ISSN 2075-8545 (online)

Nanotechnologies in construction
Нанотехнологии в строительстве
2026; 18 (3): 379–392

Nanobuild.ru

EFFICIENT USE OF RECYCLED RESOURCES

Original article
https://doi.org/10.15828/2075-8545-2026-18-3-379-392

The potential of using «green» concrete and waste glass in the manufacture of light-transmitting decorative products

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ABSTRACT

Introduction. The volume of industrial, agricultural, and household waste generated annually in Vietnam has been steadily increasing, while the demand for building materials is growing. This study evaluates the feasibility of using cement-free "green" concrete based on thermal power plant fly ash, blast furnace slag, and glass waste to produce translucent decorative elements. **Materials and methods.** The study used research methods that comply with current Vietnamese standards, as well as a specially developed experimental setup to determine the light transmittance coefficient of decorative "green" concrete samples. Cement-free binders were produced using fly ash from the Pha Lai Thermal Power Plant and finely ground granulated blast furnace slag from the Hoa Phat Steel Plant, combined with an activator consisting of a 1:1 mixture of aqueous solutions of NaOH and Na_2SiO_3. The concrete mixtures also included glass waste of various colors, crushed to particles sized 5.0–20.0 mm, decorative fine aggregate with a fraction of 2.5–5.0 mm, and a superplasticizing admixture under the trade name MVN-SR manufactured by Silkroad Hanoi. Synthetic polypropylene fibers in the form of individual filaments and steel mesh fiber were used to provide dispersed reinforcement for decorative translucent products to improve their crack resistance and mechanical properties. Additionally, various pigment powders in red, yellow, blue, and other colors were used to impart the desired color range and aesthetic properties to the decorative products. **Results.** Four compositions with waste glass contents ranging from 5 to 20% by weight were developed to analyze their effect on the workability of concrete mixes, as well as the physical and mechanical properties and light transmittance of decorative products. The obtained results showed that with an increase in the glass content, the workability of concrete mixes according to the cone flow decreased from 25 to 19 cm, while their average density increased from 2068 to 2169 kg/m 3. After curing for 28 days, the compressive strength of concrete samples was 38–46 MPa, tensile strength in bending was at least 4.9 MPa, wear resistance was 0.3–0.51 g/cm^3, water absorption by weight was from 7.3 to 8.5%, and the light transmittance coefficient increased from 11.8 to 20.5%. **Conclusion.** The resulting light-transmitting decorative products are suitable for interior and exterior decoration, simultaneously providing the required performance characteristics and creating a soft light diffusion effect indoors. Furthermore, the use of high-volume industrial waste helps reduce natural resource consumption and carbon dioxide emissions, confirming the potential of this decorative finishing material to enhance the architectural expression of residential and public building interiors.

KEYWORDS: "green" light-transmitting concrete, waste glass, decorative products, light transmittance coefficient

SOURCES OF FUNDING FOR THE SCIENTIFIC WORK THAT RESULTED IN THE PUBLICATION: The content of this article is partially derived from the university-level scientific and technological product incubation project for 2025 at Hanoi University of Mining and Geology (HUMG), entitled "Development of Translucent Decorative Concrete Products Using Glass Waste and Dispersed Fiber Reinforcement" (Project Code: DAUT.01.2005).

ACKNOWLEDGEMENTS: The authors sincerely acknowledge the laboratory facilities of Hanoi University of Mining and Geology (HUMG), which supported the implementation of this research project.

FOR CITATION:
Lam Tang Van, Nguyen Sang, Bulgakov B.I., Lukyanova N.A. The potential of using «green» concrete and waste glass in the manufacture of light-transmitting decorative products. *Nanotechnologies in construction.* 2026;18(3):379–392. https://doi.org/10.15828/2075-8545-2026-18-3-379-392. – EDN: UFUZGU.

ISSN 2075-8545 (online)

Nanotechnologies in construction
Нанотехнологии в строительстве
2026; 18 (3): 379–392

Возможность использования «зелёного» бетона и отходов стекла для изготовления светопропускающих декоративных изделий

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АННОТАЦИЯ

Введение. Объем промышленных, сельскохозяйственных и бытовых отходов, образующихся ежегодно во Вьетнаме, постоянно увеличивается, в то время как потребность в строительных материалах становится все более актуальной. В данном исследовании оценивается возможность использования бесцементного «зеленого» бетона на основе золы-уноса тепловых электростанций, доменного шлака и отходов стекла для изготовления светопропускающих декоративных изделий. **Материалы и методы.** В работе применялись методы исследований, соответствующие действующим вьетнамским стандартам, а также специально разработанная экспериментальная установка для определения коэффициента светопропускания образцов декоративных «зеленых» бетонов. Для получения бесцементного вяжущего были использованы зола-уноса ТЭС «Фа Лай» и тонкомолотый доменный гранулированный шлак металлургического завода «Хоа Фат» в сочетании с активизатором, состоящим из смеси водных растворов NaOH и Na_2SiO_3 в соотношении 1:1. В состав бетонных смесей также входили стекольные отходы разного цвета, измельченные до частиц размером 5,0–20,0 мм, декоративный мелкий заполнитель фракции 2,5–5,0 мм, суперпластифицирующая добавка под торговым названием MVN-SR производства компании «Silkroad Ханой». Для дисперсного армирования декоративных светопропускающих изделий с целью повышения их трещиностойкости и улучшения механических свойств использовались синтетические полипропиленовые волокна в виде отдельных филаментов и стальная сетчатая фибра. Кроме того, для придания декоративным изделиям требуемой цветовой гаммы и эстетических характеристик применялись различные пигментные порошки красного, желтого, синего и других цветов. **Результаты и обсуждения.** Были разработаны четыре состава с содержанием отходов стекла от 5 до 20% мас. с целью анализа их влияния на удобоукладываемость бетонной смеси, а также физико-механические свойства и способность декоративных изделий пропускать свет. Полученные результаты показали, что при увеличении содержания стекла удобоукладываемость бетонных смесей по расплыву конуса снизилась с 25 до 19 см, тогда как их средняя плотность увеличилась с 2068 до 2169 кг/м^3. В возрасте твердения 28 суток прочность бетонных образцов на сжатие составила 38–46 МПа, прочность на растяжение при изгибе – не менее 4,9 МПа, износостойкость 0,3–0,51 г/см^3, водопоглощение по массе от 7,3 до 8,5%, а коэффициент светопропускания повысился с 11,8 до 20,5%. **Заключение.** Полученные светопропускающие декоративные изделия подходят для внутренней и наружной отделки и одновременно обеспечивают требуемые эксплуатационные характеристики, а также создают внутри помещений эффект мягкого рассеивания света. Кроме того, использование крупнотоннажных промышленных отходов способствует снижению потребления природных ресурсов и выбросов углекислого газа, что подтверждает потенциал использования разработанного декоративно-отделочного материала для усиления архитектурной выразительности интерьеров жилых и общественных зданий.

КЛЮЧЕВЫЕ СЛОВА: «зеленый» светопропускающий бетон, стекольные отходы, декоративные изделия, коэффициент светопропускания

ИСТОЧНИКИ ФИНАНСИРОВАНИЯ НАУЧНОЙ РАБОТЫ, РЕЗУЛЬТАТОМ КОТОРОЙ СТАЛА ПУБЛИКАЦИЯ: Содержание данной статьи является частью результатов научно-исследовательского проекта по инкубации научно-технологической продукции Ханойского горно-геологического университета (HUMG) на 2025 год «Разработка светопропускающих декоративных бетонных изделий с использованием стеклянных отходов и дисперсного армирования» (код проекта: DAUT.01.2005)

БЛАГОДАРНОСТИ: Авторы выражают искреннюю благодарность лаборатории Ханойского горно-геологического университета, предоставленной для реализации данного проекта.

ДЛЯ ЦИТИРОВАНИЯ:
Лам Танг Ван, Нгуен Санг, Булгаков Б.И., Лукьянова Н.А. Возможность использования «зеленого» бетона и отходов стекла для изготовления светопропускающих декоративных изделий. *Нанотехнологии в строительстве.* 2026;18(3):379–392. https://doi.org/10.15828/2075-8545-2026-18-3-379-392. – EDN: UFUZGU.

INTRODUCTION

In recent years, the development of green building materials and the promotion of a circular economy model have become an important policy area for many countries, including Vietnam, with the aim of reducing greenhouse gas emissions, conserving natural resources, and limiting environmental pollution. The production of building materials, particularly cement and traditional concrete, is considered a significant source of CO_2 emissions and is accompanied by high consumption of non-renewable mineral resources [1]. Under these conditions, research into green concrete using cement-free binders or reduced cement content in combination with the use of large-scale industrial waste, such as fly ash from thermal power plants and metallurgical slag, is attracting increasing interest from the scientific community and industrial practice [2, 3].

In parallel with the problem of emissions from the production of traditional building materials, the volume of glass waste generated during construction, building renovation, and household consumption is constantly increasing, especially in large cities. Glass is a material that is difficult to decompose, persists for a long time in the natural environment, and creates a significant burden on solid waste disposal systems in the absence of effective recycling [4]. At the same time, due to its chemical stability, high strength, and good light transmittance, glass waste has significant potential for reuse as a functional material in construction and decorative products, and not just as waste subject to recycling (Fig. 1).

For interior and exterior building cladding, translucent materials such as art glass, translucent stone, and specialty composites are increasingly in demand due to their high aesthetic value and ability to create expressive light effects. However, most such products are currently characterized by high costs, energy-intensive production processes, and insufficient environmental sustainability. Meanwhile, research into translucent concrete or glass-filled concrete has primarily focused on large-format architectural structures or cladding panels, while insufficient attention has been paid to research focused on medium- and small-sized decorative products that simultaneously impose requirements on their mechanical properties, light transmittance, and aesthetic qualities [5].

In particular, for translucent decorative products, the material must not only ensure strength and operational stability but also facilitate efficient light distribution, create a harmonious visual effect, and match the interior and exterior spaces. The combination of "green" concrete with waste glass for the production of translucent decorative panels is considered a new approach that simultaneously promotes the efficient use of solid waste and expands the scope of "green" concrete's application, from structural applications to decorative and architectural finishing [6, 7].

Based on the stated premises, this study aims to evaluate the feasibility of using cementless "green" concrete in combination with waste glass for the production of translucent decorative products. The paper examines material selection, design principles for the mixture composition, manufacturing technology, and key product characteristics, including light transmittance, mechanical properties, and potential for use in interior and exterior finishes. The results obtained are expected to contribute to the development of scientific foundations for the development of durable and environmentally friendly decorative materials, as well as to ensure more efficient use of glass waste for the production of modern building materials with great architectural expressiveness.

Fig. 1. Decorative items made using glass waste:
a – Decorative box-type lamp; b – Decorative cladding panel

ISSN 2075-8545 (online)
Nanotechnologies in construction
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MATERIALS AND METHODS

2.1. Materials

a) Binder.

The binder used to produce the light-transmitting decorative concrete product included a mixture of fly ash from the Phả Lại Thermal Power Plant, which complies with the requirements of the Vietnamese standard TCVN 10302:2014 "Active mineral additive – fly ash for concrete, mortar and cement" (Fig. 2), and finely ground granulated blast furnace slag from the Hòa Phát metallurgical plant, which complies with the requirements of the TCVN 11586:2016 "Ground granulated blast-furnace slag for concrete and mortar" (Fig. 3) [8].

b) Aggregates.

The aggregates used included glass waste of various colors and sizes, obtained from solid waste landfills, crushed to particles of 5.0–20.0 mm, as well as decorative fine aggregate of 2.5–5.0 mm.

In this study, glass particles served as coarse aggregate and met the requirements of TCVN 7570:2006 " Aggregates for concrete and mortar – Specifications" (Fig. 4, 5).

Prior to use, the crushed glass particles were washed and classified according to color and size (Fig. 6). The average bulk density of the glass particles was approximately 2480 kg/m^3.

Decorative fine aggregate was used to reduce shrinkage and enhance the load-bearing framework of the product. The particles of decorative fine aggregate were obtained

Fig. 2. Fly ash from the "Pha Lai" Thermal Power Plant

Fig. 3. Fine-ground blast furnace granulated slag from the "Hoa Phat" metallurgical plant

Fig. 4. Glass waste at a recycling collection point

Fig. 5. Glass waste particles after crushing

ISSN 2075-8545 (online)

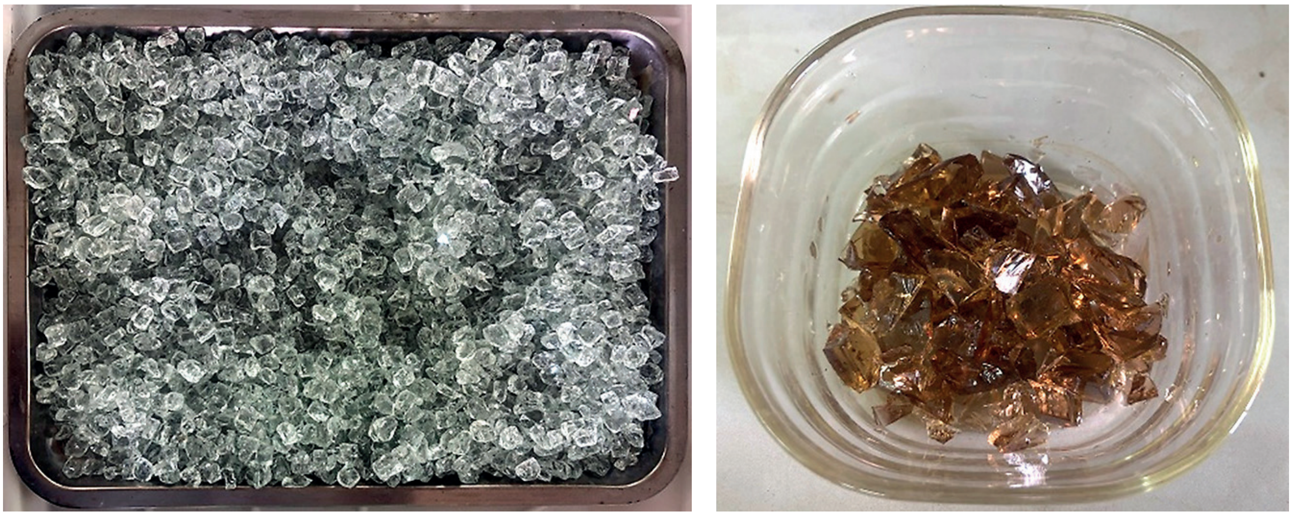

Fig. 6. Glass particles after processing and sorting

by sieving coarse yellow sand through sieves with mesh sizes ranging from 2.5 to 5.0 mm (Fig. 7).

In decorative concrete products in the form of thin panels, cracking is often observed after molding due to the high fluidity of the plastic binder suspension. Therefore, the use of fine decorative aggregate is necessary. However, when the aggregate content is excessively increased, the rheological properties of the mixture and its ability to fill the mold with the binder composition during the forming process are adversely affected [9].

c) Superplasticizing additive and activating solution.

In this study, a superplasticizer commercially known as MVN-SR, produced by the concrete admixture manufacturer Silkroad Hanoi (SILKROAD HANOI JSC), was used. This admixture belongs to the third-generation high-range water-reducing admixtures based on polycarboxylates. The density of the aqueous solution of the admixture is approximately 1.15 g/cm^3 at a temperature of 25 ± 5 °C, complying with the requirements of TCVN 8826:2024 "Chemical Admixtures for Concrete" (Fig. 8). In this research, the superplasticizer was used at a dosage of 1.5% by mass of binder to obtain a plastic suspension with adequate flowability and self-compacting ability under its own weight during the forming process.

The activating solution used in this study consisted of a mixture of a 10 M NaOH solution and a Na_2SiO_3 solution with a SiO_2/Na_2O ratio of 2.75. The mass ratio between the 10 M NaOH solution and the Na_2SiO_3 solution was 50:50%.

The mixture of the superplasticizer and the activating solution used in this study is shown in Fig. 9.

Fig. 7. Decorative fine aggregate

Fig. 8. MVN-SR superplasticizer

ISSN 2075-8545 (online)
Nanotechnologies in construction
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Fig. 9. Mixture of the superplasticizer and the

d) Fiber.

Synthetic polypropylene fibers in the form of individual filaments and steel mesh fiber were used for the dispersed reinforcement of decorative translucent products to improve their crack resistance and mechanical properties. The fibers were uniformly distributed throughout the raw material composition to reduce local stress concentration [10] (Fig. 10).

e) Water and pigments.

Water used for preparing the concrete mixture and for subsequent curing complied with the requirements of TCVN 4506:2012 "Water for concrete and mortar – Technical speccification".

In addition, various pigment powders, including red, yellow, blue, and other colors, were used in this study to provide the decorative products with the desired color range and aesthetic characteristics, depending on the design requirements of the products (Fig. 11).

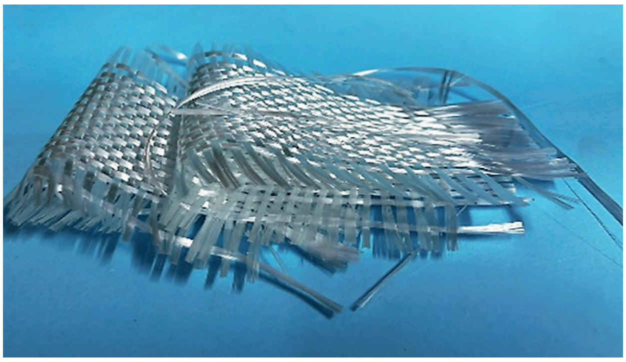

Fig. 10. Fibers for crack prevention

2.2. Composition of the concrete mixture and technology for producing translucent decorative products

The composition of the concrete mixture for producing "green" concrete was developed based on the use of fly ash and blast furnace slag as the main binders, combined with fine and coarse aggregates, water, and

Fig. 11. Decorative pigment powder

chemical admixtures to obtain a highly plastic mixture suitable for molding decorative products. The content of glass particles was selected according to the requirements for light-transmitting effects and aesthetic appearance of the products, rather than being determined solely based on physical and mechanical properties, as is commonly practiced in the mix design of conventional structural concrete.

Based on preliminary laboratory investigations, the following proportions of raw materials were adopted for 1 m³ of concrete mixture:

- Binder: 1000 kg;
- The content of thermal power plant fly ash and finely ground granulated blast furnace slag varied from 0 to 1000 kg to reach a total binder mass of 1000 kg;
- Decorative fine aggregate: 500 kg;
- Glass particle content: 5, 10, 15, and 20% by mass of binder;
- Fiber content: 5 and 10% by mass of binder;
- Superplasticizer dosage: 1.5% by mass of binder;
- Colored pigment dosage: 1.0% by mass of binder;
- Activating solution-to-binder ratio: 0.25;
- Water-to-binder ratio: 0.15.

The compositions of the concrete mixtures used to produce the green concrete are presented in Table 1.

The technological process for producing light-transmitting decorative concrete products was carried out through the following main stages:

1. Preparation of molds for manufacturing the products.
2. Preparation of raw materials.
3. Dosing of components and preparation of the concrete mixture.
4. Development of the decorative pattern and placement of glass particles in the molds.
5. Casting of the concrete mixture into the molds and forming of the products.
6. Demolding, curing of the products, application of a protective adhesive coating, and final surface finishing.

Fly ash, blast furnace slag, pigment powder, and the admixture were first dry-mixed to ensure uniformity of the mixture. After that, water was added, and mixing was continued until the required plasticity of the mixture was achieved. The glass particles were arranged in the molds according to the designed composition in order to create the light-transmitting effect and ensure the aesthetic expressiveness of the products. After preparation, the concrete mixture was carefully poured into the molds to minimize the coverage of the glass element surfaces and thereby ensure the required light-transmitting capacity of the finished products [11, 12] (Fig. 12 and 13).

2.3. Test methods

In this study, the physical and mechanical properties of specimens in the form of thin panels of various sizes and thicknesses (square panels of 200×200 mm and 300×300 mm, as well as rectangular panels of 200×300 mm and 300×400 mm, with thicknesses ranging from 10 to 20 mm) made of "green" light-transmitting decorative concrete were determined in accordance with the requirements of TCVN 7744:2013 "Terrazzo Tiles".

a) The following standardized parameters specified in this standard were determined:

- The slump flow of the concrete mixtures was determined using a standard truncated cone in accordance with TCVN 12209:2018 [13] (Fig. 14);
- The average density of translucent green concrete was determined in accordance with TCVN 3115:2022 [14];
- The water absorption of the concrete was determined in accordance with TCVN 7744:2013 [15];
- The abrasion resistance of the concrete was determined in accordance with TCVN 3113:2022 [16];
- The compressive strength at different curing ages was determined using cube specimens of 100×100×100 mm in accordance with TCVN 3118:2022 [17];
- The flexural tensile strength at the age of 28 days was determined using prism specimens of 100×100×400 mm in accordance with TCVN 3119:2022 [18].

b) Model for determining the light transmittance coefficient of experimental concrete specimens.

The light transmittance coefficient of decorative materials is used to evaluate the ability of light to pass through a material under the influence of an incident light source.

Table 1. Concrete mix compositions

Concrete mixture	Component content, kg									Total
	Fly ash "Pha Lai"	Blast furnace slag "Hoa Phat"	Glass particles	Fine decorative aggregate	Fiber	MVN-SR Superplasticizer	Activating solution	Colored pigments	Water	
GreCor-01	1000	0	50	500	100	15	250	10	150	2075
GreCor-02	600	400	100	500	100	15	250	10	150	2125
GreCor-03	400	600	150	500	50	15	250	10	150	2125
GreCor-04	0	1000	200	500	50	15	250	10	150	2175

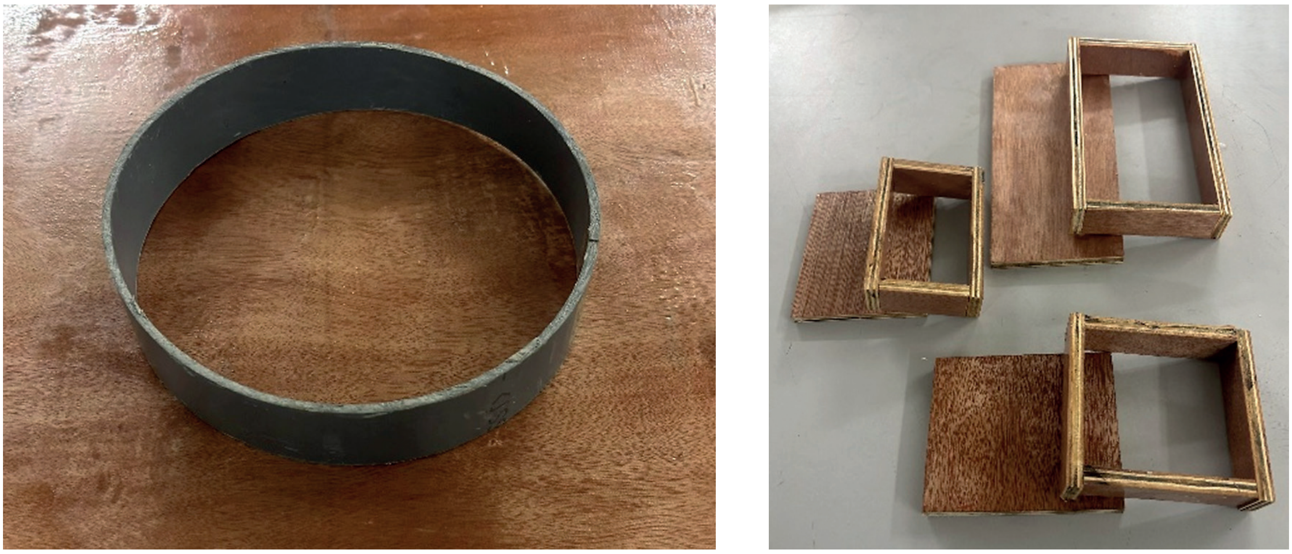

Fig. 12. Wooden molds for product casting

Fig. 13. Preparation of molds and casting of the concrete mixture for product molding

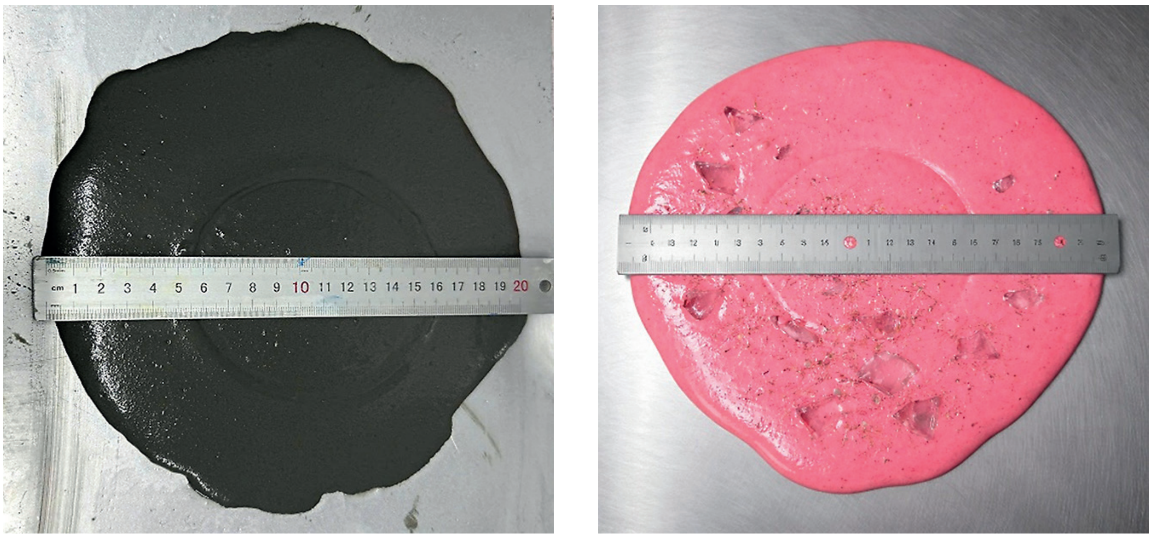

Fig. 14. Measurement of the slump flow of concrete mixtures

In this study, the light transmittance coefficient was defined as the ratio between the intensity of light transmitted through the material specimen (in lux) and the initial light intensity incident on the surface of the specimen (in lux).

For translucent concrete materials, the light transmittance coefficient reflects the efficiency of light transmission through the light-conducting components (such as glass particles or transparent phases) distributed within the concrete matrix. The value of this coefficient depends on the structure of the material, the proportion and size of the light-transmitting components, as well as the thickness of the specimen.

In this study, the light transmission intensity of the developed "green" decorative concretes was measured using a Testo 540 illuminance meter (Germany) (Fig. 15).

In this study, the experimental setup used to evaluate the light transmittance of decorative concrete products was designed and fabricated under laboratory conditions. It was constructed as a dark box in order to minimize the influence of ambient light on the measurement results (Fig. 16).

The light transmittance coefficient of "green" decorative concrete specimens (Ψ) is defined as the ratio between the light intensity (I, lux) transmitted through the material specimen and the initial light intensity (I_0, lux) incident on the surface of the specimen, as expressed by the following equation:

$$\Psi = I/I_0 \times 100\%,$$

where: Ψ – light transmittance coefficient, %; I – light intensity transmitted through the tested specimen, lux; I_0 – initial light intensity incident on the surface of the specimen, lux.

Fig. 15. Testo 540 illuminance meter (Germany)

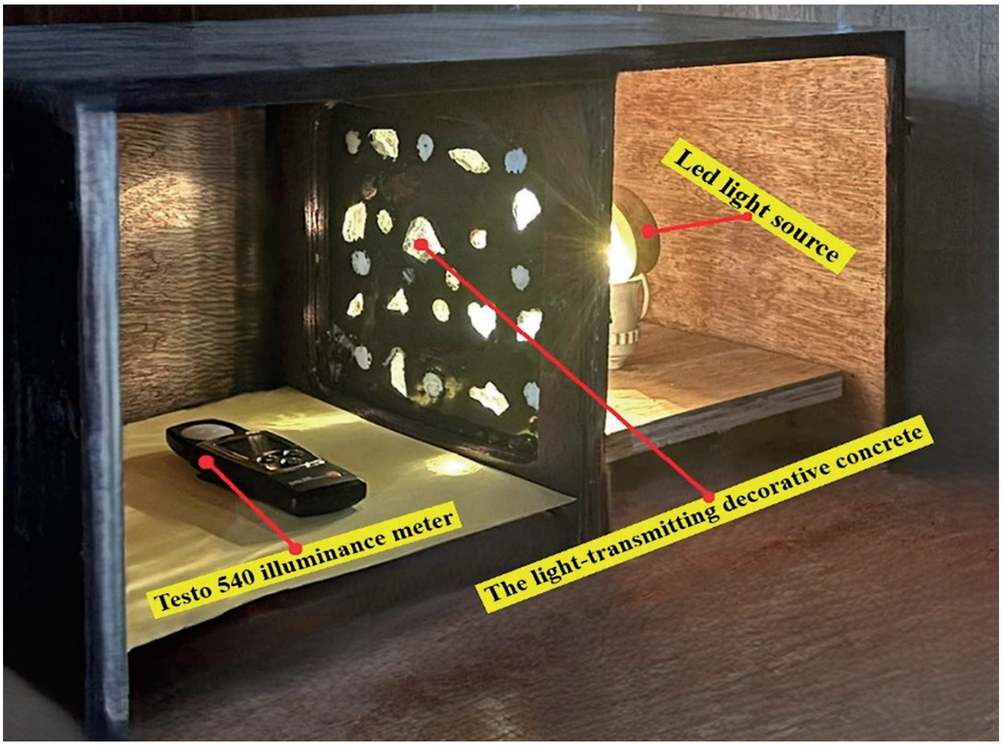

Fig. 16. Experimental setup for determining the light transmittance coefficient of the light-transmitting decorative concrete specimens

ISSN 2075-8545 (online)

Nanotechnologies in construction | 2026; 18 (3): 379–392
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RESULTS AND DISCUSSION

The experimental results obtained under laboratory conditions for the concrete mixtures and the hardened specimens of cement-free translucent decorative concrete are presented in Tables 2, 3.

3.1. Effect of fly ash, blast furnace slag, and glass particle content on the properties of concrete mixtures

With an increase in the content of blast furnace slag and a corresponding decrease in the content of fly ash in the binder composition, the color of the concrete mixtures gradually changed from dark gray to light gray and eventually to white. This is attributed to the color characteristics of the raw materials: fly ash has a dark gray color, whereas the blast furnace slag used in this study exhibited a light, nearly white color.

In addition, as the content of glass particles increased from 5% to 20% by mass of binder, significant changes in the properties of the concrete mixtures were observed. The workability, expressed in terms of slump flow, decreased from 25 to 19 cm, and the surface of the specimens became rougher compared to those containing lower amounts of glass particles.

The experimental results indicate that concrete mixtures with higher glass particle content exhibit reduced workability, which adversely affects their ability to fill molds during the forming process.

Furthermore, considering that the average bulk density of the glass particles is approximately 2480 kg/m^3, an increase in their content leads to a slight increase in the average density of the concrete mixtures, from 2068 to 2169 kg/m^3.

3.2. Properties of "green" light-transmitting decorative concrete

The experimental results presented in Table 3 indicate significant changes in the physical and mechanical properties of green concretes with increasing contents of blast furnace slag and glass particles in the concrete mixtures. Glass particles perform a dual function: they act as coarse aggregates and simultaneously determine the light-transmitting capacity of the product.

As the content of glass particles increased, the compressive strength and flexural tensile strength increased by 24% and 8%, respectively. In addition, the abrasion resistance improved significantly, with the abrasion loss decreasing from 0.51 to 0.30 g/cm^2, while the water absorption by mass decreased from 8.5% to 7.3%. At the same time, the

Table 2. Properties of concrete mixtures

Parameter	GreCor-01		GreCor-02		GreCor-03		GreCor-04	
	Mean value	Standard deviation	Mean value	Standard deviation	Mean value	Standard deviation	Mean value	Standard deviation
Slump flow diameter (cm)	25	2.1	23	2.2	20	1.5	19	2.5
Average density (kg/m^3)	2068	7.5	2117	6.3	2119	8.2	2169	8.0
Color	Dark gray		Light gray		Grayish white		White	

Table 3. Physical and mechanical properties of the light-transmitting decorative concrete specimens at 28 days

Parameter	GreCor-01		GreCor-02		GreCor-03		GreCor-04	
	Mean value	Standard deviation	Mean value	Standard deviation	Mean value	Standard deviation	Mean value	Standard deviation
Average density (kg/m^3)	2048	4.0	2090	4.2	2110	4.0	2138	4.5
Water absorption (% by mass)	8.5	0.8	8.1	1.0	7.5	0.9	7.3	0.8
Abrasion resistance (g/cm^2)	0.51	0.25	0.48	0.15	0.36	0.2	0.3	0.1
Compressive strength (MPa)	38	2.1	41	2.2	43	2.4	46	2.4
Flexural tensile strength (MPa)	4.9	0.66	5.1	0.85	5.3	0.9	5.4	1.1
Light transmittance coefficient (%)	11.8		15.7		17.2		20.5	
Surface condition	Smooth dark gray surface		Smooth light gray surface		Rough grayish-white surface		Rough white surface	

light transmittance coefficient increased from 11.8% to 20.5% (Fig. 17). Thus, the glass aggregate plays a key role in determining both the strength characteristics and the light-transmitting capacity of the specimens.

In addition, the water absorption by mass at 28 days of curing of the green decorative concrete specimens decreased significantly, by 15.6%, as the content of glass particles increased from 5% to 20% by mass of binder. This trend can be explained by the low water absorption capacity of glass particles [19].

The compressive strength and flexural tensile strength of the obtained light-transmitting decorative concrete specimens are presented in Fig. 18.

As shown in Fig. 18, when the compressive strength of the light-transmitting decorative concrete specimens increased from 38 to 46 MPa, the flexural tensile strength also increased from 4.9 to 5.4 MPa at the age of 28 days. The ratio between flexural tensile strength and compressive strength ranged from 1/8 to 1/9, which is comparable to the relationship between

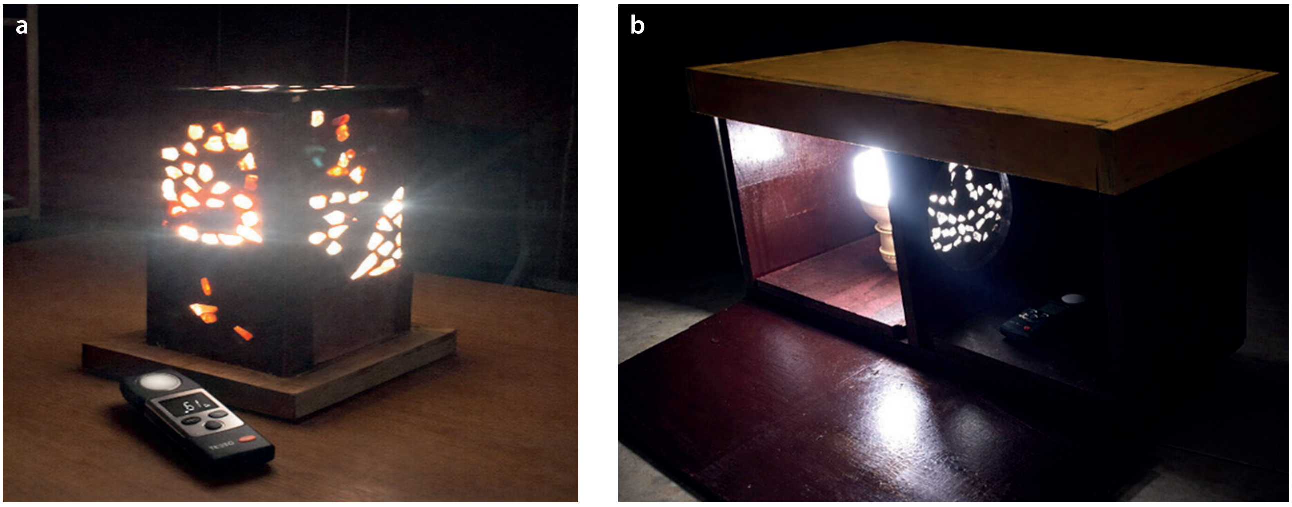

Fig. 17. Measurement of the light transmittance of light-transmitting decorative concrete products: a– Measurement of the light transmission of a table lamp; b – Measurement of the light transmission of a thin sheet product

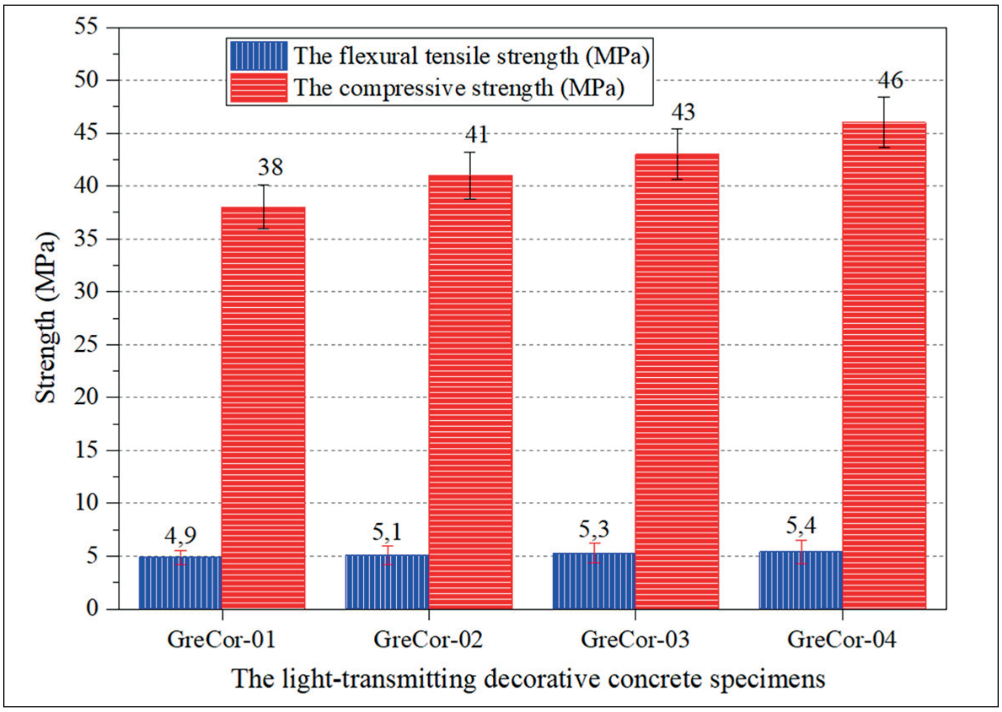

Fig. 18. Compressive and flexural tensile strengths of light-transmitting decorative concrete specimens at 28 days

these strength parameters in conventional cement-based concretes.

In addition, the experimental studies demonstrated that translucent decorative products made of green concrete and crushed glass waste are capable of transmitting light from one surface to the other through the glass inclusions. The transmitted light is not concentrated into intense light beams but is softly diffused, creating a harmonious visual effect. This feature makes such products suitable for both interior and exterior decorative applications [20].

The light-transmitting capacity of the decorative products mainly depends on the content and size of the glass particles, as well as on the color of the glass and the degree of coverage of the glass particles by the cement-free binder matrix. The light-transmitting decorative concrete specimens containing transparent or light-colored glass provide a more pronounced light-transmitting effect compared with those containing dark-colored glass particles. At the same time, controlling the process of placing the concrete mixture into the molds to prevent the binder paste from adhering to the surface of the glass particles is an important factor in maintaining the light-transmitting efficiency of the product.

Compared with traditional light-transmitting materials such as art glass or translucent stone, the "green" decorative concrete does not provide full transparency but rather produces an effect of soft, diffused, and deep illumination. This characteristic makes such products suitable for decorative architectural applications in both interiors and exteriors, preventing glare and creating a comfortable visual perception of light [21] (Fig. 19).

Overall, the obtained results indicate that optimizing the content of blast furnace slag and glass waste not only enhances the mechanical properties but also improves the light-transmitting capacity of the material, while simultaneously ensuring that both technical and aesthetic requirements for translucent decorative concrete products are satisfied.

3.3. Evaluation of the application potential of the "green" decorative concrete in construction

The research results indicate that translucent decorative products made of green concrete and glass particles have a high potential for practical application in construction, particularly in interior and exterior finishing works. With a compressive strength of up to 46 MPa and a light transmittance coefficient of up to 20.5%, such products simultaneously provide the required mechanical performance and a pronounced aesthetic lighting effect.

These products can be used as decorative cladding panels, translucent partitions, wall decorative panels, signage elements, as well as accent architectural components in residential buildings, hotels, restaurants, schools, and public spaces (Fig. 20 and 21).

Compared with imported light-transmitting materials, this product has a cost advantage due to the use of locally available waste materials such as fly ash, blast furnace slag, and crushed glas.

In addition, the use of glass cullet and large-volume industrial wastes for the production of decorative products contributes to reducing the consumption of natural resources and lowering CO_2 emissions compared with imported light-transmitting materials or conventional decorative materials [22]. This represents an important advantage of such products under current conditions, where increasing priority is given in construction to environmentally friendly and durable materials.

• Potential applications of the "green" light-transmitting decorative concrete:

- Possibility of manufacturing structural elements that simultaneously perform load-bearing and enclosure functions due to the high strength of the material;
- Possibility of using the material as an element of natural lighting in buildings, as it possesses good light-transmitting capacity;

Fig. 19. Examples of products made from the light-transmitting decorative concrete

ISSN 2075-8545 (online)

Fig. 20. Artwork "Spring in the Leaves"

Fig. 21. Artwork "Favorable Wind"

- Possibility of application in interior and exterior finishing works in combination with traditional materials, enabling the creation of unique architectural lighting effects;
- Possibility of producing decorative partition walls.

However, in order to expand the application field of decorative products made from cement-free concrete, further studies are required to optimize the manufacturing technology, improve surface quality control, reduce the tendency for crack formation, and evaluate the durability of products under different service conditions, particularly in humid environments and outdoor applications.

CONCLUSION

Based on the experimental results of the research, the following conclusion can be drawn:

1. Cement-free "green" concrete, produced using fly ash, blast furnace slag, and glass particles, can be applied in the manufacture of translucent decorative products, ensuring shape stability, relatively uniform surface quality, and mechanical strength meeting practical service requirements.

2. Glass particles incorporated into the "green" concrete matrix allow light to pass through the material, creating a soft diffused lighting effect suitable for both interior and exterior decorative applications.

3. The light-transmitting capacity mainly depends on the content, size, and color of glass particles, as well as the degree to which these particles are covered by the binder matrix. Transparent and light-colored glass provides a more pronounced lighting effect compared with darker-colored glass.

4. The use of glass waste, fly ash, and blast furnace slag contributes to reducing natural resource consumption and CO_2 emissions, which is consistent with the development direction of sustainable construction materials and the principles of the circular economy.

5. The "green" light-transmitting decorative concrete demonstrates high application potential in both interior and exterior architectural design, as well as promising prospects for further development, as it represents an environmentally friendly decorative material.

Further research is recommended to evaluate the durability, crack resistance, and color stability of decorative products made from cement-free concrete under different service conditions, particularly in outdoor environments. Such studies will provide a scientific basis for industrial-scale production and practical application of these materials.

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ADDITIONAL INFORMATION

The authors declare that generative artificial intelligence technologies and technologies based on artificial intelligence were not used in the preparation of the article.

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CONTRIBUTION OF THE AUTHORS

Tang Van Lam– scientific management; final conclusion.

Sang Nguyen – research concept; writing the draft.

B.I. Bulgakov– scientific management; final conclusion.

N.A. Lukyanova– follow-on revision of the text.

The authors declare no conflicts of interests.

The article was submitted 14.04.2026; approved after reviewing 06.06.2026; accepted for publication 10.06.2026.