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LIGHTWEIGHT CONCRETE

Virender [1], Sushil Kumar Singh [1], Mohd. Amir Jafri[2]
[1]B.Tech. Civil Engineering Student, [2]Assistant Professor, Department of Civil Engineering
Lingaya's Vidyapeeth Faridabad, Haryana, India

Abstract- *Lightweight concrete, with a history spanning over two millennia, continues to evolve technically. Despite its established technical potential and diverse applications throughout the decades, its adoption in practice is often met with hesitation and uncertainty. This stems from the challenges in aligning design, production, and execution protocols with those established for normal weight concrete. The distinct properties of lightweight concrete necessitate a tailored approach to structural design, demanding adaptations to conventional rules and methodologies. As the industry progresses, overcoming these challenges is crucial for harnessing the full benefits of lightweight concrete. The ongoing technical development aims to mitigate concerns by refining design strategies and enhancing material performance, thereby solidifying its role in modern construction and engineering projects.*

Keywords— Lightweight Concrete.

I. INTRODUCTION

Lightweight concrete is a type of concrete that is made by incorporating lightweight aggregates such as expanded clay, shale, or slates. This type of concrete has a lower density compared to traditional concrete, which makes it ideal for various construction applications. Research on lightweight concrete has shown that it provides several benefits, making it a popular choice among engineers and contractors. One of the key benefits of lightweight concrete is its weight reduction, which can lead to cost savings and improved structural performance. The lower density of lightweight concrete means that it is easier to transport and handle on construction sites. This can result in reduced labour costs and shorter construction times. Additionally, lightweight concrete has excellent thermal insulation properties, which can help reduce energy consumption in buildings and improve indoor comfort levels.

Furthermore, research has shown that lightweight concrete offers improved fire resistance and durability compared to traditional concrete. In the event of a fire, lightweight concrete can help contain the spread of flames and limit damage to structures. It also has a higher resistance to freeze-thaw cycles, making it suitable for use in harsh climates. Overall, the research on lightweight concrete demonstrates its versatility and ability to meet the evolving needs of the construction industry, making it a sustainable and cost-effective choice for building projects. The realm of construction materials has witnessed a significant shift with the advent of lightweight aggregate concrete (LC), a material that has garnered increasing attention in recent years. Its development is not a novelty; rather, LC is a time-honored material, tracing its roots back to ancient civilizations and serving as the precursor to modern concrete. The evolution of LC, particularly through the industrial production of lightweight aggregates in the 19th and 20th centuries, represents a transformative era in material technology.

Lightweight concrete stands out for its reduced building costs, simplified construction processes, and its status as a relatively eco-friendly building material. Traditional concrete is a tripartite composite consisting of cement paste, aggregates, and an interface between the aggregate and cement paste. However, LC deviates from this norm by incorporating mineral lightweight aggregates (LWA), which impart unique properties to the concrete.

Structural lightweight concrete, the focus of this discourse, is based on LWAs like perlite, vermiculite, pumice, expanded shale, slate, and clay. These materials, along with gassing agents such as aluminum powder or foaming agents, and plastic granules like expanded polystyrene foam (EPS) or polyurethane, contribute to the production of LC. The choice of aggregate is pivotal, as the strength of the aggregate directly influences the strength of the resulting concrete.

II. LITERATURE REVIEW

In the field of construction, lightweight aggregates (LWA) have been specified in international standards, including EN 13055, ASTM C330M, ASTM C331M, and ASTM C332. It is established that these standards categorize LWA based on their intended use in structural lightweight concrete, masonry lightweight concrete, and insulating concrete. The origins of LWA are diverse, with sources ranging from natural materials to by-products of industrial processes, including recycled materials. The properties of LWA, particularly density, play a crucial role in distinguishing them from normal weight aggregates. It is specified that the compressive strength and splitting tensile strength are essential requirements for LWA. ACI 213R-14 "Guide for Structural Lightweight-Aggregate Concrete" specifies a minimum cylinder strength of 17 MPa and an equilibrium density between 1120 and 1920 kg/m3 for structural lightweight concrete (SLC) and without any strength requirement an equilibrium density between 800 and 2240 kg/m3 for specified density concrete (SDC). SLC with compressive strength of 40 MPa at 28 days is classified as high strength lightweight concrete. Key aspects, such as nomenclature and the value of certain tests, are discussed. Common mix design and production issues are addressed, along with unintended consequences. Additionally, we critically examine in formation provided in existing European concrete standards regarding the mechanical properties of structural lightweight concrete. Finally, we present the latest advancements in very light lightweight concretes, including the introduction of infra-lightweight concrete—an innovative approach that extends the range of lightweight concrete applications based on case records.

- The range of LWA types and their applications has been further defined in EN 13055, which sets forth restrictions on loose bulk density (ρs) not exceeding 1200 kg/m³ and particle density (ρk) limited to 2000 kg/m³ or less. These parameters are critical in determining the suitability of LWA for various concrete applications. The standards serve as a guideline for the production and use of LWA, ensuring that the materials meet the necessary quality and performance criteria for their intended use in construction.
- The significance of LWA in the construction industry cannot be overstated, as they contribute to the development of lightweight concrete that offers numerous advantages, such as reduced structural weight, improved thermal insulation, and enhanced fire resistance. The use of LWA in concrete not only leads to a reduction in the overall weight of the structure but also impacts the design, transportation, and construction methodologies.
- The development of LWA has been influenced by various factors, including the availability of raw materials, the demand for sustainable building practices, and the need for innovative construction solutions. The evolution of LWA technology has been marked by continuous research and development, aimed at improving the properties and expanding the applications of these aggregates. The use recycling products as LWA is also very interesting field. The potential base materials, such as rice husk ash, dredged silt, and polyethylene terephthalate waste, are some examples of the numerous possibilities

In conclusion, the international standards for LWA provide a comprehensive framework for the classification, production, and application of these materials in the construction industry. The standards ensure that LWA meet the necessary criteria for quality and performance, facilitating their use in a wide range of construction projects.

III. OBJECTIVE

The broad objectives of the study to investigate analysis of lightweight concrete and its merits over conventional concrete. We always curious to know which concrete will be right for high rise buildings and what possible actions may take to control heavy dead load of construction materials.

IV. METHODOLOGY

Mix Design of Light-Weight Concrete-

- Mix preparation is particularly important when using very lightweight aggregates. For the anticipated testing exactly six different mixtures of component materials were produced d (they are labeled as series from C1 to C6). Modified waste expanded polystyrene aggregates (MEPS) was used as 0%, 25%, 50%, 75%, and 100% of natural aggregate by volume and three concrete prism specimens were produced for each mixture proportion. For the 100% MEPS concrete, 50% fine MEPS + 50% coarse MEPS aggregate were used (C1). For a second group, 25% of fine MEPS were replaced with natural sand. Thus, 25% fine MEPS + 50% coarse MEPS + 25% natural sand were used (C2). For the third group, 50% coarse MEPS aggregate + 50% natural sand was used (C3). The fourth group was made up of 50% fine MEPS and 50% coarse natural aggregate (C4). The fifth group consisted of 25% fine MEPS + 25% coarse MEPS and 25% natural sand + 25% coarse natural aggregate (C5). Finally, 25% fine MEPS aggregate + 25% natural sand + 50% coarse natural aggregate were used (C6). The complete details of the MEPS aggregate and natural aggregate ratios are presented in Table.
- The mixing of materials was done in a specific sequence, by placing a part of the water with superplasticizer in the mixture and adding the dry MEPS aggregates, which was thoroughly mixed for about 5 min to get the aggregates wetted with water and plasticizer. The mixing was continued until a mix of uniform consistency was achieved. The slump value for all the concretes varied between 25 mm and 50 mm. Properties of freezing and thawing of MEPS aggregate concrete were obtained by a rapid test in water according to the ASTM C 666.

Mix type	MEPS/NA(%) (F+CA)/(F+CA*)	cement (kg)	MEPS (kg)		NA (kg)		SP (kg)	w/c	Fresh density (kg/m3)	Slump values (mm)
			F	CA	F	CA				
C1	50% + 50%/0%	500	106	78	-	-	2.5	0.38	865	25
C2	25% + 50%/25% + 0%	500	52	76	405	-	2.5	0.39	1225	32
C3	0%+50%/50% + 0%	500	-	75	784	-	2.5	0.41	1544	32
C4	50% + 0%/0% + 50%	500	103	-	-	809	2.5	0.41	1668	532
C5	25% + 25%/25% + 25%	500	52	35	395	425	2.5	0.41	1556	45
C6	25% + 0%/25% + 50%	500	52	-	380	780	2.5	0.43	1945	50

- **Strength**
  - As with dense concrete, the compressive strength of foamed concrete will depend on the density, cement content, water/cement ratio properties of aggregates, methods of manufacture and curing. The density of Foam concrete falls within the range 400-1600kg/m3 and can be produced at a compressive strength of 0.5 to 10N/mm2.
- **Fire Resistance**
  - Foam concrete is an inorganic material and therefore unlikely to catch fire. Tests carried out in several countries, including tests to ASTM Standards, show that a load bearing foam concrete slab wall, 15cm thick, has a fire resistance exceeding 7 hours.
- **Thermal Conductivity**
  - One of the main advantages of lower density foamed concrete (Foam-concrete) is its lower thermal conductivity which gives it better insulation properties.
  - This is due to the great number of closed cavities that form the multi-cellular structure and results in a 50mm layer of foam concrete, with a density of 400kg/m3, having approximately the same excellent heat insulation value as a 25mm thickness of cork.
- **Shock-Absorption**
  - Foamed concrete has been investigated for use as a bullet trap in high intensity US military firearm training ranges. This work resulted in the product SACON being fielded by the U.S. Army Corps of Engineers, which when worn out, can be shipped directly to metal recycling facilities without requiring the separation of the trapped bullets, as the calcium carbonate in the concrete acts as a flux.
  - The energy absorption capacity of foamed concrete was approximated from drop testing and found to vary from 4 to 15 MJ/m3 depending on its density. With optimum absorption estimated from a 1000 kg/m3 moderate density mix at water to cement (w/c) ratios from 0-6 to 0-7.
- **Low coefficient of permeability**
  - The hydraulic conductivity of porous materials generally decreases with an increasing amount of air in the pores of the material. Foam concrete is made up with a matrix of non-interconnecting micro bubbles, or air voids, thus the material has a relatively low permeability.
- **Low water absorption**
  - The solid matrix of cementitious slurry surrounding the fine cell structure of the foam concrete greatly reduces the capillary action of moisture through the material.
- **Freeze and thaw resistance**
  - Foam concrete has excellent freeze thaw resistance.
  - lightweight concrete exhibits a higher frost resistance due to the existence of 20–50% voids in the lightweight aggregates. Hence, C1, C2, and C4 without any anti-frost treatment (air entrainment) can still fulfill the normal anti-frost requirements, 60% RDME, up to 180 cycles of freeze–thaw tests. However, C3 and C5 fell below 60% RDME at 150 cycles and C6 at 180 cycles. The highest performance was observed, up to 240 cycles, for mixture C4. RDME of C4 was over 40% at 240 cycles. The performance of C3 was lower than that of C4 even though both of them have the same percentage (50%) of MEPS aggregate.

V. CONCLUSION

The following point wise conclusions are drawn from this research are as under:-

Lightweight concrete, characterized by its low density and thermal conductivity, has emerged as a promising material in the field of construction. In this research, we explored various aspects of lightweight concrete, focusing on its properties, applications, and impact on infrastructure development.

The aim of this study was to evaluate the usability of MEPS as an aggregate for concrete. All the MEPS concretes without any special bonding agents show good workability and could be easily compacted. It was noticed that a fairly uniform concrete may be achieved by limiting the amount of vibration to the period when the fine MEPS aggregates just start to accumulate at the top of the mold. The addition of MEPS aggregate reduced the workability of the concrete. Research has shown that fine MEPS aggregate particles (0–2 mm) increase the bond between the paste and the coarse aggregate. The strength of MEPS concretes was found to be directly proportional to the concrete density. The strength of MEPS concrete marginally increased as the aggregate size decreased, and increased as the natural coarse aggregate size increased.

The increase of splitting-tensile strengths with increasing MEPS concrete density was about 31%, reaching up to 64% when natural aggregates were used. A high amount of MEPS as aggregate is known to decrease the concrete density. MEPS concretes with densities ranging from 980 kg/m3 to 2025 kg/m3 is mostly used.

Let's delve into the key takeaways:

Density and Weight Reduction:

Lightweight concrete, incorporating an expanding agent, significantly reduces the dead weight of structures.

Its low density makes it ideal for applications where weight constraints are critical, such as high-rise buildings and bridges.

By replacing conventional concrete with lightweight variants, we can achieve substantial weight savings without compromising structural integrity.

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