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Effect of Plastic Optical Fiber on Light Transmitting Concrete

C.Madhu Anjeneyulu[1] and A. Mahendranath[2]
[1]Assistant Professor, Department of Civil Engineering, SVR Engineering College, Nandyal.
Email: madhuanjeneyulu.civil@svrec.ac.in
[2]M. Tech Scholar, Department of Civil Engineering, SVR Engineering College, Nandyal.
Email: angammahendra@gmail.com

***Abstract*— One new type of concrete that was introduced recently is transparent concrete, which is also known as translucent or light transmission concrete. It is the inclusion of glass rods or optical fibers that makes its special feature of light transmission possible. This concrete's main benefits are its lowered dead weight, its shortened building processes during construction, and its lowered shipping and handling costs. The material also has different properties such as low density, thermal conductivity, and is lighter than regular concrete.**

Light from one side of the block facade is able to reach the other side through the glass rods that are embedded in the wall and run the entire length. Being transparent and flexible, optical glass fibres can carry light through a waveguide or "light pipe" created by joining the two ends. Its thickness is only a little more than that of human hair. It can be either plastic or glass (silica).

The main aim of this research is to fabricate transparent substantial blocks using sand, concrete, glass poles, and optical filaments and then to compare their various physical and design characteristics with those of standard substantial blocks. For this purpose, optical strands and glass poles are propounded at four different levels 1%, 1.3%, 1.6%, and 1.9% of the total weight, respectively, in the considerable mix weight, and then the samples are taken at intervals of cm.

The essential primary goal of this research is to discern the effects of varying fibre content (from 0% to 1.9% by weight) on the compressive strength and density of concrete cubes of 100 mm x 100 mm x 100 mm in size.

***Important Terms*— optical fibres, compressive strength, transmission concrete, and density of concrete.**

I. INTRODUCTION

Concrete is a construction material which comprises cement (generally Portland cement), additional cementitious materials (for instance, fly ash and slag concrete), aggregate (normally a coarse aggregate, like rock, limestone or stone, and a fine aggregate, like sand), water, and synthetic additives. The English word "concrete" is derived from the Latin word "concretus," which means "solidified" or "hard." Concrete solidifies and hardens after being combined with water through a chemical reaction called hydration (Shing Mei Chiew, 2020).

Concrete is the most widely used man-made material and has more applications than any other man-made material.

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The worldwide annual concrete production in 2006 was more than 7 cubic kilo meters, which is more than one cubic meter per person. It was Thomas Edison who gave the patent for Portland cement in 1907. Since then, many different uses have been developed for it (H.B. Valambhiya, 2017).
Concrete can be made to produce various things such as furniture, sinks, buildings, and sidewalks. Concrete is made from dry cement which is mixed with other materials and water. Recently there have been innovations in the making of concrete and cement that allow for the growth of plants, the passing of light, and the capability of bending.

A. Light Transmitting Concrete

One of such futuristic building materials includes concrete that is visually transparent. In 2001, the Hungarian architect Aron Losonczi came up with a new type of cement which made use of 4 to 5 percent optical strands to allow light to pass through. "Light sending concrete" is a term that is used to describe a specific kind of material that is capable of letting light through it. The material has a strength similar to that of normal cement and its binding does not basically weaken. Kumar, Awadhesh (2016) mentioned that the fiber can carry light without any loss for up to 20 meters, thus, it can keep on passing light beyond the thickness of the obstacles.

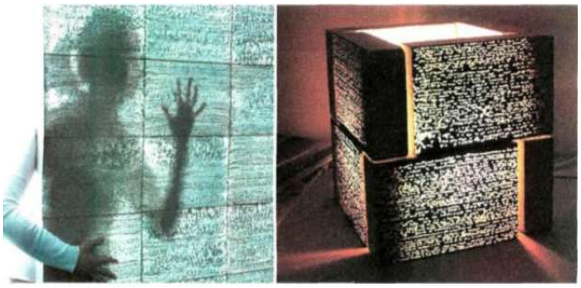


Fig 1: Light transmitting Concrete

A. Functional Principle of Light Transmitting Concrete

Soft sunshine and general illumination confuse the colour wheel, which is the surface through which the concrete panels are changing the colour. The sun is the cheapest way to light up a room. If you set the panel free-standing or close to a window, you will not need to use an artificial source of light. Research on "Nano-Optics" has been a signal for the coming of a different kind of concrete which is either translucent or transparent. Fibres which are used in optics are still very efficient in light transmission even when the small holes for the fibres are vertically aligned rather than being staggered. On slits, the optical fibres in concrete are the ones that give the material the light it needs to be seen through it.

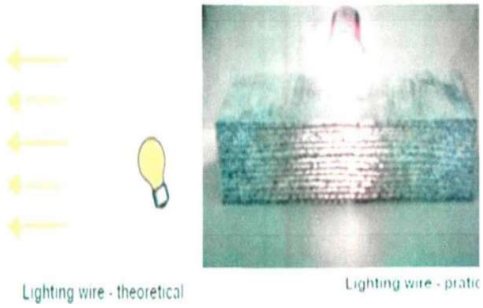


Fig 2: Functional principle of light transmitting concrete

B. Objectives of the study

Light-transmitting concrete was fabricated in the laboratory using plastic optical fibre so that scientists could perform experiments and measure its numerous characteristics.
This study examines the impact of changing the volume fraction of plastic optical fibers on different concrete properties. In particular, this study intends to:

- To create a novel "Light Transmitting Concrete" for building purposes.

- To perform a pilot study measuring the light transmission capacity of light-emitting substances applying known-force radiant and incandescent light sources while considering different amounts of plastic optical fibre content.
- Based on "IS 516:1959 methods for test for strength of cement," determine the compressive strength of light-sending concrete by changing the concrete grade and the quantity of plastic optical fibre.

II. Experimental Program

The main goal of this research was to find the compressive strength of light-transmitting concrete with different plastic optical fiber content ratios and, at the same time, to study the properties of light transmission. For this purpose, a full-scale experimental program was planned (Gandhi, 2018).
The tests carried out planned to study compressive strength and light transmittance. How much air and water can be allowed by light-transmitting concrete? The materials of light-sending concrete consisting of Ordinary Portland Cement (OPC), sand, coarse aggregate, plastic optical fiber, and water were tested as per the Indian Standard Codes of Training (Jayaraman, 2020).

- Preparing the concrete mix for the specified design.
- Making and curing the test pieces as per the test requirements.
- Testing the compressive strength and light transmission properties of the materials.
- Determining the different properties of the light-transmitting concrete by using the data obtained.

III. Materials used

A. Cement

The investigation used ordinary Portland concrete with an ACC bond rating of 53, which was bought.

Fig 3: OPC 53 grade cement

B. Coarse aggregate

Particles larger than 4.75 mm are generally called "coarse totals" in this context, with their sizes most commonly lying between 9.5 mm and 37.5 mm. They can be either new, recycled or mixed materials. The best or most natural totals are those obtained from land or sea. A rough marine-won total is rock, and won coarse totals also include beat shake. Rock constitutes by far the largest share of a concrete coarse aggregate source, while crushed stone makes up most of the rest.
The coarse aggregate that has been used in this experiment has had its nominal sizes varying between 12 mm and 20 mm.

Fig 4: 20mm coarse aggregates and 12mm coarse aggregates

C. Fine aggregate

The large majority of fine aggregates are sands, which may be either naturally occurring or extracted from the sea or land. Most of the particles in fine aggregates usually go through a 4.75mm sieve, but they can also be made of broken stone or ordinary sand. A variety of fine materials, such as river sand obtained from a local community, are used in this experiment.

Fig 5: Fine aggregates

D. Plastic Optical fiber

Their diameter is at most 2 mm. Even pure sunlight can be used to illuminate a POF. By employing these fibres in cement, one can let light enter from one side of the material and come out from the other. The light that is introduced into the POF's core is almost completely free of signal attenuation. The samples were made using P.O.F. with a diameter of 0.5 mm.

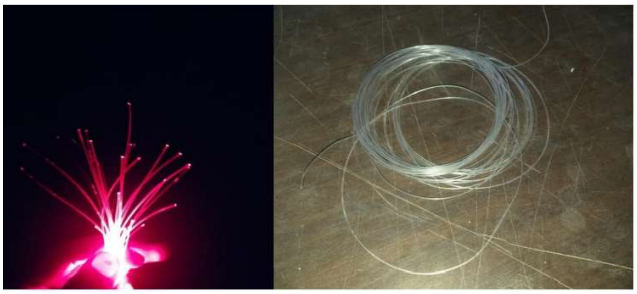


Fig 6: Plastic Optical Fiber

E. Percentage and number of fibers need for cube specimen

Optical fibre strands with a diameter of 0.5 mm are used in accordance with the proportion of plastic optical fibre utilised in the stacks.

TABLE I

Percentage of plastic optical fibre	Number of PDF strands used
0%	0
1%	500
2%	1000
3%	1500

F. Preparation of specimen for light transmittance and compressive strength test

The American Society for Testing and Materials (ASTM) demands that the 3D objects for compressive strength tests should have dimensions of no less than 5 cm and no more than 15 cm in length and 5 cm in both width and height. A task that was presumably about making wooden moulds of a size of 10cmxlOcmxlOcm out of punched hardwood sheets was carried out. The sheets for the production of electrical switches are made of wood. By attaching perforated hardwood sheets with different numbers of holes to the moulds, you could get P.O.F. blocks with different rates of perforation. How did the fibre content of the 3D square influence the changes of the apertures' width and depth.

Fig 7: Bundle of Optical Fiber Plates

Fig 8: Bundle of Optical Fiber

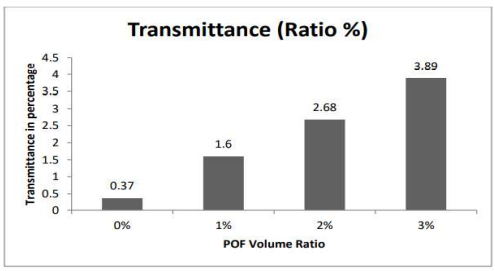
G. Preparation specimens

Using a water-cement ratio of 0.45 and two different mix proportions of 1:1.5:3 (cement: sand: aggregates), three-dimensional shapes of 10cm x 10cm x 10cm were made. The investigation included the use of 0%, 1%, 2%, and 3% Plastic Optical Fibres to evaluate POF's strength and light transmission properties. After the fibres were put, plates were attached to the wooden moulds. After concrete was poured into the moulds, they were placed on the vibrating table. The concrete was vibrated until the moulds were filled to the brim, with no fibres visible. The cubes were compacted properly on the vibrating table. The cubes were made with POF having a diameter of 0.5mm.

Fig 9: Cubes after curing for 7 days curing

IV. Experimental Results

A. Light passing characteristics



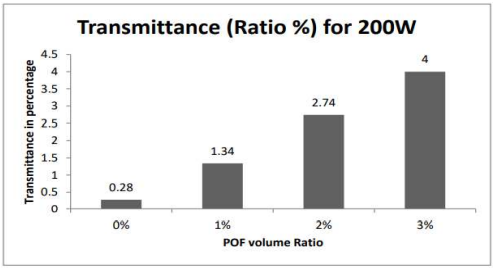


Fig 10. Graph 1: Comparison of transmittance ratio in percentage (100W)

Fig 11. Graph 2: Comparison of transmittance ratio in percentage (200W)

B. Density of concrete

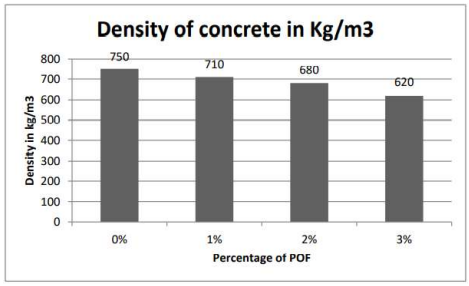


Fig 12. Graph 3: Comparison of density of concrete

C. Compressive strength of concrete

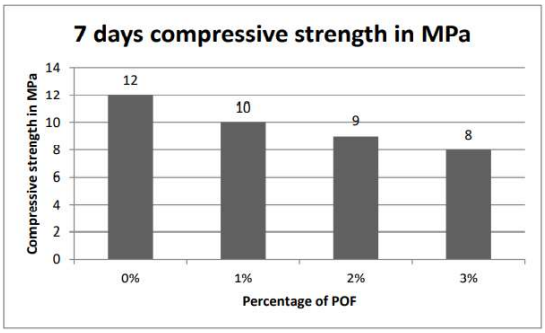


Fig 12. Graph 4: 7days compressive strength in MPa

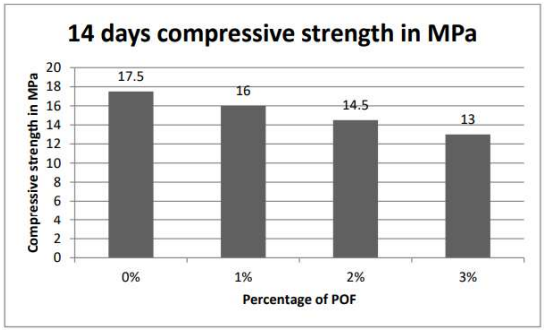


Fig 13. Graph 5: 14 days compressive strength in MPa

V. CONCLUSION

The following objectives can be realized as a result of the findings of this research exploratory.

- Light transmitting concrete is one of the essential building materials. It can be used by green buildings to increase their energy efficiency even more.
- Without a doubt, it is a material that will determine the future of architectural structural design, and its application in construction will be expanded over time.
- The transmittance (ratio%) of 100w and 200w increases in a direct correlation with the POF fraction.
- The higher number of POF leads to less dense concrete that is able to transmit light.
- The compressive strength value after 7, 14, and 28 days of curing drops as the POF fraction increases.

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