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Translucent Concrete by using Fibre Optic Strands

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***Abstract* – Transparent concrete is the new type of concrete introduced in modern era which carries special property of light transmitting due to presence of optical fiber strands & is also known as translucent concrete or light transmitting concrete.**

Light is transmitted from one surface of the wall to the other due to the presence of optical fibers along the overall width of the wall which allows light to pass through.

An optical glass fiber strand is a flexible, transparent fiber made of silica or plastic, slightly thicker than a human hair & can function as waveguide, or "light pipe" to transmit light between the two ends.

Main aim of the study is to design translucent concrete blocks with the use of optical fiber strands with mortar & cement and then analyze their various physical & engineering properties with respect to conventional concrete blocks by adding optical fibers of 3 % 4 % and 5%. In this project, we will check and perform tests on compressive strength and light transmittance property of translucent concrete.

The principal objective of this project is to design translucent concrete blocks with the use of optic fiber strands and then analyze their various properties and characteristics.

All tests further performed on the translucent concrete samples are done to ascertain the improvements of the casted blocks over normal concrete blocks of the same size and with the same design ratio's, and to ascertain practical utility of using translucent concrete as a building material.

INTRODUCTION

Concrete has been used since Roman times for the development of infrastructure and housing, but its basic components have remained the same. Three ingredients make up the dry mix: coarse aggregate, consisting of larger pieces of material like stones or gravel; fine aggregate, made up of smaller particles such as sand; and cement, a very fine powder material that binds the mix together when water is added.

Just a few decades ago concrete was often misunderstood, disliked and captured by its image fixed due to the rapid urbanization of the 1960s. But since that time, concrete has made considerable progress, not only in technical terms, but also in aesthetic terms. It is no longer the heavy, cold and grey material of the past; it has become beautiful and lively.

By research and innovation, newly developed concrete has been created which is more resistant, lighter, white or colored, etc. Concrete has learned to adapt to almost all new challenges that appeared.

In 2001, the concept of transparent concrete was first put forward by Hungarian architect Aron Losonzi at the Technical University of Budapest, and the first transparent concrete block was successfully produced by mixing large amount of glass fiber into concrete in 2003, named as LiTraCon.

The transparent concrete mainly focuses on transparency and its objective of application pertains to green technology and artistic finish.

It is the "combination of optical fibers and fine concrete". At present, green structures focus greatly on saving energy with indoor thermal systems.

Therefore, it is imperative to develop a new functional material to satisfy the structure in terms of safety monitoring (such as damage detection, fire warning), environmental protection and energy saving and artistic modeling. Due to globalization and construction of high-rise building, the space between buildings is reduced; this causes to increasing the use of non- renewable energy sources, so therefore there is a need of smart construction technique like green building and indoor thermal system.

Translucent concrete (Transparent concrete) is new technique different from normal concrete. Translucent concrete allows more light and less weight compared to normal concrete.

The use of sunlight source of light instead of using electrical energy is main purpose of translucent concrete, so as to reduce the load on non- renewable sources and result it into the energy saving. Optical fibers are a sensing or transmission element, so decrease the use of artificial light, the normal concrete is replaced by translucent concrete, which has natural lighting and art design.

Energy conservation is a key and emerging global issue for sustainable infrastructure development. The building sector energy demand accounts approximately 34% of the world's energy demand . Artificial lighting consumes around 19% of the total delivered electricity, worldwide. The electric lighting demand has constantly been increasing with the increase in the population, urbanization and construction of high-rise buildings. The production of electricity contributes to the increase in the greenhouse gas emissions. According to EIA report, the total CO2 emission related to lighting was approximately 7% of the total global CO2 emission in 2005. A lot of efforts have been made to reduce the energy consumption of lighting by fabrication of energy efficient lighting equipment's, improving lighting designs and using lighting control systems. Translucent concrete is an

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innovative solution towards significantly reducing the need for artificial lighting. This in turn reduces the carbon footprint by allowing transmission of natural light into building's interior when the translucent concrete is used as structural façades and architectural walls, thus fostering the development of green buildings.

Natural light is a form of energy reflected as electromagnetic wave that contains full spectrum of the sunlight, which is healthy for human beings and a preference than artificial light. Indoor environments with adequate natural light illumination have been proven to decrease stress of occupant, improve visual comfort and render better employee retention. It is then essential to develop a new type of construction material, which can allow transmittance of appropriate luminance level of natural light into buildings and integrate the concept of green energy saving..

EXPERIMENTAL PROGRAM

A-Materials

Cement- The cement used in this experimental works is 53 Grade Ordinary Portland Cement. The specific gravity of cement was 3.14. The initial and final setting times were found as 51 minutes and 546 minutes respectively.Fine Aggregate – Fine Aggregate was purchased which satisfied the required properties of the fine aggregate and conforming to Zone III as per specifications of IS 383:1970

Fine Aggregate – Fine aggregate is the inert or chemically inactive material, most of which passes through a 4.75 mm IS sieve and contains not more than 5 per cent coarser material. The specific gravity 2.75 and fineness modulus of 2.80 were used as fine aggregate.

Fiber Optic Strands – The fiber optic strand used in this experiment slightly thicker than a human hair. It can function as a waveguide, or light pipe to transmit light between the two ends. The diameter of 1 fiber optic strand = 0.5mm.

Water – Water is used in the study is tap water free from dirt and oil.

B-Preparation of Light Transmitting Concrete Specimens

In this study wooden moulds of size 100mm X 100mm X 100mm (Fig.1) with the perforated wooden (Fig.2). Perforated wooden sheets with varying number of drilled holes (Fig.2) were attached to the cube moulds for accommodating varying percentage Fiber Optic Strands.

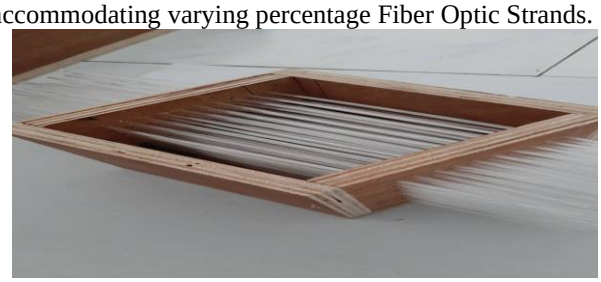

Fig.1 Moulds with fiber in place

Fig.2 Perforated wooden plates

METHODOLOGY

M20 Grade of Concrete was prepare by mixing cement and fine aggregate as per proportion of mix design. Also preparation of moulds and instillation of fiber optic strands in the moulds in this study wooden moulds of size 100 mm X 100 mm X 100 mm were prepared with varying number of drilled holes to accommodating varying percentage of fiber optic strands. They were tested for Compressive strength and light transmittance property after required curing period. Light transmittance test was performed to study the light transmittance characteristics of the specimens. It is very important test since the main purpose of translucent concrete is to transmit light.

Fig.3 Drying of cubes after casting

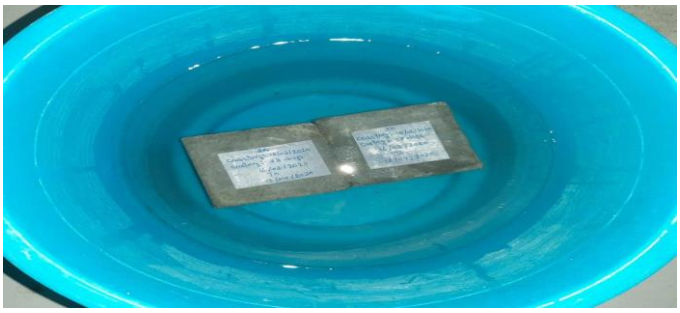

Fig.4 Curing of cubes

Fig.5 Cubes after curing for 28days

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Fig.6 Sun light passing through cubes

Table – 1: Light Transmittance Property test 100W (1500 lumens) incandescent source of light

Sl. No.	% fibre optic strands volume	Transmittance %
1	3%	3.54
2	4%	5.32
3	5%	6.69

Table – 2: Light Transmittance Property test 200W (3000 lumens) incandescent source of light

Sl. No.	% fibre optic strands volume	Transmittance %
1	3%	4.14
2	4%	5.60
3	5%	6.40

Table – 3: Light Transmittance Property test 500W (11000 lumens) halogen source of light.

Sl. No.	% fibre optic strands volume	Transmittance %
1	3%	3.33
2	4%	4.58
3	5%	6.03

Table – 4: Compressive Strength of cube on 28 Days

%f fibre optics strands	**Average 28 day compressive strength (N/mm^2)**
	M20
	28 days
3%	24.94 N \ mm^2
4%	25.00 N \ mm2
5%	25.06 N \ mm2

RESULTS AND DISCUSSION

Results for various percentages of fiber optic strands are as follows:-

A-For Compression Test:

1-For 3% Compressive Strength after 28 days were 24.94 N \ mm^2

2-For 4% Compressive Strength after 28 days were 25.00 N \ mm2

3-For 5% Compressive Strength after 28 days were 25.06 N \ mm2

A-For Light Transmittance Property Test:-

First:-For 100W (1500 lumens) incandescent source of light.

1- For 3% transmittance percentage were 3.54.
2- For 4% transmittance percentage were 5.32
3- For 5% transmittance percentage were 6.69

Second:- 200W (3000 lumens) incandescent source of light.

1- For 3% transmittance percentage were 4.14
2- For 4% transmittance percentage were 5.60
3- For 5% transmittance percentage were 6.40

Third:- For 500W (11000 lumens) halogen source of light.

1- For 3% transmittance percentage were 3.33
2- For 4% transmittance percentage were 4.58
3- For 5% transmittance percentage were 6.03

CONCLUSIONS

From whole study it can be concluded that: -

- The light transmittance up to 6.69% was achieved by using 5% plastic optical fibers. This can be further increased and light transmitting concrete can be used efficiently in green buildings. It can ensure natural light inside the buildings throughout the day.
- Based on compressive strength test results, it can be said that strength of higher-grade light transmitting concrete is not significantly affected by inclusion of POFs.
- Light transmitting concrete requires skilled labour for its production, as POF should be properly placed in concrete, and special attention is needed while placing concrete, to ensure no damage of POFs.
- Light transmitting concrete can be used in structures to make them architecturally and aesthetically beautiful, as various types of glowing patterns can be made with this concrete.
- Cost of manufacture of light transmitting concrete is also high due to plastic fiber optic strands used and special care is required during its preparation. But its cost is fully justified because of its usefulness as eco-friendly, energy efficient, aesthetically beautiful on sustainable ground.

Note: All the results mentioned above are strictly for educational use only and anyone intending to use the concept for practical purpose must carry out all the tests independently. The author doesn't owe any explanation if the results are used for any purpose other than educational activities.

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