iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** VI **Month of publication:** June 2023

DOI: https://doi.org/10.22214/ijraset.2023.54243

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VI Jun 2023- Available at www.ijraset.com

An Experimental Study of Transparent Concrete by Using Optical Fibers

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Abstract: ***Transparent concrete is the new type of concrete introduced in the modern era which carries special property of light transmitting due to presence of optical fibers & is also known as translucent concrete or light transmitting concrete. 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, lower haulage & handling cost. Light is transmitted from one surface of the brick wall to the other due to glass rods along the overall width of the wall which allows light to pass through. An optical glass fiber (or optical fibre) is a flexible, transparent fibre made of glass (silica)or plastic, slightly thicker than a human hair & can function as waveguide, or "light pipe" to transmit light between the two ends. Main aim of the study is to design translucent concrete blocks with the use of glass rods with sand & cement then analyse their various physical & engineering properties with respect to conventional concrete blocks by adding glass rods of 1%, 2 %, 3 % 4 % 5% at 1.5 cm spacing***
Keywords: Cement, Optical fibers, Fine aggregate.

I. 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: 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. Through 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 a large amount of glass fiber into concrete in 2003, named as LiTraCon. The transparent concrete mainly focuses on transparency and its objective of application pertains to 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 buildings, the space between buildings is reduced; this causes to increase the use of non-renewable energy sources, so therefore there is a need of smart construction techniques like green building and indoor thermal system. Translucent concrete (Transparent concrete) is a 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 the main purpose of translucent concrete, so as to reduce the load on non-renewable sources and result in energy saving. Optical fibers are a sensing or transmission element, so to decrease the use of artificial light, the normal concrete is replaced by translucent concrete, which has natural light in grand art design.

II. LITERATURE SURVEY

1) Edris 2021: This Research Paper author is more explained on optical fibers used in LTC, and the author explained mechanical properties and specifications of LTC. The author also explained compressive and flexure and also bond strength tests of LTC
2) Monika 2017: This Research Paper Author has explained the history of the Concrete used in structures and the advantages of using LTC and illustrated its disadvantages. The author is also explained on optical fibers and good application examples. 2.3. Bhavin K. Kashiyani 2013: They have studied to integrate the merits of concrete and optical fiber, for developing transparent concrete by arranging the high numerical aperture Plastic Optical Fibers (POF) or big diameter glass optical fiber into concrete.

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The main purpose 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 a good aesthetical view of the building.

3) Padhmabhushan MNV 2013: In this journal paper Light is conducted through the stone from one end to the other. This results into a certain light pattern on the other surface, depending on the fiber structure. Optical fibers transmit light so effectively that there is virtually no loss of light conducted through the fibers. The modeling of such translucent or transparent concrete blocks and their usage and also the advantages it brings in the field of smart construction.

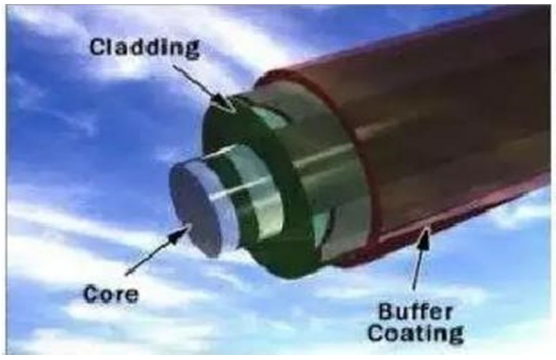
III. OBJECTIVES

1) Preparation and experimental study of transparent concrete.
2) To reduce the consumption of coarse aggregate by using optical fibers as a base material in concrete For aesthetic design.
3) Evaluation of its physical properties of cement and fine aggregate and structural characteristics such as-Compressive strength.

IV. MATERIALS USED FOR TRANSPARENT CONCRETE

1) *Cement:* Cement is a binder, a substance that sets and hardens as the cement dries and also reacts with carbon dioxide in the air dependently, and can bind other materials together. Portland cement is the most common type of cement in general use around the world, used as a basic ingredient of concrete, mortar, stucco, and most non specialty grout. The OPC was classified into three grades namely, 33 grade, 43 grade and 53 grade depending upon the strength of the cement at 28 days when tested as per IS 4031-1988. The cement used in this experimental work is “Koromandal King 53 Grade Ordinary Portland Cement”. The specific gravity of cement was 3.14. The initial and final setting times were found as 51 minutes and 546 minutes respectively. Standard consistency of cement was 40%.
2) *Fine aggregate:* Fine aggregate is the inert or chemically inactive material, most of which passes through a 4.75 mm IS sieve and contains not more than 5 per cent coarser material. The specific gravity2.75 and fineness modulus of 2.80 was used as fine aggregate. The loose and compacted bulk Density values of sand are1600 and 1688 kg/m3 respectively, the water absorption of 1.1%. The fine aggregates serve the purpose of filling all the open spaces in between the coarse particles. Thus, it reduces the porosity of the final mass and considerably increases its strength. Usually, natural river sand is used as a fine aggregate. However, at places, where natural sand is not available economically, finely crushed stone may be used as a fine aggregate.
3) *Optical Fibers Elements:*

a) *Core:* The thin glass center of the fiber where the light travels is called core.
b) *Cladding:* The outer optical material surrounding the core that reflects the light back into the core. To confine the reflection in the core, the refractive index of the core must be greater than that of the cladding.
c) *Buffer Coating:* This is the Plastic coating that protects the fiber from damage and moisture**.**



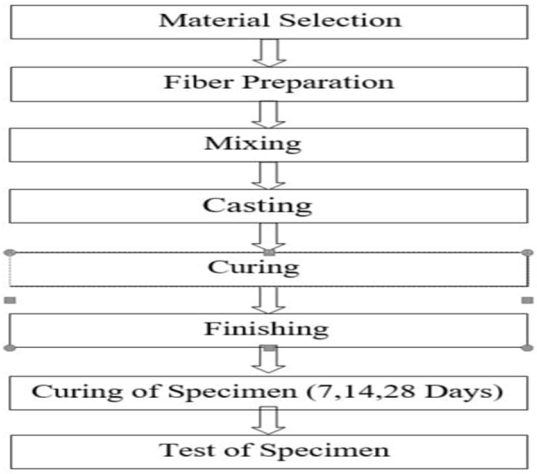
4) *Water:* Water should be free from acids, oils, alkalies vegetables, or other organic impurities. Soft waters also produce weaker concrete. Water has two functions in a concrete mix. Firstly, it reacts chemically with the cement to form the cement paste in which the inert aggregates are held in suspension until the cement paste has hardened. Secondly, it serves as a lubricant in the mixture of fine aggregates and cement.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
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V. PRINCIPLE OF TRANSPARENT CONCRETE

1) Translucent concrete is based on the concept of 'nano optics'.
2) Where optical fibers act as slits to transmit light from one side of the surface to another.
3) These optical fibers are spread evenly through the concrete and are visible on both sides of the block.

VI. METHODOLOGY



A. Manufactruing Process

1) Material Selection: The primary components of transparent concrete are cement, fine aggregates (such as sand), water, and optical fibers. The optical fibers can be made of glass or plastic and are available in different diameters and lengths. The selection of these materials should be based on their compatibility, strength, and transparency properties.



FIG 1 : CEMENT



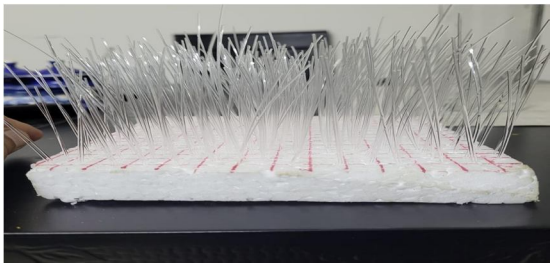
FIG 2: FINE AGGREGATE



FIG 3 : MORTAR

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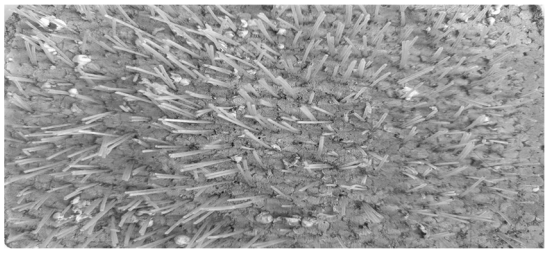

FIG 4 : OPTICAL FIBER


FIG 5: FIBER PREPARATION

2) *Fiber Preparation:* Optical fibers are prepared by cutting them into desired lengths. The lengths can vary depending on the intended application and design requirements. The fibers may also be treated with a coating to enhance their adhesion to the cement matrix.
3) *Mixing:* The concrete mixture is prepared by combining cement, fine aggregates, waterThe specific proportions and mix design should be determined based on the desired strength, workability, and transparency of the final product.


FIG 6: MIXING

4) *Casting:* The mixed transparent concrete is cast into molds or formwork, depending on the intended shape and size. Care should be taken to ensure proper alignment and distributionof the optical fibers within the


FIG 7:CASTING

5) *Curing:* After casting, the transparent concrete needs to be cured to develop its strength and durability. Curing methods may include traditional moist curing or steam curing, depending on the specific requirements of the concrete mix. Proper curing is essential to achieve optimal mechanical properties and to prevent cracking or shrinkage**.**


FIG 8: CURING

6) *Finishing:* Once the transparent concrete has achieved sufficient strength, it can be finished according to the desired architectural or design specifications. Finishing techniques may include polishing, sanding, or coating to enhance the transparency and appearance of the surface. Surface treatments can also be applied to improve resistance to staining .

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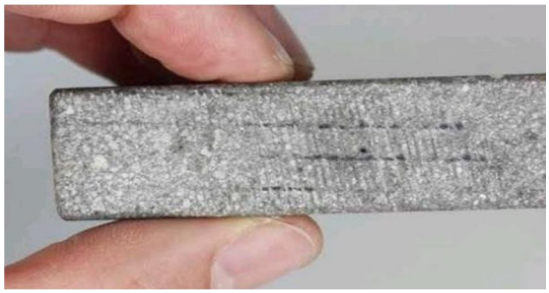


FIG 9: FINISHING

It is important to note that the methodology for producing transparent concrete can vary depending on the specific formulation, manufacturing techniques, and equipment used. Research and development in this field continue to explore new methods and technologies to improve the transparency, strength, and overall performance of transparent concrete.

VII. TEST FOR CEMENT

TABLE 1:CEMENT TEST

SL.no	Physical properties of cement	Result
1	Specific gravity test for cement	3.1
2	Normal consistency test for cement	30%
3	Fineness test for cement	3.5%

VIII. TEST FOR FINE AGGREAGATES

TABLE 2:FINE AGGREGATE TEST

SL.no	Physical properties of fine aggregates	Result
1	Specific gravity Test for fine aggregate	2.77
2	Sieve analysis test for fine aggregates	3.77

IX. COMPRESSIVE TEST

The compressive strength of concrete i.e., ultimate strength of concrete is defined as the load which causes failure of the specimen divided by the area of the cross section in uniaxial compression, under a given rate of loading. Compression test is most common test conducted on hardened concrete, partly because it is an easy test to perform, and partly because most of desirable characteristic properties of concrete are qualitatively related to its compressive strength.

To avoid large variation in the results of compression test, a great care is taken during the casting of the test specimens and loading as well. It is however realized that in an actual structure, the concrete at any point is in a complex stress condition and not in uniaxial compression. However it is customary to conduct the test in uniaxial compression only. Concrete under triaxial state can offer more resistance and will fail only after considerably large deformations. The use of 150mm cubes have been made as per IS code of practice IS 456 – 2000. The advantages of selection of IS 516 – 1959 (24) was cube as the standard test specimen is that two plane and parallel surfaces can always be found between which the load can be applied. Compression testing machine is used to test the concrete cubes.

The compression strength is calculated using the formula which is given below Compression strength = (Load/ Area) N/ mm²

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At each desired curing periods specimens were taken out of water and kept for surface drying. The cubes were tested in 2000T capacity compressive testing machine to get the compressive strength of concrete.



FIG10: COMPRESSIVE TESTING MACHINE



FIG 11: COMPRESSIVE STRENGTH

TABLE3:COMPRESSIVE STRENGTH 7 14 , 28 DAYS

SL. NO	NO OF DAYS	NO OF TRIAL	TEST RESULT	AVERAGE RESULT (kg)	STRENGTH (N/MM^2)
1	7 days	1 2	355 365	356	15.82
2	14 days	1 2	405 415	410	18.22
3	28 days	1 2	490 485	483	21.46

TABLE 4: PROPERTIES OF TRANSPARENT CONCRETE

Product	Litracon light transmitting concrete
Form	Prefabricated
Ingredients	92%Concrete,8%opticalfiber
Size	150mmX150mm
Thicknes	30mm
Colour	Grey-White
Fiber distribution	Organic
Finished	Polished
Compressive strength	21.46N/mm2

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X. RESULT AND DISCUSSION

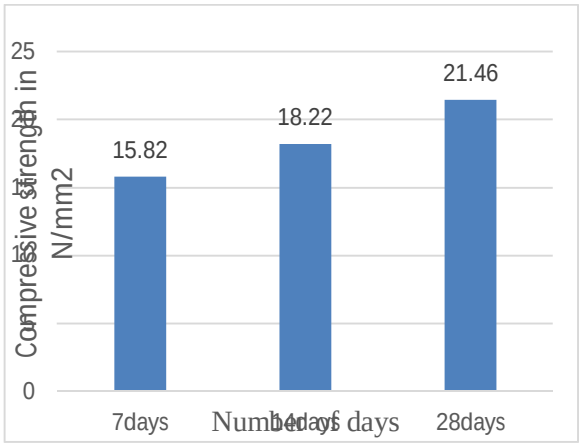


FIG 12 :COMPRESSIVE STRENGTH OF TRANSPARENT CONCRETE



FIG 13: NIGHT VIEW OF TRANSPARENT CONCRETE



FIG14: MORNING VIEW OF TRANSPARENT CONCRETE

XI. CONCLUSION

A novel architectural material called transparent concrete can be developed by adding optical fiber or large-diameter glass fiber in the concrete mixture.

The transparent concrete has good light-guiding properties and the ratio of optical fiber volume to concrete is proportional to transmission.

The transparent concrete does not loose the strength parameter when compared to regular concrete and also it has very vital properties for the aesthetical point of view.

It can be used for the best architectural appearance of the building. It can also be used in areas, where the natural light cannot reach with appropriate intensity.

This new kind of building material can integrate the concept of green energy saving with the usage self-sensing properties of functional materials .

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XII. SCOPE OF FUTURE WORK

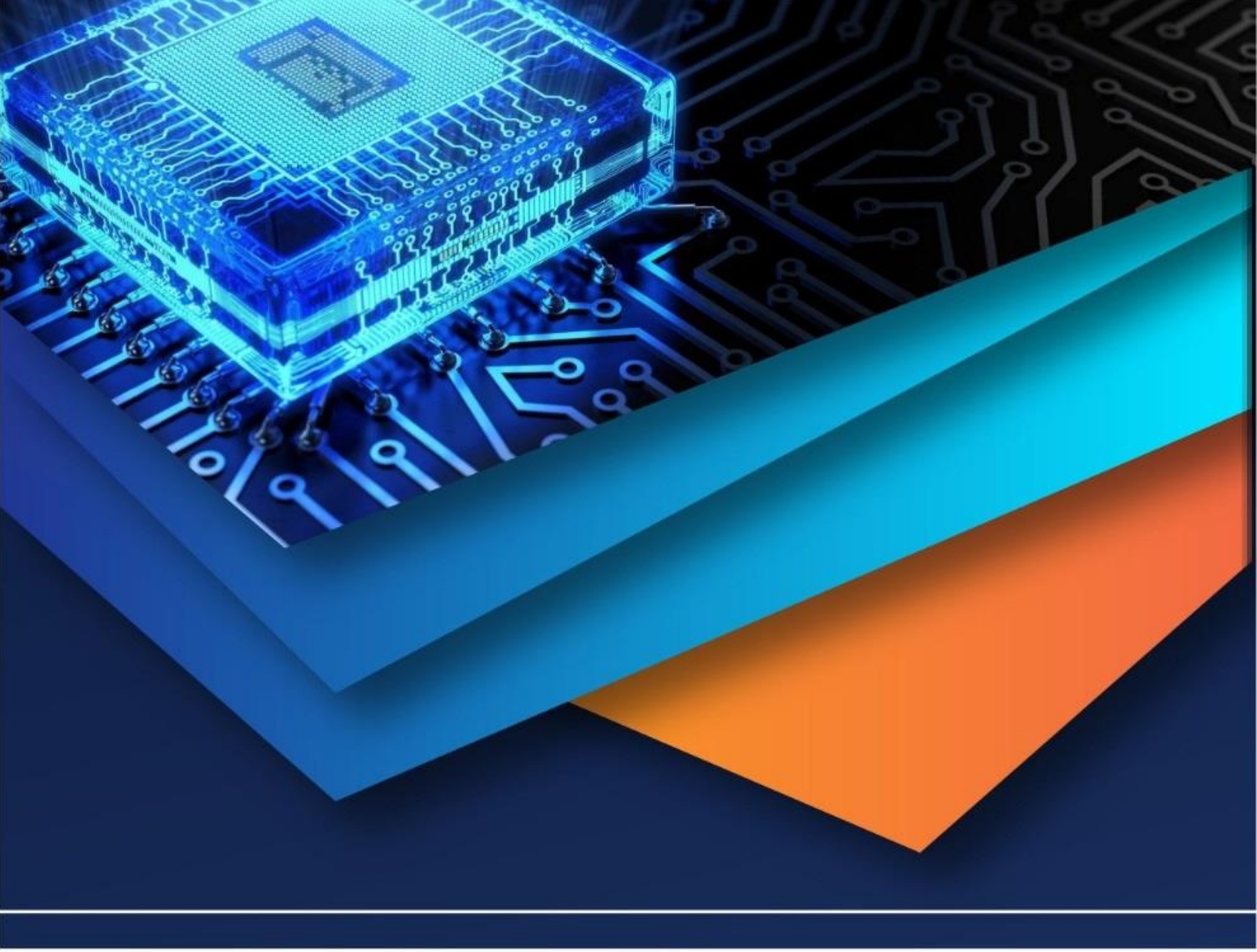
Durability of concrete with partial replacement of cement by optical fibers can be studied.

1) *Fiber Configuration and Density:* This study can help optimize the arrangement of optical fibers within the concrete matrix for improved performance.
2) *Mechanical Properties:* Conduct comprehensive mechanical testing to evaluate the strength, toughness, and durability of the transparent concrete

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