INFLUENCE OF EPS BEADS ON CONCRETE STRENGTH AND DURABILITY CHARACTERISTICS

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Abstract*:* In our day-to-day life, the harnessing waste materials form a vital role in the construction sector. River sand was traditionally employed as fine aggregates in concrete. With increasing demand of river sand, various alternatives such as M sand, Expanded Polystyrene (EPS) Beads are found to be utilized in concrete as a partial substitution for fine aggregates. EPS plays a vital role in packaging industry with disposal issues. Hence, laboratory experiments are performed on the properties of hardened concrete by partially replacing EPS beads in fine aggregate in the range of 0%, 1%, 2.5% and 5% along with M sand. The measured results show that the usage of combination of M sand along with EPS beads significantly improves properties of concrete.

Key words: EPS beads, Durability, Fine aggregates, M sand, Strength.

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1. INTRODUCTION

Concrete is extensively practiced building material in the civil engineering projects. It consists of cement, fine aggregate, coarse aggregate and water. The fine aggregate generally employed in the concrete is river sand (Chandana Sukesh et al 2013). Over the last few decades, construction industry has expanded considerably leading to overuse of river sand for construction purposes. This leads to exhaustion of natural resources. This will alter the course of river and eroding riverbank leads to flooding. Also, transportation of good quality sand from riverbed to the place of construction increases cost of construction. However, the discrepancy between the requirement and scarcity for river sand in the society has urged engineers and architect to identify for sustainable fine aggregate without compromising the quality of concrete (Asha et al 2020). One such economical and ecological alternative is Manufactured sand (M sand) obtained from crushing hard stones derived from construction and demolition waste (Sakthivel et al, 2013; Muralikrishnan et al, 2018 Lalit Kumar and Arvinder Singh 2015). At present, the world also generates 2.01 billion tonne of solid waste yearly, which adversely affect our environment. Dumping of waste as landfill also causes land pollution, foul smell, spread of diseases, whereas incineration of waste will lead to emission of harmful toxic gases and causes air pollution, one such waste is Expanded polystyrene (EPS) beads, a lightweight cellular plastic material (Sahin and. Kamaran 2012; Chandru et al 2017) which are either used in bean bags and thermacol in packingindustry.

EPS is non biodegradable material consists of 98%air and 2% polystyrene. It consists of closedcellstructurewhichisincapableofabsorbingwater.EPSbeadsarestrong,durable, and lightweight that can be used for flooring, wall panels and has a wide range of applications in various sectors. EPS beads are shock absorbent. These cannot be recycled very easily and also cannot be dumped. Therefore, utilization of the waste like EPS in concrete solves the problem of disposal as well as preserving the natural resources (Suhad M Abd et al 2016). The primary goal of this research is to make use of M sand and EPS beads as partial alternative of fine aggregate inconcrete.

2. LITERATUREREVIEW

Many researchers have investigated properties of hardened concrete by partially replacing EPS beads as fine aggregate.

Dhivakar Karthick and Bharathi (2018) studied the effect of EPS beads as a partial substitution for coarse aggregate in concrete. The decrease in compressive strength is about 29% and 55% as the percentage of EPS beads are increased to 15% and 30% respectively in concrete instead of coarse aggregate. Further, it is also emphasized that the relative strength of concrete mix is about 80% and 70% upon the addition of 15% and 30% EPS content respectively. Hence, it was concluded that increasing the amount of EPS beads reduces both compressive and split tensile strength.

Amar D. Vandale et al (2019) conducted laboratory experiments to understand the properties of EPS based concrete in which cement is partially replaced by quarry dust is used as fine aggregate. It was noticed that the properties such as sound, thermal insulation and workability oftheconcreteincreasesandcompressivestrengthdecreasesuponincreaseinEPScontent.

Ram Kumar et al (2019) investigated effectiveness of EPS beads and pumice aggregate on properties of M20 concrete mixed with four different percentages of EPS beads replacing fine aggregate. It was also concluded that EPS can be used as partitions in buildings because of lower density and higher thermalconductivity.

Ashish S. Moon et al (2020) presented the results of an investigation study on the influence of fly ash and EPS beads on the compressive strength of lightweight concrete. It was found that the concrete with 5% EPS beads possess higher compressive strength in comparison with other samples.

Mwero1 and Onchaga (2020) conducted experiments to examine the influence of lightweight EPS beads on properties of concrete. It was observed that density, compressive strength, and split tensile strength have all been reduced significantly. This enhances the potential for the use of above mixture as a economically viable light weightconcrete.

Igba et al (2020) investigated the impact of EPS beads-quarry dust mixes on various properties such as density, workability and compressive strength of concrete. It was concluded that increase in percentage of EPS beads reduces the density as well as compressive strength of concrete.

3. OBJECTIVE ANDSCOPE

The main objective of this study is to determine the effects of different percentages of EPS beads added to M sand as a partial substitution for fine aggregate on the characteristics of hardened concrete.

The detailed scope of the experimental investigation is summarized as below:

- Conducting laboratory experiments on physical properties of cement, M sand and EPS beads.
- To conduct experimental studies to assess strength and durability characteristics of conventionalconcrete.
- Studying the influence of varying percentages of EPS beads mixed with M sand on strength and durability characteristics of conventionalconcrete.
- Carry out laboratory experiments to measure compressive strength against sulphate attack of both conventional and EPS basedconcrete.
- ObtainingoptimumdosageofEPSbeadsbaseduponexperimentaltestresults.

4. MATERIALDESCRIPTION

Materials:

All the constituents of both conventional and EPS based concrete used in this experimental study satisfy provisions as per ISCodes.

A. Cement: Ordinary Portland cement of grade 53 adhering to IS 12269 – 2013 was used for this study. Several tests were carried out to confirm that the physical properties of cement complied with IS requirements.

B. Aggregate: Aggregates are filler materials in concrete. In other words, suspension of cement in water forms paste, suspension of fine aggregate in paste is termed as mortar, suspension of coarse aggregate in mortar forms concrete. Manufactured sand known as M Sand is employed as a fine aggregate in this study. It is obtained from hard granite stone by crushing. Coarse aggregate utilized for this experimental study is locally available crushed angular and rounded stone of size 20 mm and10 mm.

C. EPS beads: EPS beads used in this study is polystyrene foam, by product obtained from crude oil industry. The specific gravity and density of EPS beads used forthe present study is 0.044 and 18kg/m^3 respectively.

D. Admixtures: Admixtures used in the present study is VARAPLAST SP123 solution. It is a chloride free, super plasticizing admixture made from high-quality SNF synthetic polymers. It is available in brown solution which is instantly dispersible in water. This admixture compiles with BS 5075 – 1982, ASTM C494 Type G and IS 9103 –1999.

Casting ofSpecimen:

The mix proportions were calculated using Indian Standard Recommended Method of Concrete Mix Design (IS10262:2009) and the mix ratio was obtained for M 30 mix. The water/cement ratio was fixed as 0.45 in all the mixtures. Each mix was prepared by hand mixing. The mix design parameters are presented in Table 3. To begin, conventional concrete specimens were cast in line with the ‘‘Methods of Tests for Concrete Strength" (IS: 516 - 2004). In addition, EPS based concrete specimens with fine aggregate substituted in part by EPS beads of 1%, 2.5 percent, and 5% were cast in parallel. Then, the specimens are detached from the moulds at the end of 24 hours and kept submerged in clean water at room temperature. After curing, the specimens were withdrawn from the curing tank and dried in atmosphere prior to test.

ExperimentalInvestigation

The following tests were carried out on conventional concrete and conventional concrete blended with different percentages of EPS beads in accordance with IS code guidelines.

- Compressiontest
- Split tensiletest
- Flexuretest
- Densitytest
- Sulphate attacktest

The compression test was performed on dried specimens in cube measuring 150 x150x 150 mm in compression testing machine. The dried specimens in cylinder with a diameter of 150 mm and a height of 300 mm were held horizontally in between the loading surfaces in compression testing machine and split tensile test was performed in accordance with IS:516- 1959. The flexure test for beams of size 700x 150x 150 mm as per the IS: 516:2004. The density of cubes was determined using mass-volume relationship. Finally, the specimens in cube which were 150 mm x 150 mm in dimension were cast and immersed in the curing tank filled up with sodium sulphate solution. After 56 days, they were evacuated from the curing tank and kept in open atmosphere for drying. The compression test was performed on the dried specimens.

5. RESULTS ANDDISCUSSIONS

The influence of various percentages of EPS beads added with M sand as a partial substitution forfine aggregate in the characteristics of hardened concrete isdiscussed.

InfluenceofEPSbeadsonconcrete compressivestrength

The measured compressive strength obtained from experiments in terms of percentage of EPS beads after 7 and 28 days were presented in Figs. 1(a) and 1 (b) respectively. In the initial stages, it was noticed that increasing the amount of EPS content reduces the compressive strength of concrete. The decrease in compressive strength is 8.30% and 7.2% is observed after 7 and 28 days respectively at 1% partial replacement of EPS beads. It could be due to addition of EPS beads reduces overall density of the concrete in the initial stages. However, there is marginal gain in compressive strength gain is observed when the EPS content is increased from 1% to 2.5%. The increase in strength is 6.17% and 5.17% after 7 and 28 days at 2.5% EPS content. It may be due to increase in density and formation of strong bond between cement paste and EPS beads. However, when conventional concrete was treated with more than a 2.5 percent increase in EPS content, the decrease in compressive strength was observed.

InfluenceofEPSbeadsonconcrete splittensilestrength

The measured split tensile strength of conventional and EPS based concrete after 7 days and 14 days is also exhibited in Fig. 2. It was noticed that there is improvement in split tensile strength by 11.24% and 19.30% after 7 and 28 days respectively when it is treated with 2.5% EPS content. The enhancement in strength may be due to the creation of strong bond sandwiched between cement paste and EPS beads. However, there is a decrease in strength of 8.15% is noticed after 28 days, when the percentage of EPS content increases from 2.5% to 5%. It may be attributed to decrease in overall density when the percentage of EPS content increases.

Influence of EPS beads on concrete flexural strength

The measured flexural strength regarding percentage of EPS beads after 7 days and 14 days was presented in Figs. 3(a) and 3 (b) respectively. It was recognized that the flexural strength increases up to 2.5% EPS content. The variation of 4.64 %was observed in EPS based concrete in comparison with that of conventional mix after 7 days. It was concluded that flexural strength increases marginally by 0.678% after 28 days when it is treated with 2.5% EPS content.

Influence of EPS beads on concrete density

The influence of EPS beads on concrete density for various mixtures is demonstrated in Fig.4(a).Thereisareductionisdensityof23.14%isobservedwhenEPScontentincreases from 0% to 2.5%. There is also marginal increase in density is observed beyond this limit. As the density of light weight concrete is less than 2500 kg/m^3, the incorporation of EPS beads in concrete meets the criteria for light weight concrete.

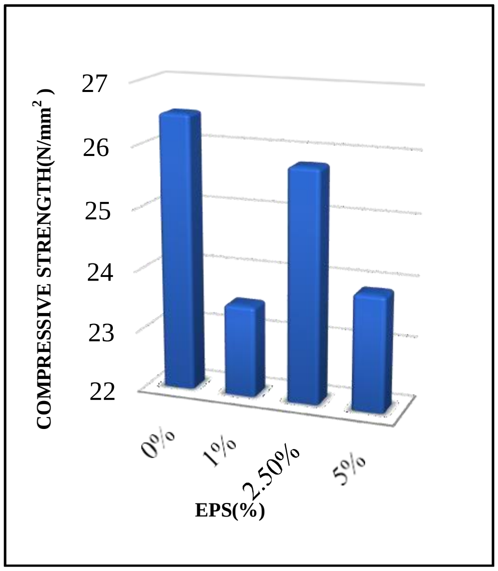
InfluenceofEPSbeadsonconcrete compressivestrengthagainstsulphateattack

The effect of EPS content on concrete compressive strength against sulphate attack after 56 days is presented in Fig. 4(b). The presence of EPS beads results reduction in compressive strength regardless of its percentage of replacement in fine aggregate. The highest reduction in compressive strength due to the addition of 5% EPS content is about 5.33 percent.

6. SUMMARY ANDCONCLUSIONS

Based on the experimental investigations which were carried out on the strength and durability behavior of conventional and EPS based concrete, the following conclusions aredrawn.

- As the percentage of EPS in fine aggregate increases, the compressive strength of concrete decreases. The optimum dosage of EPS beads is found to be 2.5 percent in order to achieve greater compressive strength.
- The increase in split tensile strength of EPS based concrete was found until 2.5 percent EPS content was added, after which it decreased.
- The flexural strength of concrete blended with 2.5% EPS beads content is 1.05 times higher than conventionalconcrete.
- As the percentage of EPS beads in concrete increases, the density of the concrete decreases.
- The compressive strength of EPS based concrete is reduced by 5.33 percent in comparison with conventional concrete, when exposed to sulphate attack.
- Even though, the strength of EPS based concrete reduces as the percentage of EPS beads in the mix increases, its lower density meets the criterion for light weight concrete. Hence it is the potential viable material to be used for non- structural applications like precast concrete members, partition walls, and wallpanels.



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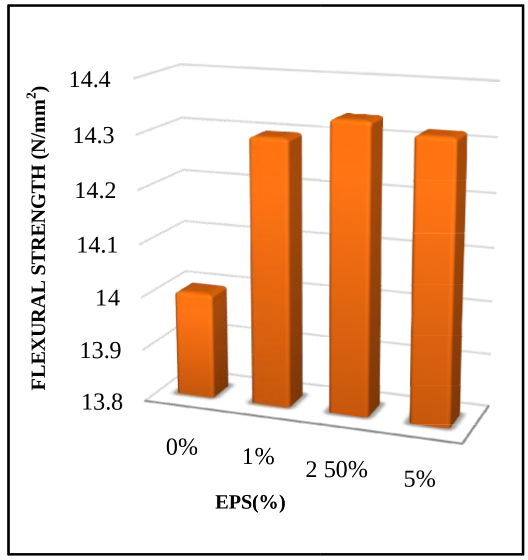

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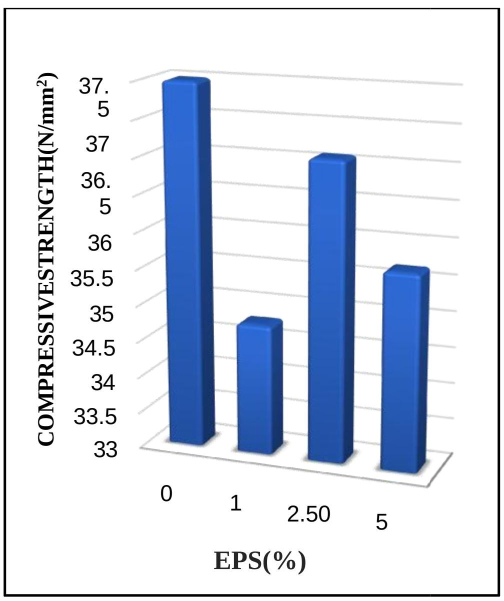

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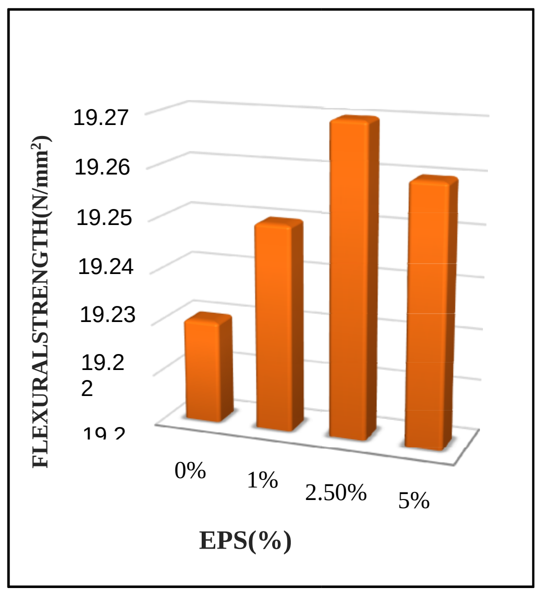
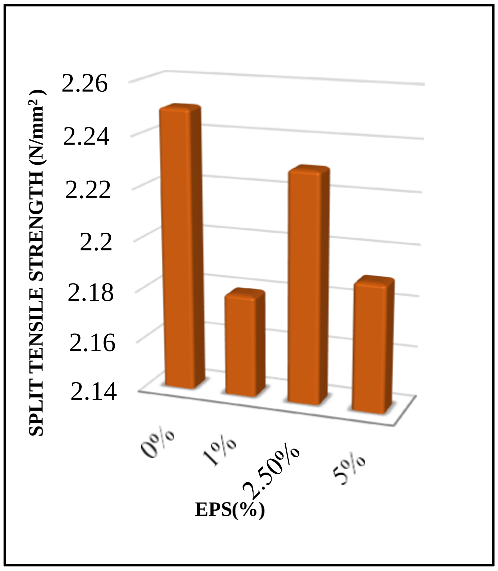


(b)

Fig 1 (a) & (b) Variation of compressive strength with increase in EPS content as a function of age of concrete

Fig 2 (a) & (b) Variation of Flexural strength with increase in EPS content as a function of age of concrete



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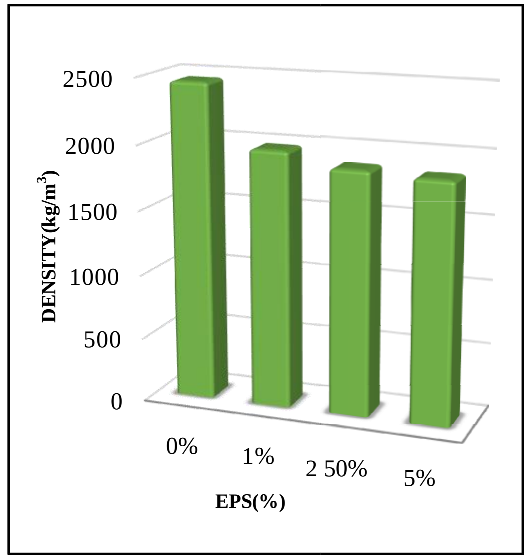

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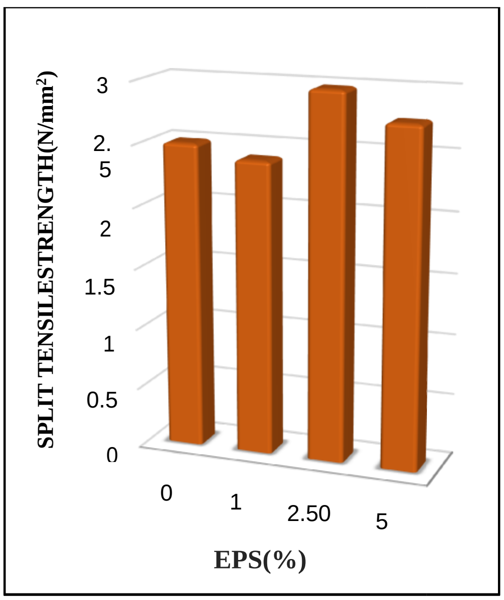

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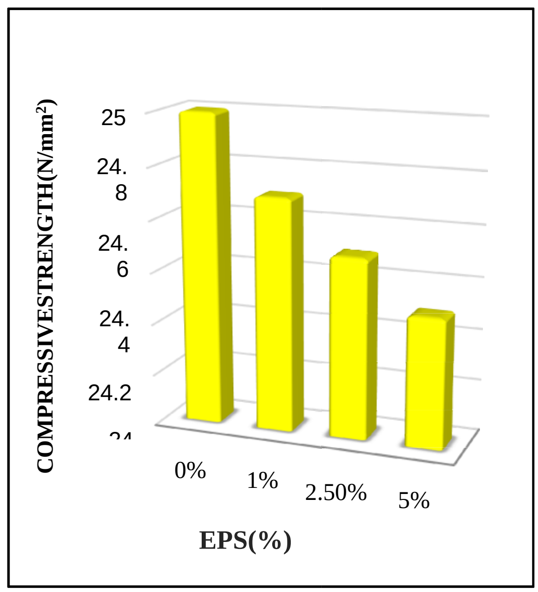

(b)

Fig 3 (a) & (b): Variation of split tensile strength with increase in EPS content as a function of age of concrete

Fig 4: Variation of (a) density (b) compressive strength due to sulphate attack with increase in EPS content as a function of age ofconcrete

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