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Some Progress on Smart Transparent Concrete

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Abstract: *Smart transparent concrete is a concrete based building material with its transparent and smart sensing properties through embedding light optical elements such as Optical fibres. Due to "green" requirements and safe evaluation for engineering structures have obtained the worldwide attention, this paper discusses the development of Smart transparent concrete based on its excellent properties of transparent and smart sensing. By dealing with its usage and also the advantages it brings in the field of smart construction, we find that it can reduce the power consumption of illumination and use the optical fiber to sense the stress of structures and also use this concrete as an architectural purpose for good aesthetical view of the building.*

Keyword: *Smart transparent concrete, optical fibre, energy saving, smart sensing, architectural*

INTRODUCTION

With the economic growth and science-technology development, more and more large-scale civil engineering structures such as tall buildings, underground buildings and landmark buildings and so on are built around the world. Those buildings are isolated biosphere only based on man-made lights to main tain people's optical activities. At the same time, most of the big buildings are built close to each other, all in the same areas, like sky scrapers. When many buildings are stacked close to each other, there is not much natural sunlight passing through and the importance of natural sunlight is pretty well known. Translucent concrete comes in as a blessing solution for easier day lighting. By arranging the high numerical aperture Plastic Optical Fibres (POF) or big diameter glass optical fiber into concrete, Optical fibres transmit light so effectively that there is virtually no loss of light conducted through the fibres[1-5].

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Due to Optical fibres' outstanding light guiding and sensing advantages, such as anti-electromagnetic interference capability, small dimensions, distributed measurement and anti-corrosion characteristics, optical fibers have been widely adopted in the communication and sensing fields. Hungarian architect, Aron Losonczi, first introduced the idea of light transmitting concrete in 2001 and then successfully produced the first transparent concrete block in 2003, named LiTraCon, shown as figure 1. However, his transparent concrete did not have smart sensing properties In 2009, Professor Zhi Zhou introduced a smart transparent concrete-novel construction material was manufactured with POF and FBG by drilling through the cement and mortar in order to utilize the light guiding ability of POF and the sensing properties of FBG respectively, shown as figure 2. The smart transparent concrete not only reduced the power consumption of illumination but also hade detection of potential internal deformation of the concrete. In 2010, Italian Pavilion in Shanghai Expo 2010 shows a kind of transparent concrete developed by mixing glass into concrete, the transparent concrete showed its application of good aesthetical view of the building. In 2013, Alejandro Fastag achieved a translucent product of embedding the cylinders. The use of architectural precast concrete components with translucent capacity has transformed the buildings appearance, making the interior areas feel light and airy.

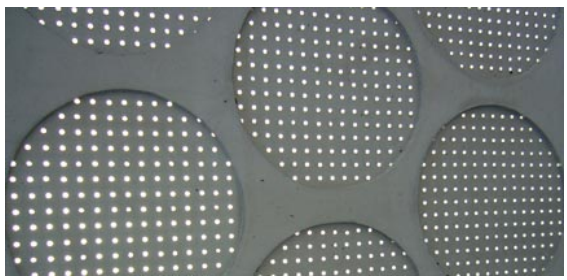

Fig 1. Picture of LiTraCon

Fig 2. Transparent demonstration of smart transparent concrete

PRINCIPLE OF OPERATION

Optical fibers work as a cylindrical waveguide that transmits light along its axis, by the process of internal reflection, shown as figure[6].

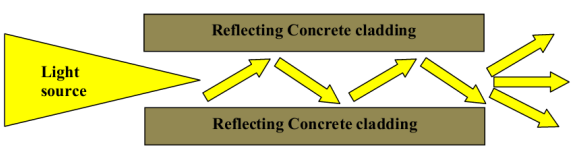

Fig 3. Light reflected in concrete panel form ALEJANDRO FASTAGl, 2013

MANUFACTURING PROCESS OF SMART TRANSPARENT CONCRETE

There are two basic materials used for making smart transparent concrete, one is from construction field and another from sensing field. The optical fiber is used as sensing element and optical transmission element. The fabrication process of standard transparent concrete block can be described as follows. First, according to the volume ratio of concrete and POF, some holes with orthogonal arrays are drilled in the plastic sheet. Second, POFs are through the holes of two plastic sheets which are fixed on the slots of wood formwork. Last, a certain concrete is poured in the formwork and fully vibrated on the shaking table.

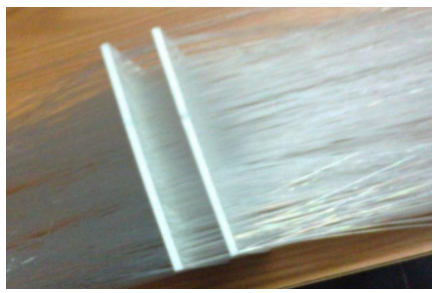

Fig 3. Optical Fibres running through 2 perforated sheetings.

To investigate any influence of the POF on the strength of the transparent concrete block, a compression test was carried out for each specimen, The test data is shown in Table.1. It can be observed that the volume proportion affects the compression strength of the concrete block for less than 10% when the proportion ratio of the POF is less than 5 percent.

Table 1. Data of the compression perform ance of the transparent concrete block

Proportion	0.0%	3.14%	3.80%	4.52%
Test data (kN)	190.5	190.0	219.0	180.5
	220.0	228.0	194.0	182.0
	195.0	185.0	174.0	184.0
Average	201.8	201.0	195.7	182.2

To investigate the functionality of self sensing of the smart transparent concrete block, a test was carried out for the specimen embedding with POF, FBG, shown in Figure 4. It can be found that FBG works well to monitor strain as large as 2050με. The data agrees well with the traditional resistance strain gauge. Such experiments shows that the internal deformation can be monitored by fiber grating inside the specimen which will not be achieved by a

traditional resistance strain gauge attached to the surface.

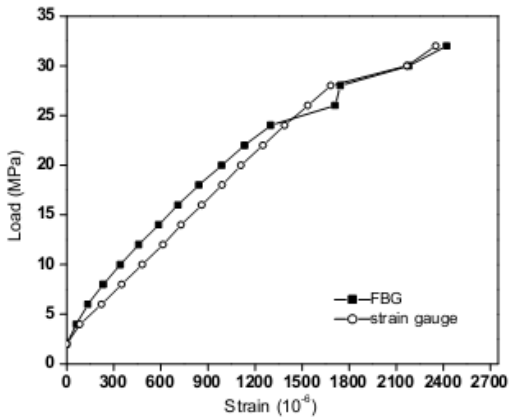

Fig 4. Test of the sensing properties of the smart transparent concrete block

USAGE OF TRANSLUCENT CONCRETE BLOCKS

Translucent concrete blocks inserted on front doors or walls next to it allow the residents to see when there is a person standing outside. Translucent concrete walls on restaurants, clubs, and other social establishments help see how many people are actually inside it. Ceilings of large corporate buildings with translucent concrete would help reduce a great deal of lighting costs during day time. Speed bumps in parking lots and highways can use translucent concrete blocks with a light source beneath or reflecting from other vehicles/sources help in navigation very effectively. Even lane markers in highways can use this material to light up the roads. Sidewalks with translucent concrete fitted with a single light source beneath would add a lot to the scenic beauty as well as safety and also encourage walking or foot travel during night times. Translucent concrete blocks incorporated in staircases and inner walls help during times of power cuts at night leading to a great deal of safety. Similarly for subways and airports etc., this translucent concrete blocks would add to the visibility. Translucent concrete blocks can be made in desired shapes and used as decorative materials like bookshelves and sunshades, tables and statues. They can also be placed as random designs on security walls which also enhance security giving the resident a hazy view of the perimeter. Lamps using translucent concrete blocks with a light source would add a great deal of aesthetic look Places like schools, museums and prison cells outer walls can find translucent walls very useful as they add safety as well as security and supervision[4].

Fig 5. Translucent Wall for Architectural View
Source: www.litracon.hu

A FEW MAJOR EXAMPLES

Translucent 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. 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[4-6].

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 6. Translucent concrete of Italian Pavilion

ADVANTAGES AND DISADVANTAGES

Natural sunlight is the best source for light which is actually free of cost. With translucent concrete walls in a room, it'd be brightly illuminated with natural sunlight. It's a requirement for green buildings; therefore it's a very good advantage for them. These optical fibers also work as heat insulators, so they'll be very effective in cold countries, thereby reducing energy and saving lots of money in both the cases. As mentioned above, translucent concrete can help add a great deal of security and supervision in places like schools, museums and prisons etc, where the presence of the people and their actions are seen but not their entire image, thereby protecting their privacy as well. Besides, on large scale objects the texture is still visible - while the texture of finer translucent concrete becomes indistinct at distance[7].

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. Energy saving can be done by utilization oftransparent concrete in building. Totally environment friendly because of its light transmitting characteristics, so energy consumption can be reduced.

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

Summing a few of the above, it is apparent that translucent concrete is a great tool in saving electricity and money as well. Its stronger than glass and possesses almost the same characteristic strengths of normal concrete blocks, therefore is a better replacement to it.

CONCLUSION AND REMARKS

The transparent concrete has good light guiding property and the ratio of optical fibre volume to concrete is proportion to transmission. 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. It can be used for the best architectural appearance of the building. Also used where the light cannot reach with appropriate intensity. This new kind of building material can integrate the concept of green energy saving with the usage self-sensing properties of functional materials. Translucent concrete blocks can be used in many ways and implemented into many forms and be highly advantageous. Yet, the only drawback would be its high cost. That doesn't stop high class architects from using it. It's a great sign of attraction and artistic evolution. Any structure with a small hint of translucent concrete is bound to make heads turn and make them stand in awe. Apart from

the beauty aspects, there's also this security and supervision. Large houses, with big security walls are often low on security. That's why they are mostly fitted with electrocuted fencing. Prison guards would know very easily if any of the inmates were trying to escape or if any of them are fighting. The same can be case for schools and colleges too as well as museums and other places. Green buildings would get an easy accreditation under daylight savings with this. Large and tall office buildings can share the lighting when the ceilings are translucent. Energy savings as well as heat insulation simple adds to the list of its amazing properties. Translucent concrete is the future. It is the smart way of optimizing and utilizing light, a smart way of living.

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