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Light Transmitting Concrete Using Waste Optical Fibre

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***Abstract* - Due to the increasing population in world and excessive use of energy, there can occur condition where all energy generating resources can be depleted. As mainly energy is generated by nonrenewable energy resources and to save these resources, there is need to make alternative energy generating as well as energy saving material. In this paper, one such construction material is reviewed which can be also called as energy saving construction material named as light transmitting concrete—Litracon. Also its manufacturing, uses, its different properties, and its effect on power consumption are reviewed. In this paper, it is conclude that, various additives and replacement in material in manufacturing of Litracon which increases its efficiency and make it more effective.**

1.INTRODUCTION

General:

An optical fiber cable, also known as fiber optic cable, is an assembly similar to an electrical cable, but containing one or more optical fibers that are used to carry light. The optical fiber elements are typically individually coated with plastic layers and contained in a protective tube suitable for the environment where the cable will be deployed. Different types of cable are used for different applications, for example long distance telecommunication, or providing a highspeed data connection between different parts of a building. Invisible IR light is used in commercial glass fiber communications because it has lower attenuation in such materials than visible light. However, the glass fibers will transmit visible light somewhat, which is convenient for simple testing of the fibers without requiring expensive equipment. The tele-communication industry is developing with an impressive rate. The competition is increasing within the telecom providers. Due to Digital revolution companies as well as consumers are upgrading to wireless networks rather than conventional telephone and internet wire lines. Due to this change in industry, optical fiber waste is produced in large amount. Hence, we can use this waste material in very efficient manner. Thus, we are using this waste optical fibers produced from telecom industry in construction of light transmitting concrete blocks. Concrete has a key role in development of infrastructure and housing. Due to great economic growth, population growth and space utilization worldwide, there is drastic change in construction technology. Small buildings are replaced by high rise buildings and skyscrapers. This arises one of the problem in deriving natural light in building, due to obstruction of nearby structures. Due to this problem use of artificial sources for illumination of building is increased by great amount. Therefore, it is very essential to reduce the artificial light consumption in structure.

The days of dull, grey concrete could be about to end. A Hungarian architect has combined the world's most popular building material with optical fiber from Schott to create a new type of concrete that transmits light. A wall made of Transparent concrete allegedly has the strength of traditional concrete but thanks to an embedded array of glass fibers can display a view of the outside world, such as the silhouette of a tree.

In order to study the light guiding property of translucent concrete, six units of translucent concrete is fabricated with different POF volume ratios of 1%, 2%, 3%, 4%, 5% and 6%, and the diameters of POF is 0.5mm. The incandescent lamp with 200W and halogen lamp with 500W are chosen to provide light. Lux meter is used for measuring light intensity.

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.

HISTORY:

This product was invented by a 27-year-old Hungarian architect by the name Aron Losonczi.

He came up with the concept while studying in the Royal university College of fine arts in Stockholm. Losconzi attributes his idea to a work of art he saw in Budapest.

The art installation was made of optical fibres and ordinary concrete and the idea of combining the two struck him and he decided to experiment. It was developed in 200.

2.OBJECTIVE

To produce light transmitting concrete by using optical fiber. Experimentally investigation on Litracon by compressive strength and light transmitting capacity test. Economical perspective of using optical fiber. To study properties of conventional concrete and its limitations with respect to light transmission. To improve performance of concrete by using plastic optical fibers as an inhere material for reinforcing. To make concrete partly transparent by using optical fibers in it to impart good appearance to structure. To study improvement in performance of concrete in light transmission by using plastic optical fiber and improve performance of structure to derive natural light. To study Energy saving for illumination by using transparent block for building. To study cost effectiveness of this high-performance concrete.

SCOPE OF PROJECT:

It is considered to be one of the best sensor materials available and has been used widely since 1990. Hungarian architect, Aron Losonczi, first introduced the idea of light transmitting concrete in 2001 and then successfully produced the first translucent concrete block in 2003, named Litracon. Since concrete is strong in compression and weak in tension and flexure. Litracon (Light Transmitting Concrete) is a cement based material which includes cement, fine aggregate, coarse aggregate, optical fiber and water. It is also known as translucent concrete. Its light transmitting properties depends on the large numbers of optical fiber in the form of strands which transmit the light through the fine concrete. But the large volume fraction of optical fiber reduces the compressive strength hence it is necessary to maintain the volume fraction of optical fiber ranges between 4% to 5% of volume of fine concrete mixture. Optical fiber use in a fine concrete which may be plastic, glassy or organic fiber. It transmits light which may be natural or artificial from one end of concrete element to another end. Light transmitting concrete greatly enhance the lighting effect of building which reduces the energy consumption of architectural lighting and promotes building energy saving. Litracon gives a good aesthetic view.It is estimated that by 2050, 50% of the developing world and 86% of the developed world will be urbanized. Increased urbanization rate along with increased global population growth will increase demand on civil infrastructure. This will lead to an increase in high rise buildings as well as skyscrapers. These type of buildings are isolated biospheres with mini-climates that mainly rely on artificial lighting internally for optical activities. Light Transmitting concrete offers a direct solution to the global indoor optical system problem.

3. LITRATURE REVIEW

Satish Kumar V and Suresh T(2015):

They produce the concrete specimen by reinforcing optical fibres with different proportion based on the volume of the cube by 0.15%, 0.25%, 0.35% to compare the strength and intensity of light passing through it. Compressive strength of the concrete is increased by 22.99% of the normal concrete for 0.25% of optical fibre. The tensile strength of the concrete is increased by 83.95% for 0.25% of optical fibre, which clearly indicates that transparent concrete transmits light without affecting the strength of concrete

Soumyajit Paul and Avik Dutta (2013)

- For obtaining transparent concrete, material comprises of mixture of polycarbonate and epoxy matrices as well as glass fibres, optical fibres, colloidal silica, silica and diethylenetriamine (DETA) and Portland cement.
- The content of the component is: epoxy matrix from 0% to 90%, and the polycarbonate matrix from 0% to 10%, colloidal silica sol from 0.5% to 5%, fiberglass from 0% to 10%, silica from 0.5% to 10%, diethylenetriamine (DETA).

Salmabanu Luhar and Urvashi Khandelwal (2015):

- They investigated the compressive strength of transparent concrete and compared with the conventional concrete, in order to find the potential of using transparent concrete for construction of green buildings.

- Three cubes of size 7cm*7cm*7cm were casted out of these two were of control concrete and one was of transparent concrete. The plastic optical fiber of diameter 1mm were embedded in it and were distributed in horizontal direction equally at distance of 8mm. they constituted 1% volume of concrete cube. The compressive strength of control concrete was observed to be 38.77N/mm2 and 40.23N/mm2 whereas that of transparent concrete was 36.70N/mm2. It can be concluded that the compressive strength of transparent concrete is similar to that of control concrete. The investigation showed that the transparent.

Sisira Sugunan , Nisha Babu , Sowparnika M (2016):

- They prepared Translucent glass Concrete block was laboratory using broken glass as aggregate. Then they get to know with all study and test on the concrete that fresh concrete made by using glass aggregate was found to have good workability.
- The provision of optical fibers along transverse direction gave ornamental effects through its translucency. The translucent glass concrete structures will become very common in the near future due to easiness in construction and the availability of raw materials. This actually makes construction more environmentally friendly due to the usage of waste glass

Urmila M Bhanuse, Abhijeet B Babar and Anil C Ranveer (December 2015):

- They study all the properties and do so many test on the concrete and came with various results. The smart translucent concrete has good light guiding property, and the optical fibers volume ratio to concrete is proportion to transmission.
- As number the Optical fibers are increased, the smaller the compressive strength is. So the transmissions cannot endless increase. Outdoor light intensity ranges from 600 lux 3500 lux in daytime between 6:00 A.M to 6:00 P.M.
- From observations it is cleared that this average value of transmission of light through block is sufficient for daily activities such as Normal Office Work, Drawing Work, Study Library, Show Rooms, Laboratories, Warehouses, Homes, Archives.

Riya Gite, Shilpa Kewate (March-2017):

- They study and research on the concrete and found out that Addition of waste glass in transparent concrete can even make the concrete sustainable and can reduce the overall cost of the project to some extent .
- The transparent concrete has good light guiding property and the ratio of optical fiber volume to concrete is proportional to transmission. The strength parameter of transparent concrete is observed to be same as the conventional concrete and it is also important fromaesthetical point of view.
- Transparent concrete can be used in temples, furniture, walls, ceiling, and panels for the best architectural appearance of the building. It can also be used in the field, where the sun light cannot reach with suitable intensity.
- This innovative kind of building material can merge the idea of green energy saving.

Bhavin K. Kashiyani, Varsha Raina, Jayeshkumar Pitroda, Dr. Bhavnaben K. Shah (February 2013):

- They prepared transparent concrete by adding optical fiber or large diameter glass fiber in the concrete mixture and they come to result with some study and test the transparent concrete has good light guiding property and the ratio of optical fiber volume to concrete is proportion to transmission.
- The transparent concrete not looses the strength parameter when compared to regular concrete and also it has very vital property for the aesthetical point of view.
- It can be used f or the best architectural appearance of the building. Also used where the light cannot reach with appropriate intensity.

Mohit Baruwala, Dr. Kaushal Parikh (January-2017);

- They made the various concrete blocks and do various test on them. Came with various results and conclusions. On usage of 4% of optical fibers the compressive strength increases.
- The compressive strength of concrete cube depends on diameter of the holes in the mould and the diameter of the optical fiber and it is directly proportion to its compressive strength.

- Translucent concrete is best option for green building concept as it is heat insulator as well as thermal insulator which maintain room temperature without being affected by external temperature.
- Weight of translucent concrete is same as conventional concrete. It can be use in many ways and highly advantageous due to power saving. That's why green building would get an easy accreditation. Translucent concrete is smart way of architectural & aesthetical evolution.

4. METHOD AND METHODOLOGY

4.1 Materials

4.1.1 Fine aggregates:

- Those fractions from 4.75 mm to 150 micron are termed as fine aggregate.
- The river sand as fine aggregate conforming to the requirements of IS: 383 used.
- Natural sand is screened, to eliminate deleterious materials and over size particles.
- Clean and dry river sand available locally is used. Sand passing through IS 4.75mm Sieve is used for casting all the specimens.

4.1.2 Cement:

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.

4.1.3 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. Ordinary potable water of normally pH 7 is used for mixing and curing the concrete. The quality of water was found to satisfy the requirements of IS: 456-2000

4.1.4 Optical Fibers

Fine Concrete: consists of cement and fine aggregate such as sand & instead of coarse aggregate optical fibers are used.

Optical fibers:

1. An optical fiber is a hair thin cylindrical fiber made of glass or transparent dielectric medium
2. Its function is to guide visible infrared light over long distances
3. It has comprises of three parts: CORE:- central tube of very thin size made up of optical transparent dielectric medium and carries the light from transmitter to receiver. The core diameter can vary from about 5um to 100um. reflection

CLADDING: outer optical material surrounding the core having reflecting index lower than core. It helps to keep the light within the core throughout the phenomena of internal reflection.

BUFFER COATING: plastic coating made of silicon rubber which protects the fiber. The typical diameter of fiber after coating is 250um -300um. 4. Three kinds of optical fiber: I. multimode graded-index fiber. II. multimode step-index fiber. III. single mode step-index fiber.

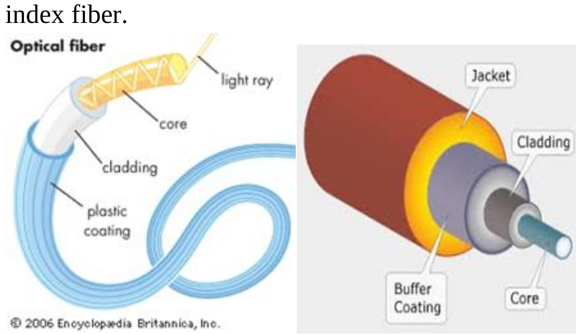


Fig No.2

4.1.5 Benefits/ Advantages of Optical Fibres:

Transparent concrete is manufactured by using combination of fiber optics and fine concrete. These fibers blend into the concrete like any other aggregates. These optical fibers can transmit light from natural and artificial sources into spaces enclosed by the translucent concrete panels. The main reason for using optical fiber in concrete is that it can transmit light even an incident angle greater than 600.

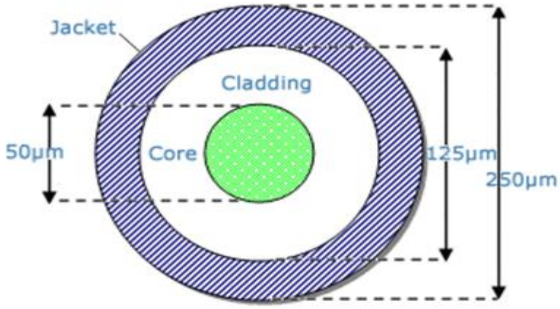


Fig No -1. Cross-section of fibres

Optical fiber consists of three layers called as core, cladding and buffer coating or jacket. The light is transmitted through the core of the optical fiber.

Transparent concrete is manufactured using fine materials only. It does not contain coarse aggregates. This concrete can have the compressive strength of that of high strength concrete around 70 MPa (10,000 psi).

4.1.5.1 Disadvantages of Optical Fibre:

Disadvantages of Optical fibre are

1. Flammable – This is definitely an advantage in that they can be melted down, however smouldering fibres can release toxic fumes into the environment.
2. Cost of Recycling – While recycling is a plus, recycling is a very costly endeavour.
3. Volume – In the United States 60% of Broadband Networks consists of optical fibres. Waste or damaged optical fibres costly to recycle and cannot be used anywhere else. As more products are being made of fibres, where this waste will this lead us in the future?
4. 4.Durability – This is an advantage as well as a disadvantage. Optical Fibres are extremely durable, which means that they last a long time. Those fibres in the landfill will be there for years

4.2 DESIGN OF MORTAR MIX

Table No 3.1 (a) Proportion of 1:3 Mortar mix

1	Cement : Sand	1:3
2	Ordinary Portland Cement 53Grade	2.053 kg
3	Plastic Optical fibers---Single Molded index fibers (0.5mm)-	3%-5%
4	Sand passing through 1.4 mm IS Sieve	6.16 kg
5	Water Ordinary potable water of normally pH 7 is used	1.026 kg

Table No 4.1 (b) Proportion of 1:4 Mortar mix

1	Cement : Sand	1:4
2	Ordinary Portland Cement53 Grade	1.662 kg
3	Plastic Optical fibers Single Molded index fibres (0.5mm)	3%-5%
4	Sand passing through 1.4 mm IS Sieve	6.65kg
5	Water Ordinary potable water of normally pH 7 is used	831 gm

4.2.1 Cutting of fibres:

- The length of optical fibres obtained was not uniform. The fibres are then chopped in small pieces. Almost 15.5 cm in length. They are chopped for making them of equal length for casting cubes. For this purpose the scissors are being used.

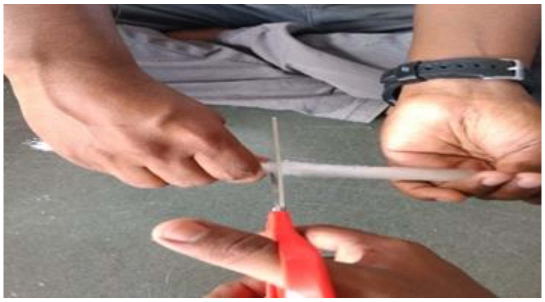


Fig No3. Cutting of fibers

4.2.2 Dry Mix:

- In this study we used 2 types of specimen i.e., 1:3 mortar mix and 1:4 Mortar mix.
- Materials used for both the types of specimen same but different in weights.
- For (1:3) ratio 2kg cement, amd 6 kg sand is used.
- For (1:4) ratio 1.662 kg cement and 6.65 kg sand is us
- For all the specimens, Cement and sand are taken by weight and are throughly mixed for about 5-10 mins.

4.2.3 Mortar Mix:(mixer used)

- After obtaining the dry mix we selected W/C ratio as 50%
- The W/C can be increased if proper consistency is not obtained.
- After adding the water proper mixing of the mortar is done and care should be taken that lumps of the mortar are not formed.


Fig No.4. Mortar Mix

4.2.4 Placing of Mortar in mould:

- After obtaining the mortar mix the placing of mortar in mould should be done
- For placing of mortar first of all the surface of the mould is oiled from all the sides so that at the time of removal of mould the cube should be removed easily without sticking to the surface of mould.
- The mortar should be placed gradually and uniformly in the mould so that the voids are minimum as possible.


Fig No.5. Placing of Mortar in mould

4.2.5 Placing of Plastic optical fibres :

- For placing of optical fiber firstly 1 layer of morter mix of thickness 1 to 1.5cm is placed in mould and immediately fibers are placed over the mortar mix.
- This procedure is repeated several times until the mould is full of mortar mix and optical fibers.
- After placing of optical fibers and mortar mix in the mould, after mould is kept for hardning of the cube.


Fig No.6.Placing of Plastic optical fibres

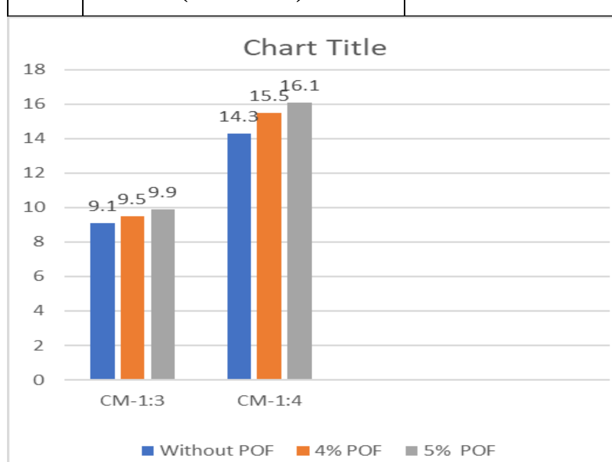
5. RESULT

The compressive strength test of 1:3 Mortar mix results were as follows.

Sr. No.	Specimen	Result (Mpa) of 28 Days curing (Avg. of 3 Cubes)
1	SPECIMEN TYPE 1 Mortar Mix 1:3 (Without POF)	9.1
2	SPECIMEN TYPE 1 Mortar Mix 1:3 (4% POF)	9.5
3	SPECIMEN TYPE 1 Mortar Mix 1:3 (5% POF)	9.9

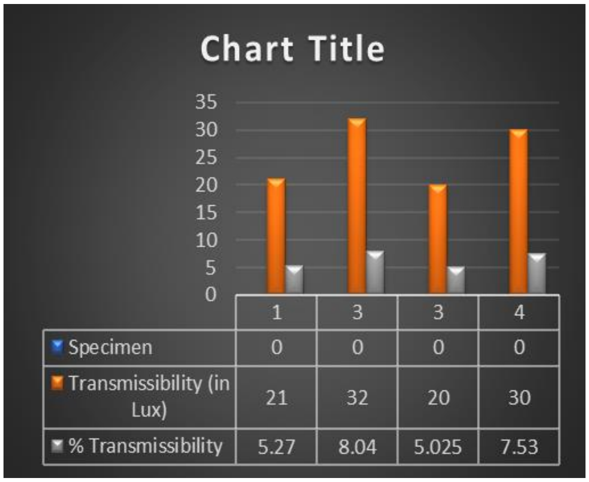
The compressive strength test of 1:4 Mortar mix results were as follows-

Sr. No.	Specimen	Result (Mpa) of 28 Days curing (Avg. of 3 Cubes)
1	SPECIMEN TYPE 4 Mortar Mix 1:4 (Without POF)	14.3
2	SPECIMEN TYPE 5 Mortar Mix 1:4 (4% of POF)	15.5
3	SPECIMEN TYPE 6 Mortar Mix 1:4 (5% of POF)	16.1



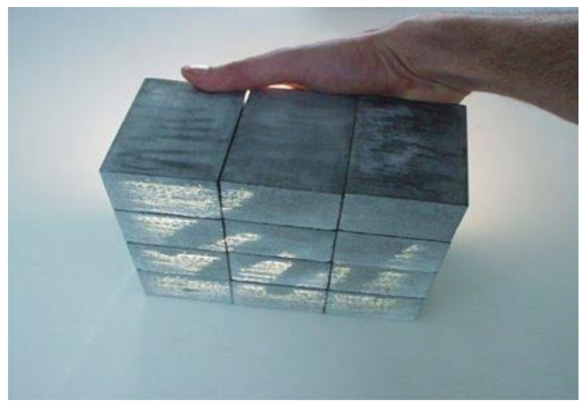
Results of Lux Meter Test :↓

	Specimen	Transmissibility (in Lux)	% Transmissibility
1	Specimen 2	21	5.27
3	Specimen 3	32	8.04
3	Specimen 5	20	5.025
4	Specimen 6	30	7.53



7. CONCLUSION

- The compressive strength of conventional concrete (0% Optical Fiber), 3% Optical fiber concrete and 5% Optical fiber concrete is changing. The compressive strength of light transmitting concrete is directly proportional to plastic optical fiber volume fraction used. Compressive strength increases with increase in volume of fiber.
- The transmissibility of light in LiTraCon is directly proportional to plastic optical fiber volume fraction used. Transmissibility increases with increase in volume of fiber.
- The transparent concrete not losses the strength parameter when compared to regular concrete and also it has vary vital property of aesthetical point of view.
- It can be used for architectural appearance of the building. Also used where the light cannot reach with appropriate intensity.
- The transparent concrete has good light guiding property
- It's a green building material reducing the lighting cost during day time. It's proved to provide both aesthetic appearance and structural stability.



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