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Translucent Concrete: Test of Compressive Strength and Transmittance

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Abstract **- Translucent concrete allows light to pass through it because of the presence of optical fibers within the opaque concrete wall. Light is transmitted from one surface of the said wall to the other, because of the presence of optical fiber strands along the width of the wall, which allows light to pass through.**

The principal objective of this project is to design translucent concrete blocks with the use of glass optical fibers, and then analyze their various properties and characteristics. All tests further performed on our concrete samples and on the optical fibers as such were done to ascertain the improvements of the casted blocks over normal concrete blocks of the same size and with the same design ratios, and to ascertain the practical utility of using translucent concrete as a building material for green building development.

Keywords: Optical fibers, Translucent concrete, Compressive strength, Transmittance

1. INTRODUCTION

Translucent lightweight Concrete is a new material with various applications in the construction field, architecture, decoration and even furniture. As can be imagined, concrete with the characteristic of being translucent will permit a better interaction between the construction and its environment, thereby creating ambiences that are better and more naturally lit, at the same time as significantly reducing the expenses of laying and maintenance of the concrete.

Thousands of optical filaments are arranged side by side on a concrete base leaving the light to pass from one side to the other. Due to the small thickness of these filaments, they combine with the concrete. Compared with a traditional electric lighting system, illuminating the indoors with daylight also creates a more appealing and healthyenvironment for building occupants.

In 2001, Hungarian architect Aron Losonczi invented LiTraCon, the first commercially available form of TC which can allow 80% light through and only 30% of weight of common concrete. It was a combination of optical fibers and fine concrete, combined in such a way that the material was both internally and externally homogeneous. It was manufactured in blocks and used primarily for decoration. LiTraCon presents the concept of light transmitting concrete in the form of a widely applicable new building material. It can be used for interior or exterior walls, illuminated pavements or even in art or design objects.

Our project of casting translucent concrete aims at analyzing the amount of transmittance and compressive strength of samples by varying the percentage by volume of optical fiber strands. We have used percentages by volume of glass optical fibers of 0.00 %, 0.09 %, 0.87 %, 1.05 % and 1.75 % respectively.

2. LITERATURE STUDY

TABLE-1 : SIEVE ANALYSIS FOR FINE AGGREGATES

Total Weight Taken = 1000 grams

S.No.	Sieve Size	Weight Retained (g)	Weight Passing (g)	Cumulative Weight % Retained	Total % Passing
1	10 mm	0	0	1000	100
2	4.75 mm	0	0	1000	100
3	2.36 mm	155.48	155.48	15.548	84.452
4	1.18 mm	249.84	405.32	40.532	59.468
5	600 micron	237.88	74.320	64.20	35.680
6	300 micron	141.88	785.08	78.508	21.498
7	150 micron	214.92	1000.00	1000.00	0

Momin et. Al[1]constructed a lux meter to measure the transmittance of the light passing through the concrete blocks. A Light Dependent Resistor was used to measure the amount of light going through. **He, Zhou and Ou**[2]concluded that the larger the POF volume ratio was, the smaller the compressive strength of the translucent concrete was observed. So endlessly increasing the transmittance by way of increasing the POF volume ratio is not possible, as it would have a detrimental effect on the casted cube's mechanical properties.**Zhou et. Al**[3]reported that the failure loads obtained for concrete blocks having 3.14%, 3.80% and 4.52% of POF by volume were found to be 201.0 kN, 195.7 kN and 182.2 kN, as opposed to a failure load of 201.8 kN for a conventionally casted concrete block of the same dimensions. This marked a decrease in compressive strength of 0.379%, 3.023% and 9.712% for the concrete blocks having 3.14%, 3.80% and 4.52% of POF by volume, respectively.**Shanmugavadivu et. Al**[4]reported that the mix proportions use by them to construct translucent concrete blocks were as follows:Cement- 360 kg; Sand- 560 kg; Fiber- 4.5 kg; Water- 190 l.**Germano**[5], in his official patent for translucent lightweight concrete, stated that the translucent lightweight concrete blocks' properties to have thermal resistance, acoustic behavior, higher possibility of finish, weight and higher durability under freeze-unfreeze conditions would allow it to be used for interior and exterior decoration.

3. SIGNIFICANCE OF STUDY

- To study the change in concrete properties on the introduction of glass optical fibers.
- To check the transmittance of the translucent concrete thus produced.

4. EXPERIMENTAL INVESTIGATION

4.1. Materials Used

Ordinary Portland Cement (Specific Gravity: 3.14), Sand and Glass Optical Fibers were used for the project.

The diameter of the glass optical fibers was 350 µ.

From table 1, fineness modulus can be found to be 2.989 (which should be between 2.2 and 3.5 for fine aggregates, hence it is safe to proceed.)

4.2. Mix Proportions

Cement = 490 kg/ m^3; Sand = 1489 kg/ m^3;Water = 220 liter;Water to cement ratio = 0.45

Cement :	Sand :	Water
1	3.039	0.450

4.3. Manufacturing Process

The manufacturing process of translucent concrete is almost same as regular concrete. Only optical fibers were placed together with the help of clay along with aggregate and cement mix. Small layers of the concrete are poured on top of each other and infused with the fibers and are then connected. Thousands of strands of optical fibers are cast into concrete to transmit light. Since manually splicing the optical fibers is a tedious task, a mechanical grinder was used for cutting the ends of the translucent concrete, owing to the absence of a splicing machine.

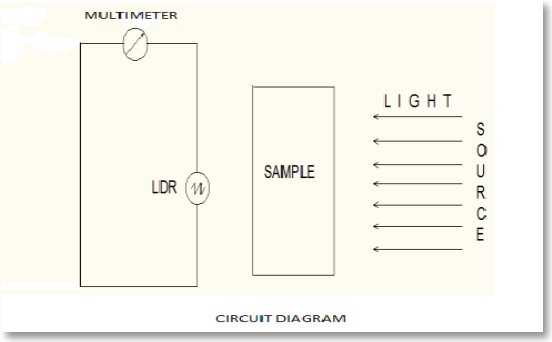
Figure 1: Translucent Concrete Cubes

4.4. Compressive Strength

Figure 2: Failure of Concrete Sample

Compressive strength is defined as the maximum compressive load a body can bear prior to failure, divided by its cross sectional area.

4.5. Transmittance



a. Circuit Diagram

b. Arrangement of Circuit for Test

Figure 3: Transmission Test

Transmittance can be directly calculated by the ratio of incident energy and transmission energy of light expressed as the following equation:

The sample during the experiment was placed at 20 cm or 0.2 m from the light source which was giving 1750 lumens of luminous flux therefore illuminance can be calculated as:

$I = 1750/ (4\pi(0.2)^2)$

Therefore, $I = 3481.5$ lumen/m^2 (lux)

Following empirical relation exists between resistance of photo resistor and light intensity:

Light Intensity (lux) = $A\left\{\frac{Resistance\ (R)}{B}\right\}^C$

Where,

A, B, C are variables which depend on type of photo resistor; R is the resistance

For used model after calibrations following relationship was established:

A=1, B=80, C= -1

Therefore I (intensity in lux) = $\frac{80}{R(resistance\ \ in\ M\Omega)}$

Thus, a relationship can be established between the change in resistance and the number of optical fibers used.

5. RESULTS AND DISCUSSION

5.1. Compressive Strength

TABLE 2: COMPRESSIVE STRENGTH TEST RESULTS

S.No.	No. Of Fibers	Percentage Of Optical Fibers (By Volume)	Load (in kg)	Compressive Strength (in N/mm^2)	Average Compressive Strength (in N/mm^2)
1	0	0	15000	26.160	27.9040
			15500	27.032	
			17500	30.520	
2	400	0.09%	15500	27.032	28.1946
			15500	27.032	
			17500	30.520	
3	4000	0.87%	12000	20.928	21.5093
			13000	22.672	
			12000	20.928	
4	4800	1.05%	12000	20.928	18.8933
			10500	18.312	
			10500	18.312	
5	8000	1.75%	10000	17.440	16.8587
			9500	16.568	
			9500	16.568	

As can be clearly seen from the table, the compressive strength increased in the case for the 0.087% optical fibers by volume sample, but then, it went on to decrease later, as is shown in the following figure.

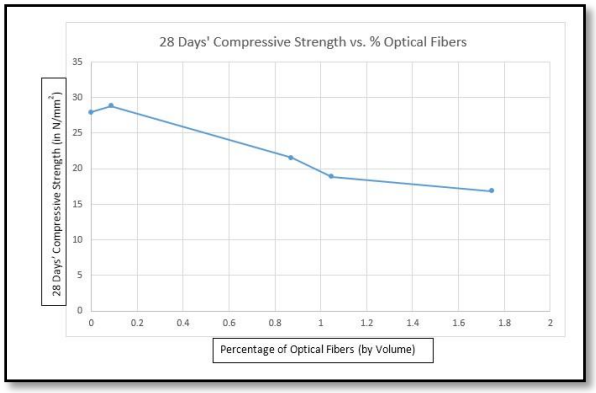


Figure-4: Compressive Strength vs. % Optical Fibers

5.2. Transmittance

TABLE 3: TRANSMISSION TEST RESULTS

S.No.	No. Of Fibres	Percentage Of Optical Fibers (By Volume)	Cube No.	Resistance Measured	Average Resistance Measured	Intensity Of Light [in (lumen/m2) or (lux)]	Transmittance	Average Transmittance
1	0	0	NOP4	O.L. (Can be treated as 20 megaohms)		N.A.	N.A.	
			NOP5	O.L.		N.A.	N.A.	
			NOP6	N.A.	O.L.	N.A.	N.A.	N.A.
2	400	0.09%	D28(400)1	O.L.		N.A.	N.A.	
			D28(400)2	O.L.		N.A.	N.A.	
			D7(400)1*	N.A.	O.L.	N.A.	N.A.	N.A.
3	4000	0.87%	D28(4000)1	15.5		5.16129	0.14824904	
			D28(4000)2	O.L.		N.A.	N.A.	
			D28(4000)3	17.68	17.7267	4.524887	0.129969464	0.139109252
4	4800	1.05%	D28(4800)1	6.93		11.54401	0.331581547	
			D28(4800)2	5.75		13.91304	0.399627847	
			D28(4800)3	7.94	6.8733	10.07557	0.289403038	0.340204144
5	8000	1.75%	D28(8000)1	2.35		34.04255	0.977812816	
			D28(8000)2	1.41		56.73759	1.629688027	
			D28(8000)3	1.9	1.8867	42.10526	1.209400062	1.272300302

As can be clearly seen from the table, the average transmission of light increased continuously on increasing the number of optical fibers, as is shown in the following figure.

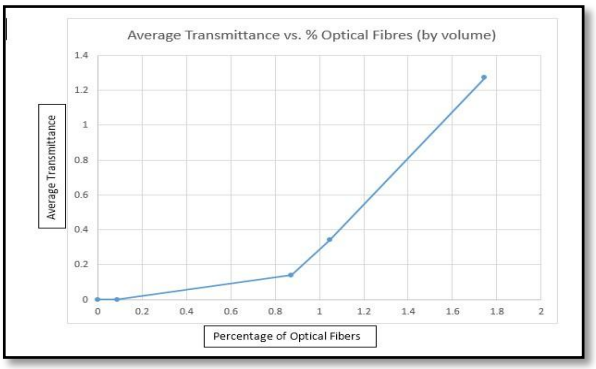


Figure-5: Avg. Transmittance vs. % Optical Fibers

6. CONCLUSIONS

1. The transmittance obtained for the various translucent concrete specimens was seen to increase with the amount of optical fibers used. But it came at a price, as the compressive strength started decreasing at a steady rate once the percentage of optical fibers by volume was increased within the concrete samples. Hence, we can conclude that the best value for use commercially can be calculated as 0.9374%optical fibers by volume, which gives us a compressive strength as high as 20 N/mm^2.

2. It is known that optical fibers as such are very costly, and we were fortunate to obtain scrap optical fibers from U.M. Cables, Silvassa, for free. But the price of a 200 m spool of single-mode optical fibers in the market today is Rs. 570. Now, for our ideal optical fiber percentage, the no. of wires used would amount to 4596 fibers of 7.5 cm length, which would amount to 344.67 m. Therefore, the market expenditure on optical fibers alone would be Rs. 982.31, and that too for a cube of dimensions 7.5 cm x 7.5 cm x 7.5 cm.

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