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Production of Mortar Blocks with Translucent Potential using Optical Fiber in Civil Construction

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Abstract:
In the search for solutions that increasingly improve the aesthetics of buildings, the optical fiber stands out for allowing light to pass through the ambients. Thus, this work aimed to produce mortar blocks with translucent potential using optical fiber. The experimental procedure consisted of making a fluid mortar in the proportion of 1:3, which was placed in 12x12 cm wooden molds, together with the functional components of the optical fiber. After making and drying the mortar blocks, it was possible to identify the transfer of light inside the blocks, which was provided by the introduction of the layers of the optical fiber components. In addition to the effects observed, the reuse of network cables containing the optical fiber in their interior encourages the principles of sustainability in civil construction. The translucent materials are a beneficial innovation in terms of design and lighting in the ambients. However, it is concluded that further studies on its properties and also an improvement of the techniques for obtaining the optical fiber are needed for future comparisons.
***Keywords**: Mortar; Translucent Mortar; Optical fiber; Civil Construction; Lighting.*

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I. Introduction

What is most sought after in the civil construction market are materials production processes, which have a vision aimed at environmental awareness [1].

With the emergence of translucent concrete, there was an innovation in construction methods, uniting principles of technology, art, quality, well-being and sustainability. This material is a conventional concrete, with the addition of optical fiber, which apparently transmits a feeling of fragility, but with high resistance [2].

In view of the use of an innovative construction system with a wide aesthetic potential, the translucent concrete seeks to improve the visual quality of the environments by offering a multiplicity of shapes, dimensions and effects. Each block of this type of material can be produced differently depending on how the fibers are arranged in the mold [2].

The use of translucent blocks with optical fiber is still little known [3], due to the high aggregate cost for its production, due to the amount of optical fiber needed to cause the intended effects in the ambients [4]. On the other hand, they eliminate the need for plastering and finishing, since for the effect to be visible, no coating can be applied [2].

In addition, translucent concrete allows light to pass from the outside to the inside ambient, seeking energy savings [1]. Thereat, more and more the number of studies on this material are concentrated in the areas of capturing natural light and reducing energy costs, with the main focus on the search for improvements in thermal and lighting properties [3, 4, 5, 6, 7, 8]. Still, other studies contemplate the manufacture of panels and tiles of different thicknesses using glass residue in the composition of translucent concrete, with satisfactory results in mechanical and translucency terms, as well as improvements in the parameters of durability and air quality [9, 10]. However, further advances are still needed regarding the propagation of light by the translucent material, without harming the thermal comfort of the environments [3].

Based on studies in concrete, this work sought to expand research on the use of optical fiber in different construction methods, thus, mortar blocks with translucent potential were produced using optical fiber. Some professionals related to the area point out that in a few years this material will be used in many environments, mainly because it is a wall that can reflect light inside. In addition, its use is interesting because it contributes to sustainable aspects, because, in addition to reducing electricity consumption due to the passage of light between ambients, it also reuses waste materials (as in the case of this article, the use of network cables), which are composed of optical fiber inside.

II. Experimental Programme

This topic describes the materials and procedures adopted in the experimental phase to collect the results of this research.

All tests for characterization of materials, production of mortar and translucent blocks were carried out in the Concrete and Mortar Laboratory of the educational institution Uceff Faculdades, Chapecó campus. Still, images were collected by Scanning Electron Microscope (SEM) at the Institute of Science and Technology (CEOSP NANOTEC), Chapecó unit, of the block produced with mortar and optical fiber.

This work aimed to produce mortar blocks with translucent potential using optical fiber in civil construction. For that, a mortar mix was chosen and later selected some materials, which were part of its composition. The binder used in this research was the CP V – ARI cement of the group Votorantim. The fine aggregate chosen was medium natural sand.

In addition, quantities of filler and third generation superplasticizer additive were used to compose the mortar mix. All components mentioned were purchased from a store specialized in construction materials located in the city of Chapecó, Santa Catarina, Brazil. The water used was that of local supply.

Regarding the material characterization tests, for cement, its specific mass was established following the NBR NM 16605 [11]. In the case of fine aggregate, the following tests were carried out: specofic mass following the NBR NM 52 [12], unit mass according NBR NM 45 [13], absorption of water obtained through the NBR NM 30 [14] and granulometry regulated by NBR NM 248 [15]. The sand samples used in the characterization tests went through the washing process and were subsequently dried to constant mass in an oven at 105 ºC.

For the production of mortar, the materials were selected and weighed in the appropriate amounts for the mix, as well as placed in a 250 liter concrete mixer for the mixing process.

Internet network cables discarded from a telecommunications company in the city of Xanxerê, Santa Catarina, Brazil, were used to obtain the fiber used in this research.

In order to obtain the translucent effect on the mortar blocks, it was necessary to remove some layers of cables that precede the fiber reach. After this process was completed, the fiber was washed with boiling water, degreasing acid detergent, alcohol and washing powder. This washing process was carried out in order to remove a kind of fat that surrounded the fiber. After the water was changed approximately 4 times, the material was clean, without oil and ready to be used in the production of the blocks. The material used to provide the translucent effect of this work was the glass core, which is capable of reflecting beams of light at very long distances, involved by each one of the cladding with a lower refractive index. Both are considered the functional components of optical fiber [16]. This material can be seen in the Fig. 1.

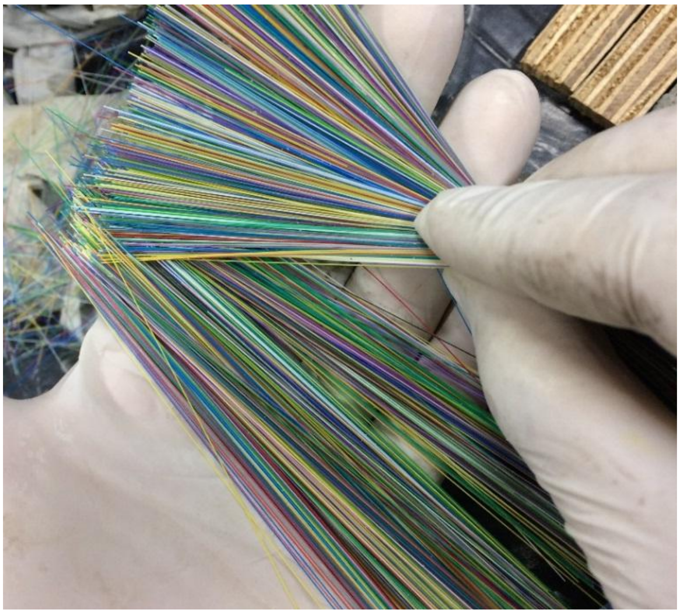

Fig. 1: Fiber optic preparation

With the aid of plywood molds, 12x12cm blocks were molded. The blocks were produced by intercalating layers of fresh mortar and fiber optics. After the deformation and cutting of these blocks, it was possible to observe the passage of light through the layers of optical fiber placed in the produced blocks.

III. Results and Discussion

First, the characterization of the mortar components was carried out. At the end of the cement specific mass test, the result obtained was 2.85 g/cm³. In the studies of Osman et al. [17] and Mane & Gosavi [18], the authors used a cement with a specific mass around 3.15 g/cm³.

The sand adopted in the tests had a specific mass equal to 2.66 g/cm³, practically the same value found (2.70 g/cm³) in the research developed by Fagbohun et al. [19]. Furthermore, the specific mass obtained in the experiments by Wagmode and Hombal [20] was equal to 2.54 g/cm³.

In the case of the test relating to the unit mass of the fine aggregate, a value equivalent to 1.59 g/cm³ was found. This data is similar to that found in the work of Wagmode & Hombal [20], which obtained the value of 1.54 g/cm³ and the result of 1.73 g/cm³ obtained in the studies by Abd-Alazeem et al [21].

The value equal to 0.57 % was the result found for the sand water absorption test in the present work. This data differs from that obtained by Fagbohun et al. [19], as the authors found a higher value in the order of 0.8 % for the water absorption of the material used.

Regarding granulometry, Fig. 2 shows the granulometric curve of the sand used.

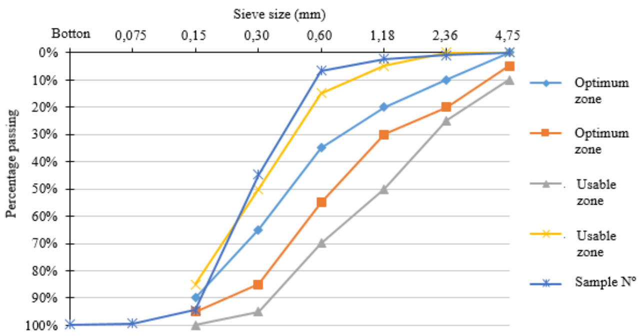

Fig. 2: Particle size curve of medium natural sand

Through the fine aggregate granulometry test, the resulting fineness modulus was 2.48, being about 11.0 % lower than the value obtained by Hailu [22] and higher in the order of 11.0 % when compared to the results of the studies of Osman et al. [17]. In the case of the maximum characteristic diameter found, it was equal to 1.18 mm, being about 51.0 % less than the value acquired by Abd-Alazeem et al [21].

After the material characterization process, mortar and fiber were prepared for the production of the blocks.

The unitary mix corresponding to each material used in the composition of the mortar is shown in Table 1.

Table 1: Description of the Mortar Mix Used.

Cement	Sand	Water/Cement Ratio	Filler	Additive
1	3	0.6	0.27	25g

The materials were placed in the mixer to mix the mortar. First, sand, the additive and a portion of the water were added, and these materials were mixed for three minutes. Subsequently, cement and filler were added, as well as the rest of the water and homogenized all materials for two more minutes. At the end, the mortar was mixed with a total of five minutes.

After this process was completed, the translucent blocks were manually assembled. The fibers were cut to 12 cm lengths, placing several layers of mortar and fiber until the 12 x 12 cm wood forms were completely filled (Fig. 3). Altogether, about 400 g of optical fiber were used to produce each block of translucent mortar.

The placement of the mortar and fiber followed this methodology, because after several tests, this was the way found for the fibers to be spread evenly within the blocks, without the occurrence of material accumulations within the form, and being possible its adherence with the mortar.

Fig. 3: Production process of translucent mortar blocks

After the molding process, three days were waited to perform the deformation, and another five days to regularize the blocks with a saw. Soon after the cuts, the blocks were sanded with grinding discs and a sander, in order to improve the external finish. Finally, from the duly regularized blocks, they were joined with a mortar of poor mix, to visualize the effect of the optical fiber in a greater proportion. These procedures can be seen in Fig. 4.

Fig. 4: Produced translucent mortar blocks

After all the presented process, with the aid of the light of a LED lamp connected to one of the sides of the blocks, it was possible to perceive the passage of light in the places where there was the concentration of the optical fiber. The images of the effects caused by the fiber were obtained by a cell phone device and are shown in Fig. 5.

In Fig. 6, when observing an image obtained by SEM with an increase of two hundred times, a sample taken from the produced block can be analyzed at 28 days of age.

When analyzing the exposed in Fig. 6, it is possible to identify the adhesion between the two materials (fiber and mortar) in the hardened state.

Fig. 5: Propagation of light by translucent mortar blocks

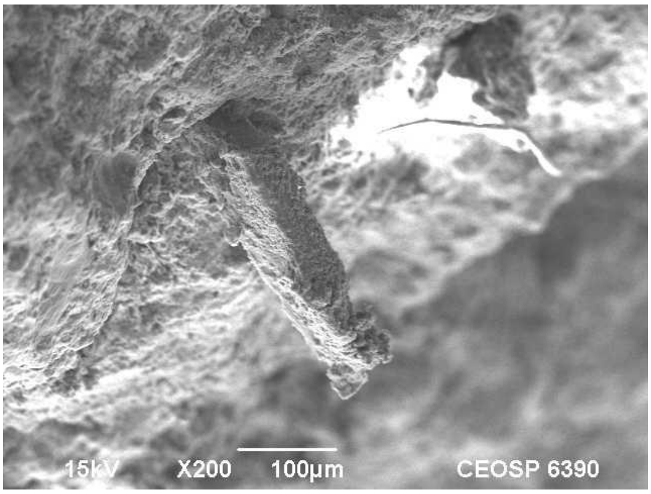

Fig. 6: Production process of translucent mortar blocks

From the observation of the blocks, it can be reported that the result of the application of the optical fiber for the purposes of propagation of luminosity was satisfactory. It is worth mentioning that the protective film was not removed from the optical fiber. In fact, it was possible to observe its effect, through the different colors presented in the passage of light obtained between the blocks.

IV. Conclusion

For the development of this research, a mix of mortar 1:3 was produced, as well as selected the functional parts of the optical fiber (core and cladding) having a length of 12 cm. By placing interlayered layers of fresh mortar and optical fiber, blocks in the dimensions of 12x12 cm were built.

After drying and cutting the produced blocks, it was possible to state that the placement of the optical fiber layers allowed the passage of light through the interior of the mortar blocks. With this, one can arrive at architectural conceptions of the most varied effects, contributing to the aesthetics of the environments.

It is worth mentioning that the process of obtaining optical fiber was through the disposal of a company's internet network cables, making it possible to reuse it and presenting itself as a sustainable solution for the destination of this material.

Still, this work did not address the costs involved in the production of translucent blocks, as well as the costs related to the process of obtaining the optical fiber, being the subject of future research. As reported, the cables containing the fiber were donated by a company, since the purchase of this material already in its state of use, would only be possible through a different country from which the research was carried out. Even so, it took time and labor in the process of reaching the optical fiber, as it was inside the cable.
Finally, it is suggested the construction of blocks with other formats and with new dispositions of the optical fiber in its interior, in order to obtain new aesthetic effects in the ambients.

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References

[1]. A. Giacomelli, and C. Mantovani. Concreto translúcido: a nova tendência estética na construção, 12° Encontro Científico Cultural Interinstitucional. 2014; ISSN 1980-7406, 14 p.
[2]. L.M.C. Restrepo. Concreto translúcido: estudo experimental sobre a fabricação de painéis de concreto com fibra ótica e as suas aplicações na arquitetura (in Portuguese) Dissertation of MSc, Faculdade de Arquitetura e Urbanismo, University of Brasilia. 2013; 178 p.
[3]. Su, X., Zhang, L., Liu, Z., Luo, Y., Lian, J., Liang, P. Daylighting performance simulation and analysis of translucent concrete building envelopes, Renewable Energy. 2020; 154, 754-766.
[4]. Ahuja, A., and Mosalam, K. M. Evaluating energy consumption saving from translucent concretebuilding envelope, Energy and Buildings. 2017; 153, 448–460.
[5]. J. He, Z. Zhou, J. Ou, M. Huang. Study on smart transparent concrete product and its performances, in: The 6th International Workshop on Advanced Smart Materials and Smart Structures Technology ANCRiSST2011, Dalian, China. 2011; 13 p.
[6]. A.A. Momin, R.B. Kadiranaikar, V.S. Jagirdar, A.A. Inamdar. Study on light transmittance of concrete using optical fibers and glass rods, in: International Conference on Advances in Engineering & Technology. 2014; 67-72.
[7]. Y. Li, J. Li, H. Guo. Preparation and study of light transmitting properties of sulfoaluminate cement-based materials, Mater. Des. 2015; 83, 185-192.
[8]. T.D.S. Henriques, D.C. Dal Molin, A.B. Masuero. Study of the influence of sorted polymeric optical fibers (POFs) in samples of a light-transmitting cementbased material (LTCM), Construction and Building Materials. 2018; 161, 305-315.
[9]. Pagliolico, S. L., Lo Verso, V. R. M., Torta, A., Giraud, M., Canonico, F., Ligi, L. A preliminary study on light transmittance properties of translucent concrete panels with coarse waste glass inclusions, Energy Procedia. 2015; 78, 1811–1816.
[10]. Spiesz, P., Rouvas, S., Brouwers, H.J.H. Utilization of waste glass in translucent and photocatalytic concrete, Construction and Building Materials. 2016; 128, 436–448.
[11]. Brazilian Association of Technical Standard (ABNT NBR NM 16605), Portland cement and other powder materials – Determination of specific gravity. (2017).
[12]. Brazilian Association of Technical Standard (ABNT NBR NM 52), Fine aggregate – Determination of specific gravity, apparent specific gravity. (2009).
[13]. Brazilian Association of Technical Standard (ABNT NBR NM 45), Aggregate – Determination of unit mass and void volume. (2006).
[14]. Brazilian Association of Technical Standard (ABNT NBR NM 30), Fine aggregate – Determination of water absorption. (2009).
[15]. Brazilian Association of Technical Standard (ABNT NBR NM 248), Determination of particle size composition. (2003).
[16]. A. Luis. Fibra ótica. Available: https://www.docsity.com/pt/fibra-optica-8/4781675/. [Online]. (2012).
[17]. Osman, K. M., ALyamany, M. A., Tawab, A. A., Thabet, A. Effect of Using Natural and Polypropylene Fibers on Fresh and Hardened Concrete Properties. Journal of Mechanical and Civil Engineering. 2020; 17, 25-36.
[18]. Mane, Y. G., and Gosavi, S. A. Experimental Study on Flexure and Compressive Strength of the Reinforced Concrete Using Crushed Sand and Steel Fiber. Journal of Mechanical and Civil Engineering. 2020; 17, 58-69.
[19]. Fagbohum, J. O., Olaleye, M. F., Omiata, T.R. Determining the Effect of Water Quality On The Strength Of Concrete Using Water Samples from Ureje River, Ado-Ekiti, Ekiti State, Nigeria. Journal of Mechanical and Civil Engineering. 2020; 17, 36-40.
[20]. Wagmode, S., and Hombal, G. Study on mix design of fly ash and GGBS based high performance geopolymer concrete. Journal of Mechanical and Civil Engineering. 2020; 17, 16-23.
[21]. Abd-Alazeem, A., Ematty, M. A., El-Aziz, M. A. A. Ahmed, Y. A. Effect Of Eggshell Powder On The Behavior Of Axially And Eccentrically Loaded Columns. Journal of Mechanical and Civil Engineering. 2020; 17, 51-62.
[22]. Hailu, E. D. Investigations on the Strength Aspects of Recycled Aggregates under M25 Grades of Concrete. Journal of Mechanical and Civil Engineering. 2020; 17, 01-15.