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Experimental Study on Light Transparency of Concrete by Using Optical Fiber

N. Ravikumar[1], S. Dharsika[2]
[1]Assistant Professor, Department of Civil Engineering, VRS College of Engineering and Technology, Villupuram
[2]M.E Structural Engineering, Department of Civil Engineering, Gnanamani Engineering College, Namakkal

***Abstract*—** *Now a day's Concrete is used in large quantities almost everywhere mankind has a need for infrastructure. Light transmitting concrete is a concrete based building material with light-Trans missive properties due to embedded light optical elements usually Optical fibers. It is Green Energy saving material by using sunlight as a light source to reduce the power consumption of illumination. In this paper, usage of optical fiber and it is strength along with its transparent is studied. Materials used for this concrete is cement, sand, optical fiber, water. Different tests were carried out on the concrete specimens like compressive strength test and light transmission test. This type smart concrete can be considered as green energy saving material & it is a promising technology for field applications in civil infrastructure.*

***Keywords*—** *Energy Saving, Optical Fiber, light transmitting concrete, Decorative materials.*

I. INTRODUCTION

Litracon is a concrete based building material with light-Trans missive properties due to embedded light optical elements. With the help of optical fibers Light is conducted through one end to the other end. Fiber-optic lighting has a wide variety of uses, from art to medicine. In a healthcare context, optical cables can be used to guide light onto an area where there is not a clear line of sight, such as in certain surgeries where it is desirable to make as small an incision as possible.

II. PRINCIPLE

Optical fibers generally work as a hollow cylindrical waveguide which transmits light along its axis, by the principle of total internal reflection. It is made up of transparent dielectrics (Sio2). In an Optical fiber central core surrounded by a cladding which is slightly lower refractive index than the core. Parts of Optical Fibers

- Core – It is thin glass center of the fiber in which the light travels.
- Cladding – It is the outer optical material surrounding the core which reflects the light back into the core. To lock up the reflection in the core, the refractive index of the core must be more than that of the cladding.
- Coating – It is the plastic coating which protects the fibers from damage and moisture.

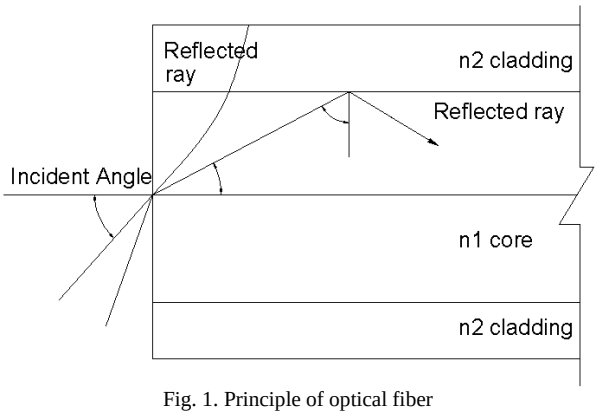

Fig. 1. Principle of optical fiber

III. MANUFACTURING PROCESS

Materials used for light transmitting concrete is cement, sand, optical fiber, water and its specifications are

TABLE I. Materials specification

S.No	Material	Specification
1	Cement	43 Grade
2	Sand	2.36 mm Sieve Passing
3	Optical Fibers	1 mm
4	Cement : Sand	1:1.5
5	W/C Ratio	0.45

The method for production of transparent concrete is almost same as regular concrete. Only optical fibers are spread throughout the aggregate and cement mix.

The first concrete mix is prepared separately in this paper 1:1.5 ratio mortar used then the fiber is inserted into the mould Small layers of the concrete are poured on top of each other and infused with the fibers.

Thousands of optical fibers are cast into concrete to transmit light, either natural or artificial. The light transmitting concrete is produced by adding 2% to 4% optical fibers by volume into the concrete mixture.

The concrete mixture is made from fine materials only it does not contain a coarse aggregate. The thickness of the optical fibers can be varied between 2µ and 2mm to suit the particular requirements of light transmission.

In this paper, we are decided to compare the result to the brick. A brick is a block made of clay burnt in a kiln. It is one of the primary building materials known to mankind. They are still being used as filler materials for framework structures as well as to construct load-bearing structures. Brick are produced in numerous classes, types, materials, and sizes which vary with region and time period, and are produced in bulk quantities. Two most basic categories of brick are fired and non-fired brick.

IV. FABRICATION OF LITRACON

The samples containing optical fibers fabricated are of size 100x100x100 mm cuboids (figure 2 indicates the mould with

optical fiber). The mould is made up of two plywood side 100x100 mm facing each other and the other two sides are Printed Circuit Boards (PCB) 100x100 mm. They are perforated boards and the sides are rested on a plywood base. The optical fiber strands, batched by volume (or fiber to cement ratio), are placed through the holes individually. The cement paste is then prepared in 1.0: 2.0 proportions and poured into the mould and agitated with the help of mechanical vibrator to avoid void formation.

Fig. 2. Mould with optical fiber

V. TESTS FOR LITRACON

A. *Light transmittance test on specimen: -*

Light measuring equipment and setup: Various light measuring equipments are available such as Lux meter, however, a simple Lux meter can be made in a laboratory using simple components. The light transmittance through the sample can be measured by measuring the current corresponding to the light which can be measured by a photo diode or a Light Dependent Resistors (LDR). The use of photodiode would require a separate sensor which would increase the cost of the project. The most choice would be LDR. The LDR connected to the Breadboard as shown in the figure 3. The experimental set up is as shown in the figure 5.

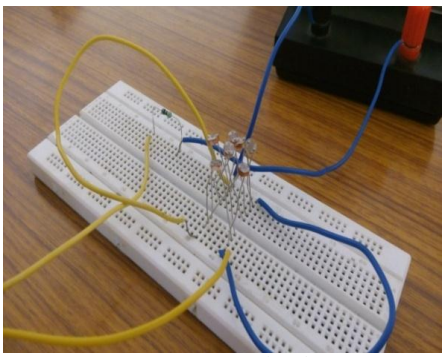

Fig. 3. LDR's connected to the breadboard

As shown in the figure 4 the LDR measures the light transmitted through the sample and converts it into the current, which in this case is measured in milliamperes (mA). Two readings are taken, one without sample (A1) and one with the sample (A2). The source of light here is taken as 100 w incandescent bulbs, a resistance of 100 Ω is applied in the circuit and a uniform DC voltage of 2.5 V is kept between the circuits. To ensure no light escapes throughout the test, a box made up of plywood (as shown in the figure 6) is made. The light source is fixed at the top of the box and LDR is placed at the bottom. The sample is placed between source and LDR and test is carried out. The circuit arrangement of the experiment is shown in the figure 3.

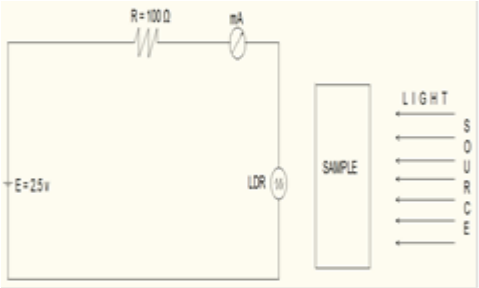

Fig. 4. Circuit diagram

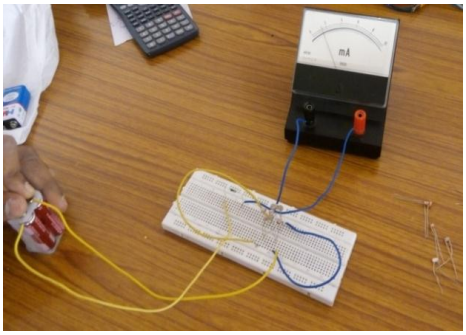

Fig. 5. Circuit setup

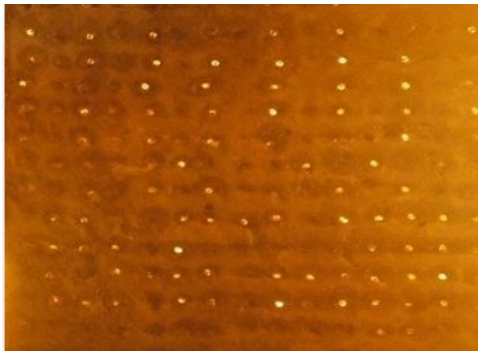

Fig. 6. Test sample

The amount of light transmitted is calculated as follows-

Light transmittance = $100 - \frac{A1-A2}{A1} X100$

Table 2 shows the light transmitted through the samples

TABLE 2. Light Transmission in %

% of fiber		1	2	3	4
Ammeter reading (mA)	Without sample (A1)	9.2	9.2	9.2	9.2
	With sample (A2)	0.4	0.75	0.95	1.2
Light transmittance (%)		3.3	7.6	10.4	13.1

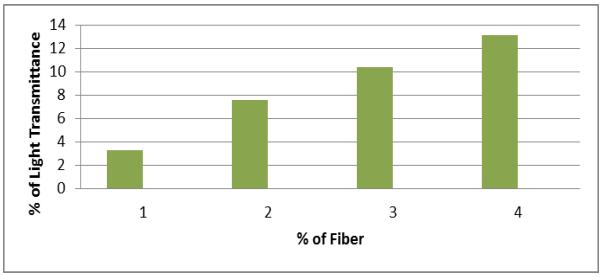

Fig. 7.

B. *Compressive Strength Test For Light Transmitting Concrete*

Compressive Strength Testing Machine: The compressive strength of samples was then determined after measuring the light transmitted by using compressive testing machines the capacity of UTM is 1000KN and test results were obtained as given in Table. Experimental setup as shown in figure 8.

Fig. 8. Test Setup

Test Results

As it can be seen from Table the compressive strength of Light Transmitting Concrete was found to be ranging between 20 – 23 N/mm2 with optical fiber specimen, which indicates that the concrete satisfies the compressive strength requirement for M20 grade concrete.

TABLE 3. Compressive strength of light transmitting concrete

% of fiber	1	2	3	4
Compressive strength (N/mm2)	22.5	22	21.8	21

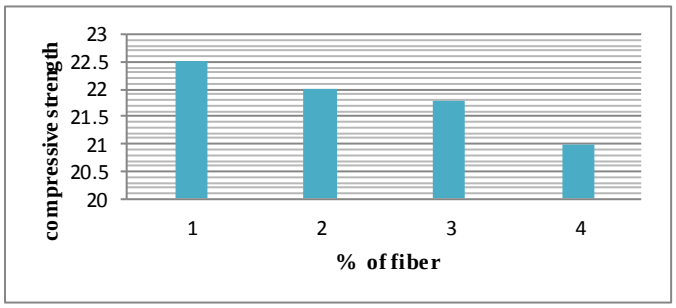

Fig. 9.

Fig. 10. During Testing

Fig. 11. After test

VI. Compressive Strength Test for Brick

The compressive strength of samples was by using UTM the capacity of UTM is 1000KN and test results were obtained as given in the table. Experimental setup as shown in the figure 12.

TABLE 4. Compressive strength for bricks

Specimen	Brick
	Compressive strength N/mm2
1	13.5
2	14
3	14
4	14

Fig. 12. Test Setup

Fig. 13. After test

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VII. Discussion About the Result

A. Combined Discussion on Compressive Strength and Reflection of Light

The table 5, shows the compressive strength of concrete block reduces with the increase the percentage of fibers (i.e. the percentage of surface area of concrete block) used in the concrete block. Combined results are given in table 5.

TABLE 5. Combined result of compressive strength and light transmittance of samples

% of fiber	1	2	3	4
Compressive strength (N / mm2)	22.5	22	21.8	21
Light transmittance (%)	3.3	7.6	10.4	13.1

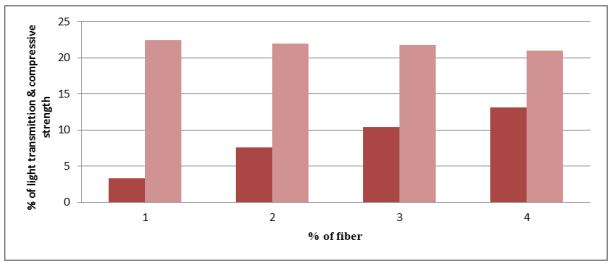

Fig. 14.

With reference to Figure 14, it gives the comparison between the light transmission test and compressive strength test. As per observed points further project work was carried out on 3% and 4% of fibers.(i.e. the percentage of surface area of concrete block) because for 4% fiber the compressive strength is slightly reduced than target strength and for 3% it is slightly higher than target strength.

B. Comparison between Compressive Strength of Light Transmitting Concrete and Brick

From the table, the compressive strength of light transmitting concrete is higher than the Brick. If we increase the percentage of fiber the strength will be reduced.

TABLE 6. Combined results of brick and light transmitting concrete

Specimen	Compressive strength N/mm2	
	Brick	Light Transmitting Concrete
1	13.5	22.5
2	14	22
3	14	21.8
4	14	21

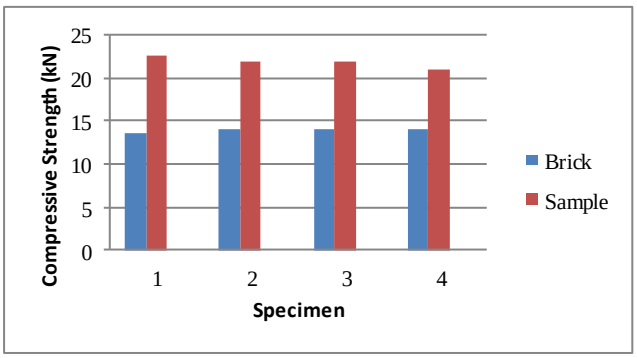

Fig. 15.

C. Comparison of Cost Between Light Transmitting Concrete Panel and Brick Wall

In this paper, we decide to compare the cost between the normal brick wall and light transmitting concrete panel, the panel size is 3m x 3m x 0.025m the manufacturing cost of this panel is Rs.2590 without installation cost.

The wall size is 3m x 3m x 0.1125m the construction cost of this size wall is Rs.5762.

From the above calculation the replacement of 0.1125m wall to 0.025m panel the cost is less. So, this material is economical and in future, this is most helpful for our environment.

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