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Investigation of Translucent Concrete by Using Optical Fibers

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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: Translucent concrete (TSC), Normal cement concrete (NCC), Compressive strength, flexural strength, light transmission test

I. INTRODUCTION

1.1 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 ambiances 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 healthy environment for building occupants. 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.

1.2 Background and Motivation

Concrete is one component of a revolutionary new material marketed as “translucent concrete”[1]. Engineering has come a long way in the field of construction [4]. When many buildings are stacked close to each other, there is not much natural sunlight passing through and the importance of natural sunlight is pretty well known. In fact, 50% day lighting is a mandatory requirement in a green building according to (IGBC) Indian Green Building Council accounting for 3 credits.[4] A concrete block is going to be built with optical fibres in it and going to be tested for other optional properties. But the main reason or purpose of the blocks is saving energy using natural light and therefore reducing the amount of heat produced from artificial light.

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Vol. 8, Issue 5, May 2019

1.3 Objectives

1. To study strength characteristics of TSC.
2. To compare strength characteristics of TSC & NCC.
3. To check the light transmittance of the TSC.
4. To cast a special type of concrete with light transmitting properties, to study their characteristics and to develop a functioning material which is not only energy saving but gives out artistic finish.

1.4 Scope of the work

Translucent concrete is also a great insulating material that protects against outdoor extreme temperatures while also letting in daylight. This makes it an excellent compromise for buildings in harsh climates, where it can shut out heat or cold without shutting the building off from daylight. It can be used to illuminate underground buildings and structures, such as subway stations. The possibilities for translucent concrete are innumerable; the more it is used, the more new uses will be discovered. In the next few years, as engineers further explore this exciting new material, it is sure to be employed in a variety of interesting ways that will change the opacity of architecture as we know it.

1.5 Advantages and Limitations

- a) The main advantage of these products is that on large scale objects the texture is still visible -while the texture of finer translucent concrete becomes indistinct at distance.
- b) When a solid wall is imbued with the ability to transmit light, it means that a home can use fewer lights in their house during daylight hours.
- c) It has very good architectural properties for giving good aesthetical view to the building.
- d) Where light is not able to come properly at that place transparent concrete can be used.
- e) Energy saving can be done by utilization of transparent concrete in building.
- f) Totally environment friendly because of its light transmitting characteristics, so energy consumption can be reduced.
- g) Concrete is very costly and requires skilled labours.

II. LITERATURE SURVEY

The translucent concrete is one of the most interesting new takes on the historically stiff and uninspiring building material. The smart transparent concrete has good light guiding property. This kind of building material can integrate the concept of green energy saving with the usage self-sensing properties of functional material. The light transmission is made of the illuminating side of the concrete. The development of a light transmitting concrete using plastic optical fibre, which will help to reduce the consumption of electric energy. An optical fibre can be easily combined with concrete and that the POF could provide a steady light transmitting ratio. The smart transparent concrete can be regarded as a green energy saving construction material.

A smart transparent concrete is aesthetically pleasing. POF-based transparent concrete could be regarded as an art which could be used in museums and specific exhibitions rather than just a construction material.

III. CONCEPTUAL BACKGROUND

3.1 FORMULATION FOR OBTAINING A TRANSLUCENT CONCRETE MIXTURE

The invention relates to a formulation for obtaining a translucent concrete mixture comprising a mixture of polycarbonate and epoxy matrices as well as glass fibers, optical fibers, colloidal silica, silica and diethylenetriamine (DETA) and Portland cement. This invention has greater mechanical strength properties than those of a standard concrete, with lower density and mechanical characteristics that enable same to be used in both a structural and architectonic manner. The inventive formulation used to obtain the translucent concrete mixture comprises a type of concrete that is different from those currently available, which combines the advantages of existing concretes with translucency.

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Vol. 8, Issue 5, May 2019

3.2 DESCRIPTION

The concrete generally used in construction generally consist of at least cement, water and aggregates (fine or coarse). As is known, traditional concrete has a greyish colour, and its high density prevents the passage of light through it, which means that it is also impossible to distinguish bodies, colors and shapes through it. With the aim of eliminating these and other drawbacks, thought has been given to the development of a translucent concrete, which concerns a formulation of concrete which, as well as permitting the passage of light through it, also works more efficiently in the mechanical sense than traditional concrete.

3.3 INGREDIENT CHARACTERISTICS

The characteristic details of this novel concrete are studied under the following description and following the same reference signs for indicating it. A polymeric matrix is expected to be provided to enhance the binding capacity and also the mechanical strength. Preferable two polymeric mixture as per our studies are required. One, epoxy and the other is polycarbonate matrix. These together with their respective catalyst shall form a good binding strength. The optical fibers used in the formulation of this concrete are basically fine glass or plastic threads that guide the light. The communication system arises from the union between the light sources that are sufficiently pure for not being altered. The types of fibers used are monomode and virgin fibers, in other words, those in the pure state and without any coatings, the aim of which is so that the light can pass through the concrete. Used as additives are: pigments; bridging agents for favoring the attachment to the matrix, giving resistance and protection against aging; lubricant agents for giving surface protection and filmogenic gluing agents for giving integrity, rigidity, protection and impregnation, metal salts, thixotropic agents (flakes of inorganic materials, glass microspheres, calcium carbonates, silicon dioxide, etc.), flame retardant agents (elements containing chlorine, bromine, phosphorus, etc.) and UV protection agents (stabilizers).

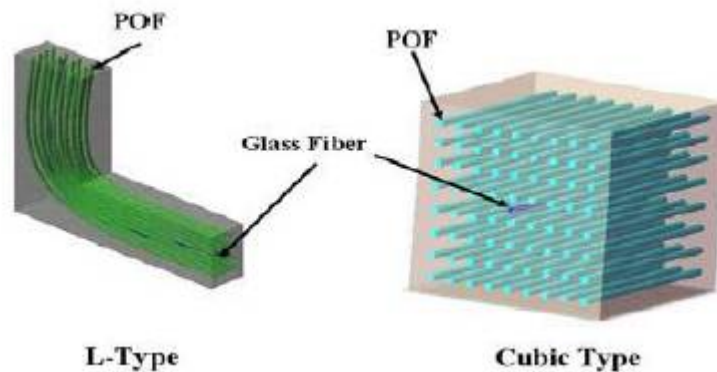


Fig: 01. Integrated model of translucent concrete cube

IV. EXPERIMENTAL PROGRAM

A. Ordinary Portland cement (OPC)

Cement is the individual unit of fine and coarse aggregate into a solid mass by virtue of its inherent properties of setting or hardening in combination with water. It will help to fill the voids and gives density to the concrete. In this study Ordinary Portland Cement-Grade 53, has been certified with IS: 12269 – 1987, Grade 53 which is known for its rich quality and high durability is used.

B. Fine Aggregate

The influence of fine aggregates on the fresh properties of the concrete is significantly greater than that of coarse aggregate. The high volume of paste in concrete mixes helps to reduce the internal friction between the sand particles but a good grain size distribution is still very important. Fine aggregates can be natural or manufactured. The grading

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 8, Issue 5, May 2019

must be uniform throughout the work and must pass through 2.36 mm sieve size which confirms to the code IS: 383 – 1970. Particles smaller than 0.125 mm size are considered as fines which contribute to the powder content.

C. Optical fibers

Generally 200 μ Diameter Strands are used for construction of translucent concrete. An optical fiber is a cylindrical dielectric waveguide made of low-loss materials such as silica glass. It has a central core in which the light is guided, embedded in an outer cladding of slightly lower refractive index.

D. Water

Water is the key ingredient, which when mixed with the cement, forms a paste that binds the aggregate together. Potable water available in laboratory was used for casting all the specimens. The quality of water was found to satisfy the requirements of IS: 456-2000

V. METHODOLOGY AND EXPERIMENT

A. Preparation of mould

In the process of making light transmitting concrete, the first step involved is preparation of mould. The mould required for the prototype can be made with different materials which can be of either tin or wood. In the mould preparation, it is important to fix the basic dimensions of mould. The standard minimum size of the cube according to IS 45 2000 is 15cm x 15cm x 15cm for concrete. In the mould, markings are made exactly according to the size of the cube so that the perforated plates can be used. Plates made of sheets which are used in electrical switch boards is used which will be helpful in making perforations and give 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.

B. Manufacturing process

The manufacturing process of transparent concrete is almost same as regular concrete. Only optical fibers are spread throughout the 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, either natural or artificial. Light transmitting concrete is produced by adding 4% to 5% optical fibers by volume into the concrete mixture. The concrete mixture is made from fine materials only it does not contain coarse aggregate. Thickness of the optical fibers can be varied between 2 μ m and 2 mm to suit the particular requirements of light transmission. Automatic production processes use woven fibers fabric instead of single filaments. Fabric and concrete are alternately inserted into molds at intervals of approximately .5cm to 1cm. Smaller or thinner layers allow an increased amount of light to pass through the concrete. Following casting, the material is cut into panels or blocks of the specified thickness and the surface is then typically polished, resulting in finishes ranging from semi-gloss to high-gloss.



Fig 2 Inserting of optical fibers

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 8, Issue 5, May 2019



Fig 3 Pouring of cement concrete



Fig 4 Translucent concrete blocks

Table I Material specifications

Sr. No	Material	Specifications
1	Cement	53 Grade
2	Sand	2.36 mm Sieve Passing
3	Optical fibers	200 μ Diameter Strands
4	W/C Ratio	0.45- For Optical Fiber

VI. TESTS CONDUCTED

A. Compression test

By definition, the compressive strength of a material is that value of uniaxial compressive stress when the material fails completely. The compressive strength is usually obtained experimentally by means of a compressive test. The compressive strength of the concrete is determined by cast the cubes of size 150mm x150mm.
Compressive strength = load/area

B. Light transmitting test

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). Two readings are taken, one without sample (A1) and one with sample (A2). The source of light here is taken as 100 w incandescent bulbs, a resistance of 100 Ω is

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Vol. 8, Issue 5, May 2019

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 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.

$$\text{Light transmittance} = 100 - (A1 - A2/A1) \times 100$$

Where;

A1= light transmitted without sample ,A2= light transmitted with sample

C. Flexural strength test

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. It is measured by loading 6 x 6 inch (150 x 150-mm) concrete beams with a span length at least three times the depth.

Flexural Strength of Concrete Flexural MR is about 10 to 20 percent of compressive strength depending on the type, size and volume of coarse aggregate used. However, the best correlation for specific materials is obtained by laboratory tests for given materials and mix design. The MR determined by third-point loading is lower than the MR determined by center-point loading, sometimes by as much as 15%. The flexural strength of the concrete is determined by conducting the test on prism by two points loading.

$$\text{Flexural strength} = Pl/bd^2$$

Where,

P – Load ,l – Length of the specimen , b – Width of the beam , d – Depth of the beam

VII. RESULTS AND DISCUSSION

A. Compressive strength test results

Table II Compressive strength comparison of NCC & TSC 7 days curing

RATIO	Compressive strength			
	7 days			
	Normal concrete	TSC .5 cm spacing	TSC 1 cm spacing	TSC 1.5 cm spacing
1:2	15.08	14.04	14.88	14.96
1:1.5	21.57	19.81	20.59	21.15

Table III Compressive strength comparison of NCC & TSC 28 days curing

RATIO	Compressive strength			
	28 days			
	Normal concrete	TSC .5 cm spacing	TSC 1 cm spacing	TSC 1.5 cm spacing
1:2	24.15	24.03	24.13	24.22
1:1.5	28.85	28.2	28.66	28.87

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Vol. 8, Issue 5, May 2019

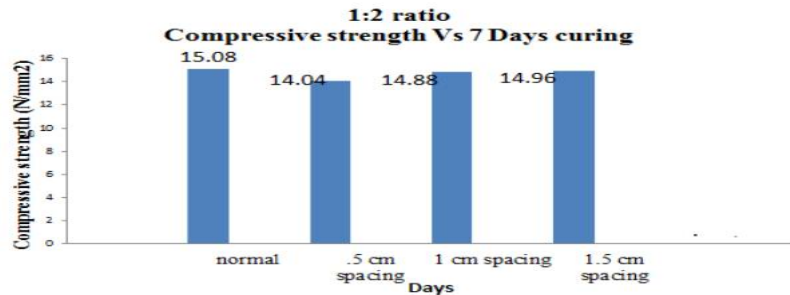


Fig 5 Strength comparison of 1:2 ratio normal concrete with translucent concrete 7 days curing

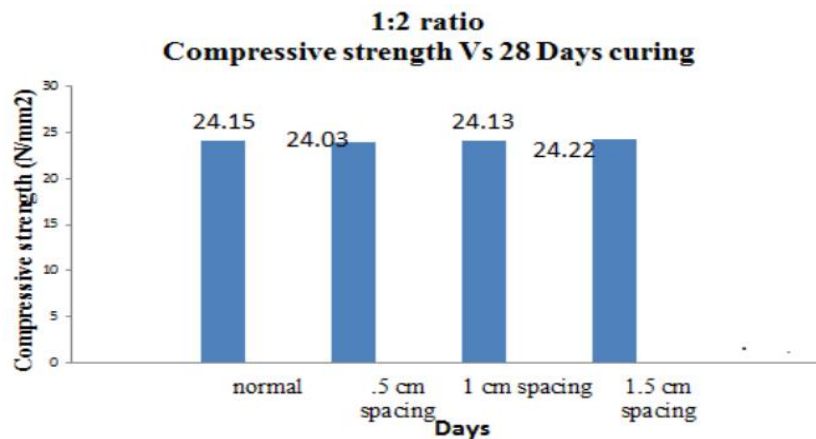


Fig 6 Strength comparison of 1:2 ratio normal concrete with translucent concrete 28 days curing

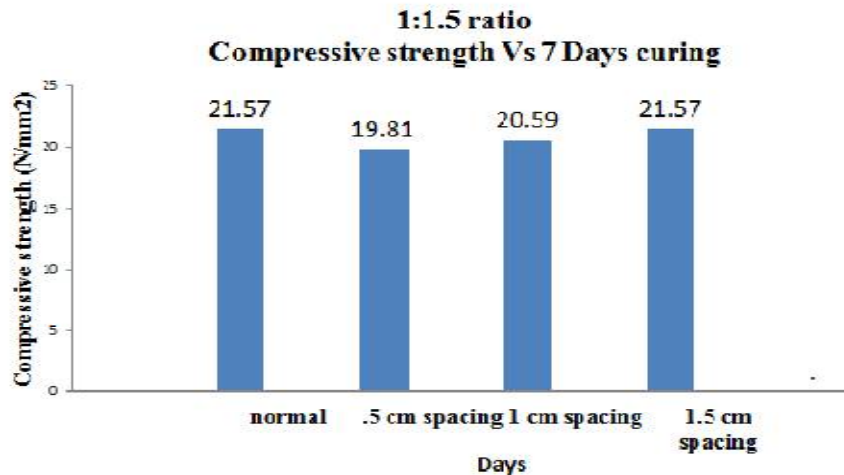


Fig 7 Strength comparison of 1:1.5 ratio normal concrete with translucent concrete 7 days curing

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 8, Issue 5, May 2019

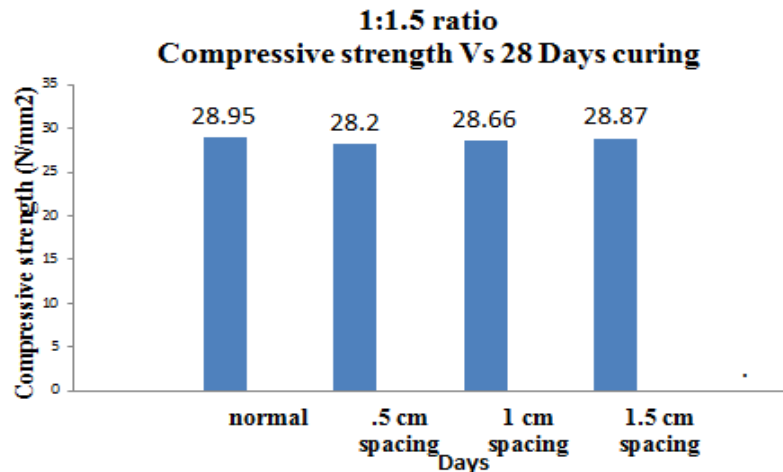


Fig 8 Strength comparison of 1:1.5 ratio normal concrete with translucent concrete 28 days curing

From the Compression strength test results we get to know that strength of cube increases proportionally with increase in spacing between optical fibres and obtains similar strengths like normal concrete cube.

B. Light transmission test results

Table IV light testing results of translucent concrete

Sample	Optical fiber specimen			
	.5 cm spacing	1cm spacing	1.5 cm spacing	
Ammeter readings	Without sample (A1)	15.2	15.2	15.2
	With sample (A2)	1.44	1.28	1.18
Light transmittance (%)	9.47	8.42	7.76	

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Vol. 8, Issue 5, May 2019

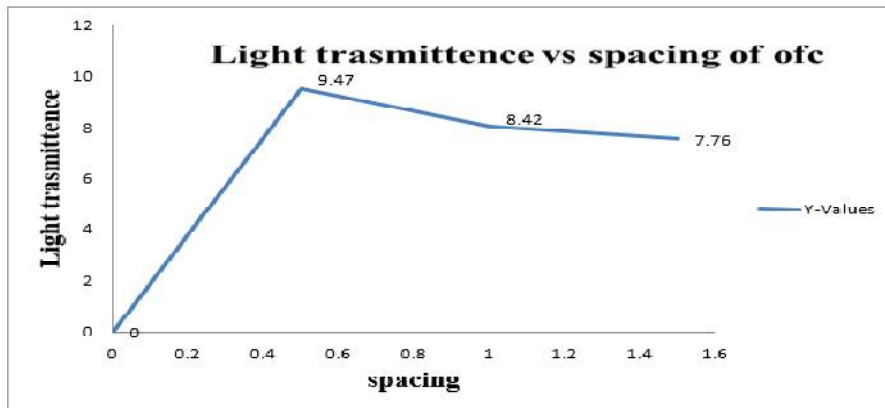


Fig 9 Light transmitting result of translucent concrete

From the results obtained from light transmission test it is seen that light transmittance decreases with increase in spacing.

C. Flexural strength test

Table V Flexural strength results of translucent concrete

Curing	Flexural strength(mpa)	
	Normal concrete	Translucent concrete
7 days	2.41	2.74
28 days	3.73	4.06

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 8, Issue 5, May 2019

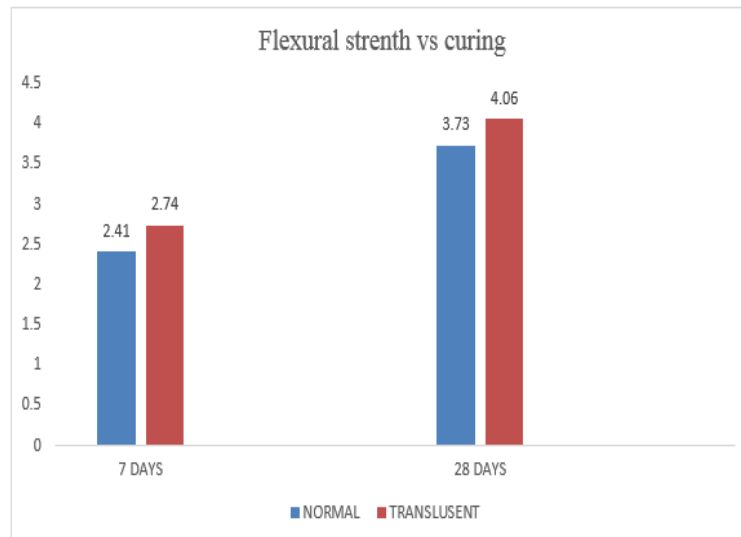


Fig 10 Flexural strength comparison of normal concrete with translucent concrete

From the results of flexural strength test it is observed that translucent concrete provides better flexural strength than normal concrete.

VIII. CONCLUSION

Translucent concrete blocks can be used in many ways and implemented into many forms and be highly advantageous. Yet, the only drawback would be its high cost. That doesn't stop high class architects from using it. It's a great sign of attraction and artistic evolution. Any structure with a small hint of translucent concrete is bound to make heads turn and make them stand. The compressive strength of Light transmitting concrete is equal to the strength of the ordinary concrete and it has the property to transmit light. If the percentage of the optical fibers increased than the strength of the concrete starts decreasing so we can conclude that the strength of translucent concrete is inversely proportional to light transmittance. Only fine aggregates are used because if we use coarse aggregates then it may destroy the optical fibers and changes their properties. Transparent concrete achieves maximum effect when used in an environment with a high degree of light contrast, such as this illuminated table in a dimly lit room. The strength results of decorative concrete are correlated with results of ordinary plain cement concrete. The results evidently show that the decorative concrete also performance based on the strength aspect is also considerably high. Hence the application of optical fibre will make the concrete decorative as well as can make the concrete structural efficient.

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Vol. 8, Issue 5, May 2019

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