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An intensive Review on using translucent concrete as energy efficient source on green buildings.
Una revisión intensiva sobre el uso de translúcido. hormigón como fuente de energía eficiente en edificios verdes.

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ABSTRACT

Green buildings are constructed mainly using sustainable materials which create healthy environment inside the building by reduced product emissions. The introduction of the translucent concrete into green buildings created a new innovation in sustainable construction. The ability to introduce refined natural lighting whereas maintaining privacy provides large environmental benefits additionally to its aesthetic ones, as well as reducing the cost of heating and lighting. The aim of the paper is a detailed study on the current status and past studies in the area of translucent concrete. Anyway, this new building material is in its developing stage and it has a wide scope in the future.

Keywords: Energy savings, Green buildings, Light transmitting characteristics, Optical fibers, Sustainable construction, Translucent concrete.

RESUMEN

Los edificios ecológicos se construyen principalmente con materiales sostenibles que crean un entorno saludable dentro del edificio al reducir las emisiones de productos. La introducción del hormigón translúcido en edificios ecológicos creó una nueva innovación en la construcción sostenible. La capacidad de introducir una iluminación natural refinada mientras se mantiene la privacidad proporciona grandes beneficios ambientales además de los estéticos, además de reducir el costo de la calefacción y la iluminación. El objetivo del artículo es un estudio detallado sobre el estado actual y los estudios pasados en el área del hormigón translúcido. De todos modos, este nuevo material de construcción se encuentra en su etapa de desarrollo y tiene un amplio alcance en el futuro.

Palabras clave: Ahorro energético, Edificación ecológica, Características de transmisión de luz, Fibras ópticas, Construcción sostenible, Hormigón translúcido.

INTRODUCTION

The structures that are resource efficient and environmental friendly throughout its life span are called as Green Building Technology. The design of the green buildings are aimed to reduce the impact that may affect on the natural environmental conditions such as waste reduction, pollution control, degradation of environment, using energy, water and resources efficiently. Green building materials are mainly two types such as those which can be replaced by nature or recycle called renewable material sand then those material other than traditional materials there are some other green building material that may perform more efficiently by using fewer resources. And also those materials that can break down the total consumption of energy is also considered as green materials.

In the past years, some incipient building parts are developed and utilized in buildings, including self-diagnosis concrete, self-compacting concrete, consolidating concrete, soundproof concrete, thermal padding concrete, and so on. All these important materials only fix the necessary features, and cannot retain energy preserving. The translucent concrete is also called as LiTraCon, light-transmitting concrete, light-emitting concrete, transparent concrete. It is a disparate functional material which preserves energy and reduces cost other than providing basic functional features to the concrete.

The translucent concrete is the fusion of both optical fibers and the normal fine concrete. Nowadays the green technology focuses mainly on the energy savings within the indoor thermal system.

In such case the innovation of an advanced functional material is required to satisfy both safety and energy savings and cost reduction of structure.

According to the EIA (Environmental Impact Assessment) report, the building sector energy demand accounts approximately 34% of the world's energy demand (T. B. Johansson et al. 2012) and about 19% of the total delivered electricity is consumed by artificial lighting in worldwide (Phillips et al. 2015). So the total CO2 emission related to lighting was approximately 7% of the total global CO 2 emission in 2005.

Therefore, the main purpose of translucent concrete is to reduce the carbon footprint by reducing the use of electrical energy source by the efficient use of sunlight which may result in the energy and cost savings.

ORIGIN OF TRANSLUCENT CONCRETE

In 2001, Hungarian architect Aron Lasonczi introduced the concept of translucent concrete for the first time. He was a pioneer and an author of the translucent concrete (Bureau M. B et al. 2015). He tried to create an advanced concrete block by replacing

coarse aggregate with optical fibers in a normal concrete. The aim was juxtaposition of the two opposing concrete features such as huge mass and transparency what creates the concrete transmit the light. In 2003, the large amount of glass fiber was mixed into the concrete to create the first ever translucent concrete. The new material was called LiTraCon from the English words Light Transmitting Concrete (Bhavin K et al. 2013).
After that not only in Hungary, but also in many European countries like Germany, Italy and outside Europe like in China and India the idea of translucent concrete was known (Bhavin K et al. 2013).

The translucent concrete that developed by Joel. S and Sergio. O. G is with the ability to allow about 80% light passes through it and has only about 30% of weight of normal concrete (Bajpai R et al. 2013).

In 2010, the Italian Pavilion in Shanghai Expo 2010 showed a translucent concrete developed by mixing glass into concrete. The main objective of translucent concrete is its ability of transparency, green technology application and aesthetical view.
Numerous experimentations were launched in aim of how the new material works. Some modification attempts were made by maintaining the transparency feature.

MATERIALS USED FOR TRANSLUCENT CONCRETE

Materials which used for the making of translucent concrete are:

Cement:

Normally Ordinary Portland Cement-Grade 53 is used for the manufacture of translucent concrete as per IS: 12269 – 1987. As in the normal concrete the cement act as a binding material in the translucent concrete also. It binds the fine aggregates and the optical fiber together to give the translucent concrete the same structural properties as that of the normal concrete (Neha R.Nagdive et al. 2013).

Fine Aggregates:

Fine aggregates is the only aggregates that used in the manufacture of translucent concrete. Fine aggregates are naturally available material which is composed of rock and mineral particles. It is found in different sizes but the size of fine aggregates should pass through 1.18 mm sieve (Neha R.Nagdive et al. 2013).

Water:

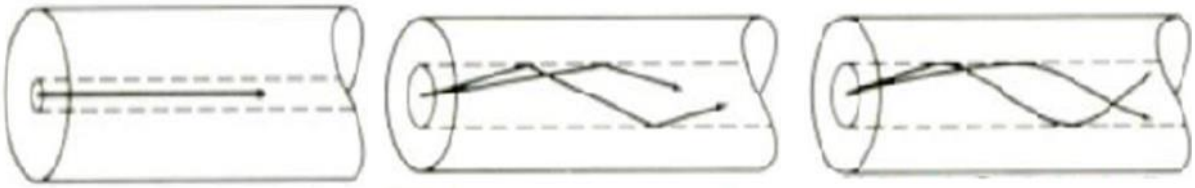
Water is the key ingredient in translucent concrete manufacture, that once mixed with cement, forms a paste that binds the aggregates and optical fiber together. The water has to be pure so as to stop side reactions from occurring which may weaken the concrete, the role of water is very important as a result of the water to cement ratio is that the most critical factor in the production of perfect translucent concrete. The quality of water was found to satisfy the requirements of IS: 456-2000 (Basma F. Bashbash et al. 2013).

Optical Fiber:

In translucent concrete the optical fibers are used most frequently as a way to transmit light between the two ends of the fiber. Along with the ability to transmit the light, the optical fiber gives strength to the structure as coarse aggregates since the translucent concrete is free from coarse aggregates (Simon Kwan et al. 2002).

Types of Optical Fiber:

There are three basic types of optical fibers as shown in the fig 1:



(i) Singlemode step-index fiber. (i) Singlemode step-index fiber. (iii) Multimode graded-index fiber.

Fig.1 The path of rays in optical fiber (Simon Kwan et al. 2002).

A multimode fiber can propagate hundreds of light modes at one time while single-mode fibers only propagate one mode as shown in fig. 1.

Since the single-mode fibers propagate light in one clearly defined path, intermodal dispersion effects are not present, allowing the fiber to operate at larger bandwidths than a multimode fiber shown in fig 1. Large intermodal dispersion effects are takes place in multimode fibers due to the many light modes of propagations it handles at one time (Simon Kwan et al. 2002).

PRINCIPLE OF TRANSLUCENT CONCRETE

The working principle of translucent concrete is based on 'Nano Optics'. The optical fiber in the concrete that act like the slits, carries the sunlight across throughout the concrete (Bhavin K. Kashiyani et al. 2013).

Manufacture process of translucent concrete is almost same as normal concrete. Small layer of the concrete is poured in the mould and on top of each layers, a layer of 4% to 5% of optical fibers by volume of concrete mixture is infused. Fiber is arranged alternatively into mould as shown in fig.2 in intervals of approximately 2 mm to 5 mm and about thousands of optical fibers are cast into the concrete to transmit light. The casted concrete is cut into panels or blocks of the specified thickness and then surface is polished (Akshaya B.Kamdi el al. 2013).

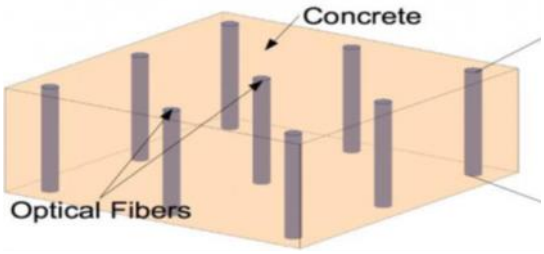


Fig.2 Arrangement of optical fiber in concrete (Bhavin K. Kashiyani et al. 2013).

Translucent concrete contains only fine aggregates, and does not contain coarse aggregate. The optical fiber can withstand harsh environments and contains a higher ductility and good flexibility property. Optical fiber transmits light in the form of electro-magnetic waves (Akshaya B.Kamdi el al. 2013).. It transmits light between two ends of fiber. Optical fiber is a three layers cable. Coating, cladding and core are the three layers of optical fiber as shown in fig.3.

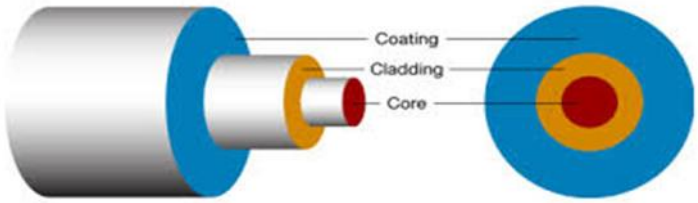


Fig.3 Layers in optical fiber (Source: http://www.fiberopticshare.com/1777.html)

The light is transmitted through the core of the fiber. Almost free energy loss light passes through optical fibers makes it possible to see the light, the shadow and even the colours through concrete even by thick wall (Bhavin K. Kashiyani et al. 2013).

PROPERTIES OF TRANSLUCENT CONCRETE

The translucent concrete has the same properties as that of the normal concrete. The company named LiTraCon Bt near the town of Csongrad which founded in 2004 is the only company that manufacture the translucent concrete in a large scale. Following are the properties of translucent concrete by TiTraCon Company in table 1.

Table.1 Properties of Translucent Concrete by LiTraCon Company

(Source: www.litracon.hu/productlist.php)

Product	Translucent Concrete
Ingredients	96% Concrete, 4% Optical Fiber
Density	2100-2400 Kg/m^2
Block size	600 mm X 300 mm
Thickness	25-500 mm
Colour	White, Grey or Black
Fiber Distribution	Organic
Finished	Polished
Compressive Strength	50 N/mm^2
Bending Tensile Strength	7 N/mm^2

APPLICATIONS OF TRANSLUCENT CONCRETE IN DIFFERENT FIELDS

Until now, translucent concrete is manufactured as precast blocks and wall panels. Therefore, the use of translucent concrete has not yet been widely applied. Next, are some of their applications:

Aesthetic Purpose:

One of the most important applications of translucent concrete is to use it in facades as an aesthetic element in buildings (R. Praveenkumar et al. 2017). They can, therefore, be used in museums, galleries and also in art or design projects used as decorative materials instead of just building materials (A. Dhonchak et al. 2016).

Illuminate The Building Interiors:

The main use of translucent concrete is to illuminate the spaces according to the ability of translucent concrete to transmit light to interior spaces such as educational buildings. Translucent concrete is used widely in exterior facades, partition walls, and floors. But there are few or no researches in the acoustic isolation properties (Yadav et al. 2018).

Staircases and Inner Walls:

When applying translucent concrete on the outer wall of an indoor stairwell, it allows the sunlight to enter the interior space, and thus can be a good during the evacuation of buildings in emergencies and power outages, especially in skyscraper buildings (Z. Zhou et al. 2013).

Energy-Saving:

Some recent researches study the application of the use of translucent concrete panels in facades or ceilings of any large building which helps reduce lighting costs, to fulfil the environment and green architecture requirements, where translucent concrete can be used as a means to reduce energy consumption by decreasing the demand of the illumination (Journal et al 2013). Translucent concrete can be considered a green energy-saving construction material, where a special sort of translucent concrete is manufactured to study properties as a material to save energy. The possibility of using waste glass with optical fibers in translucent concrete to be more environmentally friendly buildings was studied (Jiménez-Muñoz et al. 2014).

Doors, Windows and Front Walls:

Dealt with one of the suggestions regarding the application of translucent concrete is to use it in front wall and in the exterior doors of houses so that residents can know the presence of people outside and use it as the windows in schools and other public sectors to reduce use of electric light during daytime when intensity of light decreases (R. Bajpai et al. 2013).

Translucent Concrete as A Material:

According to several studies, one of the applications of the use of translucent concrete other than its light transmitting properties is to reduce the dead load on the structural structure of buildings by act as a lightweight material (U. M. Bhanuse et al. 2015). Another study about using different percentages of optical fibers mixed with concrete compared to conventional concrete, several tests were carried out such as compressive strength tests. The results showed the ability of translucent concrete to transmit light almost without affecting the strength of concrete (A. Sawant et al. 2014). Some recent researches are moving towards studying to mix new materials into translucent concrete panels to try to reduce the weight of concrete, enhance their strength and produce them as an environmentally friendly material.

Sidewalks, Speed Bumps and Roads Lane Markers:

Translucent concrete material can be used to increasing visibility in dark subway stations and to light the in sidewalks at night for public safety, in addition with the possibility of use in lighting industrial bumps. A detailed study on the application of the use of translucent concrete in the road lane markers for road lighting is need (M. Saleem et al. 2016).

Road Tunnels and Subway Stations:

Translucent concrete is applied to lighting road tunnels or Subway stations. A scale model of a tunnel road-based on the use of translucent concrete in the gaps between the beams to introduce sunlight to try to develop, and simulated the study of the use of translucent concrete in road tunnels (A. Peña-García et al. 2016). But it is expensive for road tunnels purposes (A. Peña-García et al. 2012).

Pipe:

Translucent concrete can be used to pipe manufacturing material, in order to study detailed flow in pipe. Also, the velocity of flow during pumping processes can be determined and the movement of single particles during pipe flow can be tracked (Günter et al. 2020)

Through the applications that are listed above, it seems that scientific research in the field of applications of the use of translucent concrete needs more studies to take advantage of its thermal performance and light transmission.

A FEW MAJOR EXAMPLES FOR TRANSLUCENT CONCRETE

Translucent concrete has been successfully used in some buildings. Fig.4 shows the example of the application of translucent concrete in the different building around the world (Aniket Yadav et al. 2018).

One of these buildings that were constructed using the idea of translucent concrete is (fig.4.i) the Maison Hermes in Tokyo, Japan and is designed by Architect Renzo Piano.

This building is technologically innovative by constructing in a way that it applies traditional anti-seismic systems used in Japanese temples to its modern-day structure along with its facade construction. Translucent concrete blocks of size 42.8 x 42.8 x 12 cm of about 13000 were used.

Another illustration of the art of translucent concrete is (fig.4.ii) pillars of Iberville Veteran's Memorial in Louisiana, USA. The five pillars build here which represents the five military branches using translucent concrete which reflects the harshness of war and strength of military.

Radhous building in Erfurt in Germany shown in fig.3.iii is attracted by its customers by distinctive design of glowing bicycles on its wall. The translucent facade for the approximately 70 m long, 6 m wide and between 3 and 8 m high building was made entirely of highly insulated, newly developed 8-chamber polycarbonate sheets, which are partially supplemented with foil ornaments and motifs in gold and silver tones.

Italian pavilion at Shanghai World Expo 2010 in China (fig.4.iv) also presents growing trend of transparent buildings. Here precast concrete panel protected by adding special plastic resins to an innovative mortar was adopted instead of using optical fibers. To cover the surface area of 1887 m2, 3774 translucent concrete panels were used. The weight of each plate was around 50 kg with the dimension 1x0.5 m and 5 cm in thickness.

Al-Aziz Mosque in Abu Dhabi (fig.4.v) is another example of the newly constructed building with using of translucent concrete technology. The mosque was opened in 2015 and used optical fibers transmute the light. 1.8×1.4×0.3 m translucent concrete panels with total area of 525 m2 were used in this building.

(i) Maison Hermes in Tokyo, Japan.

(ii) Pillars of Iberville Veteran's Memorial in Louisiana, USA.

(iii) Radhous building in Erfurt, Germany.

(iv) Italian pavilion at Shanghai World Expo 2010 in China.

(v) Al-Aziz Mosque in Abu Dhabi.

Fig. 4 Examples of applications of translucent concrete (Aniket Yadav et al. 2018).

FUTURE EXPECTATIONS

It will take time to use translucent concrete in worldwide construction technology, as the cost of manufacturing is very high. The company named LiTraCon Bt near the town of Csongrad which founded in 2004 is the only company that manufacture the translucent concrete in a large scale. The rising popularity of translucent concrete in a short time is an evidence to its innovation, and the days of dark, dull concrete may soon be coming to an end. If more and more buildings begin using this technology, more natural light can be utilized in indoor environment. This could lead to huge drops in the amount of power consumption used for light the buildings, as they would be natural light during the day.

CONCLUSION

The translucent concrete is used where the light cannot reach with its appropriate intensity. The use of the translucent concrete can reduce the pollution by reducing the use of greenhouse gas called carbon footprint which is emitted from fossil fuel usage in electricity. And it can be used for the best architectural appearance of the building. It is a best green building material which can be used to reduce the energy consumption. It has many applications in field of green technology and is in its developing stage. So it has a wide scope in the future.

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