

# Investigation Of The Engineering Characteristics Of Translucent Concrete

Shraddha Prakash Naik<sup>1</sup>, Dr. Sachin P. Patil<sup>2</sup>, Dr. Ravindra M. Desai<sup>3</sup>

<sup>1</sup>PG Student, Department of Civil Engineering, Sanjay Ghodawat University, A/P Atigre, Kolhapur, 416118, Maharashtra, India.

<sup>2</sup>Assistant Professor, Department of Civil Engineering, Sanjay Ghodawat University, A/P Atigre, Kolhapur, 416118, Maharashtra, India.

<sup>3</sup>Assistant Professor, Department of Civil Engineering, Sanjay Ghodawat University, A/P Atigre, Kolhapur, 416118, Maharashtra, India.

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## Abstract

This research investigates translucent concrete as a structural material that blends strength with visual appeal. Optical fibres were incorporated into M20-grade concrete at varying dosages (0.5%, 1.0%, and 1.5%) to evaluate their performance relative to conventional concrete. A range of laboratory tests—including compressive and flexural strength tests, non-destructive methods like ultrasonic pulse velocity and rebound hammer, and specialised assessments such as drop weight impact and light transmission—were conducted. Findings revealed that incorporating up to 1.5% fibre content led to approximately 10% and 15% improvements in compressive and flexural strength, respectively, while also enhancing impact resistance and internal consistency. The fibres also enabled effective light transmission, creating an aesthetically pleasing and energy-efficient material. In summary, the study demonstrates that translucent concrete offers a viable and sustainable solution for modern construction by merging structural integrity with architectural innovation.

**Keywords:** Translucent concrete, Smart construction material, Mechanical properties, Optical fibers, Litacon, Sustainable Concrete.

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## 1. INTRODUCTION

High strength, durability and ease of availability made concrete the most widely used material in the construction industry. As time progressed, new concepts of energy-efficient and green buildings emerged along with the requirement for the material to be aesthetically pleasing. This resulted in research on new materials and advancements in existing materials. In this pursuit, a new type of concrete known as translucent concrete or Litracon was developed as an innovative solution. This concrete can transmit light through it, along with a similar strength to that of regular concrete. Along with pleasing aesthetics and energy efficiency, this material completes most of the requirements of modern trends.[ Pandey et al., 2021]

Translucent concrete is made by embedding light-transmitting material like optical fibre, acrylic sheets or glass fibre within a concrete mix. This enables light to pass through the concrete partially. This light-transmitting material not only improved its aesthetic look but also contributes to energy efficiency by reducing artificial lighting during the day. As buildings account for a major chunk of energy consumption globally, using a material which transmits light makes it more efficient and economical in the construction industry.[ Harshani et al., 2023]

The development of translucent concrete was first done by a Hungarian architect, “Aron Losonczy” in 2003, originally, he prepared a concrete block by replacing coarse aggregate with optical fibres, allowing up to 80% of incident light to pass through at only 30% of the weight of the conventional concrete[Rajul & George, 2021]. From then onwards, multiple studies have been carried out to find out the influence of fibre type, orientation, etc, on the mechanical and luminous properties of concrete.

Along with the aesthetic and energy parameters, the mechanical characteristics of the material also play an important role. Using optical fibre improves the ability of concrete to transfer light, but it also impacts and alters the mechanical properties of the concrete depending on the type and proportion of the fibres. Research has shown that adjusting the content of optical fibre up to an optimum percentage can help to balance out the alteration caused by the addition of optical fibres. [Yadav et al., 2023] For example, studies using 0.75mm diameter optical fibre showed that an optimum fibre density exists beyond which mechanical strength starts to reduce due to increased void formation.[ Harshani et al., 2023]

Additionally, use of other alternatives such as fly ash, waste glass, etc., along with optical fibres for translucent concrete has also been examined to make it more economical and more environmentally friendly while not impacting its strength characteristics.[ Rajul & George, 2021][ Chiadighikaobi et al., 2023]. In 2014, variations with diameters of 1.5mm, 2mm and 3mm and percentages of optical fibre in 2,3 and 4% in translucent concrete were carried out during the research. The results obtained through this showed a reduction in mechanical strength, especially in the modulus of rupture of the concrete, with an increase in percentage and diameter of the optical fibre. They observed that 2mm diameter fibres offered relatively better compressive and flexural strength compared to other fibre sizes.[Salih et al., 2014]

A 2016 study focused on performing variations in the spacing of the optical fibre. They used a 200-micron diameter optical fibre and placed it at 50mm, 100mm and 150mm centre-to-centre spacing. This study concluded that the light transmittance decreased with an increase in the spacing of optical fibres, and a reduced strength can be observed with an increase in fibre percent.[Nikhil et al., 2016] A variation with acrylic strips was carried out in 2017, where acrylic strips were used as an alternative for optical fibres. This study showed that acrylic strips provided better illumination and were easier to handle. Their use also allowed for the possibility of using a greater size of coarse aggregate. This made it possible to achieve improved strength, overcoming a common limitation in translucent concrete where coarse aggregate is usually avoided.[Sasidharan et al., 2017]

An experimental study in 2018 evaluated the light transmittance of translucent concrete with up to 6% volume of POF, achieving about 22% transmittance. This fibre content was found suitable for precast panels in green buildings, indicating that careful control of fibre volume can balance light performance and structural utility.[Tuaum et al.], 2018. Similarly, a 2020 study achieved 6.69% light transmittance using 5% POF, showing that translucent concrete can help enhance daylight utilisation. While the compressive strength of higher-grade concrete stayed within acceptable limits, the study pointed out some real-world challenges—like the high cost, the need for skilled workers, and the precise placement of fibres—that could make practical use more difficult. [Rahman et al., 2020]

Despite the growing interest, the comparative performance of translucent concrete with conventional concrete under standard testing conditions remains unexplored. Also, how different percentages of fibre impact both the mechanical and light transmitting capacity of the concrete is yet to be investigated in detail for a reliable balance for structural performance. In this study, we aim to 1. Assess the properties of fresh translucent concrete, 2. Investigate the mechanical properties of translucent concrete incorporating different percentages of optical fibre, 3. Compare the performance of translucent concrete with that of normal concrete, 4. Determine the optimum optical fibre content.

## 2. MATERIAL AND TESTS

### 2.1 Materials Used

For this study, Conventional concrete blocks were also casted along with the translucent concrete blocks, so as to obtain results for a comparative study of both of this concrete. To do so the following material conforming to Indian standards were used,

- Ordinary Portland Cement - OPC Grade 53
- Crushed sand
- Coarse Aggregate
- Optical Fibers - Optical fiber used for this study is of 1 mm diameter and are shown in Fig1.



Fig1 Optical fiber of 1 mm diameter.

## 2.2 Testing

To assess and compare the physical and mechanical properties of both the conventional and translucent concrete, a careful testing of both the materials and the samples of beam and cubes is necessary. Material testing plays a pivotal role in this process, as it helps in selecting the appropriate materials for design of the concrete mix as per standard requirement. Moreover, accurate material characterization contributes significantly to the reliability and consistency of the overall experimental results. To do so multiple tests were carried out on each material to check whether they meet the standards required.

### 2.2.1 Tests on material:

#### 2.2.1.1 Tests on Cement.

##### Fineness test on Cement (IS 4031 Part 1)

The Fineness Test determines how fine cement particles are, which affects the rate of hydration and early strength gain. Finer cement offers a larger surface area for reaction, and in this study, sieving was used for its simplicity and effectiveness.

##### Standard Consistency Test (IS 4031 Part 4)

The Standard Consistency Test helps find the exact amount of water needed to produce a cement paste of normal consistency. This is essential for accurate results in other tests and ensures proper workability and strength in structural applications.

##### Soundness Test (IS 4031 Part 3)

The Soundness Test checks if cement maintains its volume after setting without expanding later. Using the Le Chatelier apparatus, this test helps prevent cracking or disintegration in hardened concrete due to delayed reactions.

##### Specific gravity test on cement. (IS 4031 Part 11)

The Specific Gravity Test determines the density of cement relative to water and helps verify its quality. Unusually high values may indicate deterioration from moisture or poor storage, making the test vital before use.

##### Initial Setting Time. (IS 4031 Part 5)

The Initial Setting Time Test measures how long cement remains workable after adding water. It ensures enough time for mixing and placing, especially in hot climates or large pours, and prevents premature stiffening.

##### Final Setting Time. (IS 4031 Part 5)

The Final Setting Time Test marks when cement has completely set and hardened. Staying within the standard limit ensures safe removal of formwork and avoids delays or defects during construction.

#### 2.2.1.2 Tests on Aggregates

##### Specific Gravity Test. (IS 2386 Part 3)

The Specific Gravity Test helps determine the density of aggregate particles compared to water. It gives a clear indication of the quality and strength potential of both fine and coarse aggregates. Aggregates with higher specific gravity are generally denser and stronger, which is beneficial for producing durable and high-strength concrete. This test is especially important during mix design, as it helps calculate aggregate volumes and adjust proportions accurately for structural elements like beams, columns, and foundations.

##### Water Absorption Test. (IS 2386 Part 3)

The Water Absorption Test measures how much water an aggregate can absorb into its pores when in a saturated surface dry condition. This absorbed water doesn't contribute to the concrete's workability but affects the water-cement ratio, which in turn influences strength and consistency. Fine aggregates usually absorb more water than coarse ones due to their finer texture. Monitoring water absorption is essential in ensuring that the actual mix water is sufficient but not excessive, especially in structural concrete exposed to variable site conditions.

##### Surface Moisture Test. (IS 2386 Part 3)

The Surface Moisture Test (IS 2386 Part 3) checks for the free water present on the outer surface of aggregates. This surface moisture directly adds to the mix water content and, if not accounted for, can throw off the designed water-cement ratio. Fine aggregates tend to retain more surface moisture, especially in damp or rainy environments. Regular testing is crucial on construction sites to adjust batch water accordingly, ensuring consistent workability, strength, and performance across all concrete elements.

##### Flakiness and Elongation index. (IS 2386 Part 1)

The Flakiness Index Test determines the percentage of flaky particles in coarse aggregates—those with a small thickness compared to their size. Flaky particles can reduce workability, increase water demand, and

lead to weaker, less compact concrete. They also interfere with proper bonding in concrete, affecting the strength and durability of structural members. Keeping the flakiness index below the acceptable limit (typically 25%) helps improve the overall quality and performance of concrete, especially in load-bearing elements.

The Elongation Index Test identifies the proportion of elongated aggregate particles—those that are excessively long compared to their average size. These particles are prone to breakage during mixing and compaction and can negatively impact the mechanical interlock and load transfer in hardened concrete. A high elongation index can lead to reduced strength and uneven stress distribution, particularly in members exposed to repeated or dynamic loading. Controlling elongation helps ensure better packing, bonding, and uniform performance in both structural and pavement concrete.

### **2.2.2 Tests on Concrete.**

#### **Slump cone test. (IS 1199)**

The Slump Cone Test is used to evaluate the workability and flowability of fresh concrete, ensuring it can be properly placed and compacted. It helps determine whether the mix has the correct water and admixture content. This test is widely used on-site for quality control to detect batch-to-batch variation, helping avoid issues like segregation, bleeding, or poor strength.

#### **Compressive test on concrete. (IS 516 Part 1/Sec 1)**

The Compressive Strength Test determines the ability of hardened concrete to resist compressive loads. It is the primary test to ensure that the concrete meets structural strength requirements. The results directly influence decisions regarding the safety, durability, and load-bearing capacity of structural elements, and low values may indicate problems with the mix or curing process.

#### **Flexural strength test on concrete. (IS 516 Part 2/Sec 1)**

The Flexural Strength Test measures the bending strength or modulus of rupture of concrete, which is especially relevant for slabs, pavements, and beams subjected to flexural stresses. Since concrete is weak in tension and bending, this test verifies its capability to resist cracks and deflection under service loads. It also provides insight into the concrete's tensile behaviour.

#### **Rebound hammer test on concrete (IS1331 Part 2)**

The Rebound Hammer Test (IS 1331 Part 2) is a non-destructive testing method used to assess surface hardness and estimate the compressive strength of concrete. It is ideal for quick quality checks and for identifying weak or delaminated zones in structural elements. While not a replacement for compressive testing, it is a useful tool for evaluating uniformity across different concrete areas.

#### **Ultrasonic Pulse velocity test on concrete (IS1331 Part 1)**

The Ultrasonic Pulse Velocity Test (IS 1331 Part 1) is another non-destructive test that evaluates concrete quality by measuring the velocity of ultrasonic pulses through it. Faster velocities indicate dense, well-compacted concrete, while slower ones suggest poor compaction, cracks, or voids. This method helps assess internal integrity without damaging the structure.

#### **Drop Weight Impact Test on Concrete (ACI 544.9R)**

The Drop Weight Impact Test assesses the concrete's resistance to repeated impact or sudden dynamic loads by counting the number of blows a sample can withstand before cracking. It is particularly useful for special concrete types, like fiber-reinforced or translucent concrete, where conventional tests may not reveal performance under shock loads. It helps determine durability in impact-prone environments.

#### **Light transmission test on concrete.**

The Light Transmission Test is used to evaluate how effectively translucent concrete can transmit light through its body. A light source is placed behind the specimen in a dark environment to observe transmission. This test is essential for assessing the visual and energy-efficiency performance of light-transmitting concrete used in architectural or decorative applications.

## **3. METHODOLOGY**

For the scope of this work, a comparative study on the physical and mechanical properties of both the conventional and translucent concrete is to be carried out. To do so, preliminary testing of all the required material is done as per the requirements and standards set by the Indian Standard codes. Cube, beam and disc specimens were subsequently cast and tested under laboratory conditions to find out the compressive as well as flexural strength of the translucent concrete. The results obtained from these tests help to compare and identify the efficiency of translucent concrete with conventional concrete.

The conventional concrete was prepared as per the Indian standard guidelines for the grade M20. To do so, a mix design for the M20 grade concrete was prepared based on the strength to be achieved as 20 N/mm<sup>2</sup>. This mix design followed all the criteria and conditions given by the IS456:2000 and 10262:2019. All the required constituent materials were tested for their physical and engineering properties to ensure their suitability as per Indian standards. The concrete was mixed uniformly and poured into the standard metallic cube and beam moulds. These moulds were thoroughly cleaned and oiled before casting. The concrete was placed in three layers, each layer properly compacted to obtain a uniform sample. The top surface was levelled off and a smooth finish was obtained.



Fig.2 Moulds fabricated for Concrete cubes.



Fig.3 Translucent concrete specimens.



Fig.4 Demolding of translucent concrete cubes

For translucent concrete, special moulds were fabricated with waterproof plywood and a sample mould is shown in Fig2. These moulds were designed with holes on two parallel sides at a spacing of 10 to 15 mm. These provisions were made for the insertion of optical fibre cable and made it possible for them to be anchored properly. The same concrete grade was used, and optical fibres were added in amounts of 0.5%, 1.0%, and 1.5% of the total concrete volume. This was done to avoid any huge reduction in the properties of concrete.

The details for proportioning of the materials for each variation is given below in table 3.1. The mixing and pouring process was similar to that of conventional concrete. Care was taken while pouring the concrete so that the alignment and placement of fibres throughout the moulds would not get disturbed. The specimens prepared and casted for this concrete are shown above in figure 3.

Table 3.1 Material proportions.

Mix	Water (kg/m <sup>3</sup> )	Cement (kg/m <sup>3</sup> )	Fine aggregate (kg/m <sup>3</sup> )	Coarse aggregate (kg/m <sup>3</sup> )	Optical fibre (kg/m <sup>3</sup> )
Normal M20	197	394	610	1155	0.0
Translucent (0.5% vol.)	197	394	610	1155	6.0
Translucent (1.0% vol.)	197	394	610	1155	11.9
Translucent (1.5% vol.)	197	394	610	1155	17.9

After 24 hours, the samples were demolded, and all specimens were transferred to the curing tank. The demolded specimens are shown in figure 4. The samples were cured for 7 days and 28 days to assess early and standard age strength properties. For each variation and curing period, 6 cubes were prepared to ensure consistency and accuracy in the results. After curing of the cube, multiple tests are to be carried out to understand various properties of translucent concrete. Those include: 1. Compressive strength test, 2. Flexural strength test, 3. Rebound hammer tests, 4. Ultrasonic pulse velocity test, 5. Split cylinder test, 6. Drop weight impact test, 7. Light transmission test.

#### 4. RESULTS AND DISCUSSION

##### 4.1 Results

##### 4.1.1 Results of material testing.

Before casting of concrete specimens, material testing was carried out to ensure the quality, consistency and reliability of the obtained results. This testing of material was also necessary to identify the properties of material which are essential when designing the mix design of concrete. For this purpose, various tests were carried out on material. The results for this material testing are given below.

Table 4.1 Material test results for cement.

Sr No	Test	Method of test	Average Results	Permissible Value.
1	Fineness Test	IS 269-1976	2%	< 10%
2	Standard Consistency	IS4031	38%	
3	Soundness	IS4031	1 mm	< 10mm
4	Specific Gravity	IS2720	3.12	<3.15
5	Initial setting time	IS4031	78 mins	Min 30 mins
6	Final setting time	IS4031	542 mins	Max 600 mins

Table 4.2 Material test results for Fine Aggregate.

Sr No	Test	Method of test	Average Results	Permissible Value.
1	Sieve analysis	IS2386 (Part one)	2.26	2.2 - 2.6
2	Specific Gravity	IS2386 (Part one)	2.32	2.5 - 2.7
3	Water absorption	IS2386 (Part one)	2.67	0.3 - 2.0
4	Surface Moisture	IS2386 (Part one)	1.8	0 - 7

Table 4.3 Material test results for cement.

Sr No	Test	Method of test	Average Results	Permissible Value.
1	Sieve analysis	IS2386 (Part one)	2.71	2.9 - 3.2
2	Specific Gravity	IS2386 (Part Three)	3.01	2.5 - 3.0 %
3	Water absorption	IS2386 (Part Three)	0.667	0.1 - 2.0 %
4	Surface Moisture	IS2386 (Part Three)	0.9	0 - 1%
5	Flakiness	IS2386 (Part one)	12.45%	<40%
6	Elongation index	IS2386 (Part one)	14.43%	<40%

##### 4.1.2 Results of specimen testing.

##### 4.1.2.1 Results of Compressive strength test.

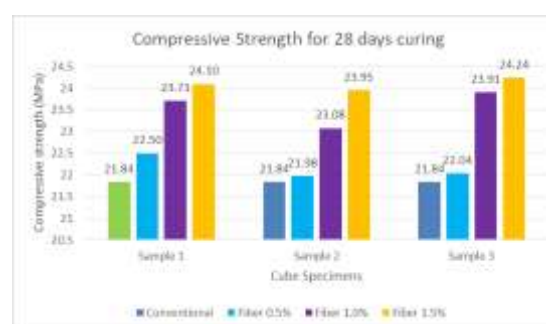
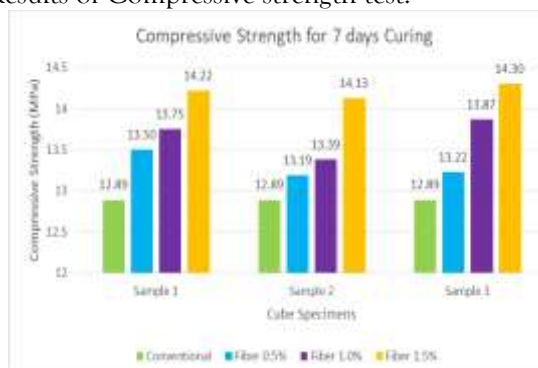


Fig.5 Compressive Strength for 7 days curing

Fig.6 Compressive Strength for 28 days curing

4.1.2.2 Results of Flexural strength test.

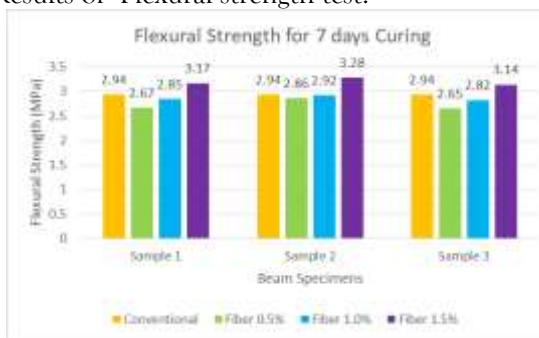


Fig.7 Flexural Strength for 7 days curing



Fig.8 Flexural Strength for 28 days curing

4.1.2.3 Results of NDT.

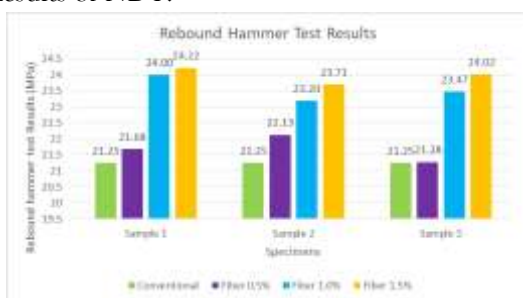


Fig.9 Rebound hammer test results

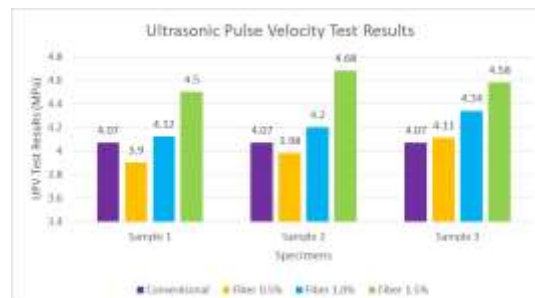


Fig.10 Ultrasonic pulse velocity test results.

4.1.2.4 Results of Drop Weight Test.



Fig.11 Drop Weight Test Result for Energy at First Crack

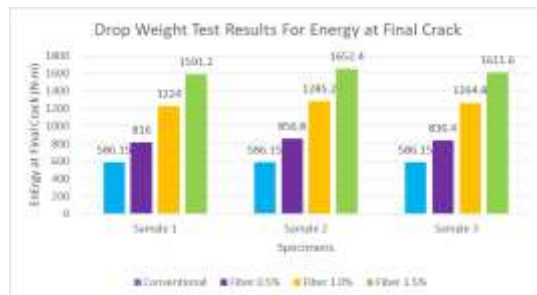


Fig.12 Drop Weight Test Result for Energy at Final Crack

4.1.2.4 Results of Light Transmittance .



Fig.13 0.5% fiber



Fig.14 1.0 % fiber



Fig.15 1.5% fiber

4.2 DISCUSSION

4.2.1 Discussion on material testing.

Before casting, a comprehensive evaluation of the constituent materials was carried out to ensure the quality and reliability of the concrete mix used in this study. The cement demonstrated compliance with all relevant IS standards, with favourable results in fineness, consistency, soundness, setting times, and specific gravity, indicating its suitability for achieving a stable and well-hydrated matrix. Fine aggregates showed acceptable gradation characteristics, with a specific gravity of 2.32 and water absorption of 2.67%,

values that align closely with standard limits and suggest adequate workability and cohesion within the mix. Similarly, the coarse aggregates met the necessary criteria, displaying a specific gravity of 3.01 and low water absorption at 0.667%, which supports effective bonding and contributes positively to the strength of the hardened concrete. Shape tests also confirmed that the aggregates were within permissible flakiness and elongation limits, promoting uniform compaction and reducing the potential for weak zones. Overall, the results affirm that the materials used in the mix were of consistent quality, providing a dependable basis for the preparation of translucent concrete and ensuring the credibility of the mechanical performance outcomes obtained.

#### **4.2.2 Discussion on Compressive Strength.**

The compressive strength results indicate that adding optical fibres to translucent concrete contributes to improved load-bearing capacity at both early and later stages of curing. At 7 days, mixes containing fibres demonstrated a strength increase of approximately 4–9% compared to the conventional mix, while at 28 days, the gain ranged between 5–10%, with the 1.5% fibre mix recording the highest average strength of about 24.15 MPa, as opposed to 21.95 MPa for the control. This enhancement can be linked to the role of optical fibres in bridging microcracks, slowing down their growth, and promoting a more cohesive and compact internal structure. The observed trend suggests that strength tends to increase in line with fibre content, although the rate of improvement becomes less pronounced at higher dosages. Overall, these results demonstrate that incorporating up to 1.5% optical fibres can enhance compressive performance without affecting the structural adequacy of translucent concrete, making it a viable option for structural applications where both strength and visual appeal are important.

#### **4.2.3 Discussion on Flexural Strength.**

The flexural strength results show a consistent improvement with the inclusion of optical fibres in the translucent concrete mix. At 7 days, fibre-reinforced specimens exhibited slightly higher flexural capacity compared to conventional concrete, with the 1.5% fibre mix showing the most notable enhancement. By 28 days, this trend became more pronounced, with the control mix averaging around 4.69 MPa and the 1.5% fibre mix reaching approximately 5.39 MPa, reflecting an overall increase of about 15%. This improvement is primarily due to the ability of the optical fibres to resist and bridge developing cracks under bending loads, thereby allowing the concrete to sustain greater tensile stresses before failure. The fibres contribute to a more gradual crack propagation process, resulting in improved ductility and a more distributed stress profile across the section. While all fibre percentages contributed positively, the greatest benefits were observed at the highest fibre content. These findings highlight that optical fibre incorporation, especially at 1.5% volume, can effectively enhance the flexural performance of translucent concrete without compromising its integrity or intended functionality.

#### **4.2.4 Discussion on NDT tests.**

The non-destructive testing (NDT) results, including both Ultrasonic Pulse Velocity (UPV) and Rebound Hammer tests, offer meaningful insights into the internal condition and surface quality of the translucent concrete mixes. The UPV test revealed a steady increase in pulse velocity with higher fibre content. The control mixes recorded values around 4.07 km/s, while the mix with 1.5% fibre achieved up to 4.68 km/s, indicating a transition from “Good” to “Excellent” quality. This improvement reflects better internal compactness and reduced microcracking in fibre-reinforced specimens. Similarly, the Rebound Hammer test showed that surface hardness improved with the addition of optical fibres, with higher rebound values observed as fibre content increased. These trends were consistent with the compressive strength results, reinforcing the reliability of the data. Overall, the NDT findings suggest that incorporating optical fibres not only enhances structural performance but also improves the overall material quality and uniformity of the concrete, making it more robust and dependable without compromising its structural soundness.

#### **4.2.5 Discussion on Drop Weight Tests.**

The drop weight test results demonstrate a notable enhancement in the impact resistance of concrete with the inclusion of optical fibres. Conventional concrete specimens showed relatively lower energy absorption, averaging around 298.57 N-m at the first visible crack and approximately 586.15 N-m at final failure. With the introduction of optical fibres, a steady and significant increase in impact performance was observed across all mixes. The 0.5% fibre mix exhibited a moderate improvement, while the 1.0% and 1.5% fibre mixes displayed substantial gains, with the highest energy absorption recorded in the 1.5% mix—ranging between 652.8–673.2 N-m at first crack and up to 1652.4 N-m at final crack. This behaviour reflects the beneficial role of fibres in enhancing the toughness and ductility of the concrete under sudden or repeated loading. The embedded fibres act to bridge developing cracks, effectively delaying their

propagation and preventing abrupt failure. As a result, the material can absorb and dissipate a greater amount of energy before reaching failure. The progressive increase in impact strength with higher fibre content suggests a strong correlation between fibre volume and improved dynamic response. Overall, the findings reinforce the understanding that optical fibres in translucent concrete not only contribute to its visual appeal but also significantly improve its ability to resist impact, making it a promising option for applications demanding both durability and aesthetics.

#### 4.2.6 Discussion on Light Transmittance.

The light transmittance results shown in Figures 13–15 highlight how the percentage of optical fibers affects the performance of translucent concrete. With 0.5% fiber, light passage through the specimen was noticeable but limited, producing only a few scattered illuminated points. When the fiber content was increased to 1.0%, both the brightness and distribution of transmitted light improved, suggesting better connectivity of fibers within the concrete matrix. The 1.5% fiber mix showed the most effective performance, with a brighter and more uniform light pattern, confirming a strong link between fiber content and the material's ability to transmit light.

## 5. CONCLUSION

- The incorporation of optical fibers in the concrete mix successfully achieved the intended translucent effect while maintaining structural integrity, making it a practical solution for applications that demand both aesthetics and performance.
- Compressive strength improved with increasing fiber content, with the 1.5% fiber mix showing around 10% higher strength than the conventional concrete at 28 days, indicating better load-bearing capacity.
- The flexural strength of the concrete was also enhanced, especially at higher fiber dosages, with the 1.5% mix showing up to 15% improvement due to better control of crack development under bending.
- Results from non-destructive tests, such as UPV and rebound hammer, reflected improved internal quality and surface hardness in fiber-reinforced concrete, suggesting better durability and a more uniform structure.
- The drop weight test clearly showed that optical fibers greatly increased the concrete's impact resistance, with the 1.5% fiber mix absorbing almost three times more energy at failure compared to conventional concrete, indicating higher toughness and resistance to sudden loads.

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3. Authors Contributions:

S.P.N selected the material, performed material testing, casting and specimen testing and drafted main manuscript text. S.P.P. and R.M.D assisted with data interpretation and figure preparation. All authors reviewed and approved the final manuscript.