Evaluation Of Strength Characteristics Of Transparent Concrete

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Abstract - ***Light transmitting concrete also known as transparent concrete, is the brightest building material developed in recent years . Transparent concrete or translucent concrete is work Based on the " Nano - Optics". Optical fibres passes as much light when tiny slits are placed directly on top of each other. They can carry because optical fibres in the concrete act like the slits and carry the light across throughout the concrete. There are 3 basic types of optical fibres : The optical graded-index fibre, multimode step-index fibre and single-mode step-index fibres . It does not lose the strength parameter and it has very vital property from the aesthetic point of view. This type of concrete can be installed at a very low cost. The application is that it can be used in decorating the interior of a hall or lobby and the ceiling to glow in dark by external lighting source and during day time the concrete glows by the light transmission from natural resource.*** **An attempt has been made in the investigation reported in this project to study mechanical properties like Compressive strength, concrete cubes and wall panels with optical fibres and compare the results with conventional concrete.**

Key words - transparent concrete, nano optics, optical fibres, compressive strength

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: coarse aggregate(consisting of larger pieces of material like 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.

By research and innovation newly developed concrete has been created which is more resistant, lighter, white coloured, etc. Concrete has learned to adopt to almost all new challenges that appeared in 2001, the concept of transparent concrete was first put forward by Hungarian architech Aron Losonzi at the technical university of Budapest ,and the first transparent concrete block was successfully produced by mixing large amount of optical fibres into concrete in 2003, named as Litracon. The transparent concrete mainly focuses and transparency and its objective of application pertain to green technology and artistic finish. It is the "combination of optical fibres and fine concrete". At present, green structures focus greatly and 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), environment protection and energy saving and artistic modelling.

Transparent concrete is new technique different from normal concrete. The use of sunlight instead of using electrical energy,The main purpose of translucent concrete, so as to reduce the load on non-renewable sources and result into the energy saving. the normal concrete is replaced by translucent concrete, which has natural lighting and art design. Conventional building materials lack the ability of deriving natural light source into the living area which has increased the use of artificial sources for illumination of building by great amount. So it is very essential to reduce the use of artificial source of light in structure.

In this paper, the main purpose is to use sunlight as a light source in order to reduce the power consumption, because the brightness of indoor environment is entirely created by artificial lighting which has consuming a large amount of power supply.

II. LITERATURE REVIEW

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Akshaya b.kamdi, issn August 2013, "transparent concrete as a green material for building", studied that how transparent concrete made and it's glowing future. they concluded that the translucent concrete is one of the most interesting new takes on the historically stiff and uninspiring building material.
Neha R. Nagdive and Shekhar D.Bhole (2013) Dec 2013, 23-30, **"**To Evaluate Properties of Translucent Concrete/Mortar and Their Panels", To evaluated that the properties of translucent concrete/mortar and their panels and was manufactured with optical Fibre by drilling through the cement and mortar in order to utilize the light guiding ability of optical Fibre. They concluded that the smart transparent concrete has good light guiding property.

III. SCOPE AND OBJECTIVES OF WORK:

From the detailed literature review the following points are evident.

- The use of optical fibres in normal concrete is necessary to increase the compressive strength and light transmitting property.
- The use of optical fibres reduces the power consumption.

Scope of work

The community has great challenges and it needs useful solution for the challenges as like the global climate change, using energy in a sustainable way and protecting the environment. We should find a good solution, for instance: using of solar energy, translucent heat insulation, passive buildings etc. The development of the building technology in the field of building industry (using the best methods) is a good way to abolish the emission of greenhouse gases, because we shall use less loam and the industry will not need to transfer those materials The former Research and Development results will be combined with the technologies of the frozen sand concrete and the non-tectonic constructions theories and practices. The results of the last decades in the field of concrete technology and material science could be combined with the new Research and Development results. New Research and Developments are developing of a simple, cheap and productive optical fiber, especially according to the production of the transparent concrete. The use of this material in the solar architecture in a cheap way. The other aim is that the people could use it more. By the results, the transparent concrete will be available for everybody, because the technology is cheap and productive due to the fiber pulling and brick technology methods. It is much of importance for developing a new kind of building material, which can integrate green energy saving with self-sensing properties of functional material. In this paper, based on the excellent properties of light guiding and elasto-optic effect of optical fibre, a novel smart transparent concrete is researched by arranging the optical fibers into the concrete. To evaluate the effectiveness of the smart transparent concrete, the light guiding based on white light test, long-term durability based on freezing and thawing test and chloride ion penetration test, and self-sensing property based on stress elasto-optic effect test are made respectively. The experiments results show that the smart transparent concrete has good transparency, mechanical and self-sensing properties.
Translucent concrete is also a great insulating material that protects against outdoor extreme temperatures while also letting in daylight .This makes it an excellent compromise for buildings in harsh climates, where it can shut out heat or cold without shutting the building off from daylight. It can be used to illuminate underground buildings and structures, such as subway stations. The possibilities for translucent concrete are innumerable; the more it is used, the more new uses will be discovered. In the next few years, as engineers further explore this exciting new material, it is sure to be employed in a variety of interesting ways that will change the opacity of architecture as we know it.

Objective

In recent past concretes were considered a structural member only, but the concept of concrete has changed today. Innovative and smart building material like light transmitting concrete have come up in which concrete can be used as a decorative material. It can be observed that the concrete with light transmitting property shows increase in strength and also provides a

pleasing appearance to concrete. Thus this project aims in making concrete stronger, attractive, energy efficient and eco-friendly green building material.
In fact, 50% day lighting is a mandatory requirement in a green building according to (IGBC) Indian Green Building Council. In coming future the light transmitting concrete would be more economical as the production cost of optical fibre will be minimized.
The objectives of the work are stated below:

1. To cast a special type of concrete with light transmitting properties.
2. To study development in performance of concrete in light transmission by using optical fibre and improve performance of structure to derive natural light.
3. To make concrete partially transparent by using optical fibres in it to impart good appearance to structure.
4. To study cost effectiveness of this high performance concrete.
5. To study Energy saving for illumination by using transparent block for building.
6. To study the strength characteristics of TSC.
7. To compare strength characteristics of TSC and NCC.

IV. EXPERIMENTAL WORK

Introduction on experimental Study

The experimental study consists of arriving at suitable mix proportions that satisfy the fresh properties of conventional concrete as per specifications. Standard cube moulds of 150mmx150mmx150mm made of cast iron were used for casting standard cubes and transparent concrete cubes. The moulds were then oiled and then kept ready for casting, specimens were demoulded. After cubes are demoulded then that cubes are cured at different curing conditions and wet curing.

Materials used

The materials used for transparent concrete are cement, coarse aggregate, fine aggregate and water.

Preparation Of Normal Cubes

Standard cube moulds of 150x150x150mm made of cast iron were used for obtaining compressive strength. 9 number of cubes of same size shall be cast, 3 for 7 days c,3 for 14 days and 3 for 28 days testing. A sample consists of 3 cube specimens and their average compressive strength represents the test result of that sample.

Figure 1 Cube Mould

Mixing:

The amount of water in the mixture plays an important role on the behavior of fresh concrete. The effects of water content in the mixture and mixing time were critical parameters which decide the concrete strength. From the preliminary was observed that the mixing period of concrete should be within 5-7 minutes as for concrete and while mixing the following steps should be followed.

- First mix all the dry materials in the pan
- Add the liquid component of the mixture at the end of dry mixing and continue the wet mixing until concrete obtains uniform colour.

Figure 2 Mixing of Materials

Casting:

The specimens were prepared by compaction the concrete in three layers. Table vibrator was used for compaction of concrete. After completion of compaction, excess material was removed and the mould was leveled by using a levelling plate.

The standard moulds were fitted such that there are no gaps between the plate of the moulds. The moulds then oiled and kept ready for casting. The materials were mixed in a pan and they are placed in moulds and compacted by placing them in vibrating machine. At the end of casting the top surface of the cube was made plane using plane and a hacksaw blade to ensure a top uniform surface. After 24 hours of casting, the moulds were kept for wet curing for the required number of days before casting.

Figure 3 Casting of Moulds

Curing:

After completion of casting all the specimens were kept to maintain the ambient conditions Temperature of 27^0C and 90% relative humidity for 24 hours .The specimens were removed from the moulds and the specimens are kept in submerged condition until just prior to testing. The temperature of water in which cubes were submerged was maintained at 27.2^0C.The specimens were cured for required number of days.

In areas with shortage of water, sustainability of water can be achieved by using suitable chemical compounds for curing of concrete. (e) Compressive strength can also be achieved by using chemical compounds for curing.

Manufacturing of transparent concrete:

The manufacturing process of transparent concrete is almost same as regular concrete. Only optical fibres are spread throughout the aggregate and cement mix. Small layers of the concrete are poured on top of each other and infused with the fibers and are then connected. Thousands of strands of optical fibers are cast into concrete to transmit light, either natural or artificial. Thickness of the optical fibers can be varied between 2 μm and 2 mm to suit the particular requirements of light transmission.Automatic production processes use woven fibres fabric instead of single filaments. Fabric and concrete are alternately inserted into moulds at intervals of approximately 2 mm to 5 mm. Smaller or thinner layers allow an increased amount of light to pass through the concrete. Following casting, the material is cut into panels or blocks of the specified thickness and the surface is then typically polished, resulting in finishes ranging from semi-gloss to high-gloss.

Preparation of mould

In the process of making light transmitting concrete, the first step involved is preparation of mould. The mould required for preparation can be made different materials which can be of either tin or wood in the mould preparation, it is important to fix the basic dimensions of mould. The standard minimum size of the cube according to IS456-2000 ,is 15*cm15*cm15cm for concrete . In the mould ,makings are made exactly to the size of the cube,so that the perforated plates can be used Plates made of sheets which are used in electrical switch boards is used which will be helpful in making perforations and give a smooth texture to the mould,holes are drilled into the wooden plate in figure.The diameter of holes taken here is 5mm and number of holes is 25 for one mould.

Figure 4 Transparent Concrete Moulds

Placing the Fibres:

Fibres are placed in layered distribution.Holes are drives on wooden through which optical fibres are allowed to pass. Before filling these holes with concrete and fibers they are coated with oil so that the concrete cubes would not adhere to the moulds.

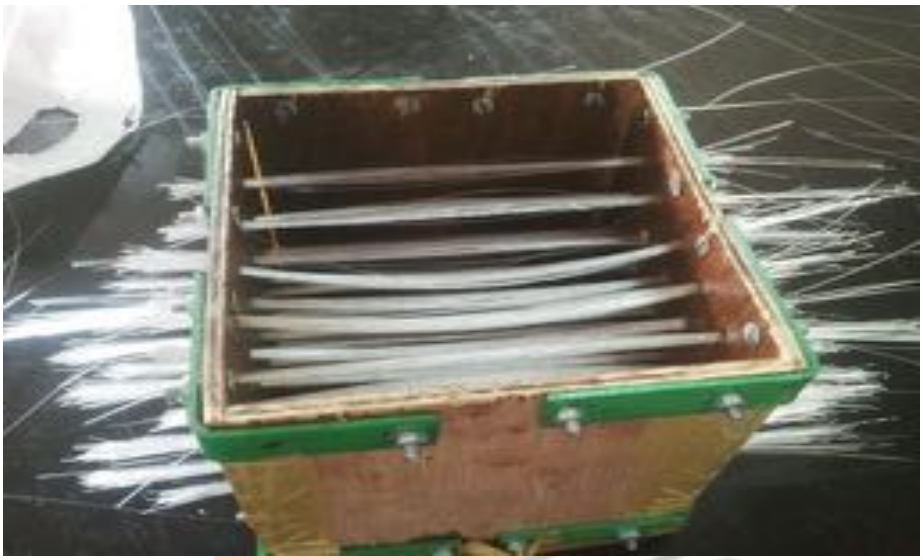

Figure 5 Placing of fibers in mould

Concreting:

The thoroughly mixed concrete is poured carefully and slowly without causing much disturbances to the previously laid optical fibres.The concrete is filled in smaller or thinner layers and is agitated with the help of vibrating tables to avoid the void formation.

Figure 6 Concreting of mould

Removing the Mould:

After 24 hrs remove the mould .The casted mould was kept undisturbed for on the levelled platform .Then it was de-moulded carefully after 24 hrs from casting. Immediately after de-moulding, the cube specimens are marked with their reapective identification marks/numbers.

Curing:

During the concrete curing humidity and temperature plays an important role to achieve designed strength of concrete.

Continuously wetting the exposed surface thereby preventing the loss of moisture from it or ponding or spraying the surface with water or leaving formwork in place or covering the concrete with an impermeable membrane after the formwork has been removed or by the application of a suitable chemical curing agent (wax etc.) or using chemicals for internal curing or by a combination of such methods. The strength of concrete is affected by a number of factors, one of which is the length of time for which it is kept moist, i.e. cured, another being the method by which it is being cured. Inadequate or insufficient curing is one of main factors contributing to weak, powdery surfaces with low abrasion resistance. In the present paper we have chosen three different methods of curing: 1. Traditional immersion or ponding method 2. Application of Wax based external coating 3. Using chemical for internal curing leading to self-compacted, self-curing concrete

The casted cubes shall be stored under the shed at a place free from vibration at a temperature 22^0C to 23^0C .The cubes are cured for required number of days.

Figure 7 Specimen taken from curing tank

Tests for cubes:
Tests for normal cubes:
At the end of the required number of days of curing the specimens were taken out and the required tests are performed.

Compressive Strength Test:
The compressive strength of a material is that value of uniaxial compressive stress reached when the material fails completely.
1. The compressive strength is of a compressive test.
2. The compressive strength of the concrete is determined by casting the cubes of size as 150x150x150
3. Compressive strength = load/area.
4. The compressive strength of the conventional usually obtained experimentally by means concrete and light transmitting concrete in 7,14 and 28 days is shown in Mix proportions.

Procedure:
1.The cement,sand,coarse aggregate were mixed as per the design mix in a pan and the mix was put in cube moulds in three layers each layer being compacted 25 times using tamping rod.
2. Then moulds are put in vibratory machine and then the surface was made even and cubes are put in a curing tank,
3. The cubes are taken from curing tank before testing and dimensions are noted.
4. The bearing surface of the machine was wiped off clean and any loose sand or other material removed from the surface of the specimen.
5. The specimen was placed in a machine in such a way that the load was applied to opposite sides of the cubes as cast that is not top and bottom
6. The axis of the specimen was carefully aligned at the center of the loading frame.
7. The load applied was increased continuously at a constant rate of 140kg/cm^2/min until the resistance of the specimen to increasing load breaks down and no longer sustained.
8. The maximum load applied on the specimen was recored.

Tests for Transparent Concrete Cubes:
Compresive Strength Test:
Compressive strength of concrete is carried out by Compressive testing machine. It is known that concrete is good in compression and weak in tension.
Procedure:
The compressive strength test procedure for transparent concrete cubes is same for normal cubes

Figure 8 Cube being tested on Compression Testing Machine

V. INTERPRETATION OF RESULTS

Compressive Strength Test Results:

The 150 mm × 150 mm × 150 mm concrete cubes are cast.The specimens are removed from the mould and subjected to curing for up to 28 days. After curing, the specimens are tested for compressive strength using compressive testing machine.

Discussion on Compressive Strength Test Results of Normal Cubes and Transparent concrete cubes:

Concrete gains strength with time after casting. It takes much time for concrete to gain 100% strength and the time for same is still unknown. The rate of gain of concrete compressive strength in higher during the first 28 days of casting and then it slows down.

The table below shows the compressive strength gained by concrete after 1, 3, 7, 14 and 28 days with respect to the grade of concrete we use.

Age in days	Strength Percent
1	16 %
3	40 %
7	65 %
14	90 %
28	99 %

Table 1: age in days vs strength percent

From above table, we see that, concrete gains 16 percent strength in one day, 40 percent in 3 days, 65% in 7 days, 90% in 14 days and 99% strength in 28 days.

Thus, it is clear that concrete gains its strength rapidly in the initial days after casting, i.e. 90% in only 14 days. When, its strength have reached 99% in 28 days, still concrete continues to gain strength after that period, but that rate of gain in compressive strength is very less compared to that in 28 days.

The compressive strength test resuts for transparent concrete cubes is a bit higher than the normal cubes. The results obtained from both the cubes can be compared.

Comparision of strength results of normal cubes and transparent cubes:

The compressive strength results of normal cubes for 7,14,28 days curing are given table number 1

S No	Age of Curing (days)	Dimension of cube(mm x mm x mm)	Area of cube(mm^2)	Failure load(kN)	Compressive Strength (N/mm^2)
1.	7	150x150x150	22500	330	14.64
2.	14	150x150x150	22500	380	16.8
3.	28	150x150x150	22500	460	20.4

Table 2 compressive strength test results for normal cubes

The compressive strength test results of transparent concrete cubes for 7,14 and 28 days curing are given in table number 6.2

S No	Age of Curing (in days)	Dimension of cube(mm x mm x mm)	Area of cube (mm^2)	Failure Load (kN)	Compressive Strength (N/mm^2)
1.	7	150x150x150	22500	350	15.5
2.	14	150x150x150	22500	390	17.3
3.	28	150x150x150	22500	480	21.3

Table 3 compressive strength test results for transparent concrete cubes

Comparision of Compressive Strength of Normal cubes and Transparent concrete cubes:

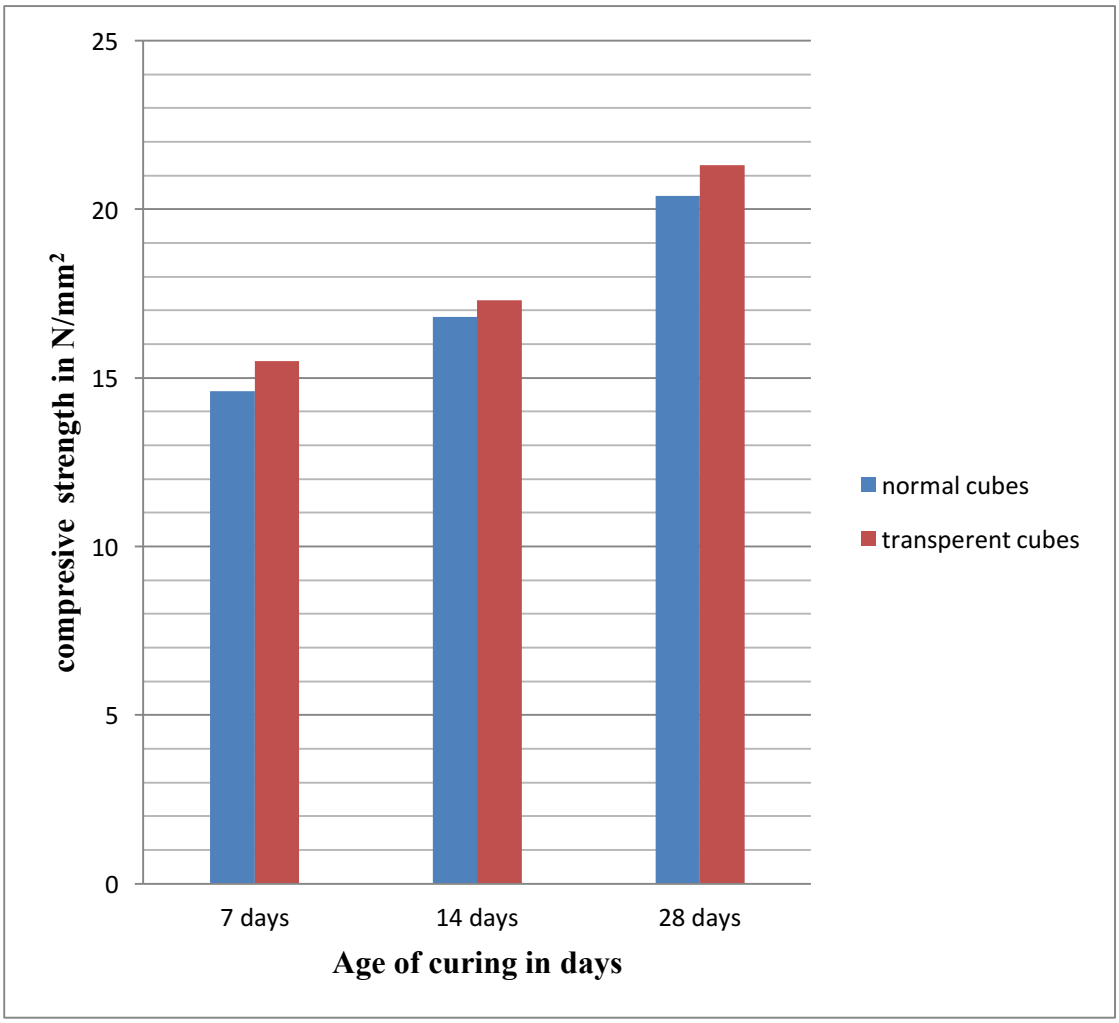

Figure 9. Compressive Strength Vs Age of curing

VI. CONCLUSION

After interpretation of results and discussions the following conclusions are arrived:

1. All the mix fresh properties values are within the range of IS specifications.
2. The compressive strength of transparent concrete is slightly higher than the normal cubes.
3. The efficiency of the application of optical fibre is studied by comparing with the normal M20 grade concrete and the test results proved that the efficiency is more in all aspects.
4. Due to small size of the fibers, they blend into concrete becoming a component of the material like small pieces of aggregate.
5. Translucent concrete combines with fluid potential of concrete with glass ability to admit light, and it also retains privacy and can be used as a structural support.
6. Translucent concrete blocks can be used in many ways and implemented into many forms and be highly advantageous. It is the smart way of optimising and utilising light, a smart way of living. The decorative concrete can be used in interior design of buildings as panels in slabs, walls etc.

7. The application of optical fibre will make the concrete decorative as well as can make the concrete structural efficient. The transparent concrete not looses the strength parameter when compared to regular concrete and also it has very vital property for the aesthetical point of view.
8. The possibilities of Translucent concrete is innumerable, the more it is used, the more new uses will be discovered. As with any new material, it is expensive and still some issues to be resolved.
9. The only drawback of transparent concrete is its high manufacturing cost. Even if the initial cost of transparent concrete is more than conventional concrete, but due to continuous increase in tarrif and pay back calculation,it is seen that this investment proves to be beneficial as payback period.
10. It will also reduce carbon emission which is dangerous for the environment. Hence this can be treated as one of the high performance concrete. The use of this high performance transparent concrete is beneficial for protecting mother earth.
11. This new kind building material can integrate the concept of green energy saving with using the self sensing properties of functional materials.

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