International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 11 | Nov 2021 www.irjet.net p-ISSN: 2395-0072

Implementing Efficiency in Transparent Concrete

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Abstract - *Transparent concrete, also known as translucent concrete or light transmitting concrete, is a new type of concrete introduced in today's world that has the special property of light transmission due to the presence of light optical fibres. It is achieved by replacing coarse aggregates with transparent alternate materials (Optical Fibers). By adding clear resins in the concrete mix, the binding material in transparent concrete may be able to transmit light. The concrete used in industry today is general concrete, which is made up of basic materials such as water, cement, coarse aggregate, and fine aggregate, and has physical properties such as grey colour, no transparency, and high density, whereas transparent concrete has the ability to identify bodies and shapes due to the presence of optical fibre. The major goal of using transparent concrete is to use sunshine as a light source, which will save or reduce power consumption. It can also be utilised for architectural purposes to create innovative designs and appealing partition walls. This study focuses on the current requirement for transparent concrete in order to take advantage of sunshine and architectural innovations. With its inherent natural qualities, this new type of concrete can meet the green energy concept.*

Key Words: Transparent Concrete, Optical Fibres, Compressive Strength, Split Tensile Strength, Flexural Strength.

1. INTRODUCTION

Concrete was often misunderstood, hated, and captivated by its image fixed due to the fast urbanisation of the 1960s only a few decades ago. But, not just in terms of technology, but also in terms of aesthetics, concrete has come a long way since then. It is no longer the heavy, cold, and dreary material of the past; it has transformed into something lovely and vibrant. Newly produced concrete has been made through research and invention that is more resistant, lighter, whiter or tinted, and so on. Concrete has learned to adapt to nearly every new issue that has presented itselfThe notion of translucent concrete was first proposed by Hungarian architect AronLosonzi in 2001, and the first transparent concrete block, known as LiTraCon, was successfully manufactured in 2003 by combining a considerable amount of glass fibre into concrete. Joel S. and Sergio O.G. created a translucent concrete material that allows for 80% light transmission while only weighing 30% of regular concrete. It's worth noting that the Italian Pavilion at the Shanghai Expo 2010 displays a type of translucent concrete created by combining glass and concrete in 2010. While translucent concrete is primarily concerned with transparency, its application goal is to promote green technology and provide an artistic finish. As a result, a new functional material must be developed to meet the structure's needs in terms of safety monitoring (such as damage detection and fire warning), environmental protection, energy conservation, and artistic modelling. Transparent or translucent concrete is a new response to architects' calls for increased transparency in their work.

2. MATERIAL DESCRIPTION

2.1 Cement

Cement is a binder, a substance that sets and hardens when it dries, reacts with carbon dioxide in the air, and can bind together other materials. The most prevalent type of cement in general usage around the world is Portland cement, which is used as a fundamental ingredient in concrete, mortar, stucco, and most speciality grouts. Based on the strength of the cement at 28 days when tested according to IS 4031-1988, the OPC was graded into three grades: 33, 43, and 53. "Coromandel King 53 Grade Ordinary Portland Cement" was employed in this research project. Cement has a specific gravity of 3.14. 51 minutes and 546 minutes were discovered to be the beginning and final setting times, respectively. Cement had a standard consistency of 40%.

2.2 Water

Acids, oils, alkalis, vegetables, and other organic contaminants should not be present in the water. Concrete is also weakened by soft seas. In a concrete mix, water serves two purposes. To begin, it combines chemically with cement to generate cement paste, which holds the inert aggregates in suspension until the cement paste hardens. Second, it acts as a lubricant in the fine aggregates and cement mixture.

2.3 Fine Aggregate

The inert or chemically inactive material that passes through a 4.75 mm IS filter and contains less than 5% coarser particles is known as fine aggregate. Fine aggregate with a specific gravity of 2.75 and a fineness modulus of 2.80 was employed. Sand has a loose bulk density of 1600 kg/m^3 and a compacted bulk density of 1688 kg/m^3, with a water absorption of 1.1 percent. The fine aggregates are used to fill up the gaps between the coarse particles. As a result, the final mass's porosity is reduced while its strength is significantly increased. Natural river sand is commonly utilised as a fine aggregate. Finely crushed stone can be utilised as a fine aggregate in situations where natural sand is not economically accessible.

2.4 Optical Fibres

Optical fibres are classified into three categories based on their refractive index profile and number of modes. They are as follows:

1) Single mode fibre with a step index
2) Multimode fibre with a step index
3) Multimode fibre with a graded index

The core diameter of a step index single mode fibre can be as small as 5-10m. Only one way of light ray transmission is available because to the limited core diameter. This type of fibre accounts for over 80% of all fibres made today.

The core diameter of a step index multimode fibre is 50 to 200 m, and the cladding diameter is 125 to 300 m. Because the core material has a consistent refractive index and the cladding material has a lower refractive index than the core, the refractive index value changes dramatically from cladding to core. Because the core has a wider diameter, many modes can propagate.

The refractive index of the core of a graded index multimode fibre is highest at the fiber's axis and gradually lowers towards the cladding. Modal dispersion can be reduced because the refractive index of the core decreases gradually.

3. MANUFACTURING PROCESS

The production of translucent concrete is nearly identical to that of conventional concrete. Optical fibres are the only ones that are dispersed throughout the aggregate and cement mix. Small layers of concrete are poured on top of each other, then linked and injected with fibres. Thousands of optical fibre strands are cast into concrete to transmit natural or artificial light. The addition of 4% to 5% optical fibres by volume to the concrete mixture produces light-transmitting concrete. The concrete mixture is comprised entirely of fine components, with no coarse aggregate. The optical fibre thickness can be adjusted between 1 mm and 2 mm depending on the light transmission requirements. Instead of single filaments, weaved fibres fabric is used in automated production processes. At intervals of around 2 mm to 5 mm, fabric and concrete are alternately placed into moulds. The amount of light that passes through the concrete is enhanced when the layers are smaller or thinner. Following casting, the material is cut into panels or blocks of the desired thickness, and the surface is often polished to achieve semi-gloss to high-gloss finishes.

3.1 Concrete Mix Design

The concrete mix ratio of the optical fiber concrete of grade **M20** as per IS 456 is **1 : 1.5 : 3** with (W/C ratio **0.5**).

3.2 Making the wooden mould for the concrete

The wooden mould should be 150 x 150 x 150 mm in size, and it should be connected together with a screw so that it can be reused for concrete preparation.

3.3 Making pores in the mould

We used a drilling machine to bore holes in the wooden mould with diameters of 1mm and 2mm so that the optical fibre could be inserted.

3.4 Inserting the optical fibres in the mould

We placed optical fibres with diameters of 1mm and 2mm into the wooden mould after drilling holes in it.

4. TEST RESULTS

The following table shows the test results of the Transparent Concrete.

Table -1: Test results of the Transparent Concrete

Sl. No.	Test Conducted	Codal Reference	Average Test Result
1.	Slump Test	IS 7320-1974	True Slump for 0.5 water cement ratio.
2.	Compaction Factor Test	IS 1199-1959	0.85
3.	Vee Bee Consistometer	IS 10510-1983	19 seconds
4.	Transparent Concrete Compressive Strength (7 Days)	IS 1489-1991	17.8 N/mm²
5.	Compressive Strength of Transparent Concrete (14 Days)	IS 1489-1991	21.9 N/mm²
6.	Transparent Concrete Compressive Strength (21 Days)	IS 1489-1991	23.2 N/mm²
7.	Transparent Concrete Compressive Strength (28 Days)	IS 1489-1991	25.5 N/mm²
8.	Transparent Concrete Split Tensile Strength (7 Days)	IS 5816-1976	5.4 N/mm²
9.	Transparent Concrete Split Tensile Strength (28 Days)	IS 5816-1976	5.9 N/mm²
10.	Transparent Concrete Flexural Strength (7 Days)	IS: 516-1959	5.5 N/mm²
11.	Transparent Concrete Flexural Strength (28 Days)	IS: 516-1959	5.8 N/mm²

Fig -1: Preperation of concrete samples

Fig -2: Testing of concrete samples

Fig -3: Transparent concrete under natural light

Fig -4: Light passing through the Optical fibre

5. CONCLUSIONS

1. The mechanical behaviour of transparent concrete samples was investigated for compressive, split tensile, and flexural strength tests with curing times of 7 days, 14 days, 21 days, and 28 days, demonstrating a characteristic rise in strength behaviour.
2. An optical fibre mix of up to 5% results in a 5 percent to 10% improvement in first compressive strength for 7 days and a 10 percent to 15% increase in initial compressive strength for 28 days.
3. When the percentage of optical fibres in the concrete mix exceeds 5%, the initial and final characteristic compressive strength gradually declines.
4. The fundamental benefit of translucent concrete is that it is lightweight, reducing the self-weight of any concrete structure. It may also be utilized as ornamental concrete in building interior design as panels in slabs, walls, and other areas.
5. According to the findings of the study, optical fibres can be employed up to 5% of the time in concrete mixes and produce great results in terms of strength and quality.

ACKNOWLEDGEMENT

I thank the management of R.M.K Engineering College, my students, and the journal staff for their assistance with my research. I had want to express my heartfelt gratitude to my friends, coworkers, and the entire Civil Engineering department staff for their unwavering support and encouragement. Without acknowledging my revered parents and family, the significance of my work would be inadequate. Their blessings and constant encouragement have showed me the way to realise my ambitions. I appreciate everything they have done for me, including countless helpful recommendations and invaluable advice.

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