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

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 06, June-2023

# "A Case Study on Translucent Concrete As A Carbon-Neutral Material"

**Suhas. R[1], Archana. D. P[2]**
[1] UG Student, Dept. of Civil Engineering, Bangalore Institute of Technology, Bengaluru
[2]Asst. Professor, Dept. of Civil Engineering, Bangalore Institute of Technology, Bengaluru
*Corresponding author

**ABSTRACT -** This experimental study aims to investigate the potential of translucent concrete as a sustainable and carbon-neutral building material. The study entails performing tests to examine the physical, mechanical, and optical features of light-transmitting concrete and analyzing its environmental effect.
This work focuses on the use of alternate cement-based substances, such as fly ash and slag, in the manufacturing of transparent concrete to minimize the carbon footprint of construction industry. Additionally, the study studies the energy efficiency advantages of translucent concrete in lowering the demand for artificial lighting throughout the day by assessing its effects on the environment, conducting tests to ascertain its compressive strength, light transmission, and flexural strength, and examining the material's effects on the practical and aesthetic aspects of buildings.
The experimental study seeks to give findings and perspectives on the performance of transparent concrete as a carbon-neutral material that may guide the evolution of environmentally conscious construction techniques and contribute to minimizing the environmental effect of the construction.

**KEYWORDS**
*Translucent concrete, Plastic optical fibers, Carbon-neutral material, Light transmitting-concrete*

## I. INTRODUCTION

Translucent concrete, often known as light-transmitting concrete, is an emerging construction material that enables light to be transmitted through it. It was initially created in 2001 by Hungarian architect Aron Losonczi, who designated his innovation "LitraCon." The primary premise of translucent concrete is to insert optical fibers in conventional concrete, enabling light to penetrate through the substance. The fibers are commonly composed of glass or plastic and are organized in a manner to maximize the quantity of light that can travel through the concrete. The result is a material that seems solid when seen from the outside, but which can transmit light from the inside. Translucent concrete presents a multitude of potential applications in design and construction. For example, it may be used to create facades that enable natural light to penetrate deeper into buildings, decreasing the need for artificial lighting. It may also be utilized in interior walls and barriers to provide a sensation of transparency and openness while yet offering seclusion.
Translucent concrete has garnered considerable attention from architects and designers and is being utilized in several prominent projects throughout the globe. For example, it has been utilized to construct the facade of a mall in Beirut, Lebanon, and for the construction of a bridge in Valencia, Spain.
While the material is still relatively new and expensive compared to traditional concrete, it has the potential to revolutionize the way buildings are designed and constructed. Translucent concrete may offer a sustainable alternative to electric illumination since it can eliminate the demand for artificial lighting and reduce energy use.

## II. LITERATURE REVIEW

**Poornima D et al. (2019)** The compressive strength of LITRACON improved by 17.13% and 22.76%, respectively, when 10% and 15% of the cement was replaced with silica fume and there was a rise in split tensile strength of 13.61% and 8.26%, respectively, when compared with the conventional concrete. It is considered as a developing trend in concrete technology since it reduces energy consumption for lighting purposes.

**Bharti Sharma and Amarnath Gupta (2018)** In this work, the development of an entirely new kind of concrete called translucent or light-transmitting concrete is investigated. It highlights the advantages and disadvantages of translucent concrete compared to regular concrete and provides instances of its use in construction. It implies that transparent concrete is a great architectural material that might improve the aesthetics and energy efficiency of buildings.

**Awetehagn Tuaum et al. (2018)** This study explains the performance of translucent concrete in transmitting light relies on the volume percentage, spacing, and quantity of optical fibers. According to experimental findings, transparent concrete made with plastic optical fibers and a 6% volume ratio performs up to 22% of light transmittance, making it ideal for pre-cast facades or panels.

**Omkar Kadam (2017)** In this experimental study the author developed translucent concrete by utilizing plastic optical fiber and fiber Bragg grating, to enhance its mechanical capabilities, self-sensing capabilities, and light transmission. With optical fiber specimens and glass rod specimens, it was discovered to have a compressive strength of 20–23 $N/mm^2$ and 24-26 $N/mm^2$, respectively. The compressive strength decreased as the plastic optical fibers increases. Epoxy resin was utilized to seal the border between plastic optic fibers and concrete in order to increase the anti-permeability of the concrete.

**Nikhil K et al. (2016)** In this work, testing on transparent concrete revealed that its compressive strength was almost identical to that of conventional concrete, but that it would decline as the proportion of plastic optical fiber rose. The light transmittance test reveal that it increases with closer spacing between optical fibers, and vice-versa and the flexural test done on the translucent concrete revealed a marginally greater flexural value than conventional concrete.

**Mohan Kumar. S et al. (2017)** In this study, the authors conducted tests on translucent concrete by employing acrylic glass fibers rather than more expensive plastic optical fibers. The findings revealed that this method improved light transmittance properties while also increasing the concrete's compressive strength and hence lowering the cost of producing translucent concrete.

## **III.** OBJECTIVES

1. To compare translucent concrete with conventional concrete to determine how effective it is as a carbon-neutral material and to assess its environmental impact.
2. Performing tests on the compressive strength, flexural strength, and light transmission on translucent concrete.
3. To research how the aesthetics and practical features of structures made with light-transmitting concrete are impacted by the material's optical characteristics, notably its light transmission,
4. To determine the difficulties and restrictions associated with utilizing translucent concrete.
5. To incorporate participants from the academic community, the general public, and the construction industry in the research process and successfully disseminate the findings in order to increase support for sustainable building practices.
6. To encourage the use of this building material which acts as a carbon-neutral materials and cutting-edge design strategies, which contributes to the creation of a built environment that is more sustainable and resilient.

## IV. WORKING PRINCIPLE

By incorporating optical fibers into the concrete mixture, translucent concrete, sometimes referred to as light-transmitting concrete, functions. It is based on "Nano-Optics," in which light is carried throughout by fibers acting as slits. From one face to another, thousands of optical fibers are reinforced and transfer light. These optical fibers generally consist of a core encased in cladding and are composed of plastic. Total internal reflection is a phenomenon where light travels through a fiber by reflecting off the border between the core and cladding because the core is constructed of a material having a higher refractive index than the cladding.

## V. UTILISED MATERIALS

**1. Cement**
Lime and clay are combined to create cement, which may then be combined with water to create mortar or with sand, gravel, and water to create concrete. Ordinary Portland cement of grade 53 has been employed in the current investigation.

**2. M-sand or Fine Aggregate**

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 06, June-2023

Fine aggregate (M-sand) passing through a 2.36mm screen was employed in the current investigation.

**3. Water**

Concrete's various ingredients are mixed with water. Portable water was utilized to produce translucent concrete.

**4. Plastic optical fiber**

A flexible, transparent fiber known as an optical fiber is created by pulling glass (silica) or plastic to a diameter only a hair's width thicker. The most popular kind of fiber used to carry light between its two ends is optical fiber. Depending on the necessity, the optical fiber's thickness should range from 2 microns to 5 mm. By volume, optical fiber is added to concrete mixtures at a rate of 4% or 5% to generate concrete. Plastic optical fiber of 200µ diameter strands is utilized.

In some situations, cement can be partly replaced by fly ash, silica fumes, or industrial waste, such as blast furnace slag, as a binder ingredient and plastic optical fibers can be replaced by acrylic glass fibers to lower the manufacturing cost of the blocks.

## VI. METHODOLOGY

**1. Mold preparation**

The first stage in the production of light-transmitting concrete is the preparation of the mold. The mold prototype may be manufactured from a variety of materials, including ply wood or cast iron. In this case, plywood with conventional dimensions of 6 inches* 6 inches* 6 inches was utilized to create the mold. On the two opposing sides of the molds with the necessary spacing, markings are formed and holes of the desired diameter are drilled.

**2. Material selection**

The primary core component of concrete namely fine aggregate and cement is used except for coarse aggregate. Plastic optic fibers are additionally used for their ability to transmit light.

**3. Fixing optical fiber**

It involves cutting it into pieces that are roughly the correct length and allowing some of it to stick out of the mold. The holes in the molds are then filled with these optical fibers.
In this case the fibers were fixed at half an inch spacing between each other.

**4. Concreting**

A concrete mix is created from 53-grade cement, M-sand, and potable water. Molds are completely cleaned and oiled to provide a smooth finishing surface. The resulting mixture is poured into the molds and subjected to vibrational compaction. The mix ratio of concrete was 1:1.5

**5. Demolding**

Concrete specimens are demolded 24 hours after casting.

**6. Curing**

After the mixture has been poured into the molds, it is cured between 7 and 28 days by being completely submerged in water.

**7. Finishing**

It involves trimming off any extra material, cleaning, polishing, and cutting the piece to the correct size and form.

## VII. ADVANTAGES

**Aesthetic appeal:** Translucent concrete allows light to pass through, producing a visually spectacular appearance that may improve any building or structure's aesthetic appeal.
**Energy Efficiency:** By allowing natural light to penetrate and brighten interior areas, translucent concrete may be utilized to make structures that use less energy. This reduces the need for lighting that is artificial and the accompanying energy expenses.
**Durability:** Translucent concrete is long-lasting and low maintenance, making it a wise long-term investment.
**Thermal Performance:** By lowering the amount of heat that enters a building and resulting in less demand for air conditioning, transparent concrete may increase thermal performance.
**Sustainable material:** Translucent concrete may be produced using sustainable materials, such as recycled glass, and industrial waste such as blast furnace slag to lessen the manufacturing process's negative effects on the environment.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 06, June-2023

## VIII. DISADVANTAGES

**Cost:** Because it costs more to embed optic fibers or other elements to achieve the necessary translucency, translucent concrete may be more costly than conventional concrete.
**Limited Availability:** Because translucent concrete is still uncommon, it might be challenging to find and use in building projects.
**Production Difficulties:** Producing transparent concrete may be difficult since it needs specialized tools and skills to get the necessary results.
**Limited application:** Translucent concrete may only have a few uses because of its distinctive aesthetics, which may not match all building designs or architectural styles.

## IX. COMPARISIONS BETWEEN CONVENTIONAL AND TRANSLUCENT CONCRETE BLOCKS

**Light transmission:** Unlike regular concrete blocks, translucent concrete blocks permit light to travel through them.
**Strength:** Both kinds of blocks are equally strong, albeit transparent concrete blocks could be a little less so since they contain more light-transmitting components.
**Insulation:** Compared to translucent concrete blocks, which might permit more heat to pass through, conventional concrete blocks provide higher insulation.
**Aesthetics:** While traditional concrete blocks are primarily employed for their structural qualities, translucent concrete blocks may be utilized for landscaping purposes since they can produce interesting lighting effects.

**Cost:** Because translucent concrete blocks need specialized materials and production techniques, their price may be higher than that of regular concrete blocks.
**Durability:** Both kinds of blocks are strong and long-lasting, however transparent concrete blocks can need more upkeep to maintain their special qualities.

## X. APPLICATIONS

**Pavements:** Translucent concrete blocks may be utilized as flooring as a passable surface when lit from underneath. It seems like standard concrete pavement during the day, but by dusk, the blocks start to glow and take on changing colors.
**Walls:** Both internal and exterior walls may be built using transparent concrete. The light-transmitting concrete may also be utilized as a wall covering that is lighted from behind, in addition to the typical uses for a wall. Additionally, transparent concrete may sometimes be used to create inventive roof designs.
**Furniture:** Reception desks made of translucent concrete blocks look attractive when put in an office.
**Highways:** Highway Lane markings may be made of translucent concrete blocks, which illuminate the road by reflecting light from passing cars.
**Staircase:** As they provide an attractive perspective, translucent concrete blocks may be utilized to create staircases in both residential and commercial structures.
**Panels:** Where there is limited access to natural and artificial light, translucent concrete blocks may be utilized as panels and partition walls in homes and offices.
**Landscape design:** To provide a distinctive and eye-catching look, translucent concrete blocks may be utilized in landscaping projects like retaining walls and garden features.
**Public art:** Translucent concrete blocks may be utilized in public artworks to give the urban environment an ethereal quality and a sense of surprise.

## XI. MATERIAL SPECIFICATION

**Table I: Material specification**

| MATERIALS AND SPECIFICATIONS | |
|---|---|
| Cement | 53 Grade |
| Sand | M-sand (2.36mm sieve passing) |
| Plastic optical fibers | 200µ diameter strands |

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 06, June-2023

| | |
|---|---|
| Water | Potable water |
| Mix ratio of concrete | 1:1.5 |
| Spacing b/w fibers | Half an inch |

## XII. TESTS CONDUCTED

### A. COMPRESSION TEST

The compression test includes applying a compressive force on a sample of the transparent concrete block until it fails. The concept behind this test is to evaluate the ability of the material to sustain pressure and calculate its load-bearing capacity. This test is significant for measuring the structural strength of the material and its capacity to sustain large loads.

### B. LIGHT TRANSMITTANCE TEST

The light transmittance test includes measuring the quantity of light that flows through a specimen of transparent concrete. The concept behind this test is to measure the degree of translucency of the material and its capacity to transmit light. This test is significant for assessing the material's aesthetic attributes and its potential for usage in architectural projects where natural light is sought.
The formula to calculate the light transmittance of translucent concrete:

Light Transmittance (%) = $\frac{T}{To} * 100$

Where:
T is the amount of light transmitted through the sample (in lumens)
$T_o$ is the amount of incident light (in lumens)
To measure T and $T_o$, photometer is used. The sample is placed between the light source and the sensor, and the readings are taken. The light source should be a standardized light source with a known luminous intensity, such as a halogen lamp.

### C. FLEXURAL STRENGTH TEST

The flexural strength test includes applying bending stress to a sample of transparent concrete until it cracks. The concept behind this test is to evaluate the capacity of the material to resist bending and calculate its flexural strength. This test is useful for assessing the material's performance under circumstances of stress and establishing its acceptability for usage in constructions that are exposed to bending loads.

## XIII. RESULTS

### A. COMPRESSIVE STRENGTH TEST RESULTS

**Table II: Compressive strength comparison of normal concrete block and translucent block at 7 days and 28 days of curing with plastic optical fiber spacing of half an inch.**

| Type of concrete block | COMPRESSIVE STRENGTH (N/mm$^2$) | |
|---|---|---|
| | 7 days | 28 days |
| Regular concrete block | 20.57 | 28.23 |
| Translucent concrete block | 19.97 | 28.88 |

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 06, June-2023

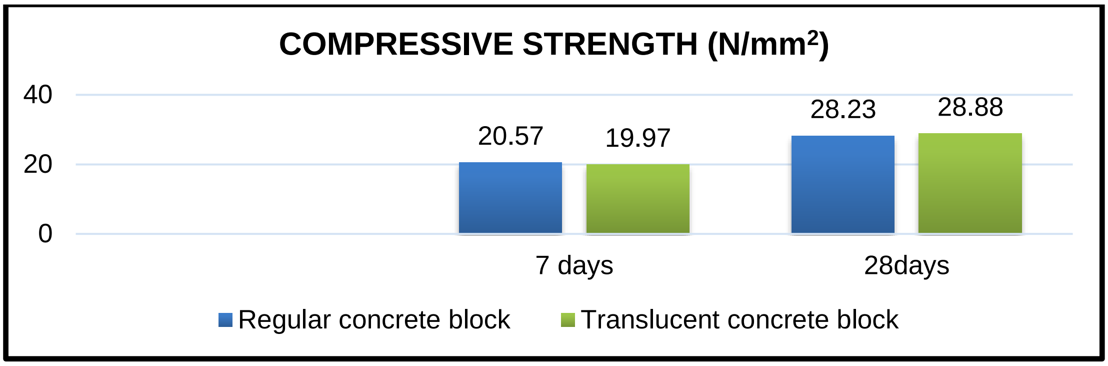


**Figure 3: Strength comparison of normal concrete with translucent concrete with 7 days and 28 days of curing**

## B. LIGHT TRANSMISSION TEST RESULTS

**Table III: Light transmission test results of translucent concrete with plastic optical fiber spacing of half an inch.**

| Description | Photometer readings (lumens) |
|---|---|
| The amount of incident light | 15 |
| The amount of light transmitted through the sample | 1.23 |
| Light transmittance (%) | 8.2 |

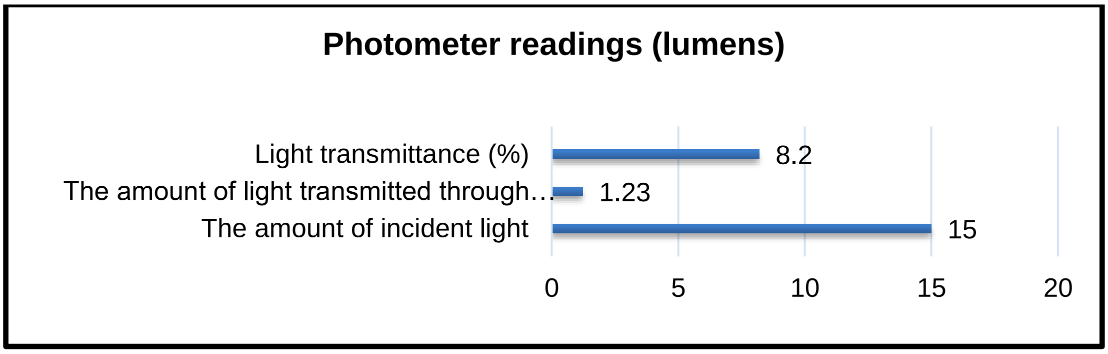


**Figure 4: Light transmission result of translucent concrete.**

## C. FLEXURAL STRENGTH TEST

**Table IV: Flexural strength test result of translucent concrete at 7 days and 28 days of curing with plastic optical fiber spacing of half an inch.**

| Type of concrete block | FLEXURAL STRENGTH (mpa) | |
|---|---|---|
| | 7 days | 28 days |
| Normal concrete | 2.67 | 2.96 |
| Translucent concrete | 4.12 | 4.53 |

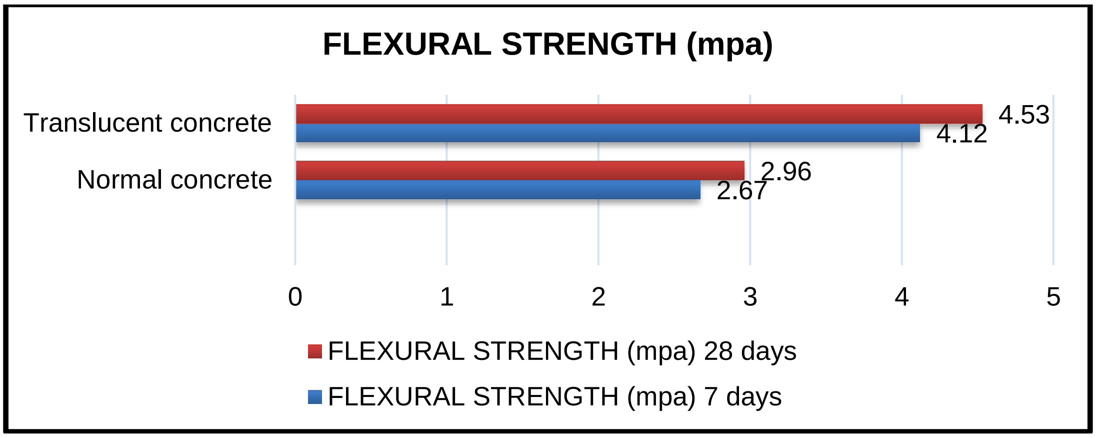


**Figure 5: Flexural strength comparison of normal concrete with translucent concrete**

## CONCLUSION

A relatively new substance called translucent concrete combines the qualities of regular concrete with the ability to transmit light. Translucent concrete has the potential to help reduce the carbon emissions related to construction even if there is no tangible evidence to support this claim.

Translucent concrete's capacity to let natural light into structures is one way it might aid in lowering carbon emissions. The amount of energy required to run artificial lights, which may be a substantial source of carbon emissions, may be reduced as a result. By enabling natural light to enter the interior areas and minimizing the demand for air conditioning, transparent concrete may also aid in lowering the energy required to cool buildings.

The use of low-carbon, sustainable resources in the manufacture of transparent concrete is another way it may help the environment. Utilizing cement substitutes like fly ash or slag or recycled aggregates, for instance, can help cut down the carbon footprint related to the manufacturing process of concrete and this translucent concrete may serve as a sustainable building material.

We conclude by stating that while translucent concrete is not carbon-neutral by nature, it may be able to help achieve carbon neutrality with low-carbon and sustainable materials, the reduction of artificial lighting and cooling requirements, and the use of clean energy sources in its manufacturing.

## REFERENCES

[1] Poornima, D., Shailaja, T., Pooja, H. P., Santosh, G., Sachidananda, B., & Rashmi, M. P. (2019). An experimental study on light transmitting concrete. *International Research Journal of Engineering and Technology (IRJET)*.

[2] Sharma, B., & Gupta, A. (2018). An overview on transparent concrete. *Int. Res. J. Eng. Technol.(IRJET)*, *5*(7), 2040-2045.

[3] Shitote, S., Tuaum, A., & Oyawa, W. O. (2018). Experimental evaluation on light transmittance performance of translucent concrete.

[4] Kadam, O. (2017). Translucent Concrete. *IOSR J. Mech. Civ. Eng. e-ISSN*, *14*(3), 18-31.

[5] Nikhil, K., Farook, U., Ahmed, S., Juraige, M. K., Saleem, R., & Omar, S. (2016). Experimental analysis of translucent concrete by using optical fibers. *SSRG International Journal of Civil Engineering (SSRG-IJCE)*, *3*(3), 76-81.

[6] Sasidharan, J., & Teja, N. S. A., Sakthivel, K., Manickavel, D.(2017). Translucent concrete. *International Journal of Engineering Research & Technology*, *6*(4).

[7] Elghezanwy, D., & Eltarabily, S. (2020). A review of translucent concrete as a new innovative material in architecture. *Civil Engineering and Architecture*, *8*(4), 571-579.

[8] Altlomate, A., Alatshan, F., Mashiri, F., & Jadan, M. (2016). Experimental study of light-transmitting concrete. *International Journal of Sustainable Building Technology and Urban Development*, *7*(3-4), 133-139.

[9] Tahwia, A. M., Abdelaziz, N., Samy, M., & Amin, M. (2022). Mechanical and light transmittance properties of high-performance translucent concrete. *Case Studies in Construction Materials*, *17*, e01260.

[10] Huong, O. W., & Kassim, U. (2019). Translucent Concrete by Plastics Fibre Optics as A Sustainable Material That Benefit to Residential Building. *J. Adv. Res. Eng. Knowl*, *6*, 1-6.

**BIODATA**

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 06, June-2023

| | |
|---|---|
| **SUHAS. R**<br>UG Student of 8th semester<br>Civil Engineering Department<br>Bangalore Institute of Technology |  |
| **ARCHANA. D. P**<br>Assistant Professor<br>Civil Engineering Department<br>Bangalore Institute of Technology |  |