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Experimental Analysis on Translucent Concrete

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ABSTRACT: The structural integrity and light transmission capabilities of translucent concrete are the main topics of this study's investigation of its qualities. We examined the material's durability, light transmittance, and compressive and flexural strengths by incorporating optical fibers into a regular concrete mix. Tests for mechanical and light transmission were performed on specimens that had been manufactured with different fiber volumes and patterns. The results indicated a considerable potential for light transmission but also a minor drop in mechanical strength as a result of the fiber incorporation. Tests on durability revealed good performance under stressful environmental conditions. Energy-efficient lighting, safety signage, and architectural design are among the promising fields where translucent concrete can be used since it combines aesthetics and utility. In the future, the mix design should be optimized to balance light transmittance and strength.

KEYWORDS: Translucent concrete, optical fibers, light transmission, compressive strength, flexural strength, durability, architectural applications, energy efficiency.

I. INTRODUCTION

Transparent concrete, an amalgamation of traditional concrete and transparent elements, presents a unique combination of structural integrity and optical clarity. Micro silica, a byproduct of silicon production, is known for its pozzolanic properties and has shown promise in enhancing concrete performance.

- **Transparent Concrete**

Transparent concrete, also known as light-transmitting concrete or translucent concrete, has garnered significant attention in recent years. Notable studies have focused on its composition, properties, and applications in architecture.

- **Micro Silica in Concrete**

Micro silica, an amorphous silica fume, is recognized for its ability to improve the properties of concrete. Previous research has demonstrated its effectiveness in enhancing compressive strength, reducing permeability, and improving durability.

Fibre optic transmission of light does not provide a suitable medium for the transmission of electricity and is thus an ideal way to light areas in an alternative manner. With the use of photocells and batteries, the light-emitting properties of concrete can be used in illuminating roads and as an emergency lighting system. Developed and modified further, the possibilities of transparent concrete are endless.

Recognized for its strength and longevity, concrete is a material used extensively in building. But traditional concrete isn't able to transmit light, which limits its use in both decorative and functional applications. This restriction is overcome by translucent concrete, an inventive material with optical fibers incorporated into it that permits light to flow through while ensuring structural integrity. The purpose of this study is to assess translucent concrete's mechanical qualities, light-transmission capabilities, and durability in order to provide light on possible uses for the material in contemporary architecture.

II. OBJECTIVES

- To analyze the impact of micro silica on the optical properties of transparent concrete.
- To evaluate the mechanical strength and durability of transparent concrete incorporating micro silica.
- To explore potential applications and benefits of this composite material.

III. SCOPE OF PROJECT

The scope of transparent concrete is vast and includes various applications in architecture and design. It can be used in the construction of walls, floors, facades, and even furniture.

Transparent concrete offers opportunities for creative and innovative designs that Incorporate natural light and create visually stunning structures. It has the potential to revolutionize the way we think about and use concrete in the built environment.

IV. MATERIAL

1. **Micro Silica:** This high-performance pozzolana has special chemical and physical characteristics that allow cement-based systems and mix designs to function more durable and perform better. Engineers can achieve and even surpass design and performance requirements with the help of silica fume. When it comes to chemical resistance, chloride attack, sulfate assault, and abrasion resistance, silica fume will significantly strengthen concrete and decrease permeability. Applications for Shotcrete and Self-Consolidating Concrete benefit from increased cohesiveness thanks to silica fume.
2. **Fly Ash:** The amount specified in IS 3812 (Part 1): 2013 for fly ash in building, a cement is a binder, a chemical that binds other materials together by setting, hardening, and adhering to them. Cement is primarily used to bond materials, like as sand, together. It is rarely used alone. Masonry mortar is made of cement combined with fine aggregate, and concrete is made of cement, sand, and gravel. Next only to water as the most utilized resource on Earth, concrete is the most commonly used material in existence.
3. **Retarder:** In concrete practice, retarding admixtures are used to delay the cement paste, mortar, and concrete's setting times. When concrete is mixed in hot weather, it might build up early and lose its workability due to handling and transportation delays. In these cases, retarders must be added. Retarders can be used for the building of large structural units, dams, exposed aggregate panels, and steam curing of concrete to compensate for the long-term reduced strengths created by the silicate phase. Retarders are also useful for keeping ready-mixed truck-returned concrete in a workable condition over night by completely freezing the hydration.
4. **Cement:** 53-grade OPC cement was used for this project. The cement that is used has a specific gravity of 3.15 and a fineness modulus of 2%, which is lower than the maximum of 7%. Following IS 8112: 2013.
5. **Wooden Mold Preparation:** Mold size 400 × 210 × 50 mm of plywood is fabricated in workshop. Ply is drilled at 1mm spacing on letter Om and then optical fiber I mm diameter are inserted.
6. **Light Transmissibility Tester:** it indicates the ability of light to pass through the concrete cube with optical fibers.it refers to the percentage of luminous flux through translucent materials compared to the incident luminous flux.



Fig No 1 Light transmission meter

Table 1.1 Material Specification for concrete mix

Sr	Material	Material Test
1	Micro silica	2.50kg
2	Fly ash	5kg
3	Cement	10kg
4	Coarse sand	40 kg
5	Water portable	5.20 liter
6	Admixture	1.70ml



Fig.2 Casting of concrete mold

7. MIX DESIGN

1. M40 grade mix
2. Type of cement- OPC 53 grade, IS 8112.
3. Max. nominal size of aggregate = 10mm
4. Minimum Cement Content = 220 kg/m³
5. Max. water cement ratio = 0.6
6. Maximum water content = 171.39kg
7. Water content = 208kg
8. Exposure condition mild = mild
9. Maximum cement content = 450 kg/m³
10. Chemical Admixture-170ml

Step 1-Target strength for mix proportioning.

$$F_{ck} = f_{ck} + 1.65S$$

$$= 40 + 1.65 \times 5$$

From table No. 1. Page No.2, IS 10262:2019 for M25 the value of S=4N/mm².

$$f_{ck} = 31.6 \text{ N/mm}^2$$

Step 2-Selection of water cement ratio-

For mild exposure condition of RCC work and for maximum nominal size of aggregate = 10mm from IS 456.

$$\text{Maximum Water} = 0.6$$

$$\text{Cement ratio} = 0.5$$

Since Slump.50mm, then for every 25mm slump water content has to be increased by 3%

Now the water content = 214.24kg

Addition of super plasticizers reduces water content upto 20% and above

Water content = 171.39kg

Step 3 -Selection of water content-

Refer Clause 42 of IS 10202: 2019

Estimate water content from 75 mm slump maximum water content = 208 liters as per IS 10262:2009

Step 4-Calculation cement content. -

Water content = 0.5

$$\text{Cement Content} = \frac{171.39}{0.5}$$

$$= 342.78 \text{ kg/m}^3$$

From Table % of IS 456-2000, for selected Exposure condition = mild

Minimum cement content = 220kg/m³ > Selected cement content = 342.78kg/m³

Hence ok,

Step 5- calculate the volume of coarse aggregate and fine aggregate.

Volume of coarse aggregate corresponding to 20mm size and fine aggregate of zone I for w/c 0.5=0.6

If w/c is less than 0.5 then volume of coarse aggregate is to be increased to decreased the fine aggregate content at the rate of =0.01 for every =0.05 change in w/c ratio.

If method of concrete placing is pumping ,then volume has to be reduced by 10%.

Step 6 Mix Calculation

a) Volume of coarse aggregate =0.60m³

b) Volume of fine aggregate =1- volume of coarse aggregate
=0.4m³

c) Volume of concrete =1m³

d) Volume of cement = $\frac{\text{mass of cement}}{\text{specific gravity of cement} \times 1000}$
=0.11m³

e) Volume of water = $\frac{\text{mass of water}}{\text{specific gravity of water} \times 1000}$
= 0.17m³

f) Volume of Admixture = $\frac{\text{mass of admixture}}{\text{specific gravity of admixture} \times 1000}$
= 0.02m³

g) Volume of all in aggregate = a-(b+c+d)
=0.70m³

h) Mass of coarse aggregate = e X volume of coarse aggregate X specific gravity of coarse aggregate X 1000
=1154.62kg

i) Mass of fine aggregate = e X Volume of fine aggregate X specific gravity of fine aggregate X 1000
= 758.51kg

Step 7- Mix proportion 1:2.2:3.4

8. Casting Process with Transparent Concrete: We cast 12 number of cubes are per requirement in IS 456-2000. The size of mould is 100×100×100 mm. Material like cement, crushed sand, coarse aggregate 5mm and 10mm, micro silica, retarder, and optical fiber. Settle a cube for 24 hours disassemble it, and keep them for curing 7 days, 14 days, and 28 days

Result on Transparent Concrete

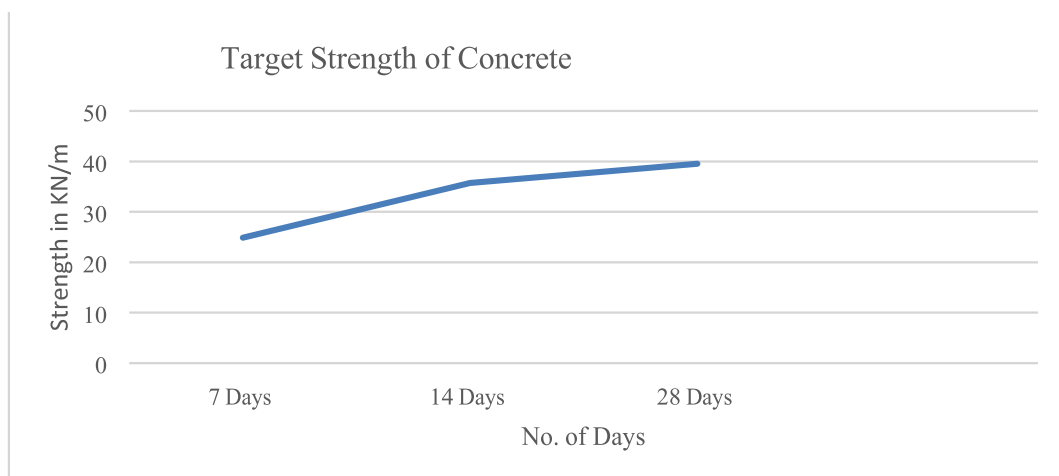


Fig. 3 Target Strength of Concrete at 28 days

V. PROBLEM FACE WHILE PREPARATION

- Difficult to get of optical fibre as per requirement i.e. specified diameter.
- It is not available in ready to used form, so optical fibers are separated from cores.
- Gloves are necessary when removing fiber because fiber fragments frequently accumulate in the fingers and hands.
- Cutting optical fiber is challenging and calls for a cutter with sharp edges.
- When inserting optical fiber into multiple holes, both sides must match.
- Extra optical fiber is needed on both sides because vibration ruins it.
- Blocks should have hinges or steel wire tightened from all sides during casting.
- Before casting, give the block a good oiling.
- Fill any damaged areas in a block with cement mortar or POP (Plaster of Paris) for a finished look.

VI. CONCLUSION

1) Compressive Strength Results: optical fiber of 1 mm diameter results for different volume fractions. The obtained results showed that, when compared to a reference sample without optical fiber, the compressive strength at 7 days of age reduces as fiber content increases. The drop was around 20.21, 19.84, and 20.04 percent for (2, 3, 4%) fiber volume fraction content, respectively.

2) However, after 14 days, the interfacial transition zone between the matrix and the optical fiber developed as a result of the cement hydration, improving the compressive strength. In comparison to the reference sample without POF, the results demonstrate a decrease in compressive strength of approximately (32.76, 31.60, and 32.18%) for fiber volume fraction contents of 2, 3, and 4%, respectively.

3) At 24 days of age, the similar pattern is seen, indicating that the POF's inclusion in the matrix had no appreciable impact on the compressive strength. In comparison to a reference sample without POF, the compressive strength of POF 1 mm diameter decreases as the fiber content increases for all age groups. At 28 days, the drop in compressive strength is (34.00, 33.59, and 33.60 %) for (2, 3 and 4%) fiber volume fraction content, respectively.

4) Light transmittance Test –The concrete exhibited effective light transmission with the amount of light depending on the fiber type, density and arrangement. Uniform Distribution of fibers resulted in consistent light.

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