Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Volume 13, Issue 03 March 2024

Experimental Study on Translucent Concrete

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Abstract: **Translucent concrete is the new methodology in the construction industry these days. In the olden days, we used only cement, fine aggregate, coarse aggregate, and water for building construction. In the early days, we were going through a new innovation of things in construction with an aesthetic appearance for the building. The translucent concrete was one of the innovations that added to the attractiveness of the building. This project is all about the light transmitting through the translucent concrete with reference to the plastic optical fiber (POF). In these experiments, we use 4% of plastic optical fibers and 96% of fine cement concrete. We are constructing small blocks that transmit light through the blocks.**

KEY WORDS**: Plastic optical fiber (POF), Translucent concrete.**

1. INTRODUCTION

Concrete, the world's most widely used building material, has been the subject of research and development by researchers and manufacturers to improve the quality and economic value of construction. Hungarian architect Aron Losonczi initiated the development of light transmitting concrete in 2001, which was later named litracon. This innovative material, made from plastic optical fibers called "NANO OPTICS," transfers light from one side of a wall to the other. Translucent concrete, manufactured using fine materials, has a compressive strength of around 70Mpa (10,000 psi) and is now being sought for its aesthetic appearance and design purposes. Translucent concrete combines traditional concrete with light transmitting concrete, offering new dimensions of aesthetics and functionality in both interior and exterior spaces. It can be used for walls, facades, and flooring, creating an ethereal beauty atmosphere. As technology advances, translucent concrete continues to evolve, pushing the boundaries of traditional construction materials and inspiring architects to think creatively about the interplay between structure and light in their designs.

2.LITERATURE REVIEW

The research studies conducted on translucent concrete for light transmission through the block are elaborated in the following literature.

Paul & Dutta (2013) Traditional concrete in the construction industry is greyish and dense, making it difficult to distinguish shapes and bodies. A translucent concrete can create better interactions with the environment, create natural lighting, and reduce maintenance costs. This new material can be used as load-bearing structures and integrate green energy saving with self-sensing properties of functional materials.

Salih et al (2014) The study explores the use of translucent concrete as a light-transmitting construction material. Results showed that SCM can produce translucent concrete with compressive and flexural strengths varying with POF volume fraction content and diameter size.

Momin et al (2014) The study compares concrete specimens reinforced with glass rods and optical fibers and compares them to normal concrete. Results show similar compressive strength and increased transparency compared to glass rods. This suggests that without affecting strength, transparency of light can enhance the architectural view in concrete.

Pagliolico et al (2015) The study explores the use of coarse glass waste in high-performance cement matrix to create translucent concrete panels for interior walls. It examines the effects of glass scraps on concrete properties, reactivity resistance, and light transmittance. Results show that using translucent concrete walls reduces energy demand by up to 16% in Palermo.

Li et al (2015) The study investigates the use of glass waste in high-performance cement matrix to create translucent concrete panels, revealing that this method can reduce energy demand by up to 16% in Palermo.

Spiesz et al (2016) The article discusses the creation of a translucent, air purifying concrete using waste glass. The composition was optimized using the modified Andreasen & Andersen model, and the properties of the concrete were investigated. The use of TiO2 and different thicknesses of concrete tiles were also examined.

Altlomate et al (2016) The study explores the performance of light-transmitting concrete (LTC) using different POF dosages and spacings. Results show LTC can provide a high light-transmitting ratio, contributing to sustainable construction alternatives. LTC reduces power consumption by allowing natural light to enter buildings through external walls. POF also increases compressive strength.

Ahuja et al (2017) Translucent concrete (TC) can offset office lighting energy by using concrete panels with optical fibers to transmit sunlight. A 6% fiber ratio can save 50% in lighting energy. The panels also reduce heating and cooling requirements, as sunlight channels heat during winter and cools during summer. The research combines thermal and lighting analyses to find the optimal fiber volumetric ratio, resulting in an 18% energy savings for a 5.6% fiber ratio.

Saleem et al (2017) The research presents a new translucent concrete-based lane separator that transmits coloured light by embedding plastic optical fibers in self-compacting concrete.

Shitote et al (2018) Translucent concrete, a new energy-saving building material, allows light transmission into indoor environments through embedded optical fibers. An experimental study evaluated the light transmittance performance of plastic optical fiber (POF) based translucent

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concrete using an electrical circuit test setup with light dependent resistor (LDR). Results showed that light transmission increased with POF volume ratio, but decreased with distance between specimen and light source. The study found that translucent concrete can be used as an energy-efficient construction material for sustainable and green building development.

Mosalam et al (2018) The study introduces a new building envelope for daylight permeability through opaque exterior façades and roofs. Experimental results demonstrate the effectiveness and limitations of this innovative solution.

Juan et al (2019) This paper explores the development of a new type of resin translucent mortar-based concrete (RTMC), focusing on its light guiding properties. The results show RTMC has excellent light transmittance, compressive strength, and thermal performance, with a thermal conductivity 60% lower than plain concrete.

Tuaum et al (2019) The research explores the development of translucent concrete façades using locally available materials to reduce energy consumption in the building sector.

Su et al (2020) Translucent concrete (TC) is a new optical fiber-enhanced building envelope with unique light transmission properties. A ray-tracing model was developed to analyse its daylighting performance. Simulation results showed that increasing the numerical aperture of OFs can enhance TC's annual average luminous flux by up to 40.62%. The optimal fiber volume ratio was determined for seven cities. Core-cladding interface losses could lead to deviations.

Said (2020) LiTraCon, an innovative construction material, has been developed by engineers to improve the energy efficiency, aesthetic appeal, and daylight indoor quality of buildings. The material is made by embedding optical fibers in concrete, allowing light to pass through itself. However, the mechanical strength of LiTraCon decreases within acceptable limits due to the presence of optical fibers.

Navabi et al (2021) The study investigates the optical and physical properties of high-performance light transmitting concrete made from Portland cement, polymethylmethacrylate optical fibers, silica fume, fine aggregate, polycarboxylate superplasticizer, silica powder, and water.

Tahwia et al (2021) Translucent self-compacting concrete (TSCC) is an energy-saving construction material made from Portland cement, limestone powder, silica fume, aggregate, water, superplasticizer, and plastic optical fibers. The research examines its compressive strength, natural and artificial light transmittance performance, and compared it to translucent self-compacting mortar (TSCM). Results show that TSCC performs up to 21.35% and 24.7% of natural and artificial light transmittance near-cube faces, making it suitable for commercial and residential buildings.

Huang et al (2022) Translucent concrete panel (TCP) is a new construction material that combines light conduits like optical fibers with lightweight, high-strength concrete. It has excellent thermal insulation and low electricity consumption, compared to traditional building envelopes. Simulations show TCP envelopes are more energy efficient in Stockholm and Nanjing than Singapore. This innovative material is suitable for light transmission and load-bearing applications in building envelopes.

Chiadighikaobi et al (2023) This paper explores the production of sustainable and energy-saving concrete, specifically translucent concrete. The study suggests that translucent concrete can be used in building construction and walkways, but not limited to these areas. The review also suggests potential future research fields and fills known research gaps.

Navabi et al (2023) This study analysed five high-performance concrete samples and their performance in daylight and electricity saving using Diva for Rhino software. Results showed that using this material and lighting sensors resulted in 45.7%, 31.5%, and 38.8% electricity savings for offices in Tehran, Vancouver, and Phoenix, respectively.

3. MATERIAL DESCRIPTION

3.1 CEMENT: Cement is a binder that hardens when dried and reacts with carbon dioxide in the air, and bind together with other materials The most prevalent type of cement in general usage around the world is Portland cement. Ordinary Portland cement of 53 grade confirming to requirements of IS: 12269 – 1987.

S.No	Properties	Results
1	Specific gravity	3.05
2	Fineness	2.10 %
3	Normal consistency	32 %
4	Initial setting time	50 min
5	Final setting time	320 min

3.2 FINE AGGREGATE: As per IS 383-2016, Fine aggregate is inert material, typically containing 5% coarse material, used to fill open spaces between coarse particles, reducing porosity and increasing strength. Typically, natural river sand or finely crushed stone is used in economically scarce locations.

S.No	Properties	Results
1	Specific gravity	2.6
2	Fineness	2.82
3	Bulking	32.22 %
4	Zone	II

3.3 PLASTIC OPTICAL FIBER: Optical fibers are a wave guide, made of transparent dielectric (glass or plastic) in cylindrical form through which light is transmitted by total internal reflection. It guides light waves to travel over long distances without much loss of energy. Optical fibers consist of an inner cylinder made of glass or plastic called core of very high refractive index. The core is surrounded by a cylindrical shell of glass or plastic of lower refractive index called cladding. The cladding is covered by a jacket which protects the fiber form moisture and abrasion.

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- TYPES OF PLASTIC OPTICAL FIBER (POF)

  Based on the refractive index profile and the number of models, optical fibers are divided into three types. They are:

  1. Step index single mode fiber
  2. Step index multimode fiber
  3. Graded index multimode fiber

3.4 MIX DESIGN: The manufacturing process of translucent concrete is almost same as the normal mix concrete. Only the plastic optical fibers are spread throughout the aggregate and cement mix. We placed the POF as single piece of fibers are placed one by one on the sheet. The POF are bend at one side of the sheet for the holding purpose. Small layers of the concrete are poured at the top of the fibers and with the help of tampering rod the cement mortar is diffused cement mortar is diffused with tampering rod of 25 blows of each layer for the mortar goes to all edges of the mould. The Strades of optical fiber are cast into concrete to transmit light, either natural or artificial. The concrete mixture is made from fine cement mortar or materials only it does not contain any coarse aggregate in the mixture of cement mortar. The thickness of the plastic optical fibers is varied from 1mm and 2mm to suit the particular requirements of light transmission. For the concrete mixing process; the material such as Ordinary Portland Cement and fine aggregate were mixed first. Then the water will add to the dry mixture of cement mortar. The was then mixed to ensure full mixing of the constituents. The calculation of proportions for each type of material is calculated. After that the cement paste is placed in the mould for preparing of blocks. Then the cubes were removed from the mould and the cubes are cured for 7 and 28 days of curing is done. The performance of translucent concrete is compared with the control concrete in terms of compressive strength and light transmitting.

Figure 1: Cube Under Compression Testing Machine

Table 1: Mix proportions

S.No	MATERIAL	Mix Proportion
1	Cement	76%
2	Fine Aggregate	20%
3	POF	4%

4. RESULTS AND DISCUSSIONS

4.1 COMPRESSIVE STRENGTH TEST: The test conducted on the concrete mould is placed under the compression testing machine for the strength properties of the concrete mould. The concrete mould was tested for compressive strength at the age of 7^{th} and 28^{th} days. As per the observation of the test conducted on the mould the strength characteristics has changed as compared to the normal concrete.

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Table 2: Compressive strength values

S.No	% Replacement of POF	Compressive Strength (MPa)	
		7 Days	28 Days
1	0	18.81	20.5
2	2	20.30	26.25
3	4	25.42	28.23

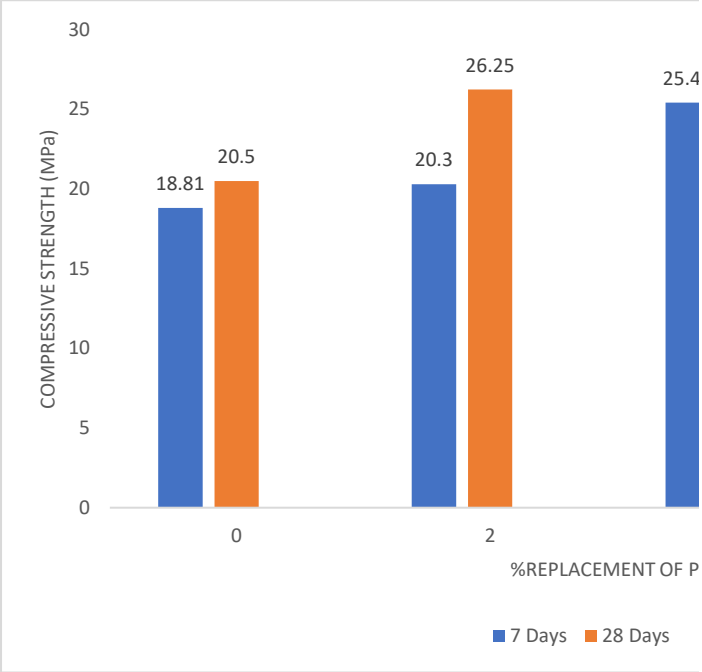

Figure 2: Compressive Strength Vs Replacement of POF

International Journal of Engineering Research & Technology (IJERT)
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4.2 SPLIT TENSILE STRENGTH: The split tensile strength obtained by testing the specimen for M20grade of concrete to all the mixes designed for various replacement given below.

Figure 3: Cylinder Under Split Tensile Testing Machine

Table 3: Split tensile strength values with 0.5cm spacing

S.No	% Replacement of POF	Split Tensile Strength (MPa)	
		7 Days	28 Days
1	0	1.9	2.2
2	2	2.1	2.5
3	4	2.5	3.1

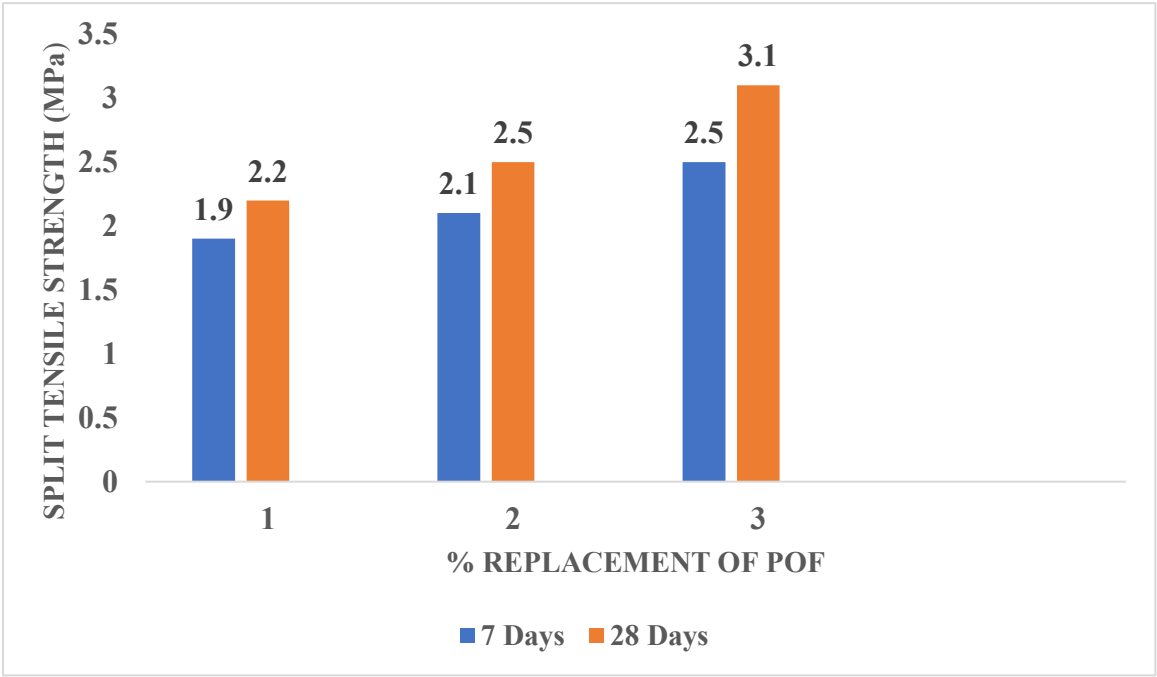

Figure 4: Split tensile strength vs % Replacement of POF

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5. CONCLUSSIONS

- The transparent concrete with inserted optical fiber gives the aesthetic appearance of the designed shapes.
- It is nowhere weak as compared to the normal concrete on the basis of the characteristic strength properties.
- This is a new type of concrete that looks awesome in architectural design.
- This new type of concrete embodies the concept of "green building" with self-sensing properties.
- Translucent concrete is a sustainable material that contributes to energy conservation, aesthetic appeal, and eco-friendliness.
- Translucent concrete is set to become a more prevalent feature in modern urban landscapes due to advancements in technology and reduced costs.

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