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Laboratory Investigation on Translucent Concrete by using Optical Fibers

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Abstract - *This paper deals with the study of characteristics strength of translucent concrete. Translucent concrete is a concrete which has light-transmittance properties, obtained by embedding optical fibers in it which transmits light from one end to the other. The paper reports on investigation on the behaviour of concrete with optical fibers and compared with conventional concrete of M20 grade. 2mm and 3mm diameter optical fibers with varied percentage from 1% to 3% were studied. The compressive strength of translucent concrete is seen to increase with the increase in fiber content. The sample with fibers of 2% showed better results in comparison with the others and the light transmittance performance of translucent concrete was evaluated using an electrical circuit test setup with light dependent resistor (LDR). The results evidently showed that translucent concrete can be successfully used as energy efficient construction material for sustainable construction and green building development.*

Key Words: Translucent concrete, light transmittance, optical fiber, light dependent resistor.

1. INTRODUCTION

Today we are living in a world where energy expenditure and environmental problems have rise to global scale. In current developed world our built environment takes energy; energy to make the materials that go into the buildings, energy to construct them, energy to heat, cool and light them. Countries with great population have buildings to be ratio higher than that of small population. Those buildings are isolated biosphere only based on manmade lights to maintain people's optical activities. For example, India consumes 20% of total electrical energy for lighting the buildings.

Nowadays, green building mainly focuses on saving energy with indoor thermal systems. Therefore, it is important to introduce a new working material to serve the purpose of the structure in terms of safety, protection of environment, energy saving and aesthetic modeling. The space between buildings is reduced due to globalization and increase in the construction of high-rise buildings. This leads to increase in the use of non-renewable energy sources. Due to this problem, use of artificial light has increased in large amount. Thus, it becomes necessary to reduce artificial light consumption in structures. This leads to the introduction of innovative concrete called TRANSLUCENT CONCRETE.

1.1 Translucent Concrete

Translucent concrete is an inventive concrete which is dissimilar from normal concrete. Translucent concrete permits light to pass through it and are light-weight as compared to normal concrete. The main aim of translucent concrete is to use sunlight as source of light in spite of using electrical energy in order to minimize the use of non-renewable sources. This technique results in to energy saving. Optical fibers are transmission element which reduces the use of non-natural light. By introducing the optical fibers to concrete, light travels from one end to other end. Translucent concrete has the same strength as regular concrete and will continue to transmit light through walls.

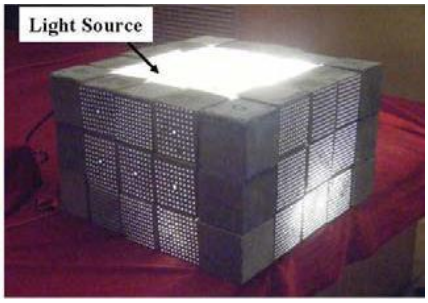

Fig 1: Translucent concrete

2. Objectives

a)To study the strength characteristics of Translucent Concrete by using combination of 2mm and 3mm diameters of POF with varying percentage.
b) To check the Luminosity of Translucent Concrete.

2.1 Materials Used and Its properties

A) Cement: Ordinary Portland Cement 53 grade is used and tests are conducted as per IS-12269:1987 with Specific Gravity 3.16

B) Fine aggregate: Clean and dry Manufactured Sand available locally is used. Sand passing through IS 2.36mm, retained on 150µ is used. The tests are conducted as per IS-650:1996 & IS-2386:1968 with Specific Gravity, Fineness Modulus as 2.58 & 3.45 respectively.

C) Coarse Aggregate: Coarse Aggregate passing through 12mm down sieve is used. The tests are conducted as per IS-2386:1963 with Specific Gravity, Fineness Modulus as 2.68 & 4.63 respectively.

D) Water: Ordinary portable water of normally pH7 is used for mixing and curing of concrete specimens.

E) Plastic Optical Fiber (POF): Optical fiber is a transparent and flexible material made of polymer. This optical fiber helps to transmit light in the cube from one end to other end. Optical fibers typically include a transparent core surrounded by a transparent cladding material with a lower index of refraction as shown in Fig 2. In the present study we are using the combination of 2mm and 3mm diameter POF's in volume fractions with end glow and wavelength of 650nm.

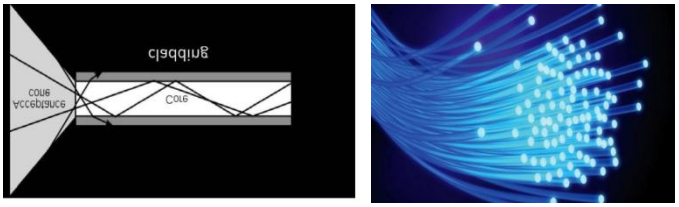

Fig 2: Plastic optical fibres (POF)

F) Mix Proportion: In the present work 1:1.78:2.3 mix proportion is calculated as per IS 10262-2000 for Concrete of M 20 grade.

3. Preparation of Mould

A prototype has been prepared made up of wood with the standard size of the cube l5cm x l5cm x l5cm and size of the beam is l5cm x l5cm x 70cm. In the mould, the perforated plates made of acrylic sheets are used for making perforations and gives a smooth texture to the mould, holes are drilled in to the plates. The diameter of the holes and number of holes mainly depends on percentage of fiber used (fig 3).

Fig 3: Wooden Mould

3.1 Casting Process

The manufacturing process of transparent concrete is same as regular concrete. The optical fibers are spread throughout the aggregate and concrete mix evenly. The combination of 2mm and 3mm diameter POF's is used with varied percentages from 0% to 3%. Optical fibers are inserted through the perforated plates into the mould in such a way that their ending part is outside the mould, which are tied firmly so that they are not bent and stay parallel to each other. After inserting the fibers the concrete mix is poured in 3 layers and compacted using external vibrator.

Fig 3.11: Mould with POF before pouring concrete in cube

Fig 3.12: Mould with POF before pouring concrete in Beam

3.2 Curing

After 24 hrs of casting concrete specimens are kept for curing in water bath with room temperature for 7 days and 28days as per standard specifications.

4. Test Results and Discussion

The basic tests of Compression and flexural tests are conducted as per Indian standards IS: 516 - 1959 to study the behavior of translucent concrete. The specimen with varying combinations of 2mm & 3mm diameter POF's in volume fractions are tested. Light transmittance test is also conducted as per LDR test.

4.1 Compression Test Results: The compressive strength of the concrete is determined

Cube	% of fibers (2+3)mm diameter	Compressive Strength (N/mm2)	
		7 days	28 days
1	0	19.1	26.52
2	1	20	24
3	2	22.89	26.67
4	3	17.33	21.43

Table 4.1: Compressive Strength Results

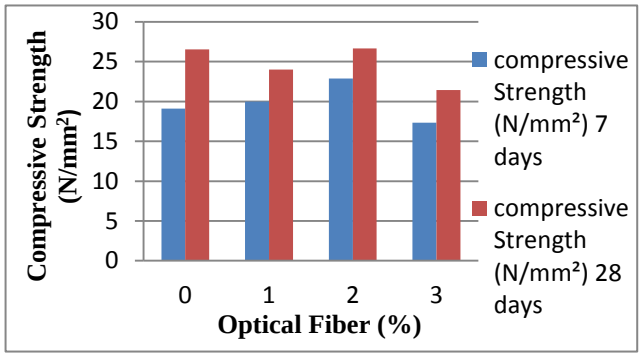

Chart 4.1: Strength Comparison of conventional concrete with translucent concrete.

Discussion: The compressive strength of concrete with varied % of POF is shown in Table 4.1 and Chart 4.1 for 7 days and 28 days.

- ✓ It is noticed that as the % of POF increases, the compressive strength of translucent concrete is increased upto 2% of POF but further increase in POF %, the strength has decreased.
- ✓ For 7 days strength of translucent concrete of 2% POF gives 22.89N/mm2 which is 16.5% more than the conventional concrete.
- ✓ For 28 days strength of translucent concrete of 2% POF showed nearer value to target strength of conventional concrete.

4.2 Flexural Test Results:

Flexural test has been conducted for conventional concrete and 2% POF translucent concrete.

Table 4.2: Flexural Strength Results

Prism	Flexural Strength (N/mm²)
Conventional Concrete	4.56
Translucent Concrete	4.77

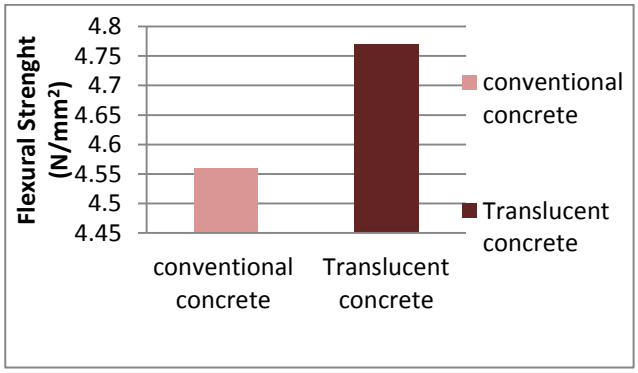

Chart 4.2: Flexural Strength Comparison of Conventional Concrete with Translucent Concrete of 2% POF.

Discussion: The flexural strength of POF of 2% in translucent concrete is compared with conventional concrete in Chart 4.2 and table 4.2

- ✓ It is notice that the failure occurred in interfacial transition zone between the POF and cement paste. This behaviour is due to smoothness of the optical fiber surface which leads to this type of surface of fraction.

- ✓ The POF of 2% in translucent concrete showed flexural strength of 4.77N/mm2 which is 4.4% greater than conventional concrete.

4.3 Light Transmittance Test: In the present study, Light transmittance through sample is measured by using Light Dependent Resistors (LDR) which measures the light transmitted through the sample and converts it into the current, which in this case is measured in mili amperes (mA). The source of light is taken as 100 w incandescent bulbs, a resistance of 10 ohm is applied in the circuit and a uniform DC voltage of 2.5V is kept between the circuits. To ensure no light escapes throughout the test, an box setup has made as shown in fig 4.3. The light source is fixed at one end of the box and LDR is placed at the other end of the box and the test is carried out.

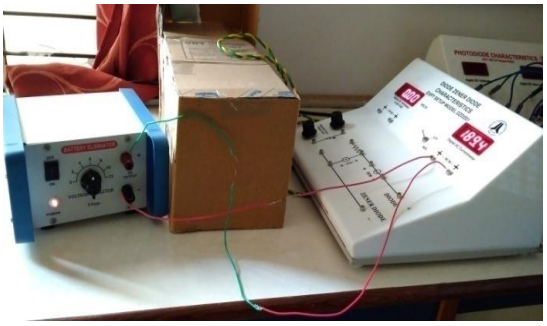

Fig 4.3: Set up for Light Transmittance test

Optical Fiber (%)	Light Transmittance (%)
1	2.674
2	4.981
3	8.608

Table 4.3 Light Transmitting Test Results

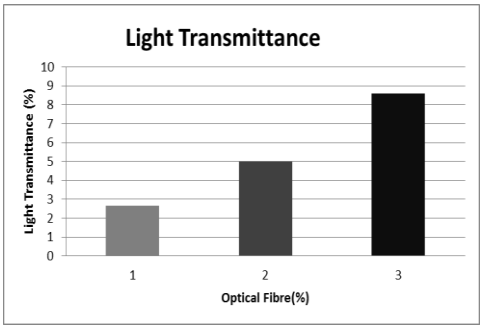

Chart 4.3: Light transmitting result of Translucent Concrete

Discussion:

- Form the Chart 4.3 and table 4.3, it is observed that as the percentage of POF increases, light transmission from the concrete also increased.
- The POF of 3% in a translucent concrete showed maximum light transmission of 8.6% when compared with other POF percentage in concrete.

5. CONCLUSIONS

From the experimental analysis and results obtained the following conclusions are made.

1. The efficiency of the application of optical fiber is studied by comparing the strength with the normal M_{20} grade concrete and the test results proved that the efficiency is more in all aspect.
2. The 7 days compressive strength of translucent concrete of 2% POF showed 22.89N/mm^2 which is 16.5% more than conventional concrete and the 28days strength achieved the target strength.
3. Flexural strength of translucent concrete of 2% POF was also increased by 4.4% when compared to Conventional concrete.
4. From above results we can say that 2% combination of 2mm and 3mm diameter of POF by volume of concrete will be the optimum percentage to be embedded in the concrete.
5. The Light Transmission of translucent concrete of 2% POF showed 4.98%.
6. It can be concluded that the transmission of light through the concrete is possible without compromising the strength characteristics of concrete. Thus, translucent concrete blocks can be used as wall elements.
7. Translucent concrete material can be used in Green building which reduces the electrical light consumption.

Future scope:

- Test can be conducted by varying the percentage of different diameter of optical fibers.
- Durability Tests can be conducted for the concrete.

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