Experimental Analysis of Translucent Concrete by using Optical Fibers

Nikhil k[#1] Ummer farook nk[*2] Silal ahmed ks[*3] Juraige mk[*4] Rameesa saleem[*5] Shabeeba omar[*6]
[#]*Faculty of Civil Department, RCET Akkikavu, India*
[*]*Student of Civil Department, RCET Akkikavu, India*

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.

Keyword- *Translucent concrete (TSC) , Normal cement concrete (NCC),Compressive strength, flexural strength, light transmission test*

I. 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 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.

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 %, 1%, 2 %, 3 % and 4 % respectively.

Prof AA Momin et al(2013) Studies on producing the concrete specimen by reinforcing optical fibers with different percentage and comparing it with the normal concrete. The various test conduted for this are compressive strength test and light transmission test. The material used for this concrete are cement(53 grade), sand(2.36 mm sieve passing) , optica fiber cables 200 micron diameter. The fine cement concrete mix ratio for this conctrete is 1:2 and water cement ratio is .45. the result of this experimental investigation shows that the compressive strength of light transmitting concrete was ranging between 20-23n/mm2 with optical fiber specimen. Which indicates that it satis fy the compressive strength requirements for m20 grade concrete and also it conclude that the transparency of light is possible in concrete with out affecting its compressive strength.

Varshara in a et al(2013) Investigated to develop the building a esthetic in modern construction and consumption of energy with eco-friendly way. The main purpose is to use sunlight as a light source to reduce the power consumption of illumination and to use the optical fiber to sense the stress of structures and also this concrete as an architectural purpose for good aesthetical view of the building. They conclude that the not looses the strength parameter when compared to regular concrete . This kind of building material can integrate the concept of green energy saving with the usage self-sensing properties of functional material.

Zhi Zhou et al(2006) Reported that the light guiding performance of concrete materials is completely determined by the internal POFs area ratio and the surface roughness in certain sections. 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.

II. OBJECTIVES AND SCOPEOFTHE INVESTIGATION

A. Objectives

- To study strength characteristics of TSC
- To compare strength characteristics of TSC & NCC
- To check the light transmittance of the TSC

B. 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.

III. 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 helps 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. It is used for constructing bigger structures like building foundations, bridges, tall buildings, and structures design to withstand heavy pressure. As such, Ordinary Portland Cement is used for quite a wide range of applications in pre-stressed concrete are dry-lean mixes, durable pre-cast concrete, and ready mixes for general purposes.

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 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

Genarally200 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. Light rays incident on the core-cladding boundary at angles greater than the critical angle undergo total internal reflection and are guided through the core without refraction. Rays of greater inclination to the fiber axis lose part of their power into the cladding atp communications in a local area network.each reflection and are not guided. As a result of recent technological advances in fabrication, light can be guided through 1 km of glass fiber with a loss as low as = 0.16 dB (= 3.6 %).

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

IV. METHODOLOGY OF 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 l5cm x l5cmx l5cm 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 µm 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 1 Inserting of optical fibers

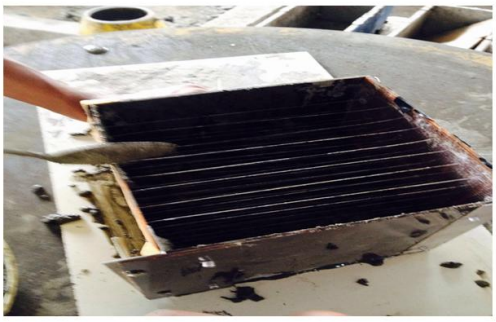

Fig 2 Pouring of cement concrete

Fig 3 Translucent concrete blocks

Table I Material specifications

Sl 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

V. TESTS CONDUCTED

A. Compression test

By definition, the compressive strength of a material is that value of uniaxial compressive stress reached 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 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). The use of photo diode would require a separate sensor which would increase the cost of the project. The most apt choice would be LDR. The LDR are soldered onto a PCB board.

The LDR measures the light transmitted through the sample and converts it into the current, which in this case is measured in mili amperes (mA). So 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 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.

Light transmittance = 100 –(A1−A2/A1)x100

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. The flexural strength is expressed as Modulus of Rupture (MR) in psi (MPa) and is determined by standard test methods ASTM C 78 (third-point loading) or ASTM C 293 (center-point loading).

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.

Flexural strength = Pl/bd2

Where,

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

VI. 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

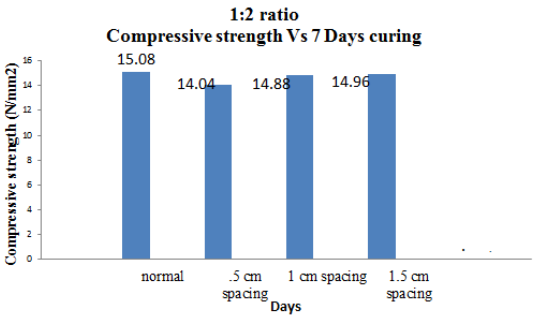

Fig 4 Strength comparison of 1:2 ratio normal concrete with translucent concrete 7 days curing

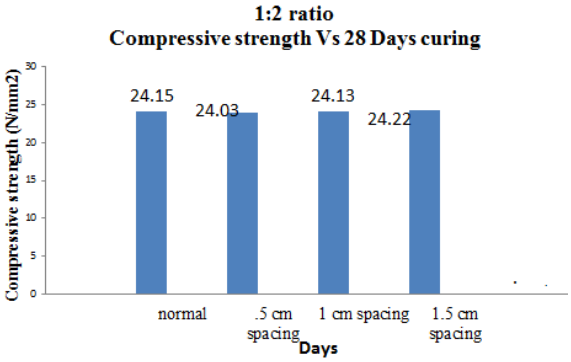

Fig 5 Strength comparison of 1:2 ratio normal concrete with translucent concrete 28 days curing

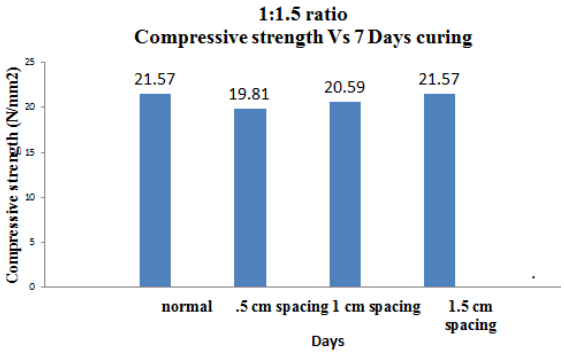

Fig 6 Strength comparison of 1:1.5 ratio normal concrete with translucent concrete 7 days curing

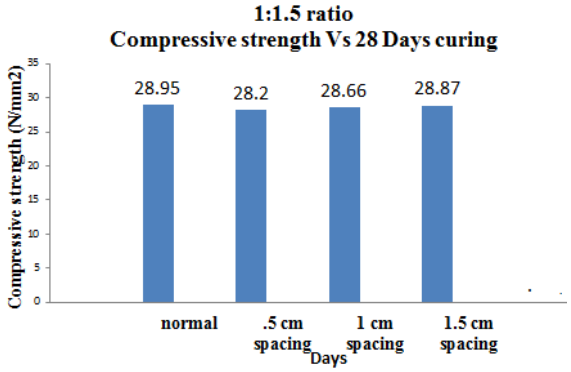

Fig 7 Strength comparison of 1:1.5 ratio normal concrete with translucent concrete 28 days curing

B. Light transmission test results

Table IV light testing results of translucent concrete

Sample		Optical fiber specimen		
spacing		.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

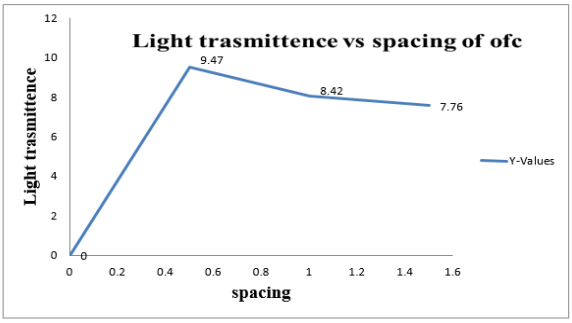

Fig 5 Light transmitting result of translucent concrete

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

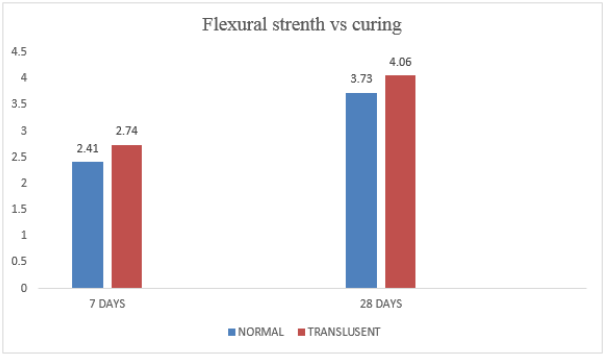

Fig 6 Flexural strength comparison of normal concrete with translucent concrete

VII. ADVANTAGES AND LIMITATIONS

1. Advantages

- 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.
- 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.
- It has very good architectural properties for giving good aesthetical view to the building.
- Where light is not able to come properly at that place transparent concrete can be used.
- Energy saving can be done by utilization of transparent concrete in building.
- Totally environment friendly because of its light transmitting characteristics, so energy consumption can be reduced.

2. Limitations

- The main disadvantage is these concrete is very costly because of the optical fibers.
- Casting of transparent concrete block is difficult for the labour so special skilled person is required.

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 in awe.

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.

ACKNOWLEDGEMENTS

First and foremost we take immense pleasure in thanking the Management and respected Principal, Dr.Priestly Shan, for providing us with the wider facilities and words are inadequate in offering our thanks to Mr Nikhil K, Asst. Professor, Department of Civil Engineering, for his encouragement and guidance .

Above all we would like to thank the Almighty God for the blessings that helped us to complete this venture smoothly.

REFERENCES

[1] Momin, A., Kadiranaikar, R., Jagirdar, V. & Inamdar, A., "Study of Light Transmittance of Concrete Using Optical Fibers and Glass Rods," Proceedings: International Conference on Advances in Engineering & Technology – 2014.

[2] He, J., Zhou, Z. & Ou, J., "Study on Smart Transparent Concrete Product and Its Performances," Proceedings: The 6th International Workshop on Advanced Smart Materials and Smart Structures Technology – 2011.

[3] Zhou, Z., Ou, G., Hang, Y., Chen, G. & Ou, J., "Research and Development of Plastic Optical Fiber Based Smart Transparent Concrete," *SPIE*, vol. 7293, no. F, 2009

[4] Shanmugavadivu, P., Scinduja, V., Sarathivelan, T. & Shudhesamithronn, C., "An Experimenal Study of Light Transmitting Concrete," *IJRET*, vol. 3, no. 11, 2014.

[5] Germano, J., "Translucent Lightweight Concrete". Europe Patent EP2410103, 2012.