MECHANICAL PROPERTIES OF CONCRETE WITH PARTIAL REPLACEMENT OF COARSE AGGREGATE WITH EXPANDED POLYSTYRENE (EPS) BEADS.

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ABSTRACT

Concrete is the most widely used construction material in civil engineering structures. It has an excellent resistant to water and can be formed into a variety of shapes and sizes. Nowadays, the concrete industry consumes enormous amount of concrete produced daily, even a small reduction in the use of raw materials in concrete mixtures will result in considerable benefit to the environment. It is with this intention, an investigation proposed to be conducted by using Expanded Polystyrene (EPS)beads of 10 mm size as replacement of natural aggregates by volume from 0% to 60% in multiple of 15% (N/EPS00, EPS15, EPS30, EPS45 and EPS60) in cement concrete. The fresh mechanical properties of concrete with and without inclusion of Expanded Polystyrene (EPS) beads were evaluated in terms of workability, unit weigh or dry density, compressive strength and splitting tensile strength. Also this properties was observed and compare with normal concrete of Expanded Polystyrene (EPS) beads grade M20. The workability of fresh concrete increases with increase in percentage of Expanded Polystyrene (EPS) beads whereas the harden properties like unit weight, compressive strength and splitting tensile strength decreases with increase in percentage Expanded Polystyrene (EPS) beads . the addition of Expanded Polystyrene (EPS) beads in concrete meets the criteria of light weight concrete

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Keyword: *Expanded Polystyrene (EPS) beads, workability, mechanical properties, Styrofoam concrete*

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1. INTRODUCTION

1.1 General

With increase in demand for construction materials, man has improved a lot in construction techniques of structures. In earlier ages structures were constructed with heavy materials, but in this modern era of construction old techniques are being more costly due to heavy loading. So the uses of lightweight materials are started.

Lightweight concrete can be produced by introducing:

(i) gassing agents such as aluminum powder or foaming agents,

(ii) lightweight mineral aggregate such as perlite, vermiculite, pumice, expanded shale, slate, and clay, or

(iii) plastic granules as aggregate, e.g., expanded polystyrene foam (EPS), polyurethane or other polymer materials.

Original EPS beads can be easily incorporated with different contents in concrete to produce lightweight concrete with a wide range of densities. Hence in the place of natural aggregates, Expanded Polystyrene (EPS) beads can be used as a substitute material.

1.2 Expanded Polystyrene Concrete (EPSC)

Expanded Polystyrene Concrete (EPSC) is a form of concrete known for its light weight made from cement and EPS (Expanded Polystyrene). Expanded Polystyrene Concrete (EPSC) is also known as EPScrete or EPS concrete or Styrofoam concrete or Lightweight concrete. It is a popular material for use in environmentally "green" homes. It has been used as road bedding, in soil or geo-stabilization projects and as sub-grading for railroad trackage.

It is created by using small lightweight Styrofoam or EPS balls as an aggregate instead of the sand or crushed stones that are used in regular concrete. It is not as strong as conventional concrete but has other advantages such as increased thermal and sound insulation properties, easy shaping and ability to be formed by hand with sculpturing and construction tools.

EPS concrete combines the construction ease of concrete with the thermal and hydro insulation properties of EPS and can be used for a very wide range of application where lighter loads or thermal insulation or both are desired.

Figure: 1 Expanded Polystyrene Concrete (EPSC)

1.3 Expanded Polystyrene (EPS)

1.3.1 General

EPS or expanded polystyrene is a rigid cellular plastic originally invented in Germany in 1950. It has been used in packaging solutions since 1958. It is 98% air but the rest is made from tiny, spherical EPS beads - themselves made only of carbon and hydrogen.

Figure: 2 Expanded Polystyrene (EPS) Beads

1.3.2 Applications

a) Wall panels
b) Partition walls
c) Cladding panels
d) Composite flooring system
e) Load bearing concrete blocks.
f) Curtain walls
g) Foot path
h) Production of low density concretes.
i) Retaining walls

1.4 Objectives

- To find the alternative material to basic materials which are used in construction from past.
- To reduce unnecessary landfills.
- To study the effectiveness of Expanded Polystyrene (EPS) Beads as substitute for coarse aggregate in concrete.
- To study the effects of Expanded Polystyrene (EPS) Beads on properties of fresh concrete like workability.
- To study the effects of Expanded Polystyrene (EPS) Beads on properties of hardened concrete like unit weight, compressive strength and split tensile strength.
- To provide the necessary information regarding the use of Expanded Polystyrene (EPS) Beads for concrete and to co-relate the past and existing studies about Expanded Polystyrene (EPS) Beads concrete.

2. SUMMARY OF LITERATURE REVIEW

On the basis of the published literature on expanded polystyrene concrete as a full or partial replacement for natural aggregates, it is apparent that unit weight, compression strength, splitting tensile strength and elastic modulus is reduced in expanded polystyrene concrete whereas durability are enhanced which are the most important parameters in certain structures resisting earthquakes and also where cyclic load is applied. So, it can be concluded that there is a promising future for EPS beads as a partial substitute for coarse aggregates in concrete, which can result in huge environmental and sustainability benefits.

3. METHODOLOGY

3.1 Raw materials

Cement

Ambuja Portland Pozzolana Cement confirming to IS 1489 having specific gravity 3.15 was used in producing the concrete mixes.

Fine Aggregate (FA)

Natural river sand confirming to Zone-II as per IS 383-1970 was used as fine aggregate. The specific gravity and water absorption of fine aggregate were 2.65 and 1.02% respectively.

Coarse Aggregate (CA)

20 mm crushed stones were used as coarse aggregates. The specific gravity and water absorption of coarse aggregate were 2.74 and 0.96% respectively.

Water

Fresh or Portable water was used to hydrate the cement in the mixtures.

Expanded Polystyrene (EPS) beads

Expanded Polystyrene (EPS) beads of size 10 mm were used as partial replacement of coarse aggregate having specific gravity 0.014.

3.2 Concrete mix design

The concrete mixes were designed as per IS 10262-2009 and IS456-2000. The mix design of reference concrete aimed to achieve a target mean strength of 26.6 MPa (often referred as grade M20) at 28 days with slump value 75mm. The EPS of 10 mm size was used as partial replacement of coarse aggregate from 0% to 60% in multiple of 15%. The amount of water and cement were all held constant, to reduce the number of variables and maintained water-to-cement ratio of 0.55 for all the mixes. Five mix proportions were used for slump test, unit weight, compressive strength and split tensile strength. The mix proportions are presented in **Table 1.**

Table 1- Mix proportions of concrete

Mixture ID	WC	Cement (kg/m^3)	Sand (kg/m^3)	Coarse Aggregate (kg/m^3)		Water (kg/m^3)	EPS	
				Volume (%)	Weight (kg/m^3)		Volume (%)	Weight (kg/m^3)
N/EPS 00	0.55	383	685	100	1157	210	0	0
EPS 15	0.55	383	685	85	984	210	15	0.9
EPS 30	0.55	383	685	70	810	210	30	1.8
EPS 45	0.55	383	685	55	636	210	45	2.7
EPS 60	0.55	383	685	40	463	210	60	3.6

Note- EPS content in (kg/m3) = volume of all in aggregate x proportion volume of coarse aggregate x mass density of EPS x percentage volume of EPS. (Ex. 0.688 x 0.62 x 0.014 x 1000 x 15 % = 0.9 kg/m3).

4. LABORATORY TESTING PROGRAM

Four different tests were carried out at the Department of Civil Engineering, Shri Saibaba Institute of Engineering Research and Allied Sciences, Rahata and consisted of slump cone test on fresh concrete as well as unit weight test, compressive strength test and splitting tensile strength test on hardened concrete which were conducted on the specimens after removing the specimens from curing tank after specified curing period.

5. RESULTS AND DISCUSSION

5.1 Slump cone test

The slump cone test is used to determine the workability or consistency of concrete mix prepared at the laboratory or the construction site during the progress of work. The effect of EPS beads on workability of concrete for various mixtures is demonstrated in Figure-3.

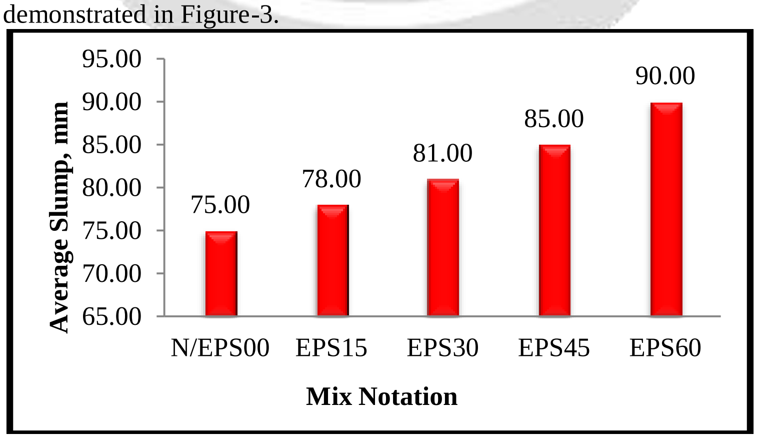

Figure 3: Average slump of all mixers

The results demonstrated that slump value (workability) of fresh concrete increased with increase in replacement of EPS beads. As seen in Figure-3, the lowest slump value happened on the reference concrete with 100% natural coarse aggregate whereas the mixture incorporating 60% EPS beads replacement reached the highest one. There is increase in slump value (workability) since the EPS beads does not absorb the water as compared to coarse aggregate.

5.2 Unit weight or Dry density test

The unit weight or dry density is the ratio of weight per unit volume of a material. The effect of EPS beads on unit weight of concrete for various mixtures is demonstrated in Figure-4.

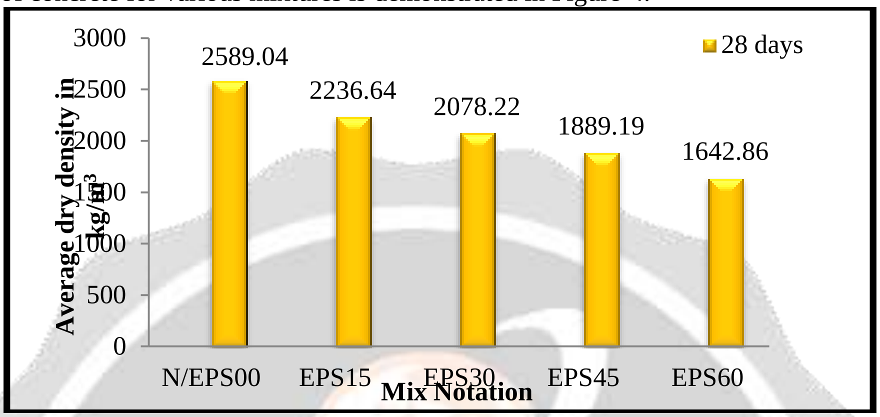

Figure 4: Unit weight or Dry density of all mixes

From the results it is noted that the unit weight or dry density decreases with increase in percentage of coarse aggregate replacement by EPS beads. The reduction in unit weight is due to the fact that density of EPS beads is very much lower than other concrete constituents. The unit weight declined from 2589.04 kg/m^3 to 1642.86 kg/m^3 with increasing EPS beads replacement rate from 0% to 60% at 28 days. From the results it is also seen that the addition of EPS beads in concrete meets the criteria of light weight concrete since density of light weight concrete is less than 2500 kg/m^3.

5.3 Compressive Strength Test

Especially for concrete compressive strength is an important parameter to determine the performance of material during service conditions. The effect of EPS beads on compressive strength of concrete for various mixtures is demonstrated in Figure-5.

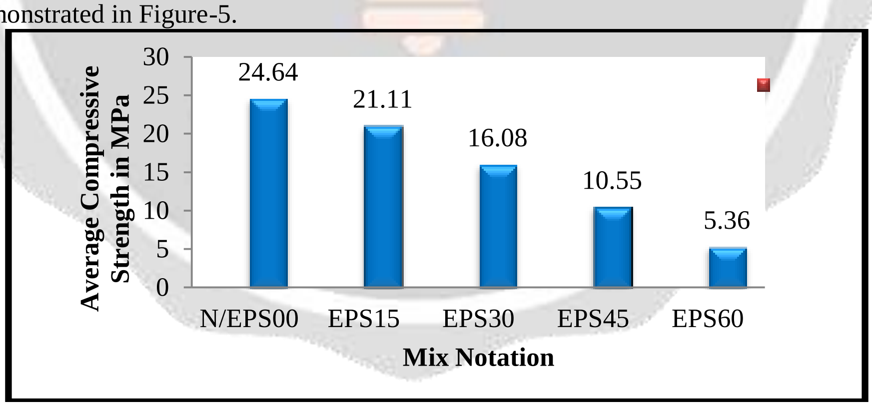

Figure 5: Compressive strength of all mixes

From the results it is observed that the compressive strength decreases with increase in percentage of coarse aggregate replacement by EPS beads. The decrease in compressive strength may be due the lack of bonding between EPS beads and surrounding cement paste and also due to reduction in overall density of concrete. The increase in EPS beads content from 0% to 60% resulted in decrease in compressive strength from 24.64 MPa to 5.36 MPa which is equivalent to about 78% reduction of strength on day 28. However the mean characteristic compressive strength is achieved by the mixtures incorporating 0% and 15% (N/EPS00 and EPS15) EPS beads in concrete on 28 day.

5.4 Splitting tensile strength

Splitting tensile strength is used to determine the tensile strength of concrete in an indirect way. The effect of EPS beads on splitting tensile strength of concrete for various mixtures is demonstrated in Figure-6.

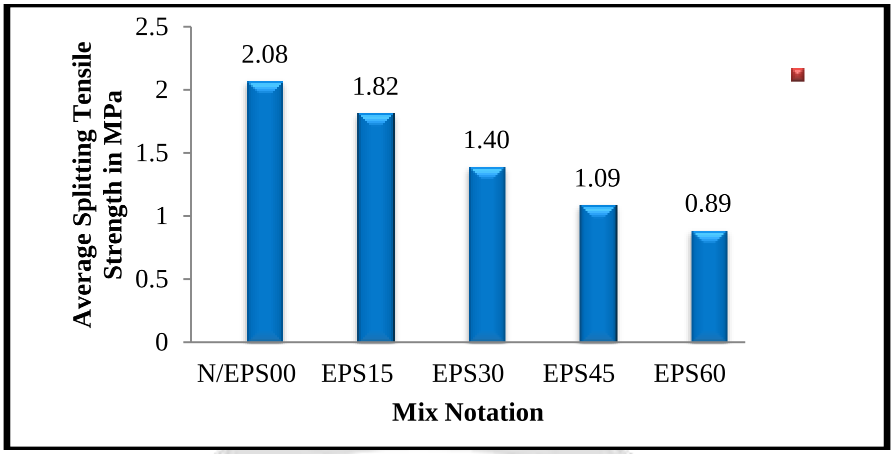

Figure 6: Splitting tensile strength of all mixes

From the results it is noted that the splitting tensile strength decreases with increase in percentage of coarse aggregate replacement by EPS beads. The decrease in strength is due to low specific gravity of EPS beads due to which there is reduction in overall density of concrete. The increase in EPS beads content from 0% to 60% resulted in decrease in splitting tensile strength from 2.08 MPa to 0.89 MPa which is equivalent to about 58% reduction of strength on day 28.

6. CONCLUSIONS

After studying the several test results of different specimens ranging in Expanded Polystyrene (EPS) Beads content from 0% to 60% in replacement of coarse aggregate, the following conclusions are deduced:

1. The workability of concrete improves due to addition of Expanded Polystyrene (EPS) Beads and is acceptable in terms of the ease in handling, the placing and finishing of wet concrete as compared to normal concrete.
2. The dry density of concrete reduces as the percentage of EPS beads content increases.
3. The compressive strength of concrete reduces as the percentage of EPS beads content increases.
4. Optimum level of replacement of coarse aggregate by EPS beads is found to be 15% to obtain better compressive strength.
5. The splitting tensile strength of concrete decreases as the EPS percentage increases.
6. Although the strength of concrete is reduced with increase in EPS beads content, its lower unit weight meets the criteria of light weight concrete.

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