"AN EXPERIMENTAL STUDY ON LIGHT TRANSMITTING CONCRETE"

Ashutosh Chauhan, Samant Rana, Mohit Kumar, ShailjaTripathi

[1, 2,3]*Dept. of Civil Engineering, MIET, Meerut, Uttar Pradesh, 250005*

[4]*Assistant Professor, Dept. of Civil Engineering, MIET, Meerut, Uttar Pradesh, 250005*

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Abstract-*The present study aims at producing the "Light Transmitting Concrete" specimens by reinforcing optical fibres and comparing it with the conventional concrete. The concrete specimens were subjected to different tests such as compressive strength test. The compressive strength results obtained for the translucent concrete specimens were almost same as that of the conventional concrete specimen. The results of the transmission test were satisfactory as the POF retain its efficiency. Thus, it is evident that the transparency of the concrete structures can be introduced with the insertion of optical fibres without compromising the strength, which is a step forward to the aspiration of achieving some new feet in modern architecture.The recent economic and infrastructure developments made us to depend on artificial sources of energy. Thus, light transmitting concrete is the need of hour. Light transmitting concrete allows natural (i.e. sunlight) or any other light to pass through it. Thus reduces electricity consumption in the buildings and makes easy for them to achieving higher LEED (Leadership in Energy and Environmental Design) rating. It has all those properties which an eco-friendly technique should have to keep up the green building concept into consideration, as it increases the use of natural resource i.e. sunlight, which is natural light and it reduces the use of electricity, thus, saving power consumption. Light transmitting concrete also gives aesthetically beautiful surface. It is made up of cement, sand, coarse aggregates and thousands of plastic optical fiber strands placed in alternate layers. But, no construction material can be used until it satisfies all constructional requirements. For this purpose, experimental study on light transmitting concrete has been carried out to determine its light transmittance characteristics with the help of Photometer device which is used to find the intensity of light in terms of lumens. The Compressive strength of light transmitting concrete is also found out by testing its cubes with the help of compression testing machine.*

Key Words:*Optical fibre, Concrete, Conventional Concrete (CC), LiTraCon, Compressive strength.*

1. **Introduction-**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. 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

ofapplication pertainsto 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. Translucent concrete (Transparent concrete) is new technique different from normal concrete. Translucent concrete allows 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 are 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. Energy conservation is a key and emerging global issue for sustainable infrastructure development. The building sector energy demand accounts approximately 34% of the world's energy demand. Artificial lighting consumes around 19% of the total delivered electricity, worldwide. The electric lighting demand has constantly been increasing with the increase in the population, urbanization and construction of high-rise buildings. The production of electricity contributes to the increase in the greenhouse gas emissions. Translucent concrete is an innovative solution towards significantly reducing the need for artificial lighting. This in turn reduces the carbon footprint by allowing transmission of natural light into building's interior when the translucent concrete is used as structural facades and architectural walls, thus fostering the development of green buildings. Natural light is a form of energy reflected as electromagnetic wave that contains full spectrum of the sunlight, which is healthy for human beings and a preference than artificial light. Indoor environments with adequate natural light illumination have been proven to decrease stress of occupant, improve visual comfort and render better employee retention. It is then essential to develop a new type of construction material, which can allow transmittance of appropriate luminance level of natural light into buildings and integrate the concept of green energy saving.

1.1. Need of Light Transmitting Concrete- This concrete is very important for sustainable development and green building point of view, as it allows, use of natural light more efficiently without compromising much on strength parameter. For green buildings, according to IGBC (Indian Green Building Council), 50% of day light is mandatory which accounts for 3 credits in a green building. Light transmitting concrete may allow sufficient light inside the building, thereby making it easier to achieve higher rating for buildings. Due to increase in land cost, requirement of increased usable space, engineers are being compelled to go for high rise buildings and skyscrapers. In these structures, people's optical activity requirements are met with the help of artificial sources of energy only. Complete dependence on artificial sources has adverse impact on our environment and health of people. As the production of artificial sources of energy, pollutes our environment by releasing harmful by products into the environment. Light transmitting concrete or translucent concrete is a special type of concrete that allows light to pass through it. It is made up of cement, sand, coarse aggregate and optical fibers, placed in alternate layers. Light transmitting concrete allows natural sunlight or any visible light to pass through it, thus, increasing the light content in the building to enhance people's optical activity. Passing of light through optical fiber is based on the principle of total internal reflection of light in the core of the plastic optical fiber. When light falls on one end of the optical fiber, it gets totally internally reflected in the fiber and gets transmitted to the other end of fiber. Very limited research has been done on various properties of light transmitting concrete regarding

its suitability as construction material. The main objective of this experimental program is to study its light transmitting and strength characteristics by varying plastic optical fiber percentage and concrete grade which may produce different effects on performance.

2. Objective-

- To produce light transmitting concrete by using plastic optical fibres.
- To study their characteristics and to develop a functioning material which is not only energy saving but gives out artistic finish.
- To compare the strength of light transmitting concrete to the conventional concrete.
- To compare the cost analysis of conventional concrete and light transmitting concrete.

3. Literature Review-

Kavya S, Karthik D, Sivaraja M [2016]. They have carried out an experimental study on light transmitting concrete using optical fibers. The project was carried out by adding 2.5%, 3.5%, 4.5%, and 5% optical fibers and concluded that the strength of concrete is high at 4.5% and gradually decreases at 5.5% respectively. The efficiency of the application of the optical fibers was studied by comparing the strength with normal M30 grade concrete and the test results proved that the efficiency is more in all aspects. Hence the application of optical fiber will make the concrete decorative as well as make the concrete structure efficient.

Gurpreet Singh, DhandeUttam, AdurkarAjit, Prof. Mrs G A [2016]. They have studied optical fibres casting of concrete involves the preparation of M25 grade concrete by cement, FA, CA, optical fibres. Casting of conventional concrete (0% of plastic optical fibre), casting of 3% of plastic optical fibre content, casting of 4% of plastic optical fibre concrete, compression test, and light transmission test are the steps involved. The % of light transmission through 3% fibre is 10.51% and 4% fiber is 12.55%. It saves electricity cost of a residential building throughout its life time. Compressive strength of 0% fibre, 3% fibre.

Amarkhail [2015]. He observed Effects of Silica Fume on Properties of High- Strength Concrete. Found that up to 10% cement may be replaced by silica fume without harming the concrete workability. Concrete containing 10% silica fume replacement achieved the highest compressive strength followed by 15% silica fume replacement with a small difference. Concrete with 15% silica fume content achieved the highest flexural strength.10% and 15% silica fume content as replacement of cement were found to be the optimum amount for significantly enhancement of compressive strength and flexural strength respectively.

Ghutke& Bhandari [2014]. They examine the Influence of silica fume on concrete. Results showed that the silica fume is a good replacement of cement. The rate of strength gain in silica fume concrete is high. Workability of concrete decreases as increase with % of silica fume. The optimum value of compressive strength can be achieved in 10% replacement of silica fume. As strength of 15% replacement of cement by silica fume is more than normal concrete. The optimum silica fume replacementpercentage varies from 10 % to 15 % replacement level.

Kashiyaniet. al. Studied light transmitting concrete using 4% to 5% optical fibers. The fibers of diameter from 2 μ m to 2 mm were used in alternate layers with concrete. The concrete was based on the principle of total internal reflection of optical fibers.

Bhusanet. al. Constructed translucent concrete block and discussed their use in walls, ceiling to make it architecturally pleasing,illuminating speed bumps, use of sidewalks,various interior and exterior surfaces of thebuildings to make them aesthetically beautiful.Plastic optical fibers (POFs) have variousadvantages like no radiation, not affected byradio magnetic interference, radio frequency andnoise. POFs are by far the best replacement forglass due to strength and giving more privacy.

Juan and Zhi Discussed the development of smart transparent concrete based on its excellent properties of smart sensing. By dealing its usage and advantages, it makes smart construction, reduces power consumption for illumination and use of optic fibers to sense stress in structures. They concluded that transparent concrete does not lose strength parameter when compared to conventional concrete. It can be used for the best architectural appearance of the building and can be used where light cannot reach with appropriate intensity.

Kamdi, B.A. Found that light transmitting concrete can be used almost anywhere, where glass of traditional concrete can be used. This concrete has dual effect, one on strength and other to transmit light. It also retains privacy and can be used for structural support. Its disadvantage is that it is expensive.

Neha and Bhole Prepared translucent concrete using optical fibers. For preparing mould, first polymer craft clay was spread into a flat circle, a ring of spray paint was used to fix over clay for using it as a mould then optical fibers were placed individually in the mould and finally concrete was poured slowly. After 24 hours, polymer clay was pulled and then plastic ring was removed. The concrete was allowed to dry and extra fibers were cut. Sand paper was used to polish. The prepared concrete was able to pass light through it.

Zhiet. al. Studied the light transmitting characteristics of light transmitting concrete by making four cube specimens of 100mm size with cement: sand: water in proportion of 1: 2: 0.44 and plastic optic fibers of 3.14%, 3.80%, 4.52% and 5.3%. They observed that light transmittance was varying from 1% to 2.25% of the incident light.

Mominet. al. Used six specimens of translucent concrete with varying POF as 1%, 2%, 3%, 4%, 5% and 6% with diameter of POF as 1mm. It was observed that for halogen lamp, transmittance varied as 0.29%, 0.59%, 0.98%, 1.41%, 1.83% and 2.36%, while for incandescent lamp of 200W, the transmittance was observed as 0.41%, 0.82%, 1.22%, 1.72%, 2.15% and 2.59% respectively. The difference in transmittance is due to light scattering angles of chosen lamps were different.

Ahuja et. al. Investigated translucent concrete by using fibers to channel solar radiation into the building, to reduce dependence on artificial power requirement during the day. They presented a geometrical ray-tracing algorithm to simulate light transmission properties of a panel of translucent concrete. They concluded that a tilt of 30*P* for the panel transmitted the maximum amount of light among all the tilt angles considered and it is natural because fibers absorb radiation of sunlight.

Shanmugavadivulet. al. Used M20 concrete for 150mm size cubes to determine compressive strength of conventional concrete and light transmitting concrete at 7days, 14days and 28 days. They found that strength is comparable.

Jimenaz and Fernandezused glass fibers of 0%, 5%, 10% and 30% and determined compressive strength of concrete at 7days and 28 days, which was reduced gradually from 33.6 MPa to 25.7 MPa at 7 days and 34.2 MPa to 26.9MPa at 28 days.

Bashbashet. al.: Used 50 mm cubes with POF of 4% having diameters of fibers as 1.5cm, 2.0cm, 2.5cm and 3.0cm. They observed that for the same percentage of fibers, the larger diameter concrete has higher strength.

Paul and Dutta:used chloride diffusion coefficient method (or electric flux method) to test permeability of translucent concrete, which can rapidly evaluate permeability of concrete by measuring electric energy through concrete. Concrete cylinders of 100mm diameter and 50mm height with 0%, 3% and 6% POF were chosen for the test and electric energy was recorded by electric flux detector. In order to evaluate the effect of interface bonding on the impermeability property, each model of the specimen was divided in two types i.e. one was covered with epoxy resin at the border of POF and other was un-covered. It was observed that total electric current without covering with epoxy resin were 1897.8 C, 3152.6 C and 3602.2 C for 0%, 3% and 6% respectively while total electric current. Traversing the specimens covered by resin were reduced to 2147 C. and 3357 C for 3% and 6% POFs respectively.

4. Materials Used-

- **Cement:** A fine substance made with calcined lime and dirt. It is blended with water and sand to frame mortar and blended with sand, rock, and water to make concrete. In assembling of Concrete shapes and barrels OPC – 43 was utilized.

- **Fine aggregate:** Aggregates are the major and important constituents of concrete. They form the whole body of the concrete as it occupies 70-80% of the volume of concrete. Fine aggregate is sand which is usually obtained from rivers or lakes. Sometimes beach sand also used. In this project we use river sand.

- **Coarse Aggregate:** The aggregates used for production of Concrete is free from sound and honeycombed practices. Those particles that are predominantly retained on the 4.75mm I.S Sieve are called coarse aggregate. The nominal size of coarse aggregate with 20mm is used in this work.

- **Optical fibers:** Optical fiber is a cylindrical wave guide, composed of transparent dielectric (glass or plastics) from which light is transmitted by absolute internal reflex. This lets light waves travel long distances, without any lack of energy. Optical fiber consists of an internal cavity, called the nucleus, with a very high refractive index made of glass or plastic. A cylindrical layer of glass or lower refractive index plastic called cladding protects the core. The surface is covered by a shield that protects the material from corrosion and abrasion.

5. Methodology-

- **Mould preparation:** In the process of producing light transmitting concrete, the first step involved is preparation of mould. The mould prototype can be made with different materials such as, cast iron or play wood. In the mould preparation, it is very important to fix the basic dimensions of mould. The standard size of the cube and cylinder according to IS 456 2000, is 15cm X 15cm X15cm and 30cm height with15cm diameter for concrete respectively. Markings are made exactly according to the size of the cube, the holes of 3mm diameter are made on two opposite sides of moulds with spacing of 2cm.

- **Optical fibers:** The optical fibers were cut into pieces of required length with certain portion emerging out of the mould. In the present study optical fiber of 0.75mm diameter has been used, tied up the four strands of optical fibers using tape.

- **Fixing of fibers:** This tied optical fibers are then passed through the 3mm diameter holes in the moulds.

- **Concreting:** In the present work the concrete mix has been prepared with ordinary Portland cement of 43 grade, M sand 2.75mm sieve passing, coarse aggregates of 12mm down size silica fume and tap water. The moulds were cleaned thoroughly and oiled to obtain smooth finishing surface. The prepared mix and the layer of optical fibers were placed alternatively, and subject for vibrator machine for compaction.

- **Demoulding:** After 24hrs of casting demould the concrete specimens**.** Curing of concrete: -After removing mould the concrete specimens were kept for curing for about 7days and 28 days.

- **Cutting and polishing:** After curing period of concretespecimens and before subjecting for tests, the extra portionof optical fibers projecting out of the cubes and cylindershas to be cut and polished for better transmission of light
  Through the optical fibers.

6. Compression Test:

- By definition, the compressive strength of material is that value of axial compressive stress reached when the material fails completely.
- The compressive strength is usually obtained experimentally by means of compressive test.
- The compressive strength of concrete is determined by cast the cubes of 150mm x 150mm x 150mm. It is the most important test for concrete.
- The compressive strength based on the average of three cubes which are 7 days 14 days and 28 days of curing of light transmitting concrete and conventional concrete.
- Place the case in the machine in such a path, to the point that the stack may be associated with the opposite sides of the strong shape cast.
- Adjust the example halfway on the base plate of the machine.
- Apply the heap bit by bit without stun and constantly till the example falls flat.
- Record the most extreme load and note any abnormal highlights in the sort of disappointment.


Aimil
COMPRESSION
TESTING
MACHINE
2000KN
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7. Result

COMPRESSIVE STRENGTH TEST

- **CONVENTIONAL CONCRETE:**

The compressive strength of conventional concrete was then determined by using compressive testing machine after 7days, 14days and 28 days of curing and the results are given below.

Days	Maximum load (KN)	Compressive strength (N/mm2)	Average (N/mm2)
7	600	26.66	**25.55**
	550	24.44	
14	800	35.55	**36.10**
	825	36.66	
28	900	40	**41.11**
	950	42.22	

- **LIGHT TRANSMITTING CONCRETE:**

The compressive strength of Light Transmitting concrete was then determined by using compressive testing machine after 7days, 14days and 28 days of curing and the results are given below.

Days	Optical Fiber %	Maximum load (kN)	Compressive strength (N/mm2)	Average
7	5%	570	25.33	**26**
		600	26.66	
14	15%	720	32	**33.56**
		790	35.11	
28	10%	950	42.22	**42.88**
		980	43.56	

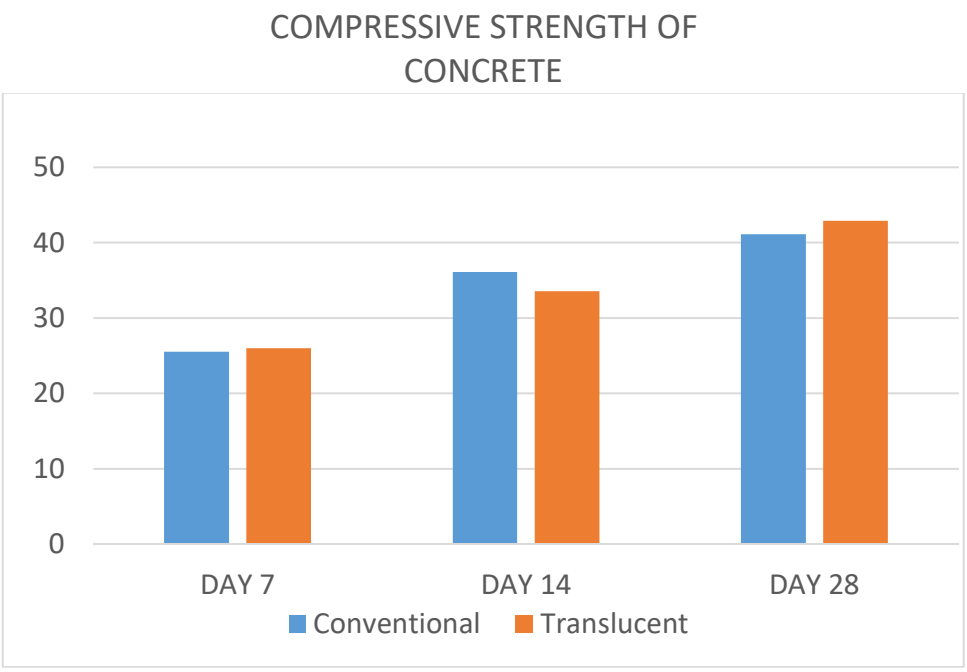

Fig. graph of compressive strength test

- **COST ANALYSIS**

The cost of material for light transmitting concrete and conventional concrete are compared.

CONVENTIONAL CONCRETE:

S.NO	Material	Weight	Rate	Unit	Amount (Rs)
1	Cement	8.91	410	Kg	**73**
2	Fine Aggregate	15.837	3000/Ton	Cu.m.	**48**
3	Coarse Aggregate	28.57	4000/Ton	Cu.m.	**114**
4	Water	3.56		Lt.	**40**
5.	Admixture	0.0334	890	Kg	**30**
				TOTAL	**Rs.305/-**

LIGHT TRANSMITTING CONCRETE:

S.NO.	Material	Weight	Rate	Unit	Amount (Rs)
1	Cement	8.91	410	Kg	**73**
2	Fine Aggregate	15.837	3000/Ton	Cu.m.	**48**
3	Water	3.56		Lt.	**40**
4	Admixture	0.0334	890	Kg	**30**
5	Optical Fibre	0.35	1500	Kg	**525**
				TOTAL	**Rs.716/-**

8. Conclusion:

After the experimental investigation, the following conclusions can be made:

- The compressive strength of light transmitting concrete was found to be ranging between **26-42 N/mm2** with plastic optical fibre specimen, which indicates that the concrete meets the compressive strength requirement for building structures.
- The initial cost of light transmitting concrete is **slightly more** than the conventional concrete. But the day time **electricity usage is reduced** by the usage of light transmitting concrete.
- Thus the study concludes that the transparency of light is possible in concrete without affecting its compressive strength, as the plastic optical fibre act as reinforcement thereby enhancing the strength and also enhances appearance.

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