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Experimental Study on Light Transmitting Concrete Using Plastic Optical Fiber

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Abstract. The present study aims at manufacturing the concrete specimens by reinforcing optical fiber and scrutinizing it with the traditional concrete. The concrete specimens were subjected to totally different things such as compressive strength tests, light-transmission tests, etc. The compressive strength results obtained for the semi transparent concrete specimens were virtually the same as that of the traditional concrete specimen. The results of the transmission take a look at were satisfactory because the Plastic Optical Fiber retained its potency. Thus, it's evident that the transparency of the concrete structures are often introduced with the insertion of optical fiber while not compromising the strength, that may be a breakthrough to the aspiration of achieving some new feat in modern architecture.

Introduction

Concrete may be an artifact fabricated from a mix of cement, sand, coarse aggregate, pebbles and water, typically outlined as artificial stone. A word thought to be of French origin, concrete is related to engineering achievements bridges, power plants, foundries. Light transmission concrete additionally referred to as semi transparent concrete, may be a Crete based mostly artifact having light-transmissive property [1]. Light-weight transmissive property is especially thanks to uniform distribution of optical fibers throughout Its body. it's additionally notable to be transparent concrete. Translucent stone isn't solely a clear, compact artifact, but also a tool of expression within the hands of artists and architects. Philosophical, visual and material signifiers are all incorporated. Litracon presents the thought of sunshine transmission concrete within the variety of a widely applicable new artifact. It is often used for interior or exterior walls, illuminated pavements or maybe in art or design objects the clear concrete is employed for esthetic application too, by inserting the optical fibers in concrete. Each natural further as artificial light passes through the clear concrete due to optical fibers. Additionally it also makes the concrete as fiber bolstered that is its other advantage[2]. Our study, not solely strained with the ornamental purpose however the impact of fiber application in strength side is additionally taken into thought. Load carrying capacity of clear concrete will increase once fibers are organized in several layers and additionally numerous patterns are often created to create the concrete ornamental.

Materials

The materials used for making light transmitting concrete using plastic optical fiber are discussed below with its characteristics and properties before mixing with various materials.

Cement

Ordinary Portland cement of 43- Grade out there in native market is employed within the investigation[3]. The cement used has been tested for numerous properties as per IS: 4031-1988

and located to be confirmed to varied specifications of IS: 12269-1987 having specific gravity of 3.0. the figure 1 shows the ordinary Portland cement.

Figure.1 Ordinary Portland cement

Manufactured sand (M sand)

Manufactured sand (M sand) is used as a substitute for natural river sand in this study. Particles passing through 4.75 mm sieve are used[4]. Crushed angular aggregates of size 20mm and 10mm showing specific gravity 2.79 and 2.74 respectively were used in the study. Water for curing and mixing confirming to IS 456 was used.

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Figure.2 Manufactured sand

Coarse Aggregate

The coarse combination is the strongest and porous element of concrete[5]. Presence of coarse combination reduces the drying shrinkage and different dimensional changes occurring on account of movement of wetness. In our investigation we have a tendency to have used the combination passing through 20mm IS Sieve and holding on 12.5mm sieve. The particular gravity of combination was found out to be 2.50

Figure. 3 Coarse Aggregate

Plastic Optical Fiber

Plastic glass fiber is an optical fiber that's created out of chemical compounds, just like glass glass fiber, POF transmits light through the core of the fiber. Its chief advantage over the glass product, different facet being equal, is its hardiness below bending and stretching[6]. Glass fiber utilized in telecommunications is ruled by European Standards EN 60793-2-40-2011.

The idea of using light to send messages has been developed since the eighth century B.C., when the Greeks used fire signals for sending alarms or calls for help. It was only in the mid 1960s that Charles K. Kao determined that glass had a loss of 20db/km, which spurred researchers into exploring methods for making glass more pure[7]. This discovery sparked a revolution in the telecommunication industry as a new industry of processing optical fibers became commercially important. These optical fibers have great light transmission capability.

The typical fibers today are made out of glass or plastic since it is possible to make them thin and long. Also both glass and plastic are transparent at particular Wavelengths, which allow the fiber to guide light efficiently. The fiber is constructed with a core with high index surrounded by a layer of cladding at lower index. The core and cladding can be made out of both plastic and glass. For plastics, the core can be polystyrene or polymethyl methacrylate and the cladding is generally silicone or Teflon for glasses both the cladding and the core are made out of Silica with small amounts of decants such as Boron, Germanium to change its Index. Major differences exist between the two materials when it comes to making the optical fiber. In plastic core fibers they are more flexible and inexpensive compared to glass fibers[8]. They are easier to install and can withstand greater stresses and weigh 60% less than glass fiber. But losses, giving them very limited use in communication applications. Such plastic fibers are practical for short runs such as within buildings. Therefore, due to their restrictive nature glass core fibers are much more widely used because they are capable of transmitting light effectively over large distances.

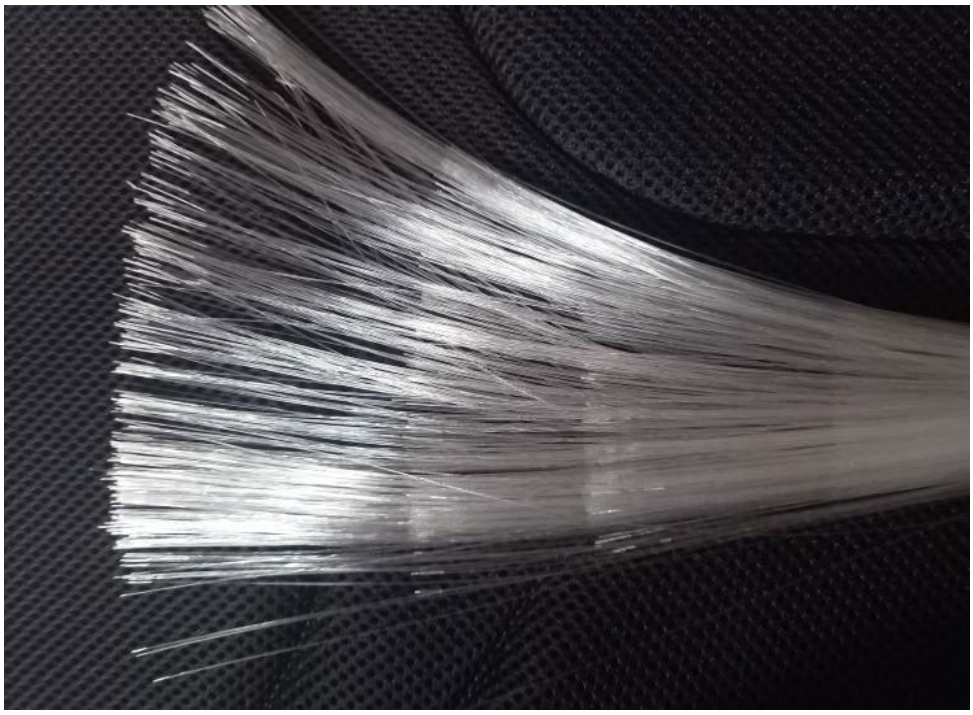

Figure 4 Plastic Optical Fiber

Characteristics of Plastic Optical Fiber

Generally, fiber protective cover is created of silicon refractive index of 1.46.High index of refraction distinction is maintained between core and cladding[9]. High numerical aperture. Have high mechanical flexibility and low price.Industry-standard IEC ⟨60793-2-40 A 4a.2) step-index fiber includes a core diameter of 1mm.Attenuation loss is concerning I dB/m @ 650 nm. Bandwidth measure is-5 MHz-km @ 650 nm.

Light Theory

The effectiveness of the wire depends on its ability to guide the light ray far distances with as little scattering or absorption of the light as possible. Doing so means that the optical fiber must exhibit total internal reflection within the wire, Thus when considering the propagation of light for an optical fiber the refractive index of the dielectric medium needs to be accounted for. As light rays become incident on an interface between two dielectrics with different index of refractions, refraction occurs between the two mediums. This can be best described by using Snell's Law of Refraction which states,

$$N1\sin Ø1 = N2\sin Ø2,$$

This equation shows that at certain angles partial internal reflection will arise, as well at other angles total internal reflection will occur as shown in following figure

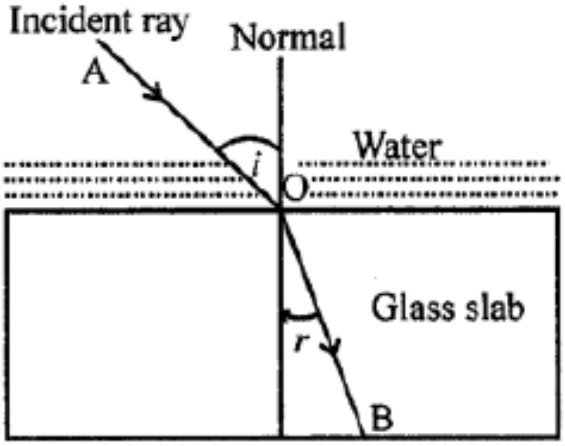

Figure 5 Light reflection diagram

Mix Design for Light Transmitting concrete

Mix designs are often outlined because of the method of choosing appropriate ingredients of concrete and deciding their relative proportions with the object of manufacturing concrete of bound minimum strength and sturdiness as economically as attainable. The main objective is to stipulate the minimum strength and sturdiness[10]. It conjointly reveals the relation between combination and paste. the opposite conditions being equal for possible mixes, the strength of concrete numerous as an inverse function of the water- cement ratio. Since, the standard of water depends upon the number of paste, it's necessary that as very little paste as attainable should be used and therefore the importance of grading.

Indian Standard Recommended Method 456

The Mix style for M20 grade of concrete has been prepared with the design stipulations. Reinforced concrete construction minimum M20 grade of concrete is used as Mix style are often outlined as the method of choosing appropriate ingredients of concrete and deciding their relative proportions with the object of manufacturing concrete of certain minimum strength and sturdiness as economically as attainable. In our investigation we've created M20 grades of concrete. The combination magnitude relation obtained when the combination style as per IS 456 for M20 (1:1.5:3). Further, the poured the concrete within the cube Moulds and completely different samples were created that are as follows

Conventional Concrete of grade M20.

Castings of cubes were performed based on the design mix and action of various specimens of light transmitting concrete. Once the concrete is totally mixed the concrete is poured within the cube, compaction is done by the vibration machine[11]. Concrete cubes were removed from the Moulds when 24 hrs and those were placed into the curing tank. Curing was done for 7, 14 and 28 days for all samples.

Placing of optical fiber

Placing of optical fiber are completely different ways of putting of glass fiber within the concrete are as follows

A. Direct mix
B. Indirect mix
C. Injection methodology

In the concrete block the optical fibers were placed, which have very small diameter, so that a bunch of fiber are prepared. According to the proportion of optical fiber, the number of fibers in particular sizes like 150, 200 fibers for 4 % & 5 % respectively. These bunches are passed transversely from the holes made at opposite face of mould, the bundles of optical fibers are laid such that it extends from face for length of at least 1 cm to make it stable and to avoid sagging during concreting and compaction. In our analysis we have used one among the ways known as the direct methodology. Once the optical were placed within the concrete they ought to be transmit

Figure.6 Placing of Optical Fiber in Concrete.

Experimental Test Results

The Light transmitting plastic optical fiber has various experimental setups to categorize the optical fiber and to check the strength of the normal concrete with light transmitting concrete.

Compressive Strength of concrete

It is defined as the Characteristic strength of 150mm size concrete cubes @28 days. As we all know that concrete is a mixture of sand, cement, and aggregate. The strength of the concrete depends upon many factors like individual compressive strength of its constituents (Cement, Sand, aggregate), quality of materials used, air entrainment mix proportions, water-cement ratio, curing methods and temperature effects. Compressive strength gives an idea of the overall strength and above-mentioned factors[12]. Through conducting this test, one can easily judge the concrete strength psi and quality of concrete produced. The table 1 gives the results of cubes tested on different days.

Table.1 Compressive strength Test Results

S.No	Test on Days	Weight of concrete (Kg)	Compressive strength(N/mm2)
1	7	7.646	8.88
2	7	7.646	9.02
3	14	7.852	14.44
4	14	7.852	15.2
5	28	7.969	18
6	28	7.969	19.25

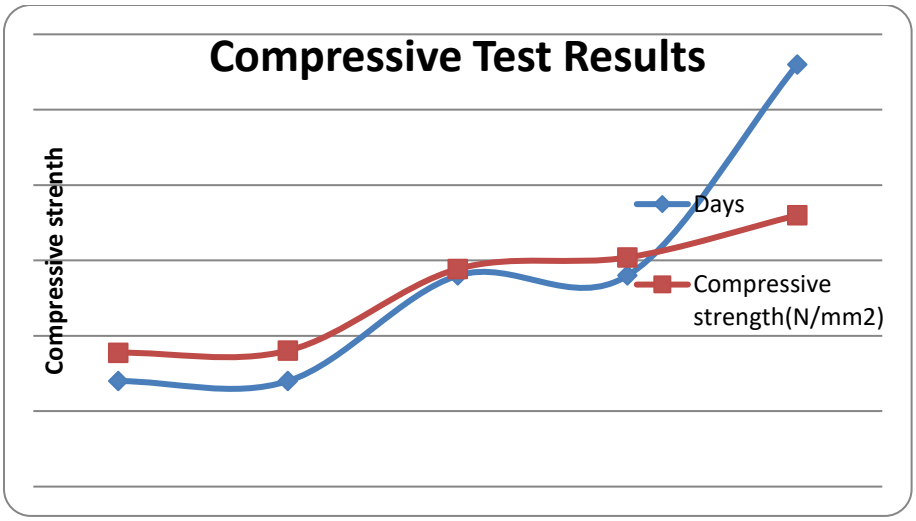

Figure.7. Compressive test results

The above figure explains the compressive strength of the cubes on different days such as 7, 14 & 28. The strength of the cube increases with the number of days as like in the normal concrete. But in this light transmitting concrete has few characteristics of light passing voids or it may be named as path of travel. In addition to this the material properties of concrete were tested. The casted light transmitting concrete was shown in the figure8.

Figure.8 Light transmitting concrete

Conclusion

This study investigates the compressive behavior of light transmitting concrete. The properties of Plastic Optical Fiber (POF) used are investigated. This paper contributes to new alternatives of concrete for property construction. The compressive strength with the quality concrete combine samples was found to be 26.52 N/mm2, and adding POF to the concrete includes a variable impact on the compressive strength, with the best improvement of 34.16 N/mm^2) accomplished with POF concrete with victimization fibers of 1.5 millimeter diameter spaced 10 millimeter apart for a proportion of 1.43% of fibers. It's clear that the compressive strength of the specimens augmented with time. The utmost quantity of sunshine passing through the cubes was 75.53 LUX using fibers of 1.5 millimeter diameter areas 10millimeter apart for a proportion of 1.43% of fibers. Thus the study shows that the transparency of light is feasible in concrete while not poignant in its compressive strength, because the fibers and fiber reinforcement enhance the strength and look.

The transmission of light through light transmitting blocks depends on the percentage of optical fiber used of that surface area. The transmission of light is increased with an increase in the percentage of optical fiber.

References

[1] Altlomate A, Alatshan F, Mashiri F, Jadan M. Experimental study of light-transmitting concrete. International Journal of Sustainable Building Technology and Urban Development. 2016 Oct 1;7(3-4):133-9. https://doi.org/10.1080/2093761X.2016.1237396

[2] Bashbash BF, Hajrus RM, Wafi DF, Alqedra M. Basics of light transmitting concrete. Global Advanced Research Journal of Engineering, Technology and Innovation. 2013;2(3).

[3] Shanmugavadivu PM, Scinduja V, Sarathivelan T, Shudesamithronn CV. An experimental study on light transmitting concrete. Int. J. Res. Eng. Technol. 2014;3(11):160-3. https://doi.org/10.15623/ijret.2014.0323035

[4] Ramana, S. Venkatachalam, K. Vishnuvardhan, M.M. Saravanan, A Study on Fresh and Hardened Properties of Concrete with Partial Replacement of Bottom Ash as a Fine Aggregate, Materials Research Proceedings, Vol. 19, pp 28-35, 2021

[5] Philips, The LED Lighting Revolution: A Summary of the Global Savings Potential, in, Koninklijke Philips Electronics NV. Netherlands, 2012.

[6] Yadav A, Shekhar S, Anand A, Badal A, Zaman B. An investigating study on a new innovative material: transparent concrete. International Journal of Engineering Research and Advanced Development. 2018;4(1):64-72.

[7] He J, Zhou Z, Ou J, Huang M. Study on smart transparent concrete product and its performances. In6thinternational workshop on advanced smart materials and smart structures technology 2011 Jul 25.

[8] Zubia J, Arrue J. Plastic optical fibers: An introduction to their technological processes and applications. Optical fiber technology. 2001 Apr 1;7(2):101-40. https://doi.org/10.1006/ofte.2000.0355

[9] Kaino T. Preparation of plastic optical fibers for near-IR region transmission. Journal of Polymer Science Part A: Polymer Chemistry. 1987 Jan;25(1):37-46. https://doi.org/10.1002/pola.1987.080250105

[10] Sawant AB, Jugdar RV, Sawant SG. Light transmitting concrete by using optical fiber. Int. J. Inventive Eng. Sci. 2014 Dec;3(1):23-8.

[11] Sunil J, Amol K, Chetan K, Pravin T. A study on translucent concrete product and its properties by using optical fibers. International Journal of Modern Engineering Research (IJMER). 2015;5:53-7.

[12] Kister G, Winter D, Gebremichael YM, Leighton J, Badcock RA, Tester PD, Krishnamurthy S, Boyle WJ, Grattan KT, Fernando GF. Methodology and integrity monitoring of foundation concrete piles using Bragg grating optical fibre sensors. Engineering Structures. 2007 Sep 1;29(9):2048-55. https://doi.org/10.1016/j.engstruct.2006.10.021