A

Seminar report

On

TRANSPARENT CONCRETE

Submitted in partial fulfillment of the requirement for the award of degree
of Bachelor of Technology in CIVIL

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Acknowledgement

I would like to thank respected Mr…….. and Mr. ……..for giving me such a wonderful opportunity to expand my knowledge for my own branch and giving me guidelines to present a seminar report. It helped me a lot to realize of what we study for.

Secondly, I would like to thank my parents who patiently helped me as i went through my work and helped to modify and eliminate some of the irrelevant or un-necessary stuffs.

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Next, I would thank Microsoft for developing such a wonderful tool like MS Word. It helped my work a lot to remain error-free.

Last but clearly not the least, I would thank The Almighty for giving me strength to complete my report on time.

Preface

I have made this report file on the topic **TRANSPARENT CONCRETE** ; I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to ……..who assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

1. 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 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. By 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 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 building, the space between buildings is reduced; this causes to increasing the use of non- renewable energy sources, so therefore there is a need of smart construction technique like green building and indoor thermal system.

Translucent concrete (Transparent concrete) is new technique different from normal concrete. Translucent concrete allow more light and less weight compared to normal concrete. The use of sunlight source of light instead of using electrical energy is main purpose of translucent concrete, so as to reduce the load on non- renewable sources and result it into the energy saving. Optical fibers is a sensing or transmission element, so decrease the use of artificial light, the normal concrete is replaced by translucent concrete, which has natural lighting and art design.

Table 1. Properties of Transparent Concrete Blocks By Litracon Company

Product	Litracon- Light Transmitting Concrete
Form	Prefabricated blocks
Ingredients	96% concrete, 4% optical fiber
Density	2100-2400 Kg/m2
Block size	600mm x 300mm
Thickness	25-500mm
Color	White, Grey or Black
Fiber distribution	Organic
Finished	Polished
Compressive strength	50 N/mm2
Bending Tensile strength	7 N/mm2

2. INGRIEDIENTS OF TRANSPARENT CONCRETE

· **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 nonspecialty 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 works 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%.

· **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 gravity 2.75 and fineness modulus of 2.80 were 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.

· **Coarse aggregate:**

Crush granite aggregate available from local sources has been used. The coarse aggregate with maximum size of 10mm having the specific gravity value of 2.6 and fineness modulus of 5.60 were used as a coarse aggregate. The loose and compacted bulk density values of coarse aggregate are 1437 and 1556 kg/m3 respectively, the water absorption of 0.4%.

· **Optical Fibers Elements:**

Core - The thin glass center of the fiber where the light travels is called core.

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.

Buffer Coating – This is the Plastic coating that protects the fiber from damage and moisture.

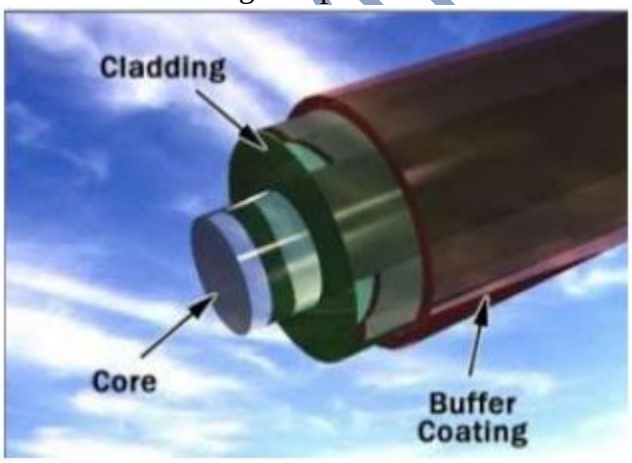


Fig 2.1 Elements of a optical fibre

· **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

3. OPTICAL FIBERS

Optical fiber is a wave guide, made of transparent dielectric (glass or plastics) in cylindrical form through which light is transmitted by total internal reflection. It guides light waves to travel over long distances without much loss of energy. Optical fiber consists of an

inner cylinder made of glass or plastic called core of very high refractive index. The core is surrounded by a cylindrical shell of glass or plastic of lower refractive index called cladding. The cladding is covered by a jacket which protects the fiber from moisture and abrasion.

3.1. Types of Optical Fibers

Based on the refractive index profile and the number of modes, optical fibers are divided into three types. They are:

Ø Step index single mode fiber
Ø Step index multimode fiber
Ø Graded index multimode fiber

A step index single mode fiber may have very small core diameter (i.e. 5- 10µm). Due to its small core diameter, only a single mode of light ray transmission is possible. About 80% of the fibers that are manufactured in the world today are of this type.

Fig 3.1 Step index single mode fiber

A step index multimode fiber has a core diameter of 50 to 200µm and an external diameter of cladding 125 to 300µm. Since the core material is of uniform refractive index and the cladding material of lesser refractive index than that of core, there is a sudden increase in the value of refractive index from cladding to core. Since the core has larger diameter, propagation of many modes within the fiber is allowed.

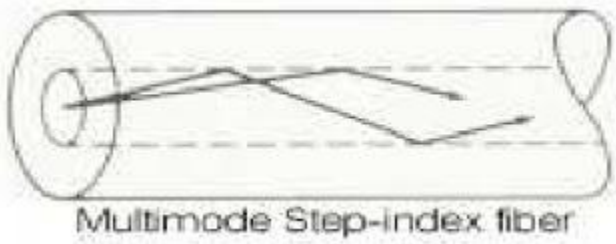


Fig 3.2 Step index multimode fiber

In a graded index multimode fiber, the refractive index of the core is maximum at the axis of the fiber and it gradually decreases towards the cladding. Since there is a gradual decrease in the refractive index of the core the modal dispersion can be minimized.

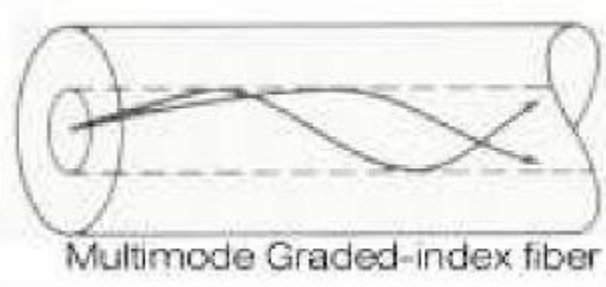


Fig 3.3 Graded index multimode fibre

3.2. Total Internal Reflection In A Fiber

The principle behind the transmission of light waves in an optical fiber is total internal reflection. The total internal reflection in the walls of the fiber can occur only by the following two conditions:

i. The glass around the centre of the fiber (core) should have higher refractive index (n1) than that of the material (cladding) surrounding the fiber (n2).

ii. The light should incident at an angle (between the path of the ray and normal to the fiber wall) greater than the critical angle, θ_c.

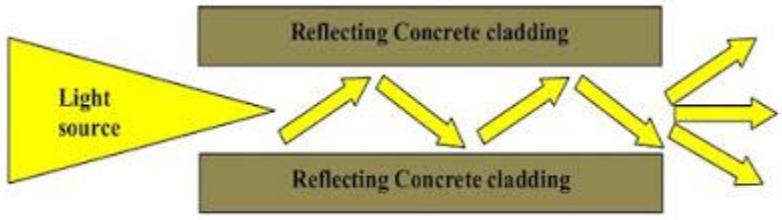


Fig 3.4 Total internal reflection

4. MANUFACTURING OF TRANSPARENT CONCRETE

Preparation of mould: In the process of making light transmitting concrete, the first step involved is preparation of mould. The mould required for the prototype can be made with 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 IS 456-2000 is 15cmx15cmx15cm for concrete. In the mould, markings are made exactly according 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 in to the plates as shown in Fig. 4.1 The diameter of the holes and number of holes mainly depends on percentage of fiber used.

Fig. 4.1 Preparation of mould

Procedure of making translucent panel:

Step 1-Preparation of the Mould:

A mould of rectangular cross section of size 150mm*150mm*150mm is made with wood or steel. Make the required size of rectangular mould from wood or tin. Place the clay or mud in the sides where the optical fibers are exposed to the mould for the easy demoulding after the concreting.

Fig. 4.2 Preparation of panel.

Step 2- Optical Fiber:

The optical fibers are cut carefully to the required size of mould. The commonly available diameters of optical fibers are .25 mm, .5 mm, .75 mm, 1 mm, and 2 mm.

Fig.4.3 Optical Fibers

Step 3- Fixing the Fibers:

Fibers are placed either in organic distribution or in layered distribution. Holes are driven on the wooden or steel plates through which optical fibers are allowed to pass through.

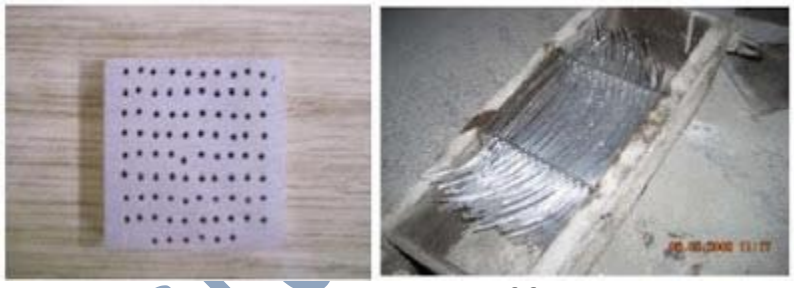


Fig. 4.4 Fixing of fibers.

Step 4- Concreting:

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

Mix proportion:

In present work Indian standard method (IS 10262-2009) is used for mix design, mix proportion are as table 4.1.

Table 4.1 Mix proportion used for testing

Cement	Sand	Coarse aggregate	Water
1	1.25	2.9	0.4

Step 5- Removing the Mould:

After 24 hrs, remove the mould and pull off the mud. The casted mould was kept undisturbed on the leveled platform. Then it was de-moulded carefully after 24 hours from

casting. Immediately after de-moulding, the cube specimens were marked by their respective identification mark/numbers (ID).

Step 6- Cutting and polishing:

Cut the extra-long fibers same as thickness of panel. Polish the panel surface by using polishing paper or using sand paper as shown in figure 4.5

Fig 4.5 Trimming and polishing of the surface

5. TESTS CONDUCTED ON TRANSPARENT CONCRETE

Several experiments were conducted on transparent concrete tostudy about its various properties. They are as follows:

5.1. EVALUATION METHOD OF LIGHT GUIDING OF SMART TRANSPARENT CONCRETE

The following are the factors to be considered for the performance of the transparency of the concrete:

(A)Transmittance (B)Haze (C)Bi-fringence (D)Refractive index. (E)Dispersion

The transmittance can be directly calculated by the ratio of the incident energy and transmission energy of light expressed as following equation:

$$\rho=\xi\times\frac{J1}{J0}\times 100\% \quad .....(1)$$

where ρ, ξ, J1 and J2 are transmittance, correction coefficient of measurement equipment, transmission energy and incident energy, respectively. While the translucent concrete studied by us is heterogeneous, its transmittance cannot be obtained by equation (1), because the number of POFs in unit area is different at different area, that is, the transmittance in unit is related to the arrangement of POF in translucent concrete. The POFs can be arranged either in organic distribution or in layered distribution.

Improvement in the calculation method for transmittance is as follows.

a) Incident light energy per unit area (ρ0):

$$\rho^0 = \frac{W_0}{A_0}$$ .....(2)

where *W*0 and *A*0 are light energy of incident probe and area of incident probe

b) Incident total energy of concrete section at the side of light (J_S^O):

$$J_0^S = \rho^0 \text{ x } A_1$$

$$= \frac{W_0}{A_0} \text{ x } A_1$$

.....(3)

where A1 is the cross-section area of translucent concrete.

c) Transmitted light energy of single POF (ρ1):

$$\rho^1 = \frac{W_1}{n_1}$$

.....(4)

where W1 and n1 are light energy of transmission probe and the number of POFs covered by transmission probe.

d) Transmitted light energy of translucent concrete (J_S^1):

$$J_1^S = \rho^1 \text{ x N}$$

$$= \frac{W_1}{n_1} \text{ x N}$$ .....(5)

where N is the total number of POFs in the translucent concrete.

Then based on equation (3) and (5), we can obtain the transmittance (ρ^s) of the translucent concrete.

$$\rho^S = \xi \times \frac{J1}{J0} \times 100\%$$

$$= \left(\frac{\xi \text{ x } N \text{ x } W_1 \text{ x } A_0}{W_0 \text{ x } A_1 \text{ x } n_1}\right) \times 100\ \%$$

5.2. LIGHT GUIDING EXPERIMENT OF TRASPARENT CONCRETE

In order to study the light guiding property of translucent concrete, six units of translucent concrete is fabricated with different POF volume ratios of 1%, 2%, 3%, 4%, 5% and 6%, and the diameters of POF is 1mm. The transmittance is measured by the Optical Power Meter and its wavelength range is 400-1100nm. The incandescent lamp with 200W and halogen lamp with 500W are chosen to provide light. To eliminate the measuring dispersion of transmittance caused by the discrepancy of POFs' position and the material, three areas (denoted as 1, 2 and 3) in the middle part of translucent concrete are chosen to test shown as figure below, and the number of POFs in each chosen area shall be equal. The number of the POFs is covered by transmission probe or integral sphere are 2 for 1% POF volume ratio, 4 for 2% POF volume ratio, 5 for 3% POF volume ratio, 7 for 4% POF volume ratio, 3 for 5% POF volume ratio and 9 for 6% POF volume ratio respectively. The incident light energy and transmission light energy are read simultaneously at each step.

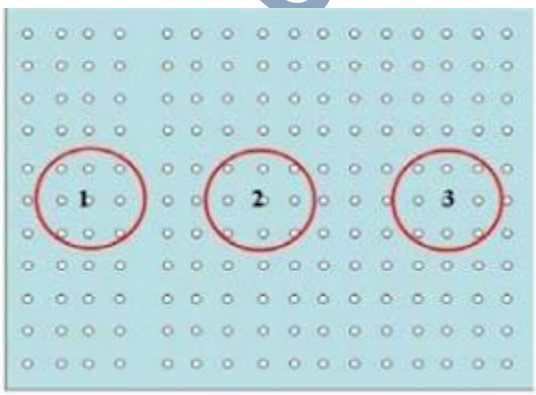


Fig: 5.1 Optical Power Meter **Fig:5.2 Measuring area of the optical fibers**

5.3. COMPRESSIVE STRENGTH

By definition, the compressive strength of a material is that value of uniaxial compressive stress reached when the material fails completely. The compressive strength is usually obtained experimentally by means of a compressive test. The compressive strength of the concrete is determined by cast the cubes of size 150mm x150mm x 150mm.

Compressive strength = load / area (6)

5.4. FLEXURAL STRENGTH

The flexural strength of the concrete is determined by conducting the test on prism by two point loading.

Flexural strength = PL/bd2 (7)

where, P – Load, L – Length of the specimen, b - width of the prism, d – depth of the prism

5.5. TEST OF MECHANICAL PROPERTY OF TRANSLUCENT CONCRETE BY FREEZING TEST

In this test, the POF volume ratios of translucent concretes chosen for test are 0% (or plain concrete), 1%, 2%, 3%, 4%, 5% and 6%. After 25 freeze-thaw cycle test, the mechanical properties of translucent concrete are evaluated by the compressive strength loss rate (Pf), expressed as follows.

$$\rho_f = [\frac{(f_{c0} - f_{cn})}{f_{c0}}] \times 100 \quad .....(8)$$

where f_{c0} and f_{cn} are compressive strength before and after freeze-thawing test.

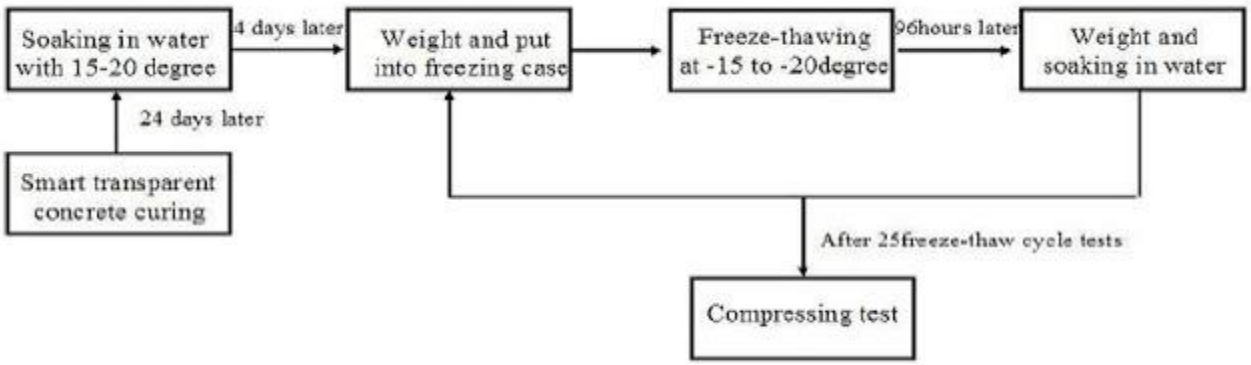


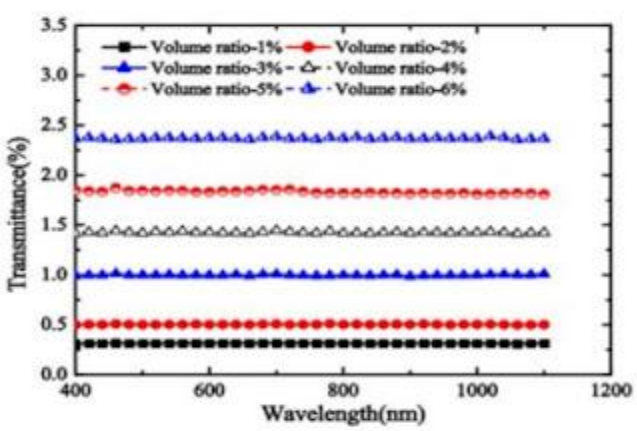
Fig 5.1 Methodology of freezing- thaw test

6. RESULTS AND DISCUSSIONS

6.1. LIGHT GUIDING PROPERTY:

(Source: SOUMYAJIT PAUL, AVIK DUTTA Transparent Concrete International Journal of Scientific and Research Publications, Volume 3, Issue 10, October 2013 1 ISSN 2250-3153)

Figure 6.1.1(a) and figure 6.1.1(b) show the light guiding property of translucent concrete with the POF volume ratio of 1%, 2%, 3%, 4%, 5% and 6% by using the halogen lamp and incandescent lamp, respectively. It can be seen that the transmittance of each type of translucent concrete almost keeps stable at whole wavelength, and the linear relationship between the POF volume ratio and its transmittance is good.



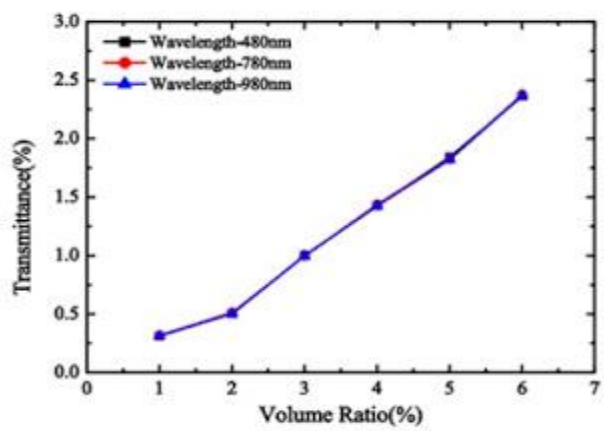
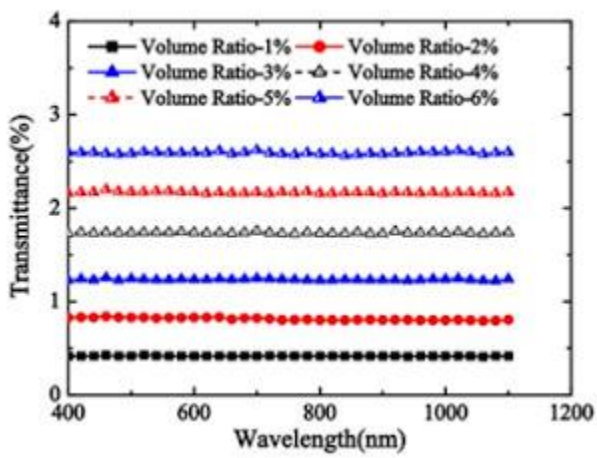


Fig 6.1.1 (a): Transmittance Fig 6.1.1(b): Relationship b/w POF volume and Transmittance

For the halogen lamp, the transmittances of the six ratio translucent concrete are 0.29%、0.59%、 0.98%、 1.41%、 1.83% and 2.36%; for the incandescent lamp, the corresponding transmittances are 0.41%、 0.82%、 1.22%、 1.72%、 2.15% and 2.59%, respectively. The discrepancy of transmittance induced by different lamp is that the light scattering's angle of the chosen lamp is different, and the POFs absorb much light scattered by incandescent lamp than that by halogen lamp.



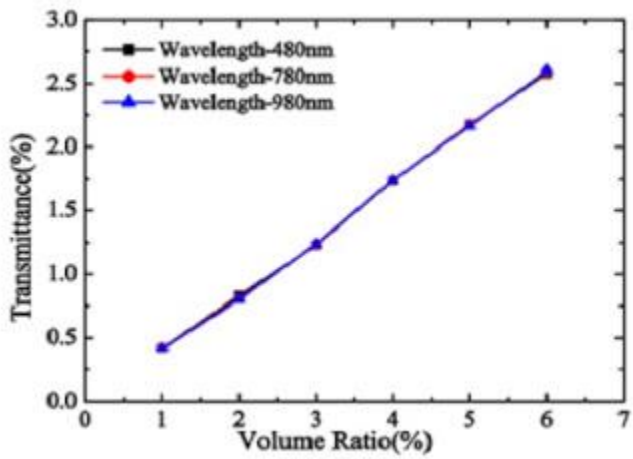


Fig 6.1.2 (a): Transmittance Fig 6.1.2(b): Relationship b/w POF volume and Transmittance

Furthermore, it is worthily of note that the large the POF volume ratio is, the large the transmittance is. In fact, the POF volume ratio and the corresponding transmittance are just like a sword with both edges. We cannot only pay attention to the high transmittance, for the POF inevitable affects the concrete strength. In the following experimental results, it can be seen that POF will reduce the concrete strength.

6.2. MECHANICAL PROPERTY OF TRANSLUCENT CONCRETE AT FREEZE-THAW

From figure 6.2.1, it can be seen that the mass of translucent concretes almost are unchanged in 25times freezing and thawing cycle and the maximum loss rate of mass is about 0.4%. Figure 6.2.2 shows the compressive strengthen of translucent concretes with freeze-thaw or not. It can be seen that the compressive strength of each type of translucent concrete have greatly decreased after 25times freeze-thaw cycle, and the maximum loss rate of compressive strength is about 42% comparison with that without bearing the function of freeze-thaw for the same type of concrete. It can be seen that the larger the POF volume ratio is, the smaller the compressive strengthen of the translucent concrete is. So we cannot endless increase the transmittance by way of increasing the POF volume ratio. One point to be mention, the compressive strengthen of the plain concrete (or the translucent concrete with 0% POF volume ratio) is smaller than that of the accustomed plain concrete. The reason is that we consider the fabrication method of the translucent concrete and ignore the normal mix proportion of cement mortar at pre-test. To improve the compressive strength of the translucent concrete, one solution is that the translucent concrete can be produced by some special high strength concrete, which can reduce the impact of the POF to the concrete's compressive strength.

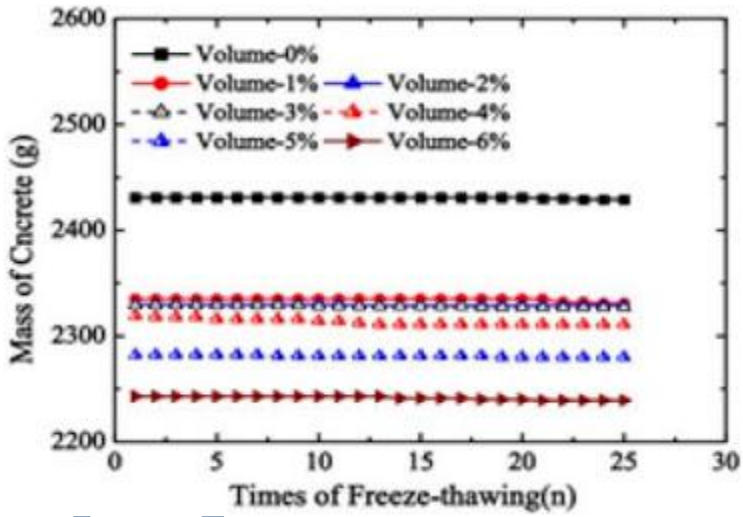


Fig 6.2.1: Loss rate of concrete mass at each freeze thawing

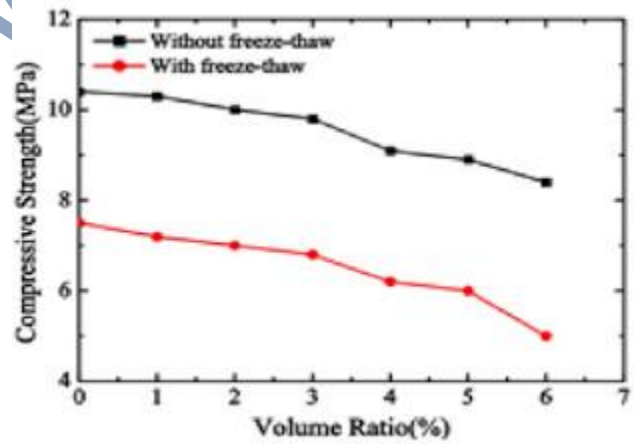
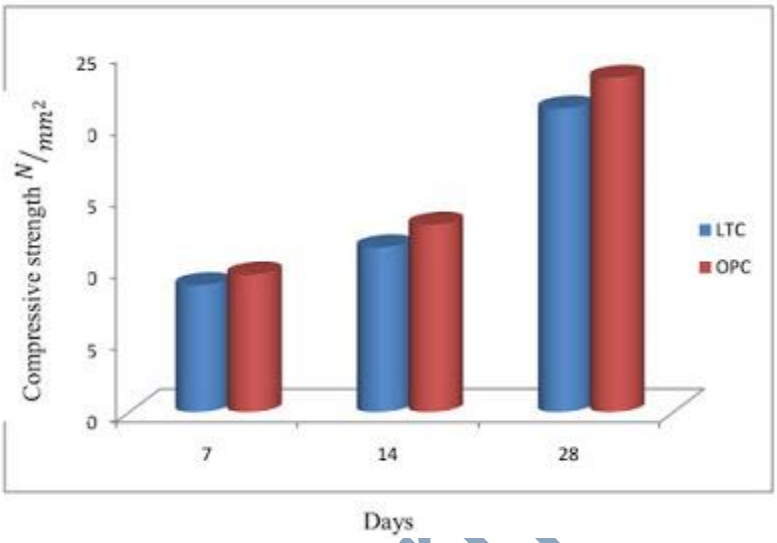


Fig 6.2.2: Compressive strength of concrete block with freeze-thaw

6.3. COMPRESIVE STRENGTH

The compressive strength for concrete cubes with and without Optical fibers has been calculated for3, 7and 28 days. From the test results, it is observed that compressive strength for 3, 7 and 28 day with Optical fibers is 8.82 N/mm2,11.45 N/mm2 and 21.10N/mm2 respectively. That for Conventional concrete is 9.56 N/2, 13.02 N/mm2 and 23.24 N/mm2 respectively.



6.4. FLEXURE STRENGTH

The flexural strength of the conventional concrete and light transmitting concrete in 7, 14 and 28 days is shown in Fig 6.4.1

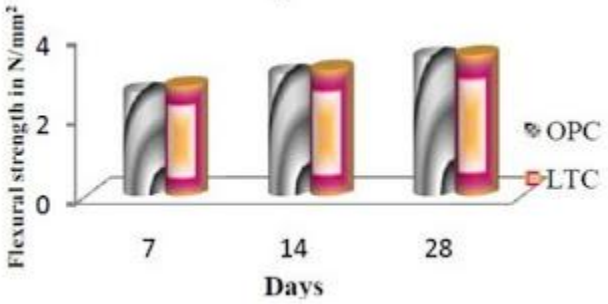


Fig 6.4.1 Flexural strength of concrete

7. APPLICATIONS

A. Illuminate Your Walls

Transparent Concrete can be used as building material for interior and exterior walls. If sunshine illuminates the wall structure, then eastern or western placement is recommended; the rays of the rising or setting sun will hit the optical glass fibers in a lower angle and the intensity of the light will be bigger. Besides the traditional applications of a wall, the light transmitting concrete can also be used as wall covering illuminated from the back.

Fig 7.1 Translucent Wall for Architectural View

B. Pavement Shine at Sunset

This concrete can be used as flooring a passable surface illuminated from below. During the day it looks like typical concrete pavement but at sunset the paving blocks begin to shine and in different colors.

C. Creative Design

The building units are versatile and can be used in many areas of design. Two successful designs using the light transmitting concrete were a jewel and a concrete bench. You can also create a logo with colorful figures, inscriptions, and pictures and can used for beautification purpose.

D. Artsy Reception Desk

If you really want to create a look that stands out, you should opt for this artsy and vogue reception desk where light up in the front and the sides.

E. A Lighting fixture and Conversational Piece

The transparent concrete cube is, without a doubt, a great conversation piece. The new cube line consists of four identical pieces of concrete and, due to its special geometry; the pieces form a stable structure without fixing them together.

It can be also applicable at:

- Transparent concrete blocks suitable for floors, pavements and load-bearing walls.
- Facades, interior wall cladding and dividing walls based on thin panels.
- Partitions wall and it can be used where the sunlight does not reach properly.
- In furniture for the decorative and aesthetic purpose.
- Light fixtures.
- Light sidewalks at night.
- Increasing visibility in dark subway stations
- Lighting indoor fire escapes in the event of a power failure.
- Illuminating speed bumps on roadways at night.

8. A CASE STUDY ON TRANSPARENT CONCRETE

Transparent concrete is a pretty rare sight. Not many people have a particular idea about this nor its applications and advantages. The largest project exhibiting this technology is an

artistic installation, called the "European Gate"(2004) which was designed to mark the celebration of Hungary joining the European Union (EU). Located at the public entrance of Fortress Monostor in the Hungarian town of Komarom, this is one of the most impressive pieces of art conjugating visual lighting display as well as artistic using translucent concrete. The sun illuminates the 37.6 ft^2 large Litracon piece of the statue in the mornings and late afternoons, and by night an even more impressive view can be seen because of the embedded light sources. One of the first projects to be ever made in a major way is this road during the day the blocks appear as concrete pavement, but at sunset they start to shine thanks to the light sources placed under then. A ringed light pattern took shape around the main square as dark came. More of the uses or applications include partitions or partition walls in office cabins or in houses, and attractive furniture, and intelligent light fixtures, lighting in dark subway stations.

The Italian pavilion at the Shanghai World Expo 2010 also uses the light transmitting concrete in the building. The transparent blocks of concrete were interspersed with opaque blocks to create a seamless façade that allows diffused light in at certain areas and emanates a glow at night.

There aren't many manufacturers of translucent concrete. There are very few of them, namely LitraCon, Lucon and Lucem Lichbeton. By using fibers of different diameters, Litracon™ designers can achieve different illumination effects. An article in the New York Times suggested that the concrete would be very expensive because of its optic fiber content, so the uses were very small in size but quite amazing to the eye. Some examples of the product are the following: On the performance side, it's simply a concrete embedded with optical fibers running in a matrix while still retaining the strength of concrete. Therefore it still retains the high density top layer. It is also frost and de-icing salt resistant, making it highly recommendable in cold countries. Similarly, it is under fire protection classification A2 and provides very high UV resistance.

Fig 8.1 Transparent concrete on Italian Pavilion

9. ADVANTAGES

- The main advantage of these products is that on large scale objects the texture is still visible - while the texture of finer translucent concrete becomes indistinct at distance.
- When a solid wall is imbued with the ability to transmit light, it means that a home can use fewer lights in their house during daylight hours.
- It has very good architectural properties for giving good aesthetical view to the building.
- Where light is not able to come properly at that place transparent concrete can be used.
- Energy saving can be done by utilization of transparent concrete in building.
- Totally environment friendly because of its light transmitting characteristics, so energy consumption can be reduced.

10. DISADVANTAGES

- The main disadvantage is these concrete is very costly because of the optical fibers.
- Casting of transparent concrete block is difficult for the labour so special skilled person is required.

11. 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 property 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 property 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 selfsensing properties of functional materials.

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