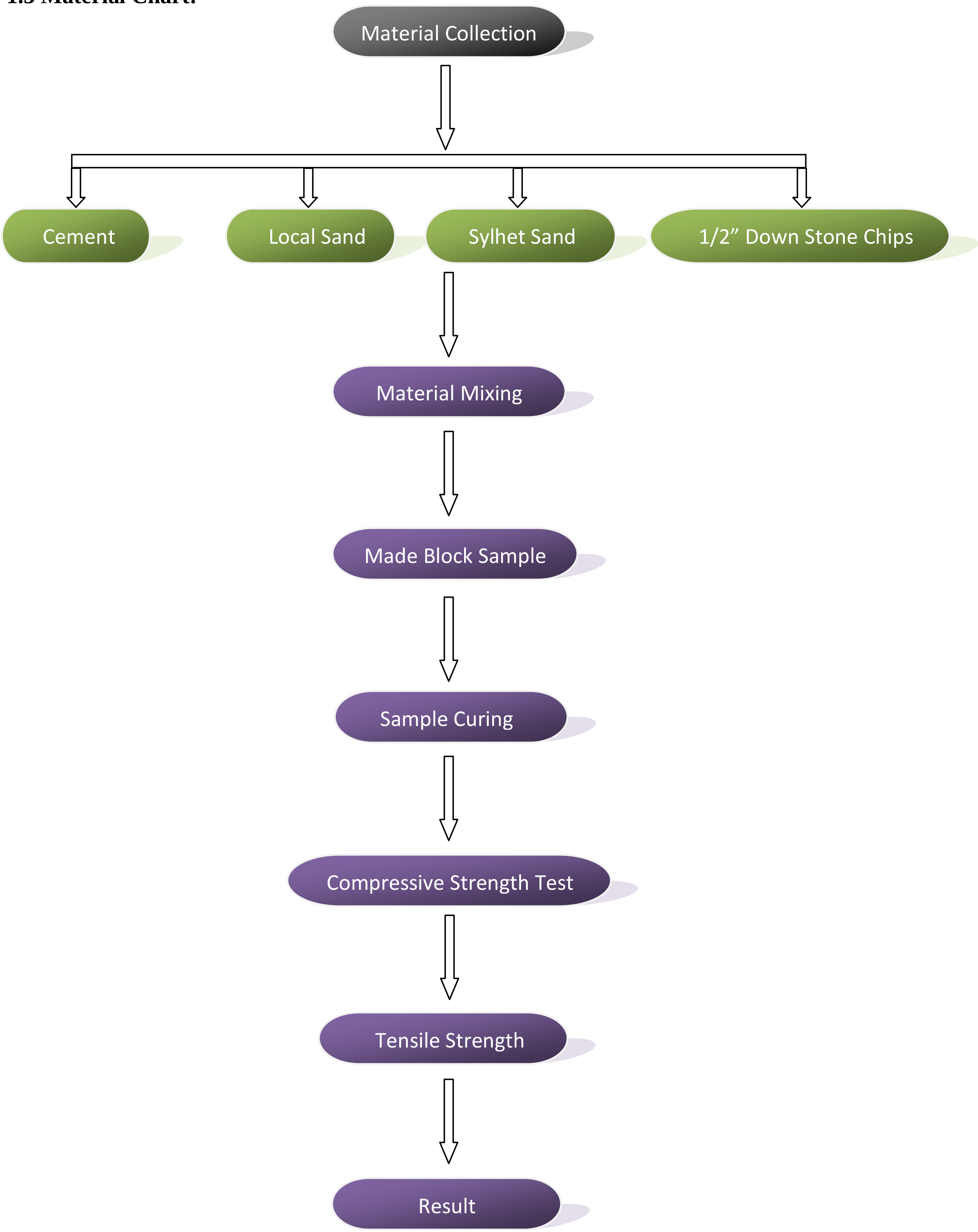
One of the basic requirements of human being to sustain in the world is shelter. After evolution of human being, the need of shelter meant for safety, arises. In ancient time, man started taking shelter in caves, excavated below ground level and under hanging mountain cliffs and this type of shelter just provided safe place from environmental extremities. The concept of stability and safety as per structural features of shelter were completely out of mind. With the development and maturity of human mind, man began to modify the structural formation of shelter so as to address the increasing needs and facilities which an optimum shelter design possessed. After achieving a feat by the use of easily available material like mud in construction walls and then the technique of burnt clay brick masonry to form structural part of shelter, there was still a long journey is coming out for the best possible material for construction of stable and safe structural units of shelter. The desire for search of safe and stable structural materials keeping in view the economy of whole structure, paved way for usage of hollow concrete blocks. Now a days, Hollow Block Concrete Brick (HBCB) and bricks are becoming very popular. These blocks are being widely used in construction of residential buildings, factories and multi-storied buildings. These hollow blocks are commonly used in compound walls due to their low cost. These hollow blocks are more useful due to their lightweight and ease of ventilation. The blocks and bricks are made out of mixture of cement, sand and stone chips. Hollow blocks construction provides facilities for concealing electrical conduit, water and soil pipes. It saves cement in masonry work, bringing down cost of construction considerably. Economy of the structure is one of the basic aspects upon which any design is based. One of the basic requirements of human being to sustain in the world is shelter. After the evolution of human being, the need of shelter meant for safety arises. In ancient times, man started taking shelter in caves, excavated below ground level and under hanging mountain cliffs and this type of shelter just provided safe place from environmental extremities .the concept of stability and safety as per structural features of shelter were completely out of mind. With the development and maturity of human mind, man began to modify the structural formation of shelter so as to address the increasing needs and facilities which an optimum shelter design possessed. After achieving a feat by the use of easily available material like mud in constructing walls and then the technique of burnt clay brick masonry to form structural part of shelter, there was still a long journey incoming out for the best possible structural material for construction of stable and safe structural units of shelter. The desire for search of safe and stable structural materials keeping in view the economy of whole structure The stability plays an important role but the best designer is one who comes out with design which gives the stable and economics structure. The development of the construction technology is closely related to development of adequate mechanization and handling technology. Hollow concrete block is an important addition to the types of masonry units available to the builders and its use for masonry is constantly increasing. A handful amount of literature is available on hollow blocks. Hollow blocks are widely used in the region of harsh temperature, especially in Europe where average temperature in winter is below freezing point and Middle Eastern countries where average temperature in summer is more than 40ºC. We tried to follow the specifications, instructions, and standard provided by Dubai Municipality, a well-established institute in Middle Eastern region. Masonry is one of the oldest forms of construction and has been widely utilized in both developed and developing countries due to ease of construction, availability of materials, relatively low cost of materials, and unskilled workers. There are many masonry materials, such as unfired clay bricks, fired clay bricks, concrete bricks, and hollow concrete blocks. Among these masonry materials, clay bricks are gradually abandoned, and hollow concrete blocks are used more and more widely due to technological advancements, environmental protection, and sustainable development. Hollow concrete blocks could offer the potential for energy savings, decreasing raw material usage, and reducing environmental impact. Therefore, hollow concrete blocks play an important role in the modern building industry. Now days, hollow concrete blocks are being very popular in construction. These blocks are being mostly used in the construction of multi- storied buildings, factories and residential buildings. These concrete hollow blocks are commonly used in compound walls because of cheapness. These concrete hollow blocks are more useful due to its lightweight and the most important feature is ease of ventilation. The concrete hollow blocks are made out of mixture of cement, sand and stone chips. It reduces cement in masonry work and reduced the cost of construction. In some cases we modified some parameter due to the local condition, especially in case of materials used. Concrete block foundations are built using concrete blocks that are typically 8 inches by 16 inches. Although they do come in various sizes, this is the size that is most commonly used for foundations. The concrete blocks rest on a concrete footing that has been poured deep and wide enough to accommodate the load of the blocks and the building.

1.2 Objective of the thesis:

- To determine compressive strength of hollow block concrete brick.
- To determine tensile strength of hollow block concrete brick.
- To comparison of first class bricks with hollow block concrete brick.

Figure: 1.1 Hollow Block Concrete Brick

1.3 Material Chart:



1.4 Background:

Concrete block construction has gained importance and has become a valid alternative to fired clay bricks. The essential ingredients of concrete are cement, aggregate (sand, gravel) and water. Concrete blocks are produced in a large variety of shapes and sizes. They can be produced manually or with the help of machines. Solid blocks have no cavities, or- according to US standards- have no voids amounting to not more than 25% of the gross cross-sectional area. Hollow blocks are the most common type of concrete blocks, having one or more holes that are open at both sides. The total void area can amount to 50% of the gross cross-sectional area. A Hollow concrete block is primarily used as a building material in the construction of walls. It is sometimes called a concrete masonry unit (CMU). A concrete block is one of several precast concrete products used in construction. The term precast refers to the fact that the blocks are formed and hardened before they are brought to the job site. Most concrete blocks have one or more hollow cavities, and their sides may be cast smooth or with a design. In use, concrete blocks are stacked one at a time and held together with fresh concrete mortar to form the desired length and height of the wall. Concrete mortar was used by the Romans as early as 200 B.C. to bind shaped stones together in the construction of buildings. During the reign of the Roman emperor Caligula, in 37-41 A.D., small blocks of precast concrete were used as a construction material in the region around present-day Naples, in Italy. Much of the concrete technology developed by the Romans was lost after the fall of the Roman Empire in the fifth century. It was not until 1824 that the English stonemason Joseph Aspdin developed Portland cement, which became one of the key components of modern concrete. Concrete block foundations are not as popular as they once were. This is partly because of the cost and partly because of the aesthetics of the foundation. In today’s society, people expect beauty and functionality to go hand in hand. A block foundation is not beautiful and it has higher maintenance than a poured foundation. The disadvantages overshadow the advantages and in time, this type of foundation will become obsolete.

The first hollow block concrete bricks was designed in 1890 by Harmon S. Palmer in the United States. After 10 years of experimenting, Palmer patented the design in1900. Palmer's blocks were 8 in (20.3 cm) by 10 in (25.4 cm) by 30 in (76.2 cm), and they were so heavy they had to be lifted into place with a small crane. By 1905, an estimated 1,500 companies were manufacturing concrete blocks in the United States. These early blocks were usually cast by hand, and the average output was about 10 blocks per person per hour. Today, concrete block manufacturing is a highly automated process that can produce up to 2,000 blocks per hour. The Compressive strength of masonry is one of the most important property in the design of masonry structure. This strength depends upon several factors such as unit strength, mortar strength, grouting, grout strength, geometry of the blocks, bedding mortar, and the type of bonding and bedding arrangements adopted. In extreme hot or cold climate countries these concrete blocks possessing low thermal conductivity and also serve as a thermal insulation material which minimize the energy consumption by minimizing the dependence on electricity for air conditioning or heating. In all countries, the different conventional materials are replacing to the concrete hollow blocks because most conventional materials cost is increasing. In the review study we found that hollow blocks of double- H shape gives more strength with semi-grouted masonry and low strength with fully grouted masonry Concrete blocks were first used in the United States as a substitute for stone or wood in the building of homes. The earliest known example of a house built in this country entirely of concrete block was in 1837 on Staten Island, New York. The homes built of concrete blocks showed a creative use of common inexpensive materials made to look like the more expensive and traditional wood-framed stone masonry building. This new type of construction became a popular form of house building in the early 1900s through the 1920s. House styles, often referred to as "modern" at the time, ranged from Tudor to Foursquare, Colonial Revival to Bungalow. While many houses used the concrete blocks as the structure as well as the outer wall surface, other houses used stucco or other coatings over the block structure. Hundreds of thousands of these houses were built especially in the Midwestern states, probably because the raw materials needed to make concrete blocks were in abundant supply in sand banks and gravel pits throughout this region. The concrete blocks were made with face designs to simulate stone textures: rock-faced, granite-faced, or rusticated. At first, considering an experimental material, houses built of concrete blocks were advertised in man Portland cement manufacturers catalogs as "fireproof, vermin proof, and weatherproof" and as an inexpensive replacement for the ever-scarcer supply of wood. Many other types of buildings such as garages, silos, and post offices were built and continued to be built today using this construction method because of these qualities.

Usually, masonry is considered as a composite structure consisting of block units and mortar and is strong in compression but weak in tension. Under loading, the behaviour of masonry is quite complex, which depends on the mechanical and geometrical characteristics of the units, the mortar, and the bond strength between units and mortar.

Mortar joints between block units play an important role in determining the behaviour of masonry; however, the mortar joints are often considered to be planes of weakness. Masonry is generally adopted for wall construction as a gravity load-bearing system, while masonry walls are subjected to in-plane shear forces during seismic events. A few of post earthquake field investigations showed that many masonry buildings were highly destroyed and damaged by the moderate and strong earthquakes due to the weak joints, resulting in many deaths and huge economic losses. It is well known that unreinforced masonry (URM) buildings are the most vulnerable during an earthquake. Among the observed failure modes, the most common failure mode is sliding shear mode, which represents horizontal shearing through the bed joints of masonry. Hence, the shear strength and deformation ability of the block-mortar bed joint in masonry is critical for the in-plane shear behaviour of masonry.

In order to enhance the in-plane shear behaviour of masonry, confined masonry (CM) structures with horizontal and vertical RC-confining elements are widely used in seismically active regions in developing countries, especially in China, due to their satisfactory behaviour. However, horizontal and vertical RC-confining elements have not been widely used in rural areas of China owing to high cost and lack of skilled workers. How to find a simple and economical construction method to improve the shear strength of masonry is crucial to improve the seismic performance of masonry structures in rural areas of China.

According to the development status of rural China and the needs of rural housing construction, an extensive research program has been carried out in Tianjin Chengjian University. The purpose of this research program is to develop simple and effective structural measures to improve the hollow concrete block masonry structures without horizontal and vertical RC-confining elements. Then, precast concrete anti-shear blocks with different dimensions were proposed to enhance the shear strength of hollow concrete masonry. In this paper, a series of direct shear tests of block masonry triplets (with and without precast concrete anti-shear blocks) have been conducted to validate the effectiveness of the proposed structural strengthening solutions.

Masonry structures has been extensively used since ancient times where the applications are not limited to building construction only, but is also widely used in construction from the smallest to huge buildings, monuments and other infrastructures. With the combination of art and great architectural work, masonry building technique will result a heritage building.

In ancient Mesopotamia, there are many types of materials used for masonry unit. One of the example of masonry material used is the sun-dried mud bricks as shown in Figure 1. It is the oldest brick in the world taken from archaeological digs at the site of ancient Jericho. The brick resembles long loaves of bread, with some bold patterns of a Neolithic thumb print impression on their rounded tops. It was used by the people of Mesopotamia for their shelter.

Until 1950's, there were no engineering methods of designing masonry for buildings. The masonry building is built based on graphical methods or simple calculation as cantilever wall, without shear wall and lead to the increased thickness of wall from top to bottom. Hence, the masonry structures built is considered very uneconomical beyond 3 or 4 storeys. At the early 20th century, masonry was relegated to secondary usage as facing, land infills and fire proofing purposes. It is because, building exceeding 3 or 4 storeys had to be constructed with steel frame or reinforced concrete frames. An example of the final masonry structure that was constructed as method mentioned above is the Monadnock Building, built in the year 1981. It was designed by John Root in Chicago, comprises of 16-storey high with 1.82 m thick walls at the base. The Monadnock Building was designed based on the considerations from 'Rule-of-Thumb' tables given in building codes and regulations at that time. The thick unreinforced masonry walls at the base of the building provided the required stability against wind loads. Such structures made it clear at the turn of the century that a size limit had been reached on masonry and construction techniques.

The first historical masonry building structure constructed in Malaysia is the A Famous heritage building that was built by the Portuguese after successfully capturing Malacca in 1511. Due to the quality of the design, the remains of the A Famous building still stays strong and stand firm until today. Later, more masonry structures were introduced during the British colonial era with the construction of various official and middle class residential buildings. The existing buildings were found located at the Harvard Estate at Gurun and the TUDM quarters at Tok Jalai, Jitra in the state of Kedah [20][21]. However after the independence of Malaya in 1957, many of these masonry buildings have been demolished to make way for new development by the Malaysian government. The application of hollow block units was further introduced mainly for the housing construction. Examples of housing construction using these hollow blocks are the low cost housing located at Taman Sri Kemuning, Jitra in the 1970's, Setapak Jaya Housing Estate in Setapak in 1978 and the Selayang Utara and Selayang Selatan in 1979 [20][21].

At the present time, some of the buildings using the traditional masonry system in Malaysia are still around and has been gazetted as a national heritage. Some of these national heritage buildings are the Sultan Abdul Samad complex in Kuala Lumpur (which was built in 1894), the Sultanah Aminah's hospital in Johor Bharu and the Federated Malay States Railway's (FMSR) building. Due to their excellent performance by overseas and local standards, this system had been approved and gazetted under the Uniform Building by- Laws in 1989. In 1994, the low-cost housing project at Chembong, Negeri Sembilan uses an innovative masonry structural system which eventually won the prestigious Prime Minister's award. From there, it was reported that a number of housing projects started using a comparable masonry system for its construction method. Unfortunately, the usage of any masonry structural system are less popular in Malaysia despite the associated advantages to this method.

Interlocking load bearing hollow block system is different from traditional concrete blocks and brick. The mortar layer is eliminated and the block unit was interconnected through natural interlocking mechanisms provided on sides or top-bottom surface such as protrusion and grooves. The elimination of the mortar layer increases the rate of construction significantly. It has been reported by that the efficiency factor of dry-stacked (mortarless) brick masonry is around 0.90. The mortar layers are also the weakest part of a masonry wall as the substitution of lime for aggregate reduces the overall strength of the joint. There has been several attempts to develop innovative ILHB system in different parts of the world in the recent past. In 1994, Juan Haener developed the Haener block system located at Canada. The block was made from concrete and it was used for the construction of load bearing walls. The system comprises of three types of block units as in Figure 3. The horizontal alignment of the blocks is ensured by interlocking keys provided at the sides while the vertical alignment between the block is achieved by small projection key at the top of the blocks. In addition, the inside web is inclined at the bottom to act as a support to the top key to interlock the blocks. This type of interlocking mechanism is very efficient to ensure the self-alignment and easy construction. Furthermore, the block also allows both horizontal and vertical reinforcement embedded in grout to be placed at suitable intervals for load bearing walls. Further development on an ILHB system was proceeded by the innovative Mecano block in Peru. The block system was invented by Cetholic in 1988 which has no interlocking mechanism as shown in Figure 4. The blocks were made from sand-lime and simply stacked on top of each other to construct a wall. The hollow cores of the block allow horizontal and vertical reinforcement with help from grouting to interlock between the block unit. The block unit must have accurate dimensions and smoothness with an allowable tolerance of 0.5 mm obtained through moulding under pressure. Furthermore, it is requiring concrete grout and must have a high degree of workability to combined each block unit.

In 1992, the modified “H” and “W” block made up of concrete was invented by Drexel University, USA. It was used mainly for reinforced masonry construction purposes and can resist earthquake. The first of the two systems is a simple modified H-block. It consists of tongue and groove as the interlocking mechanisms on both the bed and head joints. The block system is reinforced in both vertical and horizontal directions. Partial grouting is required to ensure the stability of the wall during construction prior to full grouting. The second system is the W-block interlocking system which also the possible horizontal and vertical reinforcement and the stacking of the units. The horizontal joints between the courses are staggered by using different height unit and dovetail arrangement in the head joint. Three different types of W-block is required to construct the walls. However, the vertical joints are made continuously along the height of the wall.

By 2000 the Solid Interlocking Block (or Sillblock) system made from concrete was developed by the Indian Institute of Technology, Madras. The development of the blocks was aimed to accelerated mortar less masonry construction. The system consists of two types of block system with three basic shapes for each type which is called a stretcher, jamb and corner blocks as in Figure 6. The interlocking mechanism is achieved through the dovetail design of the block for both top and side locking mechanism. Both horizontal and vertical is interlocked by means of meticulous skill which the horizontal reinforcement is only allowed at the end of the corner and the hollow cores of the corner block unit can be grouted if needed. To ensure stability during erection, mortar slurry was sprayed by using a spray gun and dipping the bottom of each block in mortar slurry for uniform and very thin mortar bedding.

In Malaysia, the latest development of the ILHB system was developed in 2004. Putra Block is a load bearing hollow concrete block and has been developed by the Housing Research Centre (HRC) of University Putra Malaysia (UPM). The block system consists of three units which comprises of the stretcher block, corner block and half block. Each block has different geometrical configuration and its function was to facilitate better masonry structures construction.

Generally, the stretcher block was the main unit used in the construction of the walls. It was functioned to resist the load acting on the wall. The corner block unit was to be used to connect between junctions and at the end of the walls while the half block unit was to be used to complete the courses of the wall so that the vertical joint would be staggered. The block also has been manufactured with hollow section allowing vertical reinforcement and grouting mortar at intervals necessary to complete the wall construction.

The development of Putra block is the latest invention of masonry structural units for the construction industry in Malaysia. It is used as an alternative to Industrialized Building System (IBS) and numerous in-depth investigations has been conducted on these block systems. It also offers various advantages in term of its design, construction cost and time and especially towards modern construction method. Experimental work done by shows the experimental work conducted to investigate the structural behaviour of every single unit of the Putra block as in Figure 8. The characteristic strength in Table 1 shows excellent properties which fulfils the requirements of standard specifications for the load bearing concrete masonry units. From further experimental studies, it was also observed that the behaviour of the ILHB wall was primarily dominated by a large lateral displacement and the dry joint opening at approximately the mid height of the wall (at the maximum moment location). Besides that, the mode of deformation and dry joint opening in the wall are affected highly by grout, reinforcement and precompressive load. Hence, further investigations of masonry unit such as the Putra Block needs to be conducted to meet the demand of the construction industry in the 11th MP and beyond.

Figure: 1.2 Hollow Block Concrete Brick Hydraulic Machine

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction:

This chapter briefly outlines all the necessary outcomes from the literature study and deduce a theoretical framework. Instead of bricks, block brick or block is being used for many construction purposes. Because there is no hassle of burning soil or soil in the making. The stone, sand and cement are used. Thousands of bricks where from 6 thousand to 8 thousand taka but Thousands of blocks there cost 9,000 to 12 thousands. A block is 3 to 4 times bigger than a brick and is folded in. So the hollow block brick is environmentally friendly, the cost of construction is low and the weight of the building is also reduced. The cost of construction of per square foot in a common building is Tk 1800. However the cost of building a using hollow block brick is only Tk 1150 per square foot. This brick is called engineering brick. Mir Ceramics manufactures this brick. Although it may seem a bit expensive, it is affordable on the other side. Three-hole bricks are being sold at a cost of tk 19500. Size of brick is used in construction of brick size 15.5" x 4"x 7.5" wall plaster is not required. This brick can take vertically more loads than ordinary bricks. They are used extensively in several Asian countries and worldwide, but in Bangladesh, the use of hollow blocks is still limited due to lack of awareness about the product. Concrete hollow blocks are mainly used for their durability, low cost, speed of construction, and eco-friendliness besides others.

H.S. Sureshchandra, G.Sarangapani, and B.G.Naresh Kumar(2014)[1] find out the compressive strength of hollow blocks with partial and full replacement of sand by quarry dust. After replacement he found that 50% replacement of sand gave high strength and 100% replacement of sand gave low strength. Ernesto S. Fortes, Guilherme A. Parsekian, and Fernando S. Fonseca, A.M.(2014)[2] studied the compressive strength of un-grouted, grouted masonry and masonry units. This research work indicate an increase in the compressive strength of the masonry with increasing compressive strength of the units. Liang Huang, Lejia Liao, Libo Yan, S.M. and Hongwei Yi(2014)[3] studied the compressive strength of double H concrete block masonry prisms under uni-axial compression. He discussed the effects of mortar strength, grouting and grout strength effect on compressive strength of the prism. The test result shows that the compressive strength of H block prism decreased with an increase of grouting and the ultimate load of the prisms increased greatly. K. S. Al-Jabri, A. W. Hago,R.Taha, A. S. Alnuaimi and A. H. Al-Saidy (2009) [4] makes the block with waste materials: vermiculite and polystyrene which were used as light weight aggregates and cement kiln dust (CKD) which was the partial replacement for cement. The result shows that the light weight concrete blocks manufactured from polystyrene had low thermal conductivity than vermiculite and ordinary concrete blocks and the addition of up to 15% CKD as cement replacement gives a negligible effect on the strength. Denise S. Sanchez and Lisa R. Feldman(2014)[5] determined that calculated tensile resistance of the reinforcement was greater for bars that were in contact and furthermore is in sensitive to the magnitude of the transverse spacing provided in the case of noncontact lap splices. Thaniya Kaosol (2010)[6] has made study on the reuse of concrete waste as crushed stone for hollow concrete masonry units. The main objective was to increase the value of the concrete waste, to make a sustainable and profitable disposal alternative for the concrete waste. Attempts were made to utilize the concrete waste as crushed stones in the concrete mix to make hollow concrete blocks. Various percentages of crusted stones have been tried the amount (i.e. 0%, 10%, 20%, 50% and 100%). From the results they found concrete waste can used to produce hallow concrete block masonry units. M.K. Maroliya (2012)[7] found that the crack patterns developed in the structural elements such as wall and the strength of wall constructed with hollow concrete block gives the less strength as compared to brick masonry but cost of construction is very less.

Minister for Forests, Environment and Climate Change said that construction of alternate brick blocks and hollow brick production and construction of public buildings are being made compulsory throughout the country to free the country from pollution. **Md.Shahab Uddin.**

He said this at an inter-ministerial meeting on environmental pollution control aimed at conserving the environment held at the Secretariat Ministry on Monday (August 8th).

About 7 million cubic feet of soil is being used to produce about 25 million bricks annually in the country. The production of agricultural land is decreasing due to the construction of bricks using the soil on the top of the agricultural land. Brick kiln is responsible for around 7% of the pollution of Dhaka city. In order to avoid this catastrophic catastrophe, we have to gradually close the old bricks and move on to new methods. Environment and pollution is causing about 100,000 tonnes of coal and brick kilns secretly in the bricks of the country, according to a representative of the Department of Environment. Extensive searching of literature was performed during and prior to study process. High density Concrete blocks are made from normal concrete, and for lower density blocks industrial wastes as aggregate are used. Use of CMU in building work is not novel in our country though it is new in our locality, reason may be same as mentioned above i.e. hike in price of bricks, unavailability of bricks due to huge rain as no soil available for bricks to be moulded, environmental issues etc. CMU in this region are generally produced with a mixture of cement, sand, and crushed stone, or lightweight aggregate. All ingredients in CMU used are not available locally and are transported from distant factories and quarries which results in increased cost of blocks. On the other hand replacement (partially or fully) of standard ingredient with alternative materials has remained active research area since long. In the following summary of research related to the topic is presented.

2.2 Bonding Material (Cement):

A cement is a binder a substance used in construction that sets and hardens and bind other materials together .cements used in construction can be characterized as being either hydraulic or non - hydraulic depending upon the ability of the cement to set in the presence of water (see hydraulic and non-hydraulic lime plaster).non -hydraulic cement will not set conditions or underwater, rather, it sets as it dries and reacts with carbon dioxide in the air. It can be attacked by some aggressive chemicals after setting hydraulic cements (e, g, Portland cement) set and become adhesive due to a chemicals reaction between the dry ingredients and water. The chemical reaction results in mineral hydrates that are not very water- soluble and so quite durable in water or underwater and further protects the hardened material from chemical attack. The chemical Process for hydraulic cement found by ancient romans used volcanic ash (activated aluminium silicates) with lime (calcium oxide) the most important uses of cement are as a component in the production of mortar in masonry, and of concrete, a combination of cement and an aggregate to from a strong building material. The world cement can be traced back to roman term opus crematorium, used to describe masonry resembling modern concrete that was made from crushed rock with burnt lime as binder. The volcanic ash and pulverized brick supplements that, were added to the burnt lime to obtain a hydraulic binder, were later referred to as cemented, and cement. Fluid cement hardness over time. Most concretes used lime -based concretes such as Portland cement concrete or concretes made with other hydraulic cements, such as cement found. however, road surfaces are also a type of concrete asphalt concrete, where the cement material is bitumen, and polymer concrete (and other hydraulic cement concrete), when the aggregate is mixed together with the dry cement and water, they form a fluid mass that is easily moulded into shape. The cement reacts chemically with the water and other ingredients to from a hard matrix which binds all the materials together into a durable stone -like materials that has many uses, often, additives (such as pozzolan or super plasticizers) are included in the mixture to improve the physical properties of the wet mix or the finished material. Most concrete is poured with reinforcing materials (such as rebar) embedded to provide tensile strength, yielding reinforced concrete. famous concrete structures include the hoover dam, the panama canal and the roman pantheon the earliest large-scale user of concrete technology were the ancient roman's ,and concrete was widely used in the roman empire the coliseum was in Rome was built largely of concrete ,and the concrete dome of the pantheon is the world largest unreinforced concrete dome .today ,large concrete structures (example ,dams and multi story care, parks) are usually made with reinforced concreted concrete. Portland cement is the most common type of cement in general use around the world, use us basic ingredient of concrete, mortar, stucco, and most non specialty grout. It was developed from other types of hydraulic lime in England in the mid19th century and usually originates from limestone it is a fine power produced by heating materials in a kiln to form what is called clinker, grinding the clinker and adding small amounts of other materials. Several types of Portland cement are available with most common being called ordinary Portland cement (OPC) which is grey in colour, but a white Portland cement is also available. Portland cement is caustic, so it can cause burns, the powder can cause irritation or with severe exposure lung cancer, and can contain some hazardous components such as crystalline silica and he xavalent chromium. Environmental concrete is the energy consumption required to mine, manufacture, and transport the cement and the related air pollution including the related of greenhouse gases (e, g carbon dioxide 0 dioxin, NOX. SO_2, and particulates. the low cost and widespread availability of the limestone, shale, and other naturally occurring material used in Portland cement make it one of the lowest cost materials widely used over the last century throughout the world. Concrete produced in the world. Concrete produced from Portland cement is one of the most versatile construction materials available in the world. After the Roman Empire collapsed, use of concrete became rare until the technology was developed in the middle 8th century. Today concrete is the most widely used man made material (measured by tonnage) the strength concrete at 7days and correlate to 28-day strength. Numerous research works have provided certain relationships. for instance, construction documents often specify a cement type based on the required performance of the concrete or the placement conditions .certain cement manufacturing plants only produce certain of Portland cement the most general sense, Portland cement is produced by heating sources of lime ,irons ,silica, and alumina ,to clinkering temperature (2500 to 2800 degree Fahrenheit) in a rotating kiln then grinding the clinker to fine power The heating that occurs in the kiln Transforms the raw materials into new chemical compounds. Therefore, the chemical composition of the cement is defined by the mass percentages and composition of the raw sources of line iron ,silica ,and alumina as well as the temperature and duration of heating .it is the variation in raw materials source and the plant specific characteristic, as well as the variation in raw materials source and the plant specific characteristics, as well as the finishing processes (I.e. grinding and possible blending with gypsum, limestone, or supplementary cementing materials), that define the cement produced .chemical test verify the content and composition of cement of cement .with physical testing demonstrates physical criteria, in Cl 501 M 85 and C595/M240, both chemical and physical properties Aare limited oxide analyses

Figure: 1.3 Cement Collecting

($Si0_2$, ca_O, Alo_3, Fe_2o_3 etc.) to allow the cement phase composition to be calculated . to allow the cement phase composition to be calculated type II cement are limited in C150/M85 to a maximum of 8 percent by mass of calcium aluminates (a cement ,phase ,often abbreviated c_3A) which impacts a cement's sulphate resistance .Certain oxides are also themselves limited by specifications :For example ,the magnesia (Mg0) content Which is limited to 6 maximum by weight for Portland cements are: air content ,fineness ,expansion ,strength ,heat of hydration ,and setting time . Most of these physical tests are carried out using mortar of paste created from the Cement. This testing confirms that cement has the ability to Perform well in concrete ingredients ,their quantity ,as well as the environment ,and the handing and placing procedures used .Although the process for cement manufacture is relatively similar across North America and much of the globe, the reference to cement specifications can be different depending on the jurisdiction .In addition test methods can vary as well as ,so that compressive strength requirements (for example) in Europe don't "translate" directly to those in North America .When ordering concrete for construction projects, work with a local concrete producer to verify that cement meeting the requirements for the project environment and application is used, and one that meets the appropriate cement specification.

2.3 Fine Aggregate (Sand):

River sand is obtained from the bank of rivers and River beds. It is usually in white, grey colour and has a very fine quality. River sand is well graded, and it is good for all types of concrete and masonry works. The natural river sand was the cheapest resources of sand. However, the excessive mining of river bed to meet the increasing demand for sand in the construction industry has lead to the ecological imbalance and adversely affecting the environment. The natural river sand was the cheapest resources of sand. However, the excessive mining of river bed to meet the increasing demand for sand in the construction industry has lead to the ecological imbalance and adversely affecting the environment.

Sand is a type of naturally-occurring material that is of a granular, loose, fragmented composition, consisting of particulate matter such as rock, coral, shells, and so on. Sand is typically finer than gravel but coarser than silt. The precise composition of sand varies depending on its source and the conditions prevalent at that location. In in-land continental regions, the predominant constituent of sand is silica (silicon dioxide), typically in the form of quartz. Sand that has been created over millions of years by such things as coral and shellfish is typically aragonite, which is a form of calcium carbonate. Sand is used to provide bulk, strength, and other properties to construction materials like asphalt and concrete. It is also used as a decorative material in landscaping. Specific types of sand are used in the manufacture of glass and as a moulding material for metal casting.

Figure: 1.4 Sylhet and Local Sand

2.4 Water:

Water is the inexpensive important ingredient of concrete. Its basin functions in concrete is to reach with cement to form a binding parse which by penetrating into the minute and multi surface irregularities of sand and whoa, brings them into close adhesion, as in other chemical reactions the cement and water combine in define probation one part but weight of Portland cement requiring, about 0.25 parts by weight for hydration. Concrete containing water in this proportion, would be very dry and should be difficult to place it into the forms. Extra water must therefore be added to lubricate the mix, which is to make it mobile or workable enough to be easily placed into forms. This extra Water however must keep minimum as the use of too much make the concrete weaker in strength. A balanced quantity of water must be determined between too little water and too much water. Water also required in addition to washing aggregates and curing of concrete. The mixing water, washing water must be free from impurities that may lead to weak concrete. The amount of the Recycled Water (RW) used to make the concrete mixes was obtained from a compacted wastewater treatment plant recently constructed in Dubai. The water is treated using the Membrane Bioreactor (MBR) technique which recycles the sewage into water with a relatively high quality makes it reusable. The MBR technique is a process that combines a membrane filtration process and an activated sludge process (Judd 2011; Hi Star Water Solution 2010). The MBR process is used in place of the secondary sedimentation tank where a sand filter is often used for tertiary treatment in the conventional activated sludge process. By adopting simple and high-performance flat sheet type membrane of 0.1m pore size, the MBR system effectively provides space-saving and easy maintenance and operation. In addition to that, the removal of nitrogen and phosphorus can be achieved by anoxic/oxic advanced treatment. The measured chlorides and sulphates contents in the effluent of the MBR process were 92 and

46 ppm, respectively. These values are significantly lower than the allowable limits in EN 1008 (2002) for mixing water used in reinforced concrete, which are 1000 and 2000 ppm, respectively (Table 2). The chlorides and sulphates in the tap water were measured to be 71 and 19 ppm, respectively.

2.5 Course Aggregate (Stone):

The compressive strength of concrete depends on the water to cement ratio, degree of compaction, ratio of cement to aggregate, bond between mortar and aggregate, and grading, shape, strength and size of the aggregate. Concrete can be visualized as a multi-phase composite material made up of three phases; namely the mortar, mortar/aggregate interface, and the coarse aggregate phase. The coarse aggregate in normal concrete are mainly from rock fragments characterised by high strength. Therefore, the aggregate interface is not a limiting factor governing the strength requirement. The onset of failure is manifested by crack growth in the concrete. For normal concrete the crack growth is mainly around the cement paste or at the aggregate/cement paste interfacial zone. The strength of concrete at the interfacial zone essentially depends on the integrity of the cement paste and the nature of the coarse aggregate. This paper reports the result of a research undertaken to investigate the effect of three different types and sizes of coarse aggregate on the compressive strength of normal concrete. The effect of using quartzite, granite, and river gravel as coarse aggregate on the physical properties of concrete was investigated .The outcome of the study revealed that the strength of concrete for a given water/cement ratio depend on the type and size of aggregate. A stone is a piece of rock. It is a mass of hard, compacted mineral. The word "stone" also refers to natural rock as a material, especially a building material. A Natural stone used as building material include granite, marble and sandstone. Manufactured, artificial products, such as concrete or clay bricks, are not stone. Stone takes a while to heat up, and stays hot for a while. It does not conduct electricity well Stone was one of the first materials used to make tools and buildings. It is a very sturdy material. It is less affected by weather than wood or brick. A stone in the river is reshaped by the water and sediment flowing around it. Stones can be used as primitive weapon. Person can throw it at enemy or animal, or use it to make more damage in hand-to-hand combat. A stone is larger than a grain of sand, gravel or pebbles. A boulder is a very large rock or stone. Crushed stone or angular rock is a form of construction aggregate, typically produced by mining a suitable rock deposit and breaking the removed rock down to the desired size using crushers. It is distinct from gravel which is produced by natural processes of weathering and erosion, and typically has a more rounded shape. Various shapes of stones are used in the construction like angular, round. The recycled aggregate (RA) was obtained from a recycling plant for demolition waste in the UAE, where the waste concrete is segregated into different categories and crushed into different sizes. Following Dubai municipality specifications, the aggregate used in this research has particle size of 10 mm. The average measured density and water absorption of the recycled aggregate were 2.51 t/m3 and 5.2%, respectively. Thus it may be classified as Low quality (L) according to Japanese Standards (Tsujino etal 2007). But in general the aggregate used has less dust and slime contamination, is better separated, better classified and particularly free from organic matters (Jungmann and Quindt 1999). This expected to make the results more consistent with less irregularity and scatter.

Figure: 1.5 - 1/2” Down Size Stone

CHAPTER 3

METHODOLOGY

3.1 Introduction:

In this chapter we will discuss about every step of work. The production of concrete blocks consists of four basic processes: mixing, moulding and curing. Some manufacturing plants produce only concrete blocks, while others may produce a wide variety of precast concrete products including blocks, flat paver stones, and decorative landscaping pieces such as lawn edging. Some plants are capable of producing 2,000 or more blocks per hour.

The following steps are commonly used to manufacture concrete blocks.

3.3 Mixing:

First, clean the place of the mixture by cleaning the amount of stone (clean stone) with medium sand, sylhet sand and cement. Mix in such a way that all the ingredients are evenly mixed. Then re-mix the ingredients again with sufficient amount of water but the mixture must be kept neat. We made mixture 1: 2: 3 ratio, for making the hollow block.

Figure: 1.6 Materials Mixing

Figure: 1.7 After Mixing

3.4 Moulding:

At the end of the mixture, clean the mould and fully mould the materials and compact them well (The compactor stand should be tilted until it touches the ground). After the compaction, the mould is shifted to the right and left. It is important to be careful not to rotate the foot. . This time remove the mould and prepare for changing blocks.

Figure: 1.8 Brick Moulding

3.5 Curing:

Curing plays an important role on strength development and durability of concrete. Curing takes place immediately after concrete placing and finishing, and involves maintenance of desired moisture and temperature conditions, both at depth and near the surface, for extended periods of time. Properly cured concrete has an adequate amount of moisture for continued hydration and development of strength, volume stability, resistance to freezing and thawing, and abrasion and scaling resistance.

American Concrete Institute (ACI) Committee 301 recommends a minimum curing period corresponding to concrete attaining 70 percent of the specified compressive strength2. The often specified seven-day curing commonly corresponds to approximately 70 percent of the specified compressive strengths. The 70 percent strength level can be reached sooner when concrete cures at higher temperatures or when certain cement/admixture combinations are used. Similarly, longer time may be needed for different material combinations and/or lower curing temperatures.

Twenty-four hours after making the block, We started curing at least three times a day. Thus, after curing for up to 15 days, the block was properly ready to use.

Figure: 1.9 Block Curing

3.6 Compressive strength:

Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, quality control during production of concrete etc. Compressive strength is the ability of material or structure to carry the loads on its surface without any crack or deflection. A material under compression tends to reduce the size, while in tension, size elongates.

Compressive strength is the capacity of material or structure to resist or withstand under compression. The Compressive strength of a material is determined by the ability of the material to resist failure in the form cracks and fissure. In this test, the push force applied on the both faces of concrete specimen and the maximum compression that concrete bears without failure is noted.

Concrete testing helps us to majorly focus on the Compressive strength of concrete because it helps us to quantify the ability of concrete to resists Compressive stresses among structures where-as other stresses such as axial stresses and tensile stresses are catered by reinforcement and other means. Compressive strength formula for any material is the load applied at the point of failure to the cross-section area of the face on which load was applied.

Compressive Strength = Load / Cross-sectional Area

For compressive tests, we tested four samples of curing seven days, and in the same way we tested four curing samples for fifteen days.

Figure: 1.10 Compressive Strength Test

Figure: 1.11 Compressive Strength Test

3.7 Tensile strength:

The tensile strength of concrete is one of the basic and important properties which greatly affect the extent and size of cracking in structures. Moreover, the concrete is very weak in tension due to its brittle nature. Hence, it is not expected to resist the direct tension. So, concrete develops cracks when tensile forces exceed its tensile strength. Therefore, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack. For the tension test,

we tested four samples of curing seven days, and in the same way we tested four curing samples for fifteen days.

Figure: 1.12 Tensile Strength Test

Figure: 1.13

CHAPTER 4

RESULTS AND DISECUSSION

4.1 Introduction:

Testing of harden concrete plays an important role in controlling and confirming the quality of cement concrete work as per ASTM standard requirement of specification, 15.5”x4”x7.5” size hollow concrete block are tested after curing two different sets containing total number of 16 and hollow concrete block respectively were test. They were differential in terms of the type of coarse aggregate used which in the tables onward. Water cement ratio of .45 and mix proportion of 1:2:3 and by selected during the investigation.

4.1 Results:

The individual hollow concrete block and brick units were tested for compression under universal testing machine and strength values were obtained and compared. The average compressive or crushing strength for hollow concrete blocks of size (15.5”x7.5”x4”) came out to be 1370.55 psi for 15 days and 903.73 psi for 7 days respectively. While as the average compressive or crushing strength of individual brick units of size (9.5” x4.5”x2.75”) comes out to be 1395.22 psi Fig 1.13, Fig 1.14, and Fig 1.15, represents crushing strength of individual hollow concrete blocks of sizes (15.5”x7.5”x4”) and individual traditional brick.

Compressive Strength Test:

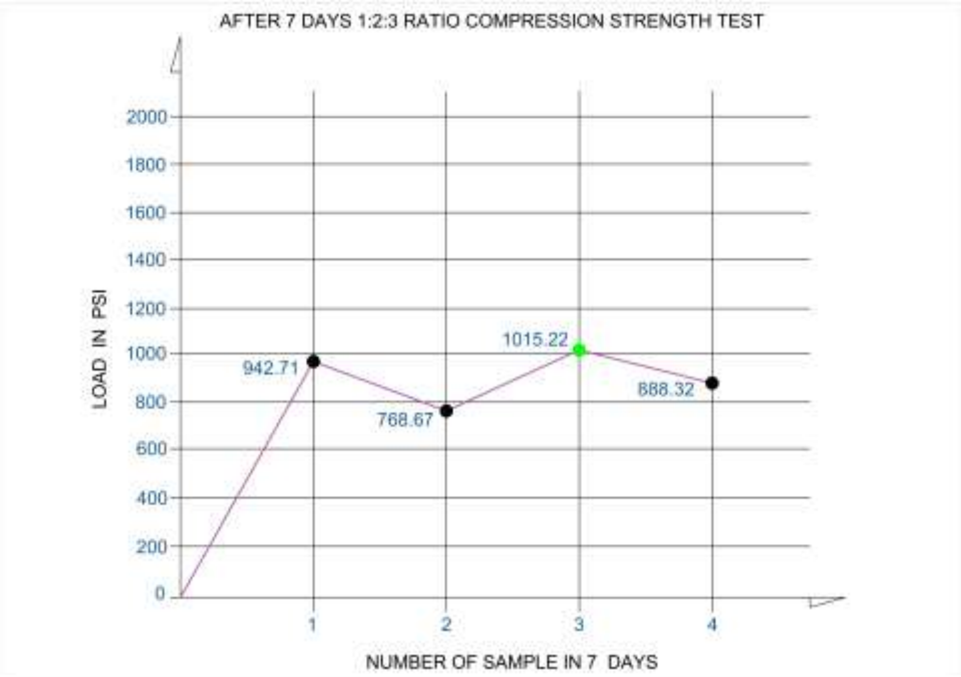


Figure: 1.14 - 7 Days Compressive Strength Test

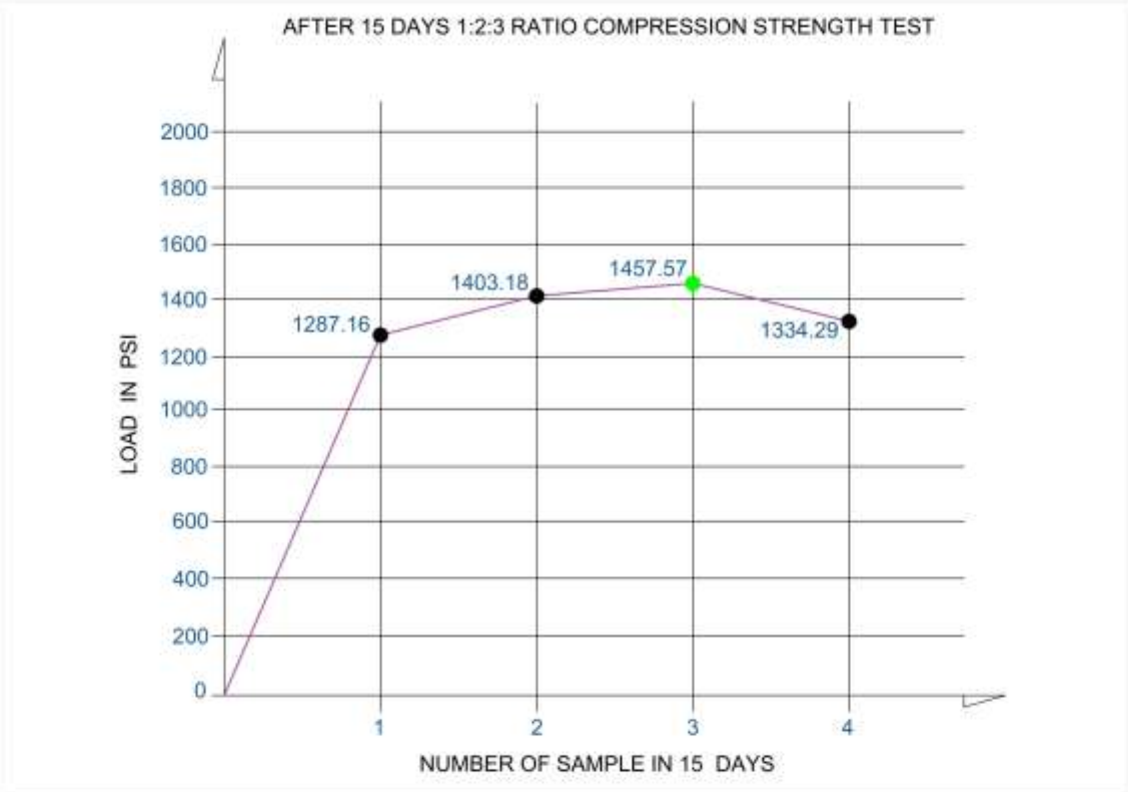


Figure: 1.15 - 15 Days Compressive Strength Test

Tensile Strength Test:

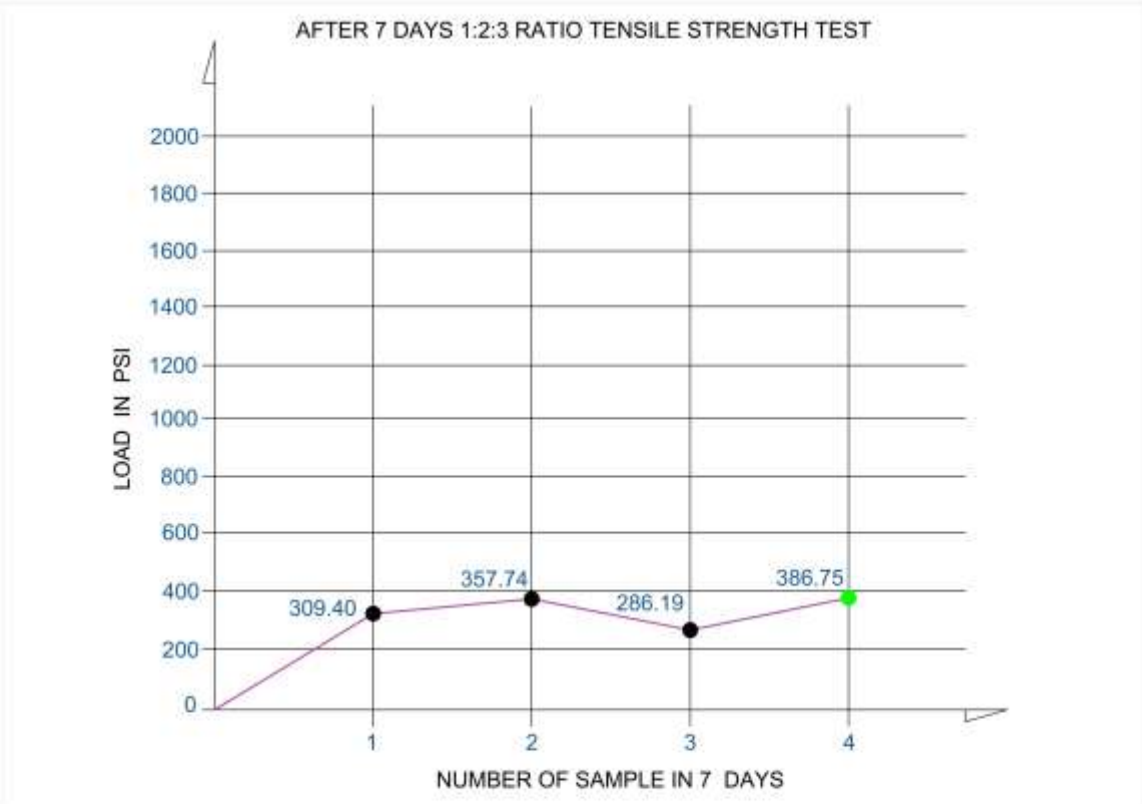


Figure: 1.16 - 7 Days Tensile Strength Test

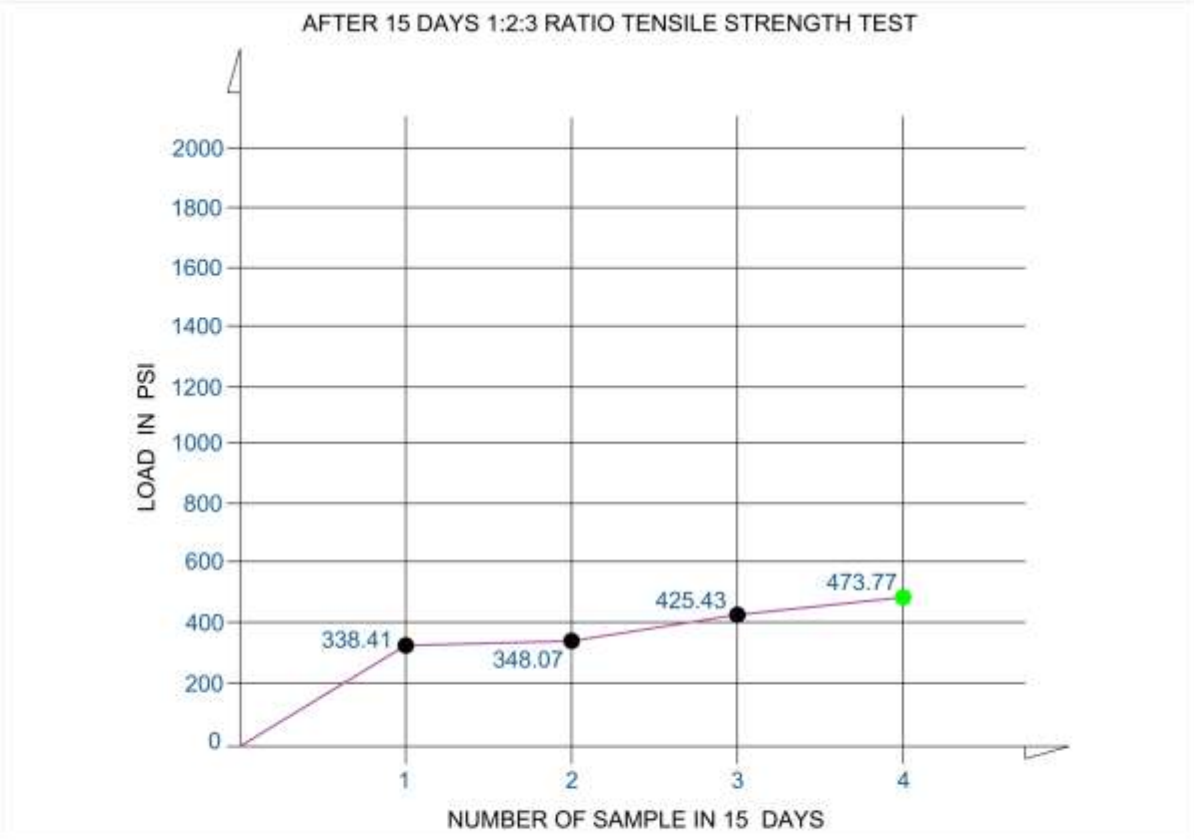


Figure: 1.17 - 15 Days Tensile Strength Test

SL No	Pressure	Days	Unit (psi)	Average strength	Remarks
1	Compression	7	942.71	903.73	
2	Compression	7	768.67		
3	Compression	7	1015.22		
4	Compression	7	888.32		
5	Tension	7	309.4	35.02	
6	Tension	7	357.74		
7	Tension	7	286.19		
8	Tension	7	386.75		

Table: 1 – After 7 Days 1:2:3 Ratio Compressive and Tension Strength Test

SL No	Pressure	Days	Unit (psi)	Average strength	Remarks
1	Compression	15	1287.16	1370.55	
2	Compression	15	1403.18		
3	Compression	15	1457.57		
4	Compression	15	1334.29		
5	Tension	15	338.41	396.42	
6	Tension	15	348.07		
7	Tension	15	425.43		
8	Tension	15	473.77		

Table: 2 – After 15 Days 1:2:3 Ratio Compressive and Tension Strength Test

First Class Brick Compressive Strength Test:

SL No	Pressure	Unit (psi)	Average strength	Remarks
1	Compression	972.82	1006.26	
2	Compression	1068.67		
3	Compression	1395.22		
4	Compression	988.32		

Table: 3 - First Class Brick Compressive Strength Test

4.2 Discussion:

Material Parameters

(a) First class bricks — size 242 mm ×114 mm ×70 mm; compressive strength185 KN

(b) Hollow concrete block — Full size 390 mm ×190 mm ×100 mm, thickness32 mm, and three compartments; compressive strength of 355 – 402 KN (Fig. 1.14).

(c) Cement mortar — mix (1:2:3)

(e) Fine medium sand FM – 1.5 as fine aggregate.

(f) Sylhet sand FM – 2.5 as fine aggregate.

4.3 Advantages:

The block is very useful for building a house. Here are some of the top advantages of using the concrete hollow block in construction.

Highly durable:

One of the major advantages of concrete hollow blocks is their high durability. Concrete hollow blocks are compacted by high pressure and vibration, which make the blocks very strong and able to withstand a high level of loading. They also have high fire resistance and no salinity which reduces their maintenance cost.

Cost-effective:

One concrete hollow block replaces five traditional bricks, and thereby reduces the construction cost. Can be easily plastered and its thickness is half that of ordinary brick. It also decreases the cost of the structural design of the building due to its light weight, which shrinks the size of structural members of both the foundation and superstructure. Hollow block construction also requires less mortar and saves labour hours, reducing both mortar and labour costs.

Speedy construction:

Concrete hollow blocks are easy to install due to their uniform size and shape. They also have less weight which facilitates rapid construction work. Even unskilled laborers can easily work with hollow blocks.

Environment-friendly:

Concrete hollow blocks are very environment-friendly. Unlike traditional brick manufacture, which releases harmful fumes, hollow blocks are machine-made, thus saving our environment. Resistant to noise, heat, fire and moisture. These are also energy efficient building materials because of their insulating properties, thereby reducing energy consumption, and helping to build a green city for the future generations.

Greater earthquake resistance:

Concrete hollow blocks another major advantage of concrete hollow blocks is that they offer superior earthquake resistance. This is owing to their light weight, which reduces the building load significantly. This provides a stable foundation and makes it resilient to natural hazards like earthquakes. Their uniformity also reduces vulnerability during natural disasters giving you a safe haven.

Comfortable interiors:

A building made of concrete hollow blocks provides comfortable interiors due to thermal insulation. The air in the hollow block does not allow outside heat or cold in the building, keeping your home cool in summer and warm in winter. Assist in the work of electrical and plumbing. The size of the room increases to 3-4 sq ft per 4 sq ft. Hollow blocks also make the building soundproof or at least keep the noise at bay due to the hollow nature of the block. Hollow block with its multitude of advantages is an innovative building product which can also be employed for low-cost housing. Brick knitting reduces weight by 5 percent, making it possible for an affordable design. Hollow blocks can be used in the construction of commercial and residential buildings, internal partition walls, and boundary walls, for architectural decoration, and on the rooftop for heat protection.

4.4 Disadvantages:

There are some disadvantages of concrete block foundations. The major ones are listed below.

People take short-cuts and not fill every block with mortar. By taking this short-cut, the integrity of the foundation is compromised and the structure is relatively weak. The mortar that is used to adhere the blocks together will crumble and disintegrate over time. Leaks are a direct result and must be dealt with as soon as they are detected. High maintenance costs for block foundations. Mortar must constantly be monitored and blocks must be sealed every so often to ensure that no leaks occur. Concrete blocks can be expensive. Concrete blocks are typically two to three times more expensive than wood construction. When the use of hollow block concrete brick will increase everywhere then the cement production will increase.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATION

5.1Conclusions:

Hollow concrete block is an important addition to the types of masonry units available to designer and engineer and its use in masonry construction is constantly increasing due to the various advantages discussed above. Since there is a lack of a ware ness regarding usage of hollow concrete blocks in masonry, this research will enable the engineers and builders to go for hollow concrete block masonry construction on a large scale where ever it is economical. There are lots of advantages of hollow block concrete bricks. Such as:

- Being light in weight Hollow Block Concrete Brick provide economy in design of sub-structure due to reduction of the loads.
- Laying of blocks saves mortar as compared with ordinary brick work. There is saving in mortar plaster work too.
- Cavity of blocks helps achieving insulation of walls and provides energy saving for all times. Hollowness results in sound insulation.
- There is no problem of appearance of salts thereby saving in maintenance of final finishes to the walls.
- Laying of blocks is much quicker as compared to brick work hence, saving in time
- Hollow Block Concrete Brick are environmentally eco-friendly.
- Factor of safety Hollow Block Concrete Brick masonry is more than brick masonry.
- Load Bearing, strength can be specified as per the requirement.
- Highly Durable: The good concrete compacted by high pressure and vibration gives substantial
  strength to the block. Proper curing increase compressive strength of the blocks.
- Low Maintenance, Color and brilliance of masonry withstands outdoor elements.
- Load Bearing, strength can be specified as per the requirement.
- Fire Resistant
- Provide thermal and sound insulation: The air in hollow of the block, does not allow outside heat or cold in the house. So it keeps house cool in summer and warm in winter.
- Economical
- Environment Friendly, fly ash used as one of the raw materials.

- Low insurance rates
- **Structural Advantages:**

  ➢ In this construction system, structurally, each wall and slab behaves as a shear wall and a diaphragm respectively, reducing the vulnerability of disastrous damage to the structure/building, during the natural hazards.

  ➢ Due to the uniform distribution of reinforcement in both vertical and horizontal directions, through each masonry element, increased tensile resistance and ductile behaviour of elements could be achieved. Hence, this construction system can safely resist lateral or cyclic loading, when compared to other conventional masonry construction systems. This construction system has also been proved to offer better resistance under dynamic loading, when compared to other conventional systems of construction.

  Constructional Advantages:

  ➢ No additional formwork or any special construction machinery is required for reinforcing the hollow block masonry.

  ➢ Only semi-skilled labour is required for this type of construction.

  ➢ It is a faster and easier construction system, when compared to the other conventional construction systems.

  ➢ It is also found to be a cost-effective disaster resistant construction system.

- **Architectural and Other Advantages**

  ➢ This construction system provides better acoustic and thermal insulation for the building.

  ➢ This system is durable and maintenance free.

  ➢ Reduction in Dead Load

  ➢ Reduced Air Conducting Load: - Approx.50% saving.

  ➢ No salt peter or leaching: - Reduction in maintenance.

  ➢ Increased carpet area: - Due to smaller in size.

  ➢ Faster construction: - Easy to work with bigger in size.

  ➢ Assured Quality: - Fully automatic block plant.

  ➢ Better sound absorption: - Being hollow in nature.

  ➢ Reduced thickness of plaster: - Due to size accuracy & less cement consumption due to fewer joints.

- Load bearing walls: - Due to higher strength of blocks.
- Recommended for earth quake resistance.
- Less water absorption:- Approx. 3 to 4%
- Environmental Eco-Friendly
- Reduce in total cost of project: - Being less dead load of walls.

5.6Recommendations:

The hollow block concrete brick masonry is somewhat ductile than brick masonry,for good insight and better results following suggestions are made when used with reinforcement,(as a reinforcement we can use various metal fibers with the mixer) it may be stronger than brick masonry, different mix ratios may be evaluated, impact of different water cement ratios may be checked, different washing techniques may be incorporated to wash the local sand and its effect on the final strength.

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Table: 3 - First Class Brick Compressive Strength Test

List of Graphs

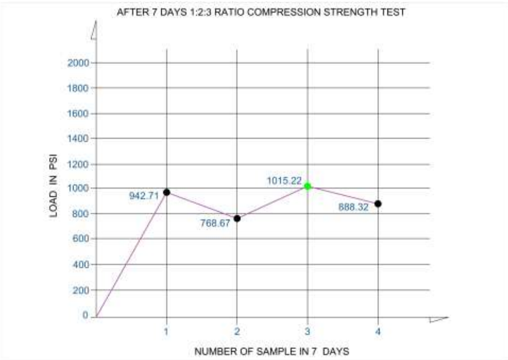

Figure: 1.14 - 7 Days Compressive Strength Test

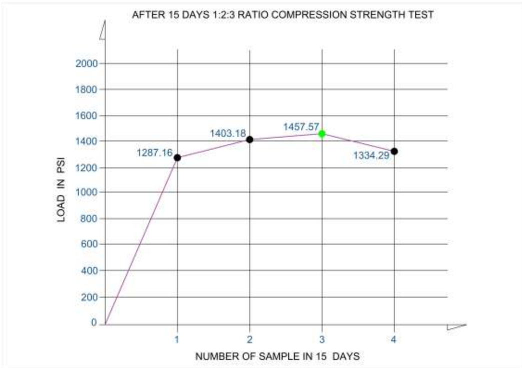

Figure: 1.15 - 15 Days Compressive Strength Test

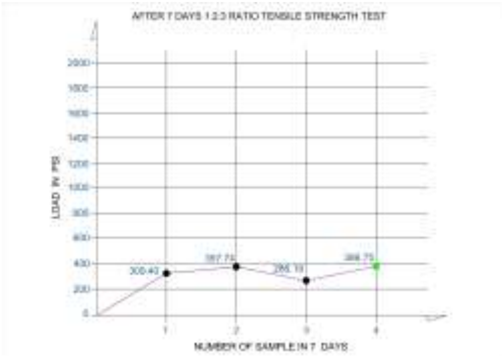

Figure: 1.16 - 7 Days Tensile Strength Test

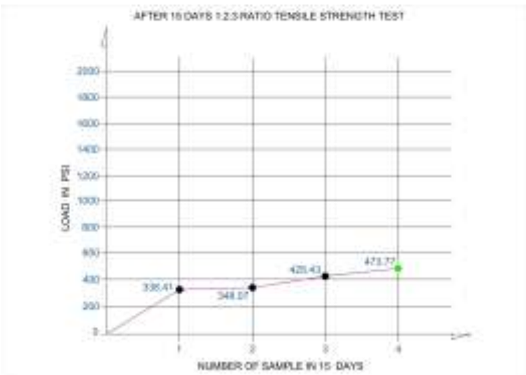

Figure: 1.17 - 15 Days Tensile Strength Test

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