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EXPERIMENTAL STUDY ON TRANSLUCENT CONCRETE BY USING OPTICAL FIBERS

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ABSTRACT

Translucent concrete is a concrete based on building material with light-Transmissive properties due to embedded light optical elements usually Optical fibers and glass powder. It is lighter than conventional concrete having special features such as low density and thermal conductivity with main advantage of reduction in dead weight, faster building rate in construction and handling cost. An optical fiber is a flexible transparent made of glass or plastic, slightly thicker than a human hair and can function as a wave guide to transmit light between the two ends. Recently, the concept of green architecture has become a common interest in various disciplines. Innovative materials are continuously developed to fulfill the green architecture requirements. Translucent Concrete is a new type of Concrete used widely in the construction industry. The main purpose of transparent concrete is to use sunlight as a light source to reduce the power consumption of illumination and to use the optical fiber to sense the stress of structures and also use this concrete as an architectural purpose for good aesthetical view of the building. The Light is conducted through the stone from one end to the other. Therefore, the fibers have to go through the whole object. Translucent concrete is also known as the transparent concrete and light transmitting concrete because of its properties. It is used in fine architecture as a facade material and for cladding of interior walls etc. The concrete considered is cement mortar which contain fine aggregate and cement. The fibers are placed in shortest direction to increase the transparency of concrete. In this paper, to integrate the merits of concrete and optical fiber, for developing transparent concrete by arranging the high numerical aperture Plastic Optical Fibers or big diameter glass optical fiber into concrete. The size of optical fiber will vary between 2μm and 2mm. in order to increase the transparency of concrete the same amount of cement is replaced by fine glass powder. The binding capacity of glass powder and cement are same. The specimen casted will contain 95% of concrete and 5% of plastic optical fibres. We reviewed the remarkable studies carried out especially last 10 years in translucent concrete techniques.

Keywords: Translucent Concrete, Optical Fibers, Glass Powder, Cement, Sand, Concrete, Glass Fibers, Transparent Concrete, Light Transmitting Concrete, Energy Saving, Material, Sustainable Concrete, Optical Concrete, Workability, Compressive Strength, Tensile Strength, Flexural Strength.

I. INTRODUCTION

Translucent Concrete is a new technology used in the construction industry. It is a new material with various applications in the construction field, architecture, decoration, and even in furniture industry. Due to great economic growth, population growth and space utilization worldwide, there is a change in concrete technology. Concrete is a strong material, and day-by-day the research work is increasing in this topic. It is a good and important binding material for constructing any reinforced cement concrete structures. Nowadays, we have available different types of Concrete in the market, and also day by day, researchers are done on this topic by research scholars. At present green structures are greatly focusing on saving energy with different systems. Research on intrinsic characteristics material which transmits the light from one end to another end is used as a construction material, known as optical fibers. Translucent Concrete is also called as light-transmitting Concrete as well as transparent concrete. It has a good property, i.e., light-transmitting property. It is one of the different techniques, and it is also different from normal conventional Concrete. It is also known as LiTraCon. It is considered to be one of the best sensor materials available and has widely been used from early 1990s. Translucent Concrete is originally found in the year 2001. Aron Losonczi, a Hungarian architect, first proposed the idea of transparent concrete in 2001. The first transparent concrete block, known as light transmitting concrete, was successfully created in 2003 utilizing a significant amount of glass fiber. However, his transparent concrete did not have smart sensing properties. As glass and optical fiber technology advances, more work will be done on transparent concrete. Optical fiber has been added to transparent concrete, which is made of the same material as normal concrete. While optical fibers are frequently used in concrete to boost the material's tensile strength, they are not employed in transparent concrete because it simply transmits light. Hardened concrete that allows light to enter through it is referred to as transparent concrete. It is also known as transparent concrete or light-transmitting concrete. Optical fiber have very good light guiding and sensing capability. Transparent concrete enhances the building's visual appeal, making it fashionable in recent years. When many buildings are stacked close to each other, there is not much natural sunlight passing through and the importance of natural sunlight is pretty well known. Translucent concrete comes in as a blessing solution for easier day lighting. Therefore, the fibers have to go through the whole object. The ornamental qualities of the light transmitting concrete are enhanced at night when moonlight illuminates your rooms. Translucent concrete is like ordinary concrete because the strength of both concrete is the same. Generally, the internal wall is made using transparent concrete. However, it is rarely utilized for exterior walls because it could interfere your privacy.

II. OBJECTIVE

The main objective of making translucent concrete is to use sunlight as the light source instead of electrical energy in order to reduce the load on non-renewable sources and to develop energy saving material. As a result of this technique, energy is saved.

- To study the fresh state and hardened state of developed concrete mix in laboratory.
- Development of light transmitting concrete by using optical fibers.
- To investigate different basic properties of concrete such as compressive strength.
- To substantiate effective usage of Optical Fibers.
- This can open a new scope for reusing sunlight.

III. METHODOLOGY

Materials- Concrete is the most widely used construction material in the world after water, and for good reason. It is strong, durable, and versatile, with a wide range of applications from buildings to bridges, roads to dams. we'll explore the ubiquitous nature of concrete and understand the different types of concrete, their composition, properties, and uses of this essential building material. Cement is defined as a binding agent that is used to bind various construction materials. Given its adhesive and cohesive properties, it is an essential ingredient of concrete and mortar. Cement is mixed with water to form a paste that binds aggregates like sand or crushed rocks. Calcium, silicon, iron and aluminum compounds are closely ground to form a fine powdered product – cement. In 1824, Joseph Aspdin created the precursor to modern-day cement – Portland cement. Due to the interlocking of the hydrates, cement gets its strength.

Materials required for making of Transparent Concrete :-

1. Cement

2. Fine Aggregate

3. Optical Fiber

4. Water

5. Fly Ash

1. Mold preparation:

The first stage in the production of light-transmitting concrete is the preparation of the mould. The mould maybe manufactured of different materials, including ply wood or cast iron. In this case, plywood with conventional dimensions of 150 mm* 150 mm* 150 mm was utilized to create the mould. On the two opposing sides of the moulds with the necessary spacing, markings are formed and holes of the desired diameter are drilled.

2. Material selection:

The primary core component of concrete namely fine aggregate and cement is used except for coarse aggregate. Plastic optic fibers are additionally used for their ability to transmit light.

3. Fixing optical fiber:

It involves cutting it into pieces that are roughly the correct length and allowing some of it to stick out of the mould. The holes in the moulds are then filled with these optical fibers. In this case the fibers were fixed at half an inch spacing between each other.

4. **Concreting:**

A concrete mix is created from 53-grade cement, M-sand, and potable water. Moulds are completely cleaned and provide a smooth finishing surface. The resulting mixture is poured into the moulds and subjected to vibrational compaction. The mix ratio of concrete was 1:1.5

5. **Demolding:**

Concrete specimens are demolded 24 hours after casting.

6. **Curing:**

After the mixture has been poured into the moulds, it is cured between 3, 7 and 28 days by being completely submerged in water.

7. **Finishing:**

It involves trimming off any extra material, cleaning, polishing, and cutting the piece to the correct size and form.

Preliminary tests were conducted on the normal concrete materials as per IS standards and specifications for its physical and engineering properties, cubes were casted in the standard metallic moulds and vibrated to obtain the required sample size of specimen. The moulds were cleaned initially and oiled on all the sides before concrete sample is poured in to it. Thoroughly mixed concrete is poured into the moulds in three equal layers and compacted using vibrating table for a small period of 5 minutes. The excess concrete is removed out of the mould using trowel and the top surface is finished with smooth surface.

The manufacturing process of transparent concrete is same as of the regular concrete blocks with the Only change is optical fibers are spread throughout the fine aggregate and cement mix and Small layers of the concrete are poured on top of each other and infused with the fibers in the wooden casted box. Light transmitting concrete is produced by adding 5%, 7%, 9%, 11%, 14% & 16% of optical fibers into the concrete mixture, the translucent concrete mixture is made from fine aggregate materials only and does not contain coarse aggregates.
Optical fibers and concrete are alternately inserted into moulds at an intervals of approximately 1.5 cm spacing and finally the surface is typically polished resulting in semi-gloss to high-gloss surface finish. After 24 hours the samples of translucent concrete were demolded and put in curing tank for the respective periods of 3, 7 and 28 days and a set of 3 samples were prepared for each stage of curing. The temperature of curing tank was maintained about 25 degree during the analysis of characteristic strength & the results were tabulated.
The main aim of the methodology is to-
To calculate the compressive strength of M25 grade translucent concrete by laboratory experiments as per IS specification.
To calculate the Split tensile strength of M25 translucent concrete by laboratory experiments as per IS specifications.
To calculate the compressive strength of M25 grade translucent concrete by adding fly ash as a replacement of cement by laboratory experiments .
To calculate the Split tensile strength of M25 translucent concrete by adding fly ash as a replacement of cement by laboratory experiments .

IV. Experimental Setup

Materials used for light transmitting concrete is cement, sand, optical fibre, water and fly ash are used in this experiment .

EQUIPMENTS:-

1. **Mould Preparation** – The mould is made up of two plywood side 100x100 mm facing each other and the other two sides are Printed Circuit Boards (PCB) 100x100 mm. They are perforated boards and the sides are rested on a plywood base.

2. **Measuring Cylinder**– Measuring cylinder is used to measure liquids like Chemical admixture & water.

3. **Compressive Strength Testing Machine:-** A compression Testing Machine (CTM) is used to measure the compressive strength of a material. The CTM is designed to apply a compressive load to the sample until it fails. The machine consists of a piston that moves up and down inside a cylinder, applying the load to the sample. The CTM machine is used in construction industries to test the quality of concrete. The compressive strength of concrete is determined by testing concrete cubes or cylinders using the CTM machine. The CTM machine can also be used to test the compressive strength of other materials

such as bricks, rocks, and metals. The most common types of CTM machines are manually operated and digital machines. The manually operated CTM machine requires a skilled operator to control the load application, while the digital CTM machine is fully automatic and can be operated by anyone with minimal training. The CTM machine consists of a load frame, a hydraulic system, and a data acquisition system. The load frame is the main body of the machine, and it supports the hydraulic system and the data acquisition system. The hydraulic system is used to apply the load to the sample, and the data acquisition system is used to measure and record the load and deformation data. To perform a compression test using the CTM machine, the sample is prepared by casting it into a cube or cylinder mould. The sample is then cured for a specific period of time and tested by placing it in the CTM machine. The load is applied to the sample at a specific rate until it fails. The load and deformation data are recorded during the test, and the compressive strength of the sample is calculated using the recorded data.

PROCEDURE:-

The method for production of transparent concrete is almost same as regular concrete. Only optical fibres are spread throughout the aggregate and cement mix. The first concrete mix is prepared separately in this paper 1:1.5 ratio mortar used then the fibre is inserted into the mould. Small layers of the concrete are poured on top of each other and infused with the fibres. A huge number of optical fibres are cast into concrete to transmit light, either natural or artificial.

The light transmitting concrete is produced by adding 5% to 16% optical fibres by volume into the concrete mixture. The concrete mixture is made from fine materials only it does not contain a coarse aggregate. The thickness of the optical fibres can be varied between 2μ and 2mm to suit the particular requirements of light transmission.

The samples containing optical fibres fabricated are of size 100x100x100 mm cuboids. The optical fibre strands, batched by volume (or fibre to cement ratio), are placed through the holes individually. The cement paste is then prepared in 1.0: 2.0 proportions and poured into the mould and agitated with the help of mechanical vibrator to avoid void formation.

Compressive Strength Testing Machine: The compressive strength of samples was then determined after measuring the light transmitted blocks by using compressive testing machines .

V. RESULT & DISCUSSIONS

In this research paper , we have observed the effect of optical fibre as replacement of coarse aggregate along with cement and fine aggregate. We have mixed these materials is different proportion and their effect on compressive strength and split tensile strength was noted.

COMPRESSIVE STRENGTH:-

Experimental observation of Compressive Strength of Concrete by replacement of Coarse Aggregate with Optical Fiber for 3, 7 and 28 days.

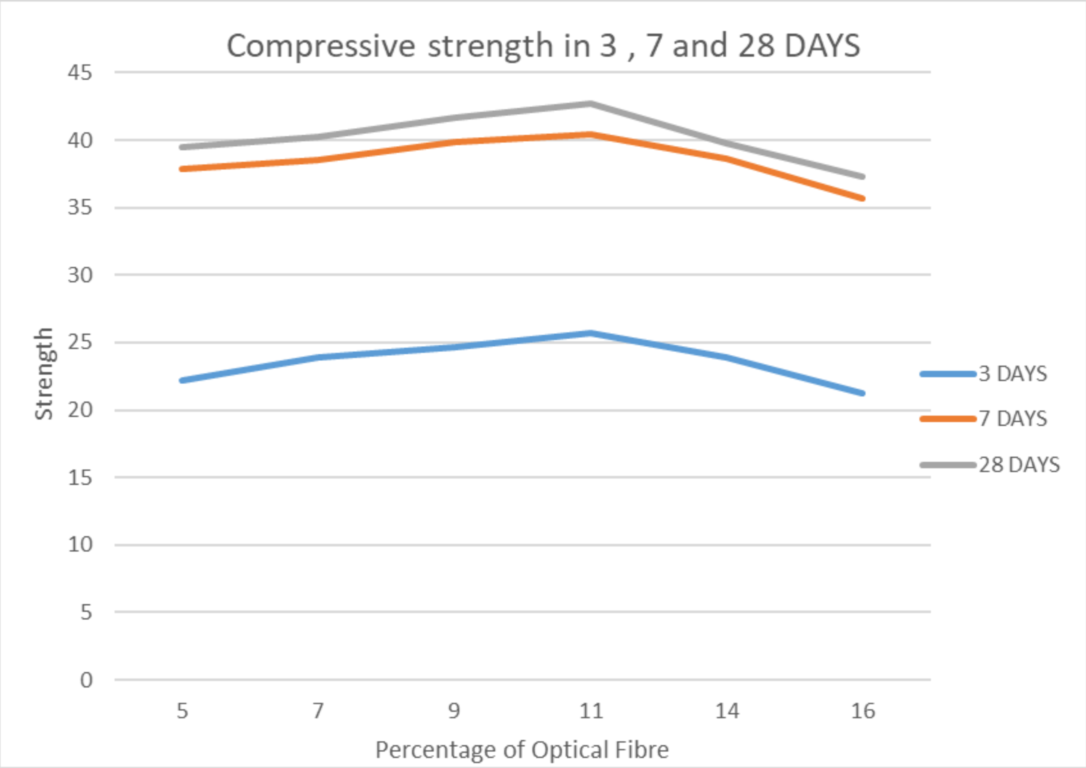
SL.NO.	Sample	Different Percentage of Optical Fiber (%)	Percentage of Fly Ash (%)	Compressive strength (N/sq. mm)		
				3 Days	7 Days	28 Days
1.	Sample 1	5	0	22.43	37.98	39.86
	Sample 2			22.22	37.87	39.52
	Sample 3			22.01	37.76	39.18
2.	Sample 1	7	0	24.06	38.82	40.67
	Sample 2			23.86	38.53	40.24
	Sample 3			23.66	38.24	39.81
3.	Sample 1	9	0	24.67	39.90	41.66
	Sample 2			24.83	40.21	41.95
	Sample 3			24.51	39.59	41.37
4.	Sample 1	11	0	25.95	40.93	42.92
	Sample 2			25.72	40.42	42.69
	Sample 3			25.49	39.91	42.46
5.	Sample 1	14	0	24.35	38.29	39.34
	Sample 2			23.43	38.97	40.12

	Sample 3			23.89	38.63	39.73
6.	Sample 1	16	0	21.27	35.65	37.26
	Sample 2			21.62	35.99	37.85
	Sample 3			20.92	35.31	36.67

Experimental observation of Compressive Strength of Concrete by replacement of Coarse Aggregate with Optical Fiber for 3, 7 and 28 days.(Average Value)

SL.NO.	Percentage of Fibre (%)	Percentage of Fly Ash (%)	Compressive strength (N/sq. mm)		
			3 Days	7 Days	28 Days
1.	5	0	22.22	37.87	39.52
2.	7	0	23.86	38.53	40.24
3.	9	0	24.67	39.90	41.66
4.	11	0	25.72	40.42	42.69
5.	14	0	23.89	38.63	39.73
6.	16	0	21.27	35.65	37.26

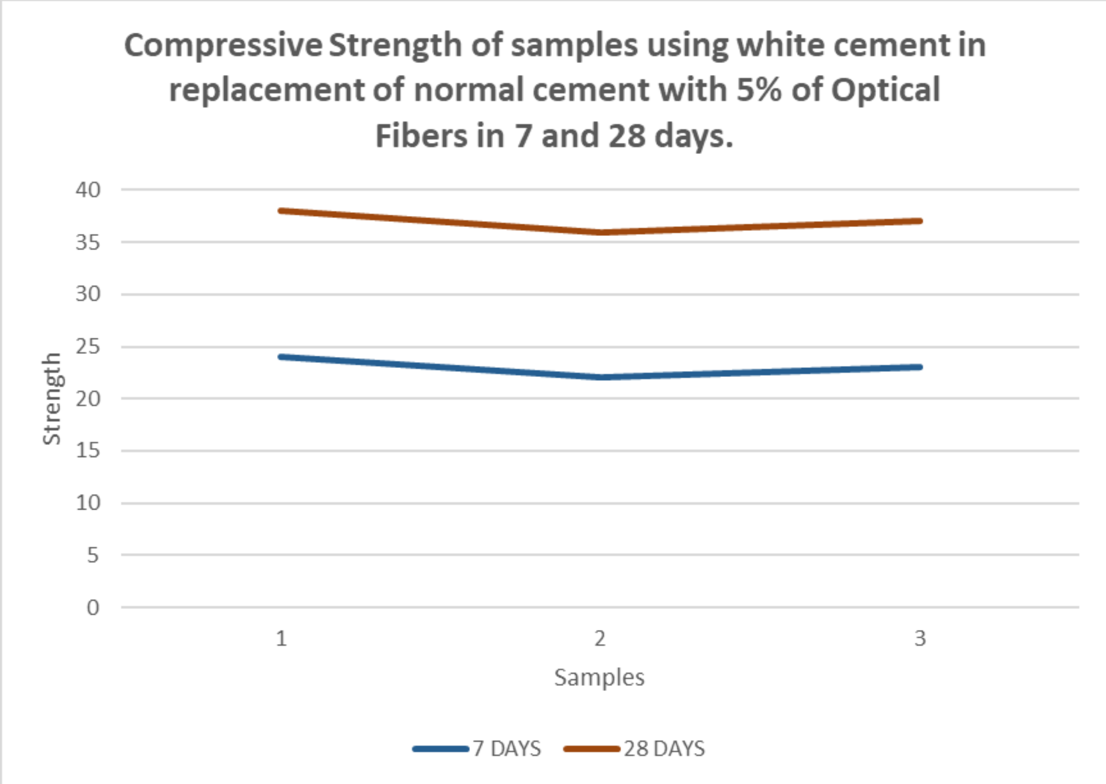
Compressive Strength by Replacement of Coarse Aggregate by Optical Fiber in 03 , 07 and 28 days.



Average Compressive Strength test of Translucent concrete samples blocks using white cement in replacement of normal cement with 5% of Optical Fibers.

SL. NO.	Curing Period (In Days)	Compressive strength**(N/sq. mm)**	Average Compressive strength**(N/sq. mm)**
1	7 Days	24	23
2		22	
3		23	
4	28 Days	38	37
5		36	
6		37	

Compressive Strength using White Cement by Replacement of Normal Cement with 5% of Optical Fiber in 07 and 28 days



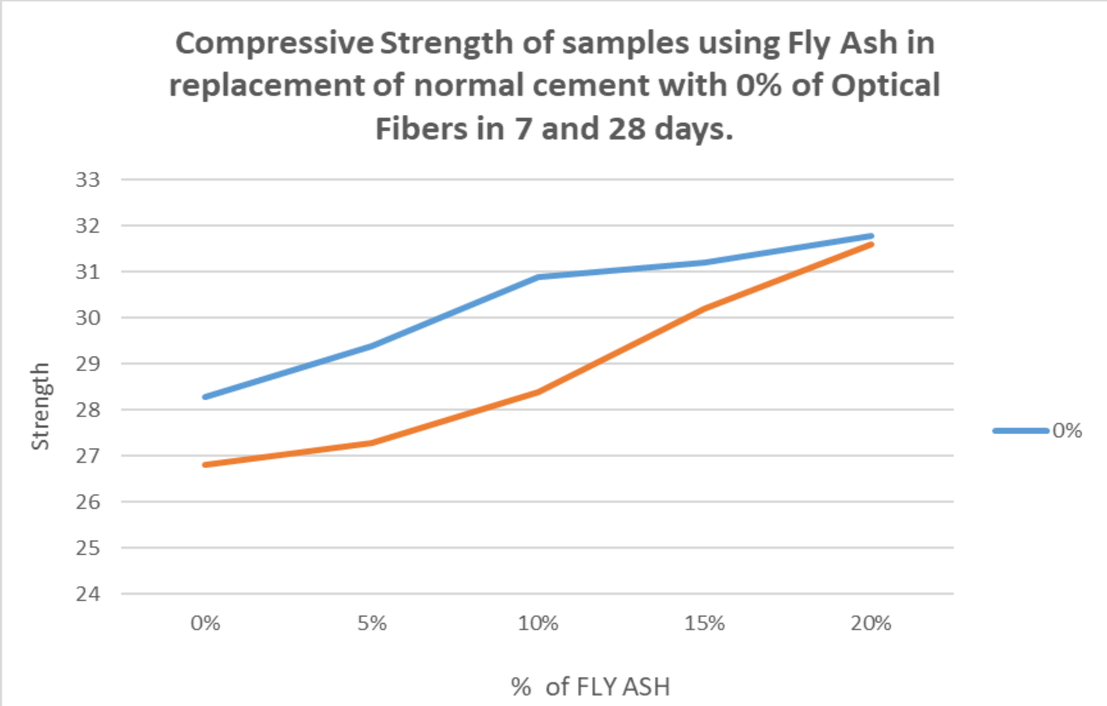
Comparison of Compressive Strength for 7 and 28 days after adding fly ash as a replacement of cement with 0% of optical fibre

Sl. No.	Replacement		Compressive Strength	
	Fly Ash	Optical fibre	7 days	28 days
01.	0%	0%	27.2	28.8
			26.8	28.3
			26.4	27.8
02.	5%	0%	27.9	29.9
			27.3	29.4
			26.7	28.9
03.	10%	0%	28.9	31.4
			28.4	30.9
			27.9	30.4
04.	15%	0%	30.7	31.6
			30.2	31.2
			29.7	30.8
05.	20%	0%	32.1	32.4
			31.6	31.8
			31.1	31.2

Comparison of Compressive Strength for 7 and 28 days after adding fly ash as a replacement of cement with 0% of optical fibre (N/mm2) (Average Value)

SL.NO.	Percentage of Fibre (%)	Percentage of Fly Ash (%)	Compressive strength (N/sq. mm)	
			7 Days	28 Days
1.	0	0	26.8	28.3
2.	0	5	27.3	29.4
3.	0	10	28.4	30.9
4.	0	15	30.2	31.2
5.	0	20	31.6	31.8

Compressive Strength after adding fly ash as a replacement of cement with 0% of Optical Fibre in 07 and 28 DAYS.



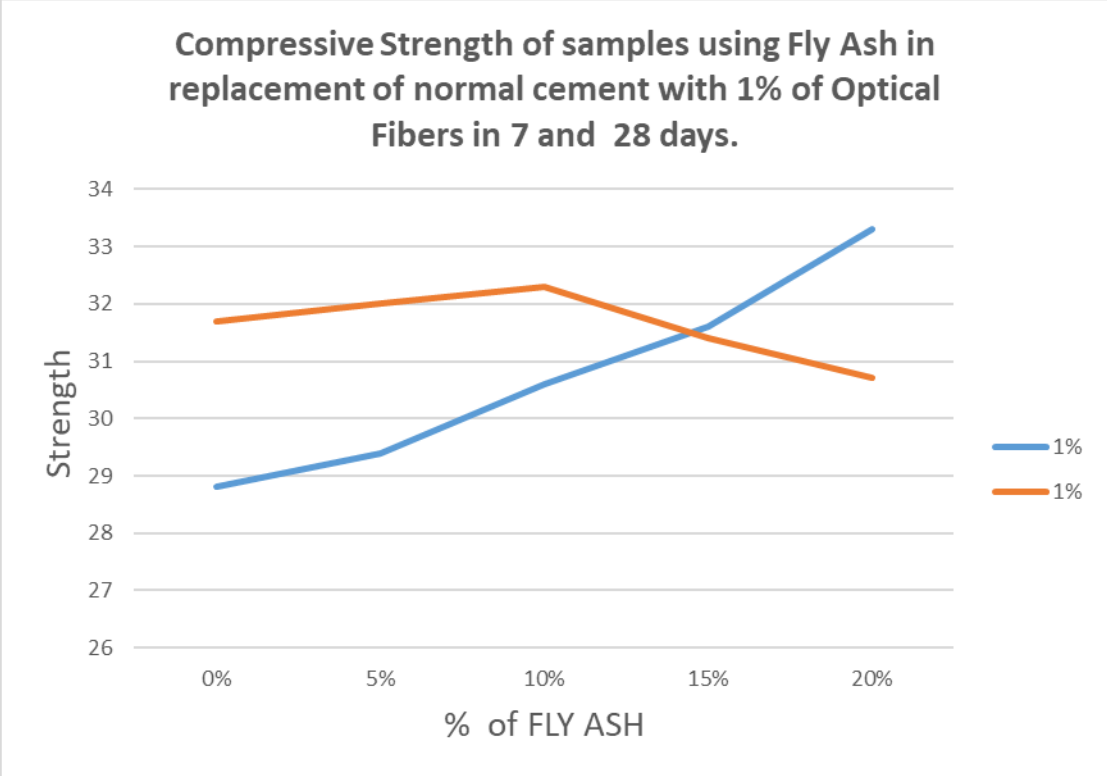
Comparison of Compressive Strength for 7 and 28 days after adding fly ash as a replacement of cement with 1% of optical fibre.

Sl. No.	Replacement		Compressive Strength	
	Fly Ash	Optical fibre	7 days	28 days
01.	0%	1%	29.6	32.4
			28.8	31.7
			28.0	31.0
02.	5%	1%	29.9	32.7
			29.4	32.0
			28.9	31.3
03.	10%	1%	31.1	32.9
			30.6	32.3
			30.1	31.7
04.	15%	1%	32.2	31.9
			31.6	31.4
			31.0	30.9
05.	20%	1%	33.8	31.3
			33.3	30.7
			32.8	30.1

Comparison of Compressive Strength for 7 and 28 days after adding fly ash as a replacement of cement with 1% of optical fibre (N/mm2) (Average Value)

SL.NO.	Percentage of Fibre (%)	Percentage of Fly Ash (%)	Compressive strength (N/sq. mm)	
			7 Days	28 Days
1.	1	0	28.8	31.7
2.	1	5	29.4	32.0
3.	1	10	30.6	32.3
4.	1	15	31.6	31.4
5.	1	20	33.3	30.7

Compressive Strength after adding fly ash as a replacement of cement with 1% of Optical Fibre in 07 and 28 DAYS.



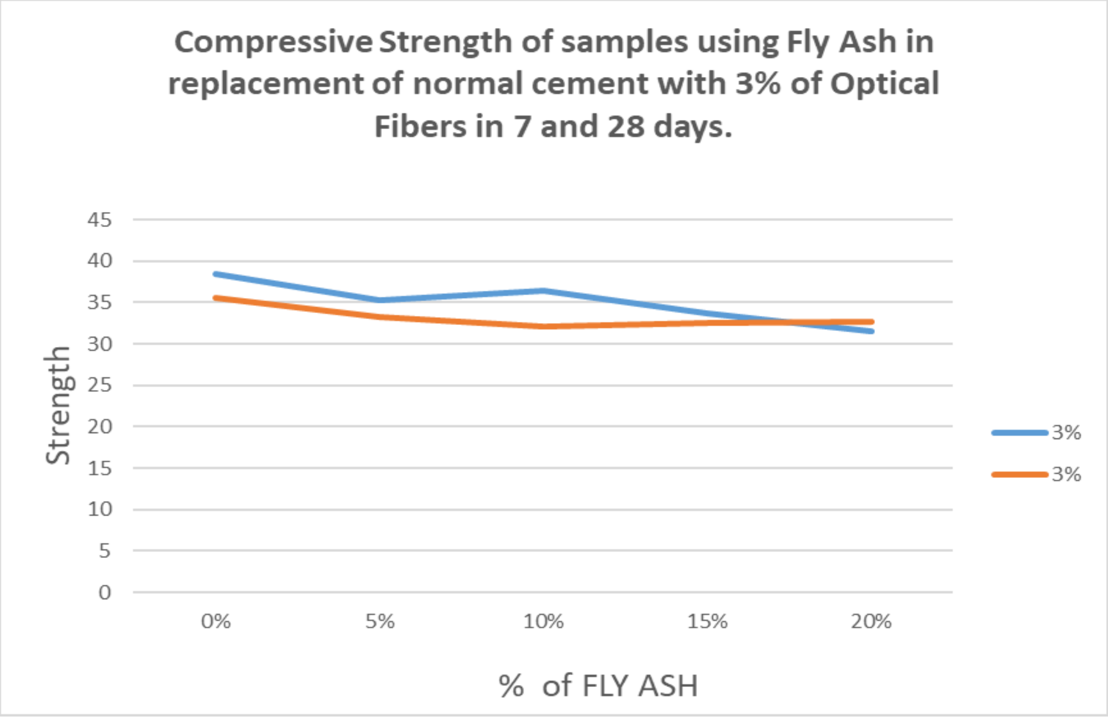
Comparison of Compressive Strength for 7 and 28 days after adding fly ash as a replacement of cement with 3% of optical fibre.

Sl. No.	Replacement		Compressive Strength	
	Fly Ash	Optical fibre	7 days	28 days
01.	0%	3%	36.1	39.2
			35.5	38.5
			34.9	37.8
02.	5%	3%	33.7	35.9
			33.2	35.3
			32.7	34.7
03.	10%	3%	32.8	37.0
			32.1	36.4
			31.4	35.8
04.	15%	3%	32.9	34.5
			32.5	33.7
			32.1	32.9
05.	20%	3%	33.4	32.2
			32.7	31.6
			32.0	31.0

Comparison of Compressive Strength for 7 and 28 days after adding fly ash as a replacement of cement with 3% of optical fibre (N/mm2) (Average Value)

SL.NO.	Percentage of Fibre (%)	Percentage of Fly Ash (%)	Compressive strength (N/sq. mm)	
			7 Days	28 Days
1.	3	0	35.5	38.5
2.	3	5	33.2	35.3
3.	3	10	32.1	36.4
4.	3	15	32.5	33.7
5.	3	20	32.7	31.6

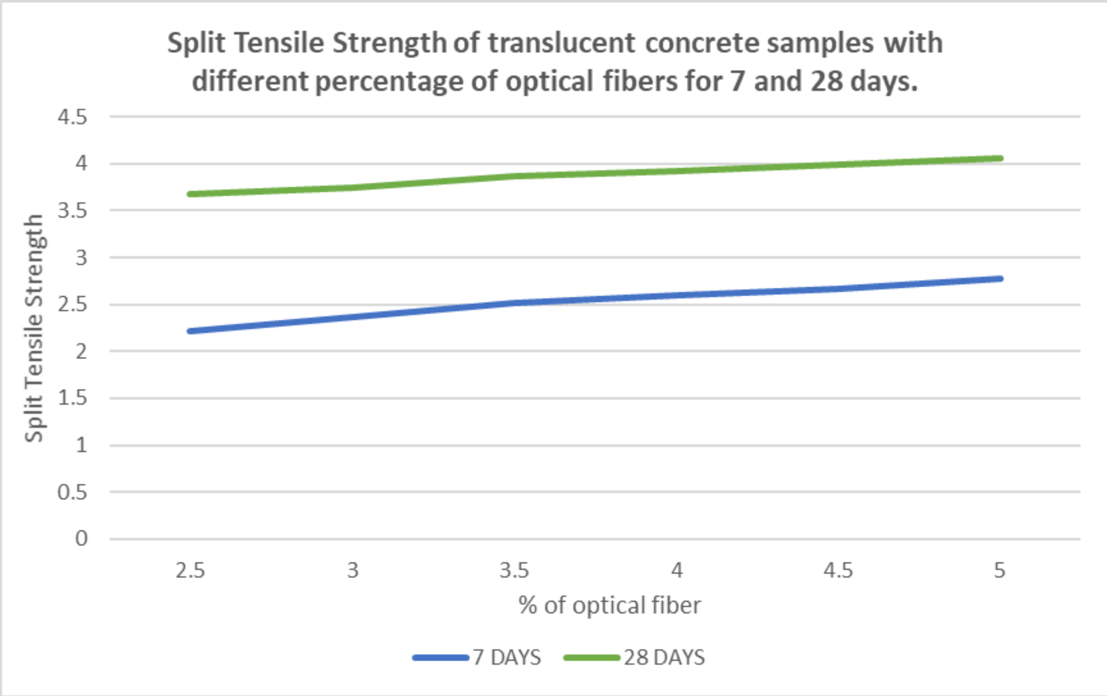
Compressive Strength after adding fly ash as a replacement of cement with 3% of Optical Fibre in 07 and 28 DAYS.



SPLIT TENSILE STRENGTH:-

Percentage of fiber (%)	Split Tensile Strength (N/sq. mm)	
	7 Days	28 Days
2.5	2.22	3.67
3	2.37	3.74
3.5	2.51	3.86
4	2.6	3.92
4.5	2.67	3.99
5	2.78	4.06

Split Tensile Strength of samples with different percentage of Optical Fibre in 07 and 28 DAYS.



VI. CONCLUSION

Using Translucent Concrete is a clever strategy to maximize the sun's energy and a way to save non-renewable energy. To increase its potential, more study in this topic is required. Most of the research, however, indicates that further study is necessary since the mechanical characteristics of transparent concrete strength are still inferior to those of regular concrete. To increase the strength performance, several of these studies used experimental research to examine the impact of optical fibre ratios on concrete mixtures ranging from 0%, 1%, 3%, 5%, 7%, 9%, 11%, 14% and 16%. As predicted, the results showed that compressive strength declined as the proportion of optical fibres increased. For this study, the diameters of the optical fibres used were 0.25 mm, 0.5 mm, 0.75 mm, 1 mm, and 2 mm as per requirements to fulfil the percentage of optical fibres in the desired cubes Based on the experimental results on the Translucent Concrete, Compressive strength, Split tensile strength and considering the "environmental aspects" the following observations made regarding of Percentage of Optical Fibres and Fly Ash added concrete.

- The Maximum Compressive Strength is "42.69 MPa" and it obtained at the ratio of 11 % Percentage of Optical Fibres, curing at a period of 28 days.
- In case of replacing cement with fly ash, the Compressive Strength is "38.5 MPa" and it obtained at the point of 3% Percentage of Optical Fibres and 0% Fly Ash, or a curing period of 28 days.
- The Maximum Split Tensile Strength is "4.06 MPa" and it obtained at the ratio of 5% Percentage of Optical Fibres, curing at a period of 28 days.
- As we are Increasing the Percentage of Optical Fibres , the light transmitting capacity in the desired translucent concrete cubes are also increasing rapidly.

By this, we can conclude that the sample containing 11% of Optical Fibre is best suitable in Compressive strength criteria as well as light transmission criteria , and also it is better to use Cement because when we are using Fly Ash as a substitute the strength is reducing.

VII. FUTURE PERSPECTIVE

Translucent concrete is just about enough light to pass through it to make it a visible material for reducing power consumption. Hence, it can be used as an eco-friendly alternative to traditional concrete in the near future.
Other than its economic and environmental advantages, translucent concrete also makes architecture more visually appealing and increases the overall aesthetic value of a structure.
However, despite its various advantages, there are a few limitations to its usage in large scale projects.
Since optical fibres are an expensive material, the production of translucent concrete is expensive compared to traditional concrete.
Another reason why translucent concrete cannot fully replace traditional concrete is the lack of expertise.
The infusion of optical fibres into the concrete mix requires skilled labour, but not many people are familiar with this technology.
Safe to say, for translucent concrete to become a viable alternative, researches will have to find economical ways of manufacturing it.
Many experts have predicted that translucent concrete can bring about a positive change in the overall market and become an economical and eco-friendly alternative to traditional concrete.

As a result, manufacturers are now working hard to develop translucent concrete at a lower cost, so it can become an affordable alternative for both commercial and residential projects.

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