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“REVIEW ON LIGHT WEIGHT CONCRETE OF GRADE M25 BY PARTIAL REPLACEMENT OF CEMENT AND FINE AGGREGATE WITH FLY ASH AND THERMOCOL”

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- :ABSTRACT

This experimental study investigates the development of lightweight concrete of grade M25 through the partial replacement of traditional ingredients with fly ash and thermocol. With the aim of reducing the weight and enhancing the properties of the concrete, varying proportions of cement, sand, and aggregate are replaced with fly ash and thermocol. The research evaluates the effects of these substitutions on the compressive strength, density, and other relevant characteristics of the concrete. Through comprehensive experimentation and analysis, this study aims to provide valuable insights into the feasibility and effectiveness of utilizing fly ash and thermocol as alternatives in lightweight concrete production.

Keywords – Lightweight concrete , fly ash ,Thermocol, Partial replacement, Grade M25, Compressive strength, Density.

INTRODUCTION :

Concrete stands as the cornerstone of modern construction, boasting a rich history as one of the oldest and most widely used building materials worldwide. Its composition, a blend of cementing materials, water, aggregates, and occasionally admixtures, forms the basis for a versatile substance that hardens into the durable substance we know as concrete. The strength, durability, and various characteristics of concrete hinge upon factors like ingredient properties, mix ratios, compaction techniques, and environmental factors such as placement, compaction, and curing.

Despite its widespread use and undeniable benefits, traditional concrete does have drawbacks. Its high density contributes to weighty structures, exceeding live load capacities and offering poor insulation. However, intensive research into structural materials has yielded alternatives, both natural and artificial, to enhance concrete's properties.

The introduction of lightweight aggregates has revolutionized concrete applications, particularly in structures where deadweight predominates.

By reducing overall weight, these aggregates enable more efficient structural designs, minimizing the dimensions of footings and foundations. Furthermore, the porosity of lightweight aggregates facilitates water retention, aiding internal curing and enhancing workability.

In conclusion, the exploration of alternative aggregates represents a significant step forward in the evolution of concrete technology. With their ability to reduce weight, improve insulation, and enhance workability, lightweight aggregates offer innovative solutions to the challenges posed by traditional concrete, ushering in a new era of sustainable and efficient construction practices

2.LIGHT WEIGHT CONCRETE

The experimental study on lightweight concrete of grade M25 by partially replacing cement and fine aggregate with ash and thermocol addresses a critical need in the construction industry – the development of sustainable and lightweight building materials. With traditional concrete posing challenges such as excessive weight and environmental impact, this study explores innovative solutions to enhance concrete's properties while reducing its carbon footprint,

Strengths:

- **Innovative Approach:** The study adopts a novel approach by incorporating ash and thermocol as partial replacements for cement and fine aggregate, respectively. This innovative methodology demonstrates the potential for utilizing alternative materials to improve concrete performance.
- **Sustainability:** By utilizing ash, a byproduct of coal combustion, and thermocol, a lightweight foam material, the study promotes sustainability in construction. These materials offer opportunities to reduce reliance on traditional cement and aggregate sources, contributing to environmental conservation.
- **Potential for Lightweight Construction:** The incorporation of thermocol as a lightweight aggregate presents an opportunity to significantly reduce the density of concrete. This has implications for lightweight construction, where the deadweight of concrete plays a significant role in structural design and load-bearing capacity.

Weaknesses:

- **Limited Scope:** While the study focuses on the partial replacement of cement and fine aggregate, it may benefit from a more comprehensive examination of other concrete properties, such as workability, durability, and long-term performance. Expanding the scope of analysis could provide a more holistic understanding of the feasibility and effectiveness of the proposed approach.
- **Environmental Impact Assessment:** While the study acknowledges the potential environmental benefits of utilizing ash and thermocol, a more detailed assessment of the overall environmental impact of lightweight concrete production is warranted. Consideration of factors such as energy consumption, emissions, and lifecycle analysis could provide valuable insights into the sustainability of the proposed methodology.
- **Practical Implementation:** The study could further explore the practical implications of implementing lightweight concrete with ash and thermocol in real-world construction projects. Consideration of factors such as cost-effectiveness, availability of materials, and compatibility with existing construction practices would be essential for assessing the feasibility of widespread adoption

3. LITERATURE REVIEW

"REVIEW ON LIGHT WEIGHT CONCRETE BY PARTIAL REPLACEMENT OF CEMENT AND FINE AGGREGATE WITH FLY ASH AND THERMOCOL"

1. Pragati J. (2020) discusses the potential of lightweight concrete as an alternative construction material for the industrialized building system, highlighting its desirable strength properties [13]. However, the paper notes that aerated lightweight concrete tends to exhibit lower strength when mixed at lower densities. This reduction in strength is attributed to the increase in voids throughout the concrete sample caused by the inclusion of foam, resulting in a decrease in compressive strength. Consequently, foamed lightweight concrete is deemed unsuitable for use in non-load bearing walls, as its compressive strength is 27% below the recommended level. Despite this, the compressive strength of foamed lightweight concrete is still considered adequate for production as a non-load bearing structure.

2. Miss Akshata (2019) conducted a study on lightweight concrete, comparing it to normal concrete in terms of density. The study found that the density of lightweight concrete is significantly lower than that of normal concrete. This reduction in density helps to decrease the dead load of the structure, enhances the speed of construction, and contributes to the overall economy of the structure.

3. Dr. G. Elangovan (September 2015) conducted a study on the partial replacement of fine aggregate with fly ash and coarse aggregate with Thermocol. The study concluded that replacing 60% of the fine aggregate with fly ash and 0.3% of the coarse aggregate with Thermocol resulted in achieving a highest strength of 23.5 N/mm², representing a 47.2% improvement. This experimental work demonstrates that fly ash can serve as a partial alternative material for fine aggregate in concrete, making the concrete more economical and eco-friendly. Additionally, a cost analysis performed in the study confirmed that this mix ratio is comparatively more economical.

4. Thousif Khan, (May 2018) Studied floating concrete using lightweight materials. In this study the coarse aggregate was partially replaced by Thermocol beads and pumice stone in varying ratios [15]. The study concluded that the mix ratio with 50% replacement of coarse aggregate pumice stone and Thermocol beads show best results for compressive strength and tensile strength. The compressive strength of 5.60 Mpa and tensile strength of 1.14 Mpa can be achieved using the materials chosen in the study. The volume of aggregates can be maintained in the range of 0.7 to 0.75 for achieving floating concrete.

5. Kothari Akash (April 2017) conducted a study on lightweight precast concrete using Thermocol as a potential aggregate. The study involved an experimental investigation into the effect of using industrial waste Thermocol to replace natural aggregate at levels of 40%, 50%, and 60% by volume, and to replace crushed sandstone with Thermocol at levels of 10% and 20% by volume [16]. The results indicated that replacing 40% of the natural aggregate with Thermocol beads and 10% of the crushed sandstone with Thermocol yielded the highest compressive strength of 6.18 N/mm². Additionally, the study found that the cost of producing these panels is 30% to 40% less than that of conventional concrete panels.

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6. Nagaswaram Roopa (March 2017) conducted an experimental study on lightweight concrete by partially replacing cement and fine aggregate with fly ash and Thermocol, respectively [17]. The study investigated the properties of M25 grade concrete with cement replaced by 35% and 40% fly ash and fine aggregate replaced by 0.2% and 0.3% Thermocol. The results showed that the compressive strength of the concrete increased from 33.25 N/mm² to 35.5 N/mm² with 35% fly ash and 0.2% Thermocol replacement, and further increased to 36.8 N/mm² with 40% fly ash and 0.3% Thermocol replacement. The study concluded that the workability of the concrete, assessed in terms of slump cone and compaction factor, showed slight changes with increasing amounts of fly ash and Thermocol. These values remained within the normal range for concrete, indicating that the modified concrete maintained acceptable workability.

7. Lakshmi Kumar (Dec 2014) conducted an experimental study on lightweight aggregate concrete using pumice stone, silica fume, and fly ash as partial replacements for coarse aggregate. The study focused on evaluating the mechanical properties of M30 grade structural lightweight concrete. Pumice stone was used as a partial replacement for coarse aggregate, along with mineral admixtures such as fly ash and silica fume. The findings indicated that using 20% lightweight aggregate as a partial replacement for natural coarse aggregate resulted in promising compressive strength. It was also observed that the density of the concrete decreased with increasing replacement levels of natural aggregate with pumice aggregate. However, the compressive strength of the concrete decreased with higher pumice content. The addition of mineral admixtures improved the compressive, split-tensile, and flexural strengths of the concrete. The study concluded that lightweight aggregate, such as pumice stone, is not inferior to natural coarse aggregate and can be effectively used for construction purposes.

8. Vinod Goud (October 2016) conducted an experimental study on the partial replacement of cement with fly ash in M25 grade concrete and its effects. The study involved replacing cement with fly ash at levels of 10%, 20%, and 30%. The research concluded that the slump loss of concrete increases with an increase in the water-cement (w/c) ratio. For the 10% and 20% fly ash replacement, the concrete showed good compressive strength after 28 days. However, at a 30% replacement level, the ultimate compressive strength of the concrete decreased.

9. Rajeswari S. (May 2016) conducted an experimental study on lightweight concrete by partially replacing coarse aggregate with pumice stone in M25 grade concrete. The study explored varying replacement levels of coarse aggregate with pumice stone at 50%, 60%, and 70%. The results showed that the concrete achieved maximum strength at 60% replacement, with a compressive strength of 22.14 MPa after 28 days of curing. In contrast, the compressive strengths were 13.32 MPa and 8.85 MPa for the 50% and 70% replacements, respectively. The study concluded that this type of lightweight concrete, especially at the 60% replacement level, is suitable for use in non-load-bearing wall panels for precast applications.

10. Dr. Md. Subhan conducted experimental work on the design of concrete structures, focusing on lightweight concrete's role in reducing density and enhancing thermal insulation. This study aimed to assess its impact on both structural integrity and serviceability. The experimental work comprised two phases. The first phase involved conducting workability tests for reference concrete and other mixtures the second phase

strength tests were conducted for both reference and other mixes after 7 days and 28 days of curing. Additionally, a cost analysis was performed for various mixes to evaluate their economic feasibility. The experimental results indicated that the concrete mix containing 40% fly ash and 0.3% thermocol exhibited improved workability and higher compressive strength. This study demonstrates that fly ash can serve as a partial alternative material for fine aggregate in concrete, resulting in more economical and eco-friendly concrete.

Cement is a versatile material that can be shaped into various forms. The proportions of cement, aggregates, and water determine its properties both in its wet state and when solidified. However, cement itself is relatively weak when subjected to typical stresses and loads. Its elasticity is about one-tenth of its compressive strength, making plain concrete vulnerable to cracking and failure under stress. To address this, concrete structures are reinforced with continuous reinforcing bars to withstand tensile stresses and compensate for the lack of elasticity and strength in plain concrete.

The addition of steel reinforcement significantly enhances the strength of concrete, resulting in a material with more uniform elastic properties. However, the development of microcracks in concrete structures needs to be controlled. The strength of concrete is its resistance to rupture, which primarily depends on the strength of the concrete paste. It can be measured in various ways, such as compressive strength, tensile strength, shear strength, or flexural strength, depending on the testing method used.

When concrete fails under compressive load, it is typically a combination of crushing and shear failure. The mechanics of this failure are complex and involve both cohesion and internal friction within the concrete.

Concrete cement, in its powdered form, is mixed with water and aggregates like sand, gravel, or crushed stone to create concrete. The water and cement form a paste that binds the other materials together as it hardens.

In the study mentioned, Ordinary Portland Cement (OPC) concrete of grade 53 was used for casting cubes for all concrete mixes. The concrete appeared as a uniform gray color with a slight greenish tint and was free from any hard lumps. Workability tests indicated that the slump cone value increased for concrete mixes containing fly ash and thermocol compared to the reference concrete mix

11. Nisha Devi (2016) conducted experiments where glass powder was partially substituted for cement, and fine aggregate of fire bricks was partially replaced with fine aggregates. The findings indicated that glass powder contributed to increased workability, while fire brick powder acted as a filler in concrete, enhancing flexural strength.

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In this project, glass powder is replaced with cement at varying percentages (10%, 20%, and 30%), while fire brick powder is substituted for fine aggregates at different levels (10%, 15%, 20%, and 25%). Ordinary Portland cement of 43 grades is utilized, and the fire brick powder belongs to Zone II.

Various strengths such as compressive strength, tensile strength, and flexural strength are measured using different specimen sizes: cubes of dimensions 150*150*150 mm for compressive strength, prisms of dimensions 150*300 mm for tensile strength, and beams of dimensions 100*100*500 mm for flexural strength. These measurements are taken at both 7 days and 28 days of curing.

The experimental results indicate that crushed spent fire brick yields higher compressive strength when replaced at 20%. However, beyond this replacement level, there is a reduction in strength. Additionally, the split tensile strength increases when fine aggregates of fire brick are replaced at 20%, but further increases in replacement result in a decrease in tensile strength.

12. S. Keerthi Narayana (2010) provides insights into the production process of fire bricks according to IS 6 and 8 specifications. These bricks are typically made from plastic and non-plastic clay and are fired in an oil kiln, with temperatures reaching up to 1350°C. Fire bricks are subjected to firing temperatures ranging from 1750 to 2200°C for thirteen to twenty days. Any bricks exhibiting insufficient strength are replaced with new ones.

Spent fire bricks (SFB) are considered industrial solid waste and must be properly disposed of. Initially, these bricks are cleaned and crushed into fine aggregates. In concrete production, these aggregates constitute 62 to 81 percent of the total volume. The performance of concrete depends largely on the chemical and physical properties of these aggregates.

Tests conducted include a comparison of crushed spent fire bricks with original fire bricks, as well as the placement of aggregates with varying physical and chemical properties. Results indicate that adding 25 to 30% crushed spent fire bricks improves tensile strength, similar to the findings of compressive strength tests.

Flexural strength is determined by applying a load until visible cracks appear in the concrete. The dimension for determining the rupture modulus is typically 150**150*700 mm. If the span exceeds 600 mm, a dimension of 100*500 mm with a 450 mm span is used, and a point load is applied for testing.

13. Tiwari Darshita (2014) conducted experiments following IS-10262 standards, where cubes of different grades (M20, M25, and M30) were formed. These cubes were crushed in the laboratory according to the criteria outlined in IS code 1343. The crushing strength was measured at 3 days, 7 days, and 28 days.

In the case of M20 grade concrete, sand was partially replaced by brick powder. It was observed that when 10% brick powder was added, the compressive strength decreased. However, with the addition of 20% brick powder, the strength increased. Beyond this point, adding more than 20% brick powder resulted in a decrease in compressive strength for M20 grade concrete.

4. MATERIALS AND METHOD

Cement 4.1

For this study, ordinary Portland cement of 43-grade conforming to IS 12269-1987 was utilized. The cement underwent thorough checks for freshness and consistency, ensuring it was devoid of any lumps and maintained its purity.

4.2 Fine Aggregate

Neighborhood clean waterway sand of Zone II, conforming to IS 383-1970 standards, was employed as the fine aggregate. The sand underwent sieving with a 4.75 mm sieve to ensure it was free from clay, silt, and organic impurities. Physical tests were conducted to assess its gradation, fineness modulus, specific gravity, and bulk modulus in accordance with IS: 2386-1963.

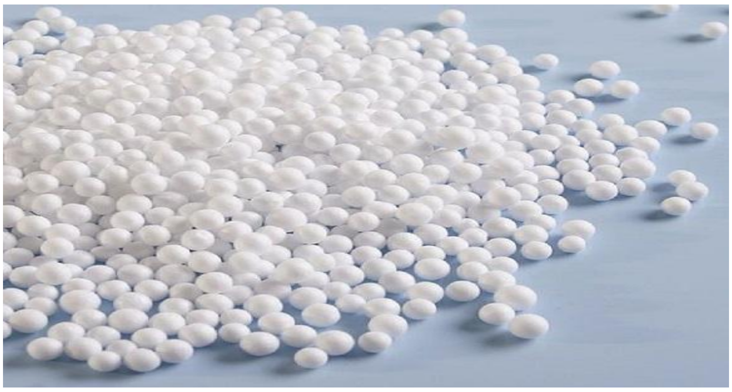
4.3 Coarse Aggregate

The coarse aggregate used in this study consisted of 20 mm and 10 mm downsize locally available crushed stone obtained from nearby quarries. Physical properties were determined as per IS: 2386-1963 standards, revealing a specific gravity of 2.68 and water absorption of 0.25%.

4.4 Water

Potable water was deemed suitable for both concrete mixing and curing purposes. It was ensured that the water met all purity requirements and adhered to the standards outlined in IS: 456-2000. The mixing water was free from undesirable organic substances or excessive inorganic constituents.

4.5 Thermocol



Thermocol, also known as Expanded Polystyrene (EPS), served as a rigid and tough closed-cell foam material. Recognized for its lightweight, water-resistant, and dimensionally stable properties, polystyrene foams like thermocol are widely employed as thermal insulators in construction applications. Grey polystyrene foam, incorporating graphite, offers superior insulation capabilities. Additionally, they find use in non-weight-bearing architectural structures such as ornamental pillars. However, it's essential to note that discarded polystyrene does not biodegrade for hundreds of years and can pose risks to the environment and wildlife due to its specific gravity, which causes it to blow in the wind and float on water. Typically, thermocol is white and comprises pre-expanded polystyrene beads.

Fly Ash 4.6

fly ash consists of fine, powdered particles predominantly spherical shape, glassy which is amorphous in nature. The particle size distribution of fly ash is generally similar to silt less than 0.075mm and specific gravity ranges from 2.1 to 3.0 and specific surface area may vary from 170 to 1000m2/Kg. The colour of fly ash varies from tan gray to black depending upon the presence of unburnt carbon in the ash.

5. MIX DESIGN

A trial mix has been designed for an assumed compaction factor of 0.80 as per IS 415 - 2000 for M25 grade. The trial mix is obtained as 1:2:2.16 for water cement ratio of 0.40. The proportions ingredients of the mix with quarry will increase with 5% ,10 %,15%.

6. METHODOLOGY

6.1 Preparation of Concrete Mix (M25 Grade)

- A concrete mix of M25 grade was meticulously prepared. Steel molds with dimensions of 150 x 150 x 150 mm were utilized to create concrete cubes. Weigh and proportion the cement, sand, aggregate, fly ash, and thermocol beads according to the mix design.
- Mix the dry ingredients thoroughly in a concrete mixer until uniform consistency is achieved.
- Gradually add water while continuing mixing until the desired workability is attained.
- Ensure uniform distribution of fly ash and thermocol beads throughout the mix.
- Two cubes were prepared for each mix proportion, with each mix requiring 3.08 kg of cement, 5.5 kg of sand, and 6.75 kg of coarse aggregate. The preparation process adhered to all specified mixing and filling criteria.

6.2 Casting of Specimens:

- Prepare steel or plastic molds of standard dimensions suitable for casting concrete specimens.
- Pour the mixed lightweight concrete into the molds, ensuring proper compaction to eliminate air voids.
- Level the surface of the specimens and finish as required.

6.3 Curing Process

- The concrete cubes were allowed to set for a duration of 24 hours. Following this period, the cubes underwent curing in a curing tank to facilitate the hydration process necessary for strength development. Clean potable water was used for curing, following IS: 456-2000 guidelines.

6.4 Determination of Initial and Final Setting Time

- The fineness of the cement was determined in compliance with IS: 4031 - 1988 standards. Using a Vicat apparatus, the initial setting time for different percentages of solution in cement was evaluated.

6.5 Compressive Strength Testing

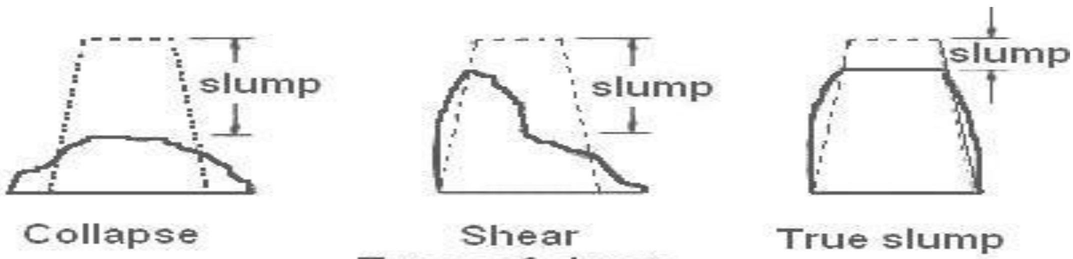
- Compressive strength testing was conducted following IS: 516-1959 standards. Tests were performed on concrete samples containing various proportions of admixtures. Additionally, initial setting time, final setting time, and slump cone tests were conducted initial and final setting time tests in accordance with relevant standards, assessing the effects of fly ash and thermocol on the setting properties
- Perform compressive strength tests on cured specimens at designated ages (e.g., 7 and 28 days) using a universal testing machine (UTM).Evaluate other properties such as density, workability, and water absorption to assess the performance of lightweight concrete with partial replacements

7. WORKABILITY TEST

(SLUM CONE TEST)

The concrete slump test measures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows. It can also be used as an indicator of an improperly mixed batch. The test is popular due to the simplicity of apparatus used and simple procedure. The slump test is used to ensure uniformity for different loads of concrete under field conditions

A separate test, known as the flow table, or slump-flow test, is used for concrete that is too fluid (non-workable) to be measured using the standard slump test, because the concrete will not retain its shape when the cone is removed.



Types of slump

DETERMINATION OF COMPRESSIVE STRENGHT OF CONCRETE :

In order to perform the cube compression testing of concrete and mortar, 150mm cubes were utilized respectively. All the required cubes were tested in saturated condition, after wiping out the surface moisture. Two cubes for each mix of quarry sand and river sand were tested at the age of 3 days, 7 days and 28 days of curing for concrete and 28th days of curing for mortar using compression testing machine. After age of 3 days, 7 days and 28 days of curing, the cubes were taken out of the curing tank, dried and tested using a compression machine. These cubes were loaded on their sides during compression testing such that the load was applied perpendicularly to the direction of casting. The cubes were placed in the compression testing machine and the loads are exerted gradually The average value of the compression strength of two cubes was considered as the compression strength

8.**CONCLUSION**

In this experimental study, the feasibility of producing lightweight concrete of Grade M25 by partially replacing cement and aggregate with fly ash and thermocol was investigated. The following conclusions can be drawn based on the experimental findings

- **Improved Lightweight Properties:** The mix achieved reduced density, making it suitable for weight-sensitive applications.
- **Enhanced Workability:** Incorporating fly ash and thermocol improved the mix's workability, aiding in easier casting.
- **Setting Time and Strength:** Initial and final setting times were acceptable, with compressive strength development comparable to conventional concrete.
- **Economic and Environmental Benefits:** Using fly ash and thermocol offers cost savings and environmental advantages by utilizing by-products and recycled materials.
- **Future Considerations:** Further research is recommended to assess long-term durability and performance in real-world scenarios. In summary, this study demonstrates the potential of lightweight Grade M25 concrete with fly ash and thermocol, offering a promising avenue for sustainable and durable construction practices.

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