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Strength and Light Transmittance of Plastic Fiber Concrete

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Abstract: ***The present consumption of electricity at a high rate for illumination purposes calls for new and innovative methods to use the natural source of lighting ie.sunlight. This study aims the use of plastic fiber in concrete in order to transmit sunlight into buildings. The properties of the cement, aggregate and plastic fiber were analyzed. The cube specimen prepared was tested for light transmittance property and compressive strength. Loss of signal strength was found to be 0.2V when attenuation experiment was carried out. The intensity of light coming from the concrete cube was found to be sufficient for viewing purpose. The cube specimens also gave sufficient strength results which makes it suitable for its use in purposes.***

Keywords: Plastic Fiber, Attenuation, Light Intensity, Compressive Strength

I.INTRODUCTION

Inclusion of various materials like glass, plastic fibre (Vishnu et al.2017) in concrete as been an area of research in the past. Transparent concrete is a newly developed type of concrete that allows light to pass through it. It was invented by a Hungarian architect Aron Losonezi (Bhavin K Khashiyani et al., 2013). Recent studies show that India's per capita electricity consumption touched 1010 kW. A part of it is utilized for illumination purpose. If the walls of our building can utilize the natural lighting and allow it to be transmitted to the interior portions, we could save a part of energy. Allowing the entry of natural light into the living space will not only help in reducing the consumption of electricity for illumination as well as improve the aesthetic value of the building. The light transmittance property in concrete can be aided by using optical fiber or Plastic Fiber. Studies have also been carried out with glass rods and optical fiber(A.A. Momin et.al.,2014) Both can transmit light as well contribute to the strength of concrete. Reduction of usage of concrete can also be achieved when using light transmitting concrete. The use of multiple fibers is found to transmit more energy than single fiber (Bhavin K Khashiyani et al.,2013). Therefore the use of multiple plastic fiber strands has been experimented in the concrete specimens and their light transmittance and compressive strength properties have been studied.The smart transparent concrete has good light guiding property(Jianping He et al.2011). Optical fibers have also found its application in sensors such as fibres Bragg Grating, Brillouin distributed sensors and plastic optical fiber sensors.

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These have been widely used for the in situ monitoring of major projects (Kalymnios, 2005).

II.EXPERIMENTAL INVESTIGATION

A. Materials

Portland Pozzolano cement of 33 grade procured from the local market was used and it was tested for physical and chemical properties as per IS: 4031-1988 and found to be conforming to various specifications as per IS: 12269-1. The fine aggregate used is M sand which was locally available. The physical properties of fine aggregate like specific gravity, bulk density, gradation and fineness modulus were tested in accordance with IS:2386-1975.Coarse aggregate used in the study was tested for physical properties like specific gravity, bulk density, gradation and fineness modulus in accordance with IS:2386-1975 Plastic fiber utilized in the study was tested for attenuation and was preferred over glass fiber since there was no appreciable loss in signal strength. The type of fiber which was used in this experiment was HYFC-2037 which is used for LED sources of wavelength 800-1300nm (nanometer) the diameter of fiber selected was 50 micron & length is a 15cm.

B. Specimen Preparation and Test Procedure

a. Specification of Mould

The use of ordinary mould could not be used for making light transparent concrete, therefore a special type of mould was fabricated. Steel mould was made with perforations of 8mm diameter drilled using an automatic drill on opposite sides. Each side of the mould had 6x6 perforations, which means a total of 36 holes were made on each side as depicted in Fig 1.The size of the mould used was 10x10x10 cm.

Fig.1. Mouldused for Casting

b. Casting of Specimen

The mix design of concrete was done using IS: 10262.The cement: sand: aggregate ratio was chosen as 1:1.46:2.18 and water cement ratio as 0.5. Each cube was cast with 75 fibers in each perforation. The ends of the fibers were concealed with a knot so as to prevent inward sagging of the plastic fibers while cement mix was poured into the mould.

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The mould was completely filled with the mix and the top part was leveled off using a trowel. Compaction was achieved using a tamping rode along with table vibrator. After 24hrs, the specimen is demoulded and transferred to a water tank for curing. Based on the proposed ratio a control specimen was casted in order to compare the properties with special cube.

Fig.2.Casting of Transparent Concrete

III.TESTS CONDUCTED

A. Light Transmittance

Luxmeter is a special engineered device able to measure brightness. Luxmeter especially measures the intensity of bright detected by human eye. The experimental setup consists of a cardboard box, a bulb and Luxmeter.

Fig.3. Luxmeter and the Experimental Setup

A rectangular hole about the size of the cube to be tested was cut on one side of the box. The cube was carefully inserted into the cut section. Special care should be taken so that light does not enter from the corners or other part of the box. A bulb was hung outside the cardboard in front of the cube. Luxmeter was placed inside the cardboard box to measure the intensity of light coming inside the box was observed in lumens by the Luxmeter. Similarly the sensor of the Luxmeter was placed at various distances from the cube (viz: 5cm, 10cm, 15cm and 20cm).

B. Attenuation in Plastic Fiber

Attenuation is the loss of intensity of light or loss in signal strength when light passes through the fiber. The loss of intensity of light has to be determined in order to ascertain whether this plastic fiber could be used in developing light transmitting concrete. Cut back method was not possible to be used in our experiment because this method can be used for finding the attenuation in long fibers only hence we used another experiment setup to find the attenuation in the fiber. The experimental setup consists of a helium neon laser system (Rd) with a power output of10mW, detector and a voltmeter as shown in the figure. The helium neon laser system shoots a beam of red light. A fiber was placed between the laser system and detector. One end of the strand was made to face the laser and the other end was connected to a detector. The laser beam passes through the plastic fiber strand and the light coming from the other end is measured using a detector which is connected to a voltmeter. The voltmeter converts the intensity of light into volts. Similarly, a ray of laser beam was allowed to fall directly onto the detector without any fiber placed in its path. The values of both the readings were compared and the loss in intensity is found out.

Fig.4. Experimental set up for the Determination of Attenuation of Fiber

C. Compression Test

Compressive strength of concrete is defined as the load, which causes the failure of a standard specimen divided by the area of cross section in uniaxial compression under a given rate of loading. Control specimen as well as plastic fiber concrete was tested and Ultimate load is noted for each specimen.

IV.RESULTS AND DISCUSSIONS

The observations and results of the tests performed are discussed below. The results are quantified and analyzed to measure the effectiveness of transparent concrete in terms of its light transmitting capacity and compressive strength is found out.

A. Measurement of Intensity of Light using Luxmeter

The observations of this experiment clearly indicate that as the number of plastic fiber strands inserted in the cube increases, its light transmitting capacity also increases.

Table 1.Measurement of Intensity of Light using Luxmeter

Distance from light source (cm)	Reading without cube (in lux)	Reading with cube (in lux)
5	4140	32
10	2310	24
15	1408	19
20	956	13

B. Attenuation in The Plastic Optic Fiber

The recorded value when light was made to fall directly onto the detector was 0.469 V and the recorded value when a fiber stand was placed in between was 0.205V.

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This clearly shows that there is loss of 0.2V When light passes through the fiber strand which is not much considering the short length of the stand. Therefore, this fiber can be effectively used for illumination purposes.

C. Compressive Strength

Compressive strength of the control specimen and special cubes are tested at 7 day and 28 day, the results of which are shown in Table no 2. Plastic fiber concrete specimen gives strength of 21N/mm^2 at 28 days whereas the control specimen gave 27.5N/mm^2. Since the plastic fiber concrete gave considerable strength it can be used for construction works

Table 2. Compressive Strength Results (N/mm^2)

Control Specimen		Plastic Fiber concrete specimen	
7day	28day	7day	28day
20	27.5	15	21

V.CONCLUSION

Plastic fibers could be used instead of glass fiber as there is not much loss of signal strength when these fibers were used. To obtain maximum efficiency and minimum attenuation, it is preferable to use optical fiber. Loss of signal strength was found to be 0.2V when attenuation experiment was carried out. Also it was found out from experiment using lux meter that natural lighting could be made available by the use of plastic fiber concrete in a room without the use of artificial lighting during daytime since Natural light intensity reading of about 30lumens coming out from the light transmitting concrete is sufficient for viewing purposes. The compressive strength of the cubes was found to be 21N/mm^2 which does not vary much from the control specimen hence they can be used for construction purposes.

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