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Light Transmitting Concrete: A Review

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Abstract: **Researchers have focused on the concept of sustainable development looking forward to innovate something using energy conservation. Light transmitting concrete (LTC) or 'LiTraCon' is an example of such phenomenal innovation. This review evaluates the principles involved in this, manufacturing process, pros and cons and applications of LitraCon. It has been described how the Litracon developed from 90's and further. Embedding optical fibres in the concrete reduces electricity demands. Hence, it can be used as an eco -friendly alternative to traditional concrete in the near future. The applications of LiTraCon, illustrates its positive impact worldwide. LiTraCon can become an affordable alternative for both commercial and residential projects.**

Keywords: **Light Transmitting concrete, optical fibre, energy saving, sustainable development, green technology.**

I. INTRODUCTION

Development is reaching its height. To cope up with this new advanced technological world, upgradation to a great extent is needed. Civilization has moved towards urbanization. Materials needed for construction has its own variance. Similarly, concrete has got different types and usage according to the needs of people. Light Transmitting Concrete is a type of concrete which transmits light and reduce the consumption of electricity. Indirectly, it saves non-renewable resource up to a certain extent.

The proliferating urbanization reveals the growth of concrete fathomlessly. There is no denying that concrete and the technology surrounding it has come a long way since its discovery and development.From the great pyramids at Giza to smart sensors for testing concrete properties,technology swiftly ameliorated. Although extension development creates hazards which includes high production, high consumption, high pollution and other ill-effects to environment. Among all these, power production by using a non-renewable resource is deep-rooted day by day. In 2021,about 4,116billion kilowatt hours of electricity were generated at utility-scale electricity generation facilities in the UnitedStates where 21.8% share of total is coal energy source. The world has proven reserves equivalent to 133.1times its annual consumption. This means it hasabout 133yearsof coal left(excluding unproven reserves).

Light Transmitting concrete or LiTraCon is embedded with light optical elements having light transmissive property. Usually, optical fibers are used within it from one end to another. Therefore, the fibers have to go through whole object. This results in a certain light pattern on the other surface, depending on the fiber structure. In theory, the optical fibers could carry light to a distant but with increasing its length transmission property is reduced, depending on type of fibers and how it is bend. Since the fibers have bend and roughness on the cut surfaces so the transmission is reduced.

Fig. 1

Apart from fine fiber patterns due to the use of optical fibers or textiles some products with much coarser light pattern are available. 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. Further pictograms and lettering can be realized with this technology.

An approach that does not use waveguides involves using transparent aggregate and binders. However, chemically this would not necessarily resemble concrete, and might resemble fiberglass. Unlike materials requiring alignment of optical fibers, however, it might be transported and pouring using existing infrastructure.

Light Transmitting Concrete was first stated on October 27, 1922 a patent filed under United States Patent office Paul Liese of Tempeloh of Germany. His inventions were related to transparent building blocks or panels on august 4, 1925. Later in 1965, a method of constructing a LTC panel by James N. Lowe, London, England; was patented in United States Patent office. The invention relates to a method of making translucent (other name of LTC) concrete panels which are used, for example, church windows. In the early 1990s, when major advancements in the field of polymer-based optical fibers led to its development, Litracon was introduced.

In 2001, first, the concept of transparent concrete was put forward by Hungarian architect AronLosonzi, and the first transparent concrete block was successfully casted by mixing a large amount of glass fiber into concrete in 2003. Joel S. and Sergio O.G. casted a transparent concrete material, which allow 80% light through and only 30% of the weight of common concrete. The hope is that the new material will create new interior aspect. Soon it became popular in countries including Italy, Germany, and even China. The most notable installation of it to date is Europe Gate – a 4m high sculpture made of LiTraCon blocks, erected in 2004 in observance of the entry of Hungary into the European Union. The product won the German "Red Dot 2005 Design Award" for "Highest design qualities". Though expensive, Litracon appeals to architects because it is stronger than glass and translucent, unlike concrete. It was considered as possible sheathing for New York's One World Trade Center.

Today several companies produce translucent concrete with very different production systems. Some manufacturers are – FlorakBauunternehmungGmbh (Heinsberg / Germany), LMB EFO (Berching / Germany), LiTraConBt (Csongrad / Hungary), LUCEmGmbh (Aachen / Germany), LucconLichtbetonGmbh (Klaus / Austria), LiCrete (Gravelli / Czech Republic).

II. LITERATURE REVIEW

- **Poornima D**[15] carried out an experimental study on light transmitting concrete using optical fibers. Mix proportion M20 (1:2.85:2.17) concrete was taken. Cement is replaced by 10% and 15% of silica fume. The compressive strength of conventional concrete, concrete with silica fume and Litracon were tested. The project was carried out by adding 10% and 15% optical fibers and concluded that the compressive strength of light transmitting concrete with 10% and 15% replacement of cement by silica fume had been increased by 17.13% and 22.76% respectively than that of conventional concrete. Application of optical fiber will make the concrete structurally efficient by acting as reinforcing material.

- **T .G. Ram Kumar**[18] compared the strength of light transmitting concrete to the conventional concrete. The compressive strength of of 7, 14 and 28days were observed. The conclusion had been taken as the strength of LTC was found to be ranging between 30-37MPa indicated concrete meet the strength requirement for building structures. The initial cost of LTC is slightly more than that of conventional concrete. But the daytime electricity usage is reduced by the reduced of light transmitting concrete.

- **S. Ravivarman**[14] introduces with the replacement of small buildings with high rise buildings and sky scrapers. This arise the problem of natural light, due to obstruction of nearby structures. To overcome this problem, artificial light source is increased. Litracon successfully produced the first transparent concrete block in 2003. It is very essential to reduce the artificial light consumption in structure, since concrete is strong in compression and weak in tension and flexure.

- **Sangmesh R**[12] makes concrete blocks with the use of optical fibers. Different percentages of optical fibers are used in conventional concrete with addition of 1.5% GI fibers. It concluded that the reduction in the strength of light transmitting concrete with plastic optical fiber and without any other additional fibers can be overcome by the addition of 1.5% GI fiber. It's green building material reducing the lighting cost during day time. Provides both aesthetic appearance and structural stability.

- **Urmila M Bhanuse**[11] compared 28days compressive strength of conventional light translucent concrete to light weight light translucent concrete. The smart translucent concrete has good light guiding property, and the optical fibers volume ratio to concrete is proportion to transmission. It will also reduce the carbon emission which is dangerous for the environment. Hence this can be treated as one if the high performance concrete. The use of this concrete is beneficial for protecting mother earth.

- **AnuragWahane**[14] studied about the translucent concrete samples made with different fiber amount varies from 2% to 4% and with thickness 0.25mm to 0.75mm. The studied cases were done on 100mm cube mold. The compressive strength of translucent concrete was observed to be similar to conventional concrete. This can be used as decorative concrete.

- **Basma F. Bashbash**[9] has done an experimental study using different diameters (1.5mm, 2mm, 2.5mm and 3mm) and different percentages (2%, 4% and 6%) of plastic optical fibers (POF). Its has been noticed that on 28days of compressive strength decrease until fiber content increases, that return to drcrease weight for concrete with fiber. Flexural test is slightly decreased with fiber content 2% to 20%-55% with several diameters also at fiber content from 2% to 6% is observably decrease.

- **Agustina Robles**[10] obtained by incorporating polymeric optical fibers(0.75mm, 1mm and 1.5mm) into a high strength SCM. The rheological and mechanical properties are observed, without defects.

III. MATERIALS AND MANUFACTURING PROCESS

For the manufacturing of LightTransmitting concrete, materials used are as follows:

a) Cement/ binder: In case of cement Ordinary Portland Cement(OPC).

b) Sand: The size of sand should pass through 1.18mm sieve.

c) Water: The quality of water should be potable water.

d) Optical fibres: The thickness of the fibres should be 0.002mm to 2mm.

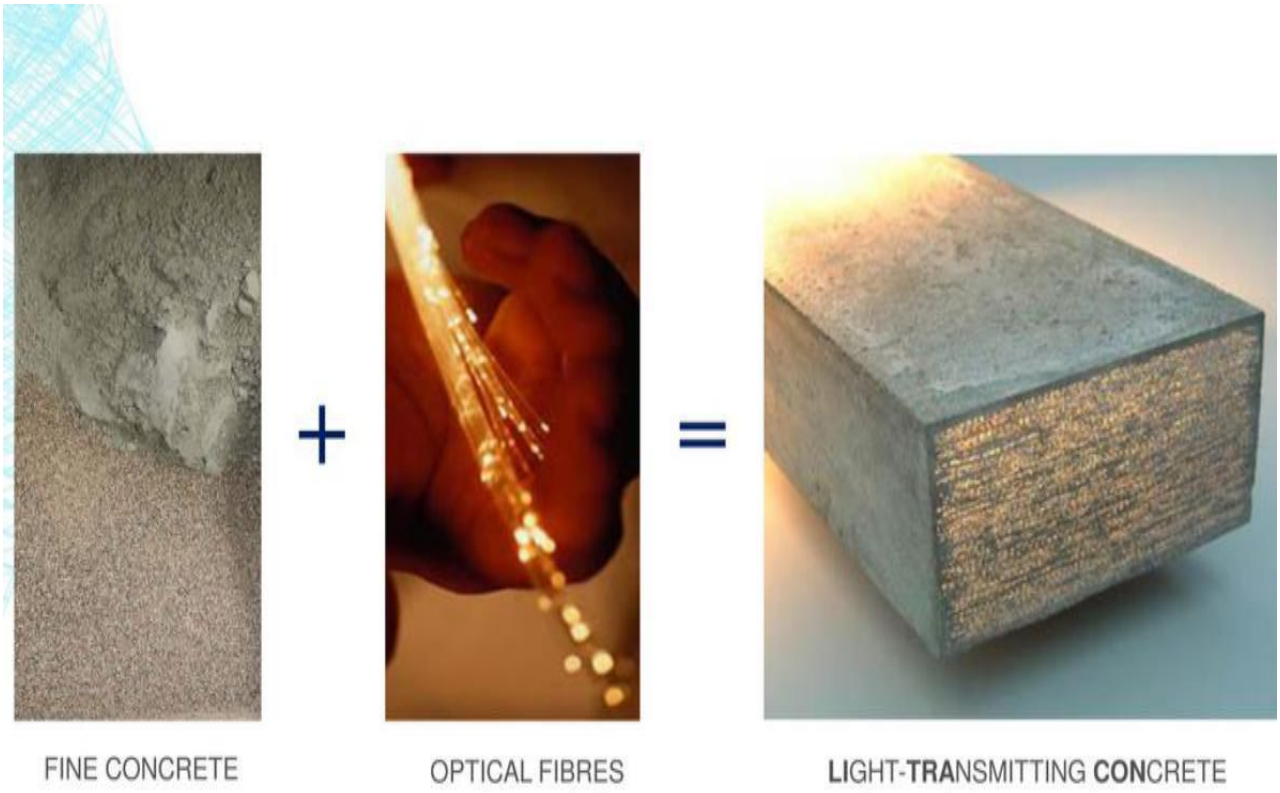

Fig. 2

No coarse aggregrate is used in this process.

For manufacturing LiTraCon several sequential methodologiesare to be taken, so that the productacquiredenough qualities.

Following are the steps of manufacturing process:

- The selection of materials for concrete from IS: 10262-2009, suitablematerials needed to be as per neccessary condition.
- Mix proportion,the grade of concrete varies generally in accordance with the changing proportionsof its constituents materials. The proportionand the ratio, in which the materials should be mixed together to obtain a certain grade of the concrete, has already been specified by IS: 456- 2000.
- The making of mold for casting LiTraCon. Special molds are made with plywood with holesin the end plates so that optical fibres can be inserted or placed from one end to the other end.
- The placing of optical fibres through the holesproperly and tightened at the ends without overstressing it.
- The casting of concrete specimens in the mold. De-molding it after 48 hours of casting and keeping for 28 days of curing.

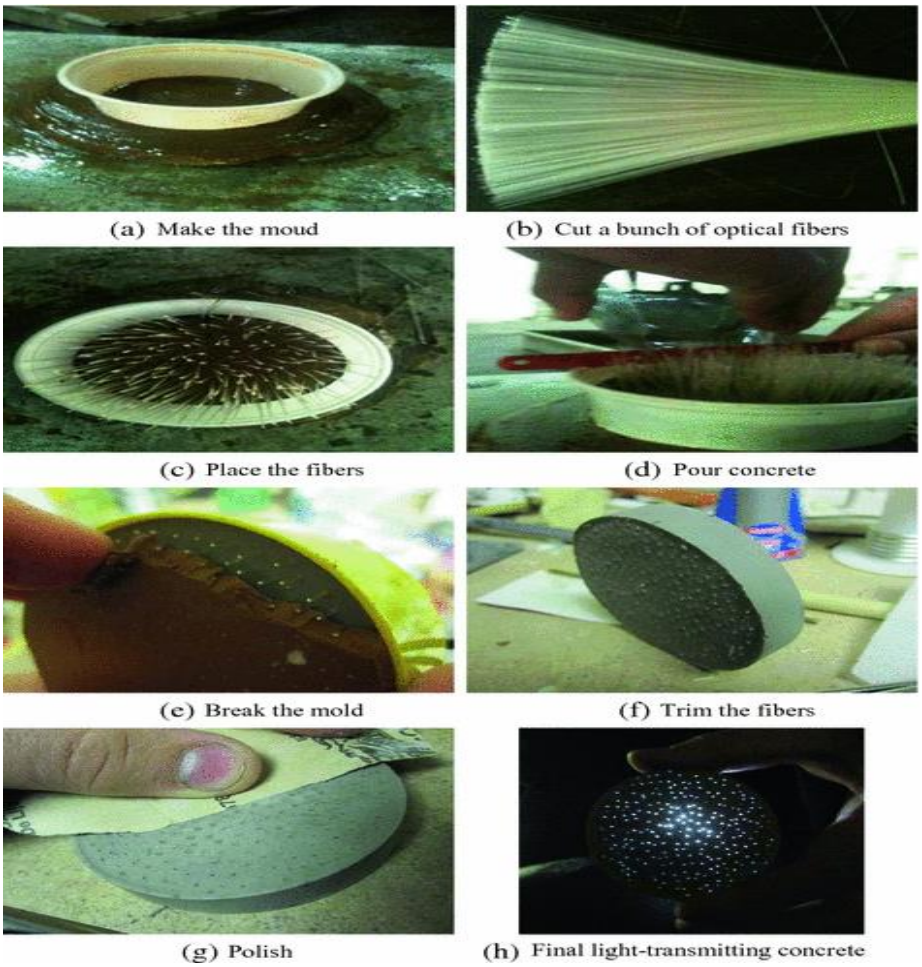

Fig. 3

IV. FUTURE SCOPE OF LIGHT TRANSMITTING CONCRETE

Translucent concrete comes in as a blessing solution for easier day lighting. When many buildings are stacked close to eachother, there is not much natural sunlight passes through and the importance of natural sunlight is pretty well known. In fact, 50% day lighting is a mandatory requirement in green building. Translucent concrete blocks inserted on front doors or walls next to it allow the residents to see when there is a person standing outside. It let just about pass enough light to pass through it to make it a viable material for reducing power consumptions. Hence, it can be used as an eco-friendly alternative to traditional concrete in the near future.

V. CONCLUSIONS AND DISCUSSIONS

We are living in a world, where energy consumption and environmental problem have increased to ultimate level. Everybody has to focus on "green technology". New innovations are adopted and pursued by all. Buildings are constructed with artificial light because of obstruction for enough day light coming inside to closed area. Demands on efficiency makes the researchers thing towards eco-friendly ways. Development and adaptation of different concretes attracts marketing zone.

LiTraCon, gives a solution to the problem. It put its effect on people. Construction of buildings and monuments with LTC shows magical effect during non-light hours. In future, LTC may be seen to be used worldwide. Using it in partition walls, panels ,treads of staircase, halls, and other areas of commercial buildings not only increase beauteousness but also saves consumption of electricity. Using LTC in rigid pavements can deduce lots of electricity use. It also can be used as a highlightner on the pavement showing different road features.

But the manufacturing process lends down the growth of market. Need of skilled workers is a challenge for the production. Availability of the skilled workers at a low rate reduce its rising trend. One more big cause is the raw material cost and finally high production cost. High productivity cost makes constructors to avoid LTC inspite of good features. For the upcoming future agenda, researchers need to focus on efficient and economical way for the production of LTC.

This review, broadly elaborate about Light Transmitting concrete, concluding with the facts that up gradation in the making process will enhance its uses worldwide. Beyond traditional concrete, it expands the concept of "Green architecture". Recently, it has been found that a boy in Uttar Pradesh has developed a cheap "transparent concrete" with steel, iron and plastic fibre scraps which will allow the sun rays to filter in. The invention was made by RamanshBajpai,a student of the MTech course in civil engineering at the Harcourt Butler Technical University (HBTU) in Kanpur.Apart from it, if we can enhance this concrete by making it to absorb the sunlight energy during the day and illuminate it back during night without any consumption of power. World is escalating, denudation of environment should be ceased, green technology should be enhanced, encouraging sustainable development.

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