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Lightweight Concrete as an Alternative to AAC Blocks for Slab Levelling

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Abstract: Lightweight concrete, particularly foam concrete, has emerged as a potential material in modern construction due to its low density, improved thermal and sound insulation, and ease of use. This material is created by mixing a stable foam with a cement-based composition, resulting in air bubbles inside the matrix.

The entrained air gaps dramatically reduce the density of the concrete, making it lighter and more adaptable than conventional choices. The aim of this project is to investigate the properties, applications, and practical implications of foam concrete, especially in high-rise buildings and prefabricated structures, where load reduction on foundations is crucial.

Key aspects of this research include examining the compressive strength, thermal conductivity, workability, and durability of foam concrete across different densities. Various mix designs will be tested to determine the optimal balance between lightweight benefits and structural performance, ensuring that the material remains suitable for both load-bearing and non-load-bearing applications.

The study will also explore the environmental advantages of foam concrete, given its reduced need for raw materials and potential use of recycled components, making it a sustainable alternative in the context of eco-friendly construction practices. By the end of this research, findings are expected to provide actionable insights into the use of foam concrete in diverse construction scenarios, highlighting its potential as a sustainable, efficient, and practical solution for future project

Keywords: Lightweight concrete, AAC Block, Compressive strength, Workability etc.

I. INTRODUCTION

Lightweight concrete, especially foam concrete, has rapidly evolved as a highly viable material in the construction industry due to its unique set of advantages, including low density, thermal insulation, soundproofing capabilities, and ease of application. Unlike traditional concrete, which can be heavy and challenging to transport and apply in certain conditions, foam concrete offers significant reductions in weight while maintaining acceptable structural properties. The technology behind foam concrete production involves incorporating a stable foam into a cementitious mixture, creating a matrix with air bubbles throughout. These air bubbles reduce the density of the concrete, making it suitable for a variety of applications where lighter materials are beneficial. Foam concrete's primary advantage lies in its ability to reduce dead load on structures, which is particularly valuable in high-rise buildings, roof slabs, and prefabricated building components. The lightweight nature of foam concrete also simplifies transport and installation, leading to faster construction times and lower overall costs. Additionally, the material's fluid nature allows it to fill complex shapes and voids efficiently, making it highly adaptable for unique structural requirements, void filling, and even rehabilitation of damaged sections in existing buildings. The growing interest in sustainable building practices has highlighted foam concrete as a viable alternative. Foam concrete is environmentally friendly since it reduces the amount of raw materials required and allows for the use of recyclable materials such as fly ash. This reduces the environmental impact of building projects, making it a more sustainable option than traditional concrete mixes. Furthermore, foam concrete has high thermal insulation capabilities, which contribute to increased energy efficiency in buildings by reducing heat transfer and thus lowering heating and cooling requirements. This study seeks to comprehensively investigate the properties and applications of foam concrete. Through a series of experiments, it will explore crucial metrics such as compressive strength, thermal conductivity, workability, and durability across various mix designs. Aerated concrete autoclaved (AAC), also known as autoclaved cellular concrete, aircrete, porous concrete, and autoclaved lightweight concrete, is a lightweight precast foam concrete that is recyclable, porous, reusable, non-toxic, and renewable. It was developed in 1924 by a Swedish architect who was looking for alternative building materials with qualities similar to wood. AAC is made of aluminum powder, water, cement, lime, gypsum, and pulverized fly ash.

Aluminum powder, water, cement, lime, gypsum, and pulverized fly ash are mixed to make the precast material AAC before it is placed into a mould. When aluminum powder is mixed with lime and fly ash in concrete, it reacts and produces numerous small hydrogen bubbles. After being separated into blocks, the aerated concrete undergoes pressure and steam curing in an autoclave for 8 - 12 hours.

Lightweight concrete is a more efficient choice for larger areas or where faster execution and better load distribution are required. It's particularly beneficial if you're leveling over a structural slab and plan to install additional finishes.

AAC blocks might still be viable for smaller areas or budget-constrained projects, especially where thermal insulation is a higher priority than structural strength. To evaluate the feasibility of using lightweight concrete as an alternative to AAC (Autoclaved Aerated Concrete) blocks for slab levelling, we can assess it based on three key criteria: structural performance, cost, and time efficiency

II. AIM & OBJECTIVES

The primary aim of this study is to evaluate the feasibility of using lightweight concrete as an alternative to Autoclaved Aerated Concrete (AAC) blocks for slab levelling applications. The research seeks to systematically analyze and compare the performance of both materials in terms of structural behavior, cost efficiency, and time effectiveness, with the ultimate goal of recommending a more efficient, economical, and structurally sound solution for slab levelling in modern construction projects.

To develop suitable lightweight concrete mixes for slab levelling purposes This involves selecting appropriate materials such as lightweight aggregates (e.g., expanded clay, perlite, vermiculite) or foaming agents, optimizing the water-cement ratio, and achieving a balance between reduced density and adequate strength. Mixes will be tested to determine their workability, consistency, and suitability for site application.

To evaluate and compare the structural performance of lightweight concrete and AAC blocks Comparative testing will be conducted on parameters such as compressive strength, density, load distribution behavior, and bonding with the structural slab.

This objective will assess how well each material can perform under Structural and service load conditions relevant to slab levelling.

To conduct a detailed cost analysis for both materials and methods A comprehensive cost evaluation will be performed considering: Material costs (cement, aggregates, AAC blocks, additives, etc.)

Labor costs (manual work vs. machine-assisted pouring) Equipment or machinery usage (mixer, pump, cutting tools, etc.) Ancillary materials (mortar, adhesives, curing compounds) This will help determine which method is more cost-efficient for different scales of construction.

To analyze the time efficiency and speed of construction using both materials Time taken for preparation, application, curing or setting, and final finishing will be measured and compared.

Lightweight concrete's ability to be pumped and placed quickly versus the manual placement of AAC blocks will be critically analyzed, especially for large-scale slab applications.

To provide recommendations based on performance, cost, and time analysis Based on the findings from experimental work and site observations, the study will propose clear, evidence-based recommendations.

These will address scenarios where lightweight concrete may serve as a superior alternative to AAC blocks for slab levelling, as well as limitations or considerations that must be accounted for.

III. METHODOLOGY

During the execution phase of the internal project, a significant construction challenge was identified pertaining to the floor slab elevations. It was observed that the structural slabs across the project had been cast at a depth of 275 mm below the final required finished floor level (FFL). This discrepancy emerged due to a revision in the client's design specifications, which necessitated an elevation adjustment to meet functional and architectural requirements. To address this level difference, a suitable infill or levelling material must be introduced to bridge the 275 mm gap and align the slab surface with the intended floor finish level. However, a critical constraint was imposed by the original structural design of the building: the slabs were engineered to withstand a maximum imposed load of 1500 kg/m². As a result, the use of traditional dense concrete as a filler was ruled out, since it would contribute excessive dead load and potentially compromise the structural integrity of the slab system.

This challenge introduced the need for a lightweight, structurally sound, and cost-efficient solution that could be implemented within the available load capacity and without disrupting the ongoing construction schedule. Among the options considered, lightweight concrete and Autoclaved Aerated Concrete (AAC) blocks emerged as viable candidates due to their significantly lower densities and proven use in non-structural applications such as levelling, insulation, and void filling.

Therefore, the scope of this research extends to the development, evaluation, and feasibility analysis of lightweight concrete as a potential replacement for AAC blocks in the specific context of slab levelling. The study will focus on meeting key performance criteria, including:

- Compliance with structural load restrictions
- Effective levelling and bonding performance
- Economic viability in terms of materials, labor, and lifecycle cost
- Ease and speed of implementation in alignment with the project timeline

This project aims to derive an optimized, performance-based solution tailored to site-specific conditions, with potential for replication in similar construction scenarios where traditional concrete poses load challenges.

This study is centered around addressing a practical construction challenge encountered in the internal project, where the floor slabs of the structure were cast 275 mm below the intended finished floor level.

This deviation requires a corrective levelling layer to meet the updated specifications provided by the client. However, the existing slab was designed to support a maximum imposed load of 1500 kg/m², which makes the use of conventional concrete infeasible due to its high density and resulting dead load.

In response to this constraint, the scope of the project is to develop, evaluate, and propose a lightweight concrete solution that can fill the vertical gap efficiently, without exceeding the structural load limits. The solution must also be cost-effective, quick to implement, and compatible with site conditions and project timelines.

The specific tasks and boundaries within the scope include:

1) Assessment of Existing Conditions
   - Review of structural drawings, slab capacity, and floor elevation requirements
   - Identification of the load limitations and permissible dead load for infill material
2) Development of Lightweight Concrete Mixes
   - Selection of suitable lightweight aggregates and/or foaming agents
   - Trial mixes targeting densities well below traditional concrete (ideally 1000–1500 kg/m³)
   - Achieving adequate compressive strength and workability for slab levelling use
3) Comparison with AAC Blocks
   - Evaluate AAC blocks as an alternative, considering their widespread use for non-structural levelling
   - Compare installation method, density, compressive strength, and load implications
4) Experimental Testing and Validation
   - Laboratory tests on both materials: compressive strength, density, shrinkage, and workability
   - Simulated field tests or pilot area application to monitor curing, bonding, and final surface finish
5) Cost-Benefit Analysis
   - Detailed cost estimation for material procurement, labor, and equipment for both methods
   - Assessment of waste, rework, and finishing costs
   - Financial implications of faster or slower project turnaround times
6) Time Efficiency Study
   - Measure time required for material preparation, application, curing, and readiness for the next stage
   - Compare both methods in terms of manpower requirements and scheduling impacts
7) Implementation Feasibility
   - Analysis of ease of execution on-site, including pumping, finishing, and adapting to slab irregularities Evaluation of long-term performance considerations (settlement, cracking, thermal movement)
8) Recommendations and Conclusion
   - Provide a well-supported recommendation for the most suitable material and method
   - Highlight the benefits, limitations, and ideal use cases for each solution Offer practical guidelines for similar future projects

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A. *Concrete Cube Test*

- Trial 1 : Test Report (4 Days)

Concrete Cube test Report									
Location :-Cfc1 2nd Floor Passage							Format No :-RMC/405/REV-01		
							Date of Testing :-04.09.2024		
Grade of Concrete :-		Light Weight Concrete 01					Age in Days :-04days		
Date of Casting :-		31.08.2024					Cementitious Content:-585Kg/M3		
Cube Test Results :									
Sr. No	Cube No	Length (mm)	Breadth (mm)	Height (mm)	Weight (Kg)	Load (KN)	Strength (N/mm^2)	Avg. Strength (N/mm^2)	Percentage (%)
1	1	150	150	150	1689	10	0.44	0.53	1.11
2	2	150	150	150	1711	13	0.58		
3	3	150	150	150	1760	13	0.58		

- Trial 1 : Test Report (28 Days)

Concrete Cube test Report									
Location :-Cfc1 2nd Floor Passage							Format No :-RMC/405/REV-01		
							Date of Testing :-28.09.2024		
Grade of Concrete :-		Light Weight Concrete 01					Age in Days :-28days		
Date of Casting :-		31.08.2024					Cementitious Content:-585Kg/M3		
Cube Test Results :									
Sr. No	Cube No	Length (mm)	Breadth (mm)	Height (mm)	Weight (Kg)	Load (KN)	Strength (N/mm^2)	Avg. Strength (N/mm^2)	Percentage (%)
1	4	150	150	150	1810	18	0.80	0.77	1.60
2	5	150	150	150	1667	17	0.76		
3	6	150	150	150	1776	17	0.76		

- Trial 2 : Test Report (5 Days)

Concrete Cube test Report									
Location :-Cfc1 2nd Floor Passage							Format No :-RMC/405/REV-01		
							Date of Testing :-05.09.2024		
Grade of Concrete :-		Light Weight Concrete 02					Age in Days :-05days		
Date of Casting :-		31.08.2024					Cementitious Content:-585Kg/M3		
Cube Test Results :									
Sr. No	Cube No	Length (mm)	Breadth (mm)	Height (mm)	Weight (Kg)	Load (KN)	Strength (N/mm^2)	Avg. Strength (N/mm^2)	Percentage (%)
1	1	150	150	150	2323	37	1.64	1.69	3.50
2	2	150	150	150	2466	43	1.91		
3	3	150	150	150	2399	34	1.51		

- Trial 2 : Test Report (9 Days)

Concrete Cube test Report									
Location :-Cfc1 2nd Floor Passage							Format No :-RMC/405/REV-01		
							Date of Testing :-09.09.2024		
Grade of Concrete :-		Light Weight Concrete 02					Age in Days :-09days		
Date of Casting :-		31.08.2024					Cementitious Content:-585Kg/M3		
Cube Test Results :									
Sr. No	Cube No	Length (mm)	Breadth (mm)	Height (mm)	Weight (Kg)	Load (KN)	Strength (N/mm^2)	Avg. Strength (N/mm^2)	Percentage (%)
1	4	150	150	150	2362	30	1.33	1.57	3.25
2	5	150	150	150	2363	41	1.82		
3	6	150	150	150	2462	35	1.56		

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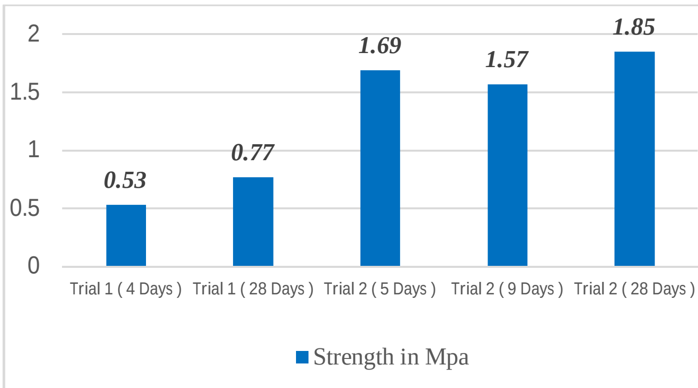
- Trial 2 : Test report (28 Days)

Concrete Cube test Report									
Location :-Cfc1 2nd Floor Passage							Format No :-RMC/405/REV-01 Date of Testing :-28.09.2024		
Grade of Concrete :-		Light Weight Concrete 02					Age In Days :-28days		
Date of Casting :-		31.08.2024					Cementitious Content:-585Kg/M3		
Cube Test Results :									
Sr. No	Cube No	Length (mm)	Breadth (mm)	Height (mm)	Weight (Kg)	Load (KN)	Strength (N/mm^2)	Avg. Strength (N/mm^2)	Percentage (%)
1	7	150	150	150	2349	34	1.51	1.85	3.84
2	8	150	150	150	2530	52	2.31		
3	9	150	150	150	2418	39	1.73		
4	10	150	150	150	2367	40	1.78	1.64	3.41
5	11	150	150	150	2359	35	1.56		
6	12	150	150	150	2449	36	1.60		

Chart 1 : Overall Results of all test trials



IV. RESULT DISCUSSION

These findings indicate a clear improvement in compressive strength in Trial 2 over Trial 1. While Trial 1 did not achieve desirable strength even after 28 days, Trial 2 consistently showed higher values throughout the curing period. This implies that Trial 2's mix design (potentially adjusted water-cement ratio, additives, or aggregate proportion) was more effective in producing a denser and stronger concrete matrix.

Moreover, the strength gain in Trial 2 from 5 days (1.69 MPa) to 28 days (1.85 MPa) shows a moderate rate of increase, suggesting that most of the hydration and strength development occurred early, which is beneficial for applications requiring faster formwork removal and early-stage load handling.

V. CONCLUSION

Based on the findings of this study, it can be concluded that lightweight concrete presents a technically viable and practically efficient alternative to Autoclaved Aerated Concrete (AAC) blocks for slab leveling applications in modern construction. The experimental and analytical evaluations demonstrated that lightweight concrete achieves structural performance comparable to AAC blocks, making it suitable for non-load bearing applications such as floor leveling, where strength and stability are essential but not critical in a load-bearing context.

One of the major advantages observed is its superior workability, which allows for easier mixing, placing, and leveling on site. This property significantly reduces construction time and contributes to faster project execution, especially in multi-unit residential and commercial buildings. Unlike AAC blocks, which require precise cutting, alignment, and bonding, lightweight concrete can be poured or pumped directly over the surface, minimizing labor dependency and reducing human error during application.

In terms of cost-efficiency, lightweight concrete offers savings in both material handling and labor costs. Since it is pumpable and self-leveling in nature, it eliminates the need for additional finishing layers or extensive manual adjustments, which are often required with AAC block leveling.

Furthermore, its lower density reduces the dead load on slabs, which may allow for optimization in structural design and further material savings in the long run. The material also displayed a lower tendency to develop surface cracks, enhancing the durability and finish quality of the slab. Its adaptability to different slab configurations and on-site conditions—including uneven or irregular surfaces—adds to its versatility and makes it particularly suitable for both new construction and renovation projects. Overall, lightweight concrete proves to be a more adaptable, time-efficient, and cost-effective solution compared to AAC blocks for slab leveling. Its practical advantages, combined with acceptable structural behavior, position it as a strong candidate for widespread use in modern construction practices.

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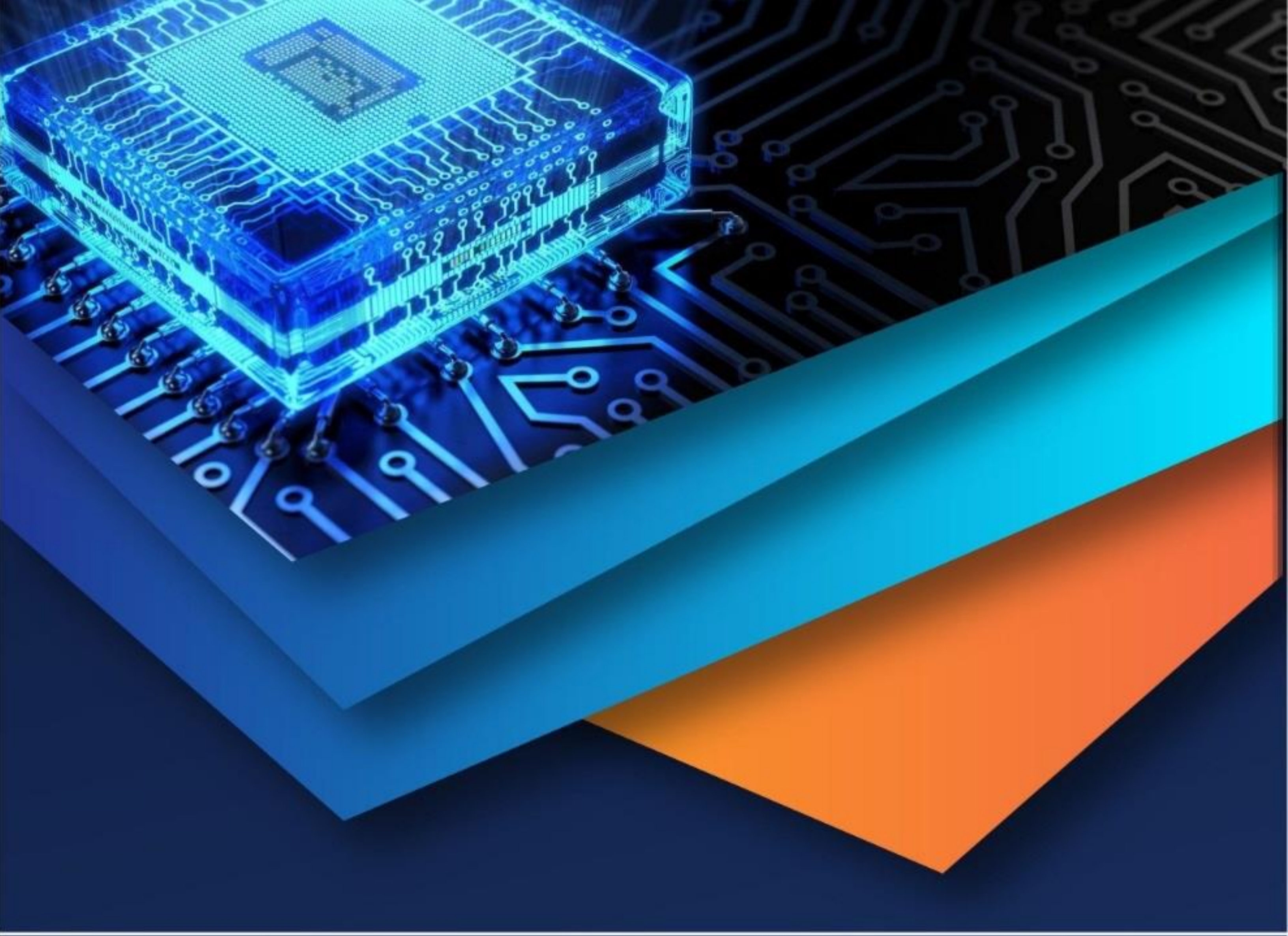

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