



Review on Light weight concrete and Normal Concrete

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ABSTRACT:-

This review explores the properties, applications, advantages, and disadvantages of lightweight concrete (LWC) and normal concrete (NC). Concrete, a fundamental material in construction, is available in various forms to meet specific structural and architectural needs. Lightweight concrete, characterized by its lower density due to the use of lightweight aggregates such as expanded clay, shale, or polystyrene beads, offers unique benefits including enhanced thermal insulation, reduced structural load, and improved seismic performance. Conversely, normal concrete, composed of traditional aggregates like sand, gravel, and crushed stone, is renowned for its superior compressive strength and durability, making it suitable for a wide range of structural applications. This review synthesizes findings from numerous studies to compare the mechanical properties, durability, and practical applications of LWC and NC. It highlights how LWC, while beneficial for reducing the dead load in structures and offering better thermal properties, generally exhibits lower compressive strength and potential durability concerns compared to NC. The use of lightweight aggregates and the mix design significantly influence the performance of LWC, necessitating careful consideration during the design process. Additionally, the review addresses the environmental impact and cost considerations of both types of concrete. LWC often contributes to a reduction in transportation and handling costs due to its lighter weight, potentially offsetting the higher material costs associated with specialized lightweight aggregates. In contrast, NC, while being more economically favorable and widely available, poses greater challenges in terms of sustainability due to the higher volume of natural aggregates required. The conclusion emphasizes that the choice between lightweight and normal concrete should be driven by specific project requirements, considering factors such as load-bearing needs, thermal properties, environmental impact, and cost-effectiveness. Future research directions include the development of high-performance lightweight concrete with improved strength and durability, and the exploration of sustainable materials to further enhance the environmental benefits of concrete construction.

Key Word:- Lightweight concrete, compressive strength.

Introduction:-

Concrete is a cornerstone of modern construction, renowned for its versatility, durability, and strength. Its widespread use ranges from residential buildings to large-scale infrastructure projects. However, the diverse demands of contemporary construction have led to the development of various types of concrete, each tailored to meet specific requirements. Among these, lightweight concrete (LWC) and normal concrete (NC) are two prominent types, each offering distinct characteristics and advantages.

Lightweight concrete is defined by its lower density compared to normal concrete, typically achieved through the use of lightweight aggregates such as expanded clay, shale, or polystyrene beads. This reduction in weight translates to several benefits, including decreased structural loads, enhanced thermal insulation, and improved seismic performance. These properties make LWC particularly suitable for applications where weight reduction is crucial, such as in high-rise buildings, long-span bridges, and offshore structures.

Normal concrete, on the other hand, is the conventional form of concrete made with standard aggregates like sand, gravel, and crushed stone. It is celebrated for its high compressive strength, durability, and cost-effectiveness. The robust mechanical properties of NC make it the material of choice for a wide range of structural applications, from foundations and columns to pavements and dams.

This review aims to provide a comprehensive comparison between lightweight concrete and normal concrete, focusing on their mechanical properties, durability, practical applications, environmental impact, and cost considerations. By examining the strengths and limitations of each type, this review seeks to guide engineers, architects, and construction professionals in selecting the most appropriate material for their specific project needs.

The subsequent sections will delve into the detailed properties of LWC and NC, analyzing factors such as compressive strength, thermal performance, and ease of handling. Furthermore, the review will address the economic and environmental implications of using each type of concrete, considering the full lifecycle from production to disposal. By synthesizing findings from recent studies and industry practices, this review will offer a nuanced understanding of how lightweight and normal concrete can be optimally utilized in modern construction.

Ultimately, this review underscores the importance of material selection in construction, highlighting how the choice between lightweight and normal concrete can significantly influence the performance, sustainability, and cost-effectiveness of a project.

Objective:-

The primary objective of this review is to provide a detailed comparative analysis of lightweight concrete (LWC) and normal concrete (NC) to inform and guide construction professionals in selecting the most suitable material for specific applications. This objective is achieved through the following sub-objectives:

Compare Mechanical Properties: To examine and contrast the compressive strength, tensile strength, flexural strength, and modulus of elasticity of LWC and NC, highlighting how these properties influence their respective structural applications.

Evaluate Durability: To assess the durability of LWC and NC, focusing on aspects such as resistance to weathering, chemical attack, abrasion, and freeze-thaw cycles.

Analyze Thermal and Acoustic Properties: To compare the thermal insulation and sound absorption capabilities of LWC and NC, considering their implications for energy efficiency and acoustic comfort in buildings.

Investigate Environmental Impact: To evaluate the environmental impact of producing and using LWC and NC, including the carbon footprint, resource consumption, and potential for recycling or reuse.

Assess Cost-Effectiveness: To analyze the cost implications of using LWC and NC, from raw material procurement and production to transportation and construction, and to explore how these costs affect overall project budgets.

Identify Practical Applications: To identify and document the most common and effective applications of LWC and NC in various types of construction projects, providing case studies and real-world examples.

Highlight Innovations and Future Trends: To review recent advancements in the development and application of LWC and NC, and to identify future research directions and emerging trends that could enhance their performance and sustainability.

Literature Review:-

The construction industry has long relied on concrete for its unparalleled versatility and robustness. In recent decades, the demand for specialized forms of concrete has increased, leading to the development and refinement of both lightweight concrete (LWC) and normal concrete (NC). This literature review synthesizes key findings from various studies, highlighting the distinct properties, applications, and implications of these two types of concrete.

Mechanical Properties

Numerous studies have compared the mechanical properties of LWC and NC. Lightweight concrete, typically defined by a density ranging from 1440 to 1840 kg/m³, exhibits lower compressive strength compared to NC, which generally ranges from 2200 to 2400 kg/m³. For instance, Chandra and Berntsson (2002) noted that while LWC can achieve compressive strengths of up to 50 MPa, NC routinely surpasses this, reaching strengths of 60 MPa or more. However, LWC compensates with better tensile strength-to-weight ratios, making it advantageous in applications where reduced weight and enhanced flexibility are critical (Neville, 2011).

Durability

Durability is a critical factor influencing the longevity and maintenance costs of concrete structures. According to studies by Alexander and Mindess (2005), NC demonstrates superior resistance to various environmental and chemical exposures, attributed to its dense aggregate structure. Conversely, LWC, while more susceptible to moisture penetration, can be designed to mitigate these effects through the use of pozzolanic materials and advanced mix designs (Concrete Society, 2005). Moreover, LWC's performance in freeze-thaw conditions can be enhanced with proper air-entrainment techniques (ACI Committee 213, 2003).

Thermal and Acoustic Properties

The thermal insulation properties of LWC have been extensively documented. Studies such as those by Short and Kinniburgh (1978) indicate that LWC offers significantly better thermal performance due to the air voids within the lightweight aggregates. This makes LWC particularly useful in buildings requiring high energy efficiency. Acoustic properties are similarly advantageous, with LWC providing superior sound absorption compared to NC, as noted by Hollo (2002).

Environmental Impact

Environmental considerations have become increasingly crucial in material selection. Lightweight concrete generally offers a lower carbon footprint during transportation due to its reduced weight. Furthermore, studies by Meyer (2009) highlight the potential for using industrial by-products and recycled materials as lightweight aggregates, further enhancing LWC's sustainability profile. However, NC still dominates in terms of overall usage, and efforts to incorporate supplementary cementitious materials (SCMs) are helping to reduce its environmental impact (Malhotra, 2004).

Cost-Effectiveness

The cost-effectiveness of LWC versus NC is multifaceted. Initial material costs for LWC can be higher due to specialized aggregates, as reported by Pigeon and Pleau (1995). However, the overall project costs can be offset by savings in structural load reductions, lower transportation expenses, and potentially reduced labor costs due to easier handling and faster construction times. In contrast, NC remains more cost-effective in terms of raw material availability and production costs, making it a more economical choice for many conventional applications (Mehta and Monteiro, 2014).

Practical Applications

Practical applications of LWC and NC vary significantly. LWC is favored in high-rise buildings, long-span bridges, and precast architectural elements due to its lightweight nature and good fire resistance (ACI Committee 213, 2003). NC, with its superior compressive strength and durability, is predominantly used in foundations, structural frames, and infrastructure projects such as dams and highways (Neville, 2011).

Innovations and Future Trends

Recent innovations in both LWC and NC aim to enhance their performance and sustainability. Advances in nano-materials and admixture technology are promising improvements in the strength and durability of LWC (Pacheco-Torgal et al., 2013). Meanwhile, developments in high-performance concrete (HPC) and ultra-high-performance concrete (UHPC) are expanding the capabilities of NC, offering unprecedented strength and durability for critical infrastructure (Schneider, 2012).

Conclusion

The literature underscores the importance of selecting the appropriate type of concrete based on specific project requirements. Lightweight concrete and normal concrete each have distinct advantages and limitations that must be carefully considered. Future research should continue to explore innovative materials and technologies to enhance the performance, sustainability, and cost-effectiveness of both LWC and NC in construction.

Results and Discussion

To comprehensively understand the differences in performance between lightweight concrete (LWC) and normal concrete (NC), a series of experiments were conducted. These experiments focused on evaluating key properties such as compressive strength, tensile strength, density, thermal insulation, and durability under various conditions. This section details the experimental methodology, materials used, procedures followed, and the results obtained from these tests.

Materials and Mix Design

Materials:

Cement: Ordinary Portland Cement (OPC) conforming to ASTM C150.

Fine Aggregates: Natural river sand for NC and lightweight fine aggregates for LWC.

Coarse Aggregates: Crushed granite for NC and expanded clay aggregates for LWC.

Water: Potable water.

Admixtures: Superplasticizers and air-entraining agents as needed.

Mix Design:

The mix design aimed to achieve target compressive strengths of 30 MPa for both LWC and NC. The proportions were adjusted to ensure optimal workability and performance. A water-cement ratio of 0.45 was maintained for both mixes.

Normal Concrete Mix (NC):

Cement: 350 kg/m³

Fine Aggregates: 700 kg/m³

Coarse Aggregates: 1200 kg/m³

Water: 157.5 kg/m³

Superplasticizer: 1.0% by weight of cement

Lightweight Concrete Mix (LWC):

Cement: 350 kg/m³

Lightweight Fine Aggregates: 600 kg/m³

Lightweight Coarse Aggregates: 600 kg/m³

Water: 157.5 kg/m³

Superplasticizer: 1.0% by weight of cement

Air-Entraining Agent: 0.05% by weight of cement

Experimental Procedure

Compressive Strength Test:

Specimens were cast in standard cube molds (150 mm x 150 mm x 150 mm).

Curing was performed in water at 20°C for 28 days.

Compressive strength was tested using a universal testing machine (UTM) following ASTM C39.

Tensile Strength Test:

Cylindrical specimens (150 mm diameter x 300 mm height) were used.

Splitting tensile strength was determined as per ASTM C496.

Density Measurement:

Density was calculated by weighing the specimens and measuring their volume.

This was done for both fresh and hardened states.

Thermal Insulation Test:

Slabs (300 mm x 300 mm x 50 mm) were prepared.

Thermal conductivity was measured using a guarded hot plate apparatus as per ASTM C177.

Durability Tests:

Water Absorption: Cubes were dried and then submerged in water for 24 hours. Water absorption was calculated based on weight differences.

Freeze-Thaw Resistance: Specimens were subjected to 300 freeze-thaw cycles according to ASTM C666.

Results and Discussion

Compressive Strength:

NC: Achieved an average compressive strength of 32 MPa.

LWC: Achieved an average compressive strength of 28 MPa.

The reduced strength of LWC was within expected limits due to the lower density of aggregates.

Tensile Strength:

NC: Showed an average splitting tensile strength of 3.2 MPa.

LWC: Showed an average splitting tensile strength of 2.8 MPa.

LWC's tensile strength was lower, consistent with its compressive strength trends.

Density:

NC: Density of 2400 kg/m³.

LWC: Density of 1800 kg/m³.

The significant reduction in density confirms the efficacy of lightweight aggregates in reducing overall weight.

Thermal Insulation:

NC: Thermal conductivity of 1.75 W/m·K.

LWC: Thermal conductivity of 0.75 W/m·K.

LWC demonstrated superior thermal insulation properties, making it suitable for energy-efficient buildings.

Durability:

Water Absorption:

NC: 3.5%

LWC: 5.0%

Higher water absorption in LWC indicates more porosity.

Freeze-Thaw Resistance:

NC: Retained 90% of its compressive strength after 300 cycles.

LWC: Retained 85% of its compressive strength after 300 cycles.

Both types showed good freeze-thaw durability, but NC performed slightly better.

Conclusion

The experimental results highlight the distinct characteristics of lightweight concrete and normal concrete. While NC excels in compressive and tensile strength, LWC offers significant benefits in terms of reduced density and improved thermal insulation. Both types exhibit good durability, though NC has a slight edge in freeze-thaw resistance. The choice between LWC and NC should be based on specific project requirements, considering factors such as structural load, thermal properties, and environmental conditions. Further research and optimization of mix designs can enhance the performance and applicability of both concrete types.

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