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Study and Development of Thermal Block: Perspective of Housing and Building Research Institute (HBRI)

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ABSTRACT

To develop a type of concrete block which can serve as a thermal and sound insulator is the main purpose of this study. Expanded polystyrene (EPS) was selected as an insulating materials and to protect the EPS from external effect it was covered with sand-cement mortar. As EPS can withstand against a very little amount of compressive force so rich cement mortar is being used. The block was casted in a simple mold and de-molded after 24 hours. Then it was tested followed by specified days of curing. Through this study, economic proportion of sand-cement mortar and usability of strength achieving admixture was investigated and it was found that 1:3 cement mortars with admixture gives satisfactory results regarding durability and strength. The water absorption of thermal block is four times less than the traditional burnt clay brick.

Keywords: *Thermal Block, Expanded polystyrene (EPS), Alternative Building material, Sustainable, Non Fired Brick.*

INTRODUCTION

Brick is the main building material for the construction, which has been growing at about 5.6 percent annually between 1995 and 2005, leading to an estimated growth rate of 2–3 percent for the brick sector [1].

Annually about 17.2 billion burnt clay bricks are produced allover Bangladesh whose output value is about Tk. 83 billion[2]. With about 5,000 operating kilns, brick-making is a significant sector in Bangladesh, contributing about 1% to the country‘s Gross Domestic Product (GDP) and generating employment for about 1 million people[3].These vast amounts of clay bricks consume 45 million tons of clay, 3.5 million tons of coal and 2 million tons of fire wood.

Fixed Chimney Kiln (FCK) has influence over the brick industry in Bangladesh, even though it’s massive polluting and energy-intensive features[2]. Most operating kilns consume about 18–22 tons of coal to produce 100,000 bricks[3].Kilns which burn coal release pollutants into the surrounding atmosphere, leading to detrimental effects on agricultural yields and health. Which also leads to global warming and climate change? Annually 9.8 million tons of CO_2 is emitted due to the burning of bricks in Bangladesh[3]. Also, the clay is being collected from agricultural land. Research indicates that around 45 million tons of clay is being consumed by the brick sector in this country in each year[2, 4]. If these processes continue, our food security will be in danger very soon. Considering above facts Housing and Building Research Institute (HBRI) has taken a number of research programs regarding alternative to burnt clay bricks. Thermal block is one of them. The thermal block is a type of concrete block where expanded polystyrene is used to increase the thermal resistant properties of the block and to lighten the gross block weight[5]. Cement mortar is casted over EPS and cured for specified period. As there is no need to burn anything so this block will be environment friendly, sustainable, and cost effective. The wall made of this block will provide comfortable indoor environment both in summer and winter. Due to its lightweight characteristics this will save structural cost, uses of this block in multi-storied buildings will be suitable in earth quake.

LITERATURE REVIEW

Extensive searching of literature was performed during and prior to study process. A handful amount of literature is existed on thermal blocks. Thermal 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[6], a well-established institute in Middle Eastern region. In some cases, we modified some parameter due to the local condition, especially in the case of materials used.

Concrete

Concrete, which is a combination of water, aggregate, and cement? Frequently, additives and reinforcements are added in the mixture to attain the desired physical property of the finished material[7]. A fluid is formed when these ingredients are mixed together, which is easily molded into shape. A durable stone-like material is formed over time, when the cement forms a hard matrix which binds the rest of the materials together into one. To make thermal bricks in this laboratory, Ordinary Portland Cement (OPC) is used with coarse grained sand collected from Sylhet. Different engineering characteristics both for cement and sand were determined prior to cast the thermal block. Water reducing and strengthening admixture (Daracem® Superplasticiser) was also used for another set of sample.

Expanded Polystyrene (EPS)

Expanded Polystyrene (EPS) has insulation property and has a shape of course, closed cells containing air. Expansion is attained by the help of small amount of pentene gas dissolved into the polystyrene base material during manufacturing process[8].

Expanded Polystyrene used for insulation or packaging. It is lightweight, versatile, sanitary, energy efficient, and most importantly it has cheap price rate. For practical civil engineering application EPS densities varies between 0.69~1.87 lb/ft3 (11~30kg/m3). For insulation EPS with higher densities are more efficient[9]. In our test EPS25 having density 1.56 lb/ft3 (25kg/m3) from Advanced Development Technologies Ltd. was used.

PROPERTIES OF MATERIALS

Cement

The cement used for our research work was collected from local market. Different tests were conducted on this cement to obtain its properties. The test results are summarized in table 1.

Table1. *Properties of cement*

SL	Test Conducted	Test Result
1	Normal consistency	25%
2	Initial Setting Time	135 Min
3	Final setting Time	185 Min
4	Compressive Strength	3 Days- 1986 psi
		7 Days- 2990 psi
		28 Days- 4142 psi
5	Tensile Strength	---
6	Fineness	99.4% passing in #100 US sieve
7	Specific Gravity	3.14

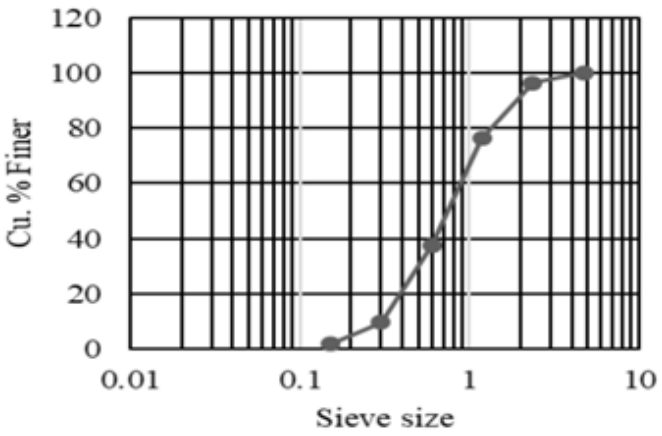

Figure1. *Seive size vs % finer curve of "Sylhet- Sand"*

Sand

In Bangladesh two types of sands are commonly used. Locally available sand collected from different rivers. Fineness modulus of finer sands varies from 1.5 to 2.2. Building designers recommended that sands having high FM are suitable for structural construction [10]. This is only used in non-bearing partition wall plastering works and construction. Other type of sand is "Sylhet-Sand" collected from hilly rivers of Sylhet. This sand is coarser and its size is more consistent than other types of sand. Its FM varies from 2.3 to 2.9. In this case, clean "Sylhet-Sand" is being used, its FM was 2.79. Figure 1 shows the sieve size vs percent finer curve of "Sylhet-Sand".

PREPARATION OF THERMAL BLOCK

Full-size (4'X8') EPS panel collected from factory is first cut into small sizes to make thermal blocks. After proper sizing and grooving, EPS pieces are placed into the steel mould. The moulds are rectangular steel box open in one side.

Cement mortar is then placed in the gap between the mould wall and EPS. These are de-molded after 24 hours and then blocks are kept for curing. The blocks can be used after 28 days of proper curing with water. The complete process of making thermal blocks can be best described by the figure 2.

Figure2. *Making process of thermal blocks*

Table2. *Compressive strength of different sample*

SL	Cement used (% of Mix)	Admixture Used (% of Cement)	Curing Age (Days)		
			7	14	28
			Compressive Strength (psi)		
1	50	0%	830	981	1189
2	50	1%	986	1145	1350
3	33	0%	755	839	1056
4	33	1%	820	1000	1228
5	25	0%	620	780	945
6	25	1%	760	820	1080
7	20	0%	562	700	836
8	20	1%	600	765	865

TEST PROGRAM

Compressive strength of thermal block was tested in accordance with Appendix B of BS 6073: Part 2[11] of five samples. Average result based on the gross area of the thermal block of each test was considered for the particular proportion. Compressive strength of 7 days, 14 days, and 28 days were measured for each set of sample. Water absorption test of thermal block was done after 28 days of water curing and 14

days of air curing following the water curing period. The test was performed in accordance with ASTM C20-00 & ASTM C1763-16 Standard [12, 13]. The percentage of water absorption by thermal blocks of different proportion was calculated for the gross weight of the blocks. Besides water absorption test of burnt clay bricks randomly collected from local market was done to compare the water absorption characteristics of two types of blocks/bricks. The test result is presented in later sections.

Test Result and Discussion

Compressive Strength Test

Results of compressive strength test are presented in the table 2. It is observed that the compressive strength of the tested thermal block increased with increasing cement content. Also, the compressive strength was considerably higher of the sample containing admixture (1% of cement used) although the proportion of cement is the same. The discrete data can be best understood by the figure 3 & 4 which compared the result of compressive strength test with different proportion of cement and admixture used.

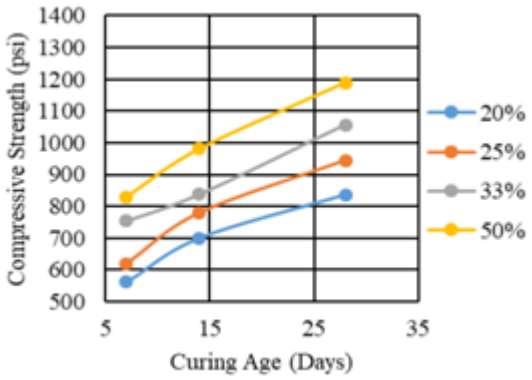

Figure3. *Thermal block without admixture*

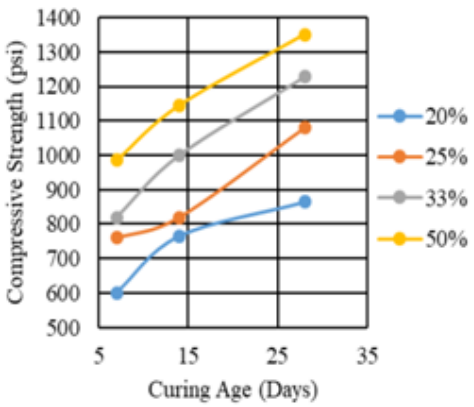

Figure4. *Thermal block with admixture*

From the figure 3 and table 2 we observe that for the sample without any admixture used, 28 days compressive strength increases by 13%, 26%, and 42%when cement content is increased to 25%, 33%, and 50% respectively. Almost similar phenomena occur in the case of the sample in which admixture is used. In this case the increasing amount is 24%, 42%, and 56%when cement content is increased to 25%, 33%, and 50% respectively (Figure 4).

We see the increasing rate in sample with admixture is higher than the sample without admixture. Almost same result can be obtained from 33% cement with admixture and 50% cement without admixture use. To understand the phenomena more clearly let us examine the figure 5.

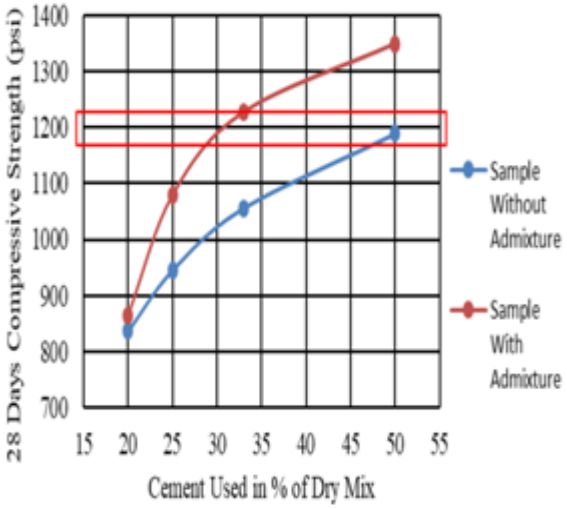

Figure5. *28 days Compressive Strength vs % of Cement used curve*

In figure 5 we see the compressive strength of thermal block having 50% cement without any admixture is almost same (1200psi) as that of the block having around 33% cement with admixture (1% of cement). Also, that compressive strength (1200 psi) satisfy the Dubai Municipality Standards [6].

Water Absorption Test

Water absorption test result of the thermal block and burnt clay bricks are presented in the figure 6. Ten samples from two different groups were tested as per ASTM standard. Different sample was taken from different proportion of cement and admixture used.

The result in the chart shows that that the absorption range for thermal block varies 3.9%to 5.8% where the range for traditional burnt brick varies from 16.8% to 26.2%.

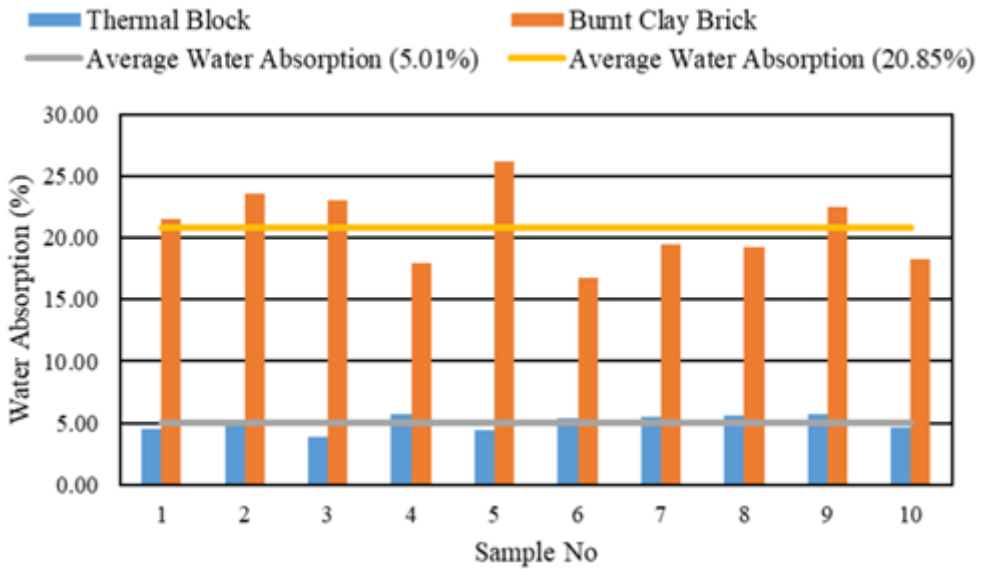

Figure6. *Water Absorption of Burnt Clay Brick and Thermal Brick*

CONCLUSIONS

From the test result and related literature study following conclusions can be drawn for the feasibility of the study on the thermal block. As saving agricultural topsoil from the aggression of brickfields is our supreme priority. So, we must find the alternative to burnt clay bricks. Considering compressive strength and water absorption thermal block can be a good alternative to burnt clay bricks to construct non-load bearing walls. These thermal blocks are 50% lower in weight compared to burnt clay bricks. Usage of the thermal block in high-rise building may help to consider less dead load in the structural compare to conventional structure in which burnt bricks have been used. Using admixture in the manufacturing of thermal block can save up to 34% of cement consumption without compromising the standard compressive strength. At present thermal blocks are cast manually.

It involves cutting the EPS sheet in pieces with groove, casting the mortar, molding and de-molding, etc. This article solely investigates the material property of the manufacture thermal block so the price of the thermal block is not incorporated in this article. But it is clear that initially cost per piece of the thermal block is little higher than locally available burnt clay bricks. Once the industrial process is adopted hopefully the cost per piece will be below the price of burnt clay bricks.

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