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Translucent Concrete-A Green Building Approach

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Concrete is considered as the solid, heavy , substantial building material. The present construction of the buildings in the universe limits the inflow of the natural light into the building. This forces to go behind the artificial illumination techniques inside the buildings. What if we can introduce light in concrete? If we can have a concrete which can allow light to pass through it, it will be a revolution and this light transmitting concrete can be advantageous as it solves the problem of power consumption, eco-friendly construction, green building concepts. Translucent concrete is achieved by replacing aggregates with transparent alternate materials. Clear resins, optical fibre and fine concrete are also used to make the concrete transparent. This paper is all about the properties of translucent materials and its green building potential.

KEYWORD

Translucent, Optical fibre, Aggregates, etc.

INTRODUCTION

The concrete today is the most versatile material for all types of construction works and has been used for innumerable construction works, either as plain concrete or as reinforced cement concrete or as precast concrete or prestressed concrete or in many other forms. In building industry ,the concrete is mainly used for structural components with foundations, coloumns, beams, slabs, staircases, lintels, doors, etc.

Translucent concrete is a concrete which has light transmissive property. The light transmissive property is mainly due to uniform distribution of high numerical distribution of aperture plastics optical fibres throughout its body. The translucent concrete concept was first introduced in 2001 by Hungarian architect Aron Losonczi and the first transparent concrete block was successfully produced by mixing a large amount of glass fiber into concrete in 2003, named as Litracon. Joel S. and Sergio O.G. developed a transparent concrete material, which can allow 80% light through and only 30% of weight of common concrete (Raviram *et al.,* 2015). Translucent concrete or transparent concrete or light transmiting concrete is achieved by replacing aggregrates with transparent alternate material. Transparent concrete is produced by mixing 4% to 5% (by volume) optical fibres in the concrete. This concrete has less weight compared to original concrete.

Translucent concrete is based on the principle of 'nano–optics'. These fibres passes as much of light when tiny slits placed directly on top of each other. Hence the optical fibres have ease to carry the light across throughout the concrete. A wall made of 'Litracon' has the strength of traditional concrete and an embedded array of glass fibres that can display a view of the outside world, such as the silhouette of a tree, for example. Thousands of optical glass fibres form a matrix and run parallel to each other between the 2 main surfaces of every block. Shadows on the lighter side will appear with sharp outlines on the darker one (Shanmugavadivu *et al.,* 2014).

Translucent concrete is enriched with variety and wide range of applications, like on floors, load bearing walls, pavements, façade walls, interior/partition walls, cladding, further if sunlight is not reached it can be used in for the dividing walls also (http://www. power

Figure 1. *Transparent concrete wall (http:// theconstructor.org/concrete)*

show. com/view/1002 aO–YZAYO/Translucent_Concrete_powerpoint_ppt_presentations (Figure 1).

HISTORY OF TRANSLUCENT CONCRETE

Translucent concrete has been first mentioned in a 1935 Canadian patent (Long, 1935). But since the development of optical glass fibers and polymer based optical fibers the rate of inventions and developments in this field has drastically increased. There have also been inventions that apply this concept to more technical applications, like fissure detection. In the early 1990s forms, like translucent concrete products popular today with fine and layered patterns were developed. History says that trasparent concrete as such in today's form was first attempted back in 2001 which Losonczi was a student of architecture, Light Transmitting Concrete (Litracon) aesthetically transforms the composition of concrete into a visually appealing, translucent material. This is accomplished by mixing thousands of strands of optical glass fibers, which bond in a parallel pattern and direct light between the two faces of the concrete block, creating both a brighter and darker side (http://inventorspot com/articles/translucent_concrete). Number of experiements were carried out using different transparent / illuminating materials in early 2000 and late 1900 and was found to be futile and the research got momentum by the introduction of optical fibres.

Litracon (light transmitting concrete) is a translucent concrete building material. Made of fine concrete embedded with 4% by weight of optical glass fibers, it was developed in 2001 by Hungarian architect Áron Losonczi working with scientists at the Technical University of Budapest.

Light transmitting concrete is manufactured by the inventor's company, Litracon Bt, which was founded in spring 2004. The head office and workshop is located 160 km from the Hungarian capital city of Budapest near the town of Csongrád. As of 2006, all light transmitting concrete products have been produced by Litracon Bt. The concrete comes in precast blocks of different sizes.

The most notable installation of it to date is Europe Gate a 4 m high sculpture made of light transmitting concrete blocks, erected in 2004 in observance of the entry of Hungary into the European Union. It may be used for the interior walls in the new Hungarian embassy in Washington, DC by Hungarian architects Antal and Veronika Lazar and Zoltan Sukosd. At present light transmitting concrete costs £830-£1,050 per square meter (http:// www.sefindia. org/forum/viewtopic.php?p = 26237.

MATERIAL FOR TRANSPARENT CONCRETE

The normal way of manufacture transparent concrete is using combination of fibre optics and fine concrete. These optic fibres blend into the concrete, like any other aggregates. These optical fibres are capable enough to transmit light from natural and artificial sources. The main reason for using optical fiber is that it can transmit light even an incident angle greater than 60^0 (http:// theconstructor.org/concrete/transparent-concrete-light-transmi). The optical fiber consists of three layers called as core, cladding and jacket and the light is mainly transmitted through the core of the optical fibre. The general cross section of the optical fiber is shown in figure 2.

Normally the transparent concrete is

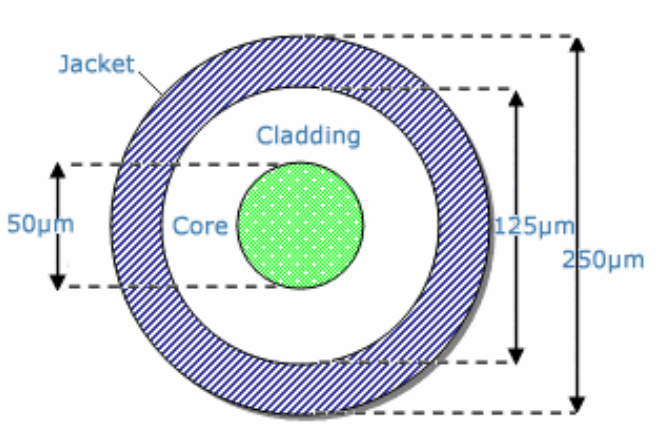

Figure 2. *Cross section of optical fibre* (http://theconstructor.org/concrete)

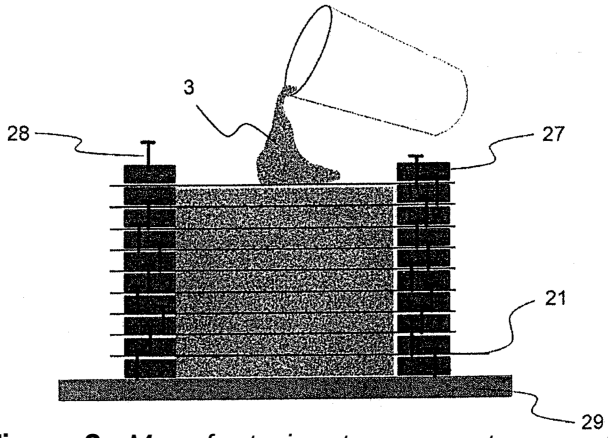

Figure 3. *Manufacturing transparent concrete* (http://theconstructor.org/concrete)

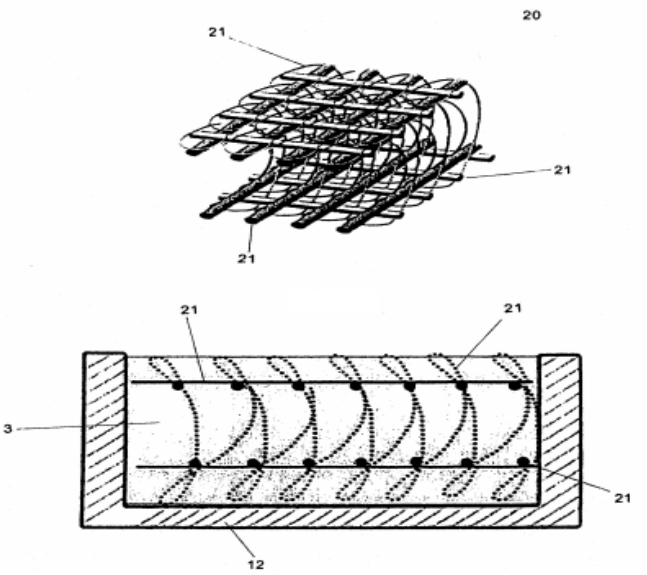

Figure 4. *Manufacturing transparent concrete* (http://theconstructor.org/concrete)

manufactured using fine materials only and coarse aggregates are not used here. Surprisingly this concrete can have compressive strength as high as 70 MPa. As explained earlier since fibre is the one mainly responsible for the transmission of light , there are no criteria on cement used, cement can be of any type, normally ordinary portland cement of 53 grade is used. In addition to cement fine sand which pass through 1.18 mm sieve is used. Sand should be free from all impurities, water used for the manufacture of transparent concrete should be of potable type. Optical fibers used generally in the range of 4 % to 5 % volume thickness of the optical fiber is varied between 2 mm and 2 mm, it depends upon the amount of light transmission expected.

METHODOLOGY

There are three basic types of optical fibers: (1) Multimode graded index fiber, (2) multimode step index fiber and (3) single-mode step index fibers. A multimode fiber can propagate hundreds of light modes at one time while single-mode fibers only propagate one mode. Where the single-mode fibers propagate light in one clearly defined path, , multimode fibers have large intermodal dispersion effects due to the many light modes of propagations it handles at one time (Raviram *et al.,* 2015).

The manufacturing process of light transmitting concrete is pretty much similar to the manufacturing of normal concrete. Layers of concrete are poured into mould and thus fibres is infused. Fibres and concrete are inverted in such a way into moulds at an interval of approximately to 2 mm to 5 mm (Figures 3 and 4).

4 % to 5% of optical fibres is added by volume to the translucent concrete as the concrete mixture is made of fine aggregrate it doesn't contain any coarse aggregrate in it.

In order to transmit light through the concrete, thousands of optical fibres are casted into concrete.

After following all the procedures of concrete,

Figure 5. *Casting of concrete blocks*

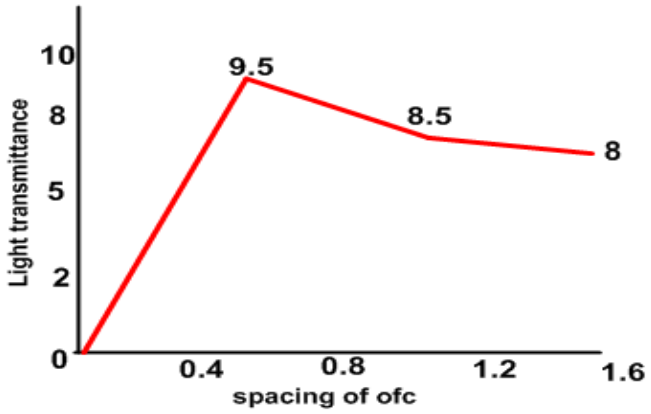

Figure 6. *Graph showing light remittance and spacing of OFC*

Figure 7. *The illuminated road incorporated with translucent concrete*

the casted material is cut into panels, blocks with the specified thickness and then the surface is typically polished, resulting in finishes ranging from semi gloss to high gloss.

The light transmitting concrete can also be understand by experimental setup, we design our sample with the mold with plastic tray and we spread optical fibre, due to small thickness of fibre we use fine concrete making a ratio of 1:2 and also clay is used to withstand optical cables. We choose the desired mold attaching clay on the bottom of the mold which includes optical fibre cables at desired shape. After induced pour fine concrete at its approximate ratio, it is allowed to set concrete. A typical concrete block is shown in figure 5. We get our translucent concrete, with a light transmitting property. Figure 6 shows the graph of light remittance vs the spacing of OFC, as spacing increases light remittance reduces (Pathade *et al.,* 2016).

HISTORY

The working environment conrtibutes considerbly to the zeal of the workers. Less ventilated concrete jungles will definitely affect the real working spirits of the workers. Traditional dim building blocks always provide an environment gloomy and dull and require makeover finally to let some light shine in. The light transmitting materials have the history from 2004 when Mr. Aron Losconzi, a Hungarian Architect who started developing prefabricated translucent concrete blocks with thousands of optical fibres molded in it. History noted that the first translucent construction happened in a public square in Stockholm, Sweden. Then after in eastern Europe, the newly renovated Bank of Georgia headquarters building features almost 300 m^2 of translucent concrete blocks (Figure 7).

PROPERTIES AND APPLICATION

As the name refers translucent concrete it transmits the light. The light carried maintains original colour. There is no much difference of conventional weight between the transparent and normal concrete. The concrete can be manufactured according to the request of the buyer. Thus it's a eco-friendly as well as user-friendly. As mentioned earlier compressive strength as high as 70 MPa can be achieved and research is being done to increase the strength. Researches show that

Table 1. *Result on compressive strength*

Weight of concrete, g	Load, KN	Compressive strength, MPa	Remark
760	190	38.77	Control concrete
780	200	40.23	Control concrete
750	180	36.7	Translucent concrete

the strength characteristics of translucent are not bad and is on par with conventional controlled concrete. Table 1 shows the result of compressive strength tests on 7 cm x 7 cm x 7 cm cubes (2 cubes of controlled concrete and one cube of concrete with plastic optical fibers) (Luhar and Kanchadvel, 2015. Table 1 shows the results of compressive strength on controlled concrete and translucent concrete.

As translucent concrete have light transmitting property, we can use in sidewalks at night. We can increase the visibility in dark subway stations lightning indoor fire escapes, in the event of power failure. Illuminating the speed bumps on railway line will be efficient application of translucent concrete. As it works on the natural energy, it reduces more consumption of power and hence gives the best output. With the lower index of refraction, the optical fibers typically include transparent core by transparent cladding material. The transparent concrete walls can also be used as partition walls, bifurcating wall, etc. Few important applications are summarized below :

1. This can be used for interior and exterior walls.

2. For columns in underground parking lots.

3. Facades, interior wall claddings, traffic dividers, thin panels, etc.

4. In subway stations where visibility is very less.

5. For aesthetic purpose in furniture.

6. Sidewalks at night.

7. Lighting fixtures and transmitting concrete walls in restaurants,clubs, party halls, etc.

ADVANTAGE

The main advantage of translucent concrete is that it can transmit light and thus uses both natural and artificial light. Thus it reduces the demand of lightening problem and saves a huge energy cost. This makes it best usage for green building concepts. The optical fibers are also working as heat insulators so it would advisable in case of cold climate countries. Now the question arises is it structurally sound, the answer will be yes hence it is classic concrete. Yes presently it is expensive because the manufacturing process is tedious and lengthy. But if we have a clear idea about it, in future it will be convenient to all. Further to all translucent concrete gives much mores security of supervision in case of schools, museums, prisons, etc., (Padma Bhusahan *et al.,* 2013). The translucent concrete can be used almost anywhere, like glass or traditional concrete is used. Translucent concrete combines the property of traditional concrete and the light transmitting ability of fibers and retains the privacy and can be used ad structural support.

1. It reduces the lighting problems as natural light is emitted from the blocks.

2. It is an add on to the green building concept where natural ventilation and lighting is enhanced.

3. Energy efficient and can be saved by using transparent concrete blocks.

4. Totally environmental friendly.

5. Provides good aesthetical view to the building.

6. Saves around 30% electrical energy during time (Rao, 2010).

7. Reduction in plastering charges.

8. Improving inmates security.

Following are the disadvantages of translucent concrete :

1. Skilled labour is required as the casting of the block involves dexterity.

2. The optical fibre is generally costlier so cost escalation is to be looked in.

FUTURE SCOPE OF THE STUDY

The above mentioned facts about translucent concrete underline the fact that translucent concrete is an effective building material which adds on to the green building concepts. Though the concept of translucent concrete is hardly a decade old extensive research is to be carried out to increase its strength characteristics and also to cost acceptable ratio. It was noticed that the translucent concrete is highly expensive but considering the aesthetical property of that, the cost is not a matter for high-class ornamental buildings. Still research is to be extended to oversee this cost issue. Further, the research also to be extended to increase the light remittance corresponding to large spacing of OFC.

CONCLUSION

The only advantages of the translucent concrete are its high cost of construction else translucent concrete blocks can be used in many ways and implemented in many forms and be highly advantageous. As it has got high security in supervision this can be used in prisons, schools, etc., protecting their privacy too. When a wall can emit light during day times then only fewer light is sufficient and it can save electricity. Translucent concrete is in part with conventional concrete in strength parameters and also superior in an aesthetical side. It can be use as architectural purpose also. The new kind of building material can integrate the concept of green energy saving with the usage self-sensing properties of functional materials.

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