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EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF COARSE AGGREGATE BY EPS (EXPANDED POLYSTYRENE) BEADS IN CONCRETE BLOCKS

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ABSTRACT

As the chemical manufacturing sector has expanded, the field of composites utilised in construction and engineering has grown in recent years. Certain thermal and mechanical qualities are added to various composite concretes as a result of this expansion. Polystyrene Concrete (Epscrete), in particular, has been making headlines due to its unique properties. It has strong thermal insulation capabilities and is stiffer and more compressible than medium clay. Concrete must be developed using a density factor to achieve a reduction in concrete self-weight range from 2000kg/m3 to 990kg/m3 total volume of eps 0-100 percent and water cement ratio 0.40 in this project. The structural self-weight is crucial since it reveals the majority of the load information. When the coarse part of low weight aggregate (EPS Beads) is partially replaced with regular aggregates, lightweight concrete with a reliable good compressive strength is produced. For varied proportions, different percentages of EPS beads are substituted according to desired design features. Various tests were carried out on fresh and hardened concrete to determine the physical and mechanical qualities of the material at 7 and 28 days of age.

Keywords: EPS, Compression Strength, Light Weight Concrete, Epscrete.

I. INTRODUCTION

(Ref. Experimental study on replacement of coarse aggregate by EPS beads in concrete to achieve lightweight concrete, Jayanth M P, Sowmya S M (2018) & Ultra-Lightweight EPS Concrete: Mixing Procedure and Predictive Models for Compressive Strength, Fayez Moutassem (2020))

Alternative ecological and cost-effective materials are gaining popularity. Because of its low density, hydrophobic characteristics, superior thermal insulation, minimal absorption, and low cost, expanded polystyrene (EPS) is commonly used as a packing material. The yearly global production of polystyrene is about fourteen million tonnes and a very substantial quantity of EPS ends up as waste elements that are transferred to dumps.

Coarse aggregates can be partially replaced with lightweight synthetic materials like EPS or Styrofoam. Greater design flexibility, significant cost savings, decreasing dead loads, thinner sections, compact structural parts, and so on are all possible with lightweight concrete blocks. Lightweight concrete blocks are defined as those that have a lower unit weight than those composed of gravel or crushed stone materials and can be utilised for partition walls in general. The weight of ordinary concrete bricks is considerable. As a result, if used, it significantly increases the structure's dead weight. Lightweight concrete not only reduces the structure's dead weight but also acts as a thermal insulator.

Studies have showed that as the percentage of polystyrene replaced increases, the strength of the concrete decreases significantly in comparison to conventional concrete. The EPScrete's compressive strength rises as the replacement levels of expanded polystyrene beads decrease. Moreover, research concludes that concrete has a lower workability than a standard mix. In addition to partial EPS bead replacement, EPScrete can be made with a lower water/cement ratio than required without sacrificing workability. The trial mixes have a lower compaction factor than regular mixtures. Also, with increasing workability, the strength of EPScrete diminishes.

In this study, discarded expanded polystyrene will be utilised as aggregates, and the impacts on concrete will be examined.

II. MATERIALS

EPS concrete is a particularly lightweight concrete with a porous structure, produced on the basis of a cement binder, with a porous granular aggregate (expanded polystyrene). The acceptable bulk density of the granulate – 15 kg per cubic meter of concrete, under special conditions up to 20 kg / m³. The size of the granules depends on the brand and class of concrete and varies in the range 0.7-5.5 mm, maximum – 10 mm. Also, air entraining agents and various modifying additives are added to the solution, improving the properties of both the mixture, in the process of application, and of the ready-made concrete during operation. Air-entraining additives are necessary to impart a porous structure to the cement stone, not only due to polystyrene balls but also through the formation of closed air cells. In addition, they prevent the floating of the granules, ensuring uniformity of the solution and preventing its stratification into fractions.

- EPS (Expanded Polystyrene) : EPS beads
- Cement (Grade 43)
- Fine Aggregate (locally sourced)
- Coarse Aggregate (locally sourced)
- Along with Potable Water

III. METHODOLOGY

(Ref. Experimental study on replacement of coarse aggregate by EPS beads in concrete to achieve lightweight concrete, Jayanth M P, Sowmya S M (2018 & Ultra-Lightweight EPS Concrete: Mixing Procedure and Predictive Models for Compressive Strength, Fayez Moutassem (2020))

- ❖ Styrofoam is selected as a partial replacement material for coarse aggregates.
- ❖ Styrofoam is a lightweight insulation material designed for various engineering applications such as concrete floor, roadways, rail beds, etc.,
- ❖ Samples of definite volume are to be oven dried for 24 hours to determine the dry density of Styrofoam, which approximately needs to be noted down in kg/m3.
- ❖ Mix design using IS 456: 2000, a method to be carried out for M25 grade of concrete. From which proportion of cement, sand, aggregate and water-cement (w/c) ratio will be obtained.
- ❖ Tests on wet concrete (mentioned henceforth) are performed to test its workability.
- ❖ Totally six sets of cubes i.e., two in each set of dimensions 150 x 150 x 150 mm cubes, 500mm x 150 x 150 beams, and 150mm diameter x 300mm cylinders to be casted having 50%, partial replacement of coarse aggregate with Styrofoam by weight.
- ❖ Non-Destructive Rebound Hammer test need to be performed at the interval of 7 and 28 days.
- ❖ Strength development of the concrete will be obtained at the end of 28 days, with the help of various tests mentioned below.

IV. TESTS ON CONCRETE (HERE EPSCRETE)

Tests on Fresh Concrete

a) **Vee-Bee Consistometer Test**: The main goal of the Vee-Bee test is to figure out how workable newly mixed concrete is. The Vee-Bee test determines the mobility of freshly mixed concrete.

b) **Slump Cone Test**: This test was performed to determine the fresh concrete's workability. According to IS 456:2000, the aggregate size should not exceed 20mm during testing.

c) **Compaction Factor Test:** The compaction factor test is an alternate method of determining the workability of fresh concrete. Compaction factor apparatus is utilised, which consists of two hoppers with trap doors and a cylinder.

Tests on Hardened Concrete

- **Destructive Tests**

a) **Split Tensile Test:** One of the most basic and crucial features of concrete is its split tensile strength, which has a significant impact on the degree and size of cracking in structures. The cylinders are placed on the loading platform of the compressive testing equipment, and the load is gradually added until the specimen fails. The test is conducted for 7 and 28 days.

b) **Compressive Strength Test:** Compressive strength refers to a material's or structure's ability to resist or withstand compression. The maximum compression that concrete can withstand without failure is determined in this test by applying a push force to both sides of the concrete specimen in accordance with IS 516. The cube should be 150 x 150 x 150 mm in size, the aggregate should be no larger than 20 mm, and attempted between 7 and 28 days.

c) **Flexural Strength Test:** Flexural testing is performed to determine a material's flex or bending qualities. It entails inserting a sample between two points or supports and beginning a load with a third point or with two points, which is referred to as 3-Point Bend and 4-Point Bend testing, respectively. A flexure strength test was performed on a beam with dimensions of 100x100x500mm. Third point loading was used to test all of the beams. The load is applied until it fails.

- **Non – Destructive Tests**

a) **Ultrasonic Pulse Velocity Test:** UPV Test is used to inspect the quality of concrete. The velocity of an ultrasonic pulse flowing through a concrete structure is measured in this test to determine the strength and quality of concrete. This test is carried out by sending an ultrasonic pulse into the concrete being tested and measuring the time it takes for the pulse to pass through the construction. Pulse velocity=(Path length/Travel time). Slower velocities may suggest concrete with many fractures or voids, whereas higher velocities indicate good quality and continuity of the material.

b) **Rebound Hammer Test:** This test provides a quick and easy assessment of the concrete's compressive strength. The rebound hammer is made out of a spring-loaded mass that slides on a plunger inside a tubular chassis. The rider is taken by the hammer with it along the guide scale, the rider is kept in place by clicking the button, and the rebound number is observed.

V. RESULTS, DISCUSSION, AND PROPOSED MODELS

(Ref. Ultra-Lightweight EPS Concrete: Mixing Procedure and Predictive Models for Compressive Strength, Fayez Moutassem)

I. Experimental Testing Results

Table below shows the results of the trials for each combination, including slump, air content, fresh density, hardened density, and compressive strength at 7 and 28 days The sections that follow will go over the relevance of the collected results, as well as present and discuss the proposed compressive model's calibration and precision models of strength. Results of the Experimental testing is given in the table below:

Table 1. Experimental Testing Result

Mix #	Slump (mm)	Air (%)	Fresh Density (kg/m3)	Hardened Density (kg/m3)	f'c (7d) (MPa)	f'c(28d) (MPa)
1	70	0	978	996	7.05	7.79
2	40	6	778	794	3.46	5.16
3	150	11	764	759	3.58	3.99
4	220	15	622	629	2.78	3.16
5	240	11	699	646	2.35	3.45

II. Workability and Surface Finish

The slump test was used to assess the workability of fresh concrete. For 28 mixes, high workability was attained to ensure ease of casting and placement. Table 3 shows that mixtures 4 to 30 had high flow characteristics, with slump values surpassing 220 mm. Figure 2 depicts a slump test for a common mix, demonstrating the mixture's great workability, uniformity, and stability. For EPS concrete to connect properly with other materials, it must have a good surface finish, especially if it is used as a core infill material for partition walls or other applications. The successful mix is confirmed by its consistency, uniformity, stability, and surface finish.

III. Concrete Density

Density is an important characteristic in EPS concrete because it can regulate a variety of physical characteristics.

The porosity of the specimen, which is mainly controlled by the volume fraction of air (entrapped and entrained), capillary porosity, which is dependent on the water to cementing materials ratio, and the volume fraction of the EPS beads, which are of negligible density and strength, dominate the density and compressive strength of EPS concrete.

The experimental values for densities fresh and hardened ranging from 458 to 996 kg/m3.

Related to the mixture proportions using the following relationship proposed in this study

□, f'c □ (w + a + eps) / cm. The volume fractions of water, air, EPS, and cementing ingredients in the concrete mix are represented by w, a, eps, and cm.

Unlike standard concrete, which uses heavy aggregate, ultra-lightweight concrete uses EPS aggregates with lower densities than the density of water. Water that is not consumed during the hydration phase, would eventually evaporate, leaving voids in place.

It's possible that losing a lot of weight will have a big impact on the general density of the lightweight concrete that has been hardened.

IV. Compressive Strength

The concrete mixtures' 28-day compressive strength values (f'c28d) listed in the table above. The maximum and minimum compressive strength values for the five mixtures are 7.79 MPa and 3.45 MPa, respectively.

The density of light-weight concrete is the most important factor influencing its compressive strength, according to several prior research.

As a result, this study looked into the relationship between density and compressive strength of the EPScrete. This work also establishes a link between the plastic density of fresh concrete and the compressive strength of hardened concrete, in addition to the presented predictive models. This is necessary to ensure quality control prior to the casting of concrete.

V. Rate of Strength Development and Concrete Age

Similar to standard concretes, the rate of strength development of the Epscrete was higher at first and then dropped over time. According to the findings of this study's experiments, concrete develops roughly 48 percent of its 28-day strength in one day and 83 percent of its 28-day strength in seven days. These findings reveal that EPS concrete develops strength at a faster rate than typical normal density concretes.

Only 28-day strength was created and calibrated in the proposed strength models because it is the primary mix design requirement. However, because the 28-day compressive strength is linked to early-age strengths, it is critical to accommodate tight construction timelines.

VI. CONCLUSION

(Ref. Effect of matrix particle size on EPS lightweight concrete properties, Duc Hoang Minh and Ly Le Phuong (2018) & Experimental Investigation on Styrofoam based Concrete, Ashish Paranje, Preeti Kulkarni (2017) & Experimental study on replacement of coarse aggregate by EPS beads in concrete to achieve lightweight concrete, Jayanth M P, Sowmya S M (2018) & Ultra-Lightweight EPS Concrete: Mixing Procedure and Predictive Models for Compressive Strength, Fayez Moutassem (2020))

From the analysis and discussion focusing on the mechanical properties of self-compacting concrete with the utilization of Styrofoam to produce lightweight concrete brick, the following conclusion can be drawn:

a) All of the variation of Styrofoam content meets the slump flow properties when the appropriate amount of superplasticizer is used.

b) Although the use of more Styrofoam will increase the water absorption as well as decrease the compressive strength and the flexural strength, the decrease of weight of volume which reaches the lightweight concrete criteria is important.

c) The proposed variation of Styrofoam as natural aggregate replacement is 50% as its properties meet the standard and the weight volume is the lowest among other variations.

d) The reduction of mass density of EPS concrete makes it suitable for applications as non-load bearing light weight concrete such as partitions, panels, exterior facades etc., Further research would be more valuable when it includes the test on the addition of Styrofoam content as partially coarse aggregate substitution. In addition, another method of concrete casting is also required to get better distribution of Styrofoam.

However, it is seen that as the percentage replacement of Styrofoam increases the samples undergo more ductile failure, which shows that Styrofoam based concrete, has better energy absorption as compared to the conventional concrete. The flexural strength of Styrofoam based concrete increased with the increase in Styrofoam and this increase was more significant in case of 15% sample.

The research investigated the effect of EPS in structural concrete. The effects of EPS on the mechanical properties, durability and workability of the concrete were investigated. From the results and analysis of this research, it was observed that as the volume of the EPS dosage increases, the workability decreases, the compressive strength decreases, the flexural strength decreases, the tensile strength increases up to 10% EPS and then decrease, thus making the EPS concrete a weak concrete. It can be used for low-strength components of a structure.

VII. REFERENCES

[1] Adeala A.J., Soyemi O.B. (2020). Structural Use of Expanded Polystyrene Concrete. International Journal of Innovative Science and Research Technology. Volume 5, Issue 6, pp 1131-1138.

[2] Jayanth M.P., Sowmya S.M. (2018). Experimental Study on Replacement of Coarse Aggregate by EPS Beads in Concrete to achieve Lightweight Concrete. International Research Journal of Engineering and Technology (IRJET). Volume 5, Issue 7, pp 610-616.

[3] Ashish P., Preeti K. (2017). Experimental Investigation on Styrofoam Based Concrete. International Journal of Mechanical and Production Engineering (IJMPE). Volume-5, Issue-12, pp 56-61.

[4] Ankur K. (2021). Strength and Durability of Polystyrene Concrete. International Journal of Recent Technology and Engineering. Volume 9, Issue 5, pp 166-171.

[5] Solikin M. and Ikhsan N. (2018). Styrofoam as partial substitution of fine aggregate in lightweight concrete bricks. AIP Conference Proceedings 1977, 030041.

[6] Ahmad M. H., Loon L. Y., Noor N. M., & Adnan S. H. (2008). Strength development of lightweight Styrofoam concrete. International Conference on Civil Engineering.

[7] Alam B., Ullah Z, Jan F.U., Shahzada K. and Afzal S. (2013). Investigation of Styrofoam as Lightweight Aggregate, International Journal of Advanced Structures and Geotechnical Engineering. Volume 2, No. 2, pp 50-53.

[8] Duc H.M. & Ly L.P. (2018). Effect of matrix particle size on EPS lightweight concrete properties. MATEC Web of Conferences. 251. 01027.

[9] Fayez M. (2020). Ultra-Lightweight EPS Concrete: Mixing Procedure and Predictive Models for Compressive Strength. Civil Engineering and Architecture. Volume 8, No. 5, pp 963 - 972.

[10] Divya P., Uresh K., Mehul S., and Rahul S. (2017). Experimental Study on Lightweight Concrete with Styrofoam as a Replacement for Coarse Aggregate. International Conference on Research and Innovations in Science, Engineering &Technology. Volume 1, pp 103–108.