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DESIGN AND CHARACTERIZATION OF LIGHTWEIGHT CONCRETE USING EXPANDED POLYSTYRENE(EPS) BEADS

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Abstract — Lightweight concrete using Expanded Polystyrene (EPS) beads is an innovative construction material designed to reduce the self-weight of structures while maintaining adequate strength and durability. In this type of concrete, conventional aggregates are partially or fully replaced with EPS beads, which are lightweight, spherical particles made from polystyrene. The inclusion of EPS beads significantly decreases the density of concrete, making it suitable for non-load bearing walls, insulation layers, partition panels, and precast elements. The main objective of using EPS beads in concrete is to improve thermal insulation, reduce dead load, and enhance workability. Due to its low density, EPS concrete also provides good sound insulation and energy efficiency in buildings. The production process involves mixing cement, fine aggregates, water, and EPS beads in proper proportions to achieve the desired strength and workability.

I. INTRODUCTION

Lightweight concrete using Expanded Polystyrene (EPS) beads is an innovative construction material developed to reduce the self-weight of concrete while improving its thermal and sound insulation properties. EPS beads are lightweight, spherical particles made from polystyrene, and when they are used as a partial or full replacement for conventional coarse aggregates, they significantly decrease the density of concrete. This makes the concrete easier to handle, transport and place. Conventional concrete is often heavy, which increases the load on structural members and foundations. By incorporating EPS beads, the overall dead load can be reduced without compromising essential performance for non-structural and semi-structural applications. EPS-based lightweight concrete also offers advantages such as better workability, resistance to moisture, and improved energy efficiency due to its low thermal conductivity. Because of these benefits, EPS lightweight concrete is increasingly used in partition walls, insulating layers, prefabricated blocks, and low-loadstructural elements. Its eco-friendly nature, resulting from reduced raw material consumption and energy savings, makes it a promising material for sustainable construction practice.

II. LITERATURE REVIEW

Abdulkar kan , et al(2009):

This paper reports the results of an investigation study on the effects of using expanded polystyrene beads (EPS) in a lightweight concrete as a aggregates. In this project eps beads are used in form of aggregate. In this study, we get to know that in Aggregate the foam which is used is a thermally modified waste EPS foam. By heat treatment method we had get expanded polystyrene
aggregates (MEPS)by a hot air oven at 125°C for 20 min and keeping EPS foams in that oven. By introducing the weight concrete can be produced:(1) gas-sing material like-aluminium powder or we can use fibre, (2)plastic granules like aggregates, e.g., expanding urethanesfoam(EPS),urethane or different polymer materials.

Mohali Patil, et al(2016):

This paper present the outcomes of an exploratory examination into the engineering properties like, the compressive property and splitting property of polystyrene aggregates concrete different in thickness. In Germany 1950 a unyielding cellular plastic is unusual explore which had named EPS or expanded polystyrene. Since 1958the expanded polystyre has been came into force and work in wrapping things. In this it is made up of 98% of gas but the remaining is of small, global EPS beads-which itself create of co2andhydrogen.With the quickly evolution and technology growth, the use of replacement for aggregates
in concrete has been grow a lot. In concrete building like enlarged glass and EPS beads etc.. gradually different and new substance are being made and work as renewal of aggregate in concrete raising

2022 – Y. Sun et al.

Y. Sun et al. conducted a detailed study on the properties of EPS lightweight concrete. The research mainly focused on compressive, tensile, and flexural strength of the material. It was observed that increasing EPS content leads to a reduction in overall strength due to its low density. To overcome this issue, fibers such as polypropylene were added to the mix. These fibers helped in improving bonding and reducing crack formation. However, even with fiber addition, the strength was

still lower compared to conventional concrete. The study also highlighted that EPS concrete is more suitable for non-structural applications. Overall, the research concluded that proper material modification is required to balance strength and weight.

2023 – A.H. Salih:

A.H. Salih conducted a study on lightweight concrete using EPS beads focusing on strength and density characteristics. The research showed that increasing the percentage of EPS significantly reduces the overall density of concrete. However, this reduction in density also leads to a decrease in compressive strength. The study aimed to find an optimum percentage of EPS that balances both weight and strength. It was observed that beyond a certain limit, the strength becomes too low for practical use. The research also discussed the importance of proper mix design in achieving better performance. EPS concrete was found suitable mainly for non-load-bearing and insulation purposes. Overall, the study concluded that selecting the right proportion of EPS is very important for effective utilization.

2024 – M.R.M. Al-Alusi:

M.R.M. Al-Alusi studied the mechanical and durability properties of EPS-based lightweight concrete. The research showed that the inclusion of EPS beads reduces compressive and tensile strength due to weak bonding with the cement matrix. It also highlighted that higher EPS content increases porosity and water absorption. To improve performance, the study suggested the use of mineral admixtures and fibers. These materials help in enhancing durability and reducing shrinkage cracks. The research also focused on improving the long-term performance of EPS concrete. It was observed that proper curing plays an important role in strength development. Overall, the study concluded that additives are essential to improve the quality of EPS concrete.

2025 – Q. Zhang:

Q. Zhang conducted a study on mix design and performance prediction of EPS lightweight concrete. The research focused on improving the strength and efficiency of EPS concrete through advanced design methods. It was observed that proper proportioning of materials plays a key role in achieving better performance. The study used analytical and predictive models to estimate compressive strength and density. Results showed that optimized mix design can reduce the negative effects of EPS on strength. The research also emphasized the importance of uniform distribution of EPS beads in the mix. It suggested that modern techniques can help in producing more reliable EPS concrete. Overall, the study concluded that design optimization is essential for improving structural performance.

III. MATERIALS

• **Cement:** Ordinary Portland Cement (OPC) is used as the binding material.

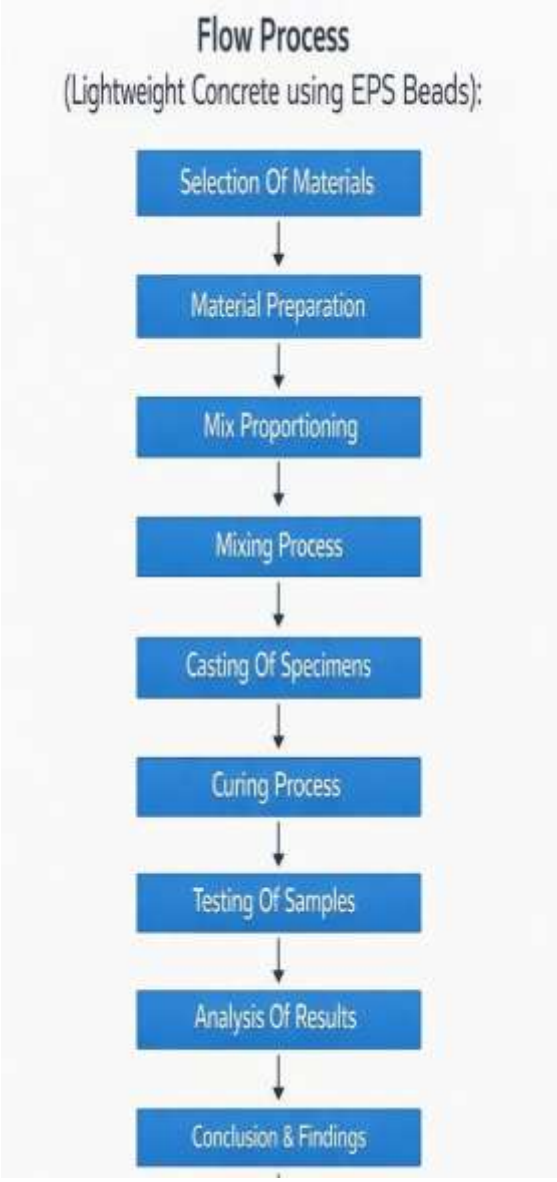
• **Fine Aggregate:** Clean river sand passing through 4.75 mm sieve.

• **Coarse Aggregate:** Crushed stone or gravel of 20 mm maximum size.

• **EPS Beads:** Lightweight Expanded Polystyrene beads used as a partial replacement for coarse aggregates.

• **Water:** Clean potable water for mixing and curing

IV. METHODOLOGY



V. EXPERIMENTAL INVESTIGATION

1. Materials Collection

• **Cement:** Ordinary Portland Cement (OPC) is used as the binding material.

• **Fine Aggregate:** Clean river sand passing through 4.75 mm sieve.

• **Coarse Aggregate:** Crushed stone or gravel of 20 mm maximum size.

• **EPS Beads:** Lightweight Expanded Polystyrene beads used as a partial replacement for coarse aggregates.

• **Water:** Clean potable water for mixing and curing.

2. Mix Design
The concrete mix is designed based on standard procedures for M20 grade concrete (or as per project requirement). EPS beads are used to replace coarse aggregates in varying percentages (e.g., 10%, 20%, 30%, and 40%) to study their effect on concrete properties. The mix proportions are calculated to maintain workability and strength.

3. Preparation of Concrete Mix
• All dry ingredients (cement, sand, coarse aggregate, EPS beads) are thoroughly mixed to achieve uniform distribution.
• Water is added gradually while mixing to ensure proper workability and uniform consistency.
• Care is taken to avoid segregation of EPS beads due to their low density.

4. Casting of Specimens
• Standard molds, such as 150 mm × 150 mm × 150 mm cubes, are prepared for testing.
• The fresh concrete mix is poured into molds in layers and compacted properly using a tamping
rod or vibration to remove air pockets.
• The surface of the specimen is leveled and finished.

5. Curing of Specimens
• After 24 hours, the concrete specimens are demolded.
• The specimens are then immersed in clean water for curing.
• Curing is done for 7 days and 28 days to attain proper hydration and strength development.

6. Testing of Concrete
After the curing period, the specimens are tested for:
• **Compressive Strength:** Using a compression testing machine as per IS 516:1959.
• **Water absorption:** The percentage of water absorbed by a dried concrete cube after immersion in
water for a specified time.
• **Workability:** Slump test to check the ease of placing and compacting the concrete mix.

VI. APPLICATIONS

1. Used for **partition walls** in buildings
2. Used in **roof insulation** to reduce heat
3. Suitable for **non-load bearing structures**
4. Used in **precast blocks and panels**
5. Applied in **floor screeds and leveling layers**
6. Used for **thermal and sound insulation**
7. Suitable for **pavements and road filling works**

VII. RESULTS AND DISCUSSION

- **Density Reduction:**
EPS concrete shows a significant decrease in density compared to normal concrete (lightweight nature achieved).
- **Compressive Strength:**
Strength decreases as EPS content increases, but acceptable strength can be obtained at optimum mix proportions.
- **Tensile & Flexural Strength:**
Both values are lower than conventional concrete due to weak bonding of EPS beads.
- **Water Absorption:**
Slightly higher water absorption is observed because of increased porosity.
- **Workability:**
Workability improves as EPS makes the mix lighter and easier to handle.
- **Thermal Insulation:**
Excellent thermal insulation properties are observed.
- **Crack Resistance:**
With fibers or admixtures, crack resistance improves.

VIII. CONCLUSION

Lightweight concrete using Expanded Polystyrene (EPS) beads shows that EPS is an effective material for reducing the density of concrete. The use of EPS significantly decreases the self weight, making it suitable for lightweight and non load bearing applications. However, as the percentage of EPS increases, the compressive, tensile, and flexural strengths of concrete decrease. Proper mix design and the use of additives like fibers or mineral admixtures can improve the strength and durability of EPS concrete. The material also provides good thermal and sound insulation properties, making it useful for energy efficient buildings. Overall, EPS lightweight concrete is an economical and eco friendly alternative, but it is mainly suitable for applications where high strength is not the primary requirement.

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