

PERFORMANCE EVALUATION OF LIGHT TRANSMITTING IN M₂₀ GRADE CONCRETE

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Abstract

Concrete structural components exist in buildings in different forms and shapes. This concrete plays vital role in construction industry and at present scenario it is important produce concrete structures without affecting the environment. So, to produce sustainable concrete a new development is necessary to deal with. Therefore Light transmitting concrete is one option that utilise the natural light source effectively and at the same time satisfying the strength and aesthetic needs. This project deals with producing light transmitting blocks using the plastic optic fiber (POF) in cement mortar and concrete. Here the Plastic optical fibers are embedded in the concrete to transmit the light effectively. Fibres (by weight) are sandwiched between each layer of mortar and concrete and comparative study carryout on compressive strength of the normal concrete and concrete with addition of POF in different percentage. The result indicates that, compressive strength of light transmitting concrete is equal to the normal concrete strength. Light transmittance through these concrete are found by measuring the current corresponding to the light which can be measured by Light Dependent Resistor (LDR). Light transmittance ability for the cement mortar blocks samples found to be 5 to 10% in and 3 to 6% in concrete blocks. The result indicates that cement mortar blocks have high transparency than concrete blocks.

Key words: *Translucentconcret , Plastic Fibre Optics ,Light Dependent Resistor Etc....*

1.INTRODUCTION:

Nowadays, Concrete is the most use building material all around, it takes on nearly any shape and forms the backbone of the variety of world's construction. It is the mixture of cement, fine aggregate and coarse aggregate. It is used to construct Massive bridges, Manmade water ways, Mega dams, Super highways, the world's tallest Skyscrapers and so on over all around the world. Because of its strength and durability it can be used in underground tunnels also. In fact, 50% of day light is mandatory requirement in a green building according to Indian Green Building Council accounting for 3 credits. But, this can be possible only by embedding plastic optic fibre in a concrete. The new development in concrete technology is allowing the day light through the concrete blocks by embedding the plastic optic fibres.

1.1 Fibre Optics:

It is a composition of fibre and optics, where the light are travelled in the kind of glass or plastic fiber. Optic fibers are worked in the principal of total internal reflection. When light incident at the interface between the core and cladding at the different angles. Some power or light is reflected back and some power is entered into cladding,

which is known as refracted. When we increase the incident angle greater than the critical angle, no more light enters into the cladding. This phenomenon is called total internal reflection.

Generally there are two types of optical fiber. Glass optical fiber (GOF) and Plastic optical fiber (POF). In this project, we used Plastic optic fibers, because of low cost when compared to glass optical fiber. It is an optical fiber which is made out of plastic. Traditionally PMMA (acrylic) is the core material, and fluorinated polymers are the cladding material. In large – diameter fibers, 96% of the cross section is the core that allows the transmission of light. Similar to traditional glass fiber, POF transmits light (or data) through the core of the fiber. The core size of POF is in some cases 100 times larger than glass fiber.

1.2 Plastic Optical Fibre

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FIG.1.PLASTIC OPTIC FIBER

The core and cladding layer are based upon Extremely pure fused silica, which is a fiber glass which almost no impurities which help to very low loss for long distance transmission. Snell's law which guides how light travels at interface of the core and cladding (reflection and refraction)

1.3 Light Dependent Resistor(LDR)

LDR is also called as Photo Resistor or photo cell is a light controlled variable resistor. The resistances of a photo resistor decreases with increasing incident light intensity. In other words, it exhibits photo conductivity. In this project, LDR is used to measure the Light transmitting property of the concrete / cement mortar blocks.

1.4 Objectives of the projects

1. To identify and study the following Fresh and Harden properties of translucent concrete:

- Workability of the concrete
- Compressive strength of the concrete
- Light transmitting property of the concrete

2. To compare the conventional concrete and the concrete in which plastic optic fibers are embedded.

1.5 Applications Of LTC :

- Light sidewalks at night & lamps
- Increasing visibility in dark subway stations
- Lighting indoor fire escapes in the event of a power failure
- Illuminating speed bumps on roadways at night
- Stairs & Decorative tiles

1.6 Scope Of Project

In the current scenario, energy efficient building materials and concepts have been attracted much attention by the engineers. Usually, office buildings like IT park, and commercial buildings like theatres, malls are constructed by concrete material. The luminosity of those indoor environment is completely with stand by the artificial lights which consume much electricity. Constant maintenance and repairing is needed to enhance the life cycle of those environment. There is only one way to minimize the cost of electricity in those buildings by making the concrete as a transparent, which allows the day light to inside of the building. The current approach is to achieve this kind of concrete by inducing or embedding plastic optic fiber.

This also helps to improve the architectural view of the structure as a facade material and for cladding of interior walls. The main purpose is to use sunlight as a light source to reduce the power consumption of illumination and to use the optical fiber to sense the stress of structures. This technology have more scope on making glowing sidewalks, and speed bumps for drivers at night.

Another approach is made to replace the traditional concrete materials, coarse aggregate (gravel), fine aggregate like sand and cement with plastics and glass of various sizes and bind them together with transparent glue which having more scope in the manufacturing of transparent panels.

In order for this concrete to be a viable construction material, it must be able to compete economically with existing light transmitting concrete materials. This project deals specifically with the concrete embedded by the low cost plastic optic fibres.

2.METHODOLGY

2.1 GENERAL:

The following procedure is followed to make light transmitting blocks:

2.2Preparation Of Light Transmitting Concrete Block:

2.2.1 Preparation Of Mould

Separate mould prepared to construct these blocks, the dimension of our mould is 30(l) x 30(b) x 30(h) cm. Here, length and breadth of this mould is equal to same as the length of the fibre what we using.



FIG. 3 PREPARED MOULD (30x30x30cm)

2.2.2 Batching Of Materials

Batching of materials can be done by taking weight of each material using to make transparent concrete blocks. Here Batching done for Concrete / Cement mortar and Plastic optic fibres used to construct one single block.



Fig-3 (a).53 Grade PPC Cement



Fig-4(b). Sieved fine aggregate



Fig-6 (c).Sieved coarse aggregate



Fig-7 (d).Plastic optic fiber

3.2.3 Mixing Of Materials

After the Batching process, materials are ready to mix. By adding the water using the water cement ratio value the fresh concrete/ Cement mortar are made.



FIG.5WATER

**FIG.6 MIXING**

3.2.4 Casting Process

These blocks are made by the making the alternate layers of concrete and fibres. Fibres layers are placed according to weight proportion of the concrete layer. Due to this simultaneous layers of the fibre, light can be transmit effectively through the concrete. Here, the cement mortar and concrete block contains 20 and 7 layers of POF respectively. In order to achieve the good strength, each layer of concrete and cement mortar are vibrated upto 30 - 35 and 45 - 50 sec. respectively

**(a).Concrete layer**



(b). Fibre layer

FIG.7 DISTRIBUTION OF LAYERS

3.2.5 Curing process

Once the Casting process is completed, the cube is allowed for curing for a particular period. Here the cube is kept for 7 days curing.



FIG.8 CURING



FIG.9 HARDENING

2.2.6 Cutting The Excess Faces

After the curing process gets completed the cube is taken away from the curing area and allowed to dry the surface of the concrete cube. Then the excess faces are marked for cutting. By using concrete cutting machine, these excess faces are removed and which allows light to transmit from one face to another.



FIG.10 CUTTING PROCESS

2.2.7 Final Product:



FIG.11 LIGHT TRANSMITTING BLOCKS

3.Experimental Analysis

3.1 Compressive Strength Test:

Compression test is the most common test conducted on hardened concrete, partly because it is an easy test to perform and partly because of the most desirable characteristic properties of concrete is qualitatively related to its compressive strength.

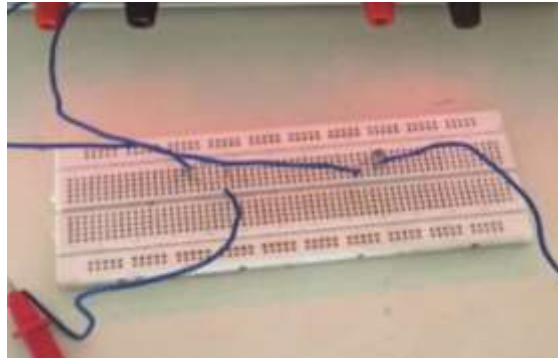
The compression test is carried out on specimens cubical or cylindrical in shape. Prism also sometimes used, but it is not common in our country. Sometimes, the compression strength of concrete is determined using parts of beams used in flexure. The end parts of the beam are left intact after failure in flexure and because of the beam is usually square cross section, this part of the beam could be used to find the compressive strength.

In this project we adopted the addition of 1% of POF by its total volume of concrete and a nominal mix without any addition of fibres (0%). For each percentage we casted 3 cubes in order to test the cubes after the completion of 28 days curing

3.2 Experimental Setup To Find The Light Transmitting Property Of Concrete:

The light transmittance through the sample can be measure by measuring current corresponding to the light which can be measured by a photo diode or a light dependent resistors (LDR).

The source of light here is taken as 60 w incandescent bulbs, to ensure no light escapes throughout the test, a box made up of cardboard is made.



(a). Bread board



(b)Circuit setup



(c). Circuit arrangement



(d). Cardboard setup

The light source is placed at the top of the specimen and LDR is placed at the bottom. The sample is placed between source and LDR and test is carried out. Reading are taken by differing the voltage. So two readings are taken, one without sample (A₁) and one with sample (A₂).

Amount of light transmitted is calculated as follows

$$\text{Light transmittance} = 100 - \left[\frac{A_1 - A_2}{A_1} \times 100 \right]$$

Where,

A₁ = Ammeter reading without specimen.

A₂ = Ammeter reading with specimen.

4. Results And Discussion

4.1 General:

Preliminary test results were stated at the end of each test procedure and the materials which we used in making the concrete provides satisfactory results during the preliminary test on materials.

In this chapter the major test results of compressive strength on concrete, cement mortar cubes and light transmitting test are described below,

4.2 Compressive Strength Test On Cement Mortar Cubes:

The main purpose of the cement mortar test is to observe the cement – fine aggregate behavior in paste phase.

TEST RESULT FOR CEMENT MORTAR RATIO 1:3

After 28 days, **Compressive strength = load/area**

$$= 475 \times 10^3 / 22.5 \times 10^3$$

$$= 22.89 \text{ N/mm}^2$$



Compression Test On Cement Mortar

TABLE 3 - COMPRESSIVE TEST RESULTS FOR CEMENT MORTAR:

S.No	Concrete Specification	Days	Compressive strength N/mm ²			Average N/mm ²
1	Normal mortar	7	8.74	8.14	8.59	8.49
		14	13.1	12.2	12.8	12.7
		28	26.2	24.4	25.7	25.4
2	Optical fibre mortar	7	7.63	7.40	7.63	7.5
		14	11.4	11.1	11.4	11.3
		28	22.8	22.2	22.8	22.6

4.3 Compressive Strength Test On Concrete Cubes:

The cubes are tested for curing period of 28 days, after the curing process gets completed the cubes are taken away from the curing area and allowed to dry the surface of the concrete cubes only and not the inner portion of the cube, the inner portion should be in a wet state this state is called saturated surface dry condition (SSD). About 6 cubes have been casted in our project and all the cubes are tested in the saturated surface dry condition only.

The accurate strength attained by the concrete is determined only when it is tested in SSD condition, if the concrete specimens are allowed to dry for a long period and it is not tested under SSD conditions, then it shows misleading results, so testing of the specimen under SSD condition is ideal and advisable.

Special attention should also be adopted when placing the concrete cubes in the compressive strength testing machine, as the cubes are placed centrally in the direction of the load application, then the cubes are broken at the exact failure load, if the cubes get failure at a lower failure load itself, so placing of the specimen in the testing machine also plays a vital role in the testing process.

TEST RESULTS FOR M20 GRADE:

After 28 days

Compressive strength = load/area

$$= 580 \times 10^3 / 22.5 \times 10^3$$

$$= 23.11 \text{ N/mm}^2$$



FIG.16 Compression Test On Concrete

Table-4-Compressive Test Results For Concrete:

S.No	Concrete Specification	Days	Compressive strength N/mm ²			Average N/mm ²
1	Normal mortar	7	8.7	8.1	8.5	8.4
		14	13.1	12.2	12.89	12.7
		28	26.2	24.4	25.7	25.4
2	Optical fibre mortar	7	7.6	7.4	7.6	7.5
		14	11.4	11.1	11.4	11.3
		28	22.8	22.2	22.8	22.6

4.4 Light Transmission Results On Concrete Blocks:

TABLE 5 - TEST RESULTS FOR LIGHT TRANSMISSION

Input voltage (V)	Output		
	Without specimen	Concrete	
	Current (mA)	Current (mA)	Light (%)
5	10	0.6	6
10	20	0.9	4.5
15	32	1.25	3.9
20	44	1.5	3.4
25	60	2	3.3

Amount of light transmitted is calculated as follows:

$$\text{Light transmittance} = 100 - \left[\frac{A_1 - A_2}{A_1} \times 100 \right]$$

Where, A_1 = Ammeter reading without specimen.

A_2 = Ammeter reading with specimen.

5. Conclusion:

After this experimental investigation , following conclusion can be made.

- 1.The compressive strength of Light Transmitting cement mortar block was found to be as same as the normal concrete strength due to vibration of each layer for a certain period.
- 2.The compressive strength of Light transmitting concrete was found to be as same as the normal strength requirement for M20 grade concrete.
- 3.Light transmittance for the samples was found to 5 to 10% in cement mortar blocks and 3 to 6% in concrete blocks.
- 4.The transparency of the cement mortar block with POF is more as compared to the concrete block with POF and also justifies the fact that more the transparency of the material more will be the light transmittance.

It concludes that the transparency of light is also possible in concrete blocks without out affecting its compressive strength, as the plastic optical fibers are embedded through it, there by enhancing the strength and also enhances appearance.

6. References

- [1]M.N.V. Padma Bhushan et.al **“Optical fibers in the modeling of Translucent Concrete Blocks”** International journals of Engineering Research and Application, ISSN: 2248 – 9622. Vol.3, Issue 3, May – June 2013.
- [2]Prof.A.A.Momin et.al **“Study on Light Transmittance of Concrete using optical Fiber and glass rods”**.IOSR Journal of Mechanical And Civil Engineering .
- [3]Bhavink.Kashiyani, et.al **“A Study on Transparent Concrete : A Novel Architectural Material to Explore Construction Sector ”** International Journal of Engineering and Innovative Technology.
- [4]AkshayaB.Kamdi**“Transparent Concrete as a Green Material For Building”**International journal of structural and Civil Engineering Research ISSN 2319 – 6009. Vol. 2, No.3, August 2013.
- [5]Soumyajit Paul and AvikDutta **“Translucent Concrete”** International Journal of Scientific and Research Publications, Volume 3, Issue 10, October 2013.
- [6]Jianping He et.al **“Study on Smart Transparent Concrete Product and Its Performances”** The 6th International Workshop on Advanced Smart Materials and Smart Structures Technology.July 25 – 26, 2011, Dalian, China.
- [7] Basma F. Bashbash et.al **“Basics of Light Transmitting Concrete”** Global Advanced Research Journal of Engineering, Technology and Innovation (ISSN:2315-5124) Vol.2(3) pp.076-083, March, 2013.