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RESEARCH ARTICLE

DEVELOPMENT OF LIGHTWEIGHT CONCRETE BLOCKS USING EPS BEADS

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ABSTRACT

Lightweight concrete is a type of concrete whose density is lower than the normal concrete. These lightweight blocks came into use mainly to reduce the dead weight of the structure and to reduce the cost due to use of heavy materials in construction. This project deals with the development of lightweight blocks by using EPS beads. Polymers and other plastics are widely accepted as aggregate substituents in concrete construction.Expanded polystyrene (EPS) is a type of polystyrene foam that is rigid, tough and closed cell form in nature. It is usually white and it is made up of pre-expanded polystyrene beads having density between 16 – 640 kg/m^3. Mixing of this concrete is similar to that of traditional concrete mixing except substituting the coarse aggregates by shredded poly styrene granules. In this study the mix proportion for lightweight blocks using EPS beads has been arrived, the compressive and tensile strengths were studied. Being light in weight these blocks exhibits additional property of floating in water due to its low density.

Key words: Lightweight blocks, EPS beads, Density, Compressive strength.

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INTRODUCTION

Concrete in its various forms is probably the most used construction material in the world. Lightweight concrete is a type of concrete which is most commonly used now a days compared to traditional concrete due to its various advantages. The main advantage of using lightweight concrete is to reduce the structure's dead load and thereby reducing its cost. Lightweight concrete are concretes having dry density not exceeding 1840 kg/m^3, but can be as low as 800 kg/m^3 depending on the materials used with compressive strength varying between 1 and 65 N/mm^2. But technically concrete with bulk density 350 kg/m^3 is possible. Structural lightweight concrete should have concrete strength greater than 17.0 Map and density on the order of 1440 to 1840 kg/m³ compared to normal concrete of density in the range of 2240 to 2400 kg/m³. There are various types of lightweight concretes based on method of production and based on purpose. Based on the method of production it is classified as lightweight aggregate concrete, aerated concrete and no fines concrete. Based on purpose it is classified as structural lightweight concrete, concrete used in masonry units and insulating concrete. In this project light weight blocks are developed using shredded polystyrene granules (EPS beads). Expanded polystyrene (EPS) is a type of polystyrene foam that is rigid and tough, closed cell form in nature. It is usually white and it is made up of pre-expanded polystyrene beads having density between 16 – 640 kg/m^3.

Currently millions of waste polystyrene are produced in the world. They are very difficult to be disposed and cause pollution and it is harmful to ecosystem. Therefore, utilization of waste polystyrene in concrete not only solves the problem of disposing this ultra-light solid waste but also helps in preserving natural resources. The primary aim of this project is to develop lightweight concrete blocks using expanded polystyrene and also in imparting floating property to the concrete.

MATERIALS AND METHODS

The various strength properties of the concrete are dependent upon the cementitious content, water cement ratio, compaction level and aggregate gradations and its quality. The raw materials used in this experimentation are Portland Pozzolona Cement (PPC), fly ash, river sand, EPS balls, SBR Latex. Potable tap water was used for mixing and curing.

Cement: The type of cement used was Portland Pozzalona Cement confirming to 1489-1991 (part 1) and the properties are shown in Table 2.1.

Fly ash: Fly ash is a pozzolan, a substance containing aluminous and siliceous material that forms cement in the presence of water. When mixed with lime and water it forms a compound similar to Portland cement. In this experiment fly ash having density of 911.12 kg/m^3 was used.

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Table 2.1. Properties of cement

S.No	Description	Results
1.	Specific gravity	3.14
2.	Fineness	3%
3.	Consistency	33%
4.	Initial setting time	35 min

Fine aggregate: The aggregates passing through 4.75 mm sieve is generally termed as fine aggregate. Fine aggregates used in this project were river sand passing through 1.18 mm sieve and the properties are shown in Table 2.2.

Table 2.2: Properties of fine aggregate

S.No	Description	Results
1.	Specific gravity	2.6
2.	Bulk density	1453 kg/m^3
3.	Fineness modulus	2.2

Expanded polystyrene Beads (EPS): Expanded Polystyrene (EPS) is a type of polystyrene foam that is rigid and tough, closed cell form in nature. The Expanded Polystyrene used in this project was spherical in shape and size varying between 1.16 to 2.56 mm in diameter. SBR Latex (Styrene-butadiene or styrene-butadiene rubber latex) is a carboxylated styrene butadiene copolymer latex admixture that is designed as an integral adhesive for cement bond coats, mortars and concrete to improve bond strength and chemical resistance is used as bonding agent.

Mix Proportion: The selection of EPS beads was made mainly due to its low density, closed cellular structure, hydrophobic and energy absorbing characteristics. But due to the size of EPS beads being very small varying between 1.16 to 2.56 mm in diameter the arrival of mix ratio was difficult. So trial and error method was adopted by replacing various materials by its volume. To impart additional floating property to the concrete, coarse aggregate was completely eliminated and the density of the blocks was reduced. Various trials were adopted in finding the percentage of EPS to be added in concrete and to make the concrete float as shown in Table 3.1. From these various proportions trial 5 was selected to arrive the mix proportion of thee concrete block and the percentage of cement, fine aggregate, fly ash and EPS beads were 30%, 15%, and 40% respectively.

Experimental Program

Preparation of mould: The final ratio was arrived from trial and error method and the samples were casted and tested further. Weigh batching was practiced with the help of electronic weigh balance. Batching was done as per mix proportion. The mix was prepared manually. First the dry materials like cement, sand and fly ash were mixed dry through as shown in figure 1, and then by adding water and EPS beads it was mixed until it made a uniform mixture as shown in figure 2. Moulds were cleaned and oiled to prevent the formation of bond between concrete and moulds. The fresh concrete filled into the moulds with hand and hand compacted properly. After the compaction has been completed, the excess mortar was removed from the mould with the help of trowel and the surface was leveled. After placing fresh concrete in moulds, it was allowed to set for 24 hours. Concrete samples were demoulded and it was kept in potable water in a curing

Fig 1. Dry mixing of concrete

Fig 2. Uniform mix of concrete after adding water

tank for curing purpose. After particular time span concrete samples were removed from curing tank to conduct tests on hardened concrete

Tests on concrete

Workability Test (Slump Cone Test): The concrete slump test is used to find the consistency of concrete before it sets. It is an empirical test that measures the workability of fresh concrete. It also acts as an indicator for improperly mixed batch. The measured slump must be within a set range, or tolerance, from the target slump.

Compressive Strength Test: Compression strength test is the most common test conducted on hardened concrete. The compression test shows the best possible strength concrete can reach in perfect conditions. It measures concrete strength in the hardened state. It is a method of determining the behavior of materials under a compressive load. Compression strength test is conducted by loading the test specimen between two plates and then applying a force to the specimen by moving the crossheads pushing towards.

Split Tensile Strength Test: The tensile strength is also the important properties of concrete. However the determination of tensile strength of concrete is necessary to determine the load at which the concrete member may crack. The cracking may be in the form of tension failure. Thus the Split tensile strength test is taken on concrete cylinder and it is a method to determine the tensile strength of concrete.

Table 3.1. Trial proportions

Trial	Materials	No of samples casted	Density (kg/m^3)	Floating Property
1	C+ F.A(M-sand) + EPS	1	1297.7	Not attained
2	C+ F.A(River sand) + EPS	1	655.97	Attained
3	C + Fly ash + River sand + EPS	2	481.04	Attained
	(by varying EPS percentage)		413.99	Attained
4	C + Fly ash + River sand + EPS	4	731.23	Attained
	(by varying each of its percentage)		577.34	Attained
			802.56	Attained
			558.22	Attained
5	C + Fly ash + River sand + EPS	3	752.01	Attained
	(by varying Flyash		801.54	Attained
	&EPS percentages)		Block was not stable	

Density Test: Density of concrete is one of the important parameter in structural behavior. The density of concrete is a measure of its weight. The more density of concrete the dead load on structure will be more. Here it is done to ensure that the density of the block prepared is less than the density of Water so that the block can float.

Water absorption test: A concrete with low permeability resists ingress of water and is not as susceptible to freezing and thawing. The water absorption of concrete is found by drying a specimen to a constant weight, weighing it, immersing it in water for specified amount of time, and weighing it again. The increase in weight as a percentage of the original weight is expressed as its absorption (in percent). The average absorption of the test samples shall not be greater than 5% and with no individual unit greater than 7%.

RESULT AND DISCUSSION

In this, the results of various tests for lightweight EPS blocks are studied for the arrived ratio.

Fresh concrete

Workability Test (Slump Cone Test): The slump cone test was carried out and true slump was observed with slump value 110 mm. Experimentally, we conclude that the concrete containing EPS beads had high workability. But mixing process was observed to be difficult due to the lightweight of EPS beads.

Hardened concrete

Compressive Strength Test: Compressive strength test of the cubes were carried out in Compression Testing Machine (CTM) of 200T capacity. The load is applied on the specimen uniformly, without any shocktill the specimen fails. The specimen placed in such a way that center of the specimen and center of the moving plates are same as shown in Figure 3. A set of two cubes of 70 x 70 x 70 mm were tested after 7 days, 14 and 28 days of curing for the proportion arrived from trial 5. The maximum load taken by specimen was noted for each specimen. Average strength was calculated for every set of specimens. After testing the specimen was checked for cracks, EPS beads distribution. The results of compressive strength test are given in Table 5.1. It was observed that, the compressive strength of all the concrete mixes increases with increase in age of concrete. It is seen that the larger the amount of EPS beads lesser the compressive strength. The specimen before and after testing is shown in Figure 3.

Fig 3. Specimen before and after testing

Table 5.1. Compressive strength of the specimen

S.no	Specimen	Average compressive strength (N/ MM^2)
1	7^{TH} DAY	1.179
2	14^{TH} DAY	1.710
3	28^{TH} DAY	2.22

Table 5.3. Density of specimens

S.no	Specimen	Weight (kg)	Average density kg/m^3
1	Cube 1	0.276	
2	Cube 2	0.292	830
3	Cube 3	0.286	

Fig 4. Split view of the specimen

Split Tensile Strength Test: Split Tensile strength test of the cylinder was carried out on Compression Testing Machine (CTM) of 200T capacity. The load applied on the specimen uniformly, without any shocks up to the specimen fails. The specimen placed like the center of specimen and center of moving plates are same. Cylinders of 150 mm in diameter and 300mm heights are tested for concrete mix of 7 days and 14 days of curing for the proportion arrived from trial 5. The maximum load taken by specimen was noted and the strength was calculated for the specimens. After testing the specimen was checked for cracks, EPS beads distribution and the split view of the specimen in as shown in Figure 4. The results of Split Tensile strength test are given in Table 5.2. It was observed that the split tensile strength of all concrete mixes increases with increase in ages. It was seen that the larger the amount of EPS beads lesser the split tensile strength. The specimen before and after cracking is shown in Figure 5.

Table 5.3. Density of specimens

S.no	Specimen	Weight kg	Average density kg/m^3
1	Cube 1	0.276	830
2	Cube 2	0.292	
3	Cube 3	0.286	

Fig 5. Specimen before and after testing

Density Test: The density test was carried out on the specimen. By calculating the volume and weight of specimen, the density was calculated by taking ratio of weight in kg and volume in $m^3$and the results are shown in Table 5.3.

Water absorption test: The Water absorption test was carried out on the specimen. The dry weight and wet weight of the sample were taken for the specified time period of 24 hours and it was found that concrete exhibited 6.1% of water absorption. The concrete block satisfies the condition that for good concrete the individual water absorption should not be greater than 7%.

Conclusion

Based on the experimental results the following conclusions are drawn.

- The compressive strength and split tensile strength decreased with increase in EPS beads percentage and the strength were increased with increase in age of concrete.
- Mixing of concrete was difficult due to the low density of the expanded polystyrene beads.
- Due to lesser density of the concrete block and the buoyant force being higher than the gravity force, the concrete can float. But due to this lesser density, the strength of the specimen is low, resulting in difficulty to be use as structural components.
- The replacement by using EPS has shown a positive application as an alternate material in building nonstructural members with scope for nonstructural applications like wall panels, partition walls, etc.
- Expanded polystyrene being difficult to recycle, replacement by EPSserves as a solution for EPS disposal.

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