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Experimental Study of Fly Ash Based Translucent Concrete Projects: A Review

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Abstract: By 2050, it is predicted that the manufacturing of regular cement for institutional, commercial, and residential structures will spew around 3800 tonnes of carbon dioxide into the atmosphere and use 38% of the world's energy. It has become crucial to create a new class of construction materials that combine eco-friendly, energy-saving, and self-sensing capabilities**.** Translucent concrete, created through innovation in the material sciences and the fusing of fibre optics and concrete technologies, helps to create structures that are cosier, more artistic, safe, and energy-efficient. The creation of Smart Transparent Concrete, based on its exceptional transparent and smart sensing qualities, is discussed in light of "green" standards and safe evaluation for engineering constructions that have attracted global attention. Dealing with its application and the benefits it offers in the area of smart construction, discover that it can save lighting power consumption, utilise an optical fibre to detect structural stress, and use this concrete as an architectural feature for a pleasing aesthetic sight of the building. Fly ash is used in concrete to explore the partial additional of cement with fly ash. Translucent concrete blocks can be used in many ways and implemented into many be highly advantageous.

Keywords: Translucent Concrete, Optical Fiber, Fly Ash, Compressive Strength, Light Transmission.

1. Introduction:

In addition to a good view, energy efficiency is a key feature that the construction materials industry seeks with the advancement of science and technology. Therefore, the best and only source of light that is genuinely free is the sun. A room with transparent concrete walls would be well-lit by natural sunshine. It's a prerequisite for green buildings, and it may significantly increase security and supervision in settings like schools, museums, and jails, among others, where people's presence and actions are visible but not their complete picture, safeguarding both their privacy and their right to privacy [1].

The concept of light-transmitting concrete was first proposed by Hungarian architect Aron Losonczi in 2001, and the first transparent concrete block, known as Litracens, was successfully created in 2003. But his transparent concrete lacked intelligent sensing capabilities. In order to take advantage of POF's ability to guide light and FBG's sensing properties, a smart transparent concrete-novel construction material was introduced by Professor Zhi Zhou in 2009. It was made by drilling through cement and mortar and using POF.[2] The Indian engineers who conducted the experiments were aimed at evaluation of the transparency level and at the fundamental concrete experimentation, which is compression resistance. The translucent concrete had sparked the most attention among them.[3]

To transmit light, either natural or non-natural, into all places surrounding the resulting translucent panels, thousands of optical fibre strands are cast into concrete. Concrete specimens can be made to transmit light through optical fibres, allowing one to see light, hues, and even colours through extremely thick walls..[4]

2. Literature review

The review paper includes the work of several authors as well as the findings of many research papers. The primary findings of these studies are enumerated and discussed at the end of this chapter, which includes papers published in a variety of national and international publications, PhD theses, reports, and books.

2.1 Plastic optical fiber (POF)

Fibers of Plastic Optical, Plastic optical fibre is a flexible, transparent material formed of pure glass (silica). It transmits light between its two ends by acting as a waveguide or "light pipe. “To transmit light between the two ends of the fibre, use a "light pipe."[5] Optical fibres are flexible, thin wires that have been made transparent and ready for light transmission.[6]The application of optical fiber will make the concrete attractive as well as can make the concrete structural effective. By using plastic optical fibers in concrete specimens, light transmission arises through optical fibers, which make it likely to see light, shades and even colours through very thick walls. [4] stated implications of varying OF ratio, spacing and angle of incidence of source light.[7] Preliminary research indicates that a translucent concrete panel with a volumetric Plastic Optical Fiber (POF) ratio of 6% can reduce lighting capacity by around 50%.[8]

Investigated the creation of transparent smart concrete with smart sensing capabilities using Fiber Bragg Grating and Plastic Optical Fiber. The studies' findings demonstrate that an optical fibre and concrete may be simply coupled, and that the plastic optical fiber can offer a stable light transmitting ratio.[9]

According to studies, optical fibres should have a diameter between 0.5mm and 3mm if they are to transmit light uniformly. Smaller-diameter optical fibres performed better. [5] A concrete-based substance called translucent concrete has the ability to transmit light due to the addition of light-optical components like optical fibres. From one end of the stone to the other, light passes. This results in a particular pattern of light depending on the fibre structure on the surface opposite. Since optical fibres are so effective at transmitting light, very little light is lost as it passes through them.[4]

2.2 Compressive strength

Compressive strength is one of the crucial characteristics that should be assessed in order to establish a construction material's potential for compressive resistance. [10] The placement of the plastic optical fibres inside the crushed element is crucial, according to the compression resistance studies done on translucent concrete specimens.[3] Although it has consistently discovered a variety of parameters (including cementitious material composition, the fine/coarse aggregates ratio, and the impact of test ages) that affect compressive strength.[11]

Compressive strength is observed to rise as fibre content increases up to 4%, then reduction at 6% fibre content for all diameters. However, the concrete's compressive strength reaches its peak after seven days at 4% fibre concentration because higher fibre contents weaken the bonds that hold the material together.[5] Cement - 53 grade, sand - 2.36 mm sieve passing, optical fibre cables 200-micron diameter, a fine cement concrete mix ratio of 1:2, and a water cement ratio of 0.45 are the ingredients utilised in this concrete. These experimental investigation's findings are tangible. When tested using optical fibre specimens, light transmission concrete's compressive strength varied between 20 and 23 N/m, demonstrating that it satisfies the standards for M20 grade.[12]

When compared to normal cement mortar, the compressive strength of the light-transmitting cement mortar with a volumetric proportion of 4% optical fibre is 81% higher. They also came to the conclusion that gaps between the fibre and mortar interface were a factor in the compression strength reduction using scanning electron microscopic (SEM) examination.[13] In comparison to the Self compacted concrete without fibre for the M20 grade mixes, the specimens with 0.05%, 0.1%, 0.15%, and 0.2% of glass fibre exhibit increases in compressive strength of 8.2%, 9.2%, 7.02%, and 3.5%, respectively.[14]

2.3 Fly ash

Currently, fly ashes are being formed that differ from one another in composition and other ways considerably more significantly than had previously been observed. [15] We can draw the conclusion that using fly ash to substitute cement is beneficial for lower-grade cements like M20. It can be said that the strength qualities significantly enhance when fly ash replaces cement by 25%. As the percentage of fly ash rises, the strength of concrete first drops with the increase and then increases again. Fly ash can lessen disposal costs for the coal and thermal industries and deliver "greener" concrete for building.[16]

Portland cement and natural aggregates can be replaced with recycled plastic and additional cementitious ingredients to decrease the carbon footprint of the concrete industry. In order to understand the impact of adding fly ash, nano-silica, and recycled plastic in the cost and mechanical qualities of eco-friendly, structural concrete, two mixture designs are used in this study. According to the results, plastic may replace 44% of coarse aggregate when 2.5% nano silica and 10% Fly ash are added.[17]

Fly ash can be applied as a cement replacement, reducing cement usage, thus environmentally and economically beneficial. Fly ash makes concrete effective; increasing its levels may reduce water demand and superplasticizer requirements. Fly ash can improve mechanical and durability limits of concrete.[18]

OPC cement grouts and fly ash cement grouts were compared in micro piles. The sediments have been created for different water-cement ratios, including 0.400, 0.450, 0.500, and 0. 550. They were observed for a duration ranging from two to ninety days. It has also been examined how to correct the water penetration under pressure and the chloride diffusion coefficient to improve the compressive strength test and durability qualities. Following the experiment, the scientists came to the conclusion that FA grouts offer good resistance to the entry of chlorides, minimise aggressive matter penetration, and reduce porosity, all of which boost the longevity of micropiles.[19]

2.4 Architectural And Environment Aspect

Translucent concrete, created through innovation in the material sciences and the fusing of fibre optics and concrete technologies, helps to create structures that are cosier, more artistic, safe, and energy-efficient. It acts as a cutting-edge building envelope that permits daylight to pass through the opaque portions of outside facades and roofs.[20]

Infrastructure must prioritise two things: energy efficiency and a beautiful view. Smart translucent concrete is a gifted technology for field applications in civil infrastructure because it can be well-thought-out a "green" energy-saving construction material.[5] Staircases and interior walls: Applying translucent concrete to an indoor stairwell's exterior wall permits sunlight to enter the interior space, which makes it an excellent option for emergency and power outage building evacuation, particularly in scraper structures.[21]

It can cut down on lighting power requirements, sense structural tension via optical fibers, and utilise this concrete for architectural purposes to improve the building's aesthetics.[2] Lighting energy savings of about 50% result from the TC panel's adoption of a volumetric fibre ratio of 6%. If panels can lower the office space's need for heating and cooling, their utility is increased. When sunlight is transmitted over optical fibers, it can help heat a space in the winter but increases cooling loads in the summer.[22]

3. Advantages & Disadvantages

The finest and cost-free source of light is genuine sunlight. A room with transparent concrete walls would be better by natural sunshine. It is a prerequisite for green buildings, making it a huge benefit for them. These optical fibres can also act as heat insulators, making them particularly useful in cold climates where they can reduce energy use and save a lot of money. As was already said, translucent concrete may significantly increase security and monitoring in locations like schools, museums, and prisons, among others, where people's presence and actions are visible but not their whole picture, safeguarding their privacy as well[2]. Transparent concrete has identical strength characteristics to regular concrete. As a result, it can be utilised in place of regular concrete. The production process is not difficult. It is simple to produce and put to use. [7]The biggest downside is the high expense of the concrete due to the optical fibres. Transparent concrete block casting is thought-provoking for labour, so a specific trained individual is needed. Combining some of the the above, it is clear that translucent concrete is an excellent instrument for cutting costs and saving electricity. It is a better alternative because it is stronger than glass and has approximately the same characteristic strengths as regular concrete blocks.[2]

4. Conclusion

Our infrastructures need to change as technology advances. To satisfy the rising demand for energy, we must adopt the usage of renewable energy sources for greater development in the building industry. The ideal solution to the aforementioned issue is translucent concrete. The translucent concrete used in a building's exterior walls makes it simple to direct light from the source to the interior. When compared to regular concrete, transparent concrete has a significantly higher compressive strength. Concrete that is translucent can be utilised for aesthetic purposes and is environmentally friendly. Concrete that is translucent is most frequently utilised in locations where sunlight cannot reach with the necessary intensity.

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