# An Experimental Study on Translucent Concrete

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*Abstract*— This paper deals with the usage of translucent concrete and also the advantages it brings in the field of smart construction, that it can reduce the power consumption of illumination and use the optical fiber can be made to sense the stress of structures and this concrete as an architectural purpose for good aesthetical view of the building. Translucent concrete is a concrete based material with light-transmissive properties, obtained by embedding optical fibers in it. Light is conducted through the fiber from one end to the other. This results into a certain light pattern on the other surface, depending on the fiber structure. Optical fibers transmit light so effectively that there is virtually no loss of light conducted through the fibres. This type of concrete can be installed at average cost of construction and increasing the visual appearance of the building. The work presented in this project reports an investigation on the behavior of concrete and mortar with optical fiber. Concrete and mortar cube are casted with fibers to study the properties and to compare the compressive strength between normal mix concrete with optical fiber and normal mortar with optical fiber after 7 days, 14 days and 28 days respectively. The compressive strength of concrete samples made with different fiber amount varies from 2% to 4% were studied. The compressive strength of translucent concrete is seen to increase with the increase in fiber content. The samples with fibers of 4% showed better results in comparison with the others.

***Key words:*** Light-Transmissive Properties, Optical Fiber, Translucent Concrete

## I. INTRODUCTION

### A. General:

In today's developed world energy consumption is very high. The brightness of indoor environment is entirely maintained by artificial lighting, which has consumed a large amount of resources. Translucent concrete comes in as a blessing solution for easier day lighting. Translucent concrete aims at reducing the operating energy by exploiting vast amount of energy in the form of sunlight. Translucent concrete is a concrete based building material having light transmissive property. Light transmissive property is mainly due to uniform distribution of high numerical optical fibers throughout its body.

### B. Translucent Concrete:

Translucent Concrete is a combination of fiber optics and concrete. It can be produced as prefabricated building blocks and panels. Due to the small size of the fibers, they blend into concrete becoming a component of the material like small pieces of aggregate. Because of their parallel position of fiber, the light-information on the brighter side of a wall appears unchanged on the darker side. The sharp display of shadows will fall on the opposing side of the wall. Moreover, the colour of the light also remains the same. Thousands of optical fibers form a matrix and run parallel to each other between the two main surfaces of each block. These fibers mingle in the concrete because of their insignificant size, and they become a structural component as a kind of modest aggregate. Therefore, the surface of the blocks remains homogeneous concrete.

Translucent concrete is used in fine architecture as a facade material and for cladding of interior walls. Light-transmitting concrete has also been applied to various design products. When a solid wall is imbued with the ability to transmit light, it means that a home can use fewer lights in their house during daylight hours so it is energy saving.

With the economic growth and science and technology development, many large scale civil engineering structures such as tall buildings, underground buildings and landmark buildings and so on are built around the world. Those buildings are based on artificial lightings. Most of the large buildings are built close to each other, like sky scrapers. When many buildings are stacked close to each other, there is not much natural sunlight passing through and the importance of natural sunlight is well known. Translucent concrete comes in as a blessing solution for easier day lighting. By arranging many optical fibers into concrete it transmit light so effectively that there is virtually no loss of light conducted through the fibers.

The optical fibers have proper light guiding property and sensing advantages, such as small dimensions, distributed measurement and anti- corrosion characteristics, optical fibers have been widely adopted in the communication and sensing fields.

## II. OPTICAL FIBER

An OPTICAL FIBER is a flexible, transparent fiber made of glass (silica) or plastic, slightly thicker than a human hair. It functions 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 fibres is known as fiber optics. Optical fibres are widely used in fiber-optic communications, which permits transmission over longer distances and at higher bandwidths .Fibres are used for illumination, and are wrapped in bundles so that they may be used to carry images, thus allowing viewing 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.

Fibres that support many propagation paths or transverse modes are called multi-mode fibres (MMF), while those that only support a single mode are called single-mode fibres (SMF). Multi-mode fibres generally have a wider core diameter, and are used for short-distance

 

communication links and for applications where high power must be transmitted.

Optical fiber is a transparent and flexible material made of silica. This optical fiber helps to transmit light in the cube from one end to other end. The percentage of optical fiber used for the study is 2% by volume.

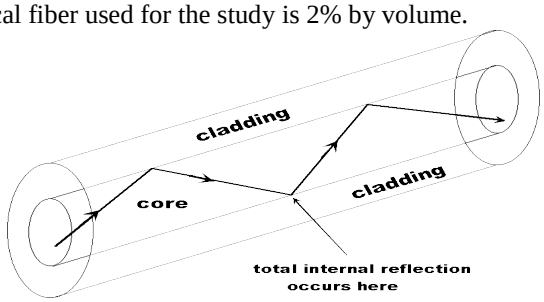


Fig. 1: Reflecting Concrete Cladding

*A. Principle of Operation:*

Optical fibers work as a cylindrical waveguide that transmits light along its axis, by the process of internal reflection.

*B. Optical Fiber Elements:*

- Core - The thin glass centre of the fiber where the light travels.
- Cladding - The outer optical material surrounding the core that reflects the light back into the core. To confine the reflection in the core, the refractive index of the core must be greater than that of the cladding.
- Coating - Plastic coating that protects the fiber from damage and moisture.

Optical fiber has good light guiding property which can be arrange to transmit the light and the sun light transmit according to pre- design road without light-heat, light-electrical or photochemical process, and photo elastic effect which can be used to study the stress distribution of structures. Combining the advantages of the concrete and optical fiber, developing a novel functional material called transparent concrete has an important value in the application of construction and sensing.

*C. Types of Optical Fiber:*

There are three basic types of optical fibers:

- Multimode graded-index fiber
- Multimode step-index fiber
- Single-mode step-index fibers

A multimode fiber can propagate hundreds of light modes at one time while single-mode fibers only propagate one mode as shown below.

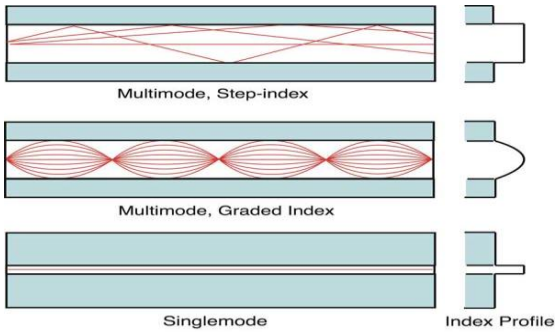


Fig. 2: Types of Optical Fibers

Transparent concrete or translucent concrete is work Based on "Nano-Optics". Optical fibres passes as much light when tiny slits are placed directly on top of each other as when they are staggered. Principal can carry because optical fibers in the concrete act like the slits and carry the light across throughout the concrete.

The fiber will change the interior appearance of buildings by illuminating them and better appearance. The main purpose of using optical fiber is that it can transmit light. Plastic Optical Fiber (POF) can with stand harsh environment and has a higher ductility and good flexibility property. POF transmits light in the form of electromagnetic waves whose properties like amplitude, phase, polarised state and frequency are directly influenced / affected by physical parameters like pressure, strain, stress, electric field, temperature and magnetic field. Optical fiber is a three layered cable, buffer coating, cladding and core are the inner layers of the fiber and the light transmissions carried out through the core of the fiber. Figure 4.4 shows cross section of fiber and ray paths.

*D. Benefits of Optical Fiber:*

- Safe- No electricity, heat, or ultraviolet light in the fibre optic cable. Ideal for use in and around water, paintings, combustible surfaces, etc.
- Versatile- Multiple applications possible from one light source.
- Economical- Operates on less than two amps.
- User friendly- The cable is durable, UV protected plastic, so there is nothing to break or burn out. Virtually maintenance free.

*E. Advantages of Optical Fiber:*

- It has very good architectural properties for giving good aesthetical view to the building.
- Where light is not able to come properly at that place transparent concrete can be used.
- Energy saving can be done by utilization of transparent concrete in building.
- Totally environment friendly because of its light transmitting characteristics, so energy consumption can be reduced.
- The main disadvantage is these concrete is very costly because of the optical fibres.
- Casting of transparent concrete block is difficult for the labour so special skilled person is required.
- When a solid wall is imbued with the ability to transmit light, it means that a home can use fewer lights in their house during daylight hours.

## III. MATERIAL SPECIFICATION

*A. Material Specification of Concrete:*

| S. No | Material | Specification |
|---|---|---|
| 1 | Cement | 53 Grade |
| 2 | Coarse aggregate | Less than 10mm |
| 3 | Fine aggregate | Passing through 2.36mm sieve |
| 4 | Concrete | M 20 Grade |
| 5 | Optical fiber | 2% - 4% |

Table 1: Material Specification of Concrete

*B. Material Specification of Mortar:*

| S. No | Material | Specification |
|---|---|---|
| 1 | Cement | 53 Grade |
| 2 | Coarse aggregate | - |
| 3 | Fine aggregate | Passing through 2.36mm sieve |
| 4 | Optical fiber | 2% - 4% |

Table 2: Material Specification of Mortar

## IV. PROPERTIES OF MATERIALS

*A. Cement:*

Ordinary Portland cement was used for casting all the specimens.

| S. No | Properties of Cement | Values obtained |
|---|---|---|
| 1 | Fineness of cement as retained on 90 micron sieve | 3% |
| 2 | Grade of cement | 53 |
| 3 | Specific Gravity | 3.15 |
| 4 | Initial Setting time | 30min |

Table 3: Properties of Cement

*B. Fine Aggregate:*

Clean and dry river sand available locally is used. Sand passing through IS 4.75mm Sieve is used for casting all the specimens**.**

| S. No | Properties | Values obtained |
|---|---|---|
| 1 | Specific Gravity | 2.53 |
| 2 | Fineness Modulus | 2.64 |

Table 4: Properties of Fine aggregate

*C. Coarse Aggregate:*

Coarse aggregate passing through 10mm sieve is used for casting all specimens.

| S. No | Properties | Values |
|---|---|---|
| 1 | Size of Aggregates | 10mm |
| 2 | Fineness Modulus | 5.01 |
| 3 | Specific Gravity | 2.35 |

Table 5: Properties of Coarse aggregate

*D. Water:*

Ordinary potable water of normally pH 7 is used for mixing and curing the concrete specimen.

*E. Mix Ratio:*

- Mix Ratio Of Concrete - 1.0 : 1.5 : 3.0 and
- Mix Ratio Of Mortar - 1.0 : 3.0

## V. SPECIMEN PREPARATION

Mould is prepared of size 150 × 150 × 150 mm cube. The mould is made up of two plywood faces with a plywood base plate. The two faces of plywood are drilled at a uniform spacing to hold the optical fiber in place during casting concrete into the mould. The two drilled plywood faces are placed opposite to each other so as to place optical fiber in a single direction. The optical fiber are cut into sufficient length and placed individually through the holes in the two plywood sides facing opposite to each other.

Fig. 3: Wooden Mould with Fibers

Now the concrete is prepared and poured into the mould. The mould is compacted to avoid improper filling and void formation.

Fig. 4: Specimen Preparation

The specimen is then allowed to harden for 24 hours and then the mould is removed and the specimen is kept for curing

## VI. COMPRESSIVE STRENGTH

*A. Average Result of Normal Concrete and Concrete with Optical Fiber:*

| No. of days | Normal Concrete | Optical fiber (2%) | Optical fiber (2.5%) | Optical fiber (4%) |
|---|---|---|---|---|
| 7 | 14.44 | 12.79 | 13.26 | 13.50 |
| 14 | 19.51 | 17.87 | 18.90 | 19.24 |
| 28 | 27.26 | 25.66 | 26.63 | 27.14 |

Table 6: Average Result of Normal Concrete and Concrete with Optical Fiber

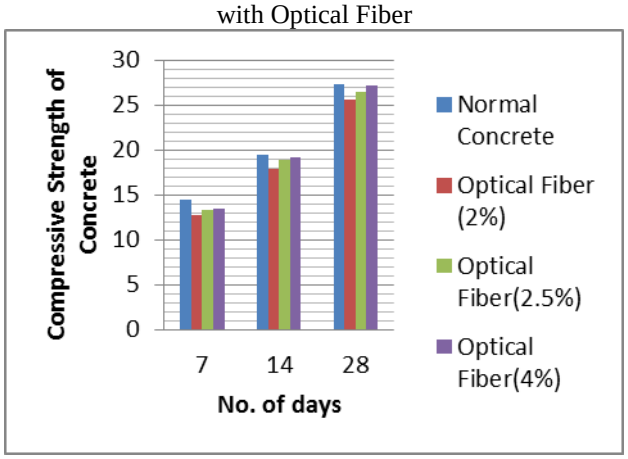


Fig. 5: Compressive Strength of Concrete with Optical Fiber

*B. Average Results of Normal Mortar and Mortar with Optical Fiber:*

| No. of days | Normal Mortar | Optical fiber (2%) | Optical fiber (2.5%) | Optical fiber (4%) |
|---|---|---|---|---|
| 7 | 12.50 | 9.93 | 11.89 | 12.30 |
| 14 | 17.89 | 15.01 | 16.82 | 17.50 |
| 28 | 24.06 | 22.15 | 23.63 | 24 |

Table 7: Average Results of Normal Mortar and Mortar with Optical Fiber

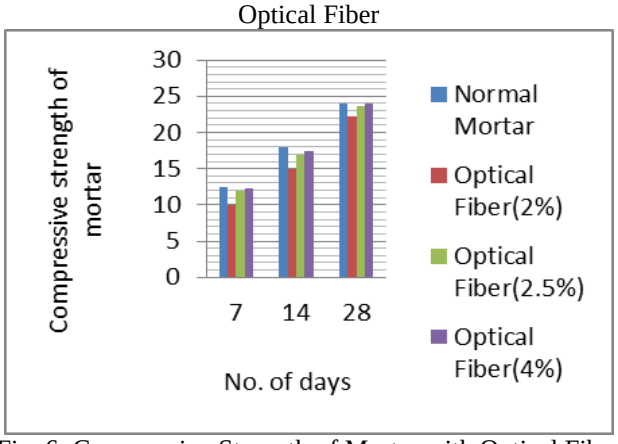


Fig. 6: Compressive Strength of Mortar with Optical Fiber

*C. Discussion on Results:*

After the experimental work done the results are as shown below:

On the usage of 2% of optical fiber, after 28 days the compressive strength of the concrete is 25.66 N/mm² and the compressive strength of mortar is 22.15 N/mm². But on usage of 4% of optical fiber the compressive strength of concrete is 27.14 N/mm² and the compressive strength of mortar is 24 N/mm². From the results it is clear that the compressive strength of concrete with optical fiber will increase with increase the usage of optical fiber.

## VII. Conclusion

It is concluded that, on usage of 4% of optical fibers the compressive strength increased. The compressive strength of concrete cube depends on diameter of the holes in the mould and the diameter of the optical fiber and it is directly proportion to its compressive strength.

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