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An Investigating Study on a new Innovative Concrete: Transparent Concrete

Pragati Suresh Humane¹, Bharti Shobhelal Mehar², Chitra Bhagwan Awasare³,
Gajendra Singh Patle⁴, Satish Sundarlal Katre⁵, Pushpak Natthu Donadkar⁶,
Ankit Ghanshyam Shende⁷, Prof. Parag Koche⁸

B.E 8th Semester Student, Department of Civil Engineering, Madhukarrao Pandav College of Engineering, Bhandara,
Nagpur, Maharashtra, India^{1,2,3,4,5,6,7}

Assistant Professor, Department of Civil Engineering, Madhukarrao Pandav College of Engineering, Bhandara,
Nagpur, Maharashtra, India⁸

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 paper. 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: Transparent Concrete, Optical Fibre, Cement, Coarse Aggregate, Fine Aggregate, Core

I. INTRODUCTION

1.1 BACKGROUND

Concrete has been used since Roman times for the development of infrastructure and housing, but its basic components have remained the same. Three ingredients make up the dry mix: coarse aggregate, consisting of larger pieces of material like stones or gravel; fine aggregate, made up of smaller particles such as sand; and cement, a very fine powder material that binds the mix together when water is added.

Just a few decades ago concrete was often misunderstood, disliked and captured by its image fixed due to the rapid urbanization of the 1960s. But since that time, concrete has made considerable progress, not only in technical terms, but also in aesthetic terms.



(Fig.1: Transparent Concrete Building Concept)

It is no longer the heavy, cold and grey material of the past; it has become beautiful and lively. By research and innovation, newly developed concrete has been created which is more resistant, lighter, white or colored, etc. Concrete has learned to adapt to almost all new challenges that appeared. In 2001, the concept of transparent concrete was first put forward by Hungarian architect Aron Losonzi at the Technical University of Budapest, and the first transparent concrete block was successfully produced by mixing large amount of glass fiber into concrete in 2003, named as LiTraCon. The transparent concrete mainly focuses on transparency and its objective of application pertains to green technology and artistic finish. It is the “combination of optical fibers and fine concrete”. At present, green structures focus greatly on saving energy with indoor thermal systems. Therefore it is imperative to develop a new functional material to satisfy the structure in terms of safety monitoring (such as damage detection, fire warning), environmental protection and energy saving and artistic modeling.

Due to globalization and construction of high-rise building, the space between buildings is reduced; this causes to increasing the use of non- renewable energy sources, so therefore there is a need of smart construction technique like green building and indoor thermal system.

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.

1.2 TRANSPARENT CONCRETE

Translucent concrete (Transparent concrete) is new technique different from normal concrete. Translucent concrete allow more light and less weight compared to normal concrete. 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. Optical fibers is a sensing or transmission element, so decrease the use of artificial light, the normal concrete is replaced by translucent concrete, which has natural lighting and art design.



(Fig.2 Transparent Concrete Block)

Transparent concrete is used to provide a better aesthetic view of a building or other architectural purposes.

The main purpose of transparent concrete is the maximum used of sunlight and reduce the electric power consumption and using the optical fiber to sense the stress of structure.



(Fig.3 : Transparent Concrete Wall)

1.2.1 HISTORY

The Transparent Concrete Concept Is First Found In 1935 by Canadian patent. But due to the development of optical fiber and other materials, this concept is not more popular.

But after some time this concept also comes and in 2001 the idea of transparent concrete is found by Hungarian architect aronlosoncz. In 2004, he started the german company, named LiTraCon, and started producing LiTraCon commercially.

II. AIM

Experimental Analysis of Transparent Concrete by using Optical Fibers.

III. OBJECTIVES OF THE STUDY

- To study strength characteristics of Transparent Concrete.
- To compare strength characteristics of Transparent Concrete & Normal Cement Concrete.



IV. INGREDIENTS OF TRANSPARENT CONCRETE

- Cement
- Fine aggregate
- Coarse aggregate
- Optical Fibers Elements
- Water

Cement:

Cement is a binder, a substance that sets and hardens as the cement dries and also reacts with carbon dioxide in the air dependently, and can bind other materials together. Portland cement is the most common type of cement in general use around the world, used as a basic ingredient of concrete, mortar, stucco, and most nonspecialty grout. The OPC was classified into three grades namely, 33 grade, 43 grade and 53 grade depending upon the strength of the cement at 28 days when tested as per IS 4031-1988. The cement used in this experimental works is “Koromandal King 53 Grade Ordinary Portland Cement”. The specific gravity of cement was 3.14. The initial and final setting times were found as 51 minutes and 546 minutes respectively. Standard consistency of cement was 40%.

Fine aggregate:

Fine aggregate is the inert or chemically inactive material, most of which passes through a 4.75 mm IS sieve and contains not more than 5 per cent coarser material. The specific gravity 2.75 and fineness modulus of 2.80 were used as fine aggregate. The loose and compacted bulk Density values of sand are 1600 and 1688 kg/m³ respectively, the water absorption of 1.1%.

The fine aggregates serve the purpose of filling all the open spaces in between the coarse particles. Thus, it reduces the porosity of the final mass and considerably increases its strength. Usually, natural river sand is used as a fine aggregate. However, at places, where natural sand is not available economically, finely crushed stone may be used as a fine aggregate.

Coarse aggregate:

Crush granite aggregate available from local sources has been used. The coarse aggregate with maximum size of 10mm having the specific gravity value of 2.6 and fineness modulus of 5.60 were used as a coarse aggregate. The loose and compacted bulk density values of coarse aggregate are 1437 and 1556 kg/m³ respectively, the water absorption of 0.4%.

Optical Fibers Elements:

The optical fiber is the thin fiber of glass or plastic that transforms light from one point to another point. The study of the optical fiber principle is known as fiber optics. fiber optics is part of applied science and engineering.

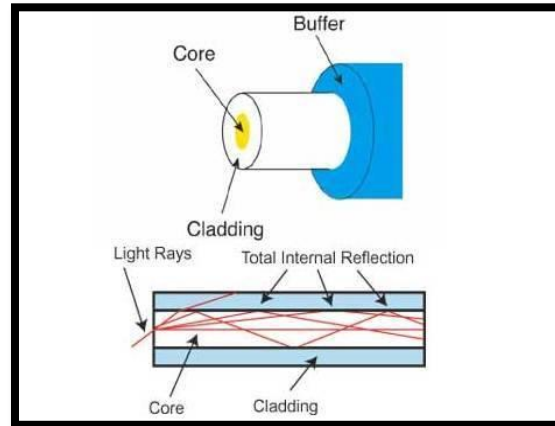
The volume of optical fiber is 4 to 5% of the total volume of concrete and the thickness of optical fiber is lies between 2micron to 4mm. the volume and thickness of optical fiber depend on the purpose of light transmission or requirement of light transmission.

The optical fiber have three parts.

Core - The thin glass center of the fiber where the light travels is called core.

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.

Buffer Coating – This is the Plastic coating that protects the fiber from damage and moisture.



(Fig.4 :OpticalFiber Parts)



(Fig.5: Optical Fibre)

Water: Water should be free from acids, oils, alkalis vegetables or other organic impurities. Soft waters also produce weaker concrete. Water has two functions in a concrete mix. Firstly, it reacts chemically with the cement to form the cement paste in which the inert aggregates are held in suspension until the cement paste has hardened. Secondly, it serves as a lubricant in the mixture of fine aggregates and cement.

V. LITERATURE REVIEW

Kamdi (2013) has focused on materials for preparation, mixing procedure, uses, environmental impact and future of TC. He mainly gives an idea about using optical fiber with fine concrete for making transparent concrete. He reveals the fact that TC is not used widely due to its limited application in developing only precasted and prefabricated blocks and panels. Nevertheless, by reducing the energy uses, transparent concrete can make a big impact on the environment.

Momin et al. (2013) have stated that specimen with optical fiber permits more transmission of light through it than a specimen with the glass rod. In their research work, they have used the mould of size 150mm x 150mm x 150mm for the casting of glass rod cubes and 150mm x 150mm x 100mm for the casting of cubes with optical fiber. Light transmitted through the glass rod and optical fiber cubes was 0.254%-1.57% and 7.41%-9.5% respectively. However, the compressive strength of optical fiber cubes was slightly less than that of glass rod cubes.

Tiwari and Saharan (2016) have studied the compressive strength properties of two different types of concrete. In the first type they studied the normal TC mix and in the second type, they added 0.625% percentage of rice husk along with 0.125% of steel fiber by mass. The optical fiber of diameter 0.5mm with the varying percentage ranging from 0.25-4% of total volume of cubes was used for both types of concrete. They used concrete moulds of size 15cm x 15cm x 15cm and cement, sand & aggregates were taken in the proportion of 1:1.5:3



respectively with water cement ratio of 0.45. As the percentage of optical fiber increases, the compressive strength of cubes decreased. However, it can be increased, by adding rice husk and steel fiber.

Bishettiet al. (2016) had prepared wooden mould of 15cm x 15cm x 15cm by drilling its two faces for holding the optical fiber. Mix design ratio of concrete was taken as 1: 2.24: 1.78. As the percentage of optical fiber increases, the compressive strength of transparent concrete decreases. Starting from 43.55MPa for 0% optical fiber, it declines up to 31.10MPa for 5% optical fiber.

In Poland, it was M. Kurpińska (2013), who started research on the TC production technologies with the use of the plastic optical fibers. She made TC specimens which contained plastic optical fibers having the 2.5% density and being 0.7-1.2mm in diameter. She also noticed that the said density enables good light conductance, where the element thickness does not matter. Furthermore, the resistance of the translucent concrete blocks fits the boundaries 50–80 MPa.

VI. USES OF TRANSPARENT CONCRETE

Transparent Concrete is emerging and new concrete and has not been used widely used across the globe. It can only be produced as pre-fabricated or pre-casted concrete blocks or panels. However, due to its light transmitting characteristics, it has the power to transform the interior of the building and make them more spacious, open and fresh. Therefore, transparent concrete has various traditional and emerging uses.

Traditional Uses-

1. Transparent blocks are used for floors, load bearing walls and pavement.
2. Based on the thickness of panels, it can also be used for facades, interior wall cladding and dividing walls.

Emerging/Trending Uses-

1. Stairs
2. For increasing visibility in dark subway stations
3. Light Fixtures
4. Furniture
5. Garden wall
6. Light sidewalks at night
7. Illuminating speed bumps on roadways at night

VII. PROPOSED METHODOLOGY

Table 1: Properties of Transparent Concrete Blocks

Product	Litracon- Light Transmitting Concrete
Form	Prefabricated blocks
Ingredients	96% concrete, 4% optical fibre
Density	2100-2400 Kg/m ²
Block size	600mm x 300mm
Thickness	25-500mm
Colour	White, Grey or Black
Fibre distribution	Organic
Finished	Polished
Compressive strength	50 N/mm ²
Bending Tensile strength	7 N/mm

1. 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 456-2000 is 15cmx15cmx15cm 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.



(Fig.6Preparation of mould)

2. Procedure of making translucent panel:

Step 1-Preparation of the Mould:

A mould of rectangular cross section of size 150mm*150mm*150mm is made with wood or steel. Make the required size of rectangular mould from wood or tin. Place the clay or mud in the sides where the optical fibers are exposed to the mould for the easy demoulding after the concreting.



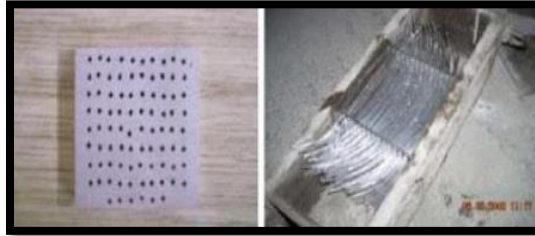
(Fig. 7 Preparation of panel)

Step 2- Optical Fiber:

The optical fibers are cut carefully to the required size of mould. The commonly available diameters of optical fibers are .25 mm, .5 mm, .75 mm, 1 mm, and 2 mm.

Step 3- Fixing the Fibers:

Fibers are placed either in organic distribution or in layered distribution. Holes are driven on the wooden or steel plates through which optical fibers are allowed to pass through.



(Fig.8 Fixing of fibers)

Step 4- Concreting:

The thoroughly mixed concrete is poured carefully and slowly without causing much disturbances to the previously laid optical fibers. The concrete is filled in smaller or thinner layers and is agitated with the help of vibrating tables to avoid the void formation.

Step 5- Removing the Mould:

After 24 hrs, remove the mould and pull off the mud. The casted mould was kept undisturbed on the leveled platform. Then it was de-moulded carefully after 24 hours from casting. Immediately after de-moulding, the cube specimens were marked by their respective identification mark/numbers (ID).

Step 6- Cutting and polishing:

Cut the extra-long fibers same as thickness of panel. Polish the panel surface by using polishing paper or using sand paper.

VIII. LIGHT GUIDING EXPERIMENT OF TRANSPARENT CONCRETE

In order to study the light guiding property of translucent concrete, six units of translucent concrete is fabricated with different POF volume ratios of 1%, 2%, 3%, 4%, 5% and 6%, and the diameters of POF is 1mm. The transmittance is measured by the Optical Power Meter and its wavelength range is 400-1100nm. The incandescent lamp with 200W and halogen lamp with 500W are chosen to provide light. To eliminate the measuring dispersion of transmittance caused by the discrepancy of POFs' position and the material, three areas (denoted as 1, 2 and 3) in the middle part of translucent concrete are chosen to test shown as figure below, and the number of POFs in each chosen area shall be equal. The number of the POFs is covered by transmission probe or integral sphere are 2 for 1% POF volume ratio, 4 for 2% POF volume ratio, 5 for 3% POF volume ratio, 7 for 4% POF volume ratio, 3 for 5% POF volume ratio and 9 for 6% POF volume ratio respectively. The incident light energy and transmission light energy are read simultaneously at each step.

By definition, the compressive strength of a material is that value of uniaxial compressive stress reached when the material fails completely. The compressive strength is usually obtained experimentally by means of a compressive test. The compressive strength of the concrete is determined by cast the cubes of size 150mm x150mm x 150mm.

IX. APPLICATIONS

Thanks to new features this material presents innovative technical solutions, semi-natural and ecological, for the traditional construction problems allowing a wide area of applications in construction, architecture, decoration and even furniture. Some of the possible applications for this new material are spread over several areas creating new possibilities to various products such as:

1. Translucent concrete blocks suitable for floors, pavements and load-bearing walls.
2. Facades, interior wall cladding and dividing walls based on thin panels.
3. Partitions wall and it can be used where the sunlight does not reach properly.
4. In furniture for the decorative and aesthetic purpose.
5. Light fixtures.
6. Light sidewalks at night.
7. Increasing visibility in dark subway stations.
8. Lighting indoor fire escapes in the event of a power failure.

9. Illuminating speed bumps on roadways at night.



(Fig.9 Transparent Concrete Bedroom)

X. ADVANTAGES AND DISADVANTAGES

The main advantage of these products is that on large scale objects the texture is still visible - while the texture of finer translucent concrete becomes indistinct at distance.

- 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.
- 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 translucent concrete can be used.
- Energy saving can be done by utilization of translucent 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 fibers.
- Casting of translucent concrete block is difficult for the labour so special skilled person is required.

XI. CONCLUSION

- A novel architectural material called transparent concrete can be developed by adding optical fiber or large diameter glass fiber in the concrete mixture. The transparent concrete has good light guiding property and the ratio of optical fiber volume to concrete is proportional to transmission. The transparent concrete does not lose the strength parameter when compared to regular concrete and also it has very vital property for the aesthetical point of view. It can be used for the best architectural appearance of the building. It can also be used in areas, where the natural light cannot reach with appropriate intensity. This new kind of building material can integrate the concept of green energy saving with the usage self-sensing properties of functional materials.
- Transparent concrete can be useful to save energy and reduce electricity bill without any fear of compressive strength, TC made with optical fiber provides better transparency than TC with glass rod. However, compressive strength of later was slightly better.
- Translucent concrete blocks can be used in many ways and implemented into many forms and be highly advantageous. Yet, the only drawback would be its high cost. That doesn't stop high class architects from using it. It's a great sign of attraction and artistic evolution. Any structure with a small hint of translucent concrete is bound to make heads turn and make them stand in awe.

FUTURE SCOPE

Transparent concrete is also a great insulating material that protects against outdoor extreme temperatures while also letting in daylight. This makes it an excellent compromise for buildings in harsh climates, where it can shut out heat or cold without shutting the building off from daylight. It can be used to illuminate underground buildings and structures, such as subway stations. The possibilities for translucent concrete are innumerable; the more it is used, the more new uses will be discovered. In the next few years, as engineers further explore this exciting new material, it is sure to be employed in a variety of interesting ways that will change the opacity of architecture as we know it.

- Transparent concrete can be used in all places where transparency, strength, and safety are 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.
- 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.

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