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LITRACON:-Light Transmitting Concrete

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***Abstract*—the term "translucent concrete" has the potential to be somewhat misleading. The concrete itself is not translucent, nor is it any different to conventional concrete. Concrete is one component of a revolutionary new material marketed as "translucent concrete". This product also contains glass fiber optics which has the capacity to communicate light frequencies. Perhaps a more suitable term could be "light transmitting concrete". It is important to differentiate, as past attempts have been made to create an actual translucent concrete, however such attempts have generally proven unsuccessful as the product becomes fragile, and incapable of withstanding wind and rain.In this paper, a translucent concrete - novel construction material was manufactured with optical fibre by drilling through the cement and mortar in order to utilize the light guiding ability of optical fibre. The main purpose was to use sunlight as a light source in order to reduce the power consumption of illumination. Experiments to study the mechanical performance of the concrete infused with optical fibre were carried out.**

Keywords—concrete; translucent;frequencies; mortar; optical fibre

I. INTRODUCTION

With over seven billion cubic meters produced each year, concrete is one of the world's most ubiquitous building materials. Concrete use has stood the test of time and is a multibillion dollar industry that provides millions of jobs throughout the world. Despite its versatility and popularity, the aesthetic reputation of concrete leaves much to be desired. Common descriptive phrases such as "concrete jungle" do little to increase the desirability of concrete's aesthetic attributes. However, in a small town in southern Hungary, a young architect is challenging these negative perceptions. In 2001, Áron Losonczi combined his artistic inspiration, technical innovation and entrepreneurial flair to create translucent concrete building blocks which can transform a solid gray mass into a luminous wall alive with shadows. In 2004, Mr. Losonczi set up LiTraCon Bt. (Litracon) to market his translucent invention.For practical and decorative reasons it is usually frequent that a building block, such as a wall-, floor- or ceiling-surface is illuminated by one or several separate sources of light, e.g. so called spotlights, directed to the surface in question. Nowadays it is also popular to mount lamps in building elements, such that they are recessed and/or flush with the surface, which provide some lighting over the surface and some lighting in adjoining surface.

However, it is impractical, time consuming and costly, as mentioned above, to mount light sources or optical cables in prepared building elements or in built walls, ceilings or floors, in order to transfer light through the building element. Particularly if small light sources, at certain points, shall be mounted in the building element. If a considerable part of a surface shall emit light, it is easily appreciated that the work will be lengthy since a large number of holes have to be made. Besides, only mounting of a limited number of light sources in the building element can be done by these known methods, if not influencing the strength of the element. In case a light emitting and/or illuminating effect is desired to be provided over a considerable part of a surface, when not a separate light source can or is desired to be used, it is in practice only possible by mounting relatively light-spreading sources in the surface layer of the building element in order to avoid that its strength is not influenced [1-3].

One day in his hometown of Csongrád, Hungary, Mr. Losonczi saw a piece of artwork that was made of large glass pieces and ordinary concrete, which gave the artwork translucent properties. Seeing this, he got the idea of combining the two materials to create a translucent form of concrete that maintained the strength, durability and texture of traditional concrete mixtures. Instead of using large glass pieces, Mr. Losonczi's invention uses thousands of glass fibers mixed with fine concrete. The fibers form a matrix and run parallel to each other between the two main surfaces of each block.Amazingly, the mixture can achieve its translucent effect with only four percent of its volume consisting of the glass fibers. Because of this and their small size, they blend into the concrete and become a part of its structural integrity, but are not visible on the surface. The resulting product looks, feels and behaves like pure concrete, but shadows and objects show through, similar to the effect of Japanese sliding screens made of rice paper. Shadows are sharply projected and light coming through the blocks does not change its original color. The blocks can be embedded with heat insulation, can be used to build structures up to a few meters thick without any light loss and can be produced in various sizes and shapes. Mr. Losonczi named his invention LiTraCon, short for Light-Transmitting Concrete. Higher bandwidths (data rates) an optical fibers is a flexible, transparent fiber made of extruded glass (silica) or plastic, slightly thicker than a human hair. It can function as waveguide, or "light pipe" [4]. To transmit light between the two ends of the fiber [5]. The field of applied science and engineering concerned with the design and application of optical fibers is known as fiber optics

Optical fibers are widely used in fiber-optic communications, where they permit transmission over longer distances and at than wire cables. Fibers are used instead of metal wires because signals travel along them with less loss and are also immune to electromagnetic interference. Fibers are also used for illumination, and are wrapped in bundles so that they may be used to carry images, thus allowing viewing in confined spaces. Specially designed fibers are used for a variety of other applications, including sensors and fiber lasers.

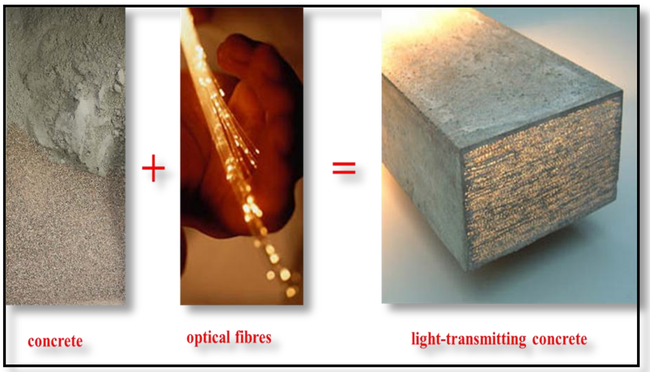

Fig. 1. Light Transmitting Concrete

II. Literature Review

In 1999 this US architect did the first samples of translucent concrete. Together with OMA architecture and Rem Koolhaas, Bill started to question himself on the possibility of manufacturing a concrete that could allow for light to go thru it. His first test considered all exchanging the different components of concrete to achieve transparency, without modifying its basic composition. He used glass and plastic aggregates and he has developed several samples. We understand from the readings he is still working on his invention and adapting the mixes to several uses [6].

While in the University of Detroit Mercy in Michigan, he mixed white silica sand, white Portland cement and short strands of fiberglass to reinforce the material. The final concrete panels were thin as a coin at the centers and close to a centimeter thick at the edges. Wittig's hope was that the panels would be translucent enough so that on a sunny day, you could sit inside and have enough light to read a book, but his results achieved thinnest sheets of the new concrete transmit about 1 percent of sunlight, sufficient light to create a glow inside the structure. However, lab tests showed that the panels were too fragile to withstand wind and rain [7].

In 2001, Time magazine showed one of the most amazing inventions of the year, Litracon™ (Light transmitting concrete) developed by Hungarian architect Aron Losonczi and his Germany Company. Instead of making concrete itself translucent, they took a different track by incorporate in transparent materials into the concrete. His Concrete modules contain glass optical fibers the thickness of a hair that transmit light from one side of the material to the other. To ensure that the ends of each fiber make contact with the surfaces on both sides of the material, the concrete blocks are built in thin layers of concrete poured into a long, narrow mold, and layers of optical fibers are laid along the length of the mold, alternating concrete and fiber. The resulting long beam is then cut into short, rectangular building blocks where varying the size of the blocks, however, doesn't change the effect and the fibers transmit light the entire length. By using fibers of different diameters, Litracon™ designers can achieve different illumination effects [8].

In April of 2007, Sergio Galvan and Joel Sosa in México registered a new formulation using a mixture of polycarbonate and epoxy materials, as well as glass fibers, optical fibers, colloidal silica, silica, diethylentriamine (DETA) and Portland cement. Gravel and sand are replaced by resins and fibers. They claim the invention has greater mechanical strength properties than those of a standard concrete, with lower density and mechanical characteristics that enable same to be used in both a structural and architectural manner, allowing strengths of 4500 kg/cm^2, volumetric weight of 2,000 kilograms per cubic meter and that its final setting is under 7 days [9].

Architecture in the 21th century began as a celebration of the age of industry and technology but it rapidly changed into a new age of information and Ecology. This school project combines both stages by using industry experience, manufacturing technology, and available information to deliver an ecology efficient product.The specific "green" requirements were to save operation costs on 12% by providing natural lighting instead of energy consumption, so we had to find a translucent walls system where we could "move light from one side of a solid surface to the other" and this had to be achieved with architectural concrete precast elements. A unique idea developed together with the architect, introduced the use of transparent acrylic cylinders aligned in different shapes across the precast panels, achieving an aesthetic solution that allowed natural light to flow across the panels, creating a remarkable effect and saving energy by bringing daylight into the building interiors thru the precast walls. The main challenges consisted in deciding the way to achieve a translucent product, embedding the cylinders aesthetically, and achieving a perfect architectural white concrete hammered finish on both interior and exterior surfaces [10].

III. OPTICAL FIBRE

An OPTICAL FIBRE is a flexible, transparent fibre made of glass (silica) or plastic, slightly thicker than a human hair. It functions as a waveguide or light pipe, to transmit light between the two ends of the fibre. The field of applied science and engineering concerned with the design and application of optical fibres is known as fibre optics. Optical fibres are widely used in fibre-optic communications, which permits transmission over longer distances and at higher bandwidths (data rates) than other forms of communication. Fibres are used instead of metal wires because signals travel along them with less loss and are also immune to electromagnetic interference. Fibres are also used for illumination, and are wrapped in bundles so that they may be used to carry images, thus allowing viewing in confined spaces. Specially designed fibres are used for a variety of other applications, including sensors and fibre lasers.Optical fibers typically include a transparent core surrounded by a transparent cladding material with a lower index of refraction. Light is kept in the core by total internal reflection. This causes the fibre to act as a waveguide. Fibres that support many propagation paths or transverse modes are called multi-mode fibres (MMF), while those that only support a single mode are called single-mode fibres (SMF). Multi-mode fibres generally have a wider core diameter, and are used for short-distance communication links and for applications where high power must be transmitted. Single-mode fibres are used for most communication links longer than 1,050 meters (3,440 ft). Joining lengths of optical fibre is more complex than joining electrical wire or cable. The ends of the fibres must be carefully cleaved, and then spliced together, either mechanically or by fusing them with heat. Special optical fibre connectors for removable connections are also available [11-12].

Optical fibre can be used as a medium for telecommunication and computer networking because it is flexible and can be bundled as cables. It is especially advantageous for long-distance communications, because light propagates through the fibre with little attenuation compared to electrical cables. This allows long distances to be spanned with few repeaters. Additionally, the per-channel light signals propagating in the fiber have been modulated at rates as high as 111 gigabits per second by NTT, although 10 or 40 Gbit/s is typical in deployed systems. Each fibre can carry many independent channels, each using a different wavelength of light (wavelength-division multiplexing (WDM). The net data rate (data rate without overhead bytes) per fibre is the per-channel data rate reduced by the FEC overhead, multiplied by the number of channels (usually up to eighty in commercial dense WDM systems as of 2008). The current laboratory fibre optic data rate record, held by Alcatel-Lucent in Villarceaux, France, is multiplexing 155 channels, each carrying 100 Gbit/s over a 7000 km fibre. Nippon Telegraph and Telephone Corporation has also managed 69.1 Tbit/s over a single 240 km fibre (multiplexing 432 channels, equating to 171 Gbit/s per channel). Bell Labs also broke a 100 Petabit per second kilometer barrier (15.5 Tbit/s over a single 7000 km fiber) [12-14].

For short distance applications, such as a network in an office building, fibre-optic cabling can save space in cable ducts. This is because a single fibre can carry much more data than electrical cables such as standard category Ethernet cabling, which typically runs at 100 Mbit/s or 1 Gbit/s speeds. Fibre is also immune to electrical interference; there is no cross-talk between signals in different cables, and no pickup of environmental noise. Non-armored fibre cables do not conduct electricity, which makes fiber a good solution for protecting communications equipment in high voltage environments, such as power generation facilities, or metal communication structures prone to lightning strikes. They can also be used in environments where explosive fumes are present, without danger of ignition. Wiretapping (in this case, fibre tapping) is more difficult compared to electrical connections, and there are concentric dual core fibers that are said to be tap-proof.

I. RESEARCH METHODOLOGY

A baseline is needed to establish an experimental design to conduct testing and observations for future development and research. All the baseline mortar and concrete material used in this study are shown in Table 1.

Table 1:- Experimental Baseline

Sr. No.	Baseline Element	Type
1	Cement	Ultra-tech 53 grade PPC.
2	Sand	Standard Sand and Wainganga Sand.
3	Optical Fibre	Fibre optic toys

Optical Fibre is an excellent media to transmit light at specific wavelengths since its refractive index is greater in core than in coating. As such, light can be transmitted through Optical Fibre in the form of total reflection. As optical fibre has a much larger core size and larger numerical aperture than common SiO_2- based optical fibres, it can absorb light at an incident angle as large as 60° and still provide a better light guiding system. Optical fibre has the advantages of greater ductility and good flexibility for a harsh environment. The light transmitted in optical fibre is in the form of electromagnetic waves whose amplitude, phase, polarized state and frequency are affected by various physical parameters, such as temperature, pressure, stress, strain, electric field and magnetic field. By analyzing performance changes in those waves, the external physical conditions can be estimated. Such sensors offer unmatched advantages like high precision, quasi-distributed monitoring, relatively small volume, steady for structural identity, anti-electromagnetic interference, anti-corrosion, ease in handling and ruggedness, and some can even be used for absolute measurements, compared to the relative strain measurements after traditional resistance strain gauges have been installed. Based on the above mentioned features, optical fibre with fibre grating in proportion with cement in concrete or a translucent concrete will provide a novel construction material that has both transparent appearance and structural assessment ability for long-term SHM(Structural Health Monitoring).

II. RESULT AND DISCUSSION

1. Light Guiding Experiment

In order to study the light guiding property of TRANSLUCENT CONCRETE, we fabricate six kinds of TRANSLUCENT CONCRETEs with different OPTICAL FIBRE volume ratios of 1%, 2%, 3%, 4%, 5% and 6%, and the diameters of OPTICAL FIBRE is 2mm. The transmittance is measured by the Newport 835 Optical Power Meter made in USA shown as figure 5.1, 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 OPTICAL FIBRES' position and the material, three areas (denoted as 1, 2 and 3) in the middle part of transparent concrete are chosen to test shown as figure 5.2, and the number of OPTICAL FIBRES in each chosen area shall be equal [15]. The number of the OPTICAL FIBREs is covered by transmission probe or integral sphere are 2 for 1% OPTICAL FIBRE volume ratio, 4 for 2% OPTICAL FIBRE volume ratio, 5 for 3% OPTICAL FIBRE volume ratio, 7 for

4% OPTICAL FIBRE volume ratio, 3 for 5% OPTICAL FIBRE volume ratio and 9 for 6% OPTICAL FIBRE volume ratio respectively. The adjustment of step of the Newport 835 Optical Power Meter is 20mm, and the incident light energy and transmission light energy are read simultaneously at each step.

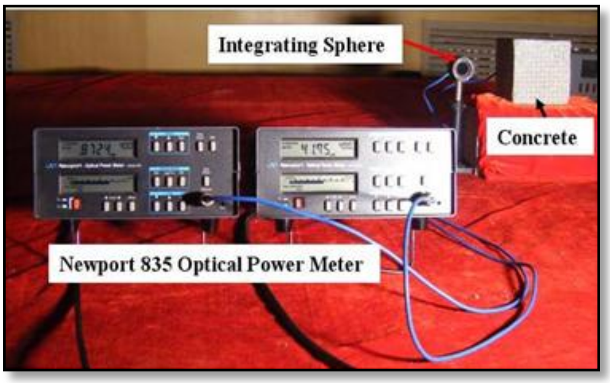

Fig. 2.Newport 835 Optical Power Meter

The function of above machine is that The Model 835 may also be operated from rechargeable sealed nickel cadmium batteries contained in the optional Model 835-BAT Rechargeable Battery Pack. A fully charged battery pack will operate the Model 835 for five hours. The BAT enunciator will turn on when the battery charge is insufficient to maintain accurate readings [16].

Thorlabs' expanding line of optical power and energy meters includes power meter consoles, a large selection of sensor heads, a wireless power meter with a built-in photodiode sensor, and a fiber optic power meter designed for use in the field. The sensor calibration data is stored in the sensor head and is automaticallyread by the console, which allows the user to use multiple sensors [17].

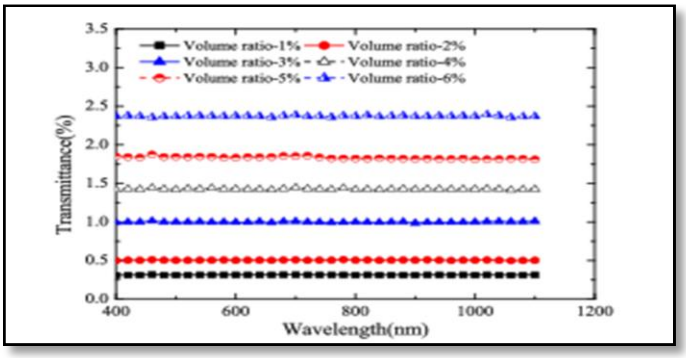

Fig. 3.Transmittance

2. Impermeability Property

For the translucent concrete, the interfacial bonding of the optical fibres and concrete is a crucial factor in determining ultimate impermeability properties. The chloride diffusion coefficient method (or electric flux method) is used to test the impermeability property of translucent concrete, which can rapidly evaluate the permeability of concrete by measuring the electric energy through concrete. In this paper, the translucent concretes with 0%, 3% and 6% optical fibre volume ratio are chosen for the test. The electric energy is recorded by the electric flux detector njw-rcp-6a made in china, and cylindrical concrete specimens with 100mm diameter and 50mm height are fabricated from the prefabricated translucent concretes by core-drilling method, shown as Figure 4. Moreover, in order to evaluate the effect of interface bonding on the impermeability property, each model of specimen has been divided two types. One is that the border of optical fibre and concrete is covered by epoxy resin, the other one is not covered by epoxy resin, as shown in Figure 5. Figure 6 shows the test configuration. The process of permeability test based on the electric flux method can be described in Figure 7.

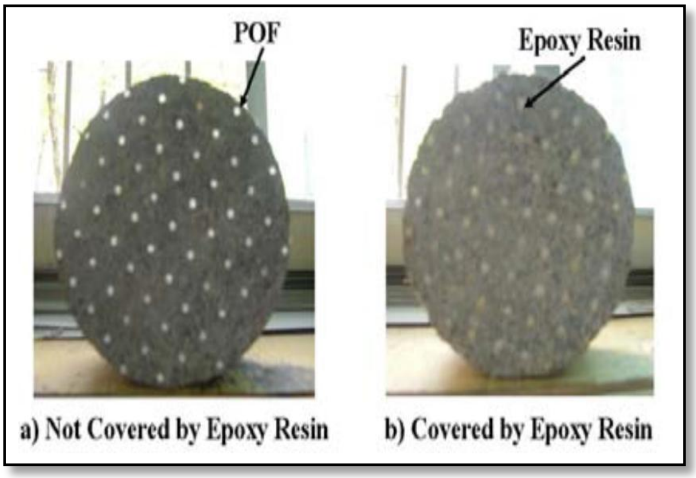

Fig. 4.Cylindrical concrete specimens for impermeability

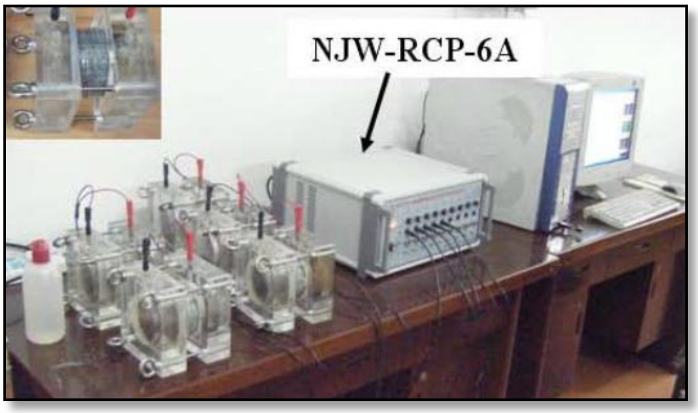

Fig. 5.Setup of test

Fig. 6.Configuration of compression tests

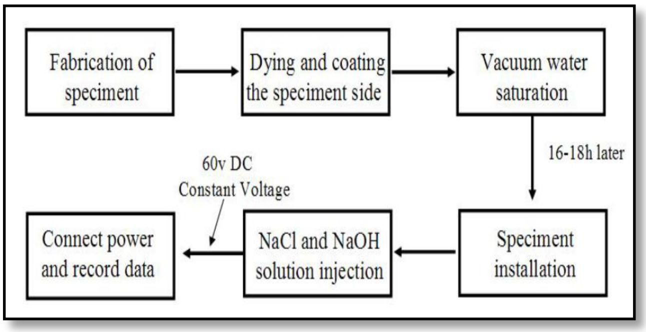

Fig. 7.Procedure of chloride diffusion coefficient test

Fig. 8. Name of College and Logo

VI. CONCLUSION

Based on the results presented above, the following conclusions can be drawn:

1. The compressive strength of translucent concrete is found to be 46 n/mm^2 which is nearly equal to that of plain concrete.
2. The smart transparent concrete has good light guiding property.
3. The optical fibre volume ratio of concrete is proportionate to transmission light guiding property.
4. Weighs about the same as conventional concrete.
5. Carries the same amount of light through a brick no matter how thick it is.
6. Creating an ecologically solution that reduces to minimum energy consumption of this project.

The transparent concrete has good light guiding property and the ratio of optical fibre volume toconcrete is proportion to transmission. Thetransparent concrete not loses the strength parameterwhen compared to regular concrete and also it hasvery vital property for the aesthetical point of view. Itcan be used for the best architectural appearance ofthe building. Also used where the light cannot reachwith appropriate intensity. This new kind of buildingmaterial can integrate the concept of green energysaving with the usage self-sensing properties offunctional materials. Translucent concrete blocks can be used in many ways and implemented into manyforms and be highly advantageous. Yet, the onlydrawback would be its high cost. That doesn't stophigh class architects from using it.

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