Study of Behaviour of Translucent Concrete using Rice Husk and Steel Fibre

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Abstract

Now a day the dependence on artificial sources of energy has increased drastically. Thus, translucent concrete is the need of an hour. Translucent concrete allows natural sunlight or any light to pass through it. It reduces electricity consumption in the buildings and makes it easier for buildings to achieve higher LEED rating. But, no construction material can be used until it satisfies all the constructional requirements. For this purpose, experimental study on translucent concrete has been carried out in order to determine it's compressive strength. As far as traditional translucent concrete is concerned, it is made up of cement, sand, fine aggregates and plastic optical fibers strands placed in alternate layers. In the present study, an experimental study is carried out and the compressive strength of translucent concrete was compared with that of traditional translucent concrete to find out the possibility of using translucent concrete for construction purposes. Usage of optical fibres reduces the compressive strength of traditional translucent concrete but an increment in compressive strength of translucent concrete is achieved by adding steel fibres and rice husk along with the optical fibres.

Keywords: *Translucent concrete, Optical fibre, Rice husk, Steel fibre, Compressive strength.*

I. INTRODUCTION

Concrete is one of the basic construction material which is used in construction work. Concrete is composition of cement and building material materials like ash, cement, fine aggregate, coarse aggregate, water. By analysis and innovation modern developed concrete has been created like betao organic concrete, self healing bacterial concrete, bendable concrete etc. The conservation of energy has become an important issue in today's world. To scale down the consumption of energy by buildings and the upcoming construction in future, development of a new construction material which will dissipate less amount of energy has attracted the attention of many researchers. Translucent concrete is one such material. Concrete is one of the most basic materials required during all types of construction. Translucent concrete is an innovative concrete which has the ability of passing light through it.

II. LITERATURE STUDY

Shen Juan and Zhou zhi,2013[1] discusses the development of smart transparent concrete based on its excellent properties of transparent and smart sensing. By dealing with its usage and also the advantages it brings in the field of smart construction, it reduces the power consumption of illumination and uses the optical fiber to sense the stress of structures. And this concrete is also used for an architectural purpose for good aesthetical view of the building. It can be used for the best architectural appearance of the building. It can also be used where the light cannot reach with appropriate intensity. It has some disadvantages such as, it requires skilled supervision and also its cost is very high due to the optical fibers used in it.

Kashiyani Bhavin K., Raina Varsha, Pitroda Jayeshkumar, Shah Bhavnaben K., 2013,[2] studied light transmitting concrete, its various ingredients, manufacturing process, construction, applications, advantages, disadvantages, etc. Light transmitting concrete was made by blending together the concrete and 4 to5%optical fibers. The thickness of optical fibers being 2micrometre to 2mm. Alternate layers of POF and concrete are placed to form light transmitting concrete. This concrete is based on the principle of total internal reflection of optical fibers, as light passes through the optical fibers in this.

Bhushan Padma, Johnsan D.(2013) et al.[3] constructed translucent concrete blocks using concrete and plastic optical fibers. They discussed about the usage of these concrete blocks such as in the walls, ceilings to make it architecturally pleasing, illuminating speed bumps, use on sidewalks, on various interior and exterior surfaces of the buildings to make it aesthetically beautiful. Plastic optical fibers have various advantages such as they do not produce radiation, also not affected by radio magnetic interference, radio frequency and noise. Plastic optical fiber is by far the best replacement for glass, as it is much stronger and gives more privacy.

Nagdive Neha R. and Bhole D. Shekhar, 2013, [4] manufactured translucent concrete by using optical fibers. For preparing mould, first polymer craft clay is spread into a flat circle, then a ring of

spray paint was used to fix over clay for using it as a mould. Then, optical fibers were placed individually in the mould and then slowly the concrete was poured. After 24hours, polymer clay was pulled and the plastic ring was removed. The concrete was allowed to dry and extra fibers were cut. Sand paper was used to polish, It was observed that the concrete prepared this way, Light was able to pass through it.

III. FUNCTIONAL PRINCIPLE OF TRANSLUCENT CONCRETE

Transparent concrete or translucent concrete is due to work based on "Nano-Optics". Optical fibers pass as much light when minute slits are placed exactly on top of each other when they are staggered. Optical fibers in the concrete act like the aperture and carry the light across throughout the concrete.

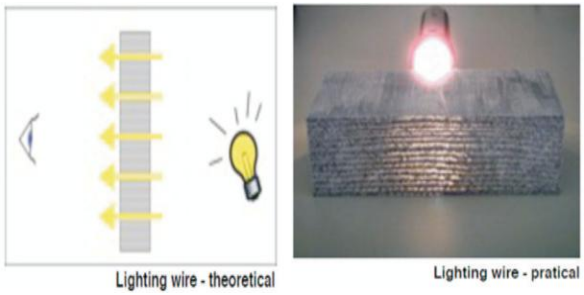


Fig : 1 Functional Principle of Light Transmitting Concrete [5]

A. Total Internal Reflection

When light passing through an optically impenetrable medium hits a boundary at a steep angle the light is completely reflected. This anomaly is called as total internal reflection. This response is used in optical fibers to confine light in the core. Light travels through the fiber core, rebound back and forth off the boundary between the core and cladding. Because the light must collide the boundary with an angle higher than the critical angle, only light that enters the fiber within a convinced range of angles can travel down the fiber without leaking out. This territory of angles is called the acceptance cone of the fiber. The proportion of this acceptance cone is a function of the refractive index difference between the fiber's core and cladding. [6]

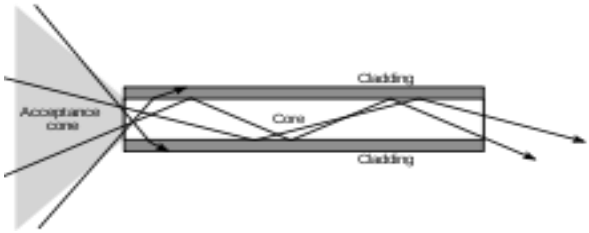


Fig :2 Propagation of Light in a Multi Mode Optical Fiber [5]

IV. MATERIAL USED

The material used for the formation of translucent concrete are cement, fine aggregates, coarse aggregates, optical fibres, rice husk & steel fibres. The properties of material used in this experimental program are as follow:

A. Cement

Ordinary Portland cement of grade 43 conforming to IS: 8112-1989 was used. Cement was tested according to IS: 4031-1988. The cement was of uniform color i.e. grey with light greenish shade. The properties of cement are given in table 1

S.N	Physical Property	Experimental
1	Consistency of cement	29%
2	Specific gravity	3.15
3	Initial setting time	30 min.
4	Final setting time	600 min.

Table No. 1

B. Aggregates

For fine aggregates river sand has been sieved from IS 1.18mm sieve. It did not contain any impurities such as vegetable matters, organic matter, lumps, etc. The physical properties of fine aggregates are given below in table 1.1

Physical tests	Values
Specific gravity	2.63
Fineness modulus	2.404
Water absorption	1.7

Table No. 2

The material which is retained on 4.75 mm sieve is known as coarse aggregate. Coarse aggregate passing 10 mm IS sieve and retained on 4.75 mm sieve was used in this experimental work.

Fig: 3 Process Of Sieving

C. Plastic Optical Fiber

An optical fiber is a bendable, transparent fiber made of extruded glass or plastic, marginally thicker than a human hair. It can transmit light

between the two ends of the fiber. Optical fiber is a barrel shaped dielectric waveguide (non regulating waveguide) that transmits light along its axis, by the technique of total internal reflection. The fiber consists of a core enclosed by a cladding layer, each of them are made up of dielectric materials. If the refractive index of the core requisite be greater than that of the cladding then it restrain the optical signal into the core. The perimeter among the core and cladding may either be blunt, in step-index fiber, or gradual, in graded-index fiber. These can have diameters up to 2mm. Plastic optical fiber allows to transmit sunlight or light from any source to pass through it. When used in concrete, these fibers transmit light that falls on one face of the concrete to the other face. There is little or no signal loss in the plastic optical fiber when light passes through its core. Plastic optical fiber of diameter 0.5mm has been used for preparing samples.

Fig : 4 Bundle of optical fibers

D. Rice Husk

Rice husk having high percentage of silica, fine silica will provide a very compact concrete. Combustion of rice husk provide rice husk ash. This rice husk ash contain nearly 85-90 % silica. The ash also is a very good thermal insulation material. The fineness of the rice husk ash also makes it a very good applicant for sealing fine cracks in civil structures, where it can seep deeper than the conventional cement sand mixture.

Fig 5: Rice husk

E. Steel fiber

Steel Fiber are generally distributed throughout a given cross section area. Steel fiber improve resistance to impact or progressive loading, and to resist material fragmentation. Steel Fibers are ordinarily added to concrete in low volume dosages (usually less than 1%), and have been shown to be useful in shortening plastic shrinkage cracking. In this experimental work we use 0.125% steel fibre by weight.

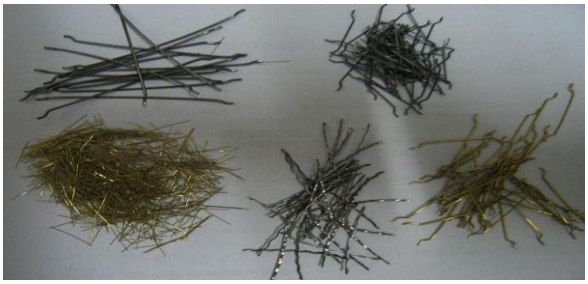


Fig : 6 Steel fibers

V. EXPERIMENTAL PROGRAM

A. Preparation of Light Transmitting Concrete Mould

In this study, wooden moulds of size 15cmx15cmx15cm were prepared with the perforated wooden sheets. Wooden sheets which are used for electrical switch boards were used. Perforated wooden sheets with varying number of drilled holes were attached in the moulds, for preparing cubes of varying percentage of P.O.F. The diameter and spacing of the holes depended on the percentage of fiber in the cube.

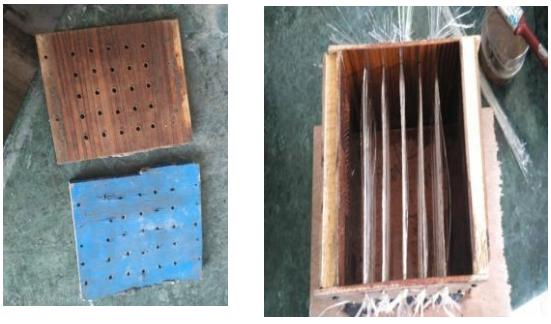


Fig :7 Mould Used for Casting Translucent Concrete

B. Preparation of Light Transmitting Concrete Specimens

Concrete of mix proportions i.e. 1:1.5:3 (cement: sand: aggregates) with water cement ratio 0.45 were used for preparing cubes of 15cmx15cmx15cm size. Varying percentage of Plastic Optical Fibers such as 0.25, 0.50, 0.75 1.0, 1.50, 2.0, 2.50, 3.0, 3.50, 4.0% were used to study strength. Concrete was poured in the moulds while placing moulds on the vibrating table. By giving vibrations concrete was completely filled in the moulds with no void left in between the fibers. The

cubes were compacted properly on the vibrating table. POF of 0.5mm diameter were used in the cubes.

Fig: 8 Shows process of vibration

Table 3 : Showing number of plastic optical fiber strands as per percentage of fiber used

Percentage of plastic	Number of plastic
0.25%	125
0.50%	250
0.75%	375
1%	500
1.5%	750
2%	1000
2.50%	1250
2.75%	1375
3%	1500
3.25%	1625
3.50%	1750
3.75%	1875
4%	2000

Table 4 : Mix Proportion of Concrete by Weight for a Cube

Material	Weight (Kg)	%
Aggregate	4.2	52.5
Sand	2.1	26.25
Cement	1.4	17.5
Rice husk	0.050	0.625
Steel Fiber	0.010	0.125

C. Compressive Strength Test on Translucent Concrete

Cubes of size 15cmx15cmx15cm of various plastic optical fiber ratio i.e. 0.25%, 0.5%, 0.75%, 1%, 1.5%, 2%, 2.5%, 3%, 3.5%, 4% were prepared. Three specimens of each plastic optical fiber percentage and mix proportion were prepared. After casting cubes, curing was done for 7 days. The cubes were tested for 28 day compressive strength on Compression testing machine (3000 KN capacity).

VI. RESULT COMPARISON

A. Compressive Strength of Traditional Translucent Concrete

Table 5: 28 Day Compressive Strength of Light Transmitting Concrete of Mix 1:1.5:3 (cement: Sand: Aggregates) with Water/Cement Ratio of 0.45.

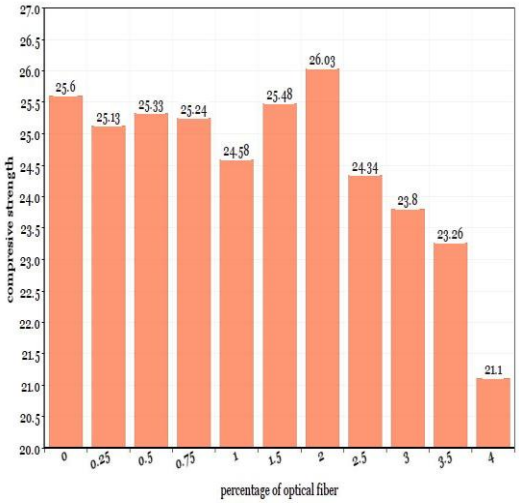
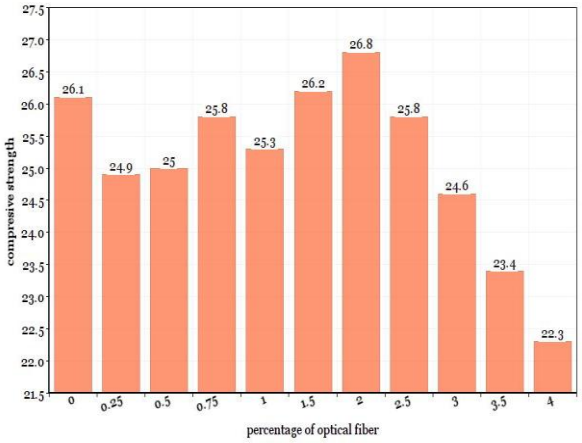


Table 5: 28 Day Compressive Strength of Light Transmitting Concrete

Proportion of Optical Fiber Used	Average 28 day Compressive strength
0%	25.26
0.25%	25.13
0.5%	25.33
0.75%	25.24
1%	24.58
1.5%	25.48
2%	26.03
2.5%	24.34
3%	23.80
3.5%	23.26
4%	21.10

B. Compressive Strength of Translucent Concrete Having Rice Husk & Steel Fibre

Table 6: 28 day compressive strength of light transmitting concrete of mix 1:1.5:3 (cement: sand: aggregates) with water/cement ratio of 0.45.



Proportion of Optical Fiber Used	Average 28 day Compressive strength
0%	26.10
0.25%	24.90
0.5%	25.00
0.75%	25.80
1%	25.30
1.5%	26.20
2%	26.80
2.5%	25.80
3%	24.60
3.5%	23.40
4%	22.30

Table 5: 28 Day Compressive Strength of Light Transmitting Concrete

VII. CONCLUSION

From this experimental study, it is concluded that light transmitting concrete is very advantageous construction material. It can be used in green buildings to increase the energy efficiency of the structure. It is definitely the future of civil engineering construction material, and its use would keep on increasing in construction as the time will go on. The following conclusions can be drawn based on the results of this experimental work.

- Light transmitting concrete requires skilled labor for its manufacture, as POF should be properly placed in concrete, and special attention is needed while placing concrete, to ensure proper manufacture of light transmitting concrete.
- When we increase the percentage of optical fibre the compressive strength of traditional translucent concrete cube decreases but by adding rice husk and steel fibre the compressive strength of cube is increases.
- Cost of manufacture of light transmitting concrete is also high due to plastic optical fibers used and care needed during manufacture. But, its cost is fully justified because of its usefulness as eco-friendly, energy efficient, aesthetically beautiful, sustainable, etc.
- By using this concrete, higher energy efficiency ratings can be ensured as it is a green building construction material.

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