PROPERTIES OF ALTERNATIVE BUILDING BLOCK MADE OF EXPANDED POLYESTYRENE (EPS) BEADS

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Dedicated

To

OUR PARENTS AND TEACHERS

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ABSTRACT

Environment pollution is the most concerned issue in today's world. Construction Industries is one of the largest sectors to pollute the environment. In Bangladesh, burnt clay block is the most commonly used building material which produce a significant amount of greenhouse gasses. For a better environment, alternative sustainable building material is a must. This study appraises alternative building materials and technologies as a walling material. Burnt clay block have been used for long in building construction and its demand is increasing rapidly with the passage of time. In the burning process of clay block air is polluted and necessary clay is collected from agricultural land. As a result, agricultural land is being diminished. So alternative building block can be the possible solution of the disadvantages of burnt clay block. In this thesis project we completed using 0% EPS Beads, 5% EPS Beads, 10% and 15% EPS Beads respectively. And here is also added admixture for compressive strength. EPS was used as partial aggregate replacement of volume in the mixes. Bricks of 9.5inch x 4.5inch x 2.75 inches in size were prepared in this study. The engineering properties of the bricks were investigated. Among the properties studied were hardened concrete density, compressive strength and water absorption of the EPS concrete bricks. Four types of curing conditions were employed in this study. These include full water curing, air dry curing,3-day curing and 28-day curing. The water absorption of block with EPS beads and admixture 0%, 5%, 10% and 15% EPS beads are 6.7%, 7.2%,7.7% and 7.0% respectively. On the other side water absorption of block with EPS beads and without admixture 0%, 5%,10% and 15% EPS beads are 5.1%, 6.2%,6.6% and 5.9% respectively .This Values are less than the absorption of clay brick. It was found that in the 0%, 5%,10% and 15% EPS beads with admixture are 3172psi, 3417psi, 3470psi and 2885 psi respectively. Here 0% and 15% EPS beads are less then clay block with 3300 psi on the other hand 5% and 10% are more then clay block in compressive strength. The minimum compressive strength of block is 1500 psi. So in construction using block from EPS beads with admixture is better than other types.

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CHAPTER 1

INTRODUCTION

Background

In this project we used EPS beads in block. With increasing construction activities, the demand of raw materials for concrete is at its peak. Since the dead load of concrete is very high because of high density (2400 kg/m3), thereby load on the structure increases. To reduce this dead load, there is need of lightweight concrete. This lightweight concrete can be used in non-structural members like wall panels, etc to reduce the dead load of structure. The lightweight concrete can be can be made by replacing standard aggregates with lighter materials. The coarse aggregates are replaced by volume by Expanded Polystyrene EPS beads. EPS beads are used for packaging of goods for easy handling and transportation. Since, EPS is lightweight, non-biodegradable, hydrophobic and chemically inert in nature, and also have good thermal and sound insulation; it can be used as a low cost replacement of the coarse aggregates for the light weight concrete.

EPS beads are widely consumed by the Ready-mix manufacturers for light weight screed production, which has remarkable characteristics of thermal cum acoustic properties used by the construction industries. EPS beads are mixed with concrete to increase its thermal rating and reduce its weight per cubic meter, which results in significant saving in structural cost.

The objectives of this studies are as follows:

i. To produce lightweight building block with more sustainably.
ii. To investigate the physical and mechanical properties of the block.
iii. To reduce environment pollution and
iv. To encourage the people to use alternate block.

1.1.1 Brick kilns top polluter in Bangladesh :

Brick kilns are the top air polluter in seven major cities in the country, particularly during dry season when most bricks are made, turning the air quality of these metropolises “severely unhealthy”.

Also to blame are construction work that kicks up dust, poorly-maintained vehicles that emit excessive harmful particles and toxic gases, and industrial air pollution, according to the Department of Environment (DoE).

A five-year survey by the department found Narayanganj has the most polluted air, followed by Dhaka. Third is Gazipur, which is followed by Rajshahi, Chattogram, Khulna, and Barisal. The air in Sylhet city, however, is cleaner.

Figure1.1Brick kilns top polluter in Bangladesh

1.1.2Agriculture land is cut by cutting soil and brick kiln

Several brick kilns, set up on farmland or close to educational institution, destroying fertility of vast agricultural land in the district.

Moreover, toxic gas from the brick kilns are posing serious health risk to students of different schools close to the brick kilns as well as local residents.

Figure1.2Agriculture land is cut by cutting soil and brick kilin

1.1.3 Significance of Research

With the rapid development and technological increase, the need of substitutes for aggregate in concrete has increased. Day by day new materials are being used as replacement of aggregates in concrete construction such as expanded glass, expanded polystyrene beads, etc. A result has to be calculated by taking EPS beads and various tests have conducted on it after 28 days respectively to measure the properties of light weight concrete blocks. Lightweight concretes (LWCs) can be used in various construction fields. EPS beads can be used to produce low density concretes required for building applications like cladding panels, Partition walls, composite flooring system and load bearing concrete blocks. At present, Bangladesh government is encouraging to use alternative building blocks instead of burnt clay bricks in all government project. In the construction process of these blocks no smoke is produced of these blocks no smoke is produced and huge amount of energy can be saved required for cooling purpose. To satisfy the green building requirements and promoting sustainable development ,these blocks may be use in Bangladesh.

1.1.4 Objectives

EPS beads can be used to produce low density concretes required for building applications like cladding panels, curtain walls, composite flooring system, and load bearing concrete blocks.

Organization of Thesis

The layout of the thesis is written through five chapters in the following sequence. Chapter One deals with the importance, objectives and significances of the research in a comprehensive style. The first chapter is the introduction to our work. Chapter Two is literature review which includes the definition of thermal insulation, advantages of thermal insulation, some common materials used for thermal insulation, Previous studies on alternate building block having thermal insulation property. Chapter Three contains Methodology and Experimental Program, Mix Design, Density, absorption and compressive strength of EPS beads block . Chapter Four contains the experimental results along with the data, figure and graphs obtained from the laboratory tests and discussions on the test results. Chapter Five describes conclusion of the research work and recommendation for further research.

CHAPTER 2

LITERATURE REVIEW

General

Alternative building block is necessary because traditional burnt clay brick having much weight produce smoke in construction process which pollutes the environment and necessary clay is collected from agricultural top soil. This practice is diminishing the agricultural land. The lightweight building blocks produced by EPS beads with admixture can be used as alternative building material in Bangladesh. These blocks are lighter and having good thermal insulation property as EPS is a good heat insulator. Heat Insulation is very important factor for the comfort of people living in residential building. Wall made from these blocks can reduce the inner house temperature. As a whole, these blocks are economical, less energy intensive, fire resistant, environment-friendly and recommended for earthquake resilient buildings.

Sand Cement Hollow Block

A Sand Cement block is one of several precast concrete products used in construction. Hollow block helps in saving construction materials and therefore use of hollow block reduces construction cost. Use of larger size concrete block reduces number of joints in work and hence helps in saving mortar. Sand Cement Hollow block masonry can safely with stand the atmospheric action and it requires no protective covering. Hollow block have good insulating properties against sound, heat and dampness. Presence of rough surface on blocks provides good bonding of mortar and plaster.[3]

Figure 2.1. Hollow Concrete Block (Md. Akhter Hossain Sarker, 2018)

Auto Claved Aerated Concrete

Autoclaved Aerated Concrete is a lightweight, precast, foam concrete building material suitable for producing concrete masonry unit (CMU) like blocks. Composed of quartz sand, calcined gypsum, lime, cement, water and aluminum powder, AAC products are cured under heat and pressure in an autoclave.

Figure 2.2 Autoclaved Aerated Concrete Block (Md. Akhter Hossain Sarker, 2018)

Compressed Stabilized Earth Block (CSEB)

Housing and Building Research Institute has produced CSEB from the dredged soil of river mixing with proportionate cement. The production cost of CSEB is near about half of the conventional burnt brick.

Figure 2.3 Compressed Stabilized Earth Block (CSEB) (Md. Akhter Hossain Sarker, 2018)

Interlocking Block CSEB

These types of blocks are prepared with proportionate mixing of dredged soil from river with cement and sand. It is possible to prepare wall without any mortar due to its' interlocking mechanism.

Figure 2.4 Interlocking Compressed Stabilized Earth Block (Md. Akhter Hossain Sarker, 2018)

Thermal Block

Thermal block is produced using Sheet with both side mortar. The advantage of thermal Block is that it has good thermal and sound insulation properties. Moreover, the weight of the block is almost half of the traditional or fire brick

Figure 2.5 Thermal Block (Md. Akhter Hossain Sarker, 2018)

Bjørn Petter Jelle concluded that nowadays there exist no single thermal insulation material which can satisfy thermal conductivity, perforation vulnerability, building site adaptability

APPLICATION OF ALTERNATIVE LIGHTWEIGHT BUILDING MATERIAL:

The burnt clay bricks are used in Bangladesh's traditional buildings for the infill and Reinforced Cement Concrete frame structures. Under the study project the researcher try to establish CSEB, Hollow Block, Thermal Block and others material as an infill wall material.

Figure 2.6 : Model House-II using Compressed Stabilized Earth Block and Thermal Block at HBRI campus

Use of Interlocking, Compressed Stabilized Earth Block (CSEB)

To find out the performance of interlocking block, HBRI has taken initiatives to complete a one storied building within an area of about 320sft. The successful implication of interlocking bricks can be proved to be an exceptional substitute to burnt clay bricks.

Figure 2.7: Model house-I with interlocking blocks

Use of Hollow Block

HBRI has Constructed a two stories Building using alternative building material at HBRI campus. Sand Cement Hollow blocks are used in the Model House. The Total area of the building is about 1300 square ft.

Use of Thermal Block

Two Model House has been constructed at HBRI campus under the study project. Thermal block are used in the second story of the Building. The Performance of the Block is pretty well. Another advantage of using thermal block is the properties of thermal and sound in solation.

Significance of Research:

Properly informing to the building owners and developers about alternative lightweight building blocks produced by EPS beads and mortar. The EPS beads are lightweight and having good thermal insulation property. At present, Bangladesh government is encouraging to use alternative building blocks instead of polluter burnt clay bricks in the government project. These blocks are the best solution in this situation. In the construction process of these blocks no smoke is produced and huge amount of energy can be saved required for cooling purposes. To satisfy green building requirements and promoting sustainable development. The government should take steps to produce the block more and more.[2]

CHAPTER 3

METHODOLOGY AND EXPERIMENTAL PROGRAMME

3.1 MATERIALS

Cement: Ordinary Portland Cement (Type I) was used which is locally available and its specific gravity is 3.15.

Sand: Sylhet sand was used for producing lightweight building block for performing compressive strength test.

Expanded-polystyrene beads:
one of the industrial solid waste that having serious problem for disposal. The world today has concern in environmental issue, the problem to accumulate of unmanaged solid waste. The is not a biodegradable type; it will not provide an environmental friendly solution to landfills. In increase concern for environmental issues, the sustainable development and energy conservation concept has become paramount importance.Many light weight, low strength materials with density between (16-27) kg/m3 and good energy absorbing characteristics. It is well known for its good thermal and acoustic insulation properties leading mainly to non-structural applications including precast roof and wall panels and lightweight infill blocks. It also in the way to reduce the density of the bricks, as well in improving thermal insulation properties, there forms the light weight brick innovation.[6]

Admixture: This Admixture is specially used for producing compressive strength which is available in local market. Although this admixture is used for other purpose also damp proofing and quick setting but here is used for producing strength.

The purpose of admixture: Producers use admixtures primarily to reduce the cost of concrete construction; to modify the properties of hardened concrete; to ensure the quality of concrete during mixing, transporting, placing, and curing; and to overcome certain emergencies during concrete operations.

Admixture in concrete: Concrete admixtures are natural or manufactured chemicals or additives added during concrete mixing to enhance specific properties of the fresh or hardened concrete, such as work ability, durability, or early and final strength.

Types of admixtures are used in concrete

- Type A: Water-reducing admixtures.
- Type B: Retarding admixtures.
- Type C: Accelerating admixtures.
- Type D: Water-reducing and retarding admixtures.
- Type E: Water-reducing and accelerating admixtures.
- Type F: Water-reducing, high range admixtures.
- Type G: Water-reducing, high range, and retarding admixtures.

Reason to use Admixture in the project:

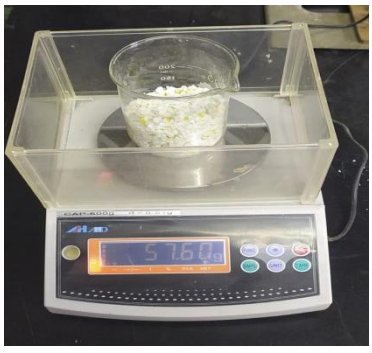
Producers use admixtures primarily to reduce the cost of concrete construction; to modify the properties of hardened concrete; to ensure the quality of concrete during mixing.

Figure:3.1 Admixture (Vitalia Neo)

(a). Cement

(b). Sand

(c).Admixture



(d). EPS Beada

Figure 3.2 Materials used in this Project

3.2 DETERMINATION OF MATERIAL PROPERTIES

3.2.1 Unit Weight: The unit weight is the weight per unit volume of a material. The symbol of unit weight is γ. A commonly used value is the unit weight of water on Earth at 4°C, which is 9.807 kN/m³ or 62.43 lbf/ft³. The terms specific gravity, and less often specific weight, are also used for relative density Determination of the unit weight of coarse and fine aggregates in a compacted condition. ASTM Test Method C 29 represents unit weight in a compacted or loose condition and calculation of voids in fine, or coarse aggregates. It is essential for selecting proportions for concrete mixtures.

3.2.2 Fineness Modulus: The Fineness modulus is an empirical figure obtained by adding the total percentage of the sample of an aggregate retained on each of a specified series of sieves, and dividing the sum by 100. Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates (ASTM C 125, C 136) was used to determine fineness modulus of fine aggregates.[4]

3.3 PREPARATION OF MIX DESIGN

Reparation of mix Design

Specie id	Water (Lt/m³)	Cement (Kg/m³)	Sand (Kg/m³)	EPS Buds (Gram)	Admixture(200ml/50kg cement)(ML)
NWC	0.72	1.440	1540	0	0
0% EPS Block	1.5	3.065	10.014	0	12.24
5% EPS Block	1.45	2.907	9.512	3.55	11.628
10% EPS Block	1.371	2.754	9.013	6.69	11.016
15% EPS	1.3	2.601	8.512	10.05	10.404

3.3.1 Mixing procedures:

For relatively less amount of mortar required manual hand mix procedure was used for mixing Concrete. All the constituent materials were collected and weighed properly. The weighted materials were taken in a pan and mixing process was completed. The manual mixing process is shown in Figure 3.3.

Figure 3.3 Manual mixing

3.5 PREPARATION OF THE SPECIMENS

3.5.1 Casting of Block of EPS Beads Types of Building Block

For performing compressive strength, density, water absorption and 8 types of building block were produced, 4 types using admixture and other 4 types without admixture. The size of the block was 9.5” X 4.5” X 2.75” which is same as burnt clay brick. The number each Type of block cased was 03. The total number of block produced was 24. Here 12 blocks are made with 0% EPS Beads, 5% EPS Beads, 10% EPS Beads and 15% EPS Beads respectively, and the remaining 12 blocks are 0% EPS Beads, 5% EPS Beads, 10% EPS Beads and 15% EPS Beads admixture and Burnt clay block was collected the worked in the figure 3.4. For making block lightweight and thermally insulated used in one type and EPS Beads was used in another type of block. All the specimens are shown in figure 3.5.

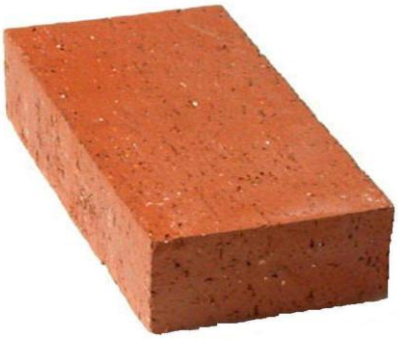


Figure 3.4 Burnt Clay block

(a)Mold

(b) casting

Figure:3.5 EPS Beads Blocks

Figure:3.6 EPS Beads Blocks with Admixture

Determination of Compressive Strength

Compressive strength test of bricks are performed according to ASTM C67-03 to determine the load carrying capacity of bricks under compression with the help of compression testing machine. This is one of the most important and significant properties of building block. In this report the compressive strength of different types of building block including burnt clay brick were determined at the age of 7, 14 and 28 days. The typical setup for compressive strength of building block is shown in the


Figure 3.6: Typical setup for compressive strength determination

The compressive strength was determined by using equation (1)
C=P/A……..(1)
Where,
C = Compressive strength
P = Failure load
A = Contact area.

Determination of Water Absorption

Water absorption test on bricks are conducted according to ASTM C-67-80 to determine durability property of bricks such as degree of burning, quality and behavior of bricks in weathering. A brick having water absorption of less than 7% provides better resistance to damage by freezing. The water absorption by bricks increase with increase in pores. So, the bricks, which have water absorption less than 3percent can be called as vitrified. This test provides the percentage of water absorption of bricks and procedure of the same is discussed below. Dry the specimen in a ventilated oven a temperature of 105°C to115°C till it attains substantially constant mass. Immerse completely dried specimen in clean water for 24 hours.

Figure 3.7: Water Absorption

CHAPTER 4

RESULTS AND DISCUSSIONS

The result obtained from the experimental investigations are reported in this chapter. All the values are the average of the three trials in each case in the testing program of the study.

4.1 Density

Comparison Of Density of Different Type Of Block with Admixture :-

Type of specimen were prepared. The differences between planned and actual densities of polystyrene foamed concrete were higher than foamed concrete specially for specimens with higher volume of EPS due to the contribution of polystyrene particles. In this study, sand volume was replaced by EPS beads volume and add Admixture and without Admixture There density is shown in figure 4.1.

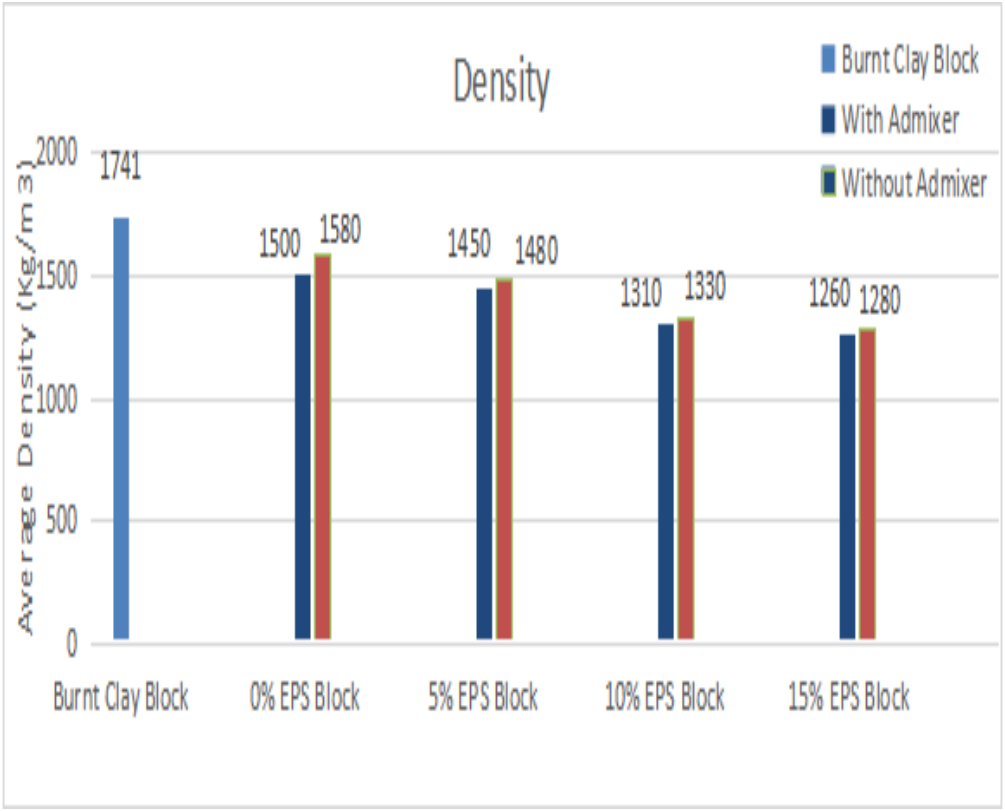


Figure 4. 1 Comparison of Density of Different Type of Block without Admixture & without Admixture

4.2 Absorption of Different Type Of Block

Water Absorption test on brick is conducted to determine the compactness of blocks as water is absorbed by pores of the block. The water absorption increase in block with the increase of pores. This Test is done to measure to physical property of block. A block having water absorption of less than 7% provides better resistance to damage by freezing .The water absorption of 4 types of building block are shown in figure. The water absorption of block with EPS beads and admixture 0%, 5%, 10% and 15% EPS beads are 6.7%, 7.2%,7.7% and 7.0% respectively. On the other side water absorption of block with EPS beads and without admixture 0%, 5%,10% and 15% EPS beads are 5.1%, 6.2%,6.6% and 5.9% respectively.This Values are less than the absorption of clay brick.

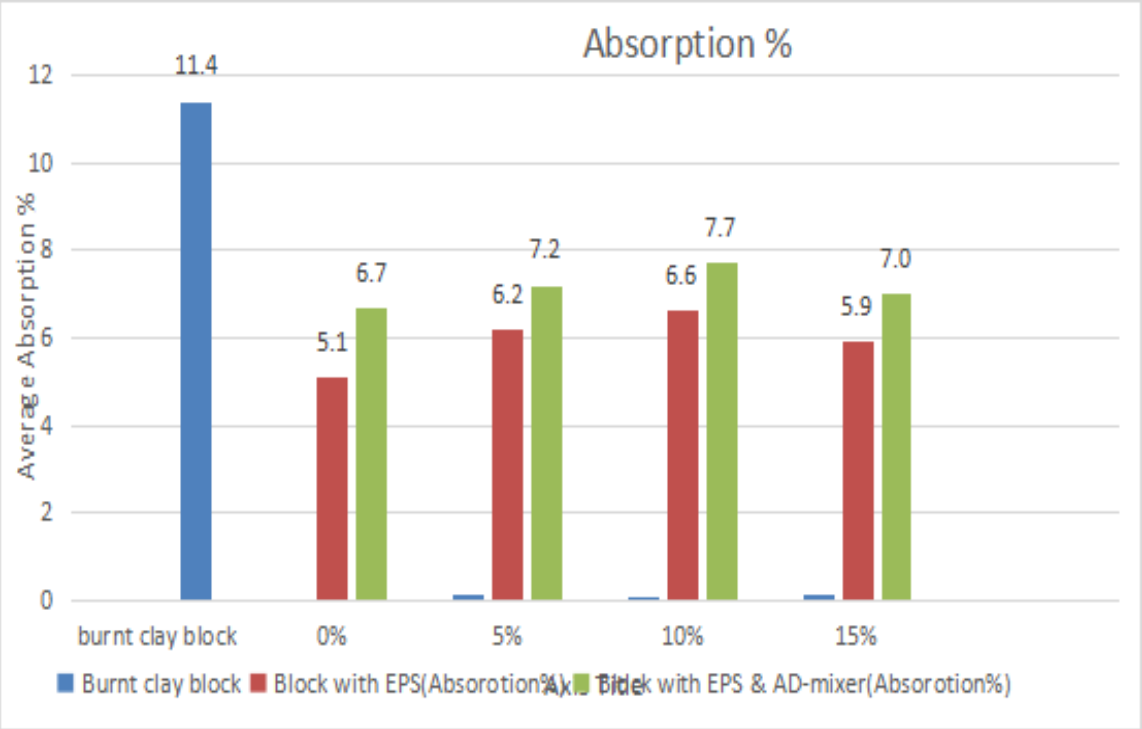


Figure 4. 2 Comparison of Absorption of Different Type of Block with and without Admixture

4.3 Compressive Strength of Building Block

Compressive Strength of Block was determined for 28 days of curing .in a previous study,comparison Compressive strength reveals that concrete with 82.22% EPS Volume reached a strength of 0.08 MPA after 28 days . while the strength of 0.067,0.24 ,0.29 0.85 MPA was obtained for specimens containing 73.10,67.40 and 45.0% Polystyrene beads, respectively (ALi A.sayadi,2016).

This test was conducted for 2 types of block.1 types of blocks were prepared with Admixture for water reducing and increase the strength and Another type block prepared with out Admixture to Compare with each other .

Comparison of Compressive Strength of Different Type of Block with Admixture and without Admixture :

Solid Block made of cement, sand, EPS beads and admixture. There Compressive Strength is Shown in figure

In this study, the 28 days compressive strength found for the block without admixture (using 0%, 5%,10% and 15% EPS beads) are 3020psi, 2950psi, 2560psi and 2650 psi respectively. Another side, the 28 days compressive strength found for the block with admixture (using 0%, 5%,10% and 15% EPS beads) are 3180psi, 3300psi, 3120psi and 2870psi respectively. . Here all the blocks are less then clay block with 3500 psi .The minimum compressive strength of block is 1500 psi. It is observed that compressive strength of block with admixture satisfy the minimum compressive strength criteria

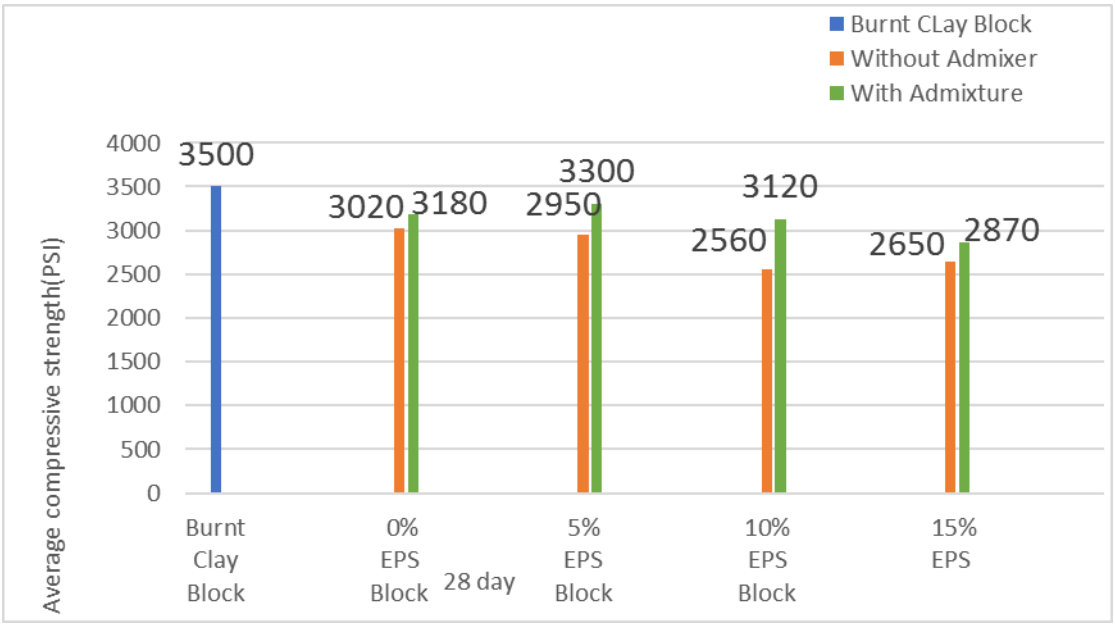


Figure 4. 3 Comparison of Average Compressive Strength of Different Type of Block with and without Admixture

CHAPTER 5

CONCLUSION

The main objective of this project is to study the compare the properties of EPS Beads Blocks and EPS Beads Blocks with admixture. The long-term performance is one of the most concerning issues when introducing EPS beads in concrete materials. The incorporation of EPS in cement mixtures aimed to make lighter weight products. These values are less than the absorption of clay brick. These values are very close to the absorption of commercial solid block. The water absorption of block with EPS beads and admixture 0%, 5%, 10% and 15% EPS beads are 6.7%, 7.2%,7.7% and 7.0% respectively. On the other side water absorption of block with EPS beads and without admixture 0%, 5%,10% and 15% EPS beads are 5.1%, 6.2%,6.6% and 5.9% respectively .This Values are less than the absorption of clay brick. It was found that the 28 days compressive strength for the block without admixture (using 0%, 5%,10% and 15% EPS beads) are 3020psi, 2950psi, 2560psi and 2650 psi respectively. Another side, the 28 days compressive strength found for the block with admixture (using 0%, 5%,10% and 15% EPS beads) are 3180psi, 3300psi, 3120psi and 2870psi respectively. . Here all the blocks are less then clay block with 3500 psi. The minimum compressive strength of block is 1500 psi. It is observed that compressive strength of block with admixture satisfy the minimum compressive strength criteria. So in construction using block from EPS beads with admixture is better than other types.

RECOMENDATION

The following recommendation may be proposed for further study:

- Before using these types of blocks commercially in construction more extensive research is need to be done.
- Types of sample and number of sample for each test should be increased for each test.

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APPENDIX

Table:1 Density of Different Type of Block with Admixture

Type of Block	Serial No	Density (Kg/m3)	Average Density (Kg/m3)
0% EPS Block	1	1513	1500
	2	1488	
	3	1500	
5% EPS Block	1	1480	1450
	2	1460	
	3	1410	
10% EPS Block	1	1310	1310
	2	1330	
	3	1290	
15% EPS Block	1	1311	1260
	2	1225	
	3	1245	

Table:2 Density of Different Type of Block without Admixture

Type of Block	Serial No	Density (Kg/m3)	Average Density (Kg/m3)
Burnt Clay Block	1	1740	1740
	2	1742	
	3	1741	
0% EPS Block	1	1567	1580
	2	1598	
	3	1574	
5% EPS Block	1	1504	1480
	2	1484	
	3	1451	
10% EPS Block	1	1335	1330
	2	1360	
	3	1296	
15% EPS Block	1	1332	1280
	2	1251	

Table:3 Absorption of Different Type of Block without Admixture

Type of Block	Serial No	Absorption%	Average Absorption%
Burnt Clay Block	1	11.4	11.4
	2	11.8	
	3	10.9	
0% EPS Block	1	4.9	5.1
	2	5.1	
	3	5.4	
5% EPS Block	1	6.3	6.2
	2	6.5	
	3	5.9	
10% EPS Block	1	6.9	6.6
	2	6.4	
	3	6.6	
15% EPS Block	1	6.2	5.9
	2	5.7	
	3	5.8	

Table:4 Absorption of Different Type of Block with Admixture

Type of Block	Serial No	Absorption%	Average Absorption%
Burnt Clay Block	1	11.4	11.4
	2	11.8	
	3	10.9	
0% EPS Block	1	6.9	6.7
	2	6.5	
	3	6.7	
5% EPS Block	1	7.4	7.2
	2	7	
	3	7.3	
10% EPS Block	1	7.9	7.7
	2	7.4	
	3	7.8	
15% EPS Block	1	6.4	7
	2	7.2	

Table:4 compressive strength of Different Type of Block without Admixture

Type of Bloc	Serial No	compressive strength(PSI)	Average compressive strength(PSI)
Burnt Clay Block	1	3560	3500
	2	3460	
	3	3480	
0% EPS Block	1	3060	3020
	2	3056	
	3	2944	
5% EPS Block	1	2896	2950
	2	2999	
	3	2954	
10% EPS Block	1	2620	2560
	2	2540	
	3	2520	
15% EPS	1	2700	2650
	2	2810	
	3	2440	

Table:4 compressive strength of Different Type of Block with Admixture

Type of Block	Serial No	compressive strength(PSI)	Average compressive strength(PSI)
0% EPS Block	1	3115	3180
	2	3260	
	3	3166	
5% EPS Block	1	3310	3300
	2	3220	
	3	3370	
10% EPS Block	1	3100	3120
	2	3130	
	3	3080	
15% EPS Block	1	2794	2870
	2	2982	
	3	2835	