Study Of Translucent Concrete As - A New Age Construction Material

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***Abstract*—** Translucent concrete is a concrete based building material with light-Trans missive properties due to embedded light optical elements usually Optical fibres. Light is conducted through the stone from one end to the other. Therefore the fibres have to go through the whole object. Transparent concrete is also known as the translucent concrete and light transmitting concrete because of its properties. It is used in fine architecture as a facade material and for cladding of interior walls. In this report, to integrate the merits of concrete and optical fiber, for developing transparent concrete by arranging the high numerical aperture Plastic Optical Fibres (POF) or big diameter glass optical fiber into concrete.

The main purpose is to use sunlight as a light source to reduce the non-renewable energy consumption of illumination and to use the optical fibre to sense the stress of structures and also use this concrete as an architectural purpose for good aesthetical view of the building. The binding material in transparent concrete may be able to transmit light by using clear resins the concrete mix.

The Paper confines with the need of transparent concrete at present to utilize the sunlight and for architecture technologies. The new type of concrete can satisfy the green energy saving with its own Natural properties.

Keywords: Translucent concrete, Optical fibres, Plastic Optical Fibres.

Introduction:

Green building is the act of making structures and utilizing forms that are environment responsible and asset proficient all through a building's life-cycle from sitting to plan, development, activity, upkeep, redesign and deconstruction. Green building is otherwise called a manageable or elite building. Green building is essentially a smart building. Green building is the specialty of making new structures and procedures that don't hurt nature and are effective in assets. With the development of the innovation segment and a deficiency of assets, each nation is practicing environmental safety to get the accompanying advantages from green structures.

There are various characteristics which can make a building 'green'. These include:

- Efficient utilization of energy, water and different assets.
- Use of sustainable power source, for example, sun based energy.
- Pollution and waste decrease measures, and the empowering of re-use and reusing.
- Use of materials that are non-dangerous and feasible.
- Consideration of the personal satisfaction of inhabitants in design, development and operation.
- A structure that empowers adjustment to a changing environment.

The international energy agency discharged a distribution which assessed that current structures are in charge of over 40% of the world's all out essential energy utilization. Distinctive nations and locales have an assortment of qualities, for example, particular climatic conditions, interesting societies and customs, different building types and ages, or wide-ranging environments, monetary and social needs – all of which shape their way to deal with green structures. A significant number of the nation’s everywhere throughout the globe are now attempting to manufacture an ever-increasing number of green structures like leadership in

energy and environmental design (LEED) which is set of rating frameworks for the plan, development, task, and support of green structures which was Produced by the U.S. Green Building council. Different endorsements framework that affirms the manageability of structures is the British BREEAM (Building Research Establishment Environmental Assessment Method) for structures and expansive scale improvements. Right now, World Green Building Chamber is leading exploration on the impacts of green structures on the wellbeing and profitability of their clients and is working with World Bank to advance Green Structures in Developing

Markets through EDGE (Excellence in Design for Greater Efficiencies) Market Change Program and confirmation. There are additionally different apparatuses, for example, Green Star in Australia and the Green Building index (GBI) dominatingly utilized in Malaysia.

1.3 **Objective of Study**

The Essential target of this exploration is to develop light transmission qualities in concrete using various fiber diameters and densities. To safeguard the arrangement and dissemination of strands over the profundity in the concrete body, self-compacting concrete is to be utilized against normal concrete that requires vibrating marvel for compaction. These vibrations may disturb the orientation of strands in the concrete body. The incorporation of optical strands in the concrete matrix, in addition to optical characteristics may likewise impact on the mechanical properties, like compressive strength, weight, permeability, etc. of concrete. These properties are required to be thoroughly studied. This entails the study on various parameters of translucent concrete. The following objectives are proposed to be achieved in this study.

i. To decide the appropriate manufacturing process for manufacturing of translucent concrete with the goal that the filaments utilized can be protected and diverse techniques can be opted on manufacturing as enforced by the circumstance.

ii. To check the power of light by changing the diameter of plastic optical filaments in translucent concrete with an aim to get inside, the desired amount of light as per the pre-requisite.

iii. To check the variation in power of light by changing the thickness of the concrete components to see whether the translucent concrete can be utilized in different ranges of thickness of members of a structure.

iv. To check the power of light by changing the surface zone possessed by plastic optical filaments to know the variation in luminance.

v. To check the structural performance of translucent concrete in compression by changing the diameter and density of plastic optical fibers so as to get the appropriate percentage and diameter of POF for most optimum strength of translucent concrete.

2. Scope of the Work:

The extent of this work is determined as pursues:

- Determination of different manufacturing procedures to safeguard the plastic optical strands in translucent concrete and to choose the appropriate materials for manufacturing.
- To figure out the amount of energy that can be spared by utilizing the translucent concrete in the buildings.
- To check for the compressive strength of the translucent concrete utilizing distinctive diameters and diverse densities of every diameter.
- To compare the performance of translucent concrete with that of normal concrete.

3. Literature Review

Ries et.al (2009)1, had carried out study on the advantages of green structures, they expressed that in building plan and developments both the green building and standard development systems are effective. Their examination researched the connection between the composite ordinary and green buildings which would add to the improvement of the green building measurements. Their outcomes included four segments:-

- Productivity, health and security including non-appearance, vitality and IEQ.
- They likewise indicated that pre and post move doubtlessly reactions were dissected with combined t-tests to comprehend whether there is any static critical change in the mean estimations of the factors.
- They additionally closed the expansion in efficiency with the assistance of green working in their study.

Zhi Zhou et.al (2009)2, Nikhil et.al (2013)28 also studied the properties of glass optical strand based translucent solid square samples and reported that use of optical fiber illuminates the squares without affecting the compressive strength of square. Consequently the utilization of optical fiber will make the solid embellishing just as can make the solid basic proficient.

Ignacio et.al (2010)3, had distributed the paper on ‘building and condition’ in which they exhibited the consequences of a lifecycle expected examination looking at the most normally

utilized building materials with same eco materials. The fundamental point of aim of distributing this paper is to profound the learning of vitality and ecological particulars of the building materials. Additionally they supported the investigation and examining their conceivable outcomes for development and giving rules to material choice in the eco structure of new building and furthermore in restoration of existing structures. The analysts inferred that so as to stay away from the creation of materials influencing the common assets, it is important to advance the best utilization of these strategies accessible and development underway.

Tatari et.al (2011)4, in their study, they confirmed that the green buildings have got large effect on the economy and psychology of humans.

Therefore promoting study on green structures has got substantial scope to benefit human life.

Jianping et.al (2011)5, studied that in view of the properties of light transmission through optical fiber, another shrewd straightforward cement is fabricated by including optical strands into the solid. The optical filaments were added to the solid by penetrating a few openings symmetrically in plastic sheets and optical strands were embedded through these gaps prior to pouring the solid. These plastic sheets were settled on the wooden formwork and finally the molds were vibrated on shake table. The process in cumbersome and moreover the vibration for compaction disturb the alignment of optical fibers, resulting in the decrease in efficiency of translucent solids.

T.Ramesh et.al (2010)6, in their study have fundamentally expressed that structures request vitality in their life cycle appropriate from its development to obliteration, additionally their exploration expressed that the majority of the contextual analyses found in writing are from cold nations where oil or gas is utilized for extensive piece of the operational stage that is for space warming. Be that as it may, as indicated by the specialists in non-cold creating nations like India, Thailand and so forth, power is mostly obtained from non-renewable energy sources and is utilized in activity stage for space cooling, lightning and different purposes.

Basma F. Bashbash (2013)7, on the same lines, investigated the quality criteria of the translucent cement. In their research, diverse measures of Plastic Optical Fiber were used. Impact of POF on quality has been checked after various time interims. Being an innovative material, the translucent cement ought to have feasible quality and should withstand distinctive burdens imposed on it, as reported by author. Quantitative evaluation w.r.t use and strength of translucent cement is lacking in their study.

3.4 Manufacturing of Translucent Concrete:

The manufacturing of translucent concrete is a new process to work, involving placing of optical fibers in a sensitive manner. The different materials used in the manufacturing of translucent concrete (TC) are as under

1) Cement OPC 43 Grade (HK brand)

2) Fine aggregates (natural sand)

3) Coarse aggregates (10mm and 20mm)

4) Optical filaments of 0.5mm, 0.75m, 1.0mm and 2.0mm diameters.

5) Plasticizers (high range water reducing admixture BASF monopolyhead 8101)

6) Water (normal portable tap water available in lab)

Prior to the manufacturing of translucent concrete, each material was individually accessed for its characteristics and quality and is briefly described here.

3.4.1 Fine Aggregates:

Fine aggregates may be natural sand or any crushed stones. Aggregates passing through 4.75mm sieve are designated as fine aggregates. In this study natural sand taken from Nallah Sindh at Ganderbal has been used and was procured in one-go (200cft) for the whole program. The fine aggregates procured, were tested as per IS standards and the results are tabulated here under in table 3.

Tests Performed	Testing Method	Results	Recommended Values
Specific Gravity	Pycnometer Test	2.79	Around 2.65
Water Absorption Test	Pycnometer Test	0.91	<3% By Weight
Fineness Modulus	Sieve Analysis	2.577	1.35 To 4.0
Surface Moisture	Glass Flask	3.5%	Around 10

3.4.2 Cement:

Cement is utilized as binding material in concrete. We have diverse brands of cement available in the local market accessible in two distinct grades viz, 43 and 53. At the onset three distinct brands of cement i,e Khyber OPC 43 grade, HK OPC 43 grade and ARCO OPC 43 grade were examined with respect to properties and availability on merit grounds HK OPC 43 grade cement was found best and has been therefore, employed in this research project. The cement is available in the bags of 50kgs each. Repeated tests on different lots of cement (HK cement) were conducted to establish the consistency in the quality of cement. The average characteristics of HK cement used in this study were experimentally obtained and arer shown in table 3.1 here

Table 3.1: Average test results of 43grade OPC

Tests Performed	Testing Method	Results	Recommended (As Per Is-8112:1989)
Fineness	Sieve Analysis	2.0%	10% Of Total Weight (Is-4031-1988)
Standard Consistency	Vicat Apparatus	31%	Around 30% Of Water By Weight Of Cement
Initial Setting Time	Vicat Apparatus	117 Minutes	30 Minutes (Minimum)
Final Setting Time	Vicat Apparatus	312 Minutes	600 Minutes (Maximum)
Compressive Strength 1) After 3 Days 2) After 7 Days 3) After 28 Days	CTM	 24.5 Mpa 34.2 Mpa 43.1 Mpa	 23Mpa (Minimum) 33Mpa (Minimum) 43Mpa (Minimum)
Soundness	Lechatliers Apparatus	2.0mm	10mm (Maximum)
Tensile Strength 1) 168 Hours 2) 672 Hours	Briquette Testing Machine	 3.6Mpa 4.9Mpa	 3.3Mpa (Minimum) 4.3Mpa (Minimum)
Specific Gravity	Lechatliers Flask	3.13kg/Ltr	Around 3.15kg/Ltr Or G/Cc

3.4.2.1 Sieve Analysis of Fine Aggregates (Sand):

Mechanical sieve shaker having sieves ranging from pan size to 20mm were arranged one over other as shown in Fig. 3.4

Dry sample of weight 2kg were put into the sieve system and was subjected to gentle shaking for a period of 5 minutes. Amount of material retained on each sieve was weighted and the results were expressed in a standard manner as shown in table 3.3

S.No.	I.S Sieve Size(Mm)	Weight Retained (%)	Cumulative Weight Retained (%)	Weight Passing
01	20mm	0	0	100
02	12.5mm	0	0	100
03	10mm	0	0	100
04	4.75mm	4.7	4.7	95.3
05	2.36mm	5.9	10.6	89.4
06	1.18mm	11.1	21.7	88.3
07	600 micron	14.2	35.9	64.1
08	300 micron	50.4	86.3	13.4
09	150 micron	12.2	98.5	1.5
10	Pan	1.5	-	-
TOTAL	-	-	257.7	-

Table 3.3: Sieve analysis of sand

Fineness Modulus = 257.7/100 = 2.577

From the results of sieve analysis, it is evident that the fine aggregate (sand) falls in zone-III and is fine in nature.

3.4.3.1 Sieve Analysis of Coarse Aggregates:

Sample of neat and clean sundried aggregates of both 10mm and 20mm size were subjected to sieve analysis and the test results are expressed in table 3.5 and 3.6 respectively.

Table 3.5: sieve analysis on coarse aggregates (10mm).

S.No.	I.S Sieve Size	Weight Retaine (%)	Cumulative Weigh Retained (%)	Weight Passi (%)	Is Limi
01	20mm	0	0	100	100
02	12.5mm	0	0	100	100
03	10mm	11.7	11.7	88.3	85-100
04	4.75mm	83.3	95.0	5.0	0-20
05	2.36mm	05.0	100	0	0-5
06	1.18mm	-	100	0	-
07	600 micron	-	100	0	-
08	300 micron	-	100	0	-
09	150 micron	-	100	0	-
10	Pan	-	-	-	-
TOTAL	-	-	606.7	-	-

Fineness Modulus = 606.7/100=6.067.

3.4.4 OPTICAL FIBERS:

Optical fiber is the main material that changes the demography of concrete from opaque to transparent nature. Normally two types of optical fibers are used in the manufacture of translucent concrete. These are glass or plastic based optical fibers of circular cross-section. Glass fibers are brittle and prone to fracture; while as plastic fibers on the other hand are flexible enough to maintain the curvature without fracture. Keeping in consideration this advantage, plastic optical fibers/filaments (POF) have been brought into use for the manufacture of translucent concrete in this research programme. The details of optical fibers used in this study are shown in table
3.7 pictorially represented in fig. 3.2

Table 3.7: Details of plastic optical fibers used in this project.

Diameter of plastic optical fibres used	No. of strands used in (150 x 150 x 150)mm cube	Chemical composition
0.5mm	16,36,49 and 64numbers of fibres strands used in concrete cube	Polymer based (typic lly PMMA).
0.75mm	16,36,49 and 64numbers of fibres strands used in concrete cube	
1.0mm	16,36,49 and 64numbers of fibres strands used in concrete cube	
2.0mm	16,36,49 and 64numbers of fibres strands used in concrete cube	

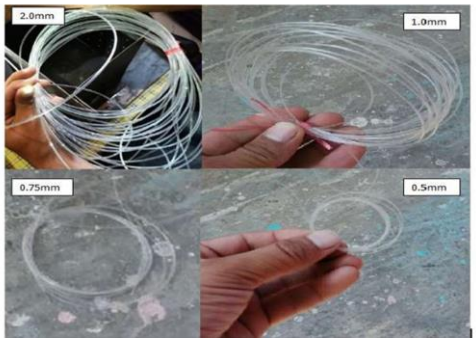

Figure 3.4: Plastic optical fibers used in this project.

3.4.6 Placing Of Optical Filaments in Concrete:

The plastic optical fibers possess delicate nature, hence beforeplacing plastic optical filaments into the concrete it was necessary to work out the efficient and easy method for placing of optical filaments into the concrete, following are the methods opted to embed plastic optical fibers into the concrete:

3.4.6.1 First Method: In this technique we take two thin cardboard square planks of size (150mm x 150mm) and punch holes in both of them at uniform spacing. The optical strands are passed through these holes and are tied over the planks at a single point, as shown in Fig 3.3, subsequent to putting of concrete. Initially one plank of cardboard is placed at the base of normal cube mould (150mm x 150mm x 150mm) and other piece over the top of the mould after completely filling the mould with concrete. On de-moulding we get scattered fibred solid concrete block. This process of casting of concrete may result in the twisting of filaments, if proper care is not taken during concreting of the moulds..

Figure 3.5: Card board holding optical fibers to be inserted in

3.1.1.1 Fourth Method: In most of the previous techniques, the strands are prefixed vertically in separate steel moulds (150mm x 150mm x 150m) while as in this method a different technique is adopted in which a wooden mould of same

measurements as that of standard cube mould are made as shown in Fig 3.6. Holes are driven on two inverse counter faces, through which plastic casing holding optical fibers are passed. Just after pouring the concrete, the casings are pulled out leaving behind optical fiber across concrete body. The only drawback of this method is that due to little large size of holes, some slurry (cement paste) is lost. The method is comparatively economical in comparison to previous methods.

Fig 3.6. Wooden moulds for casting of translucent concrete.

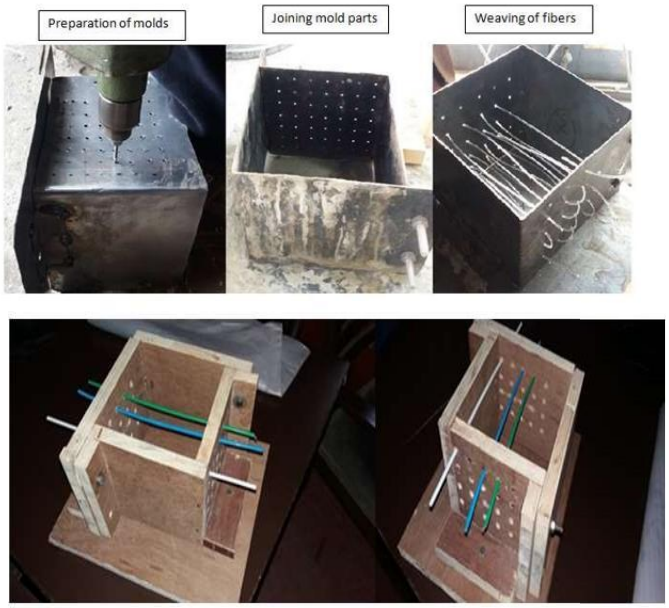

Fig 3.6. Wooden moulds for casting of translucent concrete.

Mix 3	650	850	850	0	227.5	1:1.31:1.31
Mix 4	650	680	1020	0	227.5	1:1.05:1.57
Mix 5	570	850	850	0	199.5	1:1.49:1.49
Mix 6	530	800	0	900	196.1	1:1.5:1.6
Mix 7	500	750	0	850	200	1:1.5:1.7
Mix 8	550	850	0	850	231	1:1.54:1.54
Mix 9	530	830	0	800	222.6	1:1.6:1.5
Mix 10	510	690	0	790	204	1:1.35:1.54

Figure 4.3: Translucent concrete cubes under compressive strength testing.

Test Results and Discussions:

Extensive testing has been carried out on standard cube elements with and without filaments to expedite the role of filaments on the strength, light transmission, stress-strain behavior, cracking phenomenon etc of concrete. The aim is to prepare the guidelines for the use of translucent concrete as structural element in green buildings. To achieve the desired objective the following tests were performed on translucent concrete.

01. Strength tests.
02. Light transmission tests.

4.3.1 Strength Tests:

As described compressive strength of concrete is very important property that enables it to use as structural concrete in building construction. Compressive strength tests were performed on cube elements (150mm x 150mm x 150mm) containing optical fibers of different diameters (0.5mm, 0.75mm, 1.0mm, 2.0mm) and different dosages [4x4(16 no's), 6x6 (36no's), 7x7(49no's), 8x8(64no's)]. This resulted in the testing of 144 cube elements. The test results are shown below in table 4.6

Table 4.6:Compressive strength test results of translucent concrete

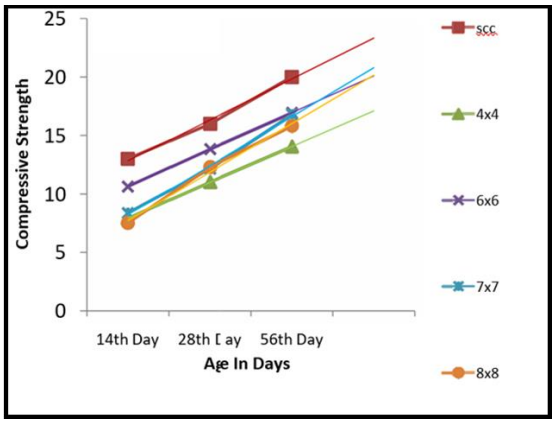

Fig 4.4. Compressive strength of 0.5 mm diameter fibered TC

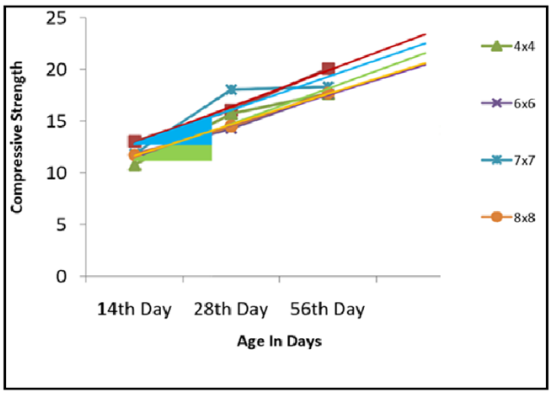

Fig 4.5 . Compressive strength for 0.75mm diameter fibered TC

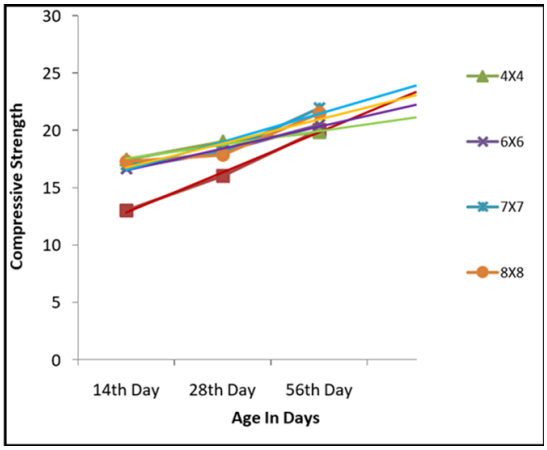

Figure 4.6: Compressive strength for 1.0mm diameter fibered TC

Conclusion:

- Since the optical filaments are prefixed in the moulds, followed by placing of concrete, therefore, it is imperative to maintain the alignment of filaments so as to fulfill the purpose of light passing.
- The efficient mechanism for the installation of filaments in concrete was discovered to be fifth method by weaving fibers in holed steel moulds.
- Small diameter filaments, when used in large quantity produce voids in concrete and hence result in decreased performance.
- From the view of production of translucent concrete self compacting concrete contain fiber content 6 x 6, of 0.502 % and diameter of fiber between 1.0mm and 2.0mm was found adequate, in this study.
- There is both increase as well as decrease in compressive strength of translucent concrete, though marginally, depending upon the amount and diameter of fibers in translucent concrete.
- The over density of small size optical fibers in concrete results in the reduction of compression quality of translucent concrete. In this research program, the decrease in compressive strength of 0.5mm diameter fiber embedded concrete was found 29.8 % and for 0.75mm fibered diameter, it was found 12% for the same amount of fiber content (4x4) when compared with conventional concrete.

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