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EXPERIMENTAL STUDY OF LIGHT TRANSMITTING CONCRETE (LITRACON) USING VARIOUS PERCENTAGES OF OPTICAL FIBRES

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Abstract *Modern times saw the introduction of a new kind of concrete called transparent concrete, which, because to the inclusion of glass rods or optical fibers, has the unique ability to transmit light. Its unique properties, such low density and thermal conductivity, make it lighter than regular concrete. This has many benefits, the most important of which are a decrease in dead weight, a quicker building rate, and cheaper shipping and handling costs. The glass rods that run the length of the brick wall enable light to travel through, illuminating both the inside and outside of the building. A translucent, flexible, and slightly thicker-than-a-human-hair optical glass fiber (or optical fiber) may serve as a waveguide or "light pipe" to transfer light from one end to the other. The primary objective of this research is to develop transparent concrete blocks by combining sand, cement, and optical fibers. These blocks will then be compared to conventional concrete blocks in terms of their physical and engineering properties after being reinforced with 1%, 2%, and 3% of the concrete mix weight of optical fibers and glass rods spaced 1.5 cms apart, respectively.*

Researching the compressive strength and density values of 100 mm x 100 mm x 100 mm concrete cubes with fibre percentages ranging from 0% to 3% is the primary goal of this research.

Key words: *transparent concrete, concrete, optical glass fiber, conventional concrete*

1. INTRODUCTION

It was in Europe when pervious concrete was first developed. Paving, load bearing walls, and prefabricated panels were just a few of the many 19th-century uses for pervious concrete. The year 1852 saw the building of two homes in the UK made of gravel and concrete. Pervious concrete did not make a comeback as a practical building material until 1923. At the time, only two-story houses could be built in places like Scotland, Liverpool, London, and Manchester. Europe saw a consistent increase in the use of pervious concrete after WWII. A home was once again the principal user of this material. As word of pervious concrete's increasing popularity spread, it was soon used in places including Russia, the Middle East, West Africa, Australia, and Venezuela. The United States did not have the same kind of post-war material shortages as Europe, therefore pervious concrete did not become widely used here until the 1970s. Its permeability properties, rather than its lower cost compared to traditional concrete, were the initial drivers of its application (Ghafoori, 1995). In the US, the issue was with excessive drainage from recently developed regions. There was a rise in the quantity of impermeable surface area due to increasing land development. Because of this, runoff increased, which in turn caused floods. Because of this, erosion and a general decline in water quality occurred in the natural environment. Although it was first used in Florida, Utah, and New Mexico, pervious concrete has now quickly expanded throughout the US to places like California, Illinois, Oklahoma, and Wisconsin. 4 Pervious concrete has evolved from a slow-moving alternative to traditional concrete into a powerful instrument in the building industry.

Light Transmitting Concrete

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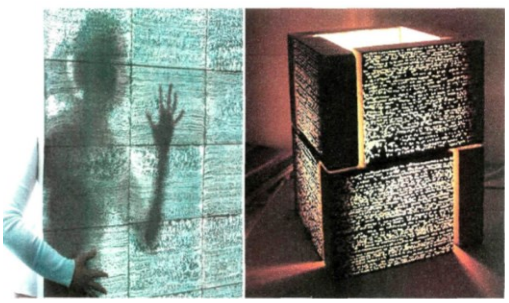
For example, light-transmitting concrete is one of the newest building materials. Using 4–5% optical fibers, a Hungarian architect named AronLosonczi[32] created a unique kind of concrete that could transmit light in 2001. Certain types of concrete, known as light transmitting concrete, really let light to travel through them. Its strength is comparable to that of standard concrete and does not decrease significantly. Since the fiber operates without light loss up to twenty meters, it can continue to transmit light through walls that are up to twenty meters thick.



Light transmitting Concrete

Need for Light Transmitting Concrete

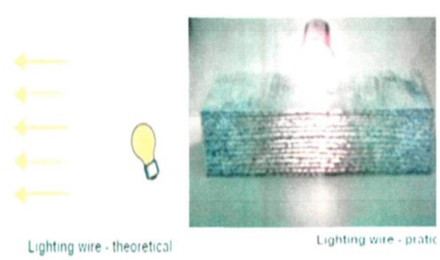
The growing need for useable space as a consequence of globalization, economic and infrastructural growth in emerging nations like China, India, etc., has led to an increase in the construction of high-rise structures and skyscrapers. In these buildings, the only means of satisfying the need for visual activity are artificial energy sources. Our environment and the health of the individuals living in these structures are negatively affected by our utter reliance on artificial sources. The production of these man-made energy sources releases toxic byproducts into the environment, which in turn harms our ecosystem.

One kind of concrete, known as light transmitting or transparent concrete, really lets light travel through it. The components, which are layered alternately, include cement, sand, fine particles, and optical fibers. A building's natural light content may be increased to boost people's ocular activity by using light-transmitting concrete, which enables visible light, including sunshine, to flow through. This lessens the need for synthetic fuels. It all comes down to the plastic optical fiber's core using 100% internal reflection of light. Optical fibers work by reflecting all incident light back into space before sending it on to its destination.

From the perspectives of green architecture and sustainable development, this concrete is crucial since it improves the use of natural light without significantly lowering the strength parameters. In order to qualify for three credits, green buildings must use at least half of the daylight that the Indian Green Building Council (IGBC) specifies. It is simpler for buildings to get better ratings when they are made of light-transmitting concrete, which enables enough light to enter the structure. There is a lack of data on the many aspects of light-transmitting concrete that may make it a good building material. The primary goal of this experimental program is to investigate its strength and light transmission properties by manipulating the amount of plastic optical fiber and concrete grade.

Functional principle of light transmitting Concrete

The colorful spectrum seen through the concrete panels is a result of the sun's and nature's rays that have been scattered. One of the cheapest sources of illumination is sunlight. You won't need any additional lighting if you set up the panel either freestanding or near a window. "Nano-Optics" research has led to the development of translucent concrete, also known as transparent concrete. The amount of light that may travel through optical fibers is same whether the slits are staggered or stacked. Like the slits, optical fibers embedded in the concrete allow light to pass through it.



Functional principle of light transmitting concrete

Objectives of the study

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1. Translucent concrete allow more light and less weight compared to normal concrete.

2. The use of sunlight source of light instead of using electrical energy is main purpose of translucent concrete, so as to reduce the load on non- renewable sources and result it into the energy saving.

3. Optical fibers is a sensing or transmission element, so decrease the use of artificial light, the normal concrete is replaced by translucent concrete.

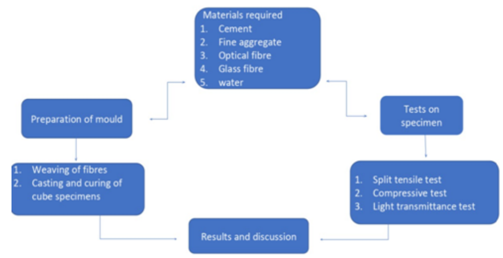
2. LITERATURE REVIEWS

M.N.V.PadmaBhushan et al (2013)[5] "optical fibres in the modeling of translucent concrete blocks'' Translucent concrete is a concrete based material with light-trans missive properties, obtained due to embedded light optical elements like Optical fibers in it. Light is conducted through the stone 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 fibers. The paper deals with the modeling of such translucent or transparent concrete blocks and their usage and also the advantages it brings in the field of smart construction.

Satish Kumar V and Suresh T (2015)[1] produce the concrete specimen by reinforcing optical fibers with different proportion based on the volume of the cube by 0.15%, 0.25%, 0.35% to compare the strength and intensity of light passing through it. The cube and cylinder mould used in the project is of standard size 150mm*150mm and 150mm*300mm respectively. Different test was carried out on the specimen like Compressive strength test, Split-Tensile strength, Intensity of light passing through it, etc. They have observed that the reinforcing of optical fiber will transmit light and also eventually increases the strength of the concrete as compared to conventional concrete. Compressive strength of the concrete is increased by 22.99% of the normal concrete for 0.25% of optical fiber. The tensile strength of the concrete is increased by 83.95% for 0.25% of optical fiber, which clearly indicates that transparent concrete transmits light without affecting the strength of concrete.

3. METHODOLOGY USED



Preparation of mould

In the process of making light transmitting concrete, the first step involved is preparation of mould. The mould required for the prototype can be made with different materials which can be of either tin or wood. In the mould preparation, it is important to fix the basic dimensions of mould. The standard minimum size of the cube according to IS 45 2000 is l0cm x l0cmx l0cm for concrete. In the mould, markings are made exactly according to the size of the cube so that the perforated plates can be used. Plates made of sheets which are used in electrical switch boards is used which will be helpful in making perforations and give a smooth texture to the mould, holes are drilled in to the plates .The diameter of the holes and number of holes mainly depends on percentage of fiber used.

For casting of translucent concrete there is required to construct different type of mould. Mould is prepared in which base and two side is of wooden surface and other surface is made up of PCB (printed circuit board) of size 10X10. PCB is chosen because it has defined holes in which optical fibers can be laid out in transverse direction. Perforated board rest on plywood base. Optical fiber are laid or batched by volume, placed through the holes individually.

Manufacturing process

The manufacturing process of transparent concrete is

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almost same as regular concrete. Only optical fibers are spread throughout the aggregate and cement mix. Small layers of the concrete are poured on top of each other and infused with the fibers and are then connected. Thousands of strands of optical fibers are cast into concrete to transmit light, either natural or artificial. Light transmitting concrete is produced by adding 4% to 5% optical fibers by volume into the concrete mixture. The concrete mixture is made from fine materials only it does not contain coarse aggregate. Thickness of the optical fibers can be varied between 2 µm and 2 mm to suit the particular requirements of light transmission .Automatic production processes use woven fibers fabric instead of single filaments. Fabric and concrete are alternately inserted into molds at intervals of approximately 5 cm to 1 cm .Smaller or thinner layers allow an increased amount of light to pass through the concrete. Following casting, the material is cut into panels or blocks of the specified thickness and the surface is then typically polished, resulting in finishes ranging from semi-gloss to high gloss.

As per Indian standard mix design for M20 grade concrete mix 1:1.5:3, porous concrete is generated by replacing the fine aggregate with coarse aggregate. Initially a zero fines porous concrete is generated by replacing the total fine aggregates with coarse aggregate by adopting the mix design. To examine the improvement in strength at different percentage of fine aggregate as replacement of coarse aggregates, different mixes have been generated with by substituting fine in place of the total aggregate content.

4. MATERIALS USED

OPC 53 Grade Cement

Ordinary Portland Cement of 53 Grade of brand name Ultra Tech Company, available in the local market was used for the investigation. Care has been taken to see that the procurement was made from single batching in air tight containers to prevent it from being effected by atmospheric conditions. The cement thus procured was tested for physical requirements in accordance with IS: 169-1989 and for chemical requirement in accordance IS: 4032- 1988.

OPC 53 grade cement

Fine aggregates

Aggregate less than 4.75 mm are known as fine aggregate fine aggregate comprises of sand dug out from riverbeds and pits having particle size from 0.075 mm to 4.75 mm Natural sand– it is the aggregate resulting from the natural disintegration of rock and which has been deposited by streams or glacial agencies as show in figure. Crushed stone sand– it is the fine aggregate produced by crushing hard stone. Crushed gravel sand- it is the fine aggregate produced by crushing natural gravel.

Fine aggregates

Portable water

Water conforming to IS 456-2000 was used for casting and curing. The role of water is important because the water to cement ratio is the most critical factor in the concrete. It should be of drinking water quality. It should be free from all impurities.

Water is acts as lubricant for the fine and coarse aggregate and acts chemically with cement to form the binding paste for the aggregate and reinforcement. Water is also used for curing the concrete after it has been cast into the forms.

Optical fibers

Optical fibres are flexible, transparent fibres made up of glass as well as plastic and are thin as human hairs. It transmits light between two ends of the fibres by process of total internal reflection. In this experiment,

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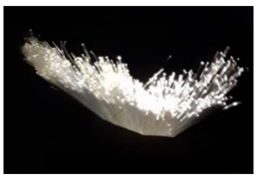
the holes of 5mm diameter were drilled and glass optical fibres of 0.5mm diameter were used. The optical fibres used were made of poly methyl methacrylate (PMMA) with outer diameter of 2 mm and 3 mm. The cladding material of the optical fiber was fluorosis... The effective bending radius was ten times greater than the diameter of the fiber and its operating temperature ranges -40ºC ~ +70ºC. The fiber was non-conductive and, its refractive index profile was step index. At 650 nm wavelength, the white light transmittance loss rate of the fiber was less than 350 dB/km.



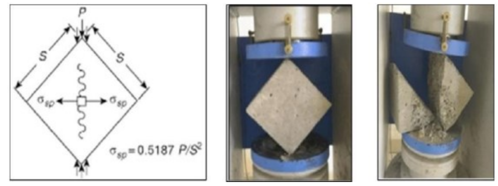
Optical fiber

5. TESTS ON SPECIMEN

Tensile splitting test on concrete cubes

Experiments were conducted to investigate the suitability of a cube splitting test for determining the indirect tensile strength of concrete, and to examine the relations between this tensile strength and the usual flexural and compressive strength values for a wide range of concretes. the cube splitting test involved loading a cube specimen on its side between two centrally placed hearing strips so that tensile failure occurred in a vertical plane between the places where the loads were applied, similar to the splitting test on cylinders.

The cube splitting test was found to give consistent result over a wide range of concretes and to be a convenient method of assessing a tensile property of concrete. the relation between tensile splitting strength and compressive strength of concretes was more uniform than the similar relation for flexural strength . A fairly uniform relation was also found between the tensile splitting strength and flexural strength, for concrete made with similar aggregate, although this ratio was found to vary with different aggregates and with increasing flexural strength. The strength relations obtained with mortars and with a lightweight aggregate concrete differed from those of the dense aggregate concretes.



Split tensile test

Compressive test

Compressive strength of concrete cube test provides an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. Concrete compressive strength for general construction varies from 15 MPa (2200 psi) to 30 MPa (4400 psi) and higher in commercial and industrial structures.

Compressive strength of concrete depends on many factors such as water- cement ratio, cement strength, quality of concrete material, and quality control during production of concrete etc

Testing of cube in compressive strength machine

Light Transmitting Test

The light transmittance through the sample can be measured by measuring the current corresponding to the light which can be measured by a photo diode or a Light Dependent Resistors (LDR). The use of photo diode would require a separate sensor which would increase the cost of the project. The most apt choice would be LDR. The LDR are soldered onto a PCB board. The LDR measures the light transmitted through the sample and converts it into the current, which in this case is measured in mile amperes (mA). So two readings are taken, one without sample (A1) and one with sample (A2). The source of light here is taken as 100 w incandescent bulbs, a resistance of 100 Ω is applied in the circuit and a uniform DC voltage of 2.5 V is kept between the circuits. To ensure no light escapes throughout the test, a box made up of plywood is made. The light source is

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fixed at the top of the box and LDR is placed at the bottom. The sample is placed between source and LDR and test is carried out.

Light transmittance = 100 – (A1−A2/A1) x 100 Where;

A1 = light transmitted without sample A2 = light transmitted with sample

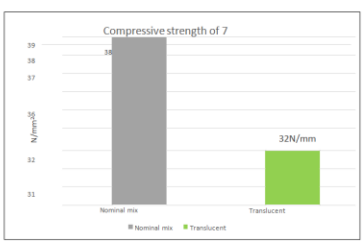
Light transmission test

6. RESULTS AND ANALYSIS

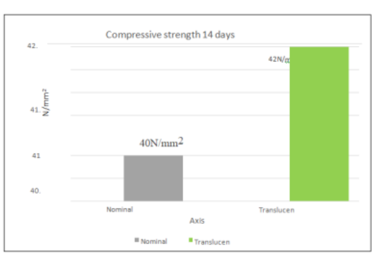
Workability Results

Grade of concrete	Proportions of concrete	Replacement of fine aggregate in percentage	Workability Cm
M20	01:05.5	Normal mix	28
	01:05.5	Optical fiber 10%	29

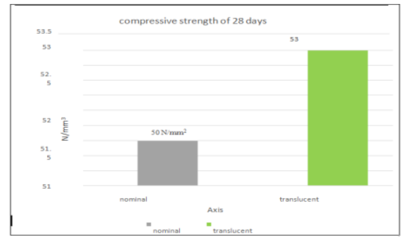
Compressive strength of concrete



7days compressive strength of concrete

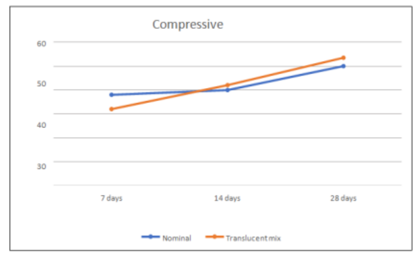


14days compressive strength of concrete



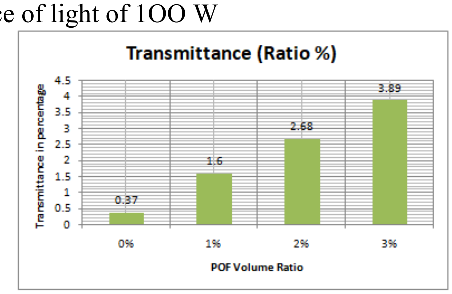
28 days compressive strength of concrete

Comparison of compressive strength of concrete

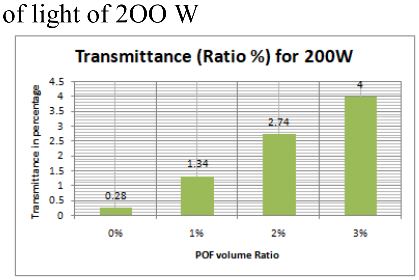


Comparison of compressive strength of concrete

Light passing characteristic using incandescent source of light of 1OO W



Light passing characteristic using incandescent source of light of 2OO W



7. CONCLUSIONS

1. Mechanical behavior of plain concrete cubes were studied for Compressive, Split tensile & Flexural strength test with curing time of 7 days, 14 days, 21 days and 28 days which shows characteristic increase in its strength behavior.

2. There is 5% to 10% increase in initial

compressive strength for 7 days & also 10% to 15% increase in initial compressive strength for 28 days to an optical fibres mix up to 3%.

3. Whereas the initial & final characteristic compressive strength gradually decreases with an increase in Optical fibres in the concrete mix.

4. It will also reduce the carbon emission which is hazardous for environment & can be treated as one of the high performance concrete.

5. The transparent concrete made with glass rods finds its applications mainly in partition wall rather than structural element such as columns and beams.

6. The main advantage of translucent concrete is its lightweight which reduces the self-weight of any concrete structure & also can be used as decorative concrete in interior design of buildings as panels in slabs, walls etc.

7. From the above study, it can be concluded that the Optical fibers can be used in concrete mix up to 5% replacement will give an excellent results both in strength & quality aspects.

8. Translucent concrete is a novel architectural material. The translucent concrete has good light guiding property and the ratio of optical fiber volume to concrete is proportion to transmission. Compressive strength is studied for light weight translucent concrete and it is found that the strength decrease up to 34% to 40% for light weight translucent concrete.

9. Strength slightly decreases about 2% to 3% when compared with theregular concrete.

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