

An Experimental Study on Smart Transparent Concrete

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ABSTRACT: Concrete is a homogeneous mixture making a single product. Transparent concrete is a concrete based building material with light-Transmitting properties due to embedded light optical elements usually Optical fibres. This concrete can also be used for aesthetic application by applying the optical fibres in concrete. There are different types of fibres used in concrete for increasing the strength aspect and durability. Optical fibres are one which helps for transmission of light through fibre. In this project, the end-lite type of fibre is used to increase the aesthetic appearance of the concrete. The concept of transparent concrete can also be used for light transmission in the wall panel which is exposed to direct sun light which transmit the image but not completely transparent. The investigation is not constrained only with the decorative purpose but the effect of fibre application will also enhance the strength which is studied in this project. The fibres are arranged in different layers and that will have an increase in the load carrying capacity because of the property of the fibre. Also the pattern can be created to make the concrete decorative. This type of concrete can be installed at a very low cost and increasing the visual appeal. The application can be used in decorating the interior of a hall or lobby and the ceiling to glow in dark by external lighting source and during day time the concrete glows by the light transmission from natural resource. The prototype study is made and the concrete is made decorative and durable also.

KEYWORDS: Concrete, Transparent concrete, Optical fibres.

I. INTRODUCTION

An optical fiber is a flexible, transparent fiber made of glass (silica) or plastic, slightly thicker than a human hair. It can function as waveguide or "light pipe" to transmit light between the two ends of the fibre. The field of applied science and engineering concerned with the design and application of optical fibres is known as fiber optics. Optical fibers are widely used in fiber-optic communications, which permits transmission over longer distances and at higher bandwidths (data rates) than other forms of communication. Fibres are used instead of metal wires because signals travel along them with less loss and are also immune to electromagnetic interference. Fibres are also used for illumination and are wrapped in bundles so that they may be used to carry images, thus allowing viewing the images in confined spaces. Specially designed fibres are used for a variety of other applications including sensors and fiber lasers. Optical fibers typically include a transparent core surrounded by a transparent cladding material with a lower index of refraction. Light is kept in the core by total internal reflection. This causes the fiber to act as a waveguide. Fibers that support many propagation paths or transverse modes are called Multi-Mode Fibers (MMF), while those that only support a single mode are called Single-Mode Fibers (SMF). Multi-mode fibers generally have a wider core diameter, and are used for short-distance communication links and for applications where high power must be transmitted. Single-mode fibers are used for most communication links longer than 1,050 meters (3,440 ft).

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

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Vol. 6, Issue 3, March 2017

II. LITERATURE STUDY

Zhi Zhou et al (2006) reported that the light guiding performance of concrete materials is completely determined by the internal Plastic Optical Fibres (POF) area ratio and the surface roughness in certain sections. They concluded that POF based concrete allows the use of sunlight for illumination in the case of emergencies, transparent concrete will be provided some relief in the case of daytime power outage for skyscrapers making evacuation safer and more efficient additionally, a smart transparent concrete is aesthetically pleasing to be used in museums and specific exhibitions rather than just a construction material.

Varsha raina et al(2013). investigated to develop the building aesthetic in modern construction and consumption of energy with eco-friendly way. 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 and also this concrete as an architectural purpose for good aesthetical view of the building. They conclude that the not loses the strength parameter when compared to regular concrete. This kind of building material can integrate the concept of green energy saving with the usage self-sensing properties of functional material. From this literature it is inferred that the plastic optical fibers increases aesthetical sense of structural elements. In this experimental work M₂₀ grade with plastic optical fibres and fly ash is used.

III. MATERIALS USED

A. WATER

In this experiment portable water with pH values of 7 is used. It is used for the purpose of hydration of cement and to provide workability during mixing and placing of concrete.

B. CEMENT

In this experimental work 53 grade ordinary Portland cement is used. The properties of cement are given in table 3.1.

Table3.1 Properties of Cement

S. No	Description	Values
1	Specific gravity	3.15
2	Standard consistency	29 %
3	Fineness (by sieve analysis)	4.60 %
4	Initial setting time	30 minutes

C. FINE AGGREGATE

Natural river sand is used as a fine aggregate in this experimental work. The sand confirmed to grading zone II of IS 383-1970. The properties of fine aggregate are represented in table 3.2.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 3, March 2017

Table 3.2 Properties of Aggregate

S. No	Description	Fine Aggregate
1	Specific gravity	2.64
2	Fineness modulus	2.76
3	Water absorption	1%
4	Bulk Density	1668.0 kg/m ³

D. FLYASH

Fly ash, also known as "pulverized fuel ash", is one of the coal combustion products from thermal power plants, composed of the fine particles that are driven out of the boiler with the flue gases. The properties of fly ash are listed in Table 3.3.

Table 3.3 Properties of Flyash

S. No	Description	Fine Aggregate
1	Specific gravity	2.6
2	Surface area (m ² /kg)	500-5000
3	Bulk Density(kg/m ³)	900-1300

E. FIBRE

Plastic optical fibres are used to transmit light and increase the strength and aesthetic sense of concrete. Though the elements has to transmit the light the length of the fibres are taken as the length of the element hence the aspect ratio of the fibres used in this experimental program is 75(cube length = length of the fibre =150mm, diameter of fibre =2mm)

**Table 3. 4 Properties of Fibre
Single Strand Fibre Optic Filament**

Product	Fibre diameter (mm)	Fibre diameter (inches)	Attenuation db/m (650nm)	Numerical aperture	Allowable bending radius	Available temperature range
FOF .25	.25	1/100 th	Under .35	0.5/0.6	>9 mm	40 - 70 ^o C
FOF .50	.50	1.25/64 th	Under .25			
FOF .75	.75	1.9/64 th	Under .20			
FOF 1.0	1.0	1.25/32 nd				
FOF 1.5	1.5	1/16 th				
FOF 2.0	2.0	5/64 th			>20 mm	
FOF 3.0	3.0	1/8 th				

International Journal of Innovative Research in Science, Engineering and Technology

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Website: www.ijirset.com

Vol. 6, Issue 3, March 2017

IV. METHODOLOGY

In this experimental programme firstly the properties of the materials used were studied. As per IS 10262- 2009 mix was designed for Light Transmitting concrete of M20 grade. The mix design is detailed in Table 4.1 . The fresh and hardened properties of light transmitting concrete such as slump flow test, Compressive Strength Test, Water Absorption , Split tensile strength Flexure Strength accelerated corrosion test was carried out. The specimen details are given in table 4.2.

Table 4.1- Mix Design				
Cement	Fly ash	Fine aggregate	Fibre	Water
Mix proportion				
341 kg	42	546	4.48	191.61
Mix ratio				
0.89	0.11	1.42	0.4	0.50

Table 4.2- Specimen Details			
Specimen	No of Specimen	Test Detail	
Cube	28	Compressive Strength Test	Conventional 9+ Litracon 9
		Durability	Conventional 2+ Litracon 2
Cylinder	6	Split tensile strength	Conventional 9+ Litracon 9
Prism	6	Flexure Strength	Conventional 3+ Litracon 3

V. EXPERIMENTAL INVESTIGATION

A. WORKABILITY

Workability is that property of plastic concrete mixture which determines the ease with which it can be placed and the degree to which it resists the segregation to produce full compaction. Workability was measured by the slump cone test.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 3, March 2017



Figure 5.1 Slump test

B. COMPRESSIVE STRENGTH TEST

Compression test is the most common test on hardened concrete, because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength.

where,

f_t – Tensile strength of the concrete

P – Load

L – Length of the cylinder

D – Diameter of the cylinder



Figure 5.2 Compressive strength test

C. SPLIT TENSILE STRENGTH TEST

Splitting tensile strength is used in the design of structural light weight concrete members to evaluate the shear resistance provided by concrete and this test method covers the determination of splitting tensile strength of cylindrical concrete specimens.

$$f_t = 2P/\pi LD$$

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 3, March 2017



Figure 5.3 Split tensile strength test

D. FLEXURAL STRENGTH TEST

Flexural testing is used to determine the flex or bending properties of the material. The specimens are tested as per IS: 516-2004.

Flexural strength (f_b) = P



$\times L / b \times d^2$

Figure 5.4 Flexural strength test

VI. RESULTS AND DISCUSSIONS

The experimental part of the strength and durability studies is done and the results are given below

A. WORKABILITY TEST

The workability was measured by the conducting the slump cone test and the observed slump value is 90mm.

B. COMPRESSIVE STRENGTH

The compressive strength results of conventional and light transmitting concrete is given in Table 6.1 & Fig 6.1.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 3, March 2017

Table 6.1 Compressive Strength Test Results

Days	Compressive strength in N/mm ²	
	Conventional Concrete	Light Transmitting Concrete
7	10.8	11.4
14	13.6	14.8
28	15.7	16.2

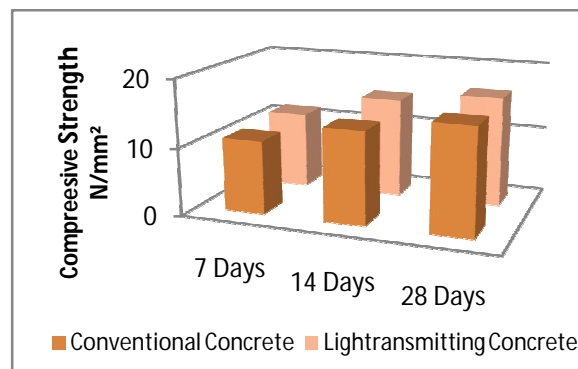


Figure 6.1 Compressive strength test

C. SPLIT TENSILE STRENGTH

The split tensile strength test results of conventional concrete and light transmitting concrete are tabulated in Table 6.2 and Figure 6.2.

Table 6.2 Split Tensile Strength Test Results

Days	Split tensile strength in N/mm ²	
	Conventional Concrete	Light Transmitting Concrete
7	1.97	1.71
14	2	1.8
28	2.52	2.3

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 3, March 2017

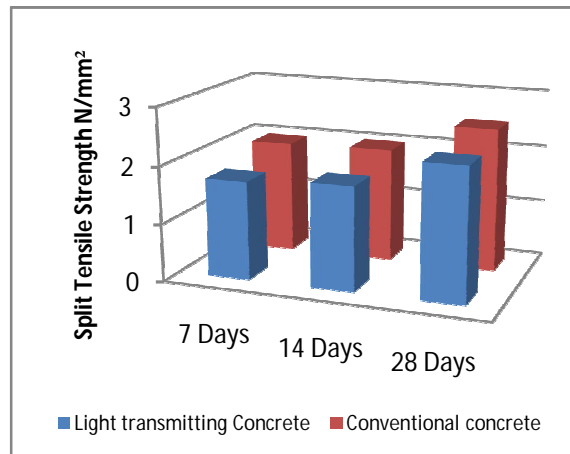


Figure 6.2 Split tensile strength test

D. FLEXURAL STRENGTH

The Flexural test results of light transmitting concrete are tabulated in table 6.3 and figure 6.3

Table 6.3 Flexural Strength Test Results

Days	flexural strength in N/mm ²	
	Conventional Concrete	Light Transmitting Concrete
7	3.53	3.53
14	8.69	7.47
28	10.64	9.22

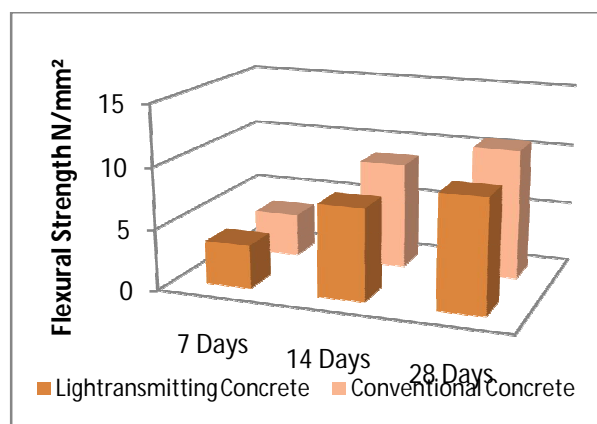


Figure 6.3 Flexural strength test

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 3, March 2017

E. WATER ABSORPTION

The Water absorption results of conventional concrete and light transmitting concrete are shown in table 6.4

Table 6.4 Water Absorption Test Results

Days	Water Absorption in %	
	Conventional Concrete	Light Transmitting Concrete
1	7	6.2

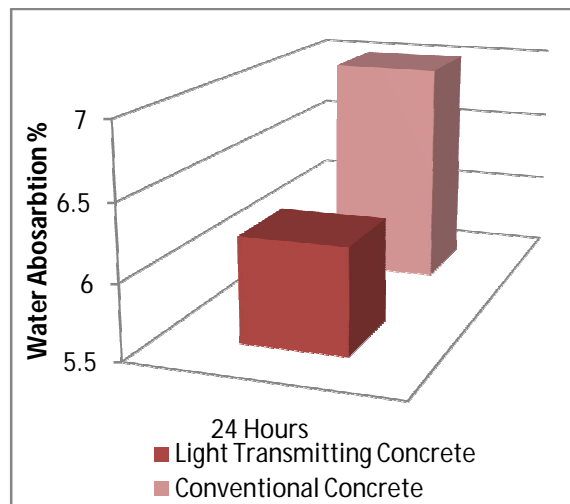


Figure 6.4 Water absorption test

F. ACCELERATED ELECTROLYTIC CORROSION TEST

The accelerated electrolytic corrosion test results of conventional concrete and light transmitting concrete are tabulated in Table 6.5 and represented in fig 6.6. the working of the accelerated electrolytic corrosion test is shown in figure 6.5



Figure 6.5 Accelerated corrosion Test

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 3, March 2017

Table 6.5 Accelerated Electrolytic corrosion Test Results

Type of concrete	Percentage loss of weight of bar
Normal Concrete	3.7
light transmitting concrete	4.5

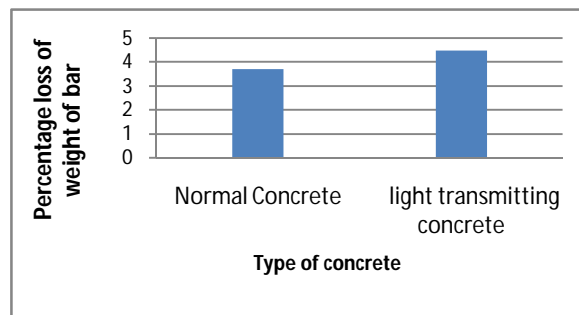


Figure 6.6. Accelerated Electrolytic corrosion Test Results

The percentage loss of weight of the bar of normal concrete was found to be less compared to the light transmitting concrete.

VI. CONCLUSION

1. The compressive strength of light transmitting concrete is slightly increased when compared to conventional concrete.
2. The tensile strength of light transmitting concrete is slightly reduced when compared to conventional concrete.
3. The flexural strength of light transmitting concrete is slightly reduced when compared to conventional concrete.
4. Water absorption of light transmitting concrete is slightly reduced when compared to conventional concrete
5. The results evidently show that the decorative concrete also performance based on the strength aspect is also considerably high.
6. Hence the application of optical fibre will make the concrete decorative as well as can make the concrete structural efficient.

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