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Experimental Investigation of Strength and Light Transmittance of Translucent Concrete

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***Abstract* – Translucent concrete is a new energy-saving building material that permits transmission of light into indoor environment because of the embedded optical fibers with application as architectural wall and structural façade of buildings. The depletion of the resources is kept on increasing with the increase in population. An average Indian is required to spend more than 1000 to 2000 rupees a month. Even if the cost is kept as a secondary criterion, the depletion of the resources is at an exponential rate. So we have to use the natural resource that is available to us, the sun light. If we can transmit the natural sunlight into our buildings, the amount of light used during the daylight is considerably reduced. When in olden times were there was no electricity the sun's natural light is used. The olden way of construction has provisions for the natural sunlight to be transmitted inside the buildings. In the new and modern era of construction the main aim of the designer and owner is optimum usage of the space than allowing transmission of light.So the idea that we take forward is what if light can pass through concrete. The concrete that allows light to pass through them is known as translucent concrete or LiTraCon.**

Keywords- Translucent concrete (TC), Normal cement concrete (NCC), Compressive strength, flexural strength, light transmission test

1. INTRODUCTION

As in the developing world, problem related to environment and energy is escalated to great scale. Energy is required to perform any task at every stage. Therefore to maintain the sustainability along with the development it is important to develop the technology which reduces the Embodies or operation energy. Hence translucent concrete is casted to explore the vast potential energy that is sunlight. According to (IGBC) Indian Green Building Council 50% day lighting is a mandatory required for GREEN BUILDING accounting for 3 credits. Hence translucent concrete comes as a great blessing which gives better interaction between construction and environment. For the structure design, the main load is considered as the dead load. And light weight concrete results in the reduce of weight of column, beam, foundation and all other load bearing elements. With the Possibility of producing a wide range of densities (400-1600) kg/m3 and also of achieving strength of at least 25 MPa, foamed concrete has the potential to fulfill these requirements and it is now widely used in the construction industry. Our project of casting translucent concrete aims at analyzing the amount of transmittance and compressive strength of samples by NCC, TC and TC (50%GGBS).

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 conducted for this are compressive strength test and light transmission test. The materials used for this concrete are cement (53 grade), sand (2.36 mm sieve passing), optical fiber cables 200 micron diameter. The fine cement concrete mix ratio for this concrete 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 satisfy the compressive strength requirements for m20 grade concrete and also it conclude that the transparency of light is possible in concrete without 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

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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 the strength characteristics of translucent concrete with partial replacement of cement with GGBS.
- To compare the strength characteristics of translucent concrete with partial replacement of cement with GGBS and Normal Cement Concrete.
- To check the light transmittance of the translucent concrete.
- To check the cost variance between translucent concrete with partial replacement of cement with GGBS and Normal Cement Concrete.

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.The Carbon emission is reduced compared to NCC because of usage of GGBS.

II. EXPERIMENTAL PROGRAM

A. Ordinary Portland cement (OPC)

Portland cement is the most common type of cement in general use around the world as a basic ingredient of concrete, mortar, stucco, and non-specialty grout. It was developed from other types of hydraulic lime in England in the mid 19th century, and usually originates from limestone. It is a fine powder, produced by heating limestone and clay minerals in a kiln to form clinker, grinding the clinker, and adding 2 to 3 percent of gypsum. Several types of Portland cement are available. The most common, called ordinary Portland cement (OPC) is grey

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

Genarally 75mm 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 at p 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

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required for the prototype can be made with different materials which can be of either foam board or alloy sheet. 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 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.

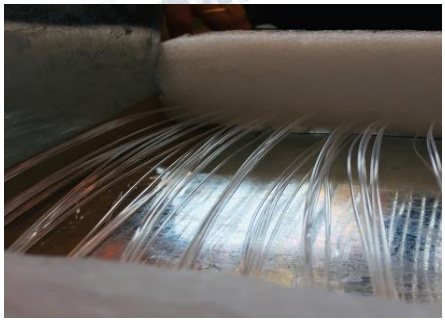

Fig 1 Inserting of optical fibers

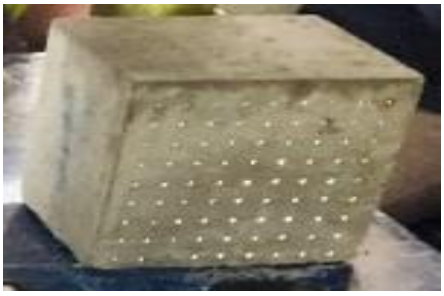

Fig 2 Translucent concrete block

Table I Material specifications

Sl No	Material	Specifications
1	Cement	53 Grade
2	Sand	2.36 mm Sieve Passing
3	Optical fibers	75mm 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 x 150mm.

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

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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 = $\left(1 - \frac{A1-A2}{A1}\right) * 100$

Where;

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

VI. RESULTS AND DISCUSSION

A. Compressive strength test results

Table II Compressive Strength values

Sl.no	Days	NCC (N/mm^2)	TC (N/mm^2)	TC (%50) (N/mm^2)
1	7 days	15.63	14.42	19.24
2	14 days	19.15	18.61	21.39
2	28 days	24.59	24.76	28.31

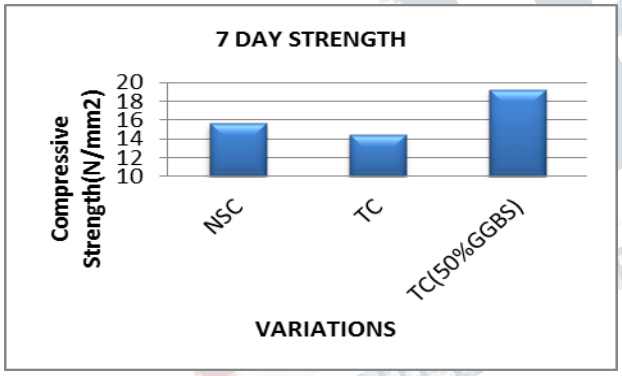

fig 3 7 Day Strength

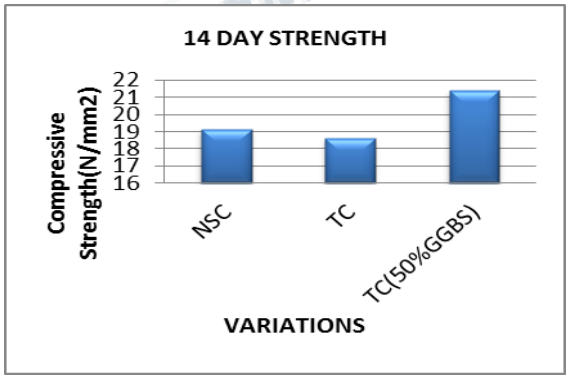

fig 4 14 Day Strength

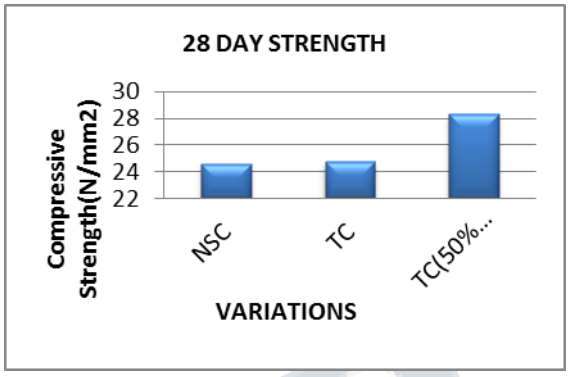

fig 5 28 Day Strength

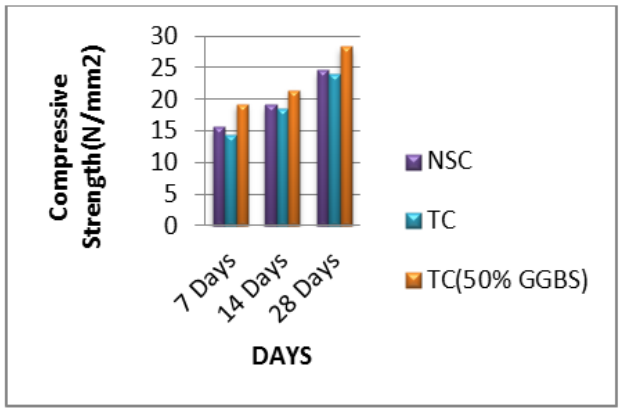

fig 6 Comparison of Strength

B. Light transmission test results

Table IV light testing results of translucent concrete

Sample	Optical fiber specimen		
		NCC	TC
Ammeter readings	Without sample (A1)	14.21	14.21
	With sample (A2)	1.75	1.68
Light transmittance(%)		12.31	11.82

VII. ADVANTAGES AND LIMITATIONS

Advantages

- The main advantage of these products is that on large scale objects the texture is still visible -while

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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.

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.

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 high degree of light contrast. 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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