

# Experimental Investigation on Light Transmission and Structural Performance of Translucent Concrete Using 3mm Diameter Plastic Optical Fibers

Nawaz Shakeel, Shalika Mehta, Khushpreet Singh

**Abstract:** Concrete is a bonding material and in present phase is used in the construction field. It normally consists of mix proportion of cement, sand and aggregates i.e, (fine or coarse). Traditional concrete being a solid construction material is being getting renovated. Now engineers have come up with new concrete mixtures that allows light to pass by using optical fibers. Optical fibers having property of light transmission are used in concrete to make concrete transparent also known as translucent concrete. Fibers are placed horizontally that causes light transmission in two opposite sides of the same block. Related to this paper we have used P.O.F of diameter 3.0 mm, using 2 different, number of fiber strands (36 & 49). The main function of this project is that we develop transparent blocks of concrete with use of P.O.F'S and to get maximum use of sunlight so that to reduce the power consumption for green and smart building construction. The tests which were carried out are compression strength, rebound hammer, light transmission, workability test.

**Index Terms:** . Architectural, Concrete, Energy saving, Light Transmission Test (LTC), Lux Meter, Plastic Optical Fiber (POF), Workability.

## I. INTRODUCTION

### 1.1 General

In every field we made some advancement in technology like we did in construction field. We require materials that fulfill the required need of building occupants. So as a result concrete has been renovated from its basic elements cement, sand, aggregates by adding optical fiber that is known as translucent concrete also known as transparent concrete. Today the whole world is dealing with energy crisis and expenses and have a lot of environmental issues growing to a very high level. Optical fiber having property of light transmission from both parallel sides in order to minimize the consumption of power inside the building to a large scale. The shape of the optical fiber is cylindrical dielectric wave length using phenomena of total internal reflection passing through its own axis. When we are dealing with the external structure that are in contact with the external environmental effects like rain, snow, wind there could happen serious damage or casualties. So we have to keep all these things in one's mind when we develop structures. To minimize these issues we

have different material known as pellucid or transparent concrete which can transmit different feature in concrete and has energy saving as well as economical in use. It is one of the latest, most applicable and comprehensive element in green buildings.

Main aim of casting translucent concrete blocks is to analyze the quantity of light that is transmitted and to check the compressive strength by putting different number of fiber strands.

### 1.2 Consumption of Power

Only 30% of electricity is being used in domestic plan in buildings for illumination target. So, necessity of using natural sunlight for lightning up the interiors is required. For daily purposes detailed utilization of energy is shown in fig 1.

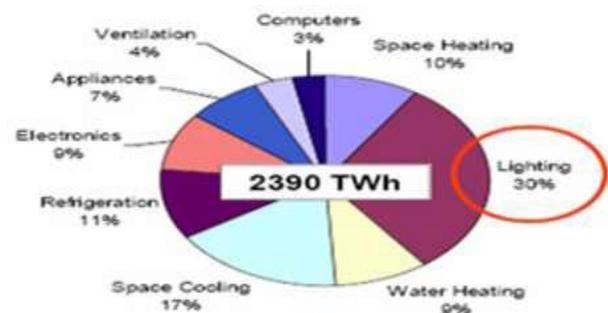


Fig. 1: Consumption of Power

### 1.3 Plastic Optical Fiber

Light transmission capability in optical fiber is great. Depending upon the wavelengths, these fibers having property of transparency for accessing them systematically transmission of light in it. Core of the fiber is protected by cladding fall of index. They are both made up of same materials i.e., glass and plastic. When it to making of optical fiber major differences of two materials. Fiber with plastic core are more pliable and economical as compared to glass fibers. Installation of these fibers are easy and can resist considerable stresses and weigh 50% less than glass fiber. Therefore, for effectively light transmission over long distances these fibers are widely used.

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Nawaz Shakeel, PG Student in Civil Engineering Department, Chandigarh University, Mohali Punjab, India

Shalika Mehta, Asst. professor in Civil Engineering Department, Chandigarh University, Mohali Punjab, India

Khushpreet Singh, Asst. professor in Civil Engineering Department, Chandigarh University, Mohali Punjab, India



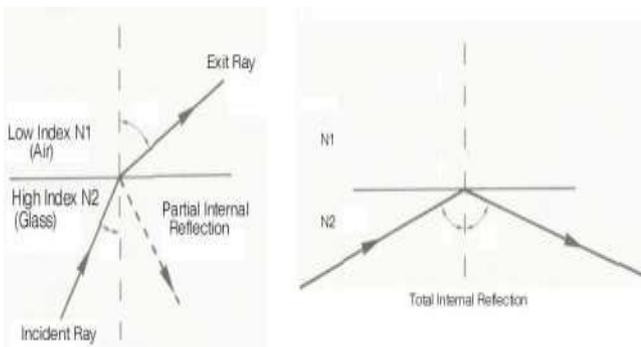
**Fig.2: Optical Fiber**

**II. LIGHT THEORY**

Scattering of light in fiber is guided showing that how effective the wire is for long distances depends upon its capability. So, we can conclude by characteristic property of fibers that it can work on internal reflection totally. We have to count the refractive index of the dielectric medium in terms of propagation of light for optical fiber. A ray of light gets incident on interface in the middle of the two mediums with different refractive index. There occurs refraction between these two mediums described by a law called Snell's law

$$N_1 \sin \theta_1 = N_2 \sin \theta_2$$

This shows at some angles refraction occurs partially and at different angles refraction occurs internally, as shown in figures.



**Fig. 3: Light Ray Diagram**

**III. MATERIALS AND ITS PROPERTIES**

**3.1 Plastic Optical Fiber**

In this study we use plastic optical fiber (p.o.f) having diameter of 3mm. Its properties are given in the Table 1.

S.NO	Particulars	Values
1	Specific gravity	0.64
2	Bandwidth	20 (MHz-km)
3	Transmission distance	Medium
4	Fiber diameter	3mm

Table 1. Properties of plastic optical fiber

**3.2 Cement**

PPC 43- Grade is used in the study, having sp. Gravity 3.15 and fineness modulus 2% lesser than maximum of 7%.

S.NO	Particulars	IS: 456-2000
1	Specific gravity	3.15
2	Initial setting time	30min
3	Final setting time	600min
4	Fineness	300 m <sup>2</sup> /kg

Table 2. Physical Properties of cement

**3.3 Fine Aggregates**

Sand is used as fine aggregate in this study which is coming under Zone-II by analysis of sieve having sp. gravity 2.65 and density found 511.4 kg/m<sup>3</sup>

IS designation	Sieve	% of passing as per IS (zone II)	% of passing obtained
10 mm		100	100
4.75 mm		90-100	95
2.36 mm		75-100	88.2
1.8 mm		55-90	67.1
600 micron		35-59	35.8
300 micron		8-30	11.7
150 micron		0-10	4.1

Table 3. Sieve analysis of sand

**3.4 Coarse Aggregates**

According to IS standards, for 10mm size coarse aggregates sp. gravity should be 2.55 and having impact in strength 14.8%.

S. No.	Particulars	Values obtained	Permissible values
1	Sp. gravity	2.55	2.5-3.0
2	Water absorption	1.71%	0.1-2.0%
3	Impact value	14.8%	≥30%
4	Abrasion value	32.8%	30-45%

Table 4. . Physical properties of coarse aggregates.

**3.5 Water**

The water used for casting of samples should be free from organic substances as it takes part in chemical reaction.

**IV. TESTS AND RESULTS**

**4.1 Compressive Strength**

This strength is performed on a machine called (UTM). As we already know about the concrete having good behavior in compression and low in tension. Samples with fibers are tested with two different numbers i.e., 36&49 fiber strands. It was observed that if we increase the number of fiber strands, compressive strength decreases. In this case strength decreases in 49 number of fiber strands. Results are shown in Table 5.

Specimen	Values in N/mm <sup>2</sup>	
	7 days	28 days
CC	18.04	29.18
OFRC - 36	21.03	29.64
OFRC- 49	17.16	24.75

Table 5. Compressive Strength

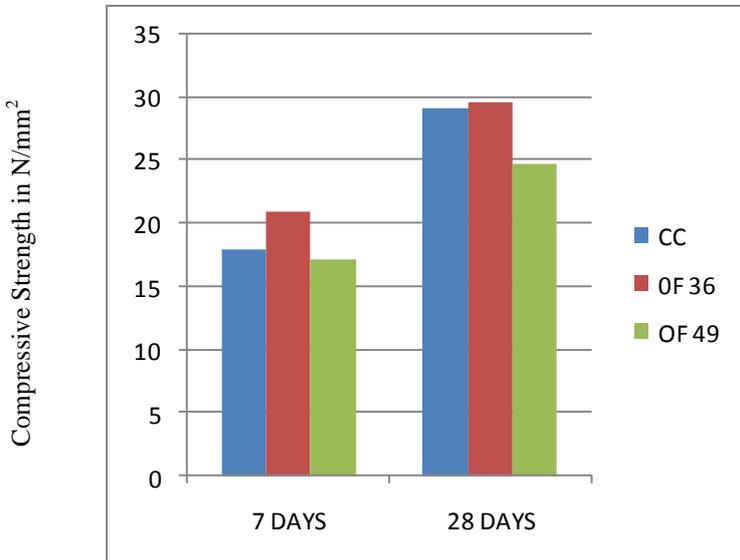


Fig. 4: 7 and 28 days for CC, OFRC 36 & 49

#### 4.2 Rebound Hammer

This test is non-destructive in nature and if performed to check the surface hardness of the concrete specimen in this study was OFRC- 36 is having higher value than CC and OFRC- 49. Results for Rebound Hammer are given in Table 6.

Specimen	Surface Hardness in N/mm <sup>2</sup>	
	7 days	28 days
CC	19.4	30.6
OFRC- 36	25.6	31.0
OFRC- 49	20.03	29.02

Table 6. Rebound Hammer

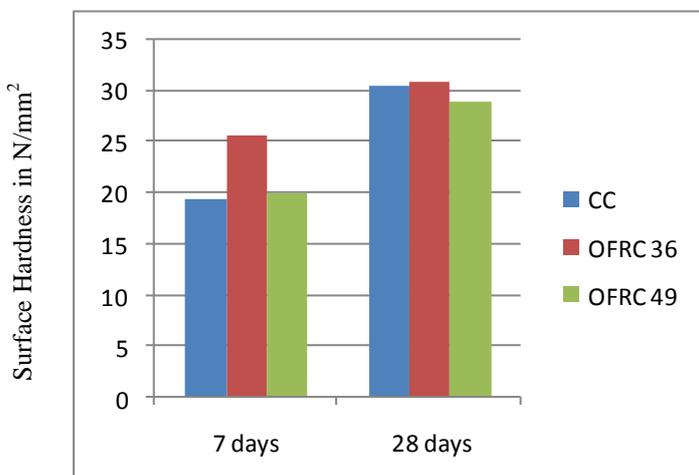


Fig. 5: 7 and 28 days Surface hardness of CC , OFRC -36 & 49

#### 4.3 Light Transmission test

In this study Light Transmission is done with the help of an electronic device called LUX meter.

##### 4.3.1 Light Transmission Through Different Areas Of Block

In OFRC-36&49, transmission of light is being investigated at different surfaces. Results are shown in Table 7&8.

Table 7. Light Transmission through OFRC-36 block

Outdoor light intensity in Lux	indoor light intensity in Lux			
	0.450sqm	0.360sqm	0.270sqm	0.203
950	380	302	220	165

Table 8: Light Transmission through OFRC-49 block

Outdoor light intensity in Lux	indoor light intensity in Lux			
	0.450sqm	0.360sqm	0.270sqm	0.203
970	420	330	245	175

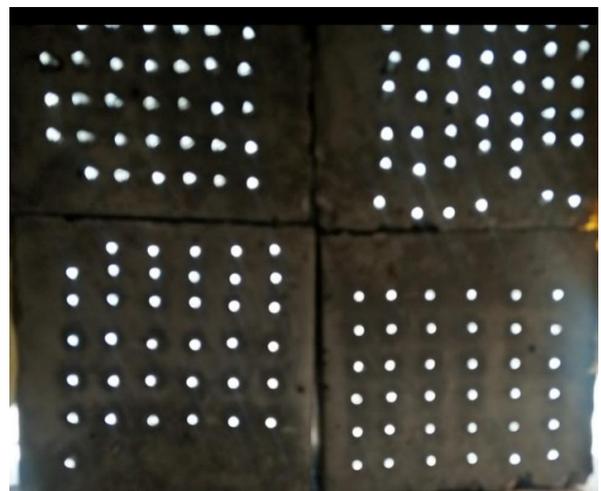


Fig. 6: Light transmission from different samples.

#### V. Analysis of Cost

Table 9. For M25 Grade of Concrete (Normal & OFRC) For 1 Cum

	Cost		Total Cost
	CC	OFRC	
CC	4650	0.00	4650

OFRC- 36	4650	21600	26250			CC	OFRC	Housing Commercial	
OFRC- 49	4650	34300	38950	0.45	20	480	1468.8	864	1382.4
				0.36	16	384	1166.4	864	1382.4
				0.27	12	288	885.6	864	1382.4
				0.20	09	216	648	864	1382.4

Table 10. Cost Comparison

S.NO	NO. of cubes	Vol. in (cum)	Normal Block	ORFC Block
1	20	0.068	480	1468.8
2	16	0.054	384	1166.4
3	12	0.041	288	885.6
4	09	0.030	216	648

**5.1 Consumption Of Power By Artificial Lightning**

When one 60 Watt bulb is used for 30 days and for 8 hrs per day. Power Consumption =  $60 \times 30 \times 8 = 14.4$  Units

Table 11. Schedule of rates/charges for Supply

Average Unit Rates	
Housing	Commercial
Rs 5/=	Rs 8/=

**VI. PAY BACK PERIOD**

**6.1 For 20 Cubes (0.450sqm)**

- with relevance to cost comparison table.  
Cost difference in 20 no. of cubes initially = **Rs 1468.8 – 480 = Rs 988.8/-**
  - Saving of energy in residential room in one year  
 **$14 \times 5 \times 12 = \text{Rs } 864/-$**
  - Period to recover extra amount for OFRC block  
 $988.8/864 = 1.1$  years
  - Saving of energy in commercial room in one year  
 **$14 \times 8 \times 12 = \text{Rs } 1382.4/-$**
  - Period to recover extra amount for OFRC block  
 $1382.4/988.8 = 1.4$  years
- It is confirmed from above cost analysis and payback period which is 1.1 years for OFRC in housing sector. Similarly 1.4 years in commercial sector.

**6.2 Pay Back Period in different Blocks**

Table 12. Cost for different blocks

Area (sqm)	No. of blocks	Cost	Energy Saving
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Table 13. Payback Period for Different Areas

Area (sqm)	No. of Blocks	Payback period	
		Housing	Commercial
0.45	20	1.1	1.4
0.36	16	1.1	1.7
0.27	12	1.4	2.3
0.20	09	2	3.2

**VII. CONCLUSION**

**7.1 According to Light Transmission Through OFRC Block**

Transmission of light depends upon the amount of plastic optical fibers used. As we increase the number of fibers in a sample the light transmission increase but at the same time the compressive strength decreases. In OFRC-36, we get 87 lux value at the face of the sample and 19 lux value at 1 feet distance from the sample. In OFRC-49, we get 96 lux value at the face of the concrete sample and 21 lux value at 1 feet distance from the concrete sample, that shows with increase in distance intensity of light also decreases.

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**7.2 According to Cost**

Cost of OFRC concrete is 5 times more than that of conventional concrete initially, but with the passage of time there is increase in scheduled rates and the time required to payback shown in chapter 6, payback analysis shows that the 16 number of cubes being constructed to form a wall, we can save bill amount up to **Rs 864/-** So, we can say period to payback surplus charges in case of OFRC block is retrieved from residential building in 1.1 years similarly from commercial buildings in 1.7 years. The emission of carbon is being reduced to some extent which is dangerous for environment and protect the earth.

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