STUDY ON LIGHT TRANSMITTING CONCRETE

S. VENKATESH[1] , G. KEERTHANA[2], G.MANI KARNIKA[2*], A. SRILATHA[2], K. PRASHANTH KUMAR[2***], S. RAKESH[2****]**

[1]ASSISTANT PROFESSOR, DEPARTMENT OF CIVIL ENGINEERING IN JAYAMUKHI INSTITUTE OF TECHNOLOGICAL SCENCES NARSAMPET, WARANGAL DIST, TELANGANA, INDIA

[2, 2*, 2**, 2***, 2****]SCHOLAR, DEPARTMENT OF CIVIL ENGINEERING IN JAYAMUKHI INSTITUTE OF TECHNOLOGICAL SCENCES NARSAMPET, WARANGAL DIST, TELANGANA, INDIA

Abstract *Transparent concrete is the new type of concrete introduced in modern era which carries special property of light transmitting due to presence of glass rods or optical fibres & is also known as translucent concrete or light transmitting concrete. It is lighter than conventional concrete having special features such as low density and thermal conductivity with main advantage of reduction in dead weight, faster building rate in construction, lower haulage & handling cost. Light is transmitted from one surface of the brick wall to the other due to glass rods along the overall width of the wall which allows light to pass through. An optical glass fibre (or optical fibre) is a flexible, transparent fibre made of glass (silica) or plastic, slightly thicker than a human hair & can function as waveguide, or "light pipe" to transmit light between the two ends. Main aim of the study is to design translucent concrete blocks with the use of glass rods & optical fibres with sand & cement then analyze their various physical & engineering properties with respect to conventional concrete blocks by adding glass rods & optical fibres of 1%,1.3 %, 1.6% and 1.9% of concrete mix weight at 1 cm spacing respectively.*

The main objectives of this project is to study the values of compressive strength and density of concrete cubes of 100mmX100mmX100mm is measured for various percentages of fibres from 0% to 1.9%.

Key words: transmitting concrete, compressive strength, density of concrete, optical fibres.

1. INTRODUCTION

Concrete is a construction material composed of cement (commonly Portland cement) as well as other cementitious materials such as fly ash and slag cement, aggregate(generally a coarse aggregate such as gravel limestone or granite, plus a fine aggregate such as sand), water, and chemical admixtures. The word concrete comes from the Latin word "concretus", which means "hardened" or "hard". Concrete solidifies and hardens after mixing with water due to a chemical process known as hydration.

Concrete is used more than any other man-made material in the world. As of 2006, about 7 cubic kilo meters of concrete are made each year—more than one cubic meter for every person on Earth. Thomas Edison patented the Portland cement in 1907. Since then it is being used for a variety of different uses. Sidewalks, buildings, sinks, and furniture are but a few of the products made from cement in the form of concrete. Cement is the dry powder when mixed with other additives and water makes concrete. Over the past decade, new types of concrete and cement have been formulated that do everything from bend, to grow plants, and let light through.

1.1 Light Transmitting Concrete

One such new construction material is light transmitting concrete. In 2001 Aron Losonczi, a Hungarian Architect developed a special concrete that allowed light to pass through it by using 4to 5% optical fibers. Light transmitting concrete is a special type of concrete that allows light to pass through it. Strength of this concrete is about same as regular concrete and strength does not reduce much. It can continue to transmit light through walls up to twenty

meters thick, as the fiber works without any loss in light up to twenty meters.

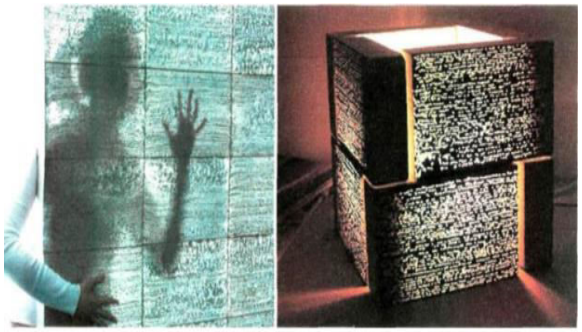


Fig 1: Light transmitting Concrete

1.2 Need for Light Transmitting Concrete

Globalization, economic and infrastructure development in the developing countries like India, China, etc. has resulted in increased usable space requirement, due to which, high rise buildings and skyscrapers are increasingly built. In these structures, people's optical activity requirements are met with the help of artificial sources of energy only. Complete dependence on artificial sources has adverse impact on our environment and health of people living in these buildings. Production of these artificial sources of energy pollutes our environment by releasing harmful by products into the environment.

Light transmitting concrete or translucent concrete is a special type of concrete that allows light to pass through it. It is made up of cement, sand, fine aggregates and optical fibers, placed in alternate layers. Light transmitting concrete allows natural sunlight or any visible light to pass through it, thus, increasing the natural light content in the building to enhance people's optical activity. This reduces the dependence on artificial sources. It is based on the principle of total internal reflection of light in the core of the plastic optical fiber. When light falls on one end of the optical fiber, it gets totally internally reflected in the fiber and gets transmitted on other end of the fiber.

This concrete is very important from sustainable development and green building point of view as it allows use of natural light more efficiently without compromising much on strength parameter much. For green buildings, according to IGBC (Indian Green Building Council), 50% of day light is mandatory which accounts for 3 credits m the green buildings. Light transmitting concrete allows sufficient light inside the building, thereby making it easier to achieve higher ratings for buildings.

Very limited research has been done on various properties of light transmitting concrete regarding its suitability as construction material. The main objective of this experimental program is to study its light transmitting and strength characteristics by varying its plastic optical fiber percentage and concrete grade.

1.3 Functional principle of light transmitting Concrete

Diffused natural light and sun light provide the frill spectrum of colors shining through the concrete panels. Sunlight is the most inexpensive light source. If the panel is mounted free standing or in front of a window, one will not need any artificial light source. Transparent concrete or translucent concrete is due to work based on "Nano-Optics". Optical fibers pass as much light when tiny slits are placed directly on top of each other when they are staggered. Optical fibers in the concrete act like the slits and carry the light across throughout the concrete.

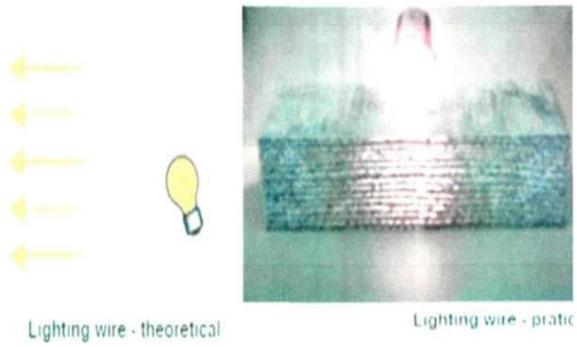


Fig 2: Functional principle of light transmitting concrete

1.4 Objectives of the study

To manufacture light transmitting concrete with the help of plastic optical fiber in the laboratory, in order

to conduct an experimental study on the light transmitting concrete investigate its various properties.

In the present study, the effect of varying the plastic optical fiber percentage (volume fraction) on various properties of the concrete is investigated. The precise objectives of the study are as follows:

1. To construct a special type of construction material "Light transmitting concrete".
2. To study experimentally light transmittance intensity of light transmitting concrete using incandescent and halogen source of light of known intensity with respect to varying percentages of plastic optical fiber in the light transmitting concrete.
3. To study the compressive strength as per "IS 516:1959 methods of test for strength of concrete" Of light transmitting concrete by varying the percentage of plastic optical fiber, and also varying the grade of concrete.

2. LITERATURE REVIEWS

Shing Mei Chiew, Izni Syahrizal Ibrahim, et al., (2020) This paper provides an overview on the development of Light-transmitting Concrete (LTC). Concrete is improved in terms of transparency by installing optical fibres into the concrete. The application of LTC in building enables light transmission, which reduces light energy consumptions and carbon footprint, providing a more sustainable living environment. From this project we conclude that Light transmitting concrete (LTC) is an innovative construction material which transmits light through the concrete and improves the lighting effect inside the building. LTC can reduce the light energy consumptions and carbon footprint produced, which promotes green building construction especially in urban area.

H.B.Valambhiya, T.J.Tuvar, P.V.Rayjada, et al. (2017) This paper describes historical development of Light Transmitting concrete and various methods to produce and given Light Transmitting concrete panel. Also discussed about two case studies on Light Transmitting concrete panel or block made project by LiTraCon and Italcementi Groups.

From this project we concluded that the Development of Light Transmitting Concrete reveals that can be used in many ways and implemented into many forms and be highly advantageous. Two case studies and compare of two companies concrete panel application i.e. Italcementi Groups, LiTraCon.

Awadhesh Kumar, Rahul Ahlawat, et al,. (2016) Light transmitting concrete is the need of hour. Light transmitting concrete allows natural (i.e. sunlight) or any other light to pass through it. Thus reduces electricity consumption in the buildings and makes easy for them to achieving higher LEED (Leadership in Energy and Environmental Design) rating. It has all those properties which an eco-friendly technique should have to keep up the green building concept into consideration, as it increases the use of natural resource i.e. sunlight, which is natural light and it reduces the use of electricity, thus, saving power consumption.

From this project we conclude that Light transmitting concrete requires skilled labour for its production, as POF should be properly placed in concrete, and special attention is needed while placing concrete, to ensure no damage of POFs. Light transmitting concrete can be used in structures to make them architecturally and aesthetically beautiful, as various types of glowing patterns can be made with this concrete. Cost of manufacture of light transmitting concrete is also high due to plastic optical fibers used and special care is required during its preparation.

3. EXPERIMENTAL PROGRAM

To achieve the objectives of this experimental study, an extensive experimental program was planned, which included studying the light transmittance characteristics, evaluation of compressive strength of the light transmitting concrete for various plastic optical fiber ratio.

The following test program was planned to investigate the light transmittance, compressive strength. Air and water permeability of the light transmitting concrete. To obtain the physical properties of the constituents of light transmitting concrete i.e. Ordinary Portland Cement (OPC), sand, coarse aggregate, plastic optical fiber and water, tests

wise carried out as per relevant Indian Standard Codes of Practice.

1. Obtaining the design mix for concrete.
2. Casting and curing of specimens as per the requirement of the test.
3. Testing of specimens for light transmittance characteristics, compressive strength.
4. Analyzing the observations to obtain various properties of the light transmitting concrete.

3.1 Materials used

3.1.1 Cement

In this examination Ordinary Portland concrete of 53 review (ACC bond) has been obtained and has been utilized.

Fig 3: OPC 53 grade cement

3.1.2 Coarse aggregate

Coarse aggregates s are particles more prominent that 4.75mm yet by and large range between 9.5mm to 37.5mm in distance across. They can either be from essential ,auxiliary or reused sources. Essential or virgin aggregates s are either land or marine-won. Rock is a coarse marine-won aggregates, arrive won coarse aggregates s incorporate rock and pounded shake. Rock comprise the greater part of coarse aggregates utilized in concrete with pulverized stone making up the majority of the rest of.

In this study coarse aggregate of nominal sizes of 20mm, 12mm are used.

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

3.1.3 Fine aggregate

Fine aggregates are essentially sands won from the land or the marine condition. Fine aggregates by and large comprise of common sand or smashed stone with most particles going through a 4.75mm sifter. The fine aggregates utilized in this investigation is stream sand which is gotten from neighborhood organization.

Fig 5: Fine aggregates

3.1.4 Water

Water is a critical element of concrete as it effectively takes part in the synthetic response with bond. Since it shapes the quality giving concrete gel, in the amount and nature of water is required to be investigated deliberately. C3S requires 24% of water by weight and C2S requires 21%.

3.1.5 Plastic Optical fiber

An optical fiber (or optical fiber) is a flexible, transparent fiber made of extruded glass (silica) or plastic, slightly thicker than a human hair. It can function as a waveguide, or "light pipe", to transmit light between the two ends of the fiber. The field of applied science and engineering concerned with the design and application of optical fibers is known as fiber optics.

These can have diameters up to 2mm. POF 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 POF when light passes through its core. P.O.F of diameter 0.5mm has been used for preparing samples.

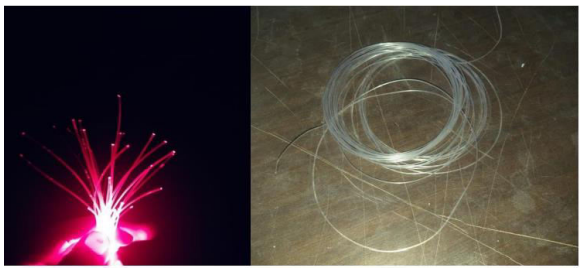


Fig 6: Plastic Optical Fiber

3.1.6 Water

Clean potable water was used from the tap in concrete lab. This water was used in making concrete specimens. Water was free from suspended solid and organic materials, which might have affected the properties of fresh and hardened concrete. The P" value of the water was 7.6.

3.2 Percentage and number of fibers need for cube specimen

Number of O.5 mm diameter POF strands as per percentage of Plastic optical fiber used in the cubes

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

3.3 Preparation of specimen for light transmittance and compressive strength test

As per ASTM, cubes for testing compressive strength should be between 5cmx5cmx5cm to 15cmxl5cmxl5cm. In this study, wooden moulds of size lOcmxlOcmxlOcm 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: Bundle of Optical Fiber Plates

Fig 8: Bundle of Optical Fiber

3.4 Preparation specimens

Concrete of two mix proportions i.e. 1:1.5:3 (cement: sand: aggregates) with water cement ratio 0.45 was used for preparing cubes of lOcmxlOcmxlOcm size. Varying percentage of Plastic Optical Fibers such as 0%, 1%, 2% and 3% were used to study strength and light transmittance characteristics of POF. After placing fibers, plates were fitted to the wooden moulds. 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 9: Cubes after curing for 7 days curing

3.5 Test for light transmittance property

Light transmittance test was performed to study the light transmittance characteristics. It is most important test to be performed, as main purpose of translucent concrete is to transmit light. Transmittance ratio is found by measuring intensity of incident light and transmitted light. Intensity of light is measured with the photometer. Photometer measures intensity of light in terms of lumens.

3.6 Experimental setup for light guiding property test

For studying light guiding property of light transmitting concrete, samples of P.O.F volume ratios of 0.00%, 1%, 2%,and 3% were cast. The transmittance was measured by Photometer (or lux meter) that measures intensity of light in lumens, having range of 0.1 to 1,00,000 lux. The incandescent lamp with lOOW, 200W and halogen lamp with 500W were chosen as light source.

A wooden box with light source fitted on one face, photometer was attached on other face in the box, such that all light transmitted from the sample falls in the box of photometer. Readings of transmitted light were noted from photometer. Precaution was taken to see that the box of photometer was correctly attached and all transmitted light fall in the box.

Fig 10: Experimental setup to find light guiding property of light transmitting concrete

3.7 Density of concrete

Density of construction materials are its mass per unit volume of materials. It is expressed in kg/m3 or lb/ft3 and shows compactness of building material.

Density is defined as the ratio of mass to volume

p = m/v

3.8 Compressive strength test

This test was directed according to ([9] IS516-1959). The cubes of standard size 150x150x150mm were utilized to locate the compressive strength of concrete. Examples were put on the bearing surface of CTM, of limit 200T without unusualness and a uniform rate of stacking connected till the disappointment of the solid shape.

Fig 11: Testing 7days compressive strength for cube

Fig 12: Specimen after failure in CTM

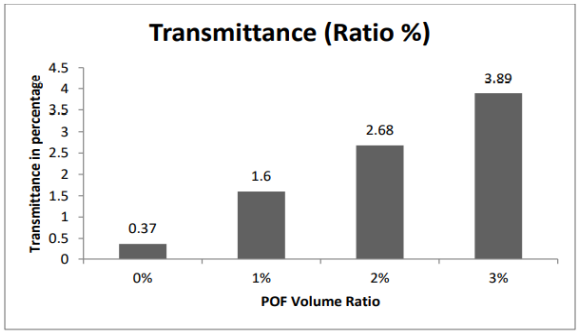
The compressive strength of cube = (P/A) N/mm2

Where, P is load at failure in N,

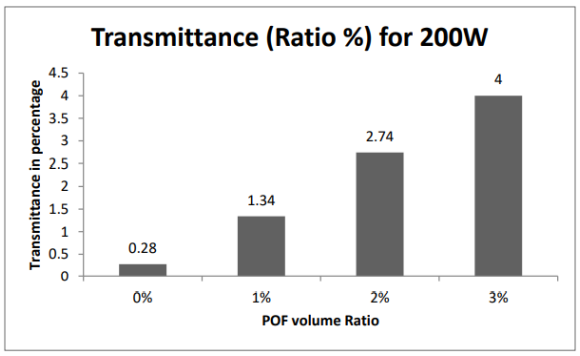
A is area of cube/contact in mm2.

4. EXPERIMENTAL RESULTS

4.1 Light passing characteristics

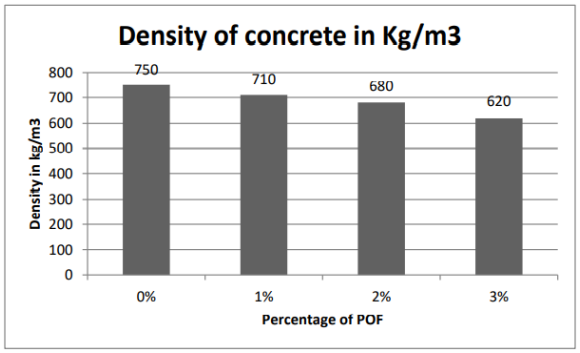


Graph 1: Comparison of transmittance ratio in percentage (100W)



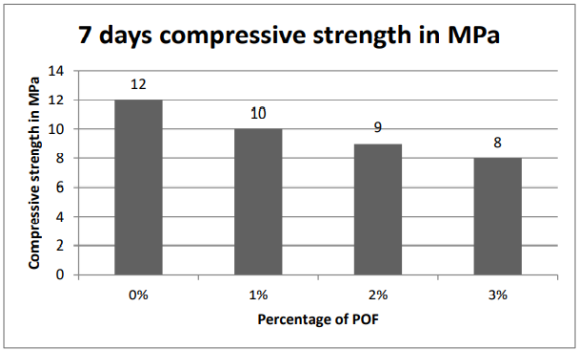
Graph 2: Comparison of transmittance ratio in percentage (200W)

4.2 Density of concrete

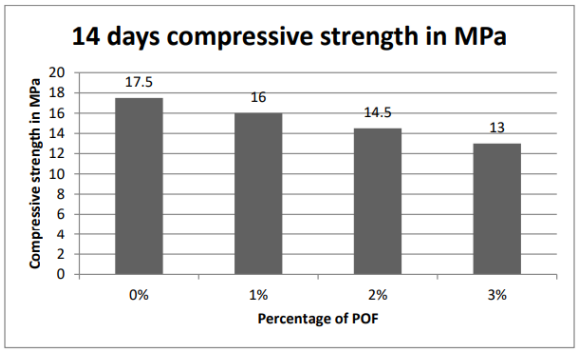


Graph 3: Comparison of density of concrete

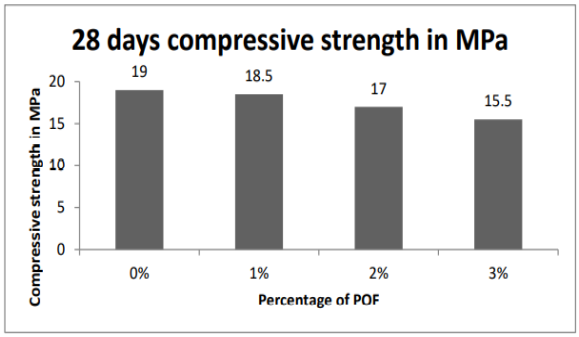
4.3 Compressive strength of concrete



Graph 4: 7days compressive strength in MPa



Graph 5: 14 days compressive strength in MPa



Graph 6: 28 days compressive strength in MPa

5. CONCLUSIONS

The following conclusions can be drawn based on the results of this experimental work.

1. The light transmitting concrete is very advantageous construction material. It can be used in green buildings to increase the energy efficiency of the structure.
2. 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.
3. The Transmittance (Ratio %) of 100w and 200w increases with increasing the percentage of the POF.
4. Density of light transmitting concrete decreases with increasing the percentage of the POF. 5. The value of compressive strength for 7, 14 and 28 days of curing decreases with increasing the percentage of the POF.

REFERENCES

[1]. Shing Mei Chiew, Izni Syahrizal Ibrahim,et al., (2020), ―DEVELOPMENT OF LIGHTTRANSMITTING CONCRETE‖, Materials Today: Proceedings.

[2]. H.B.Valambhiya, T.J.Tuvar, P.V.Rayjada, et al., (2017), ―HISTORY AND CASE STUDY ON LIGHT TRANSMITTING CONCRETE‖. Journal of Emerging Technologies and Innovative Research (JETIR).

[3]. Awadhesh Kumar, Rahul Ahlawat, et al., (2016) , ―EXPERIMENTAL STUDY ON LIGHT TRANSMITTING CONCRETE‖. IJISET - International Journal of Innovative Science, Engineering & Technology.

[4]. Poornima D, Shailaja T, Pooja H P, et al., (2019), ―AN EXPERIMENTAL STUDY ON

LIGHT TRANSMITTING CONCRETE‖. International Research Journal of Engineering and Technology (IRJET).

[5]. Kavya S, Karthik D, Sivaraja M, et al., (2016) ―AN EXPERIMENTAL STUDY ON LIGHTEMITTING CONCRETE‖. International Journal of Advanced Research in Education & Technology (IJARET).

[6]. Nikhil k, Ummer farook nk, Silal ahmed ks, et al., (2016), ―Experimental Analysis of Translucent Concrete by using Optical Fibers‖, SSR G International Journal of Civil Engineering (SSRG-IJCE).

[7]. Bhruguli Gandhi, et al., (2018), ―REVIEW ON LIGHT EMITTING CONCRETE‖, International Journal For Technological Research In Engineering.

[8]. A Jayaraman, et al., (2020), ―LIGHT TRANSMITTING CONCRETE USING ECO FRIENDLY MATERIALS (WASTE MATERIALS)‖