STUDY ON MECHANICAL PROPERTIES OF LIGHT TRANSMITTING CONCRETE

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Abstract - *Rapid growth in population has led to dense building constructions with cement and concrete with large internal lightening requirement. To achieve energy efficiency, new and innovative materials are required for sustainable construction practices. This remains as a challenging task for engineers and other building professionals to design and promote low energy requirement buildings in a cost effective and environmentally responsive way.*

In the present work, light transmitting blocks of size 200mmx100mmx100mm were prepared by using plastic optical fibers. In this work, plastic optical fibers of 0.38mm diameter were used. Fibers are inserted in mortar bricks in order to investigate the light transmitting potential and also the strength parameter i.e., Compressive strength. The optimum fiber percentage is used for casting of prisms of size 50cmx10cmx10cm with mesh, fibers and combination of both mesh and fibers to observe the flexure crack pattern and study of the flexural strength and has been compared with that of conventional concrete.

Key-words: Cement, Fine aggregate, Coarse aggregate, Optical fibers, Water, Wire mesh.

1.0 Introduction

Infrastructure development is always indicative of the development of a country. Rapid urbanization has led to the development of many innovative materials and technology for construction.

Today we are living in a world where energy expenditure and environmental problems have escalated to a global scale. The brightness of indoor environment is entirely maintained by artificial lightening, which consumes a large number of resources.

1.1 Objectives

The following are the objectives

- To arrive at optimum water cement ratio in the manufacture of the light transmitting blocks. So as to ensure a good workability for the mix.
- To quantify the losses in light transmission with thickness of the masonry blocks.
- To improve performance of concrete by using plastic optical fibers as an inhere material for reinforcing.
- To make concrete partly transparent by using optical fibers in it to impart good appearance to the structure.
- To study improvement in performance of concrete in light transmission by using plastic optical fiber and improve performance of structure to derive natural light.
- To study the strength properties such as flexure and compression of regular concrete in comparison with light transmitting concrete and its limitations with respect to light transmission.

2.0 Literature review

Zhou*et.al.* (2006) carried out experimental studies using plastic optical fiber (POF) in concrete and investigated its light transmitting, mechanical and self-cleansing properties. They concluded that an optical fiber can be easily combined with concrete and that the POF could provide a steady light transmitting ratio. The smart transparent concrete can be regarded as a green energy saving construction material.

Montilla*et.al,* (2015) studied that light incident on concrete undergo any of three optical phenomena viz., reflection, absorption or transmittance. A comparison of the three optical phenomenon's were investigated with respect to different parameters such as type of cement, size of aggregate, and thickness of mortar. From the experimental studies, masonry blocks having low light absorption were considered to be effective.

3.0 Materials

3.1 Cement: In this work, 43 grade ordinary Portland cement was used. The properties are tabulated in table 1.

Table 1: physical properties of cement

S. No	Property	Results Obtained	Specification as per IS – Code
1	Normal consistency, %	31%	26-33%
2	Initial setting time, min	60min	Should not be less than 30min
3	Final setting time	360min	Should not be more than 600min
4	Specific gravity	3.15	3.15

3.2 Fine Aggregate

In this work conventional river sand passing 4.75mm IS sieve was used and it had a specific gravity of 2.535 with a fineness modulus of 2.6. The properties are tabulated in table 2.

Table 2: physical properties of River Sand

S. No	Property	Results Obtained	Specification as per IS – Code
1	Water content corresponding to maximum bulking, %	4	<10%
2	Fineness Modulus of Sand	2.6	2.4-3.1
3	Specific gravity	2.535	2.65-2.7

3.3 Optical fibres

An optical fibre is flexible, transparent fibre made of glass (silica) or plastic to a diameter slightly thicker than that of a human hair. Optical fibres are used most often as a means to transmit light between two ends of the fibre. Optical fibres are commercially available of different diameters such as 0.75 mm, 1 mm, 1.5 mm and 2 mm. For the present studies, optical fibres viz., plastic optical fibre of 0.38mm diameter is used. The diameter is calculated by taking MSR & CVD for either ends of the optical fibres when the optical fibre is exposed to light.

3.3.1. Working principle of optical fibers

The optical fibers work on the principle of total internal reflection (TIR)

3.3.2. Total internal reflection

Total internal reflection is a phenomena which occurs When a ray of light travels from a denser to a rarer medium such that the angle of incidence is greater than the critical angle, the ray reflects back into the same medium this phenomena is called **"total internal reflection".**

3.4 Water: Water is the key ingredient, which when mixed with cement forms a paste that binds the aggregate together. Potable water available in laboratory was used for casting all the specimens. The quality of water was found to satisfy all the requirements as per IS: 456-2000.

3.5 Wire Mesh: A Square mesh of size 2mmx2mm is used in order to observe its strength property.

3.6 Coarse Aggregate: The retained material on IS 4.75mm sieve is termed as coarse aggregate. The properties are shown in table 3.

Table3: physical properties of coarse aggregate.

S.NO	Property	Result Obtained
1	Specific gravity	2.73
2	Fineness modulus	6.34
3	Water absorption	0.7%

4.0 Methodology

4.1 Preamble

- The manufacturing process of light transmitting concrete is almost same as that of regular concrete. Only optical fibers are spread throughout the aggregate and cement mix. There are different methods for the installation of optical fibers in concrete.
- One method is that small layers of the concrete are poured on top of each other and infused with the fiber and is then connected. Thousands of strands of

optical fibers are cast into concrete to transmit light, either natural or artificial.

In this work, masonry blocks of size 200 mm × 100 mm × 100 mm were used. For preparing light transmitting blocks, optical fibers were embedded in the direction parallel to 200 mm × 100 mm direction. The manufacturing process of transparent concrete is almost same as the regular concrete. Here for manufacturing of masonry blocks, a thermocol of size of base plate is taken and plastic optical fibers are placed at a uniform spacing and a mortar is poured till the top level of the mould and is been compacted and finished. This is shown in Figure 1.

Fig.1: shows the arrangement of fibers

4.2 Different configurations

Pilot studies had been done for choosing the best among the different configurations. These configurations are shown in Figure 2. The pilot studies includes trying with different water-cement ratio such as 0.45, 0.5, 0.55 and different percentage of fibers such as 2%, 4%, respectively.

In general, light-transmitting concrete was produced by adding 4% to 5% optical fibers by volume into the concrete mixture. But in the present project the light transmitting mortar is produced for 2% and 4% by volume for plastic optical fibers. For the same percentage of plastic optical fibers, light transmitting masonry blocks of different configurations were prepared.

For instance, 2% of plastic optical fibers Corresponds to 36 strands by using Original Volume Method which were embedded in 3 different configurations, i.e. a bundle of six strands at six different locations, bundle of 9 strands at 4 different locations, bundle of 12 strands at 3 different locations.

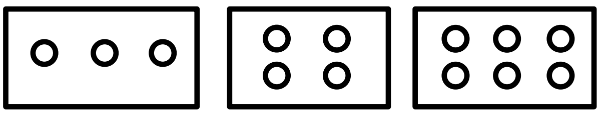

Fig.2: 2% of plastic optical fibers embedded in 3 different configurations

4.3 Experimental program

- For manufacturing light transmitting concrete block, cement mortar cubes of size 200mmx100mmx100mm are used which is same as that of standard brick size.
- The selected proportion is 1:3 (1 part of cement to 3 parts of sand)
- Cement used is 1100gm and 3300gm of fine aggregate respectively per one block of size 200mmx100mmx100mm.
- A thermocol is cut of a size equal to that of base plate and is placed at the bottom.
- Now, the optical fibers are placed or immersed into the thermocol of required or desired shape.
- Now the cement mortar is prepared by using w/c as 0.45, 0.5, 0.55, for choosing the optimum water content and optimum fiber percentage.
- After that, start filling the cement mortar in layers and by giving hand compaction such that the optical fibers placed in the thermocol should not get damaged or cut.
- After completely filling the mould with mortar, the mould should be finally placed on a vibrator for final compaction.
- The vibration is done for 3 to 5 seconds to obtain final compaction and smooth finish.
- The top layer is leveled and finishing is done for aesthetic use.

Similarly, take 4% of fibers which corresponds to 72 strands and were embedded in 3 different configurations i.e., a bundle of 12 strands at six different locations, bundle of 18 strands at four different locations, and bundle of 24 strands at three different locations and the procedure which has been followed above is to be applied for this, the strength parameters has to be calculated. With this, the optimum water cement ratio and the optimum fiber percentage are determined.
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Based on this observation, the same methodology that has been carried out is to prisms which are of standard size 50cmx10cmx10cm. A wire mesh is taken and is placed in the prism and the strength parameter such as flexure is determined and has been compared with that of nominal mix of M20.

5 Test Results

5.1 Compressive strength

The compressive strength test is conducted on a specimen of size 200mmx100mmx100mm mortar cube for 2% , 4% of fibers and the test results can be compared with that of nominal concrete or conventional concrete mortar cube for 7,14 & 28 days respectively.

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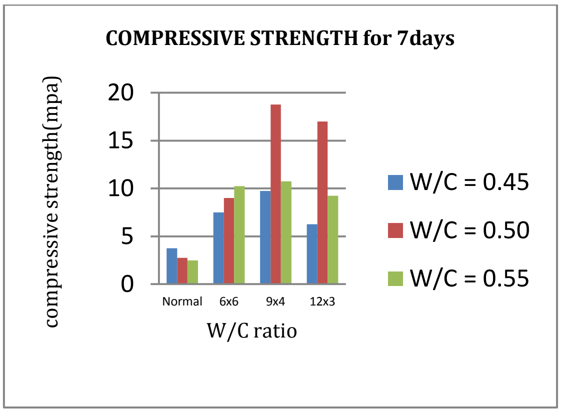

Fig.3: shows compressive strength for 2% of fibers for 7days

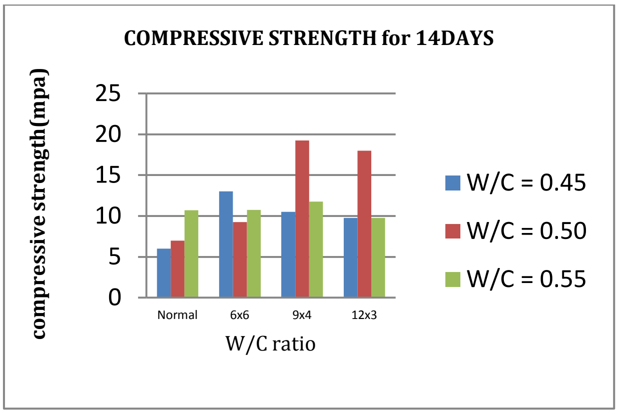

Fig. 4: shows compressive strength for 2% of fibers for 14days

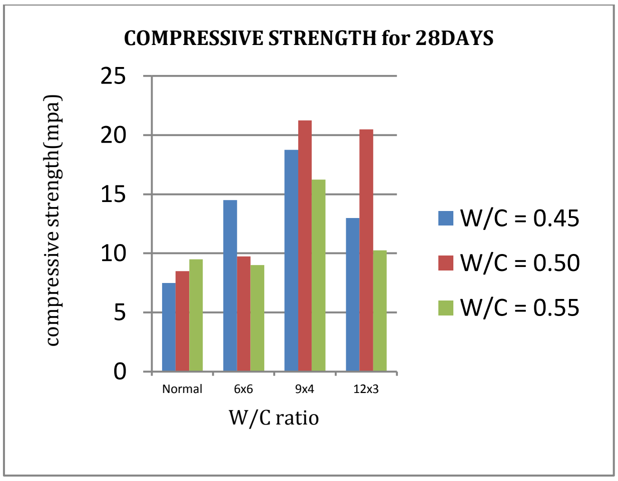

Fig. 5: shows compressive strength for 2% of fibers for 28days

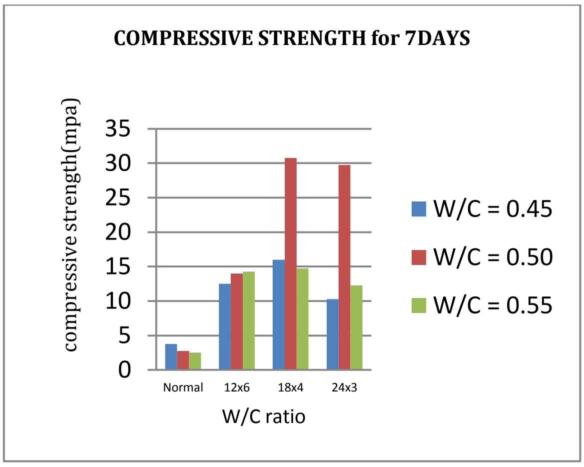

Fig.6: shows compressive strength for 4% of fibers for 7days

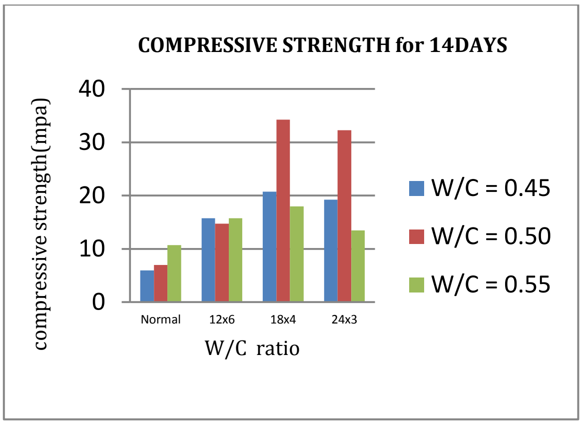

Fig.7: shows compressive strength for 4% of fibers for 14days

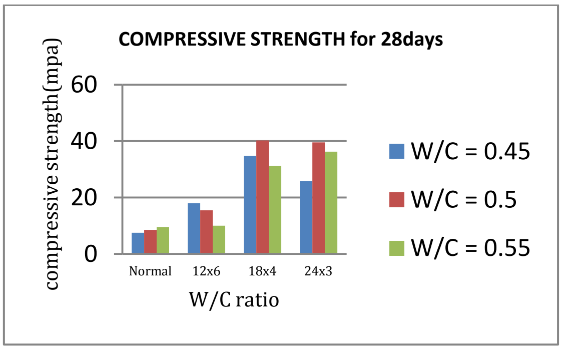

Fig.8: shows compressive strength for 4% of fibers for 28days

Out of these two percentages represented above, 4% of fiber yields the optimum water cement ratio 0.5 and optimum fiber number which is 72. As per the observation, the insertion of fibers into the concrete yields strength that is compressive and also if the fiber number increases, there will be an increase in the compressive strength up to certain limit, beyond that if

Fig.15: Light transmitting block under natural ventilation

Fig.16: Light transmitting block when placed in dark room

6. CONCLUSION

1. The compressive strength of light transmitting concrete is greater than that of conventional concrete up to some certain limit, beyond that limit the compressive strength goes on decreasing with increase in the volume of optical fiber.
2. The highest compressive strength occurs at optimum 4% of fibers with 18 strands at 4 positions.
3. The compressive strength of optimum light transmitting mortar brick is increased by 78.8% than that of nominal or conventional concrete.
4. The flexural strength of optimum light transmitting concrete prism with fiber is increased by 2.485% than that of conventional concrete.
5. Also, the flexural strength of optimum light transmitting concrete prism with mesh alone is increased by 8.053% that that of conventional concrete prism.
6. Finally, the flexural strength of optimum light transmitting concrete prism with a combination of mesh and fiber is increased by 53.03% than that of conventional concrete prism.
7. It has good light transmitting property and the ratio of optical fiber volume is proportional to transmission. It is mainly recommended for aesthetic point of view and for architectural aspects.
8. Moreover, this light transmitting concrete can be utilized in the production of special types of home furniture. Also used where light cannot reach with appropriate intensity and also carries the same amount of light through a brick no matter how thick it is.
9. It is a Clear Example of Technology Transformed into Art Creating an Ecologically Solution that Reduces to Minimum Energy Consumption

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