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Partial Replacement of Course Aggregate by Expanded Polystyrene Beads in Concrete

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ABSTRACT

With the increase in demand for construction materials, there is a strong need to utilize alternative materials for sustainable development. The main objective of this investigation is to study the properties, such as compressive strength and tensile strengths of lightweight concrete containing Expanded Polystyrene (EPS) beads. Its properties are compared with those of the normal concrete i.e., without EPS beads. EPS beads are used as partial replacement to coarse aggregates. The results showed that the amount of polystyrene beads incorporated in concrete influences the properties of hardened concrete. At 28 days, it was found that compressive strength of 0%, 10%, 20% and 25% EPS incorporated concrete strengths were 100%, 96.2%, 62.3% and 45% respectively when compared to concrete with EPS case.

KEYWORDS: Expanded polystyrene beads (EPS); Workability; Compressive strength; Split tensile strength and Flexural strength.

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1. INTRODUCTION

***1.1 General*:** Increase in the developmental activities world over, the demand for construction materials is increasing exponentially. This trend will have certainly greater impact on the economic system of any country. India also is aiming at a high developmental rate compared to other nations in Asia. There is heavy demand for the building materials in the domestic market, which is becoming scarce day by day. At this point researches and engineers who have the foresight to keep the developmental activities abreast and curtail the cost factor should look out for other alternative building materials.

In this work, an attempt is made to address the possibility of utilizing Expanded Polystyrene (EPS), a packing material in the form of beads in concrete, which otherwise is posing a threat to waste disposal as well as for waste management. This material is a cause of concern to environmentalists. In this study, it is attempted to partially replace coarse aggregates by means of EPS beads. A general discussion on EPS, its production and its application along with environmental concerns are being discussed. Expanded polystyrene (EPS) is a lightweight cellular plastics material consisting of fine spherical shaped particles which are comprised of about 98% air and 2% polystyrene. It has a closed cell structure and cannot absorb water. It has a good sound and thermal insulation characteristics as well as impact resistance. Polystyrene foam is a non-biodegradable material.It is a waste material from packaging industry. It creates disposal problem. Utilizing crushed polystyrene granules in concrete is a valuable waste disposal method.

There are many advantages to be gained from the use of lightweight concrete. These include lighter loads during construction, reduced self-weight in structures, and increased thermal resistance. Lightweight concrete is generally accepted as concrete having a density of about 1800 kg/m^3 or less. The present investigation was taken up, keeping two targets in view, disposal of the polystyrene waste from the point of view of environment and for the replacement of aggregate from the point of view of construction industry. The present study aims at utilization and the suitability of polystyrene beads as coarse aggregate. A comparative study on strength parameters is also done against conventional concrete to study the behavior of the polystyrene aggregate. For this 10%, 20%, and 25% replacement of coarse aggregate by expanded polystyrene beads is attempted in this work.

1.2 Material Collection

1.2.1 Cement (portland pozzolana cement 53 grade)

The Portland Pozzolana (PPC) cement is a kind of blended cement which is produced by either inter-grinding of OPC clinkers along with gypsum and pozzolanic materials in certain

proportions or grinding the OPC clinker, gypsum and pozzolanic materials separately or thoroughly blending them in certain proportions.

- PPC is made up of 75 -77% cement clinkers, 20% flyash and 3-5% gypsum.
- It has low percentage of sulphate alkalies, chlorides, magnesia and free lime in its composition,which makes the concrete durable.
- Slower rate of heat of hydration and is prone to less cracks and reduced shrinkage.
- Better workability and finishing (as flyash based cement are =spherical in *shape and finer in size)*.

1.2.2 Fine Aggregate

Fine aggregate means sand which is a mixture of small particles of grains and minerals which passes under 9mm sieve. Those fractions from 4.75 mm to 150 microns are termed as fine aggregate. it is used for construction purposes like concrete work and farming works etc.

1.2.3 Coarse Aggregate

Coarse aggregate means which is broke from rocks using explosives and crushed into pieces using machine and course aggregate size 10mm, 12mm, 20mm, 40mm and 60mm are divided using big sieves in machines and coarse aggregate like 10, 12 and 20mm is used to mix in concrete for construction purposes and 40mm is used for Railway Works, Road Works.

1.2.4 Eps (Expanded Polystyrene Sphear)

Expanded polystyrene sphere (EPS) is a rigid and tough closed cell foam. It is usually white and made of pre-expanded polystyrene beads. It offers a non-hydroscopic,odourless,rigid,closed cell. Application is made possible because of thermocole lightweight, water resistance, dimensional stability and inert nature.

Expanded polystyrene (EPS) is a lightweight cellular plastics material consisting fine spherical shaped particles which are comprised of about 98% air and 2% polystyrene. It has a closed cell structure and cannot absorb water. It has a good sound and thermal insulation characteristics as well as impact resistance. Polystyrene foam is a none a non-biodegradable material.

1.2.5 Water

Water is the most important material for construction, especially for making concrete. It is also the least expensive on site. Hence careless use of more water has lead to poor quality work.

2. EXPERIMENTAL INVESTIGATIONS

2.1 Concrete Mixing

Proper mixing of concrete ingredient is very much necessary as it affects the quality of concrete in its fresh state as well as in hardened state. A concrete is said to be well mixed if it fulfills the following requirements.

- Concrete mix should be uniform in color
- Concrete should achieve proper consistency for which it is designed
- Complete blending of all concrete ingredients
- Cement paste should cover all the surface of the aggregate

Fig 2.1. Concrete Mixing

2.2 Casting of Specimen

Specimens are cast on as per design mix tested after appropriate curing, tests taken are compressive strength or cubs (150x150x150mm) and split tensile strength of cylinders (150x300mm).from the studies, optimum results are found out and compared with conventional concrete.

Fig.2.2 Casting of Specimen

2.3 Compaction

Compaction of concrete is one of the important site operations that together enable the fresh concrete to reach its potential design strength, density and low permeability. Properly carried out it ensures that concrete fully surrounds and protects the reinforcement, tendons and cast-in inserts. It also has a direct impact on achieving the specified surface finish.

Fig.2.3 Compaction

2.4 Curing

Cubes must be cured before they are tested. Unless required for test at 24 hours, the cube should be placed immediately after demoulding in the curing tank or mist room.

The curing temperature of the water in the curing tank should be maintained at 27-30□. If curing is in a mist room, the relative humidity should be maintained at no less than 95%. Curing should be continued as long as possible up to the time of testing.

In order to provide adequate circulation of water, adequate space should be provided between the cubes, and between the cubes and the side of the curing tank. If curing is in a mist room, there should be sufficient space between cubes to ensure that all surfaces of the cubes are moist at all time

Fig.2.4 Curing

2.5 Weight of the concrete cube

Normally the weight of the concrete cube (150X150X150) is 8.1KG**.** By adding 10% of EPS in the place of course aggregate then the weight of the concrete cube is 7.29KG. This is light weight concrete.

Fig.2.5 Weight of Eps Concrete Cube

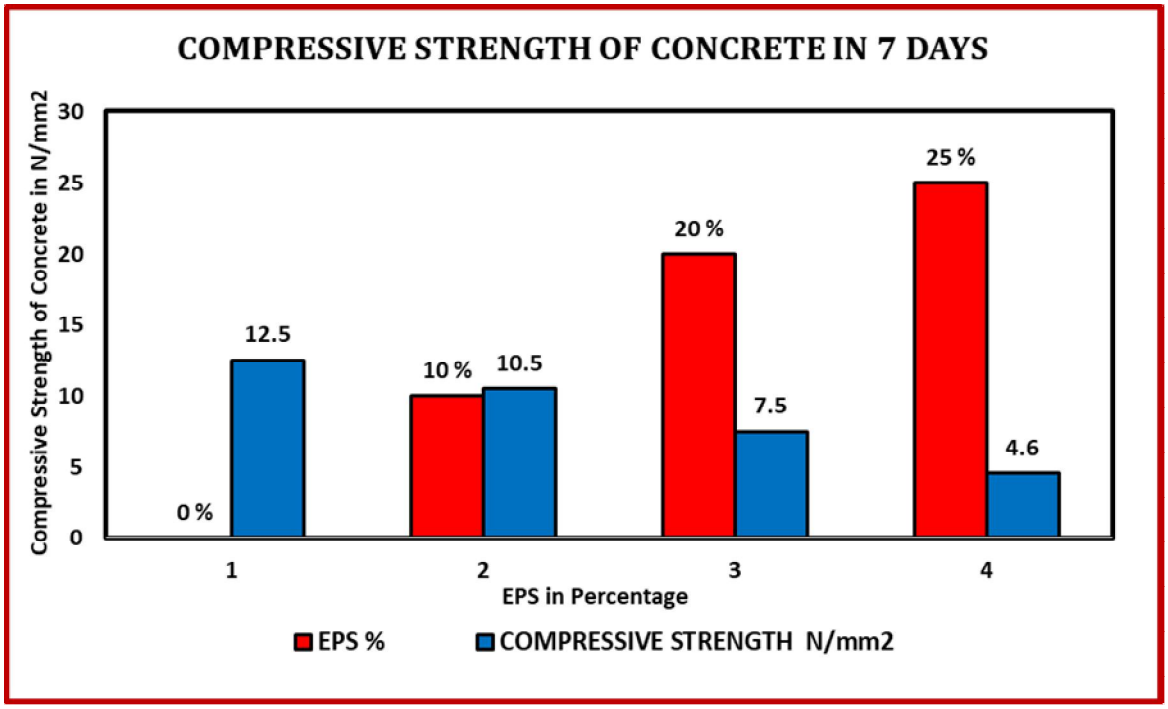
3. RESULTS AND DISCUSSION RESULT AND DISCUSSIONS

3.1 Compressive Test

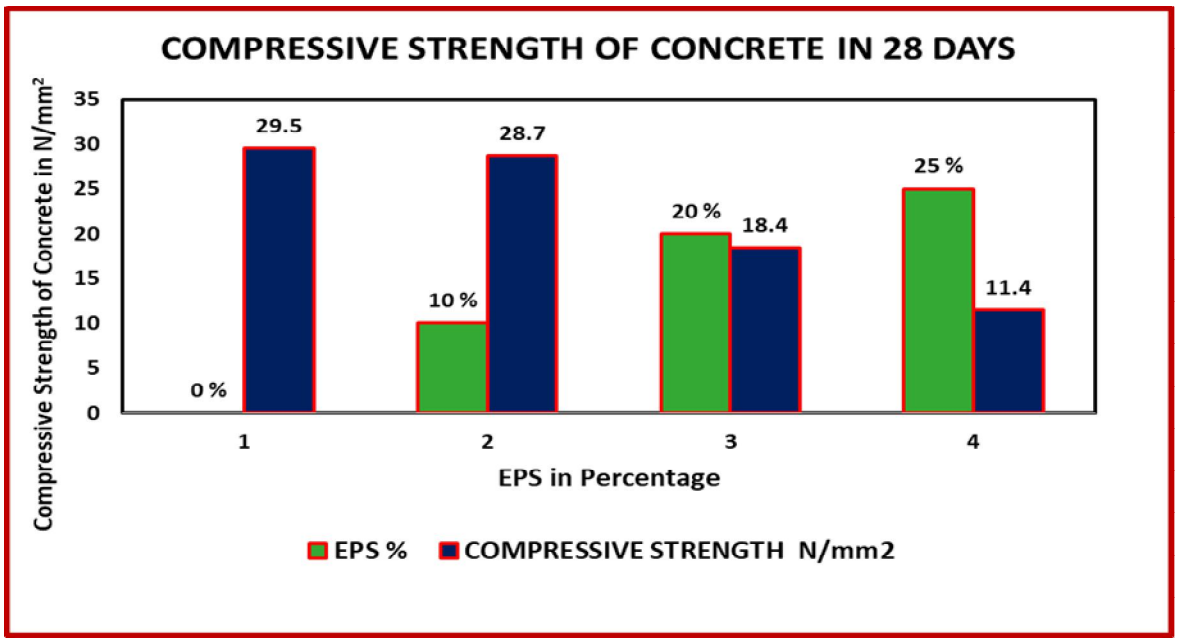
Compressive strength of cement concrete cube and various ratio of EPS in the concrete cubes obtained from the test are given below.

Table[1] Compressive strength of cement concrete cube

Specimen Name	Percentage of mixing		Curing Days	Compressive Strength of Concrete (N/mm^2)			Average Compressive Strength of Concrete
	EPS %	Coarse Aggregate (%)					
CC	0	100	3	4.8	4.3	5.1	4.7
			7	11.8	12.7	13.1	12.5
			14	20.8	19.6	21.2	20.5
			28	28.2	30.6	29.8	29.5
C- 10	10	90	3	4.1	4.3	4.2	4.2
			7	10.4	10.9	10.2	10.5
			14	18.9	19.8	19.3	19.3
			28	28.2	29.4	28.6	28.7
C -20	20	80	3	2.9	3.2	3.6	3.2
			7	8.0	7.1	7.5	7.5
			14	11.9	12.3	12.8	12.3
			28	18.6	17.8	18.8	18.4
C- 25	25	75	3	1.8	1.75	1.8	1.78
			7	4.2	4.8	4.3	4.6
			14	5.8	7.2	6.8	6.63
			28	12.2	11.6	10.4	11.4



Graph(1) Compressive strength of concrete for 7days



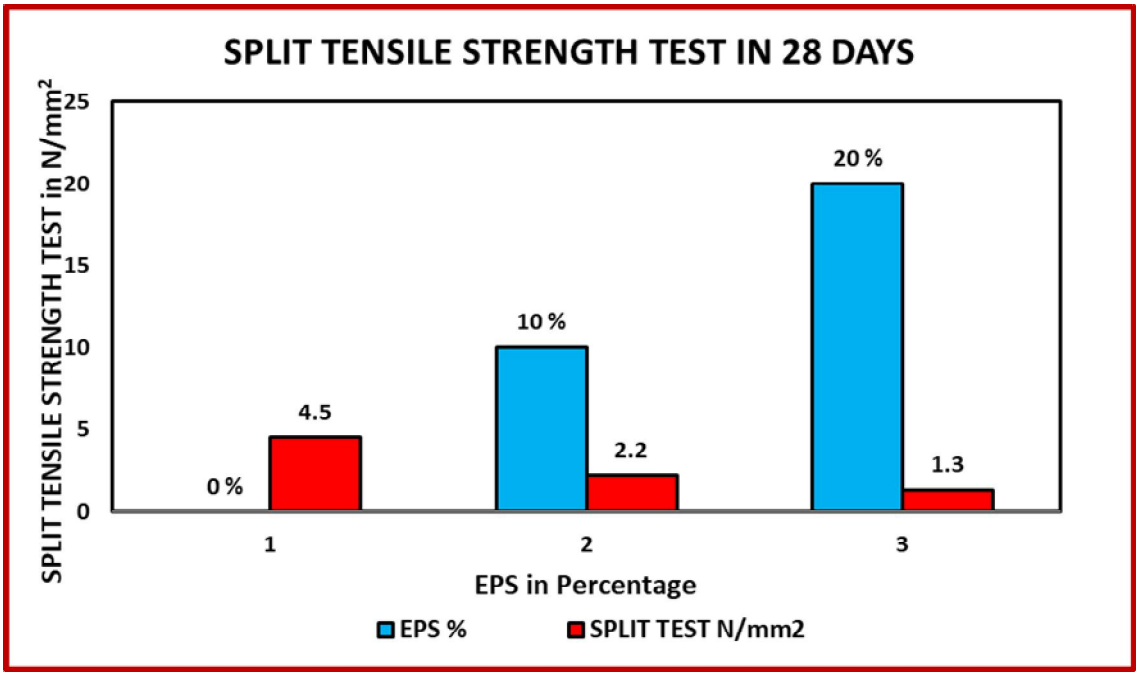
Graph(2) Compressive strength of concrete for 28days

3.2 Split Tensile Strength Test

Tensile strength governs the cracking behavior and affects other properties such as stiffness, damping action, and durability of concrete. It is also important regarding the behavior of concrete under shear load.

Table (2) Average split test of concrete for 28 days

Specimen Name	Percentage of mixing		Days of testing	Split test of concrete (N/mm^2)			Average Split test (N/mm^2)
	EPS %	Course aggregate %					
CC	0	100	28	4.2	4.6	4.9	4.5
C-10	10	90	28	2..2	2..4	2..1	2..2
C-20	20	80	28	1..6	1..2	1..1	1..3



Graph(3) Split Tensile Strength of concrete for 28days

3.3 Flexural Strength Test

Flexural test evaluates the tensile strength of concrete indirectly. It tests the ability of unreinforced concrete beams or slabs to withstands failure in bending at 10% of EPS.

Table (3) Average flexural test values for three samples

Number of Sample	Weight (Kg)	Load ($KN/m^{3)}$	Average ($KN/m^{3)}$
Sample 1	10.322	450	420
Sample 2	10.283	360	
Sample 3	10.364	450	

5. CONCLUSION

Increase in the EPS beads content in concrete mixes reduces the compressive and tensile strength of concrete.Workability increases with increase in EPS beads content.All the EPS concrete without any special bonding agent show good Workability and could easily be compacted and finished.EPS concrete has the advantages of small density, thermal insulation, and good seismic

performance.The replacement by using EPS has shown a positive application as an alternate material in building for only non-structural members, and it is also serves as a solution for EPS disposal.

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