Performance of translucent AAC block by using detergent

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***Abstract*— Autoclaved Aerated Concrete (AAC) blocks are very popular in construction for their lightweight, thermal insulation, and eco-friendly features. Translucency can better make the AAC blocks an elegant and functional item that allows partial light transmission. This paper studies the workability of these translucent AAC blocks using detergent as the foaming agent. The detergent will be analyzed against mechanical strength, density, thermal insulation, and light transmission properties of the blocks. The experimental results indicated that foaming with detergent increases porosity to improve translucency, which affects compressive strength slightly. This research aims to strike a balance between structural integrity and translucence for optimum usability in modern architecture and sustainable building design.**

***Index Terms*—Cement, Compressive strength, Detergent, Fly ash, Foaming agent, Gypsum, Optical Fiber.**

I. INTRODUCTION

Autoclaved Aerated Concrete (AAC) blocks are a commonly used building material that is characterized by their lightness, thermal insulation, and environmental sustainability. Traditionally, these blocks are produced with cement, lime, sand, and an aerating agent like aluminum powder. Nevertheless, recent technologies for building materials aim to improve both functional and aesthetic characteristics, resulting in the production of translucent AAC blocks.

The incorporation of translucency in AAC blocks enables partial transmission of light, which makes them ideal for contemporary architectural uses, including ornamental walls and energy-saving buildings. Translucency can be achieved by altering the aeration process through the use of different foaming agents. In this research, detergent is employed as a foaming agent to produce a porous structure that increases translucency.

This study targets the investigation of the performance of detergent-based transparent AAC blocks under mechanical strength, density, thermal insulation, and light transmission. The effect of detergent on the structural and physical properties of the blocks will be tested to identify their viability for actual construction applications. The outcomes of this research may be able to advance the creation of innovative building materials with strength, energy efficiency, and beauty.

SCOPE OF THE WORK

Translucent concrete is also a great insulating material that protects against outdoor extreme temperatures while also letting in daylight. This makes it an excellent compromise for buildings in harsh climates, where it can shut out heat or cold without shutting the building off from daylight. It can be used to illuminate underground buildings and structures, such as subway stations. The possibilities for translucent concrete are innumerable; the more it is used, the more new uses will be discovered. In the next few years, as engineers further explore this exciting new material, it is sure to be employed in a variety of interesting ways that will change the opacity of architecture as we know it.

OBJECTIVES

- To evaluate the properties of material.
- To evaluate the strength of foam concrete with different percentage of gypsum and optical fibre.
- To evaluate the density of concrete while maintaining its mechanical properties.
- To reduce the cost of structure.

II. LITERATURE REVIEW

Brajesh Pandey et al. (2023) [4] researched foam concrete, a light and porous substance applied in insulation, filling, and structural functions. The study examined how compressive strength, density, water absorption, and thermal conductivity are affected by mix ratio and production processes. It was determined that the best mix was 60% cement, 40% sand, and 0.4% detergent by weight of cement, having an optimal density of 1200 kg/m³. The associated properties were a compressive strength of 12.4 MPa, split tensile strength of 1.85 MPa, flexural strength of 2.54 MPa, and water absorption of 11.37%. The weight is cut by 40% and the CO_2 emission is reduced to half with the use of foam concrete, hence a cost-efficient and environmentally friendly building material.

Akash Singh et al. (2023) [6] researched foamed concrete (FC), a light, aerated concrete without coarse aggregate. It possesses a high strength-to-weight ratio and low density, with the best consistency being 1000 kg/m³ and compressive strength of 6 MPa to 14 MPa. FC can be made with densities of 400 to 1800 kg/m³, which makes it appropriate for geotechnical purposes, acoustic and thermal insulation, and fire resistance. Its advantages include minimized structural dead load, energy saving, and lower cost of construction. Although FC has a limitation with tensile strength, constant research is aimed at improving its strength and durability, thus its use in the construction sector.

Shazim Ali Memon et al. (2018) [3] researched the application of locally produced detergent powder as a low-cost option for conventional foaming agents in foam concrete. The experiments indicated that the detergent-based foam concrete exhibited similar mechanical properties, such as strength, thermal insulation, and fire resistance, while saving 42.57% of production costs. The most suitable mix was 0.3% by weight of cement detergent and the cement-to-sand ratio of 1.5. The research vindicates that the powder detergent can be a proper, economical replacement, especially ideal for developing nations.

T. Sultan et al. (2020) [5] explored the potential of using local detergent as a foaming agent in low-cost foam concrete. The research evaluated different mix ratios for compressive strength, density, water absorption, and acid resistance. Results indicated that detergent-based foam concrete possessed appropriate properties for construction with compressive strengths of 4.07–4.82 MPa, densities of 865–960 kg/m³, and water absorption of 10.5–14.5%. The best combination was 60% cement, 40% sand, and 0.4% detergent by cement weight. The research concludes that detergent is a suitable, economical substitute for commercial foaming agents and proposes further work for additional applications.

Nikhil K et al. (2016) [1] conducted research on translucent concrete, incorporating optical fibers in order to conduct light while the structure retains its strength. Compression strength and transmission of light were tested with 0–4% fiber variation. The material reached 20–23 N/mm² of strength, in compliance with the M20 grade. Applications consist of energy conservation through lighting, improved aesthetics, and possible structural monitoring through self-sensing abilities. Most beneficial in extreme environments, it insulates and offers natural light to facilities such as underground buildings. The research brings to light its potential in upcoming architectural advancements.

Er. Anish Tayal et al. (2017) [2] researched translucent concrete, incorporating optical fibers for the transmission of light without any compromise in the structural properties of the material. Designed for sustainable construction, it minimizes electricity consumption through natural light. This started in 2001 through Hungarian architect Áron Losonczi, and the outcome was the initial transparent concrete block, LiTraCon, produced in 2003. Aside from beauty, translucent concrete presents opportunities for sensing stress, providing a revolutionary, sustainable material in contemporary architecture.

III. MATERIAL USED

A. Ordinary Portland cement (OPC)

In this study Ordinary Portland Cement-Grade 53, which is known for its rich quality and high durability is used. It will help to fill the voids and gives density to the concrete. It is used for constructing bigger structures like building foundations, bridges, tall buildings, and structures design to withstand heavy pressure. As such, Ordinary Portland Cement is used for quite a wide range of applications in prestressed concrete, durable pre-cast concrete, and ready mixes for general purposes.

B. Fine Aggregate

The influence of fine aggregates on the fresh properties of the concrete is significantly greater than that of coarse aggregate. The high volume of paste in concrete mixes helps to reduce the internal friction between the sand particles but a good grain size distribution is still very important. Fine aggregates can be natural or manufactured. The grading must be uniform throughout the work and must pass through 2.36 mm sieve size which confirms to the code IS: 383 – 1970. Particles smaller than 0.125 mm size are considered as fines which contribute to the powder content.

C. Optical fibers

0.75mm Diameter plastic optical fiber Strands are used for construction of translucent concrete. Plastic optical fiber is an optical fiber that is made out of polymer. Similar to glass optical fiber, POF transmits light (for illumination or data) through the core of the fiber. Its chief advantage over the glass product, other aspect being equal, is its robustness under bending and stretching. PMMA and Polystyrene are used as the core, with refractive indices of 1.49 and 1.59 respectively. Generally, fiber cladding is made of silicone resin (refractive index ~1.46). High refractive index difference is maintained between core and cladding.

D. Water

Water is the key ingredient, which when mixed with the cement, forms a paste that binds the aggregate together. Potable water available in laboratory was used for casting all the specimens. The quality of water was found to satisfy the requirements of IS: 456-2000

E. Fly-Ash

Fly ash is a fine powder produced as a byproduct when coal is burned in thermal power plants. It is carried out with flue gases and collected using electrostatic precipitators or bag filters. Due to its pozzolanic properties, it is widely used in construction materials, particularly in cement and concrete production.

Table-1: Composition of Chemicals in Fly-Ash

Chemical compounds	Composition percents (%)
Silicon dioxide (Sio_2)	35-60
Alumunium Oxide (Al_2O_3)	10-30
Iron oxide (Fe_2O_3)	5-25
Calcium oxide (CaO)	1-30
Magnesium oxide (MgO)	0-5
Sulfer trioxide (SO_3)	0-5
Sodium oxide (Na_2O) & Potassium oxide (K_2O)	0-5
UnburntCarbon (C)	0-5

F. Detergent (Ghadi)

Detergent in concrete is a special additive that creates tiny air bubbles in the concrete mix. These bubbles improve the workability and flowability of the concrete, making it easier to pour and finish. The detergent also helps to reduce the surface tension of the water, allowing it to mix more easily with the cement and aggregate. This results in a stronger, more durable, and more resistant concrete that can withstand harsh weather conditions and heavy loads. By adding detergent to concrete, builders can create a more stable and long-lasting structure with improved freeze-thaw resistance, reduced shrinkage, and enhanced overall performance. It's a simple yet powerful tool that enhances the quality and durability of concert.

IV. EXPERIMENTAL PROGRAMME

A. Preparation of Mould

In the process of making light transmitting concrete, the first step involved is preparation of mould. The mould required for the prototype can be made with different materials which can be of either tin or wood. In the mould preparation, it is important to fix the basic dimensions of mould. The standard size of AAC block used is 60cm x 20cmx l0cm.The diameter of the holes and number of holes mainly depends on percentage of fiber used. Holes of size 1.2 mm were drilled at 2cm spacing horizontally.

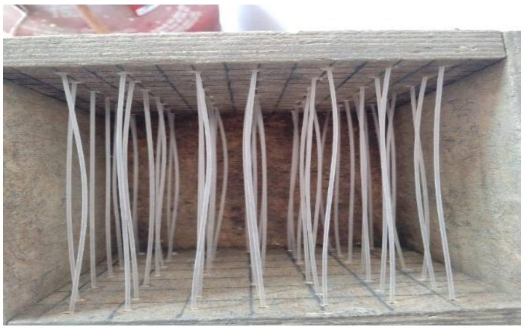
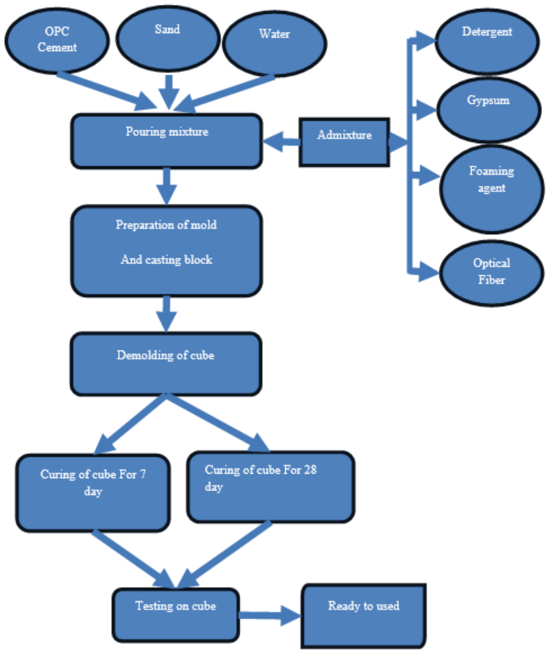


Fig-1: Optical Fibers Arranged in The Mould

B. Manufacturing Process

The manufacturing process of translucent concrete is almost same as regular concrete. Optical fibers are arranged at 2cm spacing throughout the mould. The ratio of cement to fine aggregate was fixed as 1:2 with a water – cement ratio of 0.45 after a series of trials, the first stage deals with the determination of optimum percentage of foaming agent by weight to be added to mortar with cement sand ratio 1:2.

Foamed concrete mixes were prepared with 0%, .5%, 1.5%, 2%, of foaming agent by weight of cement. The optimum percentage of fly ash powder is determined based on density and compressive strength obtained from different percentage of foaming agent. The optimum percentage was chosen as 2% with desired strength and density. The concrete are poured into the mould provided with strands of optical fibers to transmit light, either naturally or artificially. The concrete mixture was prepared using fine aggregate and cement without any coarse aggregate. Thickness of the optical fibers can be varied between 2 μm and 2 mm to suit the particular requirements of light transmission. Here we used fibres of 0.75mm diameter. Aftercasting, the blocks were cured for 28 days and then polished by grinding the surface, resulting in smooth finishes.



V. TEST CONDUCTED

Compression Test: By definition, the compressive strength of a material is that value of uniaxial compressive stress reached when the material fails completely. The compressive strength is usually obtained experimentally by means of a compressive test. The blocks after 28 days of curing, were dried and then direct loading was applied perpendicular to the axis of optical fibers in the compression testing machine. Compressive strength = load/area

VI. RESULT

The compressive test result of the finished block is tabulated in table 2.

Table 2: density and compressive strength of block

Concrete Block Id	Wet Density (Kg/M^3)	Dry Density (Kg/M^3)	Compressive Strength At 28 Days (N/Mm^{2})
1	1611	1561	3.48
2	1683	1633	3.65
3	1711	1661	3.70

VII. CONCLUSION

- Light transmittance could be achieved by using plastic optical fibers. This can be used efficiently in green buildings to reduce power consumption offering sustainability. It can ensure natural light inside the buildings throughout the day.
- Compressive strength of blocks was found to satisfy the codal provisions.
- The weight of the concrete block was successfully reduced by the addition of fly ash without compromising the strength.
- Light transmitting concrete can be used in structures to make them aesthetically beautiful with the added advantage of reducing power consumption and protecting privacy.
- Currently, the cost of manufacture of light transmitting concrete is high due to the usage of plastic optical fibres and the effort in laying it ,but this will be offset by the host of advantages it possess.

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